WORK PLAN FOR BASELINE HUMAN HEALTH RISK ASSESSMENT

McCAFFREY STREET SITE

(Site No. 442046, USEPA ID# NYD004986741)

Prepared on behalf of: Saint-Gobain Performance Plastics Corporation and Honeywell International Inc.

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List of Acronyms

1,2-DCE	1,2-dichloroethene
95UCL	one-sided 95 percent upper confidence limit for the arithmetic mean
ADAF	age-dependent adjustment factor
ADD	average daily dose
ALM	adult lead model
ARAR	applicable or relevant and appropriate requirements
Atm m^3/mol	atmosphere meter cubed per mol
ATSDR	Agency for Toxic Substances and Disease Registry
BaP	benzo[a]pyrene
BEHP	bis(2-ethylhexyl)phthalate
BERA	baseline ecological risk assessment
bgs	below ground surface
BHHRA	baseline human health risk assessment
BW	body weight
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
COC	contaminants of concern
COPC	contaminants of potential concern
CSF	cancer slope factor
CSM	conceptual site model
CTE	central tendency exposure
DoD	Department of Defense
DQO	data quality objective
DTSC	California Department of Toxic Substances and Control
EGLE	Michigan Department of Environmental, Great Lakes, and Energy
ELCR	excess incremental lifetime cancer risk
EPC	exposure point concentration
ERM	Environmental Resources Management
ESA	Environmental Site Assessment
EU	exposure unit
FOD	frequency of detection
g/mol	grams per mole
GAC	granular activated carbon
GIS	Geographical Information System
GSI	GSI Environmental Inc.
HHRA	human health risk assessment
HI	hazard index
HQ	hazard quotient

IEUBK	Integrated Exposure Uptake Biokinetic Model
IRIS	Integrated Risk Information System
IRM	interim remedial measure
IUR	inhalation unit risk
KM	Kaplan Meier
LADD	lifetime average daily dose
MCL	maximum contaminant level
MDH	Minnesota Department of Health
MDL	method detection limit
mg/kg	milligrams per kilogram
MRL	method reporting limit
NAWQC	National Ambient Water Quality Criteria
ND	non-detect
ng/L	nanograms per liter
NLCD	National Land Cover Database
NPL	National Priority List
NYCRR	New York Codes, Rules, and Regulations
NYS	New York State
NYSDEC	New York State Department of Environmental Conservation
NYSDOH	New York State Department of Health
OSWER	Office of Solid Waste and Emergency Response
PAH	polycyclic aromatic hydrocarbon
PbB	blood lead
PCB	polychlorinated biphenyl
PFAS	per-and polyfluoroalkyl substances
PFBA	perfluorobutanoic acid
PFBS	perfluorobutane sulfonate
PFCA	perfluoroalkyl carboxylic acids
PFHpA	perfluoroheptanoic acid
PFHxS	perfluorohexane sulfonate
PFNA	perfluorononanoic acid
PFOA	perfluorooctanoic acid
PFOS	perfluorooctane sulfonate
PFSA	perfluoroalkane sulfonates
PPRTV	provisional peer-reviewed toxicity value
ppt	parts per trillion
PRA	probabilistic risk assessment
PTFE	polytetrafluoroethylene
QA/QC	quality assurance/quality control
RAGS	Risk Assessment Guidance for Superfund

RBSL	risk-based screening level
REC	recognized environmental conditions
RfC	reference concentration
RfD	reference dose
RI	remedial investigation
RI/FS	remedial investigation/feasibility study
RISA	residential irrigated soil area
RME	reasonable maximum exposure
RPD	relative percent difference
RPF	relative potency factor
RSBC	rural soil background concentration
RSL	regional screening level
SAP	sampling and analysis plan
SCO	soil cleanup objectives
SGPP	Saint-Gobain Performance Plastics Corporation
SQL	sample quantitation limit
SVOC	semi-volatile organic compound
TAGM	Technical and Administrative Guidance Memorandum
TAL/TCL	target analyte list/target compound list
TCE	trichloroethene
TCEQ	Texas Commission on Environmental Quality
THQ	target hazard quotient
TPH	total petroleum hydrocarbons
µg/dL	micrograms per deciliter
µg/kg	micrograms per kilogram
µg/L	micrograms per liter
µg/m^3	micrograms per cubic meter
USEPA	United States Environmental Protection Agency
USGS	U.S. Geological Survey
VDEQ	Virginia Department Environmental Quality
VI	vapor intrusion
VISL	vapor intrusion screening level
VOC	volatile organic compound

1.0 INTRODUCTION

This Baseline Human Health Risk Assessment (BHHRA) Work Plan has been prepared by GSI Environmental Inc. (GSI) for the McCaffrey Street Site in Hoosick Falls, New York, (New York State Department of Environmental Conservation Site No. 442046) (the site, Figure 1). This Work Plan was prepared on behalf of Saint-Gobain Performance Plastics Corporation (SGPP) and Honeywell International Inc. (Honeywell) in response to a request from the New York State Department of Environmental Conservation (NYSDEC) dated 27 May 2020 pursuant to the 2016 Order on Consent for the site (NYSDEC, personal communication, 2020; NYSDEC State Superfund Program, 2016). A baseline risk assessment was requested for the site to fulfill the Comprehensive Environmental Response, Compensation and Liability Act of 1980 (CERCLA or "Superfund") requirements for Remedial Investigation/Feasibility Studies (RI/FS). Although human health risk assessment and environmental ecological assessments are different, when conducted for the same site using the same chemical sampling data, they should share common information and should be coordinated (USEPA, 1989a, 2004c). Please refer to the companion document for the Baseline Ecological Risk Assessment Work Plan.

1.1 Scope and Objectives

The goal of Superfund baseline risk assessments is to "provide a framework for developing the risk information necessary to assist decision-making at remedial sites" (USEPA, 1989a). Baseline risk assessments often include evaluations of multiple sources of variability and uncertainty in exposure and response, integrating site-specific data, scientific literature, regulatory guidance, and professional judgment. As such, risk assessments support statements regarding the probability of potential adverse effects, rather than making firm conclusions about disease, causation, or the health status of current or potential future populations. As required under CERCLA section 104(i)(5)(F), the goal of this baseline risk assessment is to characterize the probability of adverse effects from estimated exposures to potential environmental hazards at the site, using quantitative, chemical-specific characterizations and statistical models and estimates of risk (USEPA, 1989a). The assessment will consider assumptions regarding exposure scenarios and potential human receptors that may contact chemicals in the environment under both current and potential future conditions in order to inform risk management decisions (USEPA, 1989a, 1998).

The BHHRA will follow the process defined by USEPA for evaluating human health risks at Superfund sites (USEPA, 1989a, 1998). Both U.S. Environmental Protection Agency (USEPA) and NYSDEC guidance for conducting a RI/FS require that remedies at contaminated sites be protective of human health and the environment (NYSDEC, 2010a; USEPA, 1988), and the BHHRA is one of the tools that will be used to select a remedy for the site that meets this requirement.

This Work Plan outlines the procedures by which data collected as part of the remedial investigation (RI) will be evaluated to assess risks to human health. The RI sampling conducted to date informs the nature and extent of chemicals present in the Primary Project Area, including metals, polycyclic aromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs), pesticides, per- and polyfluoroalkyl substances (PFAS), and volatile and semi-volatile organic compounds (VOC/SVOC) (C.T. Male Associates, 2016, 2019a). This Work Plan presents the problem formulation and initial conceptual site model (CSM) used to define the scope of the BHHRA, the results of screening-level risk assessments for identification of human contaminants of potential concern (COPCs), and the methods for characterizing exposure, toxicity, and risk in the final baseline risk assessment.

The findings and conclusions of this BHHRA will be used in conjunction with other RI findings to determine whether remedial action is needed, and if so, to support development of risk management options.

1.2 Risk Assessment Guidance and Regulatory Framework

The methods and approach for the BHHRA are based on available risk assessment guidance, including but not limited to the key documents listed below. A more extensive list is provided in Table 1.

Federal Guidance:

- Risk Assessment Guidance for Superfund (RAGS) Volume I Human Health Evaluation Manual (Part A, B, C, D) (USEPA, 1989a, 1991a, 1991b, 2001b)
- Office of Solid Waste and Emergency Response (OSWER) Directive 9285.7-53, “Human Health Toxicity Values in Superfund Risk Assessments” (USEPA, 1988)
- OSWER Directive 9355.3-01, "Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA" (USEPA, 1988)
- RAGS, Volume II, Environmental Evaluation Manual, Interim Final. (USEPA, 1989b)
- RAGS, Volume III, Part A, Process for Conducting Probabilistic Risk Assessment (USEPA, 2001e)
- Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites (USEPA, 2002f)
- Guidance for the Data Quality Objectives Process (USEPA, 2006b)
- Exposure Factors Handbook: 2011 Edition (and subsequent updates of selected chapters) (USEPA, 2011)
- Memorandum on “Determining Groundwater Exposure Point Concentrations, Supplemental Guidance” OSWER Directive 9283.1-42, February (USEPA, 2014a).
- Exposure Factors Handbook: 2017 Update to Chapter 5: Soil and Dust Ingestion (USEPA, 2017a)
- Exposure Factors Handbook: 2019 Update to Chapter 3: Ingestion of Water and Other Select Liquids (USEPA, 2019a)
- Guidelines for Human Exposure Assessment (USEPA, 2019b)

New York State Guidance:

- NYSDEC DER-10 Technical Guidance for Site Investigation and Remediation (NYSDEC, 2010a)
- New York State Brownfield Cleanup Program - Development of Soil Cleanup Objectives - Technical Support Document (NYSDEC & NYSDOH, 2006)
- Final Commissioner Policy, CP-51, Soil Cleanup Guidance (NYSDEC, 2010b)
- Screening and Assessment of Contaminated Sediment (NYSDEC, 2014)
- Guidelines for Sampling and Analysis of PFAS Under NYSDEC's Part 375 Remedial Programs (NYSDEC, 2020d)
- New York State Department of Health (NYSDOH) Final Guidance for Evaluating Soil Vapor Intrusion in the State of New York, October (NYSDOH, 2006), and Soil Vapor/Indoor Air Matrix updates in May 2017 (NYSDOH, 2017a).

1.3 Work Plan Organization

The BHHRA Work Plan is organized as follows:

- Section 2 provides a summary of the Site setting and background.
- Section 3 provides a summary of operational history, previous and current investigations, including a summary of RI/FS work performed to date.
- Section 4 provides a summary of data collected to date, Data Quality Objectives (DQO), and Data Usability and Processing Rules.
- Section 5 details the purpose, methods for, and results of screening-level risk assessments for COPCs.
- Section 6 provides an overview of the methods for the baseline risk assessment and initial problem formulation for the BHHRA.
- Section 7 describes the preliminary conceptual site model and methods for the BHHRA exposure assessment.
- Section 8 describes the BHHRA toxicity assessment methods and rationale.
- Section 9 provides the details on the BHHRA risk characterization and Uncertainty assessment.
- Section 10 provides information on project organization and anticipated schedule.
- Section 11 provides a list of references used in the preparation of this document.

These sections are followed by the internally referenced tables, then the attachments including exhibits and appendices with additional detailed information and tables.

2.0 SITE SETTING AND BACKGROUND

This section describes the operational history and physical setting, as well as the physiographic, geologic, hydrogeologic, and relevant ecological properties of the site. More extensive discussion of the topics summarized here can be found in the RI/FS Work Plan and Supplemental Work Plans (C.T. Male Associates, 2016, 2017a, 2018b, 2019a) .

2.1 Site and Project Area Description

The McCaffrey Street Site ("site") is defined as an unfenced 6.47-acre tax parcel located at 14 McCaffrey Street in the Village of Hoosick Falls, adjacent to the Hoosic River in Rensselaer County, eastern New York State (Figure 1). The industrial facility on this property consists of an approximately 60,000 square foot manufacturing building, parking areas, loading zones, and warehouse areas. Considering variability in exposure scenarios and activities that are assessed in the human health risk assessment, the tax parcel (i.e., "on-site") is divided into two areas: 1) areas near the facility, including the building footprint, adjacent parking areas, and maintained grassy areas to the south and east of the plant buildings; and 2) wooded areas to the south and west, outside the facility but within the tax parcel boundary (Figure 1).

Current site knowledge compiled from a review of historic operations (see Section 3.1), previous investigation activities (see Section 3.3) and ongoing RI investigations have informed the geographic extent of areas potentially impacted by releases of site-related contaminants. Consistent with the Remedial Investigation/Feasibility Study (RI/FS) Work Plan for the site (dated August 30, 2016), the Primary Project Area evaluated in the baseline risk assessments includes the McCaffrey Street Site (on-site) and areas located outside the facility tax parcel boundary (i.e., "off-site") (C.T. Male Associates, 2016). Figure 1 illustrates the extent of the Primary Project Area (326 acres) inclusive of the tax parcel area (6.5 acres) facility boundary (4.2 acres), and approximately 0.75 miles of shoreline along the Hoosic River. This shoreline area also includes the Village Greenway Trail system, river access, and recreational nature trails and picnic tables. Suburban residential neighborhoods are present along the northern edge of the tax parcel. The western portion of the Primary Project Area outside the tax parcel is undeveloped and forested and is approximately 200 feet east of the Hoosic River. According to the RI/FS Work Plan, adjacent land use also includes the Village of Hoosick Falls sewer pump station to the north, and the Village of Hoosick Falls water supply well field and water treatment plant to the south (C.T. Male Associates, 2016). There are also Department of Public Works garages, youth sporting fields, and recreational areas in this general vicinity to the south of the site.

The Village of Hoosick Falls within the Town of Hoosick is a rural community located predominantly to the north of the site, that is served by the local municipal water department with drinking water sourced from three nearby groundwater wells. Due to the historic presence of perfluorooctanoic acid (PFOA) in municipal water supply wells, surface soils throughout the water district's distribution system may have been impacted with PFOA via the use of residential tap water for irrigation. Although mitigation measures have been implemented in the municipal water system and irrigation is not a current pathway, residual PFOA may still be present in soil of some yards. Therefore, this BHHRA will also evaluate risk within a "Residential Irrigated Soil Area" (RISA) specific only to the evaluation of residential areas with potential PFAS soil impacts throughout the Village municipal water distribution system (Figure 2).

If on-going investigations, including results from the baseline risk assessments, indicate exposure to site-related contaminants may occur outside the Primary Project Area boundaries, the geographic extent of the boundaries may need to be refined as part of the RI/FS investigation, in consultation with USEPA and NYSDEC.

The current owner and operator at the site is SGPP. The original developer at the site was Dodge Fibers Corporation (a producer of extruded tapes and circuit board laminates). The site ownership changed several times during a 30-year period beginning in the 1960s. Prior owners include Oak Materials Group (1967), AlliedSignal Fluorglas (1987), Furon (1996), and SGPP, which acquired the property in 1999 (C.T. Male Associates, 2016). Beginning in the late 1980s until 2003, polytetrafluoroethylene (PTFE) coated fiberglass was manufactured at the site. Other historical chemical use on-site may have included petroleum fuels, lubricants, degreasing agents, solvents, paints, Triton, and various PFAS (C.T. Male Associates, 2016).

2.2 Physical and Geologic Setting

The Village of Hoosick Falls is located in the New England Upland (Taconic Range) physiographic province, an area defined by ancient (Ordovician) mountain-building continental collisions and more recent (Pleistocene) continental glaciations. The site is located on an elevated glacial terrace underlain by bedrock of the Walloomsac Formation, an Upper Ordovician unit composed of dark-gray siliceous shale, phyllite, limestone, and minor beds of quartzite. Elevation of the terrace ranges from 430 to 460 feet MSL. Topography at the site is moderate to steep and slopes generally to the southeast. Adjacent off-site properties slope to the east, southeast, south, and southwest towards the Hoosic River, a tributary of the Hudson River. The approximately 0.75 mile reach of the Hoosic River within the Primary Project Area is at an elevation of approximately 400 feet MSL (USGS, 2019).

Surficial geology at the site is manmade and glacial in origin. Boring logs from prior investigations indicate as much as 2.7 feet of surficial fill material underlain by glacial till and outwash deposits (C.T. Male Associates, 2016). Elevated areas of the site tend to be underlain by glacial till, and low-lying southern and eastern areas are underlain by outwash and/or alluvial material comprised of sand, silt, clay, gravel, and cobbles (C.T. Male Associates, 2016, 2019a). Depth to bedrock within the tax parcel is typically 10 to 34 feet below ground surface (bgs) (C.T. Male Associates, 2019a). Depth to groundwater ranges 0.8 to 14 feet bgs within the tax parcel and 1.6 to 15 feet bgs within the broader Primary Project Area.

Two hydro-stratigraphic units have been identified in unconsolidated materials at the site. The shallower hydro-stratigraphic unit is possibly perched on top of glacial till, is located within a few feet of the ground surface in northern areas of the site and is interpreted to leak downwards into the deeper unit, approximately seven to ten feet bgs. The perched unit is not observed in the southeastern portion of the site. Groundwater flows away from the site radially (C.T. Male Associates, 2019a).

2.3 Climate

The climate in most of Central and Upstate New York is humid continental. Winter temperatures are typically below freezing, and snow cover is common in late fall, winter, and early spring. Meteorological conditions for Hoosick Falls, NY are available as a weighted average from the three nearest weather stations, corrected for differences in elevation, with weights proportional to the inverse of the distance between Hoosick Falls and a given station (Weatherspark, 2020). The nearest station, William H. Morse State Airport in Bennington, VT, is 5.6 miles to the east and contributes 74% to the estimates. The following statistics are based on hourly weather reports and model reconstruction for the period January 1, 1980 to December 31, 2016 (Weatherspark, 2020):

- The warm season lasts for 3.8 months, from May 24 to September 16, with an average daily high temperature above 70°F. The cold season lasts for 3.3 months, from December 2 to March 10, with an average daily high temperature below 41°F.
- Average precipitation for the area varies seasonally, from a low of 1.3” in January to a high of 3.7” in June and September.
- Snowfall typically occurs within a 5-month period, between October 31 and April 18, with an average monthly accumulation during this period of 0.1 inches (total liquid-equivalent; actual depth of snow on ground surface may be 5 to 10 times greater, assuming the ground is frozen).

A weather station was installed on the rooftop of the McCaffrey Street facility in November 2018 to gather meteorological data that are representative of conditions within the Village. The MetOne, All In One (AIO) Sonic Weather Sensor (model AIO-2) was purchased along with a precipitation gauge (model 360). Following installation, the station began recording meteorological data (including ambient air temperature, relative humidity, wind direction, wind speed, barometric pressure, and precipitation) shortly thereafter. Data are recorded continuously and transmitted every 15 minutes.

Data monitoring and visual inspections have been conducted in accordance with the station’s Operation and Maintenance Plan, which was included in the Work Plan (C.T. Male Associates, 2019a). A data completeness summary and a summary of audit was conducted on May 28, 2020, and based on the results of the audit, no calibration or additional maintenance was recommended at that time.

The following statistics are based on a summary of average monthly measurements during the past two years (2019 and 2020):

- The average daily high temperature was 79°F during the warm months (May through September) and 37°F during the cold months (December through February).
- Average total precipitation varied from a low of 1.5’’ in November to greater than 3.5”” in August and October.

2.4 Hoosic River Watershed and Habitat Characterization

The site is located adjacent to the Hoosic River, an approximately 76-mile-long tributary of the Hudson River (Figure 3). The Primary Project Area includes approximately 0.75 miles of shoreline of the river. The Hoosic River originates in the western Berkshire Hills of Massachusetts, flowing through the Green Mountains in southwest Vermont, into eastern New York. After flowing northward through Hoosick Falls, the river bends westward through the hamlets of Eagle Bridge and Johnsonville, and the town of Schaghticoke, at which point it drains into the Hudson River at Stillwater, approximately 15 miles north of Troy, New York.

Hoosic River water quality in the vicinity of the site is characterized by NYSDEC as generally ‘slightly impacted’ (NYSDEC, 2016b). Elevated levels of PCBs are thought to originate from historical industrial activity in the region and have resulted in contaminated river sediments (NYSDEC, 2016b), and measurable quantities of perfluorooctane sulfonate (PFOS) and other

PFAS have been detected in fish collected from the river and adjacent ponds (NYSDEC, 2016a). Regionally, the Hoosic River is also affected by non-point source contamination such as run-off from lawns, roads, and agricultural fields (Fontana, 2012).

Table 2 summarizes water use classifications for the Hoosic River for reaches near the site according to 6 New York Codes, Rules and Regulations (NYCRR) § 701 and § 940.4 (NYSDEC, 2020a, 2020c). The reach adjacent to the site is classified as a Class C waterbody, meaning that it is suitable for general recreation and supports aquatic life, but not as a water supply or bathing without treatment (NYSDEC, 2016b). Immediately downriver from the site, the designation changes to Class D, which downgrades aquatic life habitat suitability from "Propagation and Survival" to "Survival" due to changes in "such natural conditions as intermittency of flow, water conditions not conducive to propagation of game fishery, or stream bed conditions".

Fish advisories on the Hoosic River include a "Don't Eat" determination for women under 50 and children under 15 years throughout Rensselaer and Washington Counties due to elevated levels of polychlorinated biphenyls (PCBs) (NYSDEC, 2016a, 2016b). Effective July 24, 2017, NYSDOH also recommended people do not consume fish from water bodies around Newburgh and Hoosick Falls areas until testing for PFOA, PFOS, and other PFAS is complete (NYSDOH, 2017b). The Hoosic River (as well as Rensselaer County in which the site is located and the Hudson River downstream) is classified as a confined riverine community (rank G4 S3S4) by the New York Natural Heritage Program (Edinger et al., 2014). Traits typical of confined river aquatic communities (as described in Edinger et al. 2014) include:

- Relatively large, fast-flowing moderate to gentle-gradient streams.
- Alternating, pools, riffles, runs, and channel islands and bars (low sinuosity).
- Autochthonous river systems, meaning that energy supply is created *in-situ* in the form of photosynthesis from large plants and algae.
- Moderate fish diversity.
- Species assemblages characteristic of riffles and rock bottoms.
- Clear, well-oxygenated water surrounded by upland riverside communities such as riverside sand/gravel bar or cobble shore outcrop communities.

Observed fish populations in Hoosick Falls that may be relevant for human consumption are mostly non-native/introduced species such as brown trout (*Salmo trutta*), rainbow trout (*Oncorhynchus mykiss*), white sucker (*Catostomus commersonii*), carp (*Cyprinus carpio*), and smallmouth bass (*Micropterus dolomieu*) (Fontana, 2012).

Based on aerial imagery, land use classification inventories, and a site visit in August 2020, areas adjacent to the site support riparian, wetland, and forest ecological communities. Figure 4 shows land cover classifications across the Primary Project Area based on National Land Cover Classifications (NLCD) downloaded from the Multi-Resolution Land Characteristics website. This inventory indicates that the 326-acre Primary Project Area consists of approximately 40 acres (13%) of deciduous, evergreen, and mixed forest; 27 acres (8%) of woody wetlands and open water; 23 acres (7%) of agricultural land; and 88 acres (27%) of open space.

Detailed discussion of the site's ecological setting and habitats can be found in the companion baseline ecological risk assessment work plan.

3.0 SUMMARY OF PREVIOUS AND CURRENT INVESTIGATIONS

3.1 Chemical Use Based on Operational History and Early Investigations

This section summarizes chemicals that were used over the operational history of the site, as well as classes of chemicals analyzed from previous investigations. The facility was originally built on vacant land in 1961. Site ownership changed several times during a 30-year period beginning in the 1960s. Prior owners include Dodge Fibers Corp. (1961), Oak Materials Group (Oak Electronetics) (1967), AlliedSignal Laminate Systems Inc. and its predecessors (1986), Furon (1996), and SGPP, which acquired the property in 1999 (C.T. Male Associates, 2016). Operations at the site largely focused on thin film application of polytetrafluoroethylene (PTFE) to fiberglass. Depending on product specifications, PTFE was mixed with certain additives at times, pressed though an extruder, and thinly applied to fiberglass.

Historical chemical use at the site included petroleum fuels, lubricants, degreasing agents, solvents, paints, Triton, and per-and polyfluoroalkyl substances, sometimes referred to as compounds (historically abbreviated as PFCs, but hereafter abbreviated as PFAS) (C.T. Male Associates, 2016). Several previous documents, including the 1996 Parsons Phase I and Phase II Environmental Site Assessments (ESA) (Parsons Engineering Science, 1996a, 1996b) and work conducted by C.T. Male Associates (C.T. Male Associates, 2016), summarize the historical use of the following specific substances: The reported historical use of the following specific substances:

- **Chromium**: chromium-bearing wastes (elemental chromium) from coating operations and a research and development laboratory on-site (disclosed by AlliedSignal) as well as dyes and pigments containing chromium. The 1996 Parson Phase I ESA refers to “green dispersion” in reference to the list of hazardous materials used at the facility. Compounds comprised of trivalent chromium present as a green solution when dissolved in water, in contrast to compounds comprised of hexavalent chromium, which produce yellow, orange, and red solutions (Lennartson, 2014);
- **Polychlorinated biphenyls (PCBs)**: one exterior pad-mounted transformer (owned and operated by Niagara Mohawk) containing transformer fluid with PCBs;
- **Triton X**: a surfactant included in air emission permits;
- **Polyaromatic hydrocarbons (PAHs):** fuel oil (presence of one fuel oil underground storage tank used to fire the boiler at the facility), Mobiltherm™ 603 (paraffin distillate), propane tank, creosote, naphthalene;
- **PTFE products:** including Teflon™ and premixed Teflon™ dispersions;
- **Chlorinated solvents:** Saran™ (1,2-dichloroethene [1,2-DCE]) and vinyl chloride;
- **Other solvents**: benzene, toluene, xylenes, acetone, diglyme, and 1,4-dioxane; and
- **Other substances:** ammonia hydroxide, various lab packs, PTFE resins and dispersants, acids, primary alcohol ethoxylates, amines (Rustlick G-25J), and various aerosols.

Recognized environmental conditions (RECs) in the Phase I investigation included the presence of an underground storage tank (which was removed in 1995) and the presence of a floor drain and a sump in the vicinity of mixing and coating operations (Parsons Engineering Science, 1996b). The report recommended Phase II activities be conducted at the site.

The C.T. Male Associates 2016 RI/FS Work Plan (C.T. Male Associates, 2016) summarizes prior environmental investigations at the facility, including the 1996 Parsons ESAs. According to the work plan, the Phase II ESA included the following: 1) collection of six soil boring samples; 2) collection of five groundwater samples for analysis of volatile organic compounds (VOCs) and total petroleum hydrocarbons (TPHs); 3) analysis of semi-volatile organic compounds (SVOCs) and metals in two of the five groundwater samples; 4) collection of five surface soil samples - three surface from the vicinity of an old pad mounted transformer and two from beneath the asphalt of a paved (formerly gravel) driveway from “oily stained zones” (per Parsons) for analysis of PCBs and TPHs (target analytes selected based on information that prior to 1981, hydraulic oil was applied for dust suppression (AlliedSignal Fluorglas, 1995)); 5) collection of six subsurface soil samples from soil borings for analysis of VOCs and TPHs; and 6) analysis of SVOCs and metals from two of the six subsurface soil samples (C.T. Male Associates, 2016). Results were as follows:

- **VOCs:**
  - **Soil:** acetone, methylene chloride, 2-butanone, and trichloroethene (TCE) were detected but did not exceed NYSDEC Technical and Administrative Guidance Memorandum (TAGM; version January 1994) comparison values. Acetone was also detected in soil field blanks.
  - **Groundwater:** TCE was detected at levels exceeding the Federal Safe Drinking Water Act maximum contaminant level (MCL), New York State (NYS) Groundwater Class GA standard, and New York State Primary Drinking Water Quality standard in two samples from downgradient monitoring wells. 1,2-DCE (Saran™), used as a stand-alone chemical and formed as a degradation product of TCE) and chloroform were detected at estimated concentrations below federal MCLs and New York State groundwater quality standards.

- **SVOCs:**
  - **Soil:** four compounds – di-n-butylphthalate, bis(2-ethylhexyl)phthalate (BEHP), benzo(a)pyrene, and benzo(g,h,i)perylene – were detected at estimated values in soil, but did not exceed NYSDEC comparison values. BEHP was also detected in soil field blanks.
  - **Groundwater**: three compounds – diethyl phthalate, di-n-butylphthalate, and BEHP – were detected at concentrations ranging from 0.3 to 6.0 µg/L, below NYSDEC comparison values. All three compounds were also detected in groundwater field blanks.

- **TPHs:**
  - **Soil**: TPH was detected in both of the samples collected from the gravel driveway and one surface soil sample collected in the vicinity of an old transformer. There was no TAGM comparison value for TPH in soil at the time.
  - **Groundwater**: TPH and benzene, toluene, ethylbenzene, and xylenes were not detected.

- **PCBs:**
  - **Soil**: Two PCB compounds – Aroclor 1254 and Aroclor 1260 - were detected at estimated concentrations in three samples. Concentrations were well below TAGM values.

- **Metals:**
  - **Soil:** nineteen metals were detected in two samples; 11 exceeded recommended soil cleanup objective concentrations including: aluminum, beryllium, calcium, chromium, iron, magnesium, manganese, nickel, potassium, selenium, and zinc. Of those metals, five were not naturally occurring and, therefore, classified as *more of a concern*: beryllium, chromium, nickel, selenium, and zinc.
  - **Groundwater:** antimony (maximum 16 µg/L), iron (maximum 3,060 µg/L), and manganese (maximum 343 µg/L) were detected at concentrations above New York State standards. Five metals were not detected in any of the five samples: arsenic, beryllium, copper, mercury, and thallium.

As of 1996, TCE was not stored or generated at the facility. The Phase II report concluded that the source of TCE was likely related to the facility sump pit and recommended that additional record searches be performed to evaluate potential uses during operations (Parsons Engineering Science, 1996b).

Additional sampling was conducted for PFOA and PFOS in soil, groundwater, and wastewater by C.T. Male and Ramboll in 2015 (Ramboll Environ, 2016), at which point PFAS became chemicals of concern at the site. PFAS sampling and investigations are discussed in more detail in Sections 3.2 and 3.3 below.

Additional investigations planned in the C.T. Male 2016 RI/FS Work Plan included the Target Compound List (TCL) of VOCs, SVOCs, pesticides and PCBs; the Target Analyte List (TAL) of metals (including mercury); cyanide; major cations (Ca, Mg, Na, and K) and anions (Cl, SO_4, CO_3 and HCO_3); and TO-15 list of VOCs in indoor air and soil gas (C.T. Male Associates, 2016).

The Saint-Gobain Performance Plastics Site was added to the National Priorities List (NPL) in 2016. Known chemicals listed in USEPA documentation for the site included:

- **VOCs**: extruded tapes and circuit board laminates in the 1960's; halogenated (i.e., chlorinated) solvents such as TCE are known to be associated with the manufacture of circuit boards and other electronic equipment (USEPA, 2016d);
- **PFAS**: past manufacturing activities included the use of no-stick coatings and fluoropolymers known to include PFOA; and
- **PCBs**: the NPL listing documents state the soil samples collected in August 2015 indicated the presence of PCBs in site soils, and sampling by EPA in 2016 documented PCB Aroclors above background in soil borings from the northeastern part of the facility. Surface soil collected at SGPP-SS07B had 110 µg/kg Aroclor-1254 and 120 µg/kg Aroclor-1260 (USEPA, 2016d).

The key contaminants identified in the Hazard Ranking System documentation for the site included vinyl chloride, 1,2-DCE, TCE, PCBs, and PFOA (USEPA, 2016d). The document does not mention other contaminant classes such as metals, PAHs, or pesticides.

3.2 Historical Sampling Events

In 1996, Parsons Engineering performed a Phase I Environmental Site Assessment at the site (C.T. Male Associates, 2016; Parsons Engineering Science, 1996a). In response to the conditions found at the site, a Phase II Environmental Site Assessment was completed to investigate baseline soil and groundwater quality (Parsons Engineering Science, 1996b). Chlorinated VOCs including TCE and 1,2-DCE were detected in the on-site soil and groundwater (Parsons Engineering Science, 1996b; USEPA Region 2, 2016).

In 2015, C.T. Male Associates and Ramboll Environ conducted preliminary investigations and sampling to assess soil, groundwater, and wastewater at the site. The preliminary investigations included the advancement of several soil borings and installation of monitoring wells, as well as the collection of wastewater samples from a manhole and sewage ejector pit at the site. Groundwater, soil, and wastewater samples were analyzed for PFAS (C.T. Male Associates, 2016; Ramboll Environ, 2016).

Additional sampling events took place from 2016 through 2019 to investigate soil, groundwater, wastewater, and surface water, and to evaluate soil gas conditions and potential vapor intrusion into the site building (C.T. Male Associates, 2016, 2017a, 2018b, 2019b, 2020; Ramboll Environ, 2016).

3.3 Timeline of Investigation of PFAS

Site investigation activities conducted during the period 2015 through 2020 have informed the nature and extent of PFAS and other chemicals present on- and off-site. These data, together with the interim remedial measures (see Section 3.4), support the Primary Project Area identified for evaluation in the baseline risk assessments. The following timeline briefly describes key sampling events and regulatory developments during this period:

2015

- February: PFOA levels of 490 ng/L were measured in public water supply Village Well 7 (USEPA Region 2, 2016).
- June and July: PFOA concentrations of 620 ng/L and 662 ng/L were measured in Village Well 7 and the Water Plant Clearwell, respectively (USEPA Region 2, 2016, p. 2).
- August: seven monitoring wells were installed at the site. PFOA was detected in soil samples from 0 – 2 feet bgs and 2 – 4 feet bgs, particularly in the southeastern portion of the site (USEPA Region 2, 2016). Other PFAS identified during this event included: perfluoroheptanoic acid (PFHpA), perfluorohexane sulfonate (PFHxS), perfluorononanoic acid (PFNA), and PFOS (C.T. Male Associates, 2016). PFHxS was only detected in the surface soil (0-2 feet bgs). PFOA concentrations ranged from 1.0 – 4.1 µg/kg in surface soil and 0.41 – 2.4 µg/kg in soils sampled 2-4 feet bgs.
- September: C.T. Male Associates conducted two rounds of groundwater sampling. PFOA and PFHpA were identified at concentrations ranging from ~550 – 18,000 ng/L for PFOA and 10-400 ng/L PFHpA; concentrations remained similar between events (C.T. Male Associates, 2016).
- October: The site wastewater system is tested for PFAS; results show detectable PFOA (~1000 ng/L) and PFHpA (~20 ng/L) (Ramboll Environ, 2016).

2016

- April and May: USEPA Region 2 conducted a sampling event for soil, groundwater and wastewater on-site as well as off-site groundwater, residential drinking water, and raw water(USEPA Region 2, 2016, p. 2).
- June: The site is added to the state registry of inactive hazardous waste disposal sites under the NYSDEC State Superfund Project (NYSDEC State Superfund Program, 2016).

- August: C.T. Male Associates prepared a Final RI/FS Work Plan to assess surface and subsurface soil, surface water, groundwater, soil gas, and indoor air quality at the site and in the surrounding community. The Work Plan states that the RI/FS will include a Fish and Wildlife Resources Impact Analysis and a Qualitative Human Health Exposure Assessment to assess risk associated with human and ecological exposure (C.T. Male Associates, 2016).
- September: USEPA Region 2 proposed adding the site to the National Priority List (NPL) (USEPA Region 2, 2016).

2017

- May: C.T. Male Associates submitted a Supplemental Scope of Work to further investigate the extent of the PFOA impacts at and near the site, including sewer and storm water line inspections, additional soil borings, installation of several permanent and temporary monitoring wells, an electromagnetic survey, and surface water sampling (C.T. Male Associates, 2017a).
- July: The site was added to the NPL.

2018

- August: C.T. Male Associates submitted a second Supplemental Scope of Work proposing further investigations of soil vapor intrusion, roof drain/drip line soil sampling and installation of several permanent and temporary monitoring wells both on-site and in the nearby village (NYSDEC, 2018).

2019

- August: C.T. Male Associates reported on RI progress, including soil, groundwater, and surface water sample collection. Interim Remedial Measure (IRM) design work, various surveys and tests, and repair of the sewer overflow pipe were also performed (C.T. Male Associates, 2019c).
- December: NYSDEC Division of Air Resources summarized the results of a PTFE sintering oven emissions characterization study; in which the USEPA Office of Research and Development concluded that "any PFAS and PTFE decomposition emissions from the sintering ovens are minimal and are primarily the tetrafluoroethylene monomer that is a known degradation product of the sintering process" (C.T. Male Associates, 2019a; NYSDEC, 2019).

2020

- April: C.T. Male Associates submitted an update to NYSDEC on 2019 RI activities. RI activities in 2019 included the installation of several off-site groundwater monitoring wells, soil borings, groundwater monitoring (on-site and off-site), and sampling of off-site surface water (C.T. Male Associates, 2020, p. 20).

3.4 Interim Remedial Measures In-Place

Pursuant to the 2016 administrative order, Interim Remedial Measures were initiated at the site as a part of the RI/FS (NYSDEC State Superfund Program, 2016). Early measures were implemented even prior to entry of the order and described in the order consisted of the installation of a temporary granular activated carbon (GAC) water treatment system (March 2016) for the Village Municipal Water Supply and the distribution of bottled water to the community (ERM & CHA, 2020). NYSDEC coordinated the installation of point of entry treatment systems on private water supplies (ERM & CHA, 2020). The order also required the design, installation, operation, sampling, and monitoring of a full capacity GAC treatment system suitable for the permitted maximum daily flow for the municipal system (NYSDEC State Superfund Program, 2016).

The design for the full capacity GAC system was approved by New York State Department of Health on April 5, 2016, and the system became operational in February 2017 (NYSDEC State Superfund Program, 2016). Removal of PFAS from the municipal water supply continues to be demonstrated as of August 2020 (ERM & CHA, 2020). In addition to the GAC system, an IRM concept plan for groundwater interception design was submitted to the NYSDEC on August 28, 2017 (C.T. Male Associates, 2017b). A Draft Interim Remedial Measure Work Plan detailing the installation plans for the Groundwater Capture and Treatment System was submitted in August 2018 (C.T. Male Associates, 2018a), and the Interim Remedial Measure Work Plan was submitted on April 3, 2019 (C.T. Male Associates, 2019a).

Operation of the groundwater capture and treatment system within the southeastern corner of the site began August 22, 2019. Analytical results from the treated water are typically non-detect for PFAS (C.T. Male Associates & BEC Engineering and Geology, 2020a; NYSDEC & NYSDOH, 2019).

3.5 Summary of Ongoing Work

A Municipal Water Supply Study report was presented by ERM and CHA in August 2020 to assess alternative potable water sources for the Village of Hoosick Falls Municipal Water Supply as required by the 2016 consent order (ERM & CHA, 2020). An air deposition study is also ongoing to assess regional air deposition of PFAS (C.T. Male Associates & BEC Engineering and Geology, 2020b; NYSDEC & NYSDOH, 2019). Remedial Investigation work continues as of 2021 (C.T. Male Associates, 2020).

On May 27, 2020 NYSDEC notified SGPP and Honeywell that a risk assessment for both human health and ecological receptors would be required (NYSDEC, personal communication, 2020). A baseline risk assessment is required as part of the CERCLA Superfund process for RI/FS. This BHHRA Work Plan outlines the process for the human health risk assessment at the site to fulfill that requirement. A companion Work Plan is also being submitted for the BERA.

4.0 DATABASE AND DATA EVALUATIONS

4.1 Risk Assessment Database

The RI database was provided to GSI for use in the BHHRA. The RI database includes all analytical chemistry results for environmental samples collected by C.T. Male Associates for the RI during the period 2016 through 2019. The target analytes for these investigations are listed in the RI/FS Work Plan and include chemical classes on New York's target analyte list/target compound list (TAL/TCL) (e.g., metals, PAHs, PCBs, pesticides, VOCs/SVOCs), water quality parameters, as well as either a list of 12 or 21 PFAS sampled in groundwater, soil, sediment, and/or surface water, depending on the medium. Analytical chemistry results for VOCs/SVOCs also includes samples of sub-slab soil gas and indoor air from the site building, site outdoor ambient air, and soil gas from on and near the site collected in 2017 and 2019.

The BHHRA database also includes analytical chemistry results for samples of fish tissue (fillets and whole-body tissue) collected by (and obtained from) NYSDEC from the Hoosic River watershed that were analyzed for PFAS only (see Figure 3). These data may include important information on PFAS levels in fish, relevant to both the human and ecological risk assessments.

Based on preliminary discussions with USEPA Region 2 and NYSDEC, a supplemental Biota Sampling and Analysis Plan (Biota SAP) is being developed to collect biota samples within the Primary Project Area and a local reference area with comparable habitat. This is discussed in greater detail in Section 5.3.2.

The BHHRA database also includes PFAS concentrations measured in soil samples collected within or adjacent to some of the residential yards within the broader boundary referred to as the Residential Irrigated Soil Area (RISA)(see Figure 2). These data may inform exposures levels associated with direct contact exposure pathways (incidental ingestion and dermal contact) and consumption of homegrown foods by off-site current and hypothetical future residents (adult and child) (see Figure 5). Concentrations will be evaluated using site-specific risk-based screening levels (RBSLs) for PFAS, as discussed in Section 9.3.1.

4.2 Database Evaluation and Processing

The project database was evaluated for data usability in the risk assessment. Several processing steps were applied to generate this project database from the data provided by C.T. Male Associates. These processing steps are described below.

- **McCaffrey Street Site Project Area.** The first processing step involved an evaluation of the sample locations. Samples collected outside the Primary Project Area (see Section 2.1 and Figure 1) are excluded from the risk assessment but may be considered qualitatively as part of the uncertainty analysis, or as part of the evaluation specific to the RISA. The only exception is that analytical chemistry results for fish samples collected in the Hoosic River (described above) were retained. Additional information regarding local reference conditions will be provided from a field sampling program in 2021, which will include samples of sediment, surface water, and biota (described further in the Biota SAP).

- **Data Usability Assessment**. The second processing step involved screening the project database for data usability based on an evaluation of data qualifiers and sample representativeness. Consistent with standard DQO practice (USEPA, 2002a), the following samples were excluded from the project database:

  - All results qualified as *rejected* during data validation. These sample results did not pass data quality objectives specified in the analytical chemistry protocols (see RI/FS Work Plan).
  - All data for solid and aqueous treatability test samples, which lack spatial coordinates. These samples inform the RI/FS investigation, but do not directly inform the exposure assessment component of the risk assessments.
  - All data for samples collected from roof drains, which also inform the RI/FS, but not the risk assessment. In lieu of roof drain samples, results from samples of soil collected near or downgradient of roof drainage areas are incorporated in the exposure assessment.

- **Duplicate Sample Results.** The third processing step involved handling of field split samples ("duplicates"). All quality assurance/quality control (QA/QC) samples and data qualifier flags present in the main database were carried forward to the project database. This includes measurements of splits of field samples (i.e., duplicates or triplicates). Other QA/QC samples (e.g., laboratory replicates, equipment blanks) were not included in the RI database provided to GSI, but are further addressed in the RI/FS work plan documents (C.T. Male Associates, 2016, 2017a, 2018a, 2019a). Field duplicate results will be used in the baseline risk assessment to inform estimates of measurement error associated with sample collection and handling in the field, as well as sample handling, processing and analysis at the analytical laboratory. Specifically, consistent with USEPA guidance on statistical analysis of environmental samples (USEPA, 2009b), while field duplicate results were retained for evaluation of the relative percent difference (RPD) of duplicate pairs, they were not mathematically combined as an arithmetic mean. USEPA (2009b) notes that because only a fraction of the samples collected from a project area have a corresponding duplicate pair, averaging results for a portion of the samples can introduce a downward bias in estimates of the variance in concentrations within the project area. Accordingly, for samples with one or more duplicate results, a single result was selected at random for use in calculations in the risk assessment. The Uncertainty Assessment of the final BHHRA will present an RPD analysis and will demonstrate the quantitative impact on risk characterization determinations based on different data processing steps.

Concentration units were standardized in the Primary Project Area database so that the same units are used for each combination of analyte, unit dimension (e.g., mass per mass or mass per volume), and measurement basis (e.g., dry weight basis, wet weight basis). In general, chemical concentrations are reported in the following units by medium:

- Soil (milligrams per kilogram, mg/kg)
- Sediment (micrograms per kilogram, µg/kg)
- Surface water and groundwater (micrograms per liter, µg/L)
- Air (micrograms per cubic meter, $\mu g/m^3$)
- Fish tissue (milligrams per kilogram, mg/kg)

Sample results include results reported as non-detects (ND), defined as concentrations that are less than the method detection limit (MDL). Non-detect (ND) results for individual analytes are reported as equal to the full MDL and qualified with a "U" or "UJ" flag in the database. While the project database also includes the sample quantitation limit (SQL) and method reporting limit (MRL) for each result, only the MDL value is used in the risk assessment calculations involving censored datasets (i.e., dataset with one or more NDs). At the request of NYSDEC, the SQL, not the MRL, was used in the initial screening assessment to identify contaminants of potential concern (COPCs), see Section 5.

Data processing steps and statistical analysis methods applied in the exposure assessment will take into account data qualified as detected and ND concentrations. Estimated values qualified with a “J flag” (i.e., quantified but estimated to be between the MDL and MRL) will be included as detects. The approach that will be used in the exposure calculations for samples reported as ND will be determined after review of the properties of a dataset, including the frequency of detection across media, the range of MDLs, and the ranking of MDLs relative to detects. For calculations of summary statistics (e.g., sum, arithmetic mean, standard deviation) for individual chemical datasets, generally Kaplan Meier (KM) estimation methods will be applied, consistent with USEPA (2015c) guidance on the use of ProUCL software for statistical analysis of environmental data. For calculations involving multiple chemicals, consistency in proportions of cooccurring chemical mixtures across samples with a higher frequency of detection (FOD) will be explored as a means of improving estimates for NDs among sample results with a lower FOD. Uncertainty introduced by simple substitution (imputation) of proxy values for NDs (e.g., zero, ½ MDL, or MDL) is especially important when evaluating the maximum concentration (e.g., for screening to identify COPCs) as well as sample-specific calculations involving the total (sum) of concentrations for all constituents within the chemical group (e.g., carcinogenic PAHs, total PCB Aroclors). This is because inclusion of non-zero proxy values in the calculated totals can sometimes artificially inflate calculated exposure concentrations, especially if individual chemicals within the group are detected infrequently. The sensitivity of inferences based on alternative ND handling methods is discussed in this Work Plan for COPC screening (see summary tables of Appendices A and B) and will also be assessed and included in the uncertainty analysis with respect to outcomes of refined COPC screening and exposure assessment.

The RI database is maintained in a secure PostgreSQL and PostGIS database. Selected fields were also exported to develop GIS shapefiles and a Microsoft Excel® workbook, referred to as a “flat file” to facilitate data exploration and generation of data summary tables for this Work Plan. The database fields exported to the flat file are further described below and in Appendix A.

4.3 Flat File Data Columns and Relationships

All field headers for the columns in the flat file data export are listed and described in Appendix A, Table A1. There are three sets of field headers that are used to represent the sampling structure and relationships between samples:

- **Collection Identifiers.** The term *collection* is used to identify material that is collected together and that may be subsequently subdivided into distinct interpretive samples. An example is a soil boring or sediment core, where the entire boring or core is considered to be the collection, and horizons from within that boring or core are individual interpretive samples. For single grab samples (e.g., of sediment or water), the collection and the interpretive sample are one and the same, and the same identifier is used as both a collection identifier and a sample identifier. Collections are identified by unique combinations of the *study_id* and *collection_id* columns.
- **Interpretive Samples.** The term *interpretive sample* is used to identify material that is presumed to be uniform in composition and that represents the environmental conditions at a particular point in space and time, and that will be used for data analysis and interpretation. There may be multiple interpretive samples per collection. An interpretive

sample may be split to produce separate quality control (QC) duplicates. Interpretive samples are identified by unique combinations of the *study_id* and *sample_id* columns.

- **Analytical Samples.** The term *analytical sample* is used to identify material that is submitted to a laboratory for analysis. When an interpretive sample is split, each split is assigned a unique analytical sample ID. When an interpretive sample is not split, the interpretive sample ID and the analytical sample ID are one and the same. Analytical samples are identified by unique combinations of the *study_id* and *sample_no* columns.

In the flat file table, related splits (QC duplicates) can be identified because they have the same *sample_id* identifier but different *sample_no* identifiers. Ordinarily one of the splits has a *sample_no* that is the same as the *sample_id*, and one has a different identifier. The *duplicate_yn* column identifies those rows where the identifiers are different.

Whereas there are potentially three levels to the sampling hierarchy—collection, interpretive sample, and analytical sample—these data were proved by ERM in an EQuIS export, and EQuIS only accommodates two levels: a “sys_sample_code” and a “parent_sample_code”. Not every “sys_sample_code” has a corresponding “parent_sample_code”. Although EQuIS does not enforce any rules regarding the usage of these identifiers, commonly when these are both present, the “parent_sample_code” represents an interpretive sample and the “sys_sample_code” represents a split of that interpretive sample. When a “parent_sample_code” appears on another row as the “sys_sample_code”, that represents the other split.

5.0 IDENTIFICATION OF CHEMICALS OF POTENTIAL CONCERN – INITIAL SCREENING LEVEL ASSESSMENT

5.1 Purpose

The analytical sampling conducted under the RI for the McCaffrey Street Site includes an extensive list of analytes required by NYSDEC, as described above. The purpose of the initial screening procedure was to identify the subset of chemicals, for each potential exposure medium, that may potentially contribute to site-specific risks (i.e., chemicals of potential concern (COPCs)), while also minimizing the likelihood of eliminating contaminants from further analysis that could be of concern. As such, a screening assessment was conducted that compares maximum measured concentrations of each chemical in a medium to conservative human-health based regulatory screening criteria. Identification of a COPC via this screening level assessment is not an indication of risk or actual harm; rather, this step creates the subset of chemicals that will be further evaluated in the BHHRA. This risk assessment will identify both “primary” and “secondary” COPCs; the primary COPCs are analytes most likely to be site-related and of highest potential concern based on elevated maximum concentration detected compared to screening levels and a frequency of detection greater than 5%. Both primary and secondary COPCs will be carried forward into quantitative risk characterization (described in Section 9.3).

5.2 Methods

The general approach to identification of primary and secondary COPCs is based upon USEPA guidance (USEPA, 1989a, 1991c, 2001c). In general, all analytes for which the maximum concentration (detect or ND) exceeds a screening level for any exposure medium were retained as a COPC for all exposure media, and substances for which the maximum concentration detected do not exceed the screening criteria are not carried further in the risk assessment process. A more detailed description of the key steps in the COPC selection process is provided below.

RBSLs were identified from regulatory sources, as described in Sections 5.3.1. and 5.3.2.

Conservative receptor scenarios were defined to represent the most sensitive receptor exposure scenario per medium and data grouping. Each scenario involves a specific type of receptor (e.g., resident or worker), exposure medium, and Primary Project Area location (e.g., on-site or off-site). For certain scenarios involving potential exposure to soil and sediment, a representative depth interval is also applicable. These conditions informed the data grouping. The maximum concentration was identified for each data group, along with the data qualifier flag, given that in some cases, a maximum value is an ND result. At the request of NYSDEC, the SQL is used instead of the MDL for NDs in the selection of COPCs.

For each receptor scenario, analytes were retained (i.e., “screened in” as a COPC) if any of the following conditions were true:

- Maximum concentration is a detect and exceeds a screening level;
- Maximum concentration is an ND and the SQL proxy value exceeds a screening level; or
- A screening level is not available for the analyte for the receptor scenario.

[Note: for evaluation of summed analytes (i.e., PFAS in aqueous media, carcinogenic PAHs, Total PCB Aroclors), NDs were set at the sample quantitation limit for the initial screen. The sensitivity of the use of ND proxy values will be examined in the BHHRA by applying ½ MDL and MDL proxy values for NDs for individual chemical results, and ½ MDL and zero values for NDs for chemicals represented by summations.]

The frequency of detection (FOD) and availability of a soil background threshold value (NYSDEC & NYSDOH, 2006) are also noted in summary tables in Appendix B and will guide further evaluation of the COPCs in the BHHRA. Analytes for which both the FOD is greater than 5% and the maximum concentration is greater than a NYS background threshold value for soil are considered primary COPCs. Analytes for which either the FOD is less than or equal to 5% or the maximum concentration is less than or equal to a background threshold value are considered secondary COPCs. In addition, in all media, analytes that screened in, but for which the maximum concentration is ND and/or the FOD is less than 5% are also considered secondary COPCs. For analytes that lack screening levels, the analyte will be screened in and further evaluated for appropriate toxicity criteria for the BHHRA (see Section 8).

Analytes were “screened out” if they did not meet any of the three criteria listed above. Also, consistent with standard risk assessment guidance, chemicals that are essential nutrients (e.g., magnesium, calcium, potassium, sodium) and present at low concentrations were not considered COPCs (USEPA, 1989a, 2018a).

5.3 Human Health COPC Identification

The process for identifying primary and secondary COPCs, as described above was followed for the initial human health screening assessment. The occurrence, distribution, and selection of COPCs is documented in Appendix B, Tables B1.1 – B1.11, following RAGS D “Table 2” format (USEPA, 2001b).

For each analyte, in each medium and screening scenario, RBSLs and the source of the value is listed in more detail in Appendix B Tables B2.1 - B2.9 and described further below.

Published regulatory screening values were not available for all analytes. Analytes without screening level criteria, regardless of frequency of detection, will be carried forward into the BHHRA for further evaluation. Screening for the vapor intrusion pathway has some unique considerations and is described separately below.

5.3.1 Selection of RBSLs - Hierarchy and Sources of Screening Levels

To support COPC screening and identification for human health risk assessment, RBSLs were compiled from published regulatory sources according to the hierarchy described below.

All selected RBSLs are based on a target hazard quotient (THQ) of 0.1 for noncarcinogens and a target cancer risk of 1×10^{-6} for carcinogens. For cases in which multiple RBSLs are available, the lowest human health based (most health-protective) value is used, considering both assumed potential effects (i.e., noncancer and cancer), and assumed exposures to potential receptors. Several compounds or classes of compounds have unique derivation of RBSLs, described in more detail in Section 5.3.2.

RBSLs were selected for the following media:

Soil and Sediment

In order of preference, the following sources were consulted for RBSLs to screen maximum concentrations of analytes measured in soil and sediment:

1. USEPA Regional Screening Levels (RSLs) for soil (USEPA, 2020d, 2021b)
2. New York State soil cleanup objectives (SCO) (NYSDEC, 2010b; NYSDEC & NYSDOH, 2006)
3. NYSDEC guidance for PFAS in soil (NYSDEC, 2021)

Using these sources, analytes in soil were screened for both residential and commercial/industrial worker scenarios involving incidental ingestion, dermal absorption, and inhalation of soil. For the worker scenarios, either the USEPA "composite worker" RSLs (which combine the most protective exposure assumptions of the outdoor and indoor worker) or the NYS SCOs for "commercial use" (which is the more stringent state worker soil value as it includes passive recreational uses) (NYSDEC & NYSDOH, 2006) were used.

Chemistry data from off-site soil with upper depth levels <2 feet bgs were used to define the dataset for the current residential soil screening scenario, consistent with USEPA's general approach (USEPA, 1989a, 1996) and a conservative screening scenario. The <2 feet bgs soil depth is generally considered for residential exposures to account for potential gardening and other direct digging and contact scenarios. The current and future worker soil screening was conducted with on- and off-site soils with an upper depth of <1 foot bgs. It should be noted that many states, recommend use of soil sampling data <1 foot bgs or within the top inch (NYSDEC & NYSDOH, 2006) as "surface soil" potentially available for both residential and indoor worker direct human contact, and these depth profiles may be considered residential exposure scenarios in the full BHHRA. However, screening the maximum detected concentration for a given analyte across a deeper depth provides a more conservative and robust screen.

An additional screen was conducted for future on-site and off-site hypothetical residential scenarios using upper soil depths down to <10 feet bgs as "subsurface soil" (USEPA, 2002f) under the assumption that deeper soils may be resurfaced during future home construction activities, and therefore, chemistry data from subsurface soils may be relevant. This scenario would also be relevant to construction worker exposures and was therefore considered a conservative screen that would be predictive of all receptors that may be in contact with subsurface soil.

All analytical chemistry data collected from any sediment sample, regardless of depth, were used to screen against a residential exposure scenario.

See Appendix B Tables B2.1 and B2.2 for the full list of residential and commercial worker soil screening levels. Appendix B Table B2.5 lists the residential sediment screening levels and their sources.

Groundwater

In order of preference, the following sources were consulted to select RBSLs for screening analytes in groundwater:

1. USEPA RSLs for residential tap water (USEPA, 2020d, 2021b)
2. USEPA recommended screening levels for PFOA and PFOS (USEPA, 2019c)
3. NYSDEC Title 6, Part 703.5 Groundwater Quality Standards for human health (NYSDEC, 2020b)
4. NYSDEC guidance for PFAS in groundwater (NYSDEC, 2021)

Any analyte for which the maximum concentration measured exceeded the screening level listed above, or a federal or state MCL, the analyte was retained as a COPC.

See Appendix B Table B2.3 for the full list of residential groundwater screening levels and sources.

Analytes in groundwater were also screened using USEPA's residential vapor intrusion screening levels (VISLs) as described below.

Surface Water

In order of preference, the following sources were consulted to select RBSLs for analytes in surface water:

1. USEPA RSLs for residential tap water (USEPA, 2020d, 2021b)
2. USEPA national ambient water quality criteria (NAWQC) for human consumption of water and organisms (provided that the NAWQC is risk-based) (USEPA, 2020c), adjusted for THQ of 0.1 for noncarcinogens
3. NYSDEC Title 6, Part 703.5 human health Surface Water Quality Standards (NYSDEC, 2020b) for Class C and D waters (see Table 2 and defined in 6 CRR-NY Part 940.4)
4. NYSDEC guidance for PFAS in groundwater (NYSDEC, 2021)

See Appendix B Table B2.4 for the full list of residential exposure to surface water RBSLs and sources. Any analyte for which the maximum concentration measured in surface water exceeded the screening levels identified above was retained as a COPC for surface water.

Ambient Air

VOCs and SVOCs in ambient air were screened using residential air exposure scenarios and USEPA RSLs for residential ambient air. See Appendix B Tables B2.6 for the full list of residential ambient air screening levels.

Screening for Vapor Intrusion

An initial screening was also performed to evaluate the presence of COPCs via the vapor intrusion (VI) pathway - the migration of gas-phase constituents from the subsurface into commercial or residential structures. The purpose of the initial screening was to evaluate whether COPCs of sufficient volatility and toxicity are present in concentrations high enough to present a potential vapor intrusion concern for human health (NYSDOH, 2006; USEPA, 2015a).

Sampling data were evaluated prior to this screening to determine whether sufficient information was available to identify the presence and extent of site-specific vapor-forming chemicals (NYSDOH, 2006; USEPA, 2015a). Per NYSDOH Vapor Intrusion Guidance (2006), data representativeness and reliability were verified. General media-specific, RBSL concentrations for groundwater, near-source soil gas, and indoor air were generated using the USEPA Vapor Intrusion Screening Levels (VISL) Calculator at a THQ of 0.1 for noncarcinogens and a target cancer risk of $1x10^{-6}$ for carcinogens (USEPA, 2020b).

The vapor intrusion (VI) screening process was as follows:

- Available groundwater, soil gas, and air samples were evaluated for the presence of VOCs/SVOCs.

- If a given compound was not detected in groundwater, soil gas, or air with a SQL < VISL, it was excluded from the screening process.
- If a VOC or SVOC was detected, it was compared to media specific VISL (when available). Sample results were compared to residential screening values at a target hazard quotient of 0.1 or cancer risk level of 10^{-6}.
- If the maximum concentration of a compound was less than the VISL, and SQLs were lower than the VISL, then the analyte was not evaluated further and is not a COPC for VI.
- If SQLs exceed VISLs for a given VOC/SVOC, that analyte was flagged for further evaluation in the baseline risk assessment.
- If the maximum concentration was greater than the VISL, then the compound was retained as a COPC.
- If a VISL does not exist for a given analyte, it was not screened for potential vapor intrusion risk.

As discussed in Section 9.3.2 below, the risk characterization of potential VI risks will follow an approach that considers additional available lines of evidence and in-depth evaluation of data (NYSDOH, 2006, 2017a; USEPA, 2015a). Risk characterization considerations will include the potential for confounding sources, data gaps and uncertainties.

5.3.2 Unique Scenarios

NYSDEC and USEPA requested and approved the use of surrogate compounds for some select analytes for which RBSLs were not available from primary sources. In some cases, RBSLs from surrogate compounds, such as an isomer, parent compound, or total group (e.g., Total PCB Aroclors, carcinogenic PAHs) was selected. The rationale for each surrogate is provided below.

Chlordane

Technical chlordane is a mixture of more than 140 chemicals (ATSDR, 2018). Two chlordane isomers, cis-chlordane and trans-chlordane (also known as alpha- and gamma-chlordane, respectively), comprise 60-85% of the technical chlordane. Almost all toxicity data for chlordane are based on studies conducted with technical chlordane. USEPA's most recent (May 2021) RSL tables recommend using the technical chlordane oral noncancer toxicity values and RBSLs as surrogates for cis- and trans-chlordane (USEPA, 2021b).

Chromium

Chromium predominantly exists in its trivalent (III) and hexavalent (VI) oxidation states (ATSDR, 2012). Trivalent chromium occurs naturally in ores and is chromium's most stable form under environmental conditions. Hexavalent chromium primarily originates from anthropogenic sources. Although no historical records or practices indicate that hexavalent chromium was ever used or produced at the site, total chromium analytical results were compared to the USEPA RSL for hexavalent chromium for residential soil, worker soil, surface water, and residential groundwater, per NYSDEC and USEPA request. Site-specific speciation will be conducted from soil samples collected during the supplemental biota and media sample event to confirm that the chromium present is in the trivalent oxidation state (see the Biota SAP for further details). The total chromium potential applicable or relevant and appropriate requirements (ARARs) (USEPA MCL, NYSCRR Part 703.5 groundwater standard, and NYSDEC SCOs), were also included.

Dichloropropene, 1,3-

USEPA RBSLs were available for 1,3-dichloropropene, but not for the two isomers: cis- and trans-1,3-dichloropropene. Concentrations of the two isomers were compared to the USEPA RSL for 1,3-dichloropropene in worker soil; residential/recreational sediment; and residential soil, surface water, groundwater, and ambient air.

Endosulfan

Technical endosulfan contains at least 94% of two pure isomers: endosulfan I and endosulfan II (also known as alpha- and beta-endosulfan, respectively) (ATSDR, 2015). Almost all toxicity data for endosulfan are based on studies of technical endosulfan. For its soil cleanup objectives, NYSDEC and NYSDOH (2006) used toxicity values for technical endosulfan as surrogates for the toxicity values for endosulfan I and endosulfan II. Since the two isomers are primary constituents of technical endosulfan, the USEPA RSLs for endosulfan were selected as the RBSLs for endosulfan I and endosulfan II in residential soil, worker soil, surface water, and residential groundwater.

Methylcyclohexane

California Department of Toxic Substances and Control (DTSC) published a list of toxicity criteria for use in HHRAs and developing RBSLs or remediation goals. DTSC recommended using the toxicity criteria for cyclohexane as a surrogate for methylcyclohexane (California DTSC, 2019). Accordingly, the USEPA RSLs for cyclohexane were selected as the RBSLs for methylcyclohexane in residential soil, worker soil, residential/recreational sediment and surface water, and residential groundwater.

Phenanthrene

NYSDEC and NYSDOH (2006) used the toxicity value for pyrene as a surrogate toxicity value for phenanthrene in deriving the phenanthrene SCO. Similarly, the RBSLs for phenanthrene were based on the USEPA RSLs for pyrene in groundwater and surface water.

Xylene

Mixed or commercial xylene is a mixture of three xylene isomers (m-xylene, o-xylene, and p-xylene) and other constituents, like ethylbenzene (ATSDR, 2007). The predominant isomer, m-xylene, typically comprises 44-70% of mixed xylene. In its SCO technical support document, NYSDEC and NYSDOH (2006) stated that the toxicity value for mixed xylene was a reasonable surrogate for the toxicity value for other mixtures of m-xylene, o-xylene, and p-xylene. NYSDEC and NYSDOH assumed little differences in the toxic potencies between the three isomers. m/p-xylene lacks available RBSLs. Accordingly, the USEPA RSLs for xylenes were selected as surrogates for the m/p-xylene RBSLs in worker soil; residential soil, ambient air, and groundwater; and residential/recreational sediment and surface water.

Lead

For lead, USEPA derived RBSLs using regulatory risk models that include a threshold (percentile) selected from the upper tail of the predicted distribution of blood lead concentrations, rather than a THQ or cancer risk threshold (USEPA, 2003a). USEPA is currently reassessing the lead risk assessment models, parameter values, and blood lead thresholds, and new risk assessment polices have not yet been adopted. Current USEPA Regional Screening Levels (RSL) for lead, most recently posted online by USEPA in November 2020, are: 400 mg/kg in soil for current and future residents; 800 mg/kg in soil for commercial/industrial workers; 15 µg/L in drinking water;

and 0.15 µg/m^3 for residential ambient air (USEPA, 2020d). During the draft BHHRA Work Plan review, NYSDEC and USEPA requested that the soil screening levels for lead be changed to 200 mg/kg in soil for current and future residents and 400 mg/kg in soil for commercial/industrial workers. Similar to other analytes, lead concentrations in sediment were evaluated using the requested residential screening level for soil.

Aroclors

Some commercial PCB mixtures are known by their industrial trade name, Aroclor (ATSDR, 2000). Most toxicological data for PCBs are based on specific Aroclor formulations. The PCB chemical structure is critical to determining toxicity, especially for the number of chlorine atoms and their arrangement in the PCB molecule. Since PCBs found in the environment undergo degradation, the degraded PCBs differ substantially in structure and toxicity from their original Aroclor formulations. To address this discrepancy, NYSDEC established SCOs and Part 703.5 surface water and groundwater quality standards for total PCBs, rather than specific Aroclor formulations (NYCRR, 2020; NYSDEC & NYSDOH, 2006). The NYSDEC SCOs, surface water, and groundwater quality standards for total PCBs were used as the RBSLs for total PCB/Aroclors per respective medium (NYSDEC & NYSDOH, 2006). The total PCB human health-based SCO for residential land use (1 mg/kg) was selected as the soil RBSL for the future and current resident for total Aroclors, while the total PCB SCO for commercial land use (1 mg/kg) was selected as the soil RBSL for the future and current commercial/industrial worker. Total PCB/Aroclors Part 703.5 values for the protection of human consumption of fish was used for the surface water screening value. When available, individual Aroclors were also screened against their established USEPA RSLs.

In addition to the use of total Aroclors for screening and identification of COPCs for the BHHRA, NYSDEC and USEPA requested that the Aroclor 1016 RBSL be used for all Aroclors with a percent of chlorine less than 42% (i.e., Aroclor 1016, 1221, 1232 & 1242). For the more highly chlorinated Aroclors with chlorine content of 43% or greater (i.e., Aroclor 1248, 1254, 1260, 1262 & 1268) the Aroclor 1254 RBSL was used. These surrogates were used for all applicable exposure scenarios and medium.

While the method detection limits and analytical precision of Aroclor measurements are well below RBSLs for each environmental matrix, because Aroclors are defined mixtures of specific PCB congeners and each congener can be present in multiple Aroclors, uncertainty in risk characterization of PCBs can vary depending on the specific types of Aroclors detected and the relative magnitude of the concentrations. A preliminary review of the site soil datasets suggests that, with method detection limits less than 0.05 mg/kg, the highest frequency of detection in the Primary Project Area is for Aroclor 1260 (approximately 25%), followed by Aroclor 1254 (<10%). Other Aroclors are very infrequently detected, and at much lower concentrations compared with 1260 and 1254. Aroclors 1260 and 1254 have very low percent by mass compositions (e.g., < 0.03%) of PCB 126, which is the PCB congener with the highest dioxin-like toxic equivalency factor (TEF = 0.1) (Rushneck et al., 2004; Rushneck & Berg, 2019). Therefore, it is unlikely that a congener-specific analysis would yield different conclusions from a Aroclor-based risk assessment. This uncertainty will be further evaluated in the Uncertainty section (see Section 9.4).

Carcinogenic PAHs

Risk from carcinogenic PAHs was screened in terms of benzo(a)pyrene (BaP) toxic equivalents. The seven carcinogenic PAHs with toxic equivalency factors identified by USEPA in their 1993 provisional guidance (USEPA, 1993a) were used to adjust the maximum detected concentration and calculate the BaP equivalent concentration for each. Appendix B Table B3 provides the relative potencies used to calculate BaP equivalents. The sum of each BaP equivalent was compared to the RBSL for BaP for each exposure scenario and medium, as shown in Appendix B Tables B1.1 – B1.11.

PFAS

Consistent with other chemicals, PFAS RBSLs were selected from either USEPA or NYSDEC sources. Currently, only perfluorobutane sulfonate (PFBS) has RBSLs within the USEPA RSL tables (updated in May 2021), and those RBSLs were used for the initial screening and selection of COPCs. USEPA has PFOA and PFOS information within the online RSL calculator, allowing users to calculate RBSLs for any exposure scenario. The use of the RSL online calculator for PFOA and PFOS is consistent with current USEPA guidance for screening groundwater at Superfund sites (USEPA, 2019c). These RBSLs were also used to screen PFOA and PFOS in surface water. NYSDEC guidance values for screening the other PFAS (other than PFOA, PFOS and PFBS for which USEPA values exist) and total PFAS in groundwater and all PFAS soil were also used (NYSDEC, 2021). NYSDEC does not currently have any published toxicity values for any PFAS, however, the New York State MCLs for PFOA and PFOS were also retained as potential ARARs.

The following RBSLs were used:

- Groundwater and soil USEPA RSLs for PFBS, THQ equal to 0.1 (USEPA, 2021b) (USEPA, 2020d). These were also applicable to surface water and sediment screening scenarios.
- Groundwater screening levels for PFOA and PFOS, THQ equal to 0.1 (USEPA, 2019c) for residential groundwater and surface water.
- NYSDEC guidance values for PFAS in groundwater (also applied to surface water) and soil (also applied to sediment) (NYSDEC, 2021).

As with all chemicals evaluated, any PFAS without a RBSL for a respective medium was retained as a COPC and will be further evaluated in the BHHRA.

Given the dynamic nature of PFAS regulatory actions, screening levels may be subject to change in the near future. Prior to executing the BHHRA risk characterization, RBSL and toxicity criteria will be reevaluated and updated, if needed, based on the most currently available applicable values, the current best available information and state-of-the-science for PFAS, and any updated USEPA and/or NYSDEC guidance.

5.3.3 Potential Bioaccumulative Compounds and Direct Ingestion of Biotic Media

For the human health risk assessment, analytes that have a potential to bioaccumulate in the food chain require additional consideration, particularly for human consumption of backyard garden produce, home-raised chicken and eggs, and fish. Table 3 summarizes analytes that have a potential to bioaccumulate in aquatic and terrestrial food webs based on criteria applied by USEPA (2000a) and New York State (NYSDEC & NYSDOH, 2006). Analytes that are potentially bioaccumulative, detected in soil, sediment, and/or surface water, and that have screening levels that may not be protective of upper trophic level organisms, are also retained for further evaluation in the BHHRA.

Bioaccumulation potential is often estimated based on findings from studies under laboratory or field conditions, as well as predictions from statistical models that account for differences in physical/chemical properties (e.g., log K_{ow} as surrogate for lipophilicity). Differences in physical/chemical properties of PFAS compared with many other organic compounds introduces greater uncertainty in model-based estimates. Therefore, uptake of PFAS from abiotic media to biota (i.e., vegetation, chickens, and fish) will be based on both site-specific data and a comprehensive analysis of the literature at the time the BHHRA is conducted. The Department of Defense (DoD) Strategic Environmental Research and Development Program (SERDP, 2019) provides a summary of bioconcentration and bioaccumulation factors for selected PFAS based on a review of studies published as of 2019, focusing on findings under controlled (laboratory) conditions. Based on a review of the current literature for PFAS bioaccumulation potential, sufficient data are available to support quantitative estimates (both RME point estimates and probability distributions, as needed) of dietary exposure to several PFAS in backyard garden produce (fruits and vegetables), poultry (chicken and eggs), and fish. The available information for each dietary item is briefly summarized below.

Backyard Garden Produce – Fruits and Vegetables

Table 4.1 summarizes relevant literature on the bioaccumulation potential of PFAS in edible components of plants commonly grown in backyard gardens. A total of 22 studies were identified through a comprehensive literature review through May 2021. Only publications that studied uptake of PFAS into edible components of plants that are reasonably anticipated to be grown in a backyard garden in the Primary Project Area are included. Preference was given to studies conducted by cultivating plants in either soil collected from PFAS-impacted sites (“Field”) or in laboratory soils spiked with known quantities of specific PFAS (“Spiked soil”). Publications that relied on hydroponic cultivation methods were excluded since sufficient studies with plants grown in soil are available and likely better represent conditions in backyard gardens within the Primary Project Area.

Most of the studies were performed with mixtures of one or more perfluoroalkyl carboxylic acids (PFCAs) and perfluoroalkane sulfonates (PFSAs); however, other PFAS chemical classes are also represented (e.g., sulfonamides, fluorotelomers, phosphate diesters). The terms bioconcentration factor and bioaccumulation factor are applied to studies conducted in spiked soil and field soils, respectively. Some studies examined translocation factors (i.e., ratios of concentrations in different plant tissues), which is helpful for assessing potential differences between edible and nonedible tissues.

For the BHHRA, data will be grouped by plant species, tissue type, carbon chain length, and functional group to determine if differences in uptake are sufficient to warrant a range of uptake factors for quantifying dietary exposure. Plant species will be grouped by produce categories defined by USEPA for purposes of dietary risk assessment (USEPA, 2011). For home-produced food intake, USEPA classifies home-grown produce into the following categories:

- Exposed Fruits (e.g., cherries, peaches, strawberries)
- Protected Fruits (e.g., citrus, watermelon)
- Exposed Vegetables (e.g., asparagus, tomatoes, peppers, lettuce)
- Protected Vegetables (e.g., legumes, corn, melon, pumpkin)
- Root Vegetables (e.g., carrots, beets, potatoes)

A wide range of site-specific conditions can influence soil-to-plant uptake factors, including soil type, climate, and microbiological communities within the plant root zone. Given that site-specific fruits and vegetables will not be sampled, there is uncertainty in applying summary statistics of results reported in the literature. To address this uncertainty, a separate literature review was conducted to identify studies that examined uptake of PFAS in grass (roots and shoots) and tree leaves, which will be collected at the site (see Biota SAP). Table 4.2 summarizes seven such studies, including grasses grown under spiked-soil and field conditions. A comparison of site-specific estimates of bioaccumulation factors in comparable plants to the range reported in the literature will inform the uncertainty analysis of the BHHRA. Since the literature includes results for both grasses/leaves as well as edible fruits and vegetables, the more direct comparison of site-specific study results to comparable plant species will aid in the characterization of uptake potential in home-grown produce relative to literature-reported values.

Home-raised Poultry – Chicken and Eggs

Table 4.3 summarizes available literature (as of May 2021) on bioaccumulation potential of PFAS to poultry tissue (muscle) and eggs. Eight studies were identified, of which five evaluated uptake in chickens, and three examined uptake in domesticated or wild ducks (Cui, 2018; Senversa, 2018; Taniyasu et al., 2003). Each study examined uptake of PFOS along with one or more PFAS (PFCAs, other PFAS, sulfonamides, and polyfluorinated ethers).

Bioaccumulation factors were calculated based on measurements of feed, water, and/or soil along with poultry tissue and eggs. Egg transfer factors can be calculated for PFOS, PFHxS, PFOA, and PFHxA. The studies provide sufficient data to evaluate general trends in PFAS bioaccumulation potential as a function of PFAS carbon chain length and functional group.

Fish

Table 4.4 summarizes published bioconcentration factor (BCF) and bioaccumulation factor (BAF) values for fish available as of May 2021. USEPA's AQUATOX model (USEPA, 2018c) implements the same equations developed by Martin et al. (2003a, 2003b) to predict bioconcentration factors for PFAS as a function of the number of perfluorinated carbons (see further details in the footnotes of Table 4.4). These studies support observations regarding general trends in bioaccumulation potential as a function of carbon chain length, functional group, environmental conditions, and taxonomic grouping of receptors. These factors and additional literature will be further explored and discussed in the BHHRA. Additionally, the data collected pursuant to the Biota SAP provide information on spatially paired chemical concentrations and conditions of surface water, sediment, soil, aquatic invertebrates and plants, fish, terrestrial invertebrates and plants, and small mammals. Fish sampling will target multiple size classes to support exposure assessments for both the BHHRA (fillet tissue dataset) and baseline ecological risk assessment (BERA) (whole-body tissue dataset). For larger fish, both fillet and whole-body measurements will be evaluated to support site-specific estimates of ratios or regression equations to estimate concentrations in tissues. Results will be evaluated in the context of literature-reported whole body-to-fillet relationship reported for PFOS (e.g., Babut et al., 2017; de Vos et al., 2008; Fair et al., 2019; Fliedner et al., 2018; Mazzoni et al., 2019; Munoz et al., 2017) and other potentially bioaccumulative metals and organics (Bevelhimer et al., 1997).

5.4 Screening Level HHRA Results – Human Health COPCs

The final results and parameters considered for the COPC screening are shown in the "Occurrence, Distribution, and Selection of Chemical of Potential Concern" tables, Appendix B Tables B1.1 - B1.11, following the USEPA RAGS "Table 2" format. The final list of BHHRA primary and secondary COPCs by media are presented in Table 5.

The following observations are noted regarding the COPC list for the BHHRA, based on the findings shown in Appendix B Tables B1.1 – B1.11 and summarized in Table 5:

- PFOA and PFOS are identified as primary COPCs in groundwater, surface water, soil and sediment based on USEPA recommended screening levels, and all PFAS screen in based on NYSDEC's "total PFAS" screening level for groundwater. Many PFAS were infrequently detected; however, the lack of RBSLs for other PFAS result in most PFAS identified as secondary COPCs in soil. PFBS screens in as a primary COPC in groundwater using the most recent USEPA screening level (May 2021). All other PFAS will be brought into the full BHHRA for toxicity and exposure assessment (see methods in Sections 7, 8 and 9).
- The other primary COPCs are grouped mostly in metals, PAHs, and VOCs.
- TCE and cis-1,2-DCE screen in as primary COPCs based on detections in groundwater, as well as ambient air.
- A few pesticides (beta-benzenehexachloride and heptachlor) are screened in a primary COPCs, however, there has never been an operational component of the site history that manufactured pesticides (see Section 3.1).

Both primary and secondary categories of COPCs will be further evaluated in the BHHRA. The evaluation process will closely follow USEPA risk assessment guidance for COPC assessment, including consideration of the following additional lines of evidence in the risk characterization discussion and uncertainty analysis:

- Background concentrations.
- Frequency, magnitude, and pattern of detected chemicals.
- Mode of toxicity (including mutagenicity) and potential for bioaccumulation.
- Multiple contaminant (mixtures) effects.
- Exposure considerations.

These criteria listed above will not be applied in a "pass/ fail" approach, but rather, the lines of evidence will be considered in the context of site-specific information obtained during the RI investigation and other regional efforts.

6.0 BASELINE HUMAN HEALTH RISK ASSESSMENT APPROACH

6.1 Problem Formulation for the McCaffrey Street BHHRA

The screening level human health risk assessment for the McCaffrey Street Site identified numerous primary and secondary COPCs in all environmental media. PFAS and various metals consistently emerge as potential risk drivers across all media and routes for human health risks. VOCs present in groundwater may also present a vapor intrusion risk to future hypothetical residents. Other COPCs include a few PAHs and pesticides in soil and PCBs in groundwater and surface water; however, these generally occur at fairly low concentrations relative to screening level benchmarks and it is not yet clear that they are site related.

The baseline risk assessment will be conducted using reasonable but conservative exposure and dose-response assumptions to characterize the range of potential site risks. The human populations assumed to be potentially at risk will include early-life exposures, chronic lifetime exposures, and sensitive exposure windows such as reproductive/developmental. Potential exposure pathways, including inhalation, oral ingestion, and dermal absorption will be explored. Additionally, potential dietary pathways for human health (e.g., plant uptake or fish consumption) will be considered when data are available. The incorporation of site-specific exposure information will be used, when available, to reduce the uncertainty in the risk characterization for the site. Uncertainties in both exposure and dose-response information will be identified.

Based on these initial findings, the baseline risk assessment will characterize the probability of potential human health effects as a result of potential exposure to one or more of the site-related chemical stressors, in the absence of any actions taken to reduce or mitigate exposures. The results may help focus future remedial action and risk management decisions.

6.2 Overview of the Process

Key aspects of the BHHRA methods are summarized here and described in more detail in the following sections.

- **Development of Preliminary Conceptual Site Model (CSM).** A conceptual site model (CSM) is a visual representation of the sources, transport mechanisms, exposure media, and receptor populations considered in a risk assessment. Preliminary CSMs are developed in the problem formulation phase of a risk assessment and are typically refined as additional data are collected during the RI ((USEPA, 1989a, 1997b, 2001d)). The preliminary CSM for the human health baseline risk assessment identifies the way a human population may be exposed to constituents at a site, guides data collection and analysis, and ultimately facilitates the calculation of media-specific exposure point concentrations (EPCs) for each contaminant of concern. As such, the preliminary CSM provides the foundation for the problem formulation for the baseline risk assessments (see Section 7).

- **Defining Exposure Units and Exposure Point Concentrations (EPCs)**. EPCs will be calculated for each exposure unit within the McCaffrey Primary Project Area for each COPC. Reasonable maximum exposure (RME) and central tendency exposure (CTE) scenarios will be evaluated to provide estimates of the potential for adverse health effects from upper-bound and likely activity levels, respectively (see Section 7).

- **Toxicity Assessment and Toxicity Value Selection.** Toxicity values selected for COPCs rely upon well-established USEPA policy and guidance. Only values that meet USEPA's criteria for consideration will be utilized. For non-PFAS, the toxicity values used in the RBSLs for screening will be carried further. For PFAS, toxicity values will be selected following USEPA policy and guidance. PFAS without appropriate toxicity information will be evaluated in the uncertainty analysis (see Section 8).

- **Risk Characterization.** Risk characterization combines estimates of exposure (dose) with toxicity criteria to provide an assessment of the potential cancer risk and noncancer hazards for the scenarios quantified in the BHHRA. The risk characterization will convey the nature of potential risks present at the Primary Project Area in quantitative and qualitative terms and will evaluate uncertainties and variability in the findings (USEPA, 1989a, 1995b, 2000c, 2018c) (see Section 9). The risk characterization will also summarize findings from the screening of soil samples collected within the greater RISA boundary, based on site-specific soil RBSLs for PFAS.

- **Uncertainty Assessment.** Qualitative and quantitative evaluations of uncertainty in the BHHRA will be performed to assess the impacts on the risk characterization results and provide further context to support risk management decisions (see Section 9).

7.0 PRELIMINARY CONCEPTUAL SITE MODEL AND EXPOSURE ASSESSMENT

The goal of the exposure assessment is to estimate intakes and doses for each of the COPCs, for each potential receptor that may be present in an exposure unit (EU). A preliminary exposure assessment was conducted as part of the screening level risk assessment to evaluate the potential exposure pathways at the McCaffrey Street Site. The exposure assessment identifies the way in which a human population may be exposed to constituents at a site, guides development of the CSM, and ultimately results in a calculation of a media-specific EPC for each COPC.

The CSM for human health is informed by the COPCs identified in the screening level assessment and provides the foundation for the problem formulation for the baseline risk assessment. The CSM may be further refined during the course of the baseline risk assessment, as relative exposure pathways are assessed for each exposure scenario. The CSM may also be refined based on findings from the RI investigation of potential sources and mechanisms of fate and transport.

The preliminary BHHRA CSM presented herein identifies the potential sources and release mechanisms and identifies the primary exposure points, receptors, and exposure routes within the BHHRA Primary Project Area. A specific exposure pathway for a potential receptor is qualified as complete or incomplete, as well as significant or insignificant, depending on the likelihood and relative magnitude of contact (resulting in dermal absorption, inhalation, and/or ingestion) with COPCs present in an exposure medium (i.e., biota, groundwater, surface water, sediment, air, or soil). The following steps are necessary for a complete exposure pathway:

1. Source and mechanism of chemical release into the environment.
2. An environmental transport medium for the released chemical or mechanism of transport between media.
3. A point of potential receptor contact with the contaminated medium.
4. An exposure route at the point of contact (i.e., dermal absorption, inhalation, or ingestion).

In the event one of these elements is missing, considering the set of primary COPCs, the pathway is incomplete. Exposure pathways considered complete and significant will be evaluated quantitatively, while exposure pathways considered complete yet insignificant will be evaluated qualitatively in the baseline risk assessments. In order to focus the risk characterization on the essential chemicals of concern, incomplete pathways will not be further evaluated in the baseline risk assessment.

7.1 Human Health Conceptual Site Model

The human health CSM (Figure 5) illustrates the complete exposure pathways for four on-site receptor scenarios and three off-site receptor scenarios. The basis for these determinations is discussed below for each scenario. Table 6 summarizes the complete set of receptor scenarios and potential exposure media that will be evaluated in the BHHRA.

7.1.1 Current and Hypothetical Future Receptors

The McCaffrey Street Site BHHRA will evaluate potential risks for the following receptors:

- Current and future commercial and industrial workers on-site.
- Current and future construction workers on-site.

- Current and future construction workers off-site within the Primary Project Area.
- Current and future trespassers or visitors on-site.
- Hypothetical future residents on-site.
- Current and hypothetical future residents off-site within the Primary Project Area and within the Residential Irrigated Soil Area.

  Current and future recreators (waders and anglers) off-site within the Primary Project Area.

As shown in the human health CSM (Figure 5), current and hypothetical future receptors may be exposed to COPCs through a number of exposure pathways, primarily through surface and groundwater, soil, sediment, and possibly air. Under current conditions, in addition to the occupational workers at the site, it is possible for construction workers, trespassers, and visitors to be in contact with on-site environmental media. Off-site within the Primary Project Area, there are current residents as well as potential construction workers and recreational users of the Hoosic River.

Future hypothetical scenarios will also be considered and will include the possibility that any of the Primary Project Area land (on- and off-site) may be redeveloped into residential housing, which may result in human exposure to subsurface soil brought to the surface during home construction. The site and residential properties in the vicinity are currently connected to treated municipal water and it is reasonable to conclude that any future residences will also be connected to municipal water. However, in accordance with USEPA guidance (USEPA, 1989a), for the purposes of calculating hypothetical future risk to future residents from site-impacted groundwater and establishing the site’s baseline risk without groundwater treatment, the baseline risk assessment will assume that drinking water is a complete exposure pathway (via ingestion, dermal contact, and inhalation) for COPCs in groundwater.

The potentially complete exposure pathways that will be considered for evaluation across one or more of the receptor scenarios in the BHHRA are:

- Ingestion, dermal contact, and inhalation of groundwater.
- Inhalation of ambient air.
- Inhalation of fugitive dust.
- Direct dermal contact with soil, sediment, surface water, and/or groundwater.
- Incidental ingestion of soil (and dust), sediment, surface water, and/or groundwater.
- Consumption of fish from the Hoosic River.
- Consumption of backyard fruits and vegetables and home-raised chickens and eggs.

Table 6 summarizes these exposure scenarios and receptor groups, including age brackets. Each scenario is described in more detail below.

Current and Future Commercial/Industrial Workers On-Site

As the plant at the site remains active, a current and future commercial/industrial worker could be exposed to site-related constituents outdoors within the current facility boundary and when inside the current facility. Outdoor on-site exposure pathways that are considered complete include potential inhalation of COPCs via inhalation of ambient air and incidental ingestion and dermal absorption of constituents in surface soil/dust. Indoor exposure to constituents may occur due to inhalation of volatile COPCs present in groundwater and subsurface soil migrating as vapor into buildings (vapor intrusion). As there is no significant permanent standing surface water on-site, the worker scenario does not include exposure to COPCs via on-site surface water or sediment exposure.

Therefore, environmental media that will be evaluated for the assessment of potential risk to current and future adult commercial/industrial workers at the McCaffrey Street facility include surface soil, outdoor ambient air, and indoor air via vapor intrusion from the subsurface.

Current and Future Construction Workers On-Site and Off-Site within the Primary Project Area

On-site construction worker activities that could result in exposure to COPCs include installation of building foundations, trenching activities, utility work, and general construction at the site. Complete exposure pathways for construction workers include incidental ingestion and dermal contact with on-site groundwater, surface and subsurface soil, and inhalation of ambient air and surface soils/dust. Although the average depth to groundwater on-site is ~15 feet bgs, which is significantly below depths typically encountered during normal construction activities, some locations may encounter groundwater at more shallow depths and direct contact with groundwater during digging may be possible. The exposure frequency and duration of construction worker direct contact with groundwater is of limited occurrence and is likely a relatively low contribution pathway; however, at the request of NYSDEC and USEPA, this pathway is considered complete and will be evaluated for locations with groundwater at depths less than 15 feet bgs. Exposure to COPCs through inhalation of ambient air is likely relatively low as stack emissions of COPCs are limited (NYSDEC, 2019); this pathway will be evaluated, if data are available, to confirm low exposure and low risk from site-related aerial emissions. VOCs that migrate from groundwater to the surface will be immediately dispersed; however, the construction worker trench model considers inhalation of VOCs from groundwater, as well, therefore, this pathway will be evaluated for volatile compounds in groundwater.

An off-site current or future construction worker may be exposed to COPCs in the same manner as on-site current or future construction workers. Therefore, complete exposure pathways for off-site construction workers are the same as on-site construction workers and include direct contact (incidental ingestion and dermal contact) with off-site surface and subsurface soil, and direct contact (incidental ingestion, dermal contact, inhalation) with off-site groundwater. Inhalation of COPCs in ambient air (via volatilization from the subsurface) and in surface soils (via fugitive dust) are also considered complete exposure pathways and will be evaluated.

Environmental media that will be evaluated for the risk characterization for potential current and future construction workers on- and off-site within the Primary Project Area include surface soil, subsurface soil, groundwater, and ambient air.

Current and Future Trespassers/Visitors On-Site

The on-site trespasser/visitor scenario includes activities such as transiting the property to access the Hoosic River or Hoosic River Greenway. Adult and older child trespassers/visitors will be evaluated. Trespassers/visitors who enter the property could potentially be exposed to constituents in surface soil/dust through dermal contact and incidental ingestion (there is no gardening or digging activities assumed for trespasser/visitors so deeper soil depths are not necessary). Trespassers may also be exposed to stack emissions through ambient air; however, exposure to this medium is likely to be a low-contribution pathway due to short exposure duration and limited exposure frequency. Additionally, as identified by NYSDEC, stack emissions of COPCs are limited (NYSDEC, 2019). Outdoor ambient air exposure to site-related COPCs is therefore considered a negligible pathway for the trespasser/visitor receptor and risks will not be quantified. As there is generally no significant permanent standing water on-site, the trespasser/visitor scenario does not include exposure to COPCs via aquatic life ingestion, on-site surface water, or sediment exposure routes.

The potential risk to trespassers or visitors to the McCaffrey Street facility will be evaluated for COPCs in surface soil.

Current and Hypothetical Future Residents Off-Site within the Primary Project Area and within the Residential Irrigated Soil Area

Off-site current and hypothetical future residents, including younger children, older children, and adults, will be evaluated (USEPA, 1995a). Off-site current and hypothetical future resident inhalation exposure to COPCs may occur indoors due to inhalation of volatile COPCs present in groundwater and subsurface soil migrating as vapor into future residential buildings (vapor intrusion). The vapor intrusion pathway is considered potentially complete for VOCs present in groundwater off-site. Another complete exposure pathway for off-site current and future residents is direct contact (incidental ingestion and dermal contact) with off-site surface soil and subsurface soil. Exposures to both the surface soil only and surface and subsurface soil will be considered. As discussed in Section 2.1, the BHHRA will also consider potential exposure to PFAS in residential soil throughout the Residential Irrigated Soil Area, as a result of historical use of municipal tap water potentially impacted with PFAS. As described in more detail in Section 7.3 and shown in Appendix B4 tables, selected soil and dust ingestion rates for residents account for inhalation and subsequent swallowing of soil dust particles. Therefore, inhalation of dust will not be evaluated separately for residents (USEPA, 2002f, 2017a).

Ingestion of locally grown plants and backyard poultry (meat and eggs) that may have been grown in soil containing site-related COPCs is also a potentially complete exposure pathway from the soil and will be evaluated (see Section 5.3.3 for more details). Off-site current residents may be exposed to COPCs through inhalation of ambient air due to stack emissions; however, exposure to COPCs through this pathway is likely relatively low as stack emissions of COPCs are limited (NYSDEC, 2019); this pathway will be evaluated, if data are available, to confirm low exposure and low risk from site-related aerial emissions.

The Primary Project Area is, and will continue to be in the foreseeable future, on municipal water. Drinking water is currently treated. However, the risk assessment will assume that exposures may occur in a hypothetical future resident scenario if treatment becomes ineffective or an untreated new private residential potable well is installed. Therefore, exposure to COPCs in groundwater through direct contact (ingestion, dermal contact) and inhalation are considered hypothetically complete for the future off-site residential scenario and will be evaluated quantitatively.

Current and hypothetical future off-site residents may also be exposed to COPCs at low levels through several insignificant exposure pathways that will not be evaluated quantitatively in the BHHRA. Current and hypothetical future off-site residents may be exposed to site-related COPCs in non-potable groundwater used for irrigation through either ingestion of COPCs that have been taken up by plants grown in areas irrigated with groundwater, or via inhalation of site-related COPCs in ambient air released due to aerosolization of non-potable groundwater during irrigation. Current and hypothetical future off-site residents may also be exposed to site-related COPCs in groundwater at relatively low levels through ingestion of backyard poultry, ingestion of backyard poultry eggs, or ingestion of plants from a backyard garden that were subjected to COPCs in untreated municipal drinking water. However, current and hypothetical future off-site resident exposure to COPCs through these pathways would be unlikely and insignificant and data describing the uptake specifically from irrigation water into these media are lacking. These pathways may be further evaluated, if data are amenable, to ensure they do not contribute a significant exposure to current and hypothetical future residents (see Section 5.3.3 for more details). If confirmed that these pathways contribute negligible risk to current and hypothetical future residents, the pathways will be qualitatively discussed in the risk characterization and uncertainty sections of the BHHRA.

Risks within the greater area designated by the RISA boundary (see Figure 2) will be evaluated with a screening level approach using site-specific RBSLs for selected PFAS. As discussed in Section 9.3.1, the RBSLs will be back-calculated from a target hazard quotient of 0.1 and use the same set of intake equations and default exposure factors that are summarized in Section 7.3 and Appendix B. Concentrations in homegrown produce and farm-raised chicken and eggs will be estimated using models informed by literature and site-specific data on spatially paired samples of soil and vegetation (see Section 7.3.2.3). The risk characterization will include an evaluation of the number, locations, and depth intervals for any discrete samples where measured concentrations in soil are greater than one or more site-specific RBSLs.

In summary, the baseline risk assessment will characterize the potential risk to current and hypothetical future residents within the Primary Project Area to media including surface and subsurface soil, groundwater, outdoor ambient air, vapor intrusion, and homegrown food, for the purposes of informing risk management decisions. The risk assessment will also characterize the potential risk to current and hypothetical future residents who may contact soil impacted with PFAS via the historic use of residential tap water for back yard irrigation within the RISA boundary.

Hypothetical Future Residents On-Site

The purpose of the hypothetical on-site future resident scenario is to provide insight into the rationale for property deed restrictions and the feasibility of unrestricted land use. The on-site hypothetical future resident scenario does not represent risks to residents living within close proximity of the site.

Adult and child hypothetical on-site future residents will be evaluated. On-site hypothetical future resident inhalation exposure to COPCs may occur indoors due to inhalation of volatile COPCs present in groundwater and subsurface soil migrating as vapor into future residential buildings (vapor intrusion). The vapor intrusion pathway is considered potentially complete for VOCs present in groundwater.

Developed properties in the Village of Hoosick Falls are, and will continue to be for the foreseeable future, served by municipal water. Drinking water is currently treated. However, in accordance with USEPA guidance (USEPA 1989b), for the purposes of calculating hypothetical risk to future residents from site-impacted groundwater and establishing the site's baseline risk without the effective treatment, the risk assessment will assume that drinking water is a complete exposure pathway (via ingestion, dermal contact and inhalation). Therefore, exposure to COPCs in groundwater through direct contact (ingestion, dermal contact, and inhalation (e.g., from the shower)) are considered hypothetically complete for the future on-site residential scenario and will be evaluated quantitatively.

Other complete exposure pathways for hypothetical on-site future residents include direct contact (incidental ingestion and dermal contact) with on-site surface soil. As noted above, the deeper soil depths that will be included as subsurface soils may be brought to the surface during future home construction. Exposures to both the surface soil only and surface and subsurface soils combined will be considered. Ingestion of locally grown plants and backyard poultry (meat and eggs) that may have been grown in soil containing site-related COPCs is also a potentially complete exposure pathway and will be evaluated (see Section 5.3.3 for more details).

Similar to hypothetical off-site residents, hypothetical on-site future residents may also be exposed to COPCs through several insignificant exposure pathways that will not be evaluated quantitatively in the BHHRA. These include: exposure to COPCs in groundwater through ingestion of plants irrigated with impacted non-potable groundwater, or via inhalation of COPCs in ambient air released due to aerosolization of non-potable groundwater during irrigations uses; exposure to COPCs in groundwater through ingestion of backyard poultry, ingestion of backyard poultry eggs, or ingestion of plants from a backyard gardens that were impacted by COPCs in untreated municipal drinking water used for watering. These likely insignificant pathways will be evaluated as data allow to confirm they do not contribute to potential risk (see Section 7.3.2.3 for more details). Hypothetical on-site future residents may be exposed to COPCs outdoors in ambient air through inhalation of volatile compounds from the subsurface; however, exposure to COPCs through this pathway is likely relatively low as air dispersion would occur immediately upon volatilization. Under a hypothetical future on-site residential scenario, there would no longer be stack emissions from an on-site facility; as such, there is not a complete exposure pathway for future residential inhalation of constituents in ambient air. Therefore, potential risks to hypothetical future residents on-site will be evaluated for the following media: surface and subsurface soil, groundwater, indoor air, and homegrown food.

Current and Future Recreational User on the Hoosic River and the Hoosic River Greenway – Wading and Angling

The Hoosic River is classified as a class C and D waterbody, based on 6 NYCRR § 940.4 (Table 2), which means it is amenable to recreation and fishing. The Primary Project Area includes the Hoosic River Greenway and a two-mile trail used for recreational hiking, biking, and exercise (see Exhibits). It is also possible that fishing and wading occurs in the Hoosic River near the site within the Primary Project Area for all age groups. The local stretch of the Hoosic River is fairly shallow and rocky and not very amendable to full swimming (see photographs in the Exhibits). Use of the Hoosic River for other in-river activities, such as kayaking, canoeing, and tubing will not be evaluated as the river in the vicinity of the Primary Project Area is unlikely to support these activities, as well. Locations further upriver or downriver with more continuous stretches of deeper water (i.e., >3 feet) are considered to be preferred for such recreational uses.

Complete exposure pathways for recreators include direct contact (incidental ingestion and dermal contact) with Hoosic River surface water, direct contact (incidental ingestion and dermal contact) with surface soil or sediment near the Hoosic River banks, and food ingestion of aquatic life (i.e., fish) caught from the area of the Hoosic River in the Primary Project Area. The recreator receptor may also potentially be exposed to stack emissions through ambient air; however, exposure to this medium is expected to be a low-contribution pathway due to short exposure duration and limited exposure frequency. Additionally, as identified by NYSDEC, stack emissions of COPCs are limited (NYSDEC, 2019). Therefore, exposure to COPCs in outdoor ambient air for a recreator will not be evaluated quantitatively in the baseline risk assessment.

The exposure media evaluated for the recreational user of the Hoosic River near the site, therefore, include direct contact with surface water, sediment, and surface soil, associated with wading and angling activities. Although angling is reasonably expected to be limited to catch-and-release due to pre-existing fish advisories for the Hoosic River (NYSDOH, 2017b), the risk assessment will also evaluate the fish consumption pathway for purposes of informing risk management decisions for future use scenarios.

7.2 Aggregate Exposure and Risk

Each receptor scenario focuses on a specific set of activities that a receptor may engage in within the Primary Project Area. However, some receptors may participate in multiple activities addressed by more than one scenario. For example, a commercial/industrial worker may also exercise on the Hoosic River Greenway a few days a week during their lunch hour. The aggregate exposure and risk from potential combinations of scenarios will also be considered in the BHHRA. Given that the CSM includes seven different receptors, it is not practicable to evaluate all permutations of combinations.

The following potentially overlapping scenarios are considered plausible and will be evaluated in the initial risk characterization:

- Commercial/industrial worker and recreator.
- On-site construction worker and recreator.
- Commercial/industrial worker and off-site resident.
- On-site construction worker and off-site resident.
- Adult and child recreator and on-site or off-site current or future residents.

Risks from combinations of scenarios for common endpoints (i.e., cancer or noncancer) will be summed. Depending on the results of the initial risk characterization, alternative combinations may be considered, and some combinations may be eliminated. In addition, probabilistic risk assessment methods may be incorporated to refine risk estimates for combinations of scenarios. See Section 9 for further details.

7.3 Exposure Assessment

As described above, based on the physical setting of the McCaffrey Street facility and the absence of complete access controls of the facility property and Primary Project Area, it is assumed that human receptor populations may be exposed to COPCs at the site and within the Primary Project Area under current and reasonably anticipated future use conditions for all media. The potentially complete exposure pathways that will be considered for evaluation across one or more receptor scenarios in the BHHRA are:

- Inhalation of ambient air, and indoor air (volatile compounds) from groundwater.
- Direct dermal contact with soil, sediment, surface water, and/or groundwater.
- Incidental ingestion of soil (and dust), sediment, surface water, and/or groundwater.
- Consumption of groundwater as drinking water (residential tap water).
- Consumption of fish from the Hoosic River for recreators.
- Consumption of homegrown produce and farm-raised chickens and eggs.

Based on the CSM and the COPCs for human health, the receptors and exposure pathways that will be evaluated quantitatively in the BHHRA are summarized in Table 6.

7.3.1 Exposure Units

Exposure units (EUs) are the spatial constructs over which risk to receptors are estimated. An EU is the area throughout which a particular receptor may encounter an environmental medium (USEPA, 2002e). The EUs for the McCaffrey Street BHHRA have been defined based on known or anticipated exposure points and to reflect reasonable current and foreseeable future receptor scenarios. Figure 6 provides an example EU grid using 0.25-acre square grids, which is representative of the future residential exposure scenario. This grid size was selected based on a review of tax parcels in residential areas of Hoosick Falls, and is slightly smaller than the typical default assumption of 0.5 acres recommended by USEPA in the Supplemental Soil Screening Guidance (USEPA, 2002f).

For commercial/industrial worker scenarios, the EUs are defined by the property boundaries illustrated in Figure 1. The facility boundary defines the spatial extent of the EU for current commercial/industrial worker.

The sampling design is intended to provide sufficient spatial coverage to evaluate spatial variability at two scales: 1) short scale (within the EU) variance, both horizontally and vertically; and 2) large scale (across EUs) within the Primary Project Area. The short-scale variance will be evaluated for data grouped by common depth interval (as defined by the receptor scenario) within an EU. Some EUs will have sufficient sample sizes (e.g., at least 8-10 sample results) to quantify the variance and calculate 95UCLs using USEPA's ProUCL model and methods, while others will have fewer sample results but can still be helpful in exploring potential spatial autocorrelation. Given the relatively small grid sizes (i.e., 0.25-acre squares), it is not practical to obtain 8-10 samples in each grid cell for each depth interval; therefore, the Primary Project Area will contain data gaps for some EUs. The goal of the BHHRA is to characterize a sufficient fraction of the total EUs within the Primary Project Area to reliably apply the risk conclusions to the full extent of the Primary Project Area. The BHHRA will discuss the properties of the sampling design and data analysis methods that support this approach, including the use of random sampling techniques, evaluation of spatial patterns in concentrations, and correlations between chemical concentrations and properties of the environmental matrix (e.g., organic carbon, particle size distribution, soil pH).

7.3.2 Intake Equations

To estimate the potential cancer and noncancer health risks associated with an exposure to a COPC, an exposure estimate is combined with toxicological criteria. Proposed equations to estimate average daily exposure doses, or intakes, and potential cancer and noncancer risks relevant to the primary human health receptors associated with the site are provided below. These equations follow standard risk assessment methodology and are generally adapted from USEPA's RAGS Volume I documents. All equations for each receptor scenario are also presented in more detail in the Appendix B, Tables B4.1 – B4.7, in USEPA RAGS D "Table 4" format.

Cancer and noncancer dose equations, adapted from USEPA's RAGS Volume I documents including RAGS Part A (USEPA, 1989a), RAGS Part E (USEPA, 2004d), and RAGS Part F (USEPA, 2009a), are provided in the following sections. The term "intake" is defined as the estimated daily dose of a COPC, in mg/kg-day for ingestion and dermal exposures. For inhalation exposures, the intake is provided as an "exposure concentration", in µg/m^3.

For mutagenic COPCs, a dimensionless age-dependent adjustment factor (ADAF) (see Section 8.2) will be included when evaluating intakes. The ADAF is not shown in the intake equations outlined below.

The concentration terms will be estimated using the one-sided 95 percent upper confidence limit for the arithmetic mean (95UCL) summary statistic, as discussed in Section 7.3.4.

7.3.2.1 Direct Contact Pathways of Exposure

The following dose equations are used to quantify exposures associated with direct contact with COPCs that may be present in soil, sediment, groundwater, or surface water. Potential direct contact exposure pathways include ingestion, dermal contact, and inhalation. *Incidental ingestion of soil refers to the combined ingestion of soil and dust.*

The following intake equations for direct contact exposures were adapted from RAGS Part A (USEPA, 1989a) and RAGS Part E (USEPA, 2004d):

Incidental Ingestion of Soil or Sediment

$$ADD_s = \frac{C_s \times CF_1 \times IR_s \times RBA_s \times EF \times ED}{AT \times BW}$$

Where:

ADD_s = average daily dose from incidental ingestion of soil or sediment (mg/kg-day)
C_s = concentration of COPC in soil or sediment (mg/kg)
CF_1 = mass conversion factor for soil or sediment (10^{-6} kg/1 mg)
IR_s = average daily ingestion rate of soil or sediment (mg/day)
RBA_s = bioavailability from soil or sediment relative to bioavailability from water (unitless)
EF = exposure frequency (days/year)
ED = exposure duration (years)
AT = averaging time (days)
BW = body weight (kg)

Dermal Contact with Soil or Sediment

$$ADD_d = \frac{C_s \times CF_1 \times EV_s \times SA_s \times AF_s \times ABS_d \times EF \times ED}{AT \times BW}$$

Where:

ADD_d = average daily dose from skin contact with soil or sediment (mg/kg-day)
C_s = concentration of COPC in soil or sediment (mg/kg)
CF_1 = mass conversion factor for soil or sediment (10^{-6} kg/1 mg)
EV_s = event frequency for soil or sediment (events/day)
SA_s = skin surface area available for contact with soil or sediment (cm^2)
AF_s = skin surface adherence factor for soil or sediment (mg/cm^2-event)
ABS_d = dermal-soil, or dermal-sediment absorption value (unitless)
EF = exposure frequency (days/year)
ED = exposure duration (years)
AT = averaging time (days)
BW = body weight (kg)

Ingestion of Groundwater or Surface Water

$$ADD_w = \frac{C_w \times IR_w \times ABS_{GI,water} \times EF \times ED}{AT \times BW}$$

Where:

ADD_w = average daily dose from ingestion of drinking water sourced from groundwater or surface water (mg/kg-day)
C_w = concentration of COPC in groundwater or surface water (mg/L)
IR_w = average daily ingestion rate of groundwater or surface water (L/day)
$ABS_{GI,water}$ = fraction absorbed from water in gastrointestinal tract (unitless)
EF = exposure frequency (days/year)
ED = exposure duration (years)
AT = averaging time (days)
BW = body weight (kg)

Dermal Contact with Groundwater or Surface Water

$$ADD_d = \frac{DA_{event} \times EV_w \times SA_w \times EF \times ED}{AT \times BW}$$

Where:

ADD_d = average daily dose from skin contact with water (mg/kg-day)
DA_{event} = absorbed dose per event (mg/cm^2-event)
EV_w = average daily event frequency for contact with groundwater or surface water (events/day)
SA_w = skin surface area available for contact with groundwater or surface water (cm^2)
EF = exposure frequency (days/year)
ED = exposure duration (years)
AT = averaging time (days)
BW = body weight (kg)

For inorganics, the calculation of absorbed dose per event (DA_{event}) depends on event duration and the chemical-specific permeability coefficient:

$$DA_{event} = C_w \times K_p \times CF_2 \times t_{event}$$

Where:

DA_{event} = absorbed dose per event (mg/cm^2-event)
C_w = concentration of COPC in groundwater or surface water (mg/L)
K_p = chemical-specific permeability coefficient (cm/hour)
CF_2 = volumetric conversion factor for water (1 L/1000 cm^3)
t_{event} = event duration (hour/event)

For organic chemicals, the calculation of DA_{event} depends on the estimated time for the chemical to reach steady state (t*), compared with the exposure time of the event (t_{event}):

$$If\ t_{event} \leq t^{*}\ then{:}\ DA_{event} = 2\,FA \times K_p \times C_w \times CF_2 \times \sqrt{\frac{6\ tau_{event} \times t_{event}}{\pi}}$$

$$If\ t_{event} > t^{*}\ then{:}\ DA_{event} = FA \times K_p \times C_w \times CF_2 \times \left[\frac{t_{event}}{1+B} + 2\ tau_{event} \times \left(\frac{1+3B+3B^2}{(1+B)^2}\right)\right]$$

Where:

t_{event} = event duration (hour/event)
t^{*} = chemical-specific time to reach steady-state (hour)
DA_{event} = absorbed dose per event (mg/cm^2-event)
FA = fraction absorbed (unitless)
K_p = chemical-specific permeability coefficient (cm/hour)
C_w = concentration of COPC in groundwater or surface water (mg/L)
CF_2 = volumetric conversion factor for water (1 L/1000 cm^3)
tau_{event} = chemical-specific lag time per event (hour/event)
B = chemical-specific dimensionless ratio of the permeability coefficient through the stratum corneum relative to its permeability coefficient across the viable epidermis (unitless)

And using model-based estimates for organics recommended in RAGS 1E (USEPA 2004c Equations 3.8, A.1, and A.4 through A.8):

$$tau_{event} = 0.105 \times 10^{(0.0056 \times MW)}$$

$$log\ K_p = -2.80 + 0.66\ log\ K_{ow} - 0.0056\ MW$$

$$B = K_p \times \frac{\sqrt{MW}}{2.6}$$

$$If\ B \leq 0.6, then\ t^{*} = 2.4\ tau_{event}$$

$$If\ B > 0.6, then\ t^{*} = 6\ tau_{event}\left(b - \sqrt{b^2 - c^2}\right)$$

$$b = \frac{2\,(1 + B)^2}{\pi} - c$$

$$c = \frac{1 + 3B + 3B^2}{3(1+B)}$$

Where:

K_p = chemical-specific permeability coefficient (cm/hour)
K_{ow} = chemical-specific octanol/water partition coefficient (unitless)
MW = chemical-specific molecular weight (g/mol)
B = chemical-specific dimensionless ratio of the permeability coefficient through the stratum corneum relative to its permeability coefficient across the viable epidermis (unitless)

t* = chemical-specific time to reach steady-state (hour)
tau_{event} = chemical-specific lag time per event (hour/event)
b, c = correlation coefficients which have been fitted to the Flynn's data to give the equation for log K_p

7.3.2.2 Inhalation Pathway of Exposure

Inhalation of Ambient Air

The following inhalation exposure concentration equation was adapted from RAGS Part F (USEPA, 2009a):

$$EC_{air} = \frac{C_{air} \times EF \times ED \times ET \times CF_3}{AT}$$

Where:

EC_{air} = exposure concentration in ambient air (µg/m^3)
C_{air} = concentration of COPC in ambient air (µg/m^3)
EF = exposure frequency for impacted environment (days/year)
ED = exposure duration (years)
ET = exposure time spent in impacted environment (hours/day)
CF_3 = time conversion factor (1 day/24 hours)
AT = averaging time (days)

Inhalation of VOCs in the Shower

USEPA Region 2 requires that EPCs for volatile COPCs in tap water are calculated using the Schaum shower model (Schaum et al., 1994). This shower model estimates the amount of volatile compound that is released and/or volatilized into the air of a single shower room during showering and incorporates information about showering conditions and individual activity patterns. A chemical is considered volatile if its Henry's law constant (ratio of a chemical's vapor pressure in air to its solubility in water) is greater than 10^{-5} atm m^3/mol (atmosphere meter cubed per mole) (USEPA, 2015a).

The Schaum shower model equations used to estimate the shower air EPCs for the volatile COPCs in Primary Project Area groundwater are:

$$EC_{air} = \frac{C_{air} \times EF \times ED \times ET \times CF_3}{AT}$$

Where:

EC_{air} = exposure concentration of COPC in air (µg/m^3)
C_{air} = concentration of COPC in air (µg/m^3)
EF = exposure frequency (days/year)
ED = exposure duration (years)
ET = exposure time (hours/day)
CF_3 = time conversion factor (1 day/24 hours)
AT = averaging time (days)

$$C_{air} = \frac{\frac{C_{air-max}}{2} \times t_{event\ 1} + C_{air-max} \times t_{event\ 2}}{t_{event\ 1} + t_{event\ 2}}$$

Where:

C_{air} = concentration of COPC in air (µg/m^3)
$C_{air\text{-}max}$ = maximum concentration of COPC in air (µg/m^3)
t_{event1} = time in shower (hours)
t_{event2} = time in room after shower (hours)

$$C_{air-max} = \frac{C_w \times f_i \times F_w \times t_{event\ 1}}{V_a}$$

Where:

$C_{air\text{-}max}$ = maximum concentration of COPC in air (µg/m^3)
C_w = COPC concentration in water (µg/L)
f_i = chemical-specific fraction volatilized (unitless)
F_w = shower water flow rate (L/hour)
t_1 = time in shower (hours)
V_a = bathroom air volume (m^3)

For COPCs with unknown fraction volatilized (*fi*):

$$f_i = f_j \times \frac{(2.5/D_w^{0.67} + R \times T/D_a^{0.67} \times H)_j}{(2.5/D_w^{0.67} + R \times T/D_a^{0.67} \times H)_i}$$

Where:

f_i = chemical-specific fraction volatilized (unitless)
f_j = fraction volatilized for radon (unitless)
D_w = chemical-specific diffusivity in water (m^2/second)
D_a = chemical-specific diffusivity in air (m^2/second)
R = gas constant (atm m^3/mol-K)
T = temperature (K)
H = chemical-specific Henry's law constant (atm m^3/mol)

Inhalation of VOCs in the Whole House

A similar model will be used to estimate exposure to VOCs in groundwater that were volatilized from water during household use. This model considers water use such as cooking, washing dishes, and washing clothes. An exposure concentration is derived to represent a spatial average over the house (Schaum et al., 1994).

The air exposure concentration for the whole house can be estimated using the following equations:

$$EC_{air} = \frac{C_{air} \times EF \times ED \times ET \times CF_3}{AT}$$

Where:

EC_{air} = exposure concentration of COPC in air (µg/m^3)
C_{air} = concentration of COPC in air (µg/m^3)
EF = exposure frequency (days/year)
ED = exposure duration (years)
ET = exposure time (hours/day)
CF_3 = time conversion factor (1 day/24 hours)
AT = averaging time (days)

$$C_{air} = \frac{C_w \times WHF \times f_i}{HV \times ER \times MC}$$

Where:

C_{air} = concentration of COPC in air (µg/m^3)
C_w = COPC concentration in water (µg/L)
WHF = water flow rate in whole house (L/day)
f_i = chemical-specific fraction volatilized (unitless)
HV = house volume (m^3)
ER = exchange rate (changes/day)
MC = mixing coefficient (unitless)

Inhalation VOCs from Groundwater – Construction Worker Trench Model

Construction worker exposure to COPCs volatilized from groundwater during trenching activities is calculated using the Virginia Department of Environmental Quality Construction Worker Trench Model (VDEQ, 2020). The air exposure concentration of COPCs in a trench is estimated using the following equation:

$$EC_{air} = \frac{C_{trench} \times EF \times ED \times ET \times CF_3}{AT}$$

Where:

EC_{air} = exposure concentration of COPC in air (µg/m^3)
C_{trench} = concentration of contaminant in the trench (µg/m^3)
EF = exposure frequency (days/year)
ED = exposure duration (years)
ET = exposure time (hours/day)
CF_3 = time conversion factor (1 day/24 hours)
AT = averaging time (days)

$$C_{trench} = C_w \times VF$$

Where:
C_{trench} = concentration of contaminant in the trench (µg/m^3)
C_w = concentration of contaminant in groundwater (µg/L)
VF = volatilization factor (L/m^3)

The Virginia Department of Environmental Quality Construction Worker Trench Model identifies two different approaches for estimating the volatilization of a VOC from groundwater into a trench. The first set of equations is based on a groundwater depth of less than 15 feet bgs, which assumes groundwater pooling occurs in the trench. The second set of equations is based on a groundwater depth of greater than 15 feet bgs, which assumes VOC transport through vadose zone only. The equations that assume a groundwater depth of less than 15 feet bgs were conservatively selected:

$$VF = \frac{(\mathrm{K_i} \times A \times F \times CF_2 \times CF_4 \times CF_5)}{ACH \times V}$$

$$K_i = \frac{1}{\left(\frac{1}{K_{iL}}\right) + \frac{R \times T}{(H \times K_{iG})}}$$

$$KiL = \left(\frac{MW_{O2}}{MW}\right)^{0.5} \times \frac{T}{298} \times K_{L,O2}$$

$$K_{iG} = \left(\frac{MW_{H2O}}{MW}\right)^{0.335} \times \left(\frac{T}{298}\right)^{1.005 \times K_{g,H20}}$$

Where:

VF = volatilization factor (L/m^3)
K_i = chemical-specific overall mass transfer coefficient (cm/s)
A = area of the trench (m^2)
F = fraction of floor through which contaminant can enter (unitless)
CF_2 = volumetric conversion factor for water ($1\ L/1000\ cm^3$)
CF_4 = area conversion factor ($10000\ cm^2/1\ m^2$)
CF_5 = time conversion factor (3600 s/1 hour)
ACH = air changes per hour (h^{-1})
V = volume of the trench (m^3)
K_i = chemical-specific overall mass transfer coefficient (cm/s)
K_{iL} = chemical-specific liquid-phase mass transfer coefficient (cm/s)
H = chemical-specific Henry's law constant (atm m^3/mol)
K_{iG} = gas-phase mass transfer coefficient of I (cm/s)
R = ideal gas constant (atm-m^3/mol-K)
T = average system absolute temperature (k)
$K_{L,\ O2}$ = liquid-phase mass transfer coefficient of oxygen at 25° C
MW_{O2} = molecular weight of O_2 (g/mol)
MW = chemical-specific molecular weight (g/mol)
$K_{g,H20}$ = gas-phase mass transfer coefficient of water vapor at 25° C
MW_{H2O} = molecular weight of O_2 (g/mol)

Inhalation of Fugitive Dust – Construction Worker

Under the construction worker scenario, fugitive dusts may be generated from surface and soils by wind erosion, construction vehicle traffic on unpaved roads and other construction activities. The USEPA recommends evaluating this construction scenario, particularly for SVOCs and metals, for subchronic exposures using the following equation (USEPA, 2002f):

$$EC_{air} = \frac{C_{air} \times EF \times ED \times ET \times CF_3}{AT}$$

Where:

EC_{air} = exposure concentration of COPC in air (µg/m^3)
C_{air} = concentration of COPC in air (µg/m^3)
EF = exposure frequency (days/year)
ED = exposure duration (years)
ET = exposure time (hours/day)
CF_3 = time conversion factor (1 day/24 hours)
AT = averaging time (days)

For metals, pesticides, SVOCs, and PFAS

$$C_{air} = \frac{C_s \times CF_6}{PEF}$$

For VOCs

$$C_{air} = \frac{C_s \times CF_6}{V_f}$$

Where:

C_{air} = concentration of COPC in ambient air (µg/m^3)
C_s = concentration of COPC in surface soil (mg/kg)
CF_6 = Mass conversion factor for soil or sediment (1000 µg/1 mg)
PEF = Particulate emission factor (m^3/kg)
V_f = chemical-specific volatilization factor (m^3/kg)

The contribution of exposure and risk from fugitive dust to residents and commercial/industrial workers is currently assumed to be negligible (less than 10%) and this is thought to be a low contribution pathway (see CSM Figure 5). However, in the event that the exposure to fugitive dust by construction workers results in a potential risk, this exposure pathway may also need to be evaluated for residents and commercial/industrial workers.

7.3.2.3 Dietary Exposure

One of the exposure pathways that may contribute to estimated daily intake is ingestion of biota containing COPCs, particularly via human consumption of backyard garden produce, home-raised chicken and eggs, and fish. These exposure pathways have received considerable recent scientific attention, particularly for bioaccumulative PFAS (e.g., PFOS) and plant uptake of shorter chain perfluoroalkyl compounds. Uptake of PFAS from abiotic media to biota will be based on both site-specific data and a comprehensive analysis of the literature (see a summary presented in Section 5.3.3). The BHHRA will present an updated state-of-the-science overview of the available information, best practices, and key data gaps in assessing the potential for risks from exposure to bioaccumulative COPCs and PFAS through dietary exposure.

Ingestion of Fish

The following intake equation for the ingestion of fish was adapted from RAGS Part A (USEPA, 1989a):

$$ADD_{fish} = \frac{C_{fish} \times (1 - Loss) \times IR_{fish} \times \mathrm{AF}_{\mathrm{fish}} \times ABS_{GI,food} \times FI_{fish} \times ED}{AT \times BW}$$

Where:

ADD_{fish} = average daily dose from fish consumption (mg/kg-day)
C_{fish} = concentration of COPC in fish fillet (mg/kg)
Loss = fraction of chemical-specific reduction due to preparation and cooking (unitless)
IR_{fish} = average daily fish ingestion rate (kg/day)
AF_{fish} = fish ingestion rate age adjustment factor
$ABS_{GI,food}$ = fraction absorbed from food in gastrointestinal tract (unitless)
FI_{fish} = fraction of total fish intake that is site-related (unitless)
ED = exposure duration (years)
AT = averaging time (days)
BW = body weight (kg)

The fractional reduction in chemical concentration due to cooking loss (Loss) will be chemical specific and based on scientific literature for CTE calculations and will be conservatively set to zero for RME calculations.

Additional fish tissue measurements for PFAS are currently planned (see Biota SAP). Where fish tissue data are insufficient for assessing potential human health risk, the concentrations of COPCs in fish may be modeled. Several different methods can be used to model chemical concentrations in fish tissue based on chemical concentrations in sediment, surface water, and/or different tissue types (e.g., a consumer and its prey). Such methods include ratios (e.g., biota-sediment accumulation factors or bioconcentration factors), regression analyses, physiologically-based pharmacokinetic models, and food web models.

Current literature was reviewed to evaluate the state of the science informing levels of PFAS in edible portions of fish based on surface water and sediment concentrations. Key studies with BCFs and BAFs are shown in Table 4.4. For the BHHRA, the data will be evaluated for quality and for limitations in bioaccumulation information for the PFAS COPCs and representative taxonomic classes at the Site.

Ingestion of Backyard Garden Produce – Fruits and Vegetables

The site-specific potential risk to human health from backyard garden produce is unlikely to be significant, even in hypothetical future residential scenarios wherein untreated groundwater might be used for irrigation and watering of backyard gardens. For current COPCs in soil, however, the BHHRA will conduct a semi-quantitative assessment to determine if the exposure from homegrown food by residents would be greater than 10% of the intake from other routes before quantifying risk from this pathway (USEPA, 2004d).

The following intake equation for the ingestion of homegrown food products, including common backyard garden fruits and vegetables, was adapted from RAGS Part A (USEPA, 1989a):

$$ADD_{food} = \frac{C_{food} \times (1 - Loss) \times IR_{food} \times ABS_{GI,food} \times FI_{food} \times ED}{AT \times BW}$$

Where:

ADD_{food} = average daily dose from food consumption (mg/kg-day)
C_{food} = concentration of COPC in food product (mg/kg)
Loss = fraction of chemical-specific reduction due to preparation and cooking (unitless)
IR_{food} = average daily ingestion rate of food product (kg/day)
$ABS_{GI,food}$ = fraction absorbed from food in gastrointestinal tract (unitless)
FI_{food} = fraction of total food product intake that is homegrown (unitless)
ED = exposure duration (years)
AT = averaging time (days)
BW = body weight (kg)

As discussed above for ingestion of fish tissue, the fractional reduction in chemical concentration due to cooking loss (Loss) will be set to zero for RME calculations and will be chemical specific and based on scientific literature for CTE calculations, if relevant for cooked produce.

Additional paired plant (grasses and leaves) and soil samples are planned (see Biota SAP). If considered a significant contribution to overall risk (i.e., exposure is greater than 10% of the oral exposure), the concentrations of COPCs in food products, in the absence of food product-specific data, may be modeled. The uptake of COPCs from environmental media by homegrown food products can occur as a result of a variety of mechanisms. The general uptake model for homegrown food products is as follows:

$$C_{food} = C_{medium} \times uptake$$

Where:

C_{food} = concentration of COPC in food product (mg/kg)
C_{medium} = concentration of COPC in environmental medium in contact with food product (medium-specific concentration units)
uptake = chemical-specific modeled relationship between food product and environmental medium (mg/kg/medium-specific concentration units)

Uptake of PFAS from abiotic media to fruits and vegetables will be based on both site-specific data and a comprehensive analysis of the literature. See Section 5.3.3. for a review of the current state-of-the-science informing levels of PFAS in edible portions of common garden produce (fruits and vegetables) based on surface soil concentrations. Key studies with BCFs and BAFs are shown in Tables 4.1 and 4.2. For the BHHRA, the data will be updated and evaluated for quality and for limitations in bioaccumulation information for the PFAS COPCs and representative produce at the Site.

Ingestion of Backyard Chickens and Eggs

The site-specific potential risk to human health from this pathway is unlikely to be significant, even in hypothetical future residential scenarios wherein untreated groundwater is used for irrigation and watering of backyard poultry. For current COPCs in soil, the BHHRA will conduct a semi-quantitative assessment to determine if the exposure from food (homegrown garden produce and poultry intake by residents) would be greater than 10% of the intake from other routes before quantifying risk from this pathway (USEPA, 2004d).

The following intake equation for the ingestion of homegrown poultry and egg was adapted from RAGS Part A (USEPA, 1989a):

$$ADD_{food} = \frac{C_{food} \times (1 - Loss) \times IR_{food} \times ABS_{GI,food} \times FI_{food} \times ED}{AT \times BW}$$

Where:

ADD_{food} = average daily dose from food consumption (mg/kg-day)
C_{food} = concentration of COPC in food product (mg/kg)
Loss = fraction of chemical-specific reduction due to preparation and cooking (unitless)
IR_{food} = average daily ingestion rate of food product (kg/day)
$ABS_{GI,food}$ = fraction absorbed from food in gastrointestinal tract (unitless)
FI_{food} = fraction of total food product intake that is homegrown (unitless)
ED = exposure duration (years)
AT = averaging time (days)
BW = body weight (kg)

As discussed above, the fractional reduction in chemical concentration due to cooking loss (Loss) will be set to zero for RME calculations and will be chemical specific and based on scientific literature for CTE calculations.

If considered a significant contribution to overall risk (i.e., exposure is greater than 10% of the oral exposure), the concentrations of COPCs in poultry meat and eggs products may be modeled. The general uptake model for food products is as follows:

$$C_{food} = C_{medium} \times uptake$$

Where:

C_{food} = concentration of COPC in food product (mg/kg)
C_{medium} = concentration of COPC in environmental medium in contact with food product (medium-specific concentration units)
uptake = chemical-specific modeled relationship between food product and environmental medium (mg/kg/medium-specific concentration units)

Uptake of PFAS from abiotic media to home-raised chicken and eggs will be based on both site-specific data and a comprehensive analysis of the literature. See Section 5.3.3. for a review of the current state-of-the-science. Key studies are shown in Table 4.3. For the BHHRA, the data will be updated and evaluated for quality and for limitations in bioaccumulation information for the PFAS COPCs at the Site.

7.3.3 Exposure Parameter Values

The exposure dose is represented as the daily intake of a contaminant an individual receives through each exposure pathway (e.g., soil ingestion, dermal contact). Doses are calculated based on two different averaging times:

- Average daily dose (ADD) = the dose averaged over the assumed exposure duration for noncancer health effects

- Lifetime average daily dose (LADD) = dose averaged over a 70-year lifetime for potential cancer risks

Exposure doses are expressed as either administered (oral) or absorbed (dermal) doses in milligrams of contaminant per kilogram of body weight per day (mg/kg-day). The ADD or LADD for each contaminant and pathway is used in conjunction with the contaminant-specific cancer slope factor (CSF) and reference dose (RfD) to calculate cancer risks and the potential for noncancer health effects, respectively.

Exposure parameter values for the BHHRA will be selected to quantify RME (using USEPA values) and CTE (using both NYS and USEPA values). The intent of the RME is to estimate a conservative exposure case (i.e., well above the average case) that is still within the range of possible exposures (USEPA, 1989a), whereas the CTE should be representative of the average, or typical, individual in the affected population. NYS CTE exposure parameters including exposure frequency, soil ingestion rates, and soil absorption factors were identified in the New York State Brownfield Cleanup Program Development of Soil Cleanup Objectives, Technical Support Document (NYSDEC & NYSDOH, 2006). The basis of multiple NYS CTE exposure parameter values have since been updated in the USEPA Exposure Factors Handbook (USEPA, 2011, 2017a). When available, updated USEPA CTE exposure parameters consistent with Methods outlined by NYSDEC and NYSDOH were selected. Exposure parameters selected for the BHHRA did not consider fishing advisories or institutional controls.

The CTE and RME fish ingestion rates from the USEPA approved human health risk assessment conducted for the Hudson River in 2000 (TAMS Consultants, Inc, 2000) will be used. These point estimate values were derived from a 1991 New York Angler Survey of fish consumption by licensed anglers (Connelly et al., 1992). Fishing practices from the Hudson River are assumed to be an appropriate surrogate for the Hoosic River, as the Hudson River is a flowing inland river from the same geographic region and with likely similar population demographics. All exposure parameter values are presented in Appendix B Tables B4.1- B4.7 and are presented in USEPA RAGS D “Table 4” format.

The CTE and RME soil and dust ingestion rates for each receptor scenario are based on a combination of USEPA and NYS (NYSDEC and NYSDOH) guidance. Selected soil and dust ingestion rates for each receptor account for inhalation and subsequent swallowing of soil dust particles. Therefore, with the exception of the construction worker scenario, inhalation of dust does not need to evaluated separately (USEPA, 2017a). However, in accordance with USEPA soil screening level guidance, inhalation of fugitive dust will be evaluated for construction workers as construction-related activities may generate high dust levels (USEPA, 2002f). Based on feedback received from the agencies on the draft risk assessment Work Plan (see Appendix C Summary of Response to Comments), the following process was used to select exposure factors for soil and dust ingestion rate that are consistent with the current science and regulatory guidance:

1. Apply adjustments for seasonality in time outdoors to the CTE, consistent with the approach used by NYSDEC (2006), but do not adjust for seasonality for the RME; and
2. Update both the CTE and RME to reflect current guidance from USEPA’s Exposure Factors Handbook (2017).

NYSDEC and NYSDOH (2006) provide an in-depth review of the basis for exposure factors used to calculate soil cleanup objectives (SCOs) protective of human health. The approach is intended to yield estimates of the CTE average daily dose from soil and dust ingestion for the following land use scenarios and age groups:

- Unrestricted, residential, and restricted residential (child and adult)
- Commercial (child visitor and adult worker)
- Industrial (adolescent trespasser and adult worker)

With the exception of a construction worker scenario, this NYSDEC guidance provides a framework for selecting CTE values that apply to each scenario that will be evaluated in the BHHRA. NYSDEC expresses values as time-weighted averages that account for two different concepts about exposure frequency: 1) days per year that outdoor soil exposure may occur in New York; and 2) days per week that an activity pattern that leads to contact with outdoor soil may occur. Appendix B Table B5 provides a detailed summary of NYSDEC's assumptions about these two aspects of exposure frequency for each scenario, the age-specific soil and dust ingestion rates these apply to, and the final time weighted average soil and dust ingestion rate. The footnotes of Appendix B Table B5 show the equations that NYSDEC used, which are described in the text of the guidance document, but not presented as equations.

The soil and dust ingestion rates selected by NYSDEC and NYSDOH (2006) are largely based on summaries from USEPA's 1997 Exposure Factors Handbook and 2002 Supplemental Soil Screening Guidance (USEPA, 1997a, 2002f). USEPA has twice updated the recommended CTE and RME values for soil and dust ingestion rate. See Appendix B Table B6 for a side-by-side presentation of both updates (USEPA, 2011, 2017a) along with the values selected by NYSDEC and NYSDOH (2006) for the CTE. The last columns in the table show the CTE and RME values selected for use in the BHHRA. In addition, Appendix B Table B7 shows how the time-weighted average soil and dust ingestion rates would change if NYSDEC and NYSDOH were to combine the same exposure frequency assumptions with similar updates to the CTE values.

7.3.4 Exposure Point Concentrations

EPCs estimate the intake levels of each of the COPCs for each potential receptor scenario in a given exposure unit. The calculation includes estimates of the EPC, the manner and frequency of exposure, and receptor-specific characteristics such as body weight, ingestion rate, etc. Combined, these factors result in the average daily dose potentially received by receptors. To provide some understanding of the range of exposures and consequent risks, scenarios based on both RME and CTE will be evaluated. The RME is defined as the highest exposure that reasonably could be expected to occur for a given exposure pathway at a site and is intended to account for both uncertainty in the chemical concentration and variability in the exposure parameters (such as exposure frequency or averaging time) (USEPA, 1989a). The CTE is typically based on average exposure parameters.

EPCs will be calculated for all COPCs that are retained through the screening process (see Appendix Tables B1.1 - B1.11) and will be presented in USEPA RAGS D "Table 3" format in the final BHHRA. An EPC will be calculated for each constituent for each of the EUs. Exploratory data analysis and statistics will be used to evaluate the distribution, frequency of detection, and potential outliers, for constituents in soil horizontally across the Primary Project Area, and also vertically across depth profiles for a given sample location. The BHHRA will include a one-page tabular and graphical summary of the properties of the dataset for each analyte/EU combination. These properties will guide the calculation of the EPC (including determination of soil depth data grouping and whether more than one EPC based on different depth intervals may be needed) and comparison of potential exposure concentrations to background soil conditions reported by

NYSDEC and NYSDOH (2006). USEPA guidance for calculating EPCs for groundwater will be followed (USEPA, 2014a).

The statistical methods used to calculate the EPC and characterize uncertainty in these estimates, including use of non-detect values, will be consistent with USEPA guidance (USEPA, 2014a, 2015c). For analytes with at least 8-10 observations, the EPC will be based on 95UCLs. The same EPC will be used for CTE and RME risk calculations (USEPA, 1992, 2006a, 2006c)

8.0 TOXICITY ASSESSMENT

The toxicity assessment summarizes the health effects that may potentially be associated with exposure to the COPCs selected for the BHHRA and identifies doses that may potentially be associated with those effects. The toxicity of COPCs to which persons may be exposed will be discussed in the baseline risk assessment. This section discusses the two general categories of toxic effects (non-carcinogenic and carcinogenic) that will be evaluated in the BHHRA and the toxicity criteria used to calculate potential risks. The toxicological criteria required for this BHHRA were selected to reflect the potential exposure and routes represented in the CSM.

8.1 Toxicity Data Hierarchy

Selection of toxicity values for the BHHRA is prescribed in various USEPA policies and guidance documents (USEPA, 2003b, 2009a, 2013). For non-PFAS COPCs, the toxicity criteria used for the BHHRA will generally be the same as used for the RBSLs in the screening level human health assessment described above. Some updates in toxicity criteria may be applicable; for example, conservative hexavalent chromium RBSLs were used to screen total chromium in all media based on regulator request (see comment GC-14 in Appendix C). As described in Section 3.1, no historical processes or any component of the operational history suggests that hexavalent chromium was used on-site. If site-specific speciation data confirm the predominance of trivalent chromium, the toxicity information specific for trivalent chromium will be considered in the risk characterization. Toxicity values for all COPC risk estimate calculations will be reviewed carefully and will be presented in USEPA RAGS D Tables 5 and 6 formats. If no appropriate toxicity value is available, the analyte will be carried into the uncertainty analysis and will be discussed qualitatively in the BHHRA.

The selection of toxicity values for PFAS COPCs in the BHHRA will adhere to the same USEPA policy and guidance. Per USEPA policy and guidance, toxicity values should be based on the most recent, credible, and relevant data and methods. As stated in the USEPA Risk Assessment Guidance for Superfund, Volume I, Human Health Evaluation Manual (Part A), and implemented in numerous USEPA directives, the selection of toxicity criteria is based on a hierarchy of sources and an evaluation of the toxicity values to ensure they are the best value (USEPA, 1989a, pp. 7–15, 2003b)

USEPA Integrated Risk Information System (IRIS) program assessments are typically considered the top-tiered choice (Tier 1) for toxicity values based on their use of standardized methods and rigorous external peer review. However, IRIS toxicity values are not always available or up to date for all chemicals detected at a site. Tier 2 values are toxicity values developed under the USEPA Provisional Peer-Reviewed Toxicity Value (PPRTV) program by the Superfund Technical Support Center. PPRTVs are developed using the same standardized USEPA risk assessment methods as IRIS values. However, PPRTVs do not undergo the same level of peer review as IRIS values. Additionally, PPRTVs are often developed using a limited evaluation of chemical-specific information. The Tier 3 category of toxicity values includes any other USEPA (e.g., USEPA Office of Water) and non-USEPA sources of toxicity information, (e.g., Agency for Toxic Substances and Disease Registry, international values, state assessments, values within a peer reviewed publication), provided that the information is current, peer reviewed, publicly available and transparent, consistent with standard risk assessment methodology, and that the value was derived using the best available information (ECOS, 2007; USEPA, 1993b, 2003b, 2013).

Consistent with USEPA directives and guidance documents (ECOS, 2007; USEPA, 2003b, 2013), priority will be given to PFAS toxicity information that met criteria including:

- Use of established methodology consistent with best scientific information and practices used by USEPA.
- Transparency of the information and methods.
- Level of external and independent expert peer review.
- Finalized document (cannot still be in draft).

Since issuing their first peer review policy in 1993, USEPA has continually supported and valued the scientific peer review process for ensuring the quality of toxicological information (USEPA, 2015b). USEPA defines peer review as a documented critical review of a specific scientific or technical work product, conducted by qualified individuals (or organizations) who are independent of those who performed the work, but who are collectively equivalent in technical expertise. Peer review "evaluates the clarity of hypotheses, the validity of the research design, the quality of data collection procedures, the robustness of the methods employed, the appropriateness of the methods for the hypotheses being tested, the extent to which the conclusions follow from the analysis and the strengths and limitations of the overall product" (USOMB, 2004). Peer review is not the same as public comment or other stakeholder processes (USEPA, 2015b; USOMB, 2004). In accordance, toxicity value(s) for a given chemical that have not undergone appropriate peer review (USEPA, 2015b; USOMB, 2004) are not acceptable for use in a baseline risk assessment (ECOS, 2007; USEPA, 1989a, 2003b, 2013).

As of the writing of this BHHRA Work Plan, there are no Tier 1 toxicity values for PFAS. The following source of Tier 2 toxicity information is available for PFBS only:

- USEPA PPRTV for PFBS (USEPA, 2021a).

As of the writing of this BHHRA Work Plan, the following sources of Tier 3 toxicity information are available for the PFAS target analytes in this RI and meet all USEPA requirements for inclusion in human health risk calculations:

- USEPA 2016 Office of Water toxicity values for PFOA (cancer and noncancer) and PFOS (noncancer only) (USEPA, 2016b, 2016a).
- Agency for Toxic Substances and Disease Control and Registry intermediate minimal risk levels for PFHxS, PFOA, PFOS, PFNA (ATSDR, 2021)
- Luz et al. 2019 – Peer reviewed publication on PFHxA, followed USEPA methods and state-of-the-science information for risk assessment and PFAS.
- New Hampshire DES (2019) / Ali et al. 2019 – Peer-reviewed publication on PFHxS, also peer reviewed by the toxicology consultant hired by the state, followed USEPA methods and state-of-the-science information for risk assessment and PFAS (Ali et al., 2019; NHDES, 2019).
- Health Canada (2018a, 2018b) values for PFOA and PFOS were independently peer-reviewed and followed standard risk assessment methodologies and up-to-date scientific information (USEPA, 1989a).
- Michigan Department of Environmental, Great Lakes, and Energy (EGLE) – Michigan's toxicity values for PFBS, PFHxA, PFHxS, PFOA, and PFOS were derived in 2019 by their Science Advisory Workgroup, with support by staff within the Department of Health and Human Services (Dewitt et al., 2019). It is assumed, although not explicitly stated by the state, that the acceptance of the recommendations by EGLE constitutes an independent expert peer review by EGLE staff. Although the level of independent peer review is not clear, the use of an independent science advisory group that largely reviewed and selected from various components of PFAS toxicity assessments derived by others, the

recency of these values, and the transparency of the derivation process, were considered sufficient to use these toxicity values for the BHHRA.

As of the writing of this BHHRA Work Plan, we found several examples of available toxicity values for PFAS that do not meet the USEPA criteria for inclusion in a risk assessment due to either (1) lack of independent expert peer review, (2) not finalized (i.e., draft values), or (3) lack of transparent methodology such that adherence to USEPA standard procedures could not be evaluated.

The following sources of toxicity information are examples of PFAS toxicity criteria that do not meet the basic criteria for use in the BHHRA, per USEPA policy and guidance requiring independent external peer review:

- Minnesota Department of Health (MDH) – according to personal communication with a MDH toxicologist (H. Goeden, personal communication, July 9, 2020) the toxicity values derived by MDH undergo several rounds of internal review by MDH staff and management, but, do not undergo a formal external independent expert peer review process.
- Texas Commission on Environmental Quality (TCEQ) has toxicity values for several PFAS (TCEQ, 2016); however, the values are outdated (first derived in 2011 and updated only for uncertainty factors in 2016), were not derived based on today's best available science for PFAS, and were not peer reviewed. DoD has officially stated that TCEQ's PFAS toxicity values do not qualify as "to be considered" for remediation programs (US DoD, 2020).
- New Jersey Drinking Water Quality Institute/Department of Environmental Protection: PFOA, PFOS, PFNA (NJDWQI, 2015, 2017, 2018), do not undergo external peer review.
- Massachusetts Department of Environmental Protection: PFOA, PFOS (MADEP, 2019), do not undergo external peer review.
- California Office of Environmental Health and Hazard Assessment: PFOA, PFOS (CAOEHHA, 2019), do not undergo external peer review.
- Germany Bund/Länder-Arbeitsgemeinschaft Wasser (Working Group on Water Issues): perfluorobutanoic acid (PFBA), PFBS, PFHxS, PFOA, PFOS, PFNA (von der Trenck et al., 2018), methodology is not transparent and cannot be evaluated for consistency with standard EPA chemical assessment methods, level of peer review on the derived numbers is unknown.
- France Agency for Food, Environmental and Occupational Health & Safety: PFBA, PFBS, PFHxS (ANSES, 2017), level of peer review is unknown.

It should be noted that the NYS Department of Health has recently adopted state MCLs for PFOA and PFOS at 10 ng/L each and NYSDEC issued groundwater and soil screening criteria for PFAS (NYSDEC, 2021). However, supporting technical documentation for the MCLs and screening levels is incomplete. The NYS Drinking Water Quality Council recommended the MCLs; however, neither the Council nor NYSDOH has published the toxicity values used in the calculation of the MCLs or environmental screening levels. Furthermore, there does not appear to have been an expert independent peer-review of the underlying toxicity value derivation. The MCLs are identified as pending ARARs; however, under USEPA guidance, they do not qualify for calculating potential current or future risks to human health.

If no toxicity value is available for a PFAS, the analyte will be carried into the uncertainty analysis and will be discussed qualitatively in the BHHRA.

Note that toxicity information and regulatory decisions related to PFAS are often rapidly evolving. Prior to conducting the final risk calculations, GSI will determine if additional appropriate toxicity criteria have become available for any PFAS COPCs and will finalize the toxicity criteria based on the most current available information. All available PFAS toxicity criteria and rationale for selection or exclusions will be presented in a detailed table in the final BHHRA. The variability between and uncertainty within the selection of toxicity values for PFAS will be further explored and described for the PFAS COPCs in the BHHRA risk characterization and uncertainty sections.

8.2 Toxicity Values for Carcinogenic Health Effects

For chemicals assumed to have the potential to increase the risk of cancer, toxicological criteria for oral and dermal exposures are termed cancer slope factors (CSF) and criteria for inhalation exposures are termed inhalation unit risks (IUR). These criteria are developed from laboratory animal studies or epidemiological studies in which either tumors or precursors to tumors were observed. The resulting CSFs or IURs are upper-bound estimates of the carcinogenic potency of the chemicals and are used to estimate the incremental risk of development of cancer, corresponding to a lifetime of exposure at the levels estimated in the exposure assessment.

Some carcinogenic chemicals operate through a mutagenic mode of action, for which USEPA assumes that early-life exposures to these mutagenic chemicals may result in higher carcinogenic risks compared to exposures that occur later in life (USEPA, 2005a). USEPA recommends that an ADAF be considered when risks to mutagenic chemicals is characterized (USEPA, 2005b). To account for the COPCs that are considered carcinogenic by mutagenic mode of action, age-adjusted exposure parameters used for the age groupings, per USEPA guidance, will be provided. In the case of vinyl chloride, the USEPA does not recommend the use of default ADAFs. As explained in the vinyl chloride toxicity profile in the USEPA's Integrated Risk Information System (IRIS) database, they recommend that the potential for added risk from early-life exposure to vinyl chloride be accounted for by applying an uncertainty factor of two in the quantitative cancer risk estimates (USEPA, 2000b).

Carcinogenic PAHs

Several potentially carcinogenic polycyclic aromatic hydrocarbons (PAHs) were identified as preliminary COPCs for the site. Benzo(a)pyrene (BaP) is the most studied of the PAHs and is classified as "carcinogenic to humans" by the USEPA (2017c); however, the carcinogenicity of other PAHs is presumed (USEPA, 2010b). As was done in the initial screening step, carcinogenic PAHs will be evaluated for toxicity based on their relative potency factors, relative to BaP (USEPA, 1993a). It will be assumed that all carcinogenic PAHs operate through a mutagenic mode of action, and therefore, age-dependent adjustment factors will also be applied.

Final CSFs and IURs that are selected for COPCs will be presented in the BHHRA in USEPA RAGS D "Table 6.1, 6.2 and 6.3" format.

8.3 Toxicity Values for Non-Carcinogenic Health Effects

For chemicals that are assumed to have the potential to increase the risk of noncancer health effects, toxicological criteria for oral and dermal exposures are often referred to as RfDs and criteria for inhalation exposures are often called RfCs. USEPA defined the chronic RfD or RfC as a daily exposure level for the human population, including sensitive subpopulations, that is reasonably expected not to present an appreciable risk of deleterious effects during a lifetime (USEPA, 1989a). The RfD or RfC is typically calculated from laboratory animal studies or epidemiology studies. The highest concentration or dose that does not cause an observable adverse effect or a modeled effect level (e.g., benchmark dose level) is identified or calculated. Uncertainty and modifying factors that account for uncertainties in the toxicity data, differences in responses among animal species and humans, and variations in inter-individual sensitivity within the human populations are then applied. These factors provide a margin of safety to ensure that exposures resulting in actual doses less than or equal to the RfD or RfC are unlikely to result in adverse effects to exposed populations.

While dermal-specific toxicological criteria are available for some chemicals, there are no dermal-specific toxicological criteria available for the COPCs selected for the BHHRA. Thus, the oral criteria were used to evaluate toxicity for both the oral and dermal routes of exposure, with appropriate adjustments for absorption efficiency by the dermal route, as outlined in USEPA (1989a, 2004d) guidance.

Noncancer RfDs and RfCs may differ depending on the length of human exposure. Subchronic exposures are defined as lasting for at least 2 weeks but less than 7 years, and chronic exposures are defined as lasting 7 years or more (USEPA, 2020e). The exposure scenario for construction workers, for whom exposure is assumed to last 1 year, is the only exposure scenario that will be evaluated in the BHHRA for which chronic exposure assumptions are not used.

Lead

Lead is a COPC only for future residential risk on- and off-site and for residential use of groundwater. Risk related to lead exposure in these residential use scenarios will be evaluated using the Integrated Exposure Uptake Biokinetic Model (IEUBK) (USEPA, 1994a, 1994b). The IEUBK uses information on lead biokinetics and contact rates of children with contaminated media to predict expected blood (PbB) lead concentrations for a hypothetical exposed child or population of children (USEPA, 1994a, 1994b; USEPA et al., 2017). It is designed to model exposure from lead in air, water, soil, dust, diet, paint, and other sources for children aged 6 months to 7 years old, and environmental exposure parameters in the model can be customized using site-specific data (USEPA, 1994a).

Exposure to lead via soils for current and future non-residential scenarios (i.e., construction worker) will be evaluated using the Adult Lead Model (ALM) (USEPA, 2001d, 2003a). The ALM is an exposure model that estimates the probability distribution of blood lead concentrations of adults who may be exposed to site soil and dust in addition to non-site sources (i.e., baseline exposures). The model assumes an exposure duration that is long enough for the receptor to achieve a steady-state blood lead concentration, typically 90 days or more. Exposure factors are selected to be representative of a hypothetical female worker of child-bearing age, and the risk metrics are intended to be protective of a fetus (USEPA, 2003a). The model calculates a 95th percentile blood lead concentrations for the receptor as well as the percentile corresponding to a target blood lead concentration (USEPA, 2001d). To inform a quantitative uncertainty analysis for the BHHRA, target blood lead concentrations of 5 and 10 micrograms per deciliter (µg/dL) will also be calculated for each exposure scenario.

Final noncancer toxicity data selected for all COPCs will be presented in the BHHRA in USEPA RAGS D "Tables 5.1, 5.2, and 5.3" format.

9.0 RISK CHARACTERIZATION AND UNCERTAINTY ASSESSMENT

Risk characterization combines estimates of exposure (dose) with toxicity criteria to provide an assessment of the potential cancer risk and noncancer hazards for the scenarios quantified in the BHHRA. Risk characterization will convey the nature of potential risks present at the Primary Project Area in quantitative and qualitative terms, and will evaluate uncertainties and variability in the findings (USEPA, 1989a, 2007, 2018b).

9.1 Cancer Risk Calculation

Total cancer risk is the increased probability that someone may experience cancer during his or her lifetime, above the background cancer rate in the U.S. population, as a result of hypothetical exposure to COPCs associated with the site under the conservative exposure assumptions utilized in the assessment. The excess incremental lifetime cancer risk (ELCR) associated with exposure to a COPC is calculated as the product of the estimated lifetime average daily exposure (i.e., lifetime average daily dose) and the CSF. The following equation and parameters, adapted from RAGS Part A (USEPA, 1989a) and RAGS Part E (USEPA, 2004d), are used to evaluate the ELCR for each COPC and each exposure pathway:

$$ELCR = ADD \times CSF$$

Where:

ELCR = excess lifetime cancer risk (unitless)
ADD = lifetime average daily dose via the specified exposure route, cancer (mg/kg-day)
CSF = cancer slope factor $(\text{mg/kg-day})^{-1}$

For inhalation exposures, the ECLR is calculated using the following equation adapted from RAGS Part F (USEPA, 2009a):

$$ELCR = EC_{air} \times IUR$$

Where:

ELCR = excess lifetime cancer risk (unitless)
EC_{air} = exposure concentration in air ($\mu g/m^3$)
IUR = inhalation unit risk [$(\mu g/m^3)^{-1}$]

As a matter of policy, the USEPA considers the carcinogenic risk of simultaneous exposure to low doses of different carcinogens to be additive, regardless of the chemicals' mechanism of carcinogenicity or target organ sites (USEPA, 1989a). To estimate the total incremental cancer risk for each receptor exposure scenario, the COPC-specific ELCRs are first summed across all relevant exposure pathways and then across COPCs.

9.2 Noncancer Risk Calculation

Noncancer health risks are termed hazards. For the evaluation of hazards, the ratio of the exposure term (i.e., average daily dose) to the corresponding RfD is used. The hazard quotient (HQ) is calculated for each COPC and each exposure pathway using the following equation and parameters, adapted from RAGS Part A (USEPA, 1989a) and RAGS Part E (USEPA, 2004d):

$$HQ = \frac{ADD}{RfD}$$

Where:

HQ = hazard quotient (unitless)
ADD = average daily dose via the specified exposure route, noncancer (mg/kg-day)
RfD = reference dose (mg/kg-day)

For inhalation exposures, the noncancer HQ is calculated using the following equation adapted from RAGS Part F (USEPA, 2009a):

$$HQ = \frac{EC_{air}}{RfC}$$

Where:

HQ = hazard quotient (unitless)
EC_{air} = exposure concentration in air (µg/m^3)
RfC = reference concentration (µg/m^3)

To evaluate the effects of exposure via multiple exposure pathways for a receptor, the exposure pathway-specific HQs are summed for each COPC to determine a noncancer hazard index (HI) using the following equation:

$$HI = HQ_1 + HQ_2 + \cdots + HQ_i$$

Where:

HI = hazard index (unitless)
HQ_i = hazard quotient for specified exposure route (unitless)

Once HQs for individual COPCs are summed for a receptor to derive a COPC-specific HI, receptor-specific noncancer hazards can be estimated for multiple COPCs. COPC-specific HIs are summed across COPCs to derive a total HI. However, in order to avoid overstating risk, consideration must be given to the basis of each COPC's RfD. If the COPCs affect different target organs or have different health effects, they are not expected to be additive. In accordance with USEPA guidance (USEPA, 1989a), if the total HI for a receptor exceeds the target hazard for all COPCs combined, separate effect-specific HIs are estimated for groups of COPCs that affect the same target organ or have the same health endpoint.

HQ or HI values below or equal to 1 will be interpreted to mean that adverse noncancer effects are unlikely. HQ or HI values greater than 1 are interpreted to mean that there is a chance of adverse noncancer effects and closer evaluation of conservatism in the risk characterization may be necessary to better derive a predictive hazard estimate.

Noncancer (HQ/HI) and cancer (ELCR) estimates for each receptor, medium and COPC (including sums across exposure routes), and for cumulative exposure to PFAS with similar target organs/modes of action or cancer risk, will be compiled in tables (USEPA RAGS D "Table 7.1 and 7.2, Table 9.1 and 9.2, and Table 10.1 and 10.2, and in custom summary tables), presented to two significant figures in order to facilitate review and reproduction of calculations; however, consistent with USEPA guidance (see USEPA 1989a at page 8-7 footnote b of Exhibit 8-2 and page 8-9 in footnote a of Exhibit 8-4; and (USEPA, 2004b) at Section 3.3.4 *With What Precision Should EPA Results be Reported*?), final risk estimates will be interpreted to a precision of one significant figure. Accordingly, HQ/HI calculations less than or equal to 1.49 round to HQ ≤ 1 (interpreted as adverse effects are unlikely) while values greater than or equal to 1.50 round to HQ ≥ 2 (interpreted as a potential for adverse effects).

9.3 Additional Evaluation of Contaminants of Concern (COCs)

9.3.1 Consideration of Site-specific PFAS Risk-Based Screening Levels for Off-Site Residential Soil within the Residential Irrigated Soil Area

Site-specific RBSLs will be developed for selected PFAS using site-specific soil-to-biota uptake factors, PFAS chronic toxicity values for noncancer effects discussed in Section 8.1, and a target hazard quotient (THQ) of 0.1. The main goal of this data evaluation is to characterize risks to current and future residents who may contact soil impacted with PFAS via the historic use of residential tap water for back yard irrigation. Additional details regarding the development and application of site-specific RBSLs for soil are provided in Section 7.1.1.

9.3.2 Consideration of Regional Background and Frequency of Detection

The final list of contaminants of concern (COCs) will be further evaluated in the final phase of the BHHRA risk characterization to help guide the interpretation of potential site-related risks and focus risk management on the subset of COCs that may contribute to the highest site-related risks. The goal of the refinement step is to identify the primary COCs that are most likely site-related and risk drivers and should be the primary targets for risk management.

The evaluation process will closely follow USEPA risk assessment guidance for COPC assessment, including consideration of the following additional lines of evidence:

- Background concentrations.
- Frequency, magnitude, and pattern of detected chemicals.
- Mode of toxicity (including mutagenicity) and potential for bioaccumulation.
- Multiple contaminant (mixtures) effects.
- Exposure considerations.

The lines of evidence will be considered in the context of site-specific information obtained during the RI investigation and other regional efforts.

As described above, a COC may have been considered a *secondary* COPC in the quantitative risk assessment if (1) it is detected infrequently in one or more environmental media; (2) it is not detected at high concentrations; AND (3) there is no reason to believe that the chemical may be present due to site-related history. Toxicity information, chemical-specific ARARs, background concentrations in soil, SQLs and FOD and the potential for localized areas of elevated concentrations will be evaluated and discussed.

Consistent with USEPA's guidance for using background levels for constituents in soil at CERCLA sites, calculated total risks will be presented as risk that is clearly site-related versus non-site-related based on considerations of FOD and NYSDEC background values, to help inform site managers and future decisions (USEPA, 2002b, 2002c). Inorganic constituents detected at concentrations lower than New York soil background levels may also be considered secondary

COCs in the their potential contribution to site concentrations and risk will be distinguished (USEPA, 1989a, 2002b, 2015a, 2018b). As shown in Appendix B Tables B1.1 - B1.11, background human health rural soil background concentration (RSBC) values for soil were identified from "near source" and "source distant" soil background data from the NYSDEC Development of Soil Cleanup Objectives (SCO) Technical Support Document (NYSDEC & NYSDOH, 2006). To determine which NYSDEC background value is appropriate for comparison, each EU will be mapped relative to potential pollution sources (identified by NYSDEC as "trash, roads, driveways or structures" (NYSDEC & NYSDOH, 2006). 'Source-distant' values from Table 6a will be used to assess samples obtained from areas considered to be reasonable points of human contact with soil, such as yards and trails (but at least 15 feet away from potential pollution sources), and 'near source' soil samples collected near roadways and/or driveways will be compared to Table 6c.

9.3.3 Evaluation of Potential Vapor Intrusion Risks

For VOC and SVOC COPCs with an identified potential vapor intrusion risk, additional evaluation will also be carried out to fully characterize risk (NYSDOH, 2006, 2017a; USEPA, 2002d, 2015a). Primary and secondary VOC/SVOC COPCs in groundwater will be evaluated to determine where in the water table they are located. Groundwater sampling depth (monitoring wells screened intervals) will be evaluated. Only COPCs that exceed groundwater VISLs located at the highest screened intervals will be retained. Additionally, residential VISLs for indoor air and paired soil slab detections were used in the COPC identification steps, despite sample locations occurring in a large occupational building and warehouses. Primary and secondary VOC/SVOC COPCs will be evaluated for current worker conditions using occupational VISLs. Data gaps in the potential risk (e.g., VISLs) and exposure point concentrations (limitations in analytical data) will be identified and evaluated. Compounds without VISLs but with Henry's Law constants above 1E-05 atm m^3/mol or vapor pressure > 1 mm Hg will be identified. The potential for confounding sources will be evaluated by looking for inconsistencies along a defined fate and transport pathway, such as a ND in subslab soil gas and exceedance in indoor air within the same building for the same SVOC/VOC.

9.3.4 Refinement to BHHRA with Probabilistic Methods

With probabilistic risk assessment (PRA) approaches such as Monte Carlo Analysis, the same dose and risk equations are applied, but one or more of the exposure factors, and/or the toxicity value can be expressed as probability distributions rather than point estimates. USEPA guidance on PRA (USEPA, 2001e, 2010a, 2014b) includes the following key steps:

- Identify exposure factors for which data support the development of probability distributions that characterize uncertainty or variability in exposure;
- Identify toxicity studies for which dose-response data are available to describe a dose-response curve; and
- Combine the exposure and dose-response information using Monte Carlo random sampling methods.

Because PRA has been available and used for more than two decades, many risk assessors and risk managers are familiar with the general concepts, and several continue to provide leadership on the development and application of probabilistic modeling tools. Table 7 provides examples of risk assessments that have incorporated PRA to inform risk management decisions, many of which were authored by (or on behalf of) a regulatory agency rather than a responsible party (e.g., ARCADIS, 2014; Berry's Creek Study Area Cooperating PRP Group, 2017; California DTSC, 2011; Goodrum et al., 1996; Griffin et al., 1999; Integral Consulting Inc, 2013; Maddaloni et al., 2005; Oregon DEQ, 2015; Simpson et al., 2016; Tittabawassee and Saginaw River Team, 2020; USEPA, 2001a, 2004a, 2016c, 2017b, 2020a; USEPA et al., 2002; Wisconsin DNR & USEPA, 2002a, 2002b). These examples span nearly every USEPA region.

PRA tends to be most informative when the primary COPCs have low risk-based screening levels relative to the concentrations that can be detected in the environment. Historically, this has included sites where risk management decisions have focused on addressing dioxin, PCBs, methyl mercury, lead, arsenic, and radionuclides. Today, we can include PFAS to this list given that advisory levels and criteria under development are approaching similarly low (*e.g.,* parts per trillion) levels. In these cases, risk management decisions can be informed by using PRA to provide one or both of the following:

- A quantitative estimate of the distribution of risks, from which the findings of a risk assessment can include statements regarding the likelihood and magnitude of exceeding various risk thresholds; and
- A sensitivity analysis, which provides an improved understanding of the subset of exposure and toxicity variables that have the greatest effect on variability and uncertainty in risk estimates.

If point estimates of RME risks are within an order of magnitude (above or below) decision thresholds for cancer or noncancer risk in the BHHRA, a PRA will be considered as a means of refining the risk estimates. A supplemental PRA Work Plan will be prepared for review by NYSDEC and USEPA if this approach is determined to be useful for addressing uncertainty in the risk characterization. The PRA Work Plan will outline the goals, COPCs, basis for probability distributions, and key elements of the proposed PRA risk characterization methodology.

9.4 Methods for Uncertainty Analysis

9.4.1 Qualitative Uncertainty Assessments

The process of evaluating human health cancer risk and noncancer health hazards involves multiple steps, each with inherent uncertainties. Evaluation of multiple sources of toxicity information ensures that the risk information used for each chemical is the best available information. Uncertainties may exist, for example, in the environmental chemistry sampling and analysis used to conduct the risk assessment, the exposure parameters and assumptions, the toxicological information used, and the quantitative risk characterization.

Each of the main sources of uncertainty will be evaluated in the final qualitative uncertainty analysis of the BHHRA. The following are examples of topics that may be particularly relevant for this BHHRA:

- Application of toxicity information from a surrogate chemical for an analyte that is missing a toxicity value or for which the study data supporting the toxicity value are outdated.

- Potential for over-or underestimation of cancer risks using PCB Aroclor data rather than PCB congener analysis, particularly for the fish consumption pathway.

- Representativeness of hypothetical receptors and potential exposure pathways.

- Quantification of dermal exposure and risk, particularly as most of the COPCs do not have scientifically established dermal absorption values or explicit dermal toxicity values.

- Statistical power, given the sample size and sample variance.
- Spatial coverage and extrapolation to unsampled exposure units within the Primary Project Area and the RISA.
- Analytical chemistry data qualifiers.
- Frequency of detection and MDLs or SQLs relative to RBSLs, and calculation of EPCs with low frequency of detection (e.g., < 25%).
- Analytical precision of QA/QC samples (e.g., field duplicates), based on the relative percent difference (RPD) of paired parent and duplicate samples.
- Exposure parameters used to represent the RME, particularly for parameters estimated from site-specific data (e.g., bioaccumulation factors).
- Variability in model-based estimates of bioaccumulation in foods (e.g., backyard fruit and vegetables and home-raised chicken and eggs).
- Relationship between concentrations in fish whole body and fillet tissue samples across fish species.
- Use of multipliers to estimate ingestion rates for children from ingestion rates for adults.

9.4.2 Methods for the Quantitative Evaluation of Uncertainty

Uncertainties are inherent in the BHHRA process and cannot be eliminated; however, the magnitude and impact of some uncertainties can be estimated by using upper and lower bound point estimates and/or by the use of probabilistic methods (described above). The BHHRA will first evaluate the range and potential impact of uncertainties related to the choice of toxicity criteria and the calculation of exposure parameters using available alternative point estimates. If the alternative risk characterizations result in calculated risks that change the outcome (*i.e.,* change a determination of “potential risk” to “no risk” or vice versa), refined site-specific data and use of probabilistic methods may be necessary to more accurately predict human health risk.

Use of Alternative PFAS Toxicity Criteria

Evaluation of multiple sources of toxicity information ensures that the risk information used for each chemical is the best available information. For PFAS, importantly, there are currently (and will likely be still in the near future) a range of alternative toxicity criteria developed by authoritative agencies. Although the toxicity criteria may not be considered appropriate for use in a BHHRA per USEPA policies and guidance, it may be informative for the BHHRA to present alternative risk calculations based on a range of available PFAS toxicity information.

Use of Alternative Exposure Parameter Values and Exposure Point Concentrations

As described in Section 4.2, field duplicate results will be used in the baseline risk assessment to inform estimates of measurement error associated with sample collection and handling in the field, as well as sample handling, processing and analysis at the analytical laboratory. For samples with one or more duplicate results, a single result will be selected at random for use in calculations in the risk assessment. However, the Quantitative Uncertainty Assessment will present an RPD analysis and will demonstrate the quantitative impact on risk characterization determinations based on different data processing steps.

USEPA indicates that use of default exposure parameters may result in an overestimate of risk and use of site-specific exposure information, when available, is preferred. Therefore, the incorporation of site-specific exposure information will be evaluated in the uncertainty analysis, when available, to reduce the uncertainty in the risk characterization for the site. The BHHRA will utilize exposure frequency and duration estimates that are consistent with New York State Brownfield Cleanup Program Development of Soil Cleanup Objectives, Technical Support Document (NYSDEC & NYSDOH, 2006), which includes consideration of soil and surface water contact only during the warmer months of the year (for 217 days from early April through early November). For example, NYSDEC recommends an average soil ingestion rate of 74 mg/day for children and 17 mg/day for adults for residential scenarios, 9 mg/day for children and 17 mg/day for adults in commercial land use scenarios, and 8.5 mg/day for adolescents and 8.5 mg/day for adults in industrial land use scenarios. The BHHRA uncertainty analysis will present the potential risk characterization based on both default and site-specific parameter values to demonstrate the range of potential risk estimates and help provide additional quantitative information to risk managers.

10.0 PROJECT ORGANIZATION AND SCHEDULE

Once the analysis of the baseline human health risk assessment for the McCaffrey Street Site is complete, a draft report will be prepared for the USEPA and NYSDEC review. The report will be comprised of the following major subsections:

Introduction

Summary of Site Characterization

COPC Discussion

Toxicity Assessment

Exposure Assessment

Risk Characterization

Summary and Conclusions

10.1 Schedule

The following is the anticipated schedule for the BHHRA:

- 12 February 2021 – Submission of revised BERA and BHHRA Work Plans
- 19 February 2021 – Submission of draft Biota Sampling and Analysis Plan
- 11 June 2021 – Submission of revised BHHRA and BERA Work Plans
- Summer/Fall 2021 – Field program to collect additional site-specific samples of surface water, sediment, soil, aquatic invertebrates and plants, fish, terrestrial invertebrates and plants, and small mammals
- Fall/Winter 2021 – Data validation and use in BHHRA and BERA
- Fall/Winter 2021 – Submission of supplemental Work Plan for Probabilistic Risk Assessment (optional)
- Winter 2021/2022 – Submission of draft BHHRA and BERA for agency review as part of the draft RI Report

The schedule for completion of the BHHRA and BERA depends on the extent of comments received from USEPA and NYSDEC on both the risk assessment work plans and the Biota SAP.

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WORK PLAN FOR BASELINE HUMAN HEALTH RISK ASSESSMENT

McCAFFREY STREET SITE
(Site No. 442046, USEPA ID# NYD004986741)

EXHIBITS

Exhibit 1:	Photographs of Hoosic River Greenway
Exhibit 2:	Photographs Illustrative of Project Area Habitat
Exhibit 3:	Photographs Illustrative of Hoosic River

EXHIBIT 1

Photographs of Hoosic River Greenway

Looking North and South adjacent to tax parcel property

GSI Job No.: 5316
Issued: 11 June 2021

EXHIBIT 2

Photographs Illustrative of Project Area Habitat

GSI Job No.: 5316
Issued: 11 June 2021

EXHIBIT 3

Photographs Illustrative of Hoosic River

WORK PLAN FOR BASELINE HUMAN HEALTH RISK ASSESSMENT

McCAFFREY STREET SITE
(Site No. 442046, USEPA ID# NYD004986741)

TABLES

TABLE 1
Key Regulatory Guidance on Human Health Risk Assessment

McCaffrey Street Site
14 McCaffrey Street, Village of Hoosick Falls, Rensselaer County, New York
NYSDEC Site # 442046

Federal (all authors are USEPA program offices)

Risk Assessment Guidance for Superfund (RAGS) Volume I (1989 – 2001)

- Part A: Human Health Evaluation Manual (1989)
- Part B: Development of Risk-based Preliminary Remediation Goals (Risk Equations and Parameters) (1991)
- Part C: Risk Evaluation of Remedial Alternatives (1991)
- Part D: Standardized Planning, Reporting, and Review of Superfund Risk Assessments (2001)
- Part E: Supplemental Guidance for Dermal Risk Assessment (2001 and 2007 update)
- Part F: Supplemental Guidance for Inhalation Risk Assessment (2009)

RAGS Volume III, Part A: Process for Conducting Probabilistic Risk Assessment (2001)

- Policy for Use of Probabilistic Analysis in Risk Assessment (1997)
- Use of Probabilistic Techniques (including Monte Carlo Analysis) in Risk Assessment (1997)
- Risk Assessment Forum White Paper: Probabilistic Risk Assessment Methods and Case Studies (2014)
- Probabilistic Risk Assessment to Inform Decision Making: Frequently Asked Questions (2014)

Data Quality Assessment and Exposure Assessment

- Supplemental Guidance to RAGS: Calculating the Concentration Term (1992)
- Final Soil Screening Guidance, May 17, 1996. Soil Screening User's Guide (1996)
- Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites (2002)
- Data Quality Assessment: Statistical Methods for Practitioners (EPA QA/G-9S) (2006)
- On the Computation of the 95% Upper Confidence Limit of the Unknown Population Mean Based Upon Data Sets with Below Detection Limit Observations (2006)
- Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities: Unified Guidance (2009)
- Child-Specific Exposure Factors Handbook (2008) and Highlights of the Child-Specific Exposure Factors Handbook (2009)
- Human Health Exposure Factors Handbook (2011 and updates)
- Determining Groundwater Exposure Point Concentrations (2014)
- ProUCL Version 5.1.002 Technical Guide (2015)
- Guidelines for Human Exposure Assessment (2019)

Risk Characterization

- Role of the Baseline Risk Assessment in Superfund Remedy Selection Decisions (1991)
- Use of IRIS (Integrated Risk Information System) Values in Superfund Risk Assessment (1993)
- Guidance for Risk Characterization (1995)
- Policy for Risk Characterization (1995)
- Policy on Evaluating Health Risks to Children (1995)
- Guidance on Cumulative Risk Assessment. Part 1. Planning and Scoping (1997)
- Risk Characterization Handbook (2000)
- OSWER Draft Guidance for Evaluation the Vapor Intrusion to Indoor Air Pathway from Groundwater to Soils (Subsurface Vapor Intrusion Guidance) (2002 and updates)
- Guidance for Comparing Background and Chemical Concentrations in Soil for CERCLA Sites (2002)
- Role of Background in the CERCLA Cleanup Program (2002)
- EPA Risk Assessment Principles and Practices (2004)
- Guidelines for Carcinogen Risk Assessment (2005)
- Performance of Statistical Tests for Site Versus Background Soil Comparisons When Distributional Assumptions are not Met (2007)

New York State

- NYSDEC. Technical Guidance for Screening Contaminated Sediments (1999)
- NYSDEC and NYSDOH. New York State Brownfield Cleanup Program, Development of Soil Cleanup Objectives – Technical Support Document (2006)
- NYSDOH. Guidance for Evaluating Soil Vapor Intrusion in the State of New York. New York State Department of Health (2006)
- NYSDEC. CP-51 Soil Cleanup Guidance (2010)
- NYSDEC. Guidelines for Sampling and Analysis of PFAS Under NYSDEC's Part 375 Remedial Programs (2020)

TABLE 2
Summary of Fresh Water Use Classifications based on 6 NYCRR § 701

McCaffrey Street Site
14 McCaffrey Street, Village of Hoosick Falls, Rensselaer County, New York
NYSDEC Site # 442046

	Human Use				**Aquatic Life**		**Hoosic River Classifications based on Table 1 of 6 NYCRR § 940.4**
Class (1, 2)	**Drinking (3, 4)**	**Food Preparation (5)**	**Recreation (6)**	**Fishing and Shellfishing**	**Propagation and Survival (7)**	**Survival (7, 8)**	**(9, 10)**
N	X	X	X	X	X	X	
AA-S	X	X	X	X	X	X	
A-S	X	X	X	X	X		
AA	X	X	X	X	X		
A	X	X	X	X	X		
B			X	X	X		
C			X*	X	X		River reach adjacent to Project Area
D			X*	X		X	Downriver classification changes (see footnote 8)

Abbreviations

6 NYCRR = New York Codes, Rules, and Regulations Title 6

Footnotes

(1) Class N is the same as Class AA-Special (AA-S), except that Class N includes a 200 ft buffer for inputs of substances that may contribute to eutrophication or toxicity.

(2) Class AA-Special (AA-S) is the same as Class A-S, except that Class AA-S has fewer nutrient loadings (e.g., sewage), industrial inputs, and alteration to flow that may impair uses.

(3) For Class AA Waters (6 NYCRR § 701.5(b)), water treatment to achieve drinking water standards may include "approved disinfection treatment, with additional treatment if necessary to remove naturally present impurities".

(4) For Class A Waters (6 NYCRR § 701.6(b)), water treatment to achieve drinking water standards may include, "coagulation, sedimentation, filtration and disinfection, with additional treatment if necessary to reduce naturally present impurities".

(5) 6 NYCRR § 701 refers to "culinary or food processing purposes".

(6) Primary and secondary contact recreation. Asterisk on Classes C (6 NYCRR § 701.8) and D (6 NYCRR § 701.9) indicate "other factors may limit the use for these purposes".

(7) Applies to fish, shellfish, and wildlife.

(8) Class D (6 NYCRR § 701.9) may not support fish propagation "due to such natural conditions as intermittency of flow, water conditions not conducive to propagation of game fishery, or stream bed conditions".

(9) Table 1, Water Index No. H-264 description for Project Area: "From south corporation line of the Village of Hoosick Falls to the highway bridge on Route NY 7, 0.75 mile southwest of the hamlet of Hoosick".

(10) Table 1, Water Index No. H-264 description for down river area: "From the highway bridge on Route NY 7 to the New York-Vermont State line, 250 feet north of highway bridge on Route NY 346".

NYSDEC. (2020a). *6 NYCRR Part 701 Classifications—Surface Waters and Groundwaters.* https://govt.westlaw.com/nycrr/Browse/Home/NewYork/NewYorkCodesRulesandRegulations?guid=I0682f230b5a111dda0a4e17826ebc834&transitionType=Default&contextData=%28sc.Default%29

TABLE 3
Analytes Considered Bioaccumulative by USEPA and/or NYSDEC

McCaffrey Street Site
14 McCaffrey Street, Village of Hoosick Falls, Rensselaer County, New York
NYSDEC Site # 442046

Chemical Class	CAS Number	Chemical	USEPA 2000 (1)	NYS DEC 2006 (2)
Metals	7440-38-2	Arsenic	X	
	7440-39-3	Barium		X
	7440-43-9	Cadmium	X	
	7440-47-3	Chromium*	X	X
	7440-50-8	Copper	X	X
	7439-92-1	Lead	X	
	7439-96-5	Manganese		X
	22967-92-6	Methylmercury	X	
	7440-02-0	Nickel	X	X
	7782-49-2	Selenium	X	X
	7440-22-4	Silver	X	
	56-35-9	Tributyltin (oxide)	X	
	7440-66-6	Zinc	X	X
PAHs	634-66-2	1,2,3,4-Tetrachlorobenzene	X	
	95-94-3	1,2,4,5-Tetrachlorobenzene	X	
	120-82-1	1,2,4-Trichlorobenzene (TCB)	X	
	95-50-1	1,2-Dichlorobenzene	X	
	541-73-1	1,3-Dichlorobenzene	X	
	106-46-7	1,4-Dichlorobenzene	X	
	83-32-9	Acenaphthene	X	
	208-96-8	Acenapthylene	X	
	120-12-7	Anthracene	X	
	56-55-3	Benzo(a)anthracene	X	
	50-32-8	Benzo(a)pyrene	X	X
	205-99-2	Benzo(b)fluoranthene	X	
	191-24-2	benzo(g,h,i)perylene	X	
	207-08-9	Benzo(k)fluoranthene	X	
	218-01-9	Chrysene	X	
	53-70-3	Dibenzo(a,h)anthracene	X	
	206-44-0	Fluoranthene	X	
	86-73-7	Fluorene	X	
	118-74-1	Hexachlorobenzene (HCB)	X	
	87-68-3	Hexachlorobutadiene	X	
	77-47-4	Hexachlorocyclopentadiene	X	
	67-72-1	Hexachloroethane	X	
	193-39-5	Indeno(1,2,3-c,d)pyrene	X	
	29082-74-4	Octachlorostyrene	X	
	608-93-5	Pentachlorobenzene	X	
	85-01-8	Phenanthrene	X	
	129-00-0	Pyrene	X	
	25322-20-7	Tetrachloroethane	X	
Pesticides	309-00-2	Aldrin	X	
	959-98-8	alpha-Endosulfan2	X	
	319-84-6	alpha-Hexachlorocyclohexane	X	

TABLE 3
Analytes Considered Bioaccumulative by USEPA and/or NYSDEC

McCaffrey Street Site
14 McCaffrey Street, Village of Hoosick Falls, Rensselaer County, New York
NYSDEC Site # 442046

Chemical Class	CAS Number	Chemical	USEPA 2000 (1)	NYS DEC 2006 (2)
Pesticides	33213-65-9	beta-Endosulfan	X	
	319-85-7	beta-Hexachlorocyclohexane	X	
	57-74-9	Chlordane	X	
	2921-88-2	Chlorpyrifos	X	
	319-86-8	delta-Hexachlorocyclohexane	X	
	333-41-5	Diazinon	X	
	115-32-2	Dicofol	X	
	60-57-1	Dieldrin	X	X
	298-04-4	Disulfoton	X	
	72-20-8	Endrin	X	
	55283-68-6	Ethalfluralin	X	
	563-12-2	Ethion	X	
	58-89-9	gamma-Hexachlorocyclohexane	X	
	1024-57-3	Heptachlor epoxide	X	
	76-44-8	Heptachlor	X	
	72-43-5	Methoxychlor	X	
	2385-85-5	Mirex	X	
	1836-75-5	Nitrofen	X	
	42874-03-3	Oxyfluorfen	X	
	72-54-8	4,4-DDD	X	
	72-55-9	4,4-DDE	X	
	50-29-3	4,4--DDT	X	X
	82-68-8	Pentachloronitrobenzene	X	
	52645-53-1	Permethrin	X	
	66230-04-4	S-fenvalerate	X	
	13071-79-9	Terbufos	X	
	8001-35-2	Toxaphene	X	
	1582-09-8	Trifluralin	X	
Phenols	87-86-5	Pentachlorophenol	X	X
	1825-21-4	Pentachloroanisole	X	
Semi-Volatiles	7005-72-3	4-Chlorophenyl phenyl ether	X	
	101-55-3	4-Bromophenyl phenyl ether	X	

* USEPA (2000) lists "Chromium VI" with the CASRN for Chromium; NYSDEC & NYSDOH (2006) provides a BAF for "Chromium" without specifying which compound.

Footnotes

(1) USEPA (2000a). *Bioaccumulation Testing and Interpretation for the Purpose of Sediment Quality Assessment; Status and Needs.* EPA-823-R-00-001. U.S. Environmental Protection Agency. February. Table 4-2.

(2) NYSDEC & NYSDOH (2006). *New York State Brownfield Cleanup Program Development of Soil Cleanup Objectives Technical Support Document.* New York State Department of Environmental Conservation and New York State Department of Health. September. Table 8.3-1 Uptake Factors for Calculation of Bioaccumulation Based ESCOs (marked analytes have BAF values for either plant or earthworm uptake).

TABLE 4.1
Examples of Published Literature on PFAS Uptake and Distribution (Translocation) in Fruits and Vegetables.

McCaffrey Street Site
14 McCaffrey Street, Village of Hoosick Falls, Rensselaer County, New York
NYSDEC Site # 442046

					Fruit		Vegetable			
Publication	**PFAS**	**PFAS Mixture**	**Plant Species**	**Type of Study**	**Exposed**	**Protected**	**Exposed**	**Protected**	**Root**	**ADME Variables**
Bao et al., 2019	**PFCA**: PFBA, PFPeA, PFHxA, PFHpA, PFOA, PFNA, PFDA **PFSA**: PFBS, PFHxS, PFOS	Y	tomato, cucumber, eggplant, pepper, chinese cabbage	Field	N	N	Y	Y	N	none
Bizkarguenaga et al., 2016a	8:2 diPAP	N	lettuce, carrot	Spiked soil	N	N	Y	N	Y	bioconcentration factor
Bizkarguenaga et al., 2016b	PFOA, PFOS, FOSA	N	lettuce, carrot	Spiked soil	N	N	Y	N	Y	bioconcentration factor
Blaine et al., 2013	**PFCA**: PFBA, PFPeA, PFHxA, PFHpA, PFOA, PFNA, PFDA **PFSA**: PFBS, PFHxS, PFHpS, PFOS, PFDS	Y	lettuce, tomato	Field	N	N	Y	N	N	bioaccumulation factor
Blaine et al., 2014	**PFCA**: PFBA, PFPeA, PFHxA, PFHpA, PFOA, PFNA, PFDA **PFSA**: PFBS, PFHxS, PFOS	Y	radish, celery, tomato, sugar snap pea	Spiked soil	N	N	Y	Y	Y	bioconcentration factors (roots, shoots)
Dalahmeh et al., 2018	**PFCA**: PFBA, PFPeA, PFHxA, PFHpA, PFOA, PFNA, PFDA, PFUnA, PFDoA, PFTrDA, PFTeDA, PFHxDA, PFOcDA **PFSA**: PFBS, PFHxS, PFOS, PFDS **Sulfonamide**: FOSA, MeFOSA, EtFOSA, MeFOSE, EtFOSE, MeFOSAA, EtFOSAA, FOSAA **Fluorotelomer**: 6:2FTSA	Y	yam root, maize cob, sugarcane	Field	N	N	N	Y	Y	bioconcentration factor
Eun et al., 2020	**PFCA**: PFBA, PFPeA, PFHxA, PFHpA, PFOA, PFNA, PFDA, PFUnA, PFDoA, PFTrDA, PFTeDA, PFHxDA, PFOcDA **PFSA**: PFPrS, PFBS, PFHxS, PFOS, PFDS **Sulfonamide**: FOSA, N-EtFOSA, N-EtFOSAA, N-MeFOSA, N-MeFOSAA **Fluorotelomer**: 8:2FTUCA	Y	tomato, cucumber, eggplant, green pepper, zucchini, green perilla, crown daisy, spinach, carrot, sweet potato, potato	Field	N	N	Y	N	Y	none
Gredelj et al., 2020	**PFCA**: PFBA, PFPeA, PFHxA, PFHpA, PFOA, PFNA, PFDA **PFSA**: PFBS, PFOS	Y	red chicory	Spiked soil	N	N	Y	N	N	bioconcentration factor (roots), transpiration stream concentration factor
Knight et al., 2021	PFOA, PFHxS, PFOS	Y	dwarf beans	Spiked soil	N	N	N	Y	N	bioconcentration factor
Krippner et al., 2015	**PFCA**: PFBA, PFPeA, PFHxA, PFHpA, PFOA, PFNA, PFDA **PFSA**: PFBS, PFHxS, PFOS	Y	maize	Spiked soil	N	N	N	Y	N	bioaccumulation factor
Lasee et al., 2019	**PFCA**: PFHpA, PFOA, PFNA **PFSA**: PFBS, PFHxS, PFOS	Y	radish, carrot, alfalfa	Spiked soil	N	N	Y	N	Y	bioconcentration factor
Lasee et al., 2021	**PFCA**: PFHpA, PFOA, PFNA **PFSA**: PFBS, PFHxS, PFOS	Y	radish, carrot, alfalfa, tomato	Spiked soil	N	N	Y	N	Y	bioconcentration factor
Lechner and Knapp, 2011	PFOA, PFOS	Y	carrot, potato, cucumber	Spiked soil	N	N	Y	N	Y	transfer factor
Lee et al., 2014	**PFCA**: PFBA, PFPeA, PFHxA, PFHpA, PFOA, PFNA, PFDA, PFUnA, PFDoA, PFTrDA, PFTeDA **Fluorotelomer**: 6:2 FTCA, 6:2 FTUCA, 5:3 FTCA, 5:3 FTUCA **Phosphate diester**: 6:2 diPAP	Y	pumpkins, alfalfa	Field	N	Y	N	N	N	bioaccumulation factor
Liu et al., 2017	**PFCA**: PFBA, PFPeA, PFHxA, PFHpA, PFOA, PFNA, PFDA, PFUnA, PFDoA **PFSA**: PFBS, PFHxS, PFOS	Y	wheat, maize	Field	N	N	N	Y	N	bioaccumulation factor
Liu et al., 2019	**PFCA**: PFBA, PFPeA, PFHxA, PFHpA, PFOA, PFNA, PFDA, PFUnA, PFDoA **PFSA**: PFBS, PFHxS, PFOS	Y	radish root, carrot root, radish shoot, carrot shoot, chinese cabbage, chinese chives, lettuce, welsh onion, pepper, cauliflower, wheat, corn, pumpkin, soybean, celery	Field	N	N	Y	Y	Y	bioaccumulation factor
Navarro et al., 2017	**PFCA**: PFBA, PFPeA, PFHxA, PFHpA, PFOA, PFNA, PFDA, PFUnA, PFDoA **PFSA**: PFBS, PFOS	Y	spinach, tomato, corn	Spiked soil	N	N	Y	Y	N	bioconcentration factor, translocation factor

TABLE 4.1
Examples of Published Literature on PFAS Uptake and Distribution (Translocation) in Fruits and Vegetables.

McCaffrey Street Site
14 McCaffrey Street, Village of Hoosick Falls, Rensselaer County, New York
NYSDEC Site # 442046

Publication	PFAS	PFAS Mixture	Plant Species	Type of Study	Fruit		Vegetable			ADME Variables
					Exposed	Protected	Exposed	Protected	Root	
Scher et al., 2018	**PFCA**: PFBA, PFPeA, PFHxA, PFOA **PFSA**: PFBS, PFHxS, PFOS	Y	apple, asparagus, beans, beets, blackberry, broccoli, brussel sprouts, cabbage, cantalope, carrot, celery, corn, cucumber, cauliflower, chive, carrot, corn, cucumber, eggplant, grape, herbs, horseradish, kale, kohlrabi, leafy greens, lettuce, leek, onions, peapod, peas, pepper, potato, rasberry, radish, rhubarb, strawberry, spinach, squash, tomato, swiss chard, watermelon	Field	N	N	Y	Y	Y	none
Sznajder-Katarzyńska et al., 2018	**PFCA**: PFBA, PFPeA, PFHxA, PFHpA, PFOA, PFNA, PFDA **PFSA**: PFBS, PFHxS, PFOS	Y	banana, apple, lemon, orange, cherry, strawberry, potato, beetroot, carrot, white cabbage, tomato	Field	Y	Y	Y	N	Y	bioaccumulation factor
Wen et al., 2018	N-EtFOSAA	N	alfalfa, lettuce, maize, mung bean, radish, ryegrass, soybean	Spiked soil	N	N	Y	Y	Y	bioconcentration factor (roots)
Xiang et al., 2018	PFOA	N	twenty lettuce cultivars (romaine lettuce, head lettuce, loose leaf lettuce)	Spiked soil	N	N	Y	N	N	bioconcentration factor
Yu et al., 2018	PFOS	N	twenty lettuce cultivars (romaine lettuce, head lettuce, leaf lettuce)	Spiked soil	N	N	N	Y	N	bioconcentration factor, translocation factor

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Abbreviations

ADME = absorption, distribution, metabolism, elimination; PFCA = perfluoroalkyl carboxylic acid, PFSA = perfluoralkyl sulfonic acid, PFBA = Perfluorobutanoic acid, PFPeA = Perfluoropentanoic acid, PFHxA = Perfluorohexanoic acid, PFHpA = Perfluoroheptanoic acid, PFOA = Perfluorooctanoic acid, PFNA = Perfluorononanoic acid, PFDA = Perfluorodecanoic acid, PFUnA = Perfluoroundecanoic acid, PFDoA = perfluorododecanoic acid, PFBS = Perfluorobutanesulfonic acid, PFPrS = perfluoropropane sulfonate, PFHxS = perfluorohexanesulfonic acid, PFHpS = Perfluoroheptanesulfonic acid, PFOS = Perfluorooctanesulfonic acid, PFDS = Perfluorodecane sulfonic acid, PFTrDA = Perfluorotridecanoic acid, PFTeDA = Perfluorotetradecanoic acid, PFHxDA = Perfluorohexadecanoic acid, PFOcDA = perfluorooctadecanoic acid, FOSA = Perfluorooctanesulfonamide, MeFOSA = N-methyl perfluorooctane sulfonamide, EtFOSA = N-ethyl perfluorooctane sulfonamide, MeFOSE =Methyl perfluorooctanesulfonamidoethanol, EtFOSE = N-ethyl perfluorooctane sulfonamidoethanol, MeFOSAA = Methylperfluorooctane sulfonamidoacetic acid, EtFOSAA = N-Ethyl perfluorooctanesulfonamido acetic acid, FOSAA = perfluorooctane sulfonamido acetic acid, N-EtFOSA = N-ethylperfluorooctane sulfonamide, N-EtFOSAA = N-ethyl perfluorooctane sulfonamido acetic acid, N-MeFOSA = N-Methylperfluorooctanesulfonamide, N-MeFOSAA = N-methyl perfluorooctane sulfonamido acetic acid, 6:2 FTSA = 6,2 fluorotelomer sulfonate, 6:2 diPAP = 6:2 fluorotelomer phosphate diester, 8:2 diPAP = 8:2 fluorotelomer phosphate diester, 6:2 FTCA = 6:2 fluorotelomer carboxylic acid, 6:2 FTUCA = 6:2 fluorotelomer unsaturated carboxylic acid, 8:2 FTUCA = 8:2 fluorotelomer unsaturated carboxylic acid, 5:3 FTCA = 5:3 fluorotelomer carboxylic acid, 5:3 FTUCA = fluorotelomer unsaturated carboxylic acid.

TABLE 4.2
Examples of Published Literature on PFAS Uptake and Distribution (Translocation) in Grasses.

McCaffrey Street Site
14 McCaffrey Street, Village of Hoosick Falls, Rensselaer County, New York
NYSDEC Site # 442046

Publication	PFAS	PFAS Mixture	Grass Species	Type of Study	ADME Variables
Bräunig et al., 2017	**PFCA**: PFBA, PFPeA, PFHxA, PFHpA, PFOA, PFNA, PFDA **PFSA**: PFBS, PFHxS, PFOS	Y	not specified	Field	none
Bräunig et al., 2019	**PFCA**: PFBA, PFPeA, PFHxA, PFHpA, PFOA, PFNA, PFDA, PFUnA, PFDoA **PFSA**: PFBS, PFHxS, PFOS	Y	wheat grass	Field	bioaccumulation factor
Stahl et al., 2009	PFOA, PFOS	Y	perennial ryegrass	Spiked soil	none
Wen et al., 2016	N-EtFOSAA	N	alfalfa, Italian ryegrass	Spiked soil	root concentration factor
Wen et al., 2016	PFOA, PFOS	N	alfalfa, Italian ryegrass	Spiked soil	root concentration factor, shoot concentration factor, translocation factor
Yoo et al., 2011	**PFCA**: PFHxA, PFHpA, PFOA, PFNA, PFDA, PFUnA, PFDoA, PFTrDA, PFTeDA **PFSA**: PFBS, PFHxS, PFOS	Y	tall fescue, barley, bermuda grass, kentucky bluegrass	Field	grass/soil accumulation factor, grass/organic-matter accumulation factor
Zhu et al., 2019	**PFCA**: PFHpA, PFOA, PFNA, PFDA, PFUnA, PFDoA	Y	sedge, Canada wildrye, sumac	Field	root concentration factor, leaf concentration factor, translocation factor

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Abbreviations

ADME = absorption, distribution, metabolism, elimination; PFBA = Perfluorobutanoic acid, PFCA = perfluoroalkyl carboxylic acid, PFPeA = Perfluoropentanoic acid, PFHxA = Perfluorohexanoic acid, PFHpA = Perfluoroheptanoic acid, PFOA = Perfluorooctanoic acid, PFNA = Perfluorononanoic acid, PFDA = Perfluorodecanoic acid, PFUnA = Perfluoroundecanoic acid, PFDoA = perfluorododecanoic acid, PFBS = Perfluorobutanesulfonic acid, PFHxS = perfluorohexanesulfonic acid, PFHpS = Perfluoroheptanesulfonic acid, PFOS = Perfluorooctanesulfonic acid, PFDS = Perfluorodecane sulfonic acid, PFSA = prefluoroalkyl sulfonic acid, PFTrDA = Perfluorotridecanoic acid, PFTeDA = Perfluorotetradecanoic acid, PFHxDA = Perfluorohexadecanoic acid, EtFOSAA = N-Ethyl perfluorooctanesulfonamido acetic acid, N-EtFOSAA = N-ethyl perfluorooctane sulfonamido acetic acid.

TABLE 4.3
Examples of Published Literature on PFAS Uptake and Distribution Chicken and Eggs.

McCaffrey Street Site
14 McCaffrey Street, Village of Hoosick Falls, Rensselaer County, New York
NYSDEC Site # 442046

Publication	PFAS	PFAS Mixture	Poultry Species	Tissue Samples	Egg Samples	Sample Types	ADME Variables
Bao et al., 2019	**PFCA**: PFBA, PFPeA, PFHxA, PFHpA, PFOA, PFNA, PFDA **PFSA**: PFBS, PFHxS, PFOS	Y	unspecified "domestic poultry"	N	Y	water and soil, whole egg, egg white, egg yolk	none
Cui et al., 2018	**PFCA**: PFOA **PFSA**: PFHxS, PFOS **Polyfluorinated ether**: 6:2 Cl-PFESA, 8:2 Cl-PFESA	Y	free range duck	Y	Y	water, muscle, egg	none
Göckener et al., 2020	**PFCA**: PFBA, PFPeA, PFHxA, PFHpA, PFOA, PFNA, PFDA, PFUnA, PFDoA, PFTrDA, PFTeDA **PFSA**: PFBS, PFHxS, PFHpS, PFOS, PFDS **Sulfonamide**: FOSA, FOSAA, MeFOSAA, EtFOSAA	Y	chicken	N	Y	chicken feed, egg albumen, egg yolk	none
Kowalczyk et al., 2020	**PFCA**: PFBA, PFPeA, PFHxA, PFHpA, PFOA, PFNA **PFSA**: PFBS, PFHxS, PFHpS, PFOS **Sulfonamide**: FOSA, FOSAA, MeFOSAA, EtFOSAA	Y	chicken (Lohmann Brown)	Y	Y	chicken feed, muscle, egg albumen, egg yolk	none
Kowalczyk, 2014	PFOA, PFOS	Y	chicken	N	Y	chicken feed, egg	feed-to-egg transfer factors
Senversa, 2018	PFOA, PFHxS, PFOS	Y	wild duck	Y	Y	muscle, egg	feed-to-muscle transfer factors[1]
Taniyasu et al., 2003	PFBS, PFHxS, PFOS	Y	domesticated duck	Y	N	water, muscle	none
Wilson et al., 2020	**PFCA**: PFHxA, PFOA **PFSA**: PFHxS, PFOS	Y	chicken (Hy-Line brown)	N	Y	egg albumen, egg yolk	egg transfer factor tissue half-life

Notes

1. Authors derived transfer factors from Kowalczyk (2014), and discussed transfer factors later published in Wilson et al. (2020).

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Bao, J., Yu, W. J., Liu, Y., Wang, X., Jin, Y. H., & Dong, G. H. (2019). Perfluoroalkyl substances in groundwater and home-produced vegetables and eggs around a fluorochemical industrial park in China. Ecotoxicology and environmental safety, 171, 199-205.

Cui, Q., Pan, Y., Zhang, H., Sheng, N., & Dai, J. (2018). Elevated concentrations of perfluorohexanesulfonate and other per-and polyfluoroalkyl substances in Baiyangdian Lake (China): Source characterization and exposure assessment. Environmental pollution, 241, 684-691.

Göckener, B., Eichhorn, M., Lämmer, R., Kotthoff, M., Kowalczyk, J., Numata, J., Schafft, H., Lahrssen-Wiederholt, M., & Bücking, M. (2020). Transfer of Per-and Polyfluoroalkyl Substances (PFAS) from Feed into the Eggs of Laying Hens. Part 1: Analytical Results Including a Modified Total Oxidizable Precursor Assay. Journal of agricultural and food chemistry, 68(45), 12527-12538.

Kowalczyk, J. (2014). Übergang von Perfluoroctansäure (PFOA) undPerfluoroctansulfonsäure (PFOS) aus kontaminierten Futtermitteln in ausgewählte Gewebe des Mastschweins und der Legehenne. In.: Dissertation vorgelegt von Janine Kowalczyk. Eingereicht an der Landwirtschaftlich-Gärtnerischen Fakultät der Humboldt-Universität zu Berlin zur Erlangung des akademischen Grades doctor rerum agriculturarum.

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Abbreviations

ADME = absorption, distribution, metabolism, elimination; PFBA = Perfluorobutanoic acid, PFPeA = Perfluoropentanoic acid, PFHxA = Perfluorohexanoic acid, PFHpA = Perfluoroheptanoic acid, PFOA = Perfluorooctanoic acid, PFNA = Perfluorononanoic acid, PFDA = Perfluorodecanoic acid, PFUnA = Perfluoroundecanoic acid, PFDoA = perfluorododecanoic acid, PFBS = Perfluorobutanesulfonic acid, PFHxS = perfluorohexanesulfonic acid, PFHpS = Perfluoroheptanesulfonic acid, PFOS = Perfluorooctanesulfonic acid, PFDS = Perfluorodecane sulfonic acid, PFTrDA = Perfluorotridecanoic acid, PFTeDA = Perfluorotetradecanoic acid, PFHxDA = Perfluorohexadecanoic acid, FOSA = Perfluorooctanesulfonamide, MeFOSA = N-methyl perfluorooctane sulfonamide, EtFOSA = N-ethyl perfluorooctane sulfonamide, MeFOSAA = Methylperfluorooctane sulfonamidoacetic acid, EtFOSAA = N-Ethyl perfluorooctanesulfonamido acetic acid, FOSAA = perfluorooctane sulfonamido acetic acid, 6:2 Cl-PFESA = 6:2 chlorinated polyfluorinated ether sulfonate, 8:2 Cl-PFESA = 8:2 chlorinated polyfluorinated ether sulfonate, PFCAs = perfluoroalkyl carboxylic acids.

TABLE 4.4
Comparison of BCF and BAF Estimates for Fish for PFAS

McCaffrey Street Site
14 McCaffrey Street, Village of Hoosick Falls, Rensselaer County, New York
NYSDEC Site # 442046

Chemical	CAS RN	Carbon Chain Length	# Perfluorinated Carbons	BCF (L/kg ww fish)				BAF (kg ww fish / kg ww diet)			Potentially Bioaccumulative? (Yes/No) (5, 6)
				EPA AQUATOX (1, 2)	Martin et al. 2003a (1)	SERDP 2019 (3)	Species (Tissue Type)	Martin et al. 2003b (4)	SERDP 2019 (3)	Species (Tissue Type)	
PFCAs											
PFBA	375-22-4	C4	3	0.0010	0.0010	0.60	zebrafish (muscle)	0.0066	**0.0066**	rainbow trout (carcass)	No
PFPeA	2706-90-3	C5	4	0.0086	0.0086	0.23	zebrafish (muscle)	0.011	**0.011**	rainbow trout (carcass)	No
PFHxA	307-24-4	C6	5	0.071	0.071	0.69	zebrafish (muscle)	0.019	**0.019**	rainbow trout (carcass)	No
PFHpA	375-85-9	C7	6	0.58	0.58	3.2	zebrafish (muscle)	0.031	**0.031**	rainbow trout (carcass)	No
PFOA	335-67-1	C8	7	4.8	4.8	4.0	rainbow trout (carcass)	0.053	0.038	rainbow trout (carcass)	No
PFNA	375-95-1	C9	8	39	39	**39**	rainbow trout (carcass)	0.089	0.23	rainbow trout (whole body)	No
PFDA	335-76-2	C10	9	322	322	450	rainbow trout (carcass)	0.15	0.23	rainbow trout (carcass)	No
PFUnA	2058-94-8	C11	10	2,642	2,642	2,700	rainbow trout (carcass)	0.25	0.28	rainbow trout (carcass)	Yes
PFDoDA	307-55-1	C12	11	21,707	21,707	18,000	rainbow trout (carcass)	0.42	0.43	rainbow trout (carcass)	Yes
PFTriA	72629-94-8	C13	12	21,707	177,828	21,627	zebrafish (whole)	0.71	**0.71**	rainbow trout (carcass)	Yes
PFSAs											
PFBS	375-73-5	C4	4	0.084	0.0085	1.0	zebrafish (muscle)	0.011	0.020	rainbow trout (whole body)	No
PFHxS	355-46-4	C6	6	9.7	0.58	9.6	rainbow trout (carcass)	0.031	0.14	rainbow trout (carcass)	No
PFHpS	375-92-8	C7	7	104	4.7	--	NA	0.05	--	NA	No
PFOS	1763-23-1	C8	8	1,109	39	1,100	rainbow trout (carcass)	0.09	0.32	rainbow trout (carcass)	Yes
PFDS	335-77-3	C10	10	127,350	2,630	**2,630**	rainbow trout (carcass)	0.25	**0.25**	rainbow trout (carcass)	Yes
FASAs											
PFOSA	754-91-6	C8	8	--	39	**39**	rainbow trout (carcass)	0.089	0.023	rainbow trout (muscle)	No
EtFASAAS and											
NEtFOSA	2991-50-6	C11	8	--	39	**39**	rainbow trout (carcass)	--	**0.089**	rainbow trout (carcass)	No
NMeFOSAA	2355-31-9	C12	8	--	39	**39**	rainbow trout (carcass)	--	**0.089**	rainbow trout (carcass)	No
6:2 FTS	27619-97-2	C8	6	--	--	--	NA	--	--	NA	--
8:2 FTS	39108-34-4	C10	8	--	--	--	NA	--	--	NA	--

Abbreviations

BAF = bioaccumulation factor
BCF = bioconcentration factor
BMF = biomagnification factor (includes diet)
L/kg = liters per kilogram
NA = not applicable
ww = wet weight
-- = no estimate available

Footnotes

(1) For PFCAs, the EPA AQUATOX model (USEPA 2018) implements the same equation as Martin et al. (2003a): BCF = 10^(-5.724+0.9146 x C), where C = number of perfluorinated carbons.
For PFSAs, Aquatox implements: BCF = 10^(-5.195+1.03 x C).

(2) With EPA AQUATOX the modelled BCF for compounds with perfluoroalkyl chain length> 11 is assumed to be the same as the BCF for chain length = 11.

(3) Bolded values are cases in which SERDP (2019) estimated values using equations from Martin et al. 2003a and 2003b. SERDP (2019) refers to BAF from Martin et al. (2003b) as a biomagnification factor (BMF).

(4) For PFCAs and PFSAs, Martin et al. (2003b) implements the following equation: BAF = 10^(-2.86 + 0.226 x C), where C = number of perfluorinated carbons.

(5) Yes = BCF >1000 or BAF > 1; No = BCF ≤1000 and BAF ≤ 1. Compounds that are potentially bioaccumulative in fish are outlined in bolded rectangle and include C10-C12 PFCAs and C8 and C10 PFSAs.

(6) Conclusions for PFOA and PFOS are consistent with BCF estimates in a white paper by Florida Department of Environmental Protection, which conducted a literature search in May 2019 and compiled study values focusing on muscle and fillet tissues. Values are based on ratios of water and tissue concentrations (although they use the term BAF). Geometric means are 68 L/kg ww for PFOA and 2,358 L/kg ww for PFOS.

Supporting References

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TABLE 5
Human Health Screening - Contaminants of Potential Concern

McCaffrey Street Site
14 McCaffrey Street, Village of Hoosick Falls, Rensselaer County, New York
NYSDEC Site # 442046

Chemical Class	CAS Number	Chemical	Mutagenic	Media					
				Surface Soil (1)	Subsurface Soil	Ground-water[a]	Sediment	Surface Water	Ambient Air
PFAS	375-22-4	Heptafluorobutanoic acid		2	2	1			
	2991-50-6	N-ethylperfluorooctanesulfonamidoacetic acid		2	2	2		2	
	2355-31-9	N-methylperfluorooctanesulfonamidoacetic acid		2	2	2		2	
	375-73-5	Perfluorobutanesulfonic acid				1			
	335-77-3	Perfluorodecane sulfonic acid		2	2	2			
	335-76-2	Perfluorodecanoic acid		2	2	1	2		
	307-55-1	Perfluorododecanoic acid		2	2	2	2		
	375-92-8	Perfluoroheptane sulfonate		2	2	2		2	
	375-85-9	Perfluoroheptanoic acid		2	2	1	2		
	355-46-4	Perfluorohexane sulfonic acid		2	2	1	2		
	307-24-4	Perfluorohexanoic acid		2	2	1	2		
	375-95-1	Perfluorononanoic acid		2	2	1	2		
	754-91-6	Perfluorooctane sulfonamide		2	2	1			
	1763-23-1	Perfluorooctanesulfonic acid		1	1	1	1		
	335-67-1	Perfluorooctanoic acid		1	1	1	1	1	
	2706-90-3	Perfluoropentanoic acid		2	2	1			
	376-06-7	Perfluorotetradecanoic acid		2	2	2	2		
	72629-94-8	Perfluorotridecanoic acid		2	2	2	2		
	2058-94-8	Perfluoroundecanoic acid		2	2	2	2		
	39108-34-4	Sodium 1H,1H,2H,2H-perfluordecane sulfonate (8:2)		2	2	2			
	27619-97-2	Sodium 1h,1h,2h,2h-perfluorooctane sulfonate (6:2)		2	2	2			
		Total PFAS				1		1	
Metals	7429-90-5	Aluminum		1	1	2		1	
	7440-36-0	Antimony			1	1		2	
	7440-38-2	Arsenic		1	1	1		1	
	7440-39-3	Barium			2	1			
	7440-41-7	Beryllium				1			
	7440-43-9	Cadmium		2	2	1		2	
	7440-70-2	Calcium							
	7440-47-3	Chromium		1	1	1		1	
	7440-48-4	Cobalt		1	1	1		1	
	7440-50-8	Copper				1			
	7439-89-6	Iron		1	1	1		1	
	7439-92-1	Lead		1	1	1			
	7439-95-4	Magnesium							
	7439-96-5	Manganese		2	1	1		1	
	7439-97-6	Mercury				1		2	
	7440-02-0	Nickel				1			
	7440-09-7	Potassium							
	7782-49-2	Selenium							
	7440-22-4	Silver				2			
	7440-23-5	Sodium							
	7440-28-0	Thallium		1	1	2		2	
	7440-62-2	Vanadium			1	1			
	7440-66-6	Zinc				1			
PAHs	92-52-4	1,1'-Biphenyl				2		2	
	91-57-6	2-Methylnaphthalene		2	2				
	88-74-4	2-Nitroaniline				2			
	99-09-2	3-Nitroaniline		2	2	2		2	
	100-01-6	4-Nitroaniline				2		2	
	83-32-9	Acenaphthene							
	208-96-8	Acenaphthylene				2		2	
	120-12-7	Anthracene							
	56-55-3	Benzo[a]anthracene	M	1	1	1		1	
	50-32-8	Benzo[a]pyrene	M	1	1	1		1	
	205-99-2	Benzo[b]fluoranthene	M	1	1	1		1	
	191-24-2	Benzo[g,h,i]perylene				2		2	
	207-08-9	Benzo[k]fluoranthene	M	1	1	1		1	
	218-01-9	Chrysene	M	1	1	1		1	
	53-70-3	Dibenzo[a,h]anthracene	M	1	1	1		1	
	132-64-9	Dibenzofuran				2		2	
	206-44-0	Fluoranthene							
	86-73-7	Fluorene							
	193-39-5	Indeno[1,2,3-cd]pyrene	M	1	1	1		1	
	91-20-3	Naphthalene		1	1	2		2	
	85-01-8	Phenanthrene		1	1				
	129-00-0	Pyrene							
		Total B(a)P Equivalents		1	1	1		1	
PCBs	12674-11-2	Aroclor 1016				2		2	
	11104-28-2	Aroclor 1221				2		2	
	11141-16-5	Aroclor 1232				2		2	
	53469-21-9	Aroclor 1242				2		2	
	12672-29-6	Aroclor 1248				2		2	
	11097-69-1	Aroclor 1254				2		2	
	11096-82-5	Aroclor 1260				2		2	
	37324-23-5	Aroclor 1262				2		2	
	11100-14-4	Aroclor 1268				2		2	

TABLE 5
Human Health Screening - Contaminants of Potential Concern

McCaffrey Street Site
14 McCaffrey Street, Village of Hoosick Falls, Rensselaer County, New York
NYSDEC Site # 442046

Chemical Class	CAS Number	Chemical	Mutagenic	Media					
				Surface Soil (1)	Subsurface Soil	Ground-water^{a}	Sediment	Surface Water	Ambient Air
PCBs	1336-36-3	Total PCB Aroclors				2		2	
Pesticides	72-54-8	4,4'-DDD				2		2	
	72-55-9	4,4'-DDE				2		2	
	50-29-3	4,4'-DDT						2	
	309-00-2	Aldrin				2		2	
	319-84-6	alpha-Benzenehexachloride				2		2	
	1912-24-9	Atrazine		2	2	2		2	
	319-85-7	beta-Benzenehexachloride				1		2	
	86-74-8	Carbazole		2	2	2			
	5103-71-9	cis-Chlordane							
	319-86-8	delta-Benzenehexachloride				2		2	
	60-57-1	Dieldrin				2		2	
	959-98-8	Endosulfan I							
	33213-65-9	Endosulfan II							
	1031-07-8	Endosulfan sulfate							
	72-20-8	Endrin				2		2	
	7421-93-4	Endrin aldehyde		2	2			2	
	53494-70-5	Endrin ketone		2	2				
	58-89-9	gamma-Benzenehexachloride				2		2	
	76-44-8	Heptachlor				2		1	
	1024-57-3	Heptachlor epoxide				2		2	
	72-43-5	Methoxychlor						2	
	8001-35-2	Toxaphene				2		2	
	5103-74-2	trans-Chlordane							
Phenols	58-90-2	2,3,4,6-Tetrachlorophenol				2			
	95-95-4	2,4,5-Trichlorophenol							
	88-06-2	2,4,6-Trichlorophenol				2		2	
	120-83-2	2,4-Dichlorophenol				2			
	95-57-8	2-Chlorophenol							
	87-86-5	Pentachlorophenol		2	2	2		2	
Semi-volatiles	120-82-1	1,2,4-Trichlorobenzene				2		2	
	95-50-1	1,2-Dichlorobenzene				2			2
	541-73-1	1,3-Dichlorobenzene				2		2	2
	106-46-7	1,4-Dichlorobenzene				2		2	1
	105-67-9	2,4-Dimethylphenol							
	51-28-5	2,4-Dinitrophenol		2	2	2		2	
	121-14-2	2,4-Dinitrotoluene		2	2	2		2	
	606-20-2	2,6-Dinitrotoluene		2	2	2		2	
	91-58-7	2-Chloronaphthalene							
	95-48-7	2-Methylphenol							
	88-75-5	2-Nitrophenol		2	2	2		2	
	91-94-1	3,3'-Dichlorobenzidine		2	2	2		2	
	534-52-1	4,6-Dinitro-2-methylphenol		2	2	2		2	
	101-55-3	4-Bromophenyl-phenylether		2	2	2		2	
	59-50-7	4-Chloro-3-methylphenol							
	106-47-8	4-Chloroaniline				2		2	
	7005-72-3	4-Chlorophenyl-phenyl ether		2	2	2		2	
	106-44-5	4-Methylphenol							
	100-02-7	4-Nitrophenol		2	2	2		2	
	98-86-2	Acetophenone							
	100-52-7	Benzaldehyde				2			
	85-68-7	Benzyl n-butyl phthalate				2		2	
	111-91-1	bis(2-Chloroethoxy)methane							
	111-44-4	Bis(2-chloroethyl)ether		2	2	2		2	
	117-81-7	bis(2-Ethylhexyl)phthalate				2		2	
	105-60-2	Caprolactam				1			
	84-66-2	Diethyl phthalate							
	131-11-3	Dimethyl phthalate		2	2	2			
	84-74-2	Di-n-butyl phthalate							
	117-84-0	Di-n-octylphthalate				2			
	118-74-1	Hexachlorobenzene		2	2	2		2	
	87-68-3	Hexachlorobutadiene				2		2	
	77-47-4	Hexachlorocyclopentadiene		2	2	2		2	
	67-72-1	Hexachloroethane		2	2	2		2	
	78-59-1	Isophorone							
	98-95-3	Nitrobenzene				2		2	
	621-64-7	N-Nitrosodi-n-propylamine		2	2	2		2	
	86-30-6	N-Nitrosodiphenylamine						2	
	108-95-2	Phenol							
Volatiles	71-55-6	1,1,1-Trichloroethane							2
	79-34-5	1,1,2,2-Tetrachloroethane				2		2	2
	79-00-5	1,1,2-Trichloroethane		2	2	2		2	2
	75-34-3	1,1-Dichloroethane				2			2
	75-35-4	1,1-Dichloroethene				2			2
	87-61-6	1,2,3-Trichlorobenzene				2		2	
	95-94-3	1,2,4,5-Tetrachlorobenzene				2		2	
	96-12-8	1,2-Dibromo-3-chloropropane		2	2	2		2	2

TABLE 5

Human Health Screening - Contaminants of Potential Concern

McCaffrey Street Site
14 McCaffrey Street, Village of Hoosick Falls, Rensselaer County, New York
NYSDEC Site # 442046

Chemical Class	CAS Number	Chemical	Mutagenic	Media					
				Surface Soil (1)	Subsurface Soil	Ground-water^a	Sediment	Surface Water	Ambient Air
Volatiles	106-93-4	1,2-Dibromoethane		2	2	2		2	1
	107-06-2	1,2-Dichloroethane				2		2	1
	78-87-5	1,2-Dichloropropane				2		2	2
	123-91-1	1,4-Dioxane		2	2	2		2	
	78-93-3	2-Butanone							1
	591-78-6	2-Hexanone				2		2	1
	108-10-1	4-Methyl-2-pentanone							1
	67-64-1	Acetone							1
	71-43-2	Benzene				2		2	1
	39638-32-9	Bis(2-chloroisopropyl) ether		2	2	2		2	
	74-97-5	Bromochloromethane							
	75-27-4	Bromodichloromethane		2	2	2		2	2
	75-25-2	Bromoform				2		2	2
	74-83-9	Bromomethane				2		2	2
	75-15-0	Carbon disulfide							1
	56-23-5	Carbon Tetrachloride				2		2	1
	108-90-7	Chlorobenzene							1
	75-00-3	Chloroethane							
	67-66-3	Chloroform		2	2	2		2	1
	74-87-3	Chloromethane							2
	156-59-2	cis-1,2-Dichloroethene				1			2
	10061-01-5	cis-1,3-Dichloropropene				2		2	2
	110-82-7	Cyclohexane							
	124-48-1	Dibromochloromethane				2		2	2
	75-71-8	Dichlorodifluoromethane				2			1
	100-41-4	Ethylbenzene							1
	98-82-8	Isopropylbenzene							2
	179601-23-1	m,p-Xylene							1
	79-20-9	Methyl acetate							
	1634-04-4	Methyl tert-butyl ether							2
	108-87-2	Methylcyclohexane							
	75-09-2	Methylene Chloride	M						1
	95-47-6	o-Xylene							1
	100-42-5	Styrene							1
	127-18-4	Tetrachloroethene							1
	108-88-3	Toluene				2			1
	156-60-5	trans-1,2-Dichloroethene		2	2	2			2
	10061-02-6	trans-1,3-Dichloropropene				2		2	2
	79-01-6	Trichloroethene	M			1		2	1
	75-69-4	Trichlorofluoromethane							2
	76-13-1	Trichlorotrifluoroethane				2			2
	75-01-4	Vinyl Chloride	M	2	2	2		2	2

M = mutagenic, as defined by the USEPA (2020d)

1 or 2 = screened in as a COPC for human health, based on residential, recreator, and/or worker screening level risk assessment scenario.

1 = Primary COPC. Primary COPCs are constituents where the the frequency of detect is greater than 5% and the maximum concentration detected is greater than a screening level.

2 = Seconday COPC. Secondary COPCs are chemicals for which any of the following conditions occurred: the frequency of detect is less than or equal to 5%, the maximum non-detect is greater than the screening value, or the maximum detect was greater than the screening level but lower than the New York rural soil background concentration. Chemicals are also considered secondary COPCs if the concentration utilized for screening purposes (detect or non-detect) is greater than a potential ARAR but less than the risk-based screening level.

Shaded anlytes are primary COPCs.

Footnotes

(1) Groundwater, surface soil and air screening includes results from vapor intrusion screening.

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TABLE 6
Summary of the Exposure Scenarios and Receptors for the Baseline Human Health Risk Assessment

McCaffrey Street Site
14 McCaffrey Street, Village of Hoosick Falls, Rensselaer County, New York
NYSDEC Site # 442046

Current and Future Exposure Scenarios (1)	Exposure Media								Receptor Age Group		
	Surface Soil	Subsurface Soil	Ground water	Sediment	Surface Water	Ambient Air	Terrestrial Plants	Fish	Younger Child (0 to <6 yrs)	Older Child (6 to <16 yrs)	Adult (16+ yrs)
Commercial/ Industrial Workers	X		X			X					X
Construction Workers	X	X	X			X					X
Trespassors/ Visitors	X									X	X
Residents	X	X	X			X	X		X	X	X
Recreators (Waders and Anglers)	X			X	X			X	X	X	X

Footnotes

(1) Includes current and future exposure scenarios on-site and off-site within Project Area

TABLE 7

Examples of Use of Probabilistic Risk Assessment (PRA) to Inform Risk-Management Decisions at Sites in the United States

McCaffrey Street Site
14 McCaffrey Street, Village of Hoosick Falls, Rensselaer County, New York
NYSDEC Site # 442046

Site	Region	Lead Agencies	Date of Report	Primary Exposure Pathways		Primary Chemical(s) of Interest	Description of Decision Made with PRA Results (1)	References
				Soil and Dust Ingestion	Diet / Food Ingestion			
Housatonic River, MA	1	USEPA, USACE	2005	X	X	PCBs	2016 CERCLA Remedy Selection, PRA is primary basis for Biota Monitoring Performance Standards	Weston Solutions, Inc, 2005; USEPA, 2016
Hudson River, NY	2	USEPA, USACE	2000		X	PCBs	Phase 2 Reassessment RI/FS; PRA is used in Remedy Selection (Phase 3, FS)	TAMS Consultants, Inc., 2000
Berry's Creek Study Area, NJ	2	USEPA, NJDEP	2017	X	X	mercury, methyl mercury, PCBs	PRA applied for HHRA and BERA, used as primary basis for risk characterization	BCSA Cooperating PRP Group, 2017
Southern Wood Piedmont (SWP-Baldwin), FL	4	Florida DEP	2015	X		dioxin	PRA is primary basis for SCTL	Simpson et al., 2016
Lower Fox River and Green Bay, WI	5	USEPA R5, Wisconsin DNR	2001		X	PCBs	ROD (2002) notes PRA and deterministic approaches compare favorably; PRA supports PCB sediment cleanup level, CERCLA Remedy Selection; 2002 Final RI/FS: PRA applied in response to peer review	WIDNR & USEPA, 2002a, b
Tittabawassee River, MI	5	USEPA R5, MI EGLE, USACE	2020	X	X	dioxin	PRA is the primary basis for risk characterization in HHRA; BERA is in progress and also applies PRA	Tittabawassee and Saginaw River Team, 2020
San Jacinto Waste Pits, TX	6	USEPA R6	2013	X	X	dioxin	ROD (2017) notes PRA used to refine BHHRA and set PRGs	Integral Consulting Inc, 2013; USEPA, 2017
Rocky Flats, CO	8	USEPA R8, USDOE, Colorado DPHE	2002	X		radionuclides, uranium	PRA is primary basis for risk-based soil action levels (RBSLs) for radionuclides	USEPA et al., 2002
St. Helens Fiberboard, OR	10	Oregon DEQ	2014	X		dioxin	PRA completes the RI/FS and defines remedial action objectives for FS	ARCADIS, 2014; ORDEQ, 2015
SHEDS	National	USEPA	2004 - present	X	X	pesticides, lead, arsenic	Monte Carlo analysis is applied to a wide range of dietary exposure scenarios	Multiple references since 2004
All Lead Sites	National	USEPA and California DTSC	1994 - present	X		lead	Probabilistic risk characterization is incorporated in lead risk assessment models used by USEPA (i.e., IEUBK or ALM) and California (i.e., Leadspread) at all sites; a submodel that employs Monte Carlo analysis was applied by USEPA to inform risk management at sites in Regions 3 and 8	USEPA, 2020; CDTSC, 2011;, Goodrum et al., 1996; Griffin et al., 1999; Maddaloni et al., 2005
USEPA Office of Pesticide Programs - Tier 2 Models	National	USEPA	2001 - present		X	pesticides	Probabilistic methods applied to exposure and effects assessments; aquatic and terrestrial models coupled with standard exposure scenarios to assess risk to non-target receptors	USEPA, 2001, 2004, 2010

BERA = baseline ecological risk assessment; BHHRA = baseline human health risk assessment; CDPHE = Colorado Department of Public Health Environment; CDTSC = California Department of Toxic Substances Control; FS = feasibility study; MIEGLE = Michigan Department of Environment, Great Lakes & Energy; ORDEQ = Oregon Department of Environent Quality; PRG = preliminary remediation goal; RI = remedial investigation; ROD = record of decision; SCTL = Soil Cleanup Target Level; SHEDS = Stochastic Human Exposure and Dose Simulation Model; USACE = US Army Corps of Engineers; WIDNR = Wisconsin Department of Natural Resources

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McCaffrey Street Site
14 McCaffrey Street, Village of Hoosick Falls, Rensselaer County, New York
NYSDEC Site # 442046

Site	Region	Lead Agencies	Date of Report	Primary Exposure Pathways		Primary Chemical(s) of Interest	Description of Decision Made with PRA Results (1)	References
				Soil and Dust Ingestion	Diet / Food Ingestion			

Notes

(1) Each application of PRA listed was used to inform decision by federal or state regulatory agencies.

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TABLE 7
Examples of Use of Probabilistic Risk Assessment (PRA) to Inform Risk-Management Decisions at Sites in the United States

McCaffrey Street Site
14 McCaffrey Street, Village of Hoosick Falls, Rensselaer County, New York
NYSDEC Site # 442046

Site	Region	Lead Agencies	Date of Report	Primary Exposure Pathways		Primary Chemical(s) of Interest	Description of Decision Made with PRA Results (1)	References
				Soil and Dust Ingestion	Diet / Food Ingestion			

SHEDS References

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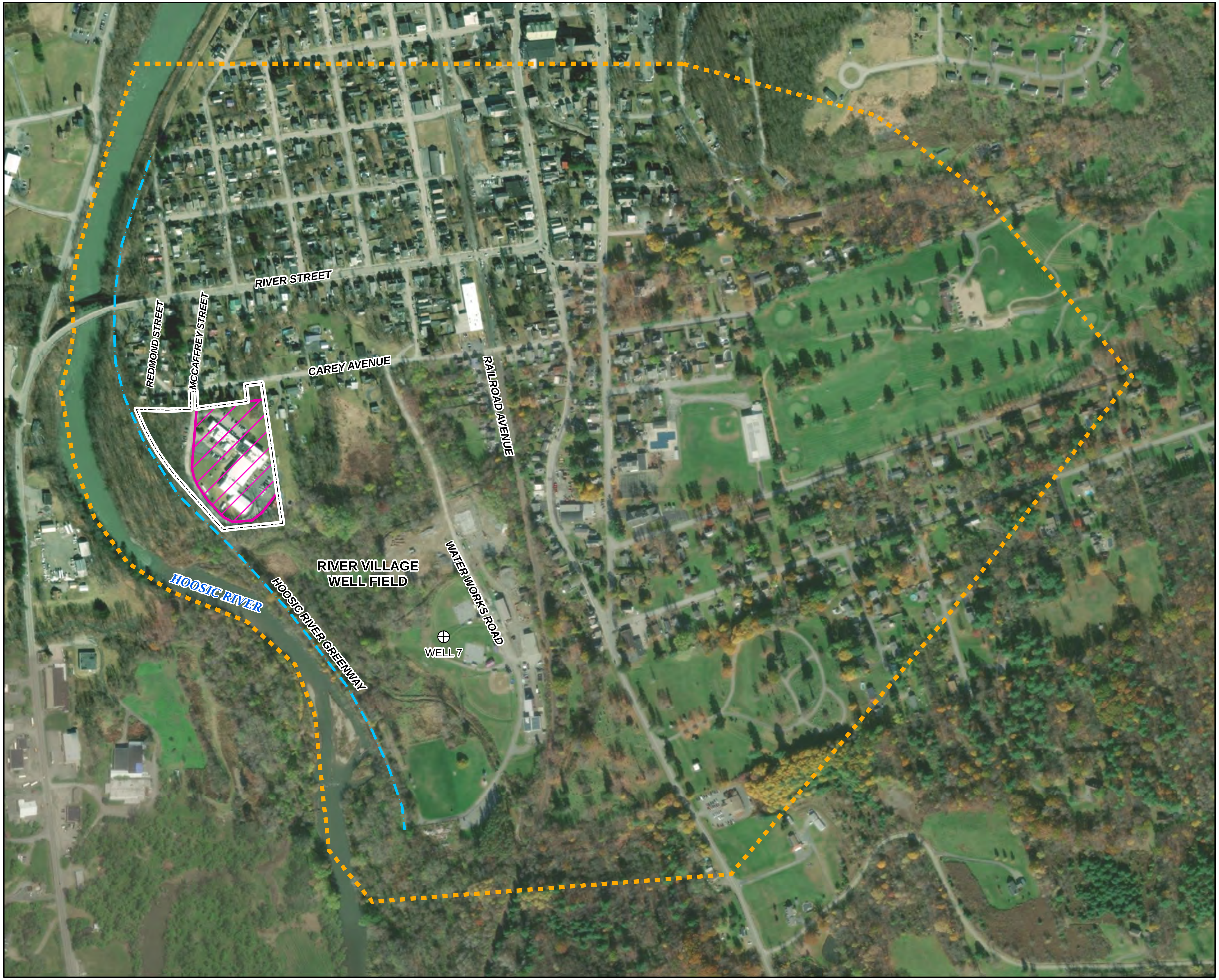
WORK PLAN FOR BASELINE HUMAN HEALTH RISK ASSESSMENT

McCAFFREY STREET SITE
(Site No. 442046, USEPA ID# NYD004986741)

FIGURES



N

LEGEND

○ Village of Hoosick Falls Well

⬚ Tax Parcel Boundary - On-Site

▨ Facility Boundary

⬚ Project Area

Note

Basemap imagery provided by ESRI World Imagery, October 2019.

Feet
0 225 450

Projected Coordinate System
Datum: NAD 1983
State Plane New York East
Units: Feet

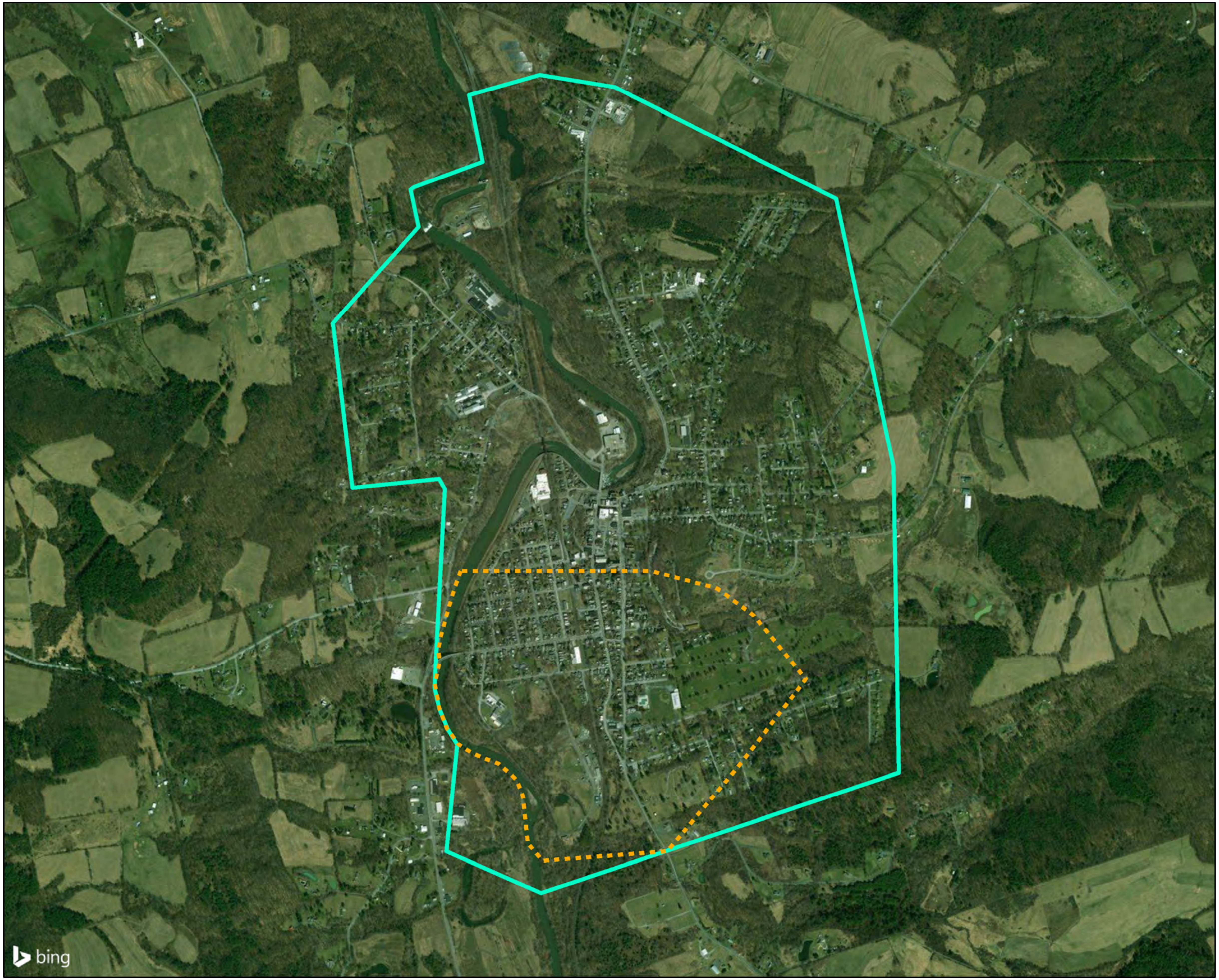
GSI ENVIRONMENTAL

McCAFFREY STREET SITE LOCATION

McCaffrey Street Site, 14 McCaffrey Street,
Village of Hoosick Falls, Rensselaer County, New York
NYSDEC Site #442046

GSI Job No.	5316	Drawn By:	BSS/AV
Issued:	11 June 2021	Chk'd By:	ARD
Map ID:	**MS_MSSL**	Appv'd By:	PEG

FIGURE 1



N

LEGEND

- ▭ Primary Project Area
- ▭ Residential Irrigated Soil Area

Note

Basemap imagery provided by Bing Maps, May 2021.

Feet
0 650 1,300

Projected Coordinate System
Datum: NAD 1983
State Plane New York East
Units: Feet

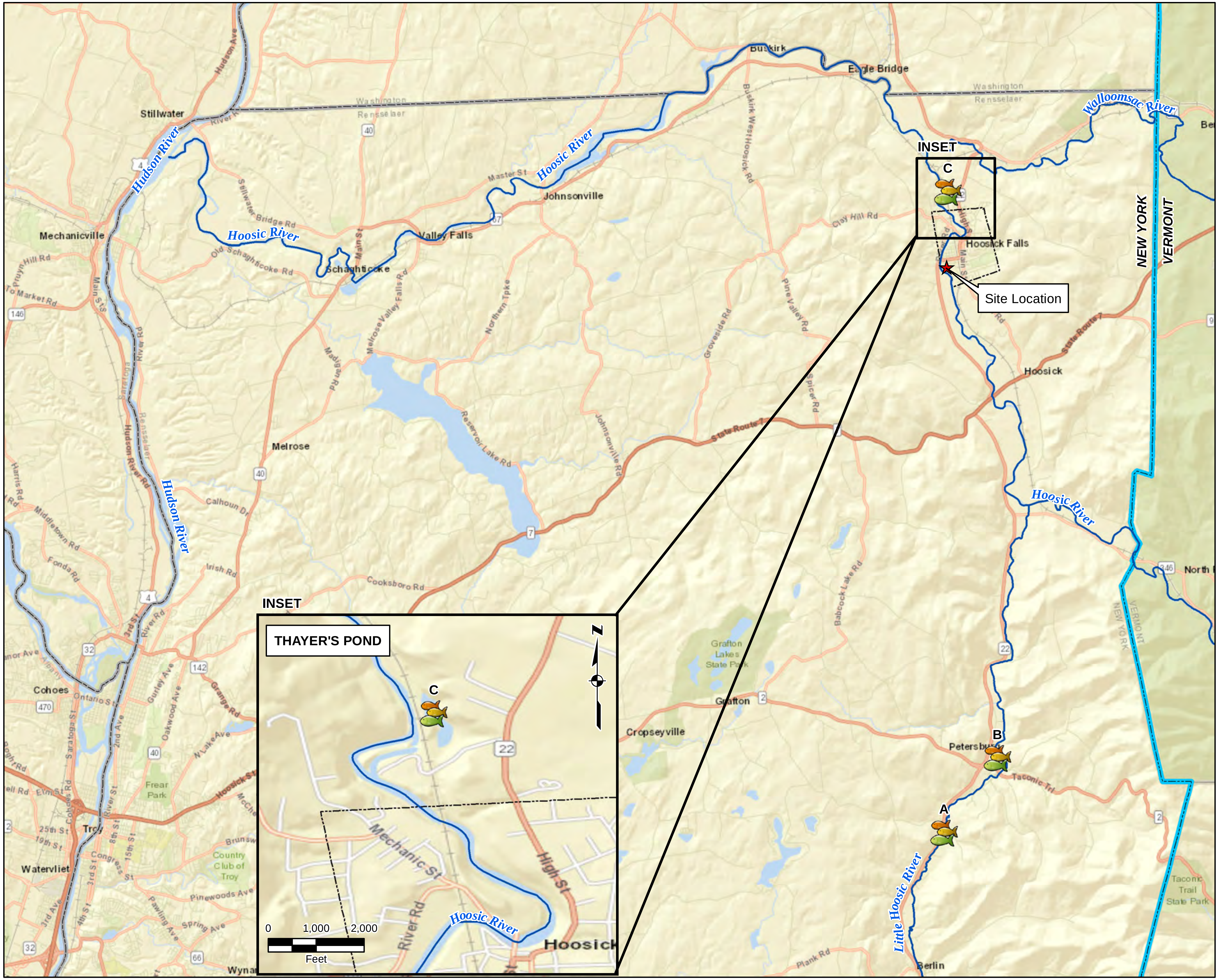
GSI
ENVIRONMENTAL

RESIDENTIAL IRRIGATED SOIL AREA

McCaffrey Street Site, 14 McCaffrey Street,
Village of Hoosick Falls, Rensselaer County, New York
NYSDEC Site #442046

GSI Job No.	5316	Drawn By:	AV
Issued:	11 June 2021	Chk'd By:	JKA
Map ID:	MS_RISA	Appv'd By:	PEG

FIGURE 2



LEGEND

- Fish Tissue Sample Location
- Hoosic River
- ▢ State Boundary
- ▢ Village of Hoosick Falls
- ▢ Counties

Notes

1) Basemap imagery provided by Esri ArcGIS Online.
2) Locations A, B, C are sites of fish sampling conducted by NYSDEC.

Feet
0 4,500 9,000

Projected Coordinate System
Datum: NAD 1983
State Plane New York East
Units: Feet

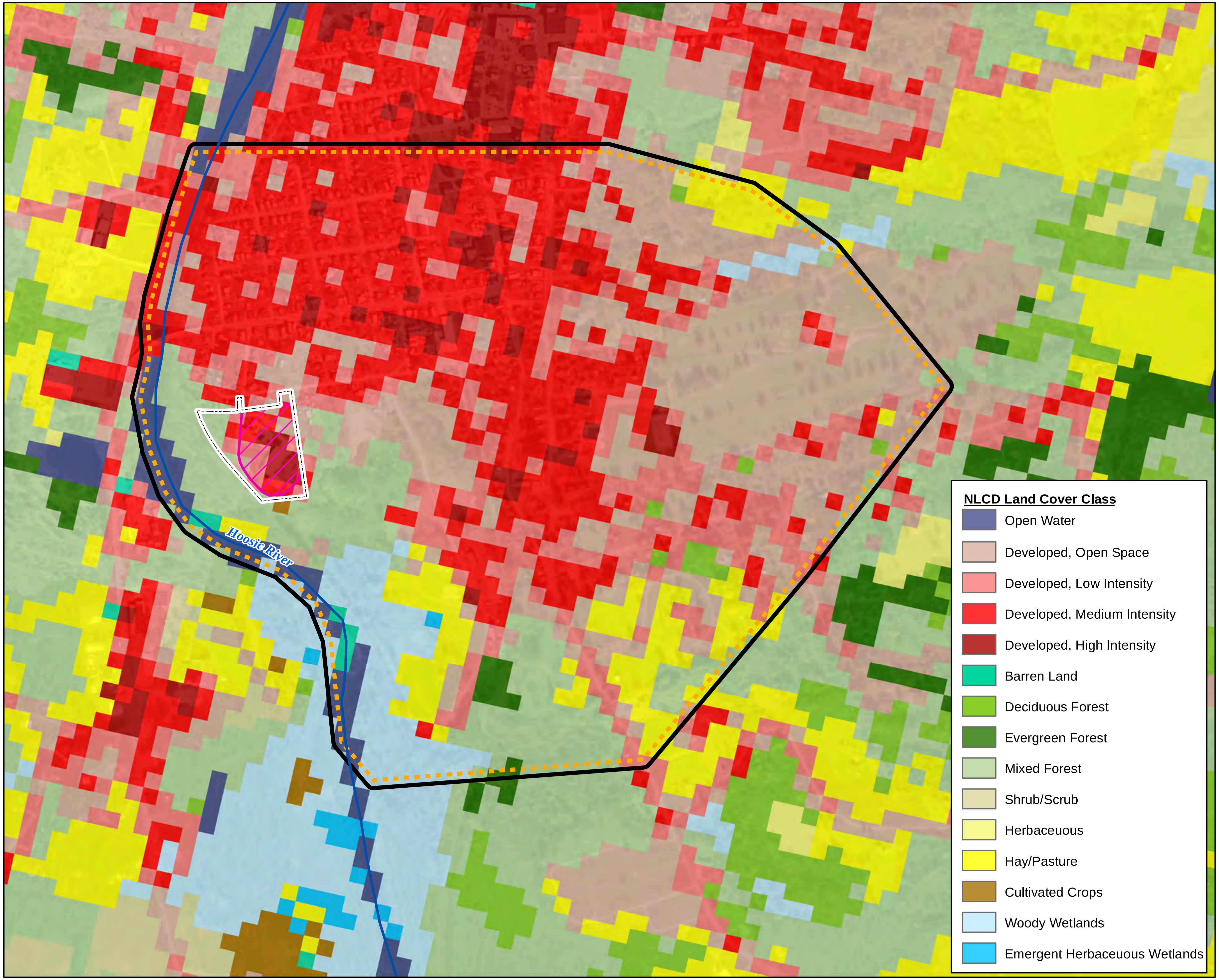
GSI ENVIRONMENTAL

HOOSIC RIVER WATERSHED AND McCAFFREY STREET SITE LOCATION

McCaffrey Street Site, 14 McCaffrey Street,
Village of Hoosick Falls, Rensselaer County, New York
NYSDEC Site #442046

GSI Job No.	5316	Drawn By:	AV
Issued:	11 June 2021	Chk'd By:	ARD
Map ID:	MS_MSSL_HRW	Appv'd By:	PEG

FIGURE 3



N

LEGEND

- Hoosic River
- Tax Parcel Boundary
- Facility Boundary
- Project Area
- 50-Foot Buffer around Project Area

Note

NLCD Land Cover Classification downloaded from the Multi-Resolution Land Characteristics website https://www.mrlc.gov/data, August 12, 2020.

Feet
0 300 600

Projected Coordinate System
Datum: NAD 1983
State Plane New York East
Units: Feet

GSI ENVIRONMENTAL

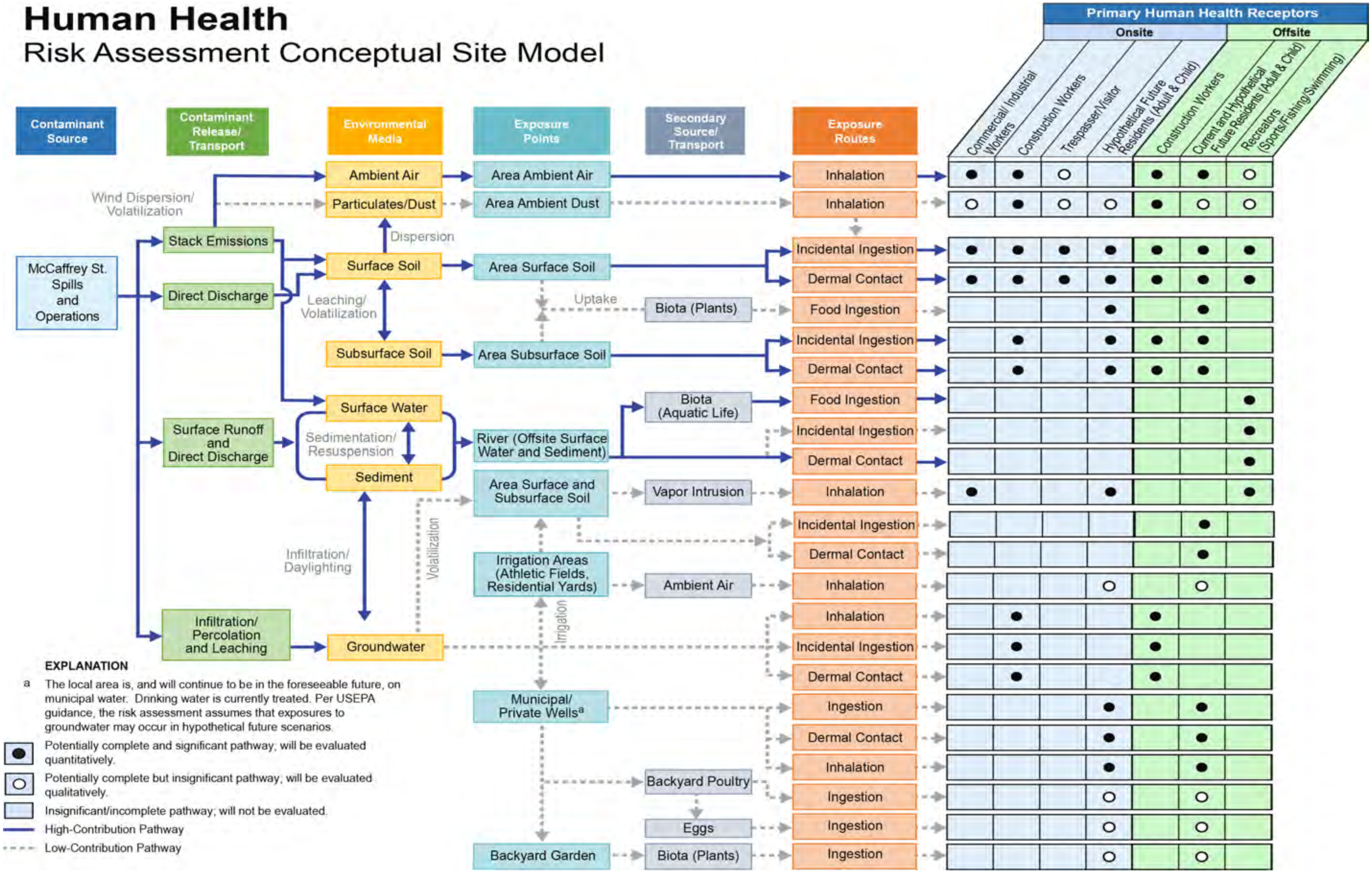
LAND USE CATAGORIES

McCaffrey Street Site, 14 McCaffrey Street,
Village of Hoosick Falls, Rensselaer County, New York
NYSDEC Site #442046

GSI Job No.	5316	Drawn By:	AV
Issued:	11 June 2021	Chk'd By:	ARD
Map ID:	**MS_MSSL_LU**	Appv'd By:	PEG

FIGURE 4

Human Health
Risk Assessment Conceptual Site Model



	Onsite				Offsite		
Exposure Routes	Commercial/ Industrial Workers	Construction Workers	Trespasser/Visitor	Hypothetical Future Residents (Adult & Child)	Construction Workers	Current and Hypothetical Future Residents (Adult & Child)	Recreators (Sports/Fishing/Swimming)
Inhalation	●	●	○		●	●	○
Inhalation	○	●	○	○	●	○	○
Incidental Ingestion	●	●	●	●	●	●	●
Dermal Contact	●	●	●	●	●	●	●
Food Ingestion				●		●	
Incidental Ingestion		●		●	●	●	
Dermal Contact		●		●	●	●	
Food Ingestion							●
Incidental Ingestion							●
Dermal Contact							●
Inhalation	●			●			●
Incidental Ingestion						●	
Dermal Contact						●	
Inhalation				○		○	
Inhalation		●			●		
Incidental Ingestion		●			●		
Dermal Contact		●			●		
Ingestion				●		●	
Dermal Contact				●		●	
Inhalation				●		●	
Ingestion				○		○	
Ingestion				○		○	
Ingestion				○		○	

EXPLANATION

a The local area is, and will continue to be in the foreseeable future, on municipal water. Drinking water is currently treated. Per USEPA guidance, the risk assessment assumes that exposures to groundwater may occur in hypothetical future scenarios.

● Potentially complete and significant pathway; will be evaluated quantitatively.

○ Potentially complete but insignificant pathway; will be evaluated qualitatively.

☐ Insignificant/incomplete pathway; will not be evaluated.

— High-Contribution Pathway

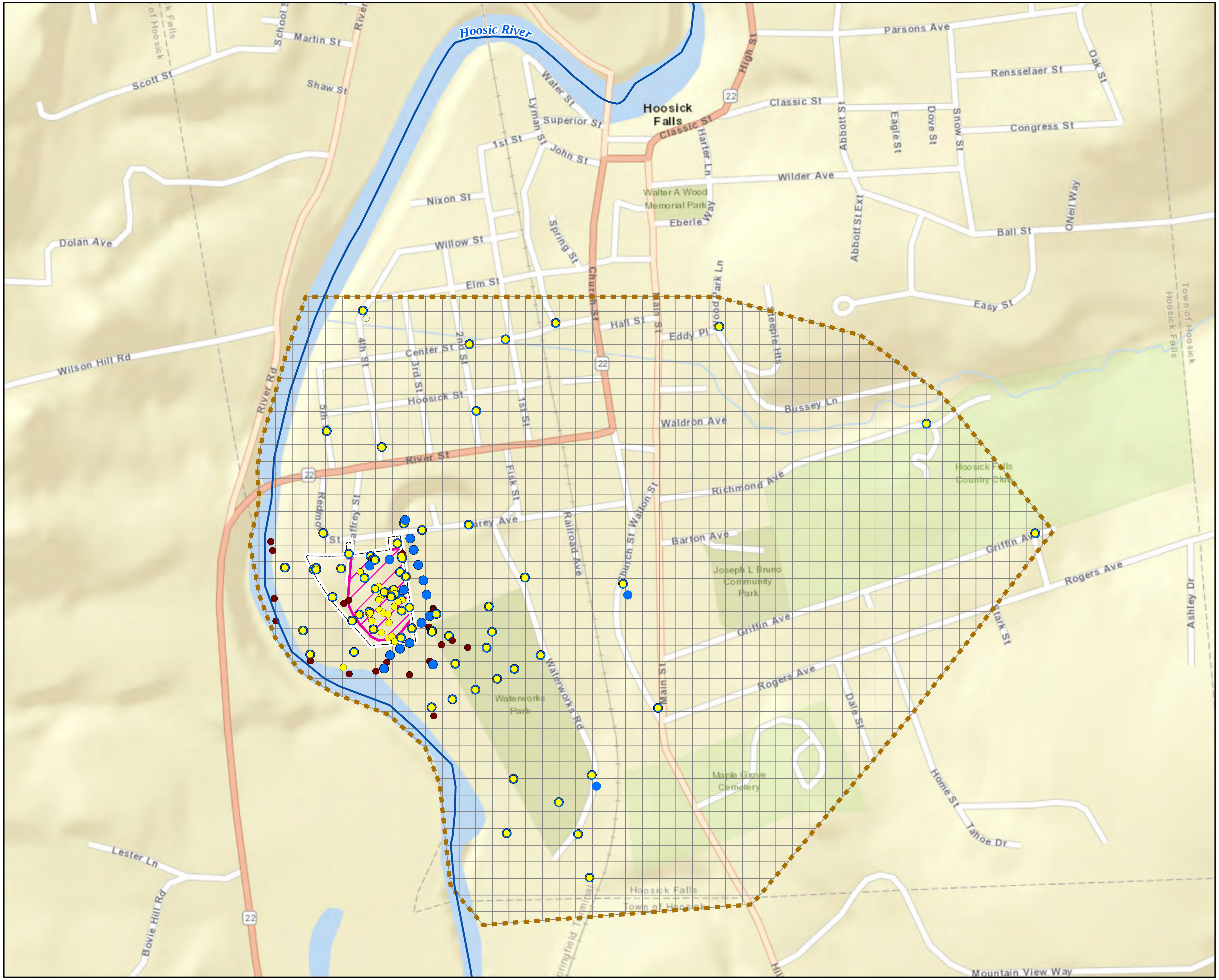
- - - Low-Contribution Pathway

FIGURE 5. HUMAN HEALTH RISK ASSESSMENT CONCEPTUAL SITE MODEL

McCaffrey Street Site

14 McCaffrey Street, Village of Hoosick Falls, Rensselaer County, NY

NYSDEC Site # 442046



N

LEGEND

- ● Sediment Sample Location
- ● Surface Soil Sample Location (≤ 2 Feet)
- ● Subsurface Soil Sample Location (> 2 Feet)
- — Hoosic River
- ☐ Tax Parcel Boundary - On-Site
- ▨ Facility Boundary
- ☐ Project Area
- ☐ 0.25-Acre Exposure Unit Grid

Note

Streetmap imagery provided by Esri ArcGIS Online.

Feet
0 300 600

Projected Coordinate System
Datum: NAD 1983
State Plane New York East
Units: Feet

GSI
ENVIRONMENTAL

0.25-ACRE EXPOSURE UNIT GRID FOR FUTURE RESIDENTIAL RECEPTOR SCENARIO

McCaffrey Street Site, 14 McCaffrey Street,
Village of Hoosick Falls, Rensselaer County, New York
NYSDEC Site #442046

GSI Job No.	5316	Drawn By:	AV
Issued:	11 June 2021	Chk'd By:	ARD
Map ID:	MS_MSSL_EUG_FR	Appv'd By:	PEG

FIGURE 6