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RCRA Facility Investigation (RFI) Report

Volume V –

Tributary One and Flood Plain
South of Pearson/Stone Roads

June 2010 FINAL

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RCRA Facility Investigation Report

Volume V

Tributary One and Flood Plain South of Pearson/Stone Roads

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Appendices (appear on separate CD only)

Acronyms, Abbreviations, and Units of Measure

Agencies	NYSDEC and USEPA
AOC	Administrative Order on Consent
c.	circa
CMS	Corrective Measures Study
CRA	Conestoga-Rovers & Associates
DDD	dichlorodiphenyldichloroethane
DDE	dichlorodiphenyldichloroethylene
DDT	dichlorodiphenyltrichloroethane
FMC	FMC Corporation
ft/s	feet per second
GMX	Geomatrix
ICM	Interim Corrective Measure
IRM	Interim Remedial Measure
LEL	Lowest Effect Level
mg/kg	milligrams per kilogram
ND	not detected
NYSDEC	New York State Department of Environmental Conservation
NYSDOH	New York State Department of Health
OSI	Off-Site Investigation
ppb	parts per billion
ppm	parts per million
QA/QC	quality assurance/quality control
RCRA	Resource Conservation and Recovery Act
R&D	research and development
RFI	RCRA Facility Investigation
SEL	Severe Effect Level
SPDES	State Pollutant Discharge Elimination System
SSLs	Soil Screening Levels
TCLP	Toxicity Characteristic Leaching Procedure
TOC	total organic carbon
UCL	upper confidence level
ug/kg	micrograms per kilogram
USEPA	United States Environmental Protection Agency

1. Introduction

FMC Corporation (FMC) owns and operates a pesticide formulations facility in the Village of Middleport, Niagara County, New York (herein the "Facility" or "Site"), which has been used for the manufacturing and/or formulation of pesticide products since the 1920s. The location of the Facility is indicated on Figure 1.1.

FMC has been implementing a Resource Conservation and Recovery Act (RCRA) Facility Investigation (RFI) to delineate and evaluate the presence of Site-related constituents in soil, surface water, sediment, soil gas, indoor air, and/or groundwater at the Facility and in off-site areas as a result of releases of hazardous waste or hazardous constituents from the Facility into the environment. An additional purpose of the RFI is to gather necessary data to support a Corrective Measures Study (CMS), if one is determined to be necessary. The RFI is one of several related investigative, monitoring, and/or remedial programs being implemented to satisfy the terms and conditions of the Administrative Order on Consent (AOC) [Docket No. II RCRA-90-3008(h)-0209] entered into by FMC, the New York State Department of Environmental Conservation (NYSDEC), and the United States Environmental Protection Agency (USEPA), effective July 2, 1991 (USEPA, NYSDEC, and FMC 1991). The NYSDEC and USEPA are referred to herein together as "the Agencies."

1.1 Overview of the RFI Report

The RFI sampling and analysis activities were performed in numerous phases from 1993 to 2005 at the direction of the Agencies under the terms and conditions of the AOC, and in consultation with the New York State Department of Health (NYSDOH). In addition, data generated from relevant investigative and monitoring programs and interim remedial actions have also been used during performance of the RFI. A Draft RFI Report (Conestoga-Rovers & Associates [CRA] 1999) presenting the RFI sample results collected from 1993 through 1997 and sampling data collected as part of other environmental investigations conducted at and around the Facility from the 1970s through 1997 was submitted to the Agencies in January 1999. FMC subsequently conducted additional investigative and remedial activities that generated data in support of the RFI.

In late 2005, FMC and the Agencies agreed that a revised RFI Report would be prepared to present and summarize the RFI sampling data and results. The revised RFI Report is organized into the following 11 volumes:

- Volume I Background and Related Information (ARCADIS and AMEC Geomatrix 2009)
- Volume II Suspected Air Deposition Study Area 1 - South of the Erie Canal and West of the Niagara/Orleans County Line and Culvert 105 Study Area South of the Erie Canal (ARCADIS 2009a)

- Volume III Former FMC Research and Development (R&D) Property
- Volume IV Culvert 105 and Flood Zone (ARCADIS 2009b)
- Volume V Tributary One and Flood Plain South of Pearson/Stone Roads (this volume)
- Volume VI Tributary One and Flood Plain North of Pearson/Stone Roads
- Volume VII Jeddo Creek, Johnson Creek, and Floodplains
- Volume VIII Groundwater Investigations and Remediation Results
- Volume IX On-Site Soil, Surface Water, and Sediments
- Volume X Suspected Air Deposition Study Area 2 - North of the Erie Canal and East of the Niagara/Orleans County Line
- Volume ES Comprehensive Executive Summary for all Volumes

Volume I of the RFI Report presents detailed information on the RFI study areas, including descriptions of current and historical operations at the Facility, current and historical land use in the area, previous and ongoing environmental investigations, monitoring programs and remedial activities, the regional setting, and the results of Middleport area soil background studies.

1.2 Objectives and Scope of the RFI in the Tributary One South Study Area

Tributary One of Jeddo Creek feeds into the Middleport Reservoir south of the Village of Middleport and runs northerly from the Reservoir approximately 6.8 miles through the Town of Royalton, the Village of Middleport (where it passes beneath the Erie Canal), the Town of Hartland, and into the Town of Ridgeway until its confluence with Jeddo Creek, south of Route 104. Figure 1.1 identifies the locations of Tributary One, Jeddo Creek, the Middleport Reservoir, the Erie Canal, and the municipal boundaries.

For the purposes of the RFI, Tributary One and its flood plain were divided into two study areas: 1) Tributary One north of Francis Street and south of Pearson/Stone Roads (referred to herein as the “Tributary One South Study Area”); and 2) Tributary One north of Pearson Road and east of Stone Road, north to its confluence with Jeddo Creek (referred to herein as the “Tributary One North Study Area”). The section of Tributary One south of Francis Street has also been studied, and represents upstream background (reference) conditions.

This document presents the soil, sediment, and surface water investigation results for the Tributary One South Study Area, which is depicted as a yellow area on Figure 1.1. The specific areas included in the Tributary One South Study Area are described in Section 2.

The objectives of the RFI investigation for the Tributary One South Study Area were to:

- Characterize the nature and extent of Site-related constituents that may be present in surface water, soil and sediment within the Tributary One South Study Area as a result of historical transport in surface water from the Facility to Tributary One through the Village of Middleport storm sewer system

- Define the horizontal and vertical extent of areas that will be evaluated in a CMS

- Provide data to perform a CMS in accordance with the terms and conditions of the AOC

To achieve these objectives, FMC used data generated from investigative programs and remedial actions conducted from 1986 through 2005. The associated sampling and analysis activities are discussed in Section 3.

The Agencies determined (in letters dated September 24, 2007 [Agencies 2007a] and March 10, 2008 [Agencies 2008]) that "there is currently sufficient data" in the Tributary One South Study Area "to complete RFI characterization and delineation activities with respect to FMC-related soil contamination, and to support the subsequent development of a Corrective Measures Study (CMS) with respect to this soil contamination." FMC agreed (in a letter dated March 28, 2008 [FMC 2008]) to:

1) Compare arsenic soil data to a **delineation** criterion of 20 parts per million (ppm; equivalent to milligrams per kilogram [mg/kg]), with consideration given to other factors potentially affecting data along Tributary One (e.g., background data variations, upstream concentrations in sediment, flood zone topography, flood plain boundaries, and historical land use); and

2) Prepare and submit this Volume V of the RFI Report to the Agencies for their review.

In addition, FMC and the Agencies agreed that the soil arsenic "delineation" criterion of 20 mg/kg is not necessarily a "remediation" criterion or standard, and that delineation of soil containing arsenic above 20 mg/kg does not necessarily mean that this soil will be required to be remediated in the future. The nature and scope of any final corrective measures in the Tributary One South Study Area will be based on the outcome of a CMS.

1.3 Report Organization

The remainder of this Volume V of the RFI Report is organized as follows:

Section 2 – Description of the Tributary One South Study Area: Reviews background information for the Tributary One South Study Area, including a review of the current

and historical stream characteristics, current and past discharges to Tributary One, remedial actions completed upstream of Tributary One, stream classification, wetlands and habitat information, and current and historical land use along this section of Tributary One.

Section 3 – Review of Sampling and Analysis: Summarizes the soil, sediment, and surface water sampling and analysis activities conducted within the Tributary One South Study Area.

Section 4 – Presentation of Tributary One South Study Area Data Sets: Describes the soil, sediment, and surface water analytical data sets for the Tributary One South Study Area, including an assessment of the data usability.

Section 5 – Evaluation of Constituents in Surface Water: Compares the surface water data to background levels and applicable Surface Water Quality Standards.

Section 6 – Identification of Soil and Sediment Background Concentrations and Screening Values: Identifies background concentrations of constituents in soil and sediment in the Tributary One South Study Area and identifies the soil and sediment screening values used in the Tributary One South Study Area.

Section 7 – Comparison of Soil and Sediment Analytical Data to Screening Values: Compares the soil and sediment analytical data to screening values for human and ecological receptors, and summarizes the ecological survey and bioassay testing conducted in 1992.

Section 8 – Source and Extent of Arsenic in Soil and Sediment: Discusses the potential non-FMC-related sources of arsenic in soil and sediment, background concentrations of arsenic in soil and sediment, and the spatial and vertical distribution of arsenic in soil and sediment in the Tributary One South Study Area.

Section 9 – Proposed Corrective Measures Study Area: Provides the rationale for the proposed extent of the CMS for the Tributary One South Study Area.

Section 10 – Findings: Summarizes the findings of the investigations and data evaluations described in this Volume V of the RFI Report.

Section 11 – References: Lists the references cited in this Volume V of the RFI Report.

2. Description of the Tributary One South Study Area

This section describes the Tributary One South Study Area, including the current and historical stream characteristics, current and historical discharges, remedial actions completed upstream, stream classification, wetland and habitat information, and current and historical land use along this section of Tributary One between Francis Street and Stone Road (herein "Tributary One South"). Figure 2.1 identifies the pathway of Tributary One South, locations of ditches and buried pipes that discharge to Tributary One South, the location of federally-classified wetland areas associated with Tributary One South, and the extent of its 100-year flood plain as identified on Federal Emergency Management Agency [FEMA] flood insurance rate maps.[1]

2.1 Description of Current Tributary One South Stream Bed, Banks, and Flood Plain

Tributary One South is characterized as a shallow stream that flows primarily over exposed bedrock, with summer and fall base flow north of the Erie Canal significantly supplemented by water released to Tributary One from the Erie Canal. A series of photographs taken along Tributary One South as it flows downstream from Francis Street to Stone Road is provided in Appendix A.

Within the Tributary One South Study Area, the total head drop of the stream is approximately 82 feet over a stream distance of approximately 9,500 feet (0.9 percent average slope) from Francis Street to Stone Road. The bank height is variable, ranging from a couple of feet in height in low lying areas to more than 10 feet (see cross-sections provided in Appendix E). Parts of the stream bank south of the Erie Canal are lined with masonry walls, rock walls or riprap.

The flow of Tributary One South varies with the seasons and precipitation events. Table 2.1 presents volumetric flow data for the stream collected at transect locations during lower flow conditions in November 2004 (approximately 1.4 million gallons per day as measured just upstream of the Erie Canal crossing) and during higher flow conditions in January 2005 (approximately 38 million gallons per day).

The width of Tributary One South, as measured during spring flows in March 2004, ranged from 13 to 54 feet, with an average of approximately 24 feet. The mid-stream depth of Tributary One South ranged from 5 to 41 inches (with an average of approximately 20 inches), and the mid-stream flow velocity ranged from 0.1 to 5.1 feet per second (ft/s) (with an average of approximately 2.1 ft/s). Table 2.2 presents the results of the stream profile survey conducted for Tributary One South in March 2004, including the stream width, stream depth, stream velocity, sediment depth, and

[1] FEMA is in the process of revising flood maps for this region of New York; revised maps should be available in Spring 2010 (see http://rmc.mapmodteam.com/rmc2/Niagara_County_NY).

sediment characterization at each of 31 sampling transects along the stream. The sediment depth and characterization information from this survey is shown on Figure 2.2.

From Francis Street to just north of Sherman Street, Tributary One flows over exposed bedrock, with only trace sediment deposits present throughout this section of the stream. Between Sherman Street and Chase Road, the stream transitions to a riffle and run environment, with thin, sandy sediment deposits (approximately one to two inches in thickness) forming. The riffle and run environment continues downstream of Chase Road, with sandy sediment deposits ranging in thickness from 2 to 32 inches. The grain size composition and organic carbon content of nine sediment samples collected within the Tributary One South Study Area and two upstream background sediment samples are presented in Table 2.3. The sediment samples collected within the Tributary One South Study Area exhibited total silt and clay contents ranging from 2.1 to 78.3 percent (with an average of 16 percent), and total organic carbon (TOC) contents ranging from 0.2 to 8.3 percent (average of 3.1 percent).

Tributary One splits into two branches approximately 400 feet south of Pearson Road, with a majority of the water passing through a channel to the west that was constructed in 1950 (based on plans from the Niagara County Department of Public Works), and the balance of the water passing through the original channel to the east. These two branches converge immediately north of Pearson Road.

2.2 Tributary One South Historical Characteristics

From the mid-1800s to the mid-1900s, a series of mill ponds was located along Tributary One between Francis Street and Pearson Road (based on review of historical fire insurance maps and aerial photographs provided in Appendix 2E of RFI Volume I). These mill ponds included the following locations:

- Between Church Street and the Erie Canal
- South of Sherman Road
- Between Sherman Road and Chase Road
- Between Chase Road and North Hartland Road
- Northeast of Chase Road

None of these mill ponds remain today. The former locations of the mill ponds and industries associated with the mill ponds are indicated on Figure 2.3.

2.3 Current Land Use and Discharges to Tributary One South

Between Francis Street and Mechanic Street, properties situated along Tributary One are occupied by residences and commercial businesses. A trailer park is situated along Tributary One south of Sherman Street (shaded yellow on Figure 2.4).

North of Sherman Street, properties situated along Tributary One include residences, wooded land, and agricultural fields. Stormwater runoff from these properties and village roadways drains to Tributary One.

The Village of Middleport Wastewater Treatment Plant discharges to the original east branch of Tributary One approximately 300 feet south of Pearson Road. Immediately north of this location, the Village's Culvert 105 storm sewer drainage ditch also discharges to the original east branch of Tributary One. Other drainage ditches and buried pipes that discharge to Tributary One are identified on Figure 2.1, to the extent known based on plans provided by the Village and observations made during the March 2004 stream profile survey.

FMC's existing State Pollutant Discharge Elimination System (SPDES)-permitted outfall (Outfall 001a) discharges to Tributary One between the Francis Street Bridge and the mainline railroad tracks. The discharge consists of treated water from FMC's water treatment plant (surface water runoff from the northern portion of the Facility and extracted groundwater) and untreated surface water runoff from the southern portion of the Facility. In addition, stormwater runoff from the Phase 2 Interim Corrective Measure (ICM) area of the FMC-owned North Railroad Property (abutting the Facility to the northwest) also discharges to Tributary One downstream of Outfall 001a. In the fall of 2008, FMC completed construction of an engineered cover system over the eastern portion of the former Northwest Conrail Area as part of the approved Phase 2 ICM for the North Railroad Property.

Water is released from the Erie Canal to Tributary One during and after precipitation events when the canal is full (during the summer and fall seasons) and at the end of the boating season in the fall. At times when the base flow of Tributary One is low, the contribution from the Erie Canal can comprise a majority of the total flow of Tributary One north of the Erie Canal.

2.4 Historical Land Uses

Historical uses of land in the Tributary One South Study Area are shown on Figure 2.3, based on information obtained from historical fire insurance maps and aerial photographs (provided in Appendix 2E of Volume I of the RFI Report). Former industries located along or near Tributary One South that may have contributed to discharges to Tributary One include a lumber and coal yard, Loud-Wendell, Inc. saw blade manufacturing plant, stave/saw mill, battery recycler, power plant, and a paper mill. In addition, some former orchards and agricultural fields have been historically situated near, or in some cases within, the Tributary One drainage area north of the Canal.

2.5 Review of Remediation Upstream of Tributary One Completed by FMC

Prior to 1977, process wastewater and surface water from the Facility were variously collected in several on-site lagoons, with outflow discharging to Tributary One through an underground sewer pipe (Outfall 001). For a number of years prior to 1977, discharge operations were conducted on a controlled basis to minimize impacts to the receiving stream from ammonia. This underground sewer exited the Facility at its northwestern boundary and joined with a portion of the Village of Middleport storm sewer system, which discharged to Tributary One beneath the Francis Street bridge (see Figure 2.1). In addition, stormwater runoff from a portion of the Facility discharged to the drainage ditches (North Ditch and South Ditch, collectively the "Northern Ditches") that ran along the north and south sides of the mainline railroad tracks, respectively, north of the Facility. These ditches emptied into the Village's Culvert 105 municipal storm sewer system, which flows to the north through a series of buried pipes and open ditches until it discharges to Tributary One immediately north of the Village of Middleport Wastewater Treatment Plant.

Between 1976 and 1978, FMC completed improvements for the handling of process wastewater and surface water at the Facility, including the following:

- Ceased discharge of process wastewater from the production of dithiocarbamates to the Eastern Process Wastewater Lagoon, with construction and operation of an evaporator system. Condensate from this system was discharged to the Village of Middleport Wastewater Treatment Plant;

- Re-graded the Facility to segregate surface water runoff from the north side of the Facility, where manufacturing and formulation activities continued to be conducted, from the south side, and to collect the surface water runoff from the north side in the Western Surface Impoundment for treatment;

- Ceased discharge of stormwater runoff to the Northern Ditches (which were owned by the railroad company prior to 2002), and constructed two additional surface water impoundments to provide retention capacity for surface water runoff from the north side of the Facility;

- Constructed an on-site water treatment plant to treat surface water runoff from the north side of the Facility;

- Plugged the existing buried sewer pipe (Outfall 001) and installed a new 30-inch buried sewer pipe (Outfall 001a) approximately 100 feet north of the existing pipe, along South Street; and

- Began discharge of treated water through the new pipe to Tributary One pursuant to the terms and conditions of the Facility's National Pollutant Discharge

Elimination System (NPDES) permit, which later became a State Pollutant Discharge Elimination System (SPDES), permit.

During 1987 and 1988, FMC constructed an engineered clay and asphalt cover (North Site Cover) over the northern portion of the Facility, removed soil/sediment from the inverts of the Northern Ditches, lined the ditches with a geotextile liner, clay, and stone, installed sub-drain collection systems, and conducted other surface impoundment pre-closure activities (refer to Section 4.2 of Volume I of the RFI Report for a detailed description of these activities) that further reduced the potential for any migration of contaminated surface water runoff from the Facility to the Northern Ditches, Culvert 105, and Tributary One.

In 1988 and 1989, FMC removed the Central and Eastern Surface Impoundments from service, closed the Central Surface Impoundment, and removed the sediments from and replaced the liner of the Western Surface Impoundment for use to collect and manage non-hazardous water.

In 2003, FMC removed the former outfall sewer pipe (Outfall 001) between the Facility and Main Street, and excavated soil along the pipe and from adjoining residential properties as an Interim Corrective Measure (ICM). Refer to Section 4.10 and Figure I4.11 of Volume I of the RFI Report for additional information on the 2003 West Properties Soil and Former Sewer Removal ICM.

In 2005, FMC completed the Phase 1 ICM project for the North Railroad Property which had been purchased from Conrail in 2002. The work activities included the excavation of impacted soils, the re-grading and re-direction of drainage areas to the Tributary One South inlet, and the construction of an engineered cover system over the Phase 1 ICM area. In the fall of 2008, FMC completed the Phase 2 ICM project for the North Railroad Property. The Phase 2 ICM activities included construction of an engineered cover system over the Phase 2 ICM area. Refer to Section 4.6.4 and Figure I4.5 of Volume I of the RFI Report for additional information on the North Railroad Property Phase 1 and Phase 2 ICMs.

2.6 Stream Classification and Wetlands

In the early 1990s, the NYSDEC reclassified Tributary One from a Class D intermittent flow stream to a Class C surface water, which is defined by the NYSDEC Water Quality Regulation (6NYCRR Part 701) as:

> *The best usage of Class C waters is fishing. These waters shall be suitable for fish propagation and survival. The water quality shall be suitable for primary and secondary recreation, although other factors may limit the use for these purposes.*

The National Wetlands Inventory identifies four wetland areas along Tributary One South (refer to Figure 2.1):

- PF01A wetland, 4.94 acres, between Sherman Road and Chase Road
- PEM1E wetland, 2.11 acres, south of Chase Road
- PEM1E wetland, 0.47 acres, north of Chase Road
- PEM1E wetland, 2.13 acres, north of the Middleport Wastewater Treatment Plant

A PFO1A wetland is a palustrine (freshwater) wetland that is vegetated with broad-leafed deciduous trees and/or shrubs, and that is briefly flooded during the year. A PEM1E wetland is a palustrine wetland that is vegetated with emergent perennial plants and that is subject to seasonal flooding and/or saturation.

The NYSDEC does not have record of known occurrences of rare or state-listed animals or plants, significant natural communities, or other significant habitats within or in the immediate vicinity of the Tributary One South Study Area (refer to September 13, 2008 letter from the NYSDEC provided in Appendix A). Tributary One is a tributary to Jeddo Creek, and occurrences of the long-eared sunfish, a listed threatened species, have occurred in Jeddo Creek.

3. Review of Sampling and Analysis

A chronology of the sampling and analysis programs conducted in the Tributary One South Study Area is presented in Table 3.1, including a summary of the analyses conducted in each program for soil, sediment, and surface water samples. The sampling and analysis activities conducted within the Tributary One South Study Area have included the following efforts:

- 1986 NYSDEC Soil/Sediment Investigation
- 1989 NYSDOH Soil Sampling Program
- 1990-1993 Off-Site Investigation (OSI)
- 1995 NYSDEC Sampling
- 1996 RFI Sampling
- 2002 RFI Sampling Program
- 2003-2004 Middleport Environmental Exposure Investigation
- 2004-2006 Soil Arsenic Bioavailability Studies
- 2004 RFI Sampling Program for Tributary One South & Culvert 105 – Phase I
- 2004 RFI Sampling Program for Tributary One South & Culvert 105 – Phase II
- 2005 RFI Sampling Program for Tributary One South & Culvert 105 – Phase III

Figure 3.1 identifies the 59 properties where samples were collected within the Tributary One South Study Area in at least one of the RFI Tributary One sampling events, the five properties (BC14, BH10, BH11, BH12, BI2) where samples were collected as part of another sampling event only, and the five properties (BH8, BI2, BJ5, AK1, and BO2) where samples were not collected during the 2004 and 2005 RFI sampling events because access permission could not be obtained. For reference, the Tributary One South Study Area has been divided into eight reaches (T1 to T8). The locations of the reaches are shown on Figure 3.2. The soil and sediment sampling locations are overlain on an aerial photograph of the Tributary One South Study Area on Figure 3.3, and are shown in detail on Figures 3.4 through 3.9. Surface water sampling locations are shown on Figure 3.10.

The soil and sediment analytical data from these programs are tabulated in Appendix B for arsenic in soil and sediment samples (organized by reach) and in Appendix C for all other constituents in soil and sediment samples. The surface water analytical data are provided in Table 3.2. As referenced in Sections 3.2 to 3.8 of this Volume V, descriptions of sample collection and validation of the analytical results for samples collected from 1986 to January 2004 were previously presented in reports submitted to the Agencies. A comparable description for RFI samples collected from 2004 through 2005 is provided in Sections 3.10 to 3.12 of this Volume V (validated results were previously provided to the Agencies).

3.1 FMC Master Compound List and Site-Specific Parameter Lists

A list of materials used and/or produced at the Facility prior to 1988, including known degradation products and impurities, is presented in a document titled “Master Compound List and Various Related Lists for Environmental Studies, FMC Corporation, Middleport, New York,” dated December 19, 1988 (hereafter called the Master Compound List) (FMC 1988). The Master Compound List was submitted to the NYSDEC in December 1988 together with site specific parameter lists for sampling program purposes and was included for reference in Appendix 2A of Volume I of the RFI Report.

From 1990 to 1993, FMC conducted an investigation of specific off-Site areas located around the Facility (called the “Off-Site Investigation” or OSI), including the Tributary One South Study Area, under an administrative consent order with the NYSDEC (NYSDEC and FMC 1990). Soil, sediment, and surface water samples were analyzed for constituents on the “Off-Site Parameter List” (provided for reference as Table 3.3 of this Volume V), which was developed as a sub-set of the Master Compound List based on criteria that included the quantity of a compound handled at the Facility, and its persistence and mobility in the environment. The list of 52 compounds on the Off-Site Parameter List included arsenic, lead, other metals, chlorinated pesticides, chlorinated herbicides, organophosphate pesticides, phenolic compounds, furans, and methyl carbamates.

3.2 1986 NYSDEC Soil/Sediment Investigation

The Niagara County Health Department collected sediment samples from the 0- to 6-inch depth interval at two locations along Tributary One South in 1986. These samples were analyzed by the NYSDOH for arsenic, lead, chlorinated pesticides, manganese and zinc. The results were provided in the NYSDEC report titled “Surface and Subsurface Soil/Sediment Investigations at Royalton-Hartland Schoolyard, Jeddo Creek, Culvert 105 Extension” (NYSDEC 1987). Sampling locations associated with this event are identified as “DEC-25” and “DEC-30” on Figures 3.4 and 3.6, respectively.

3.3 1989 NYSDOH Soil Sampling Program

The NYSDOH collected soil samples from the 0- to 3-inch depth interval at eight locations along Tributary One between Francis Street and the Erie Canal in January 1989. These samples were analyzed for arsenic, lead, and 19 other metals. The results were provided in the NYSDOH report titled “Soil Sampling Program, January 10-11, 1989, Study Design and Results, Middleport, NY” (NYSDOH 1989). Sampling locations associated with this event are identified as “DOH-11” through “DOH-18” on Figure 3.4.

3.4 1990-1993 Off-Site Investigation

During the OSI sampling from 1990 to 1993, the following samples were collected within or upstream of the Tributary One South Study Area:

- 13 soil samples from the 0- to 6-inch or 12- to 18-inch depth intervals at 11 locations
- 15 sediment samples from the 0- to 6-inch depth interval at 14 locations along the stream bed of Tributary One South
- Seven upstream sediment samples from the 0- to 6-inch or 6- to 12-inch depth interval at four locations from Tributary One or the Erie Canal (adjacent to the spillway discharge to Tributary One) to represent background conditions
- Five surface water samples at five locations along Tributary One South
- Three upstream surface water samples at three locations from Tributary One or the Erie Canal to represent background conditions

Initially in 1990, sediment samples could not be collected at locations south of the Erie Canal due to the absence of sufficient sediment; therefore, soil samples were collected from the banks in those locations (samples “T3” and “T4”), and are presented as soil in this RFI Volume V. In 1993, sediment samples were collected in these locations and others by forming composites of sediment found over an approximate 50-foot length of the Tributary One stream bed.

All of the above samples were analyzed for arsenic, lead, and chlorinated pesticides. Sub-sets of the samples were also analyzed for the other constituents on the Off-Site Parameter List (see Table 3.3), and for TOC. Two soil samples were also analyzed for leachable arsenic, lead, cadmium, copper, mercury, and chlorinated pesticides by the Toxicity Characteristic Leaching Procedure (TCLP). The results are presented in the “Off-Site Investigation Report” (OSI Report) (CRA 1993). Sampling locations associated with the OSI are identified as “S8” to “S15,” “T1” to “T7,” “SD-1” to “SD-11,” and “E-1.” Soil and sediment sampling locations are identified on Figures 3.4 to 3.8, while surface water sampling locations are identified on Figure 3.10.

Compounds detected in samples collected within the Tributary One South Study Area during the OSI included arsenic, lead, and chlorinated pesticide constituents, as well as other metals at levels consistent with background levels found in sediment samples collected from Tributary One south (upstream) of Francis Street and from the Erie Canal immediately upstream of the overflow to Tributary One during the OSI. The constituent that was most frequently identified at levels above background concentrations in the OSI soil and sediment samples was arsenic. To a lesser extent, lead and select chlorinated pesticides were identified at levels above background.

3.5 1995 NYSDEC Sampling

In November 1995, the NYSDEC collected two surface soil and six sediment samples from locations along Tributary One between Francis Street and Stone Road. All of the samples were analyzed for arsenic, and the soil samples were also analyzed for lead and for 21 other metals. The results were presented in two NYSDEC memoranda (NYSDEC 1996a and 1996b). The sampling locations associated with this event are identified as "9014##" on Figures 3.4 to 3.8.

3.6 1996 RFI Sampling

In July 1996, the NYSDEC collected a sample ("WSS18") from the upper 3 inches of soil at a residential property along Tributary One near Francis Street (see Figure 3.4). The sample was split with FMC and was analyzed for arsenic.

3.7 2002 RFI Sampling Program

In 2002, as a result of review of existing data and discussions with the Agencies, FMC undertook additional investigation work in a number of off-Site areas in accordance with an Agencies-approved work plan. This work included the collection of soil and sediment samples along 23 transects crossing Tributary One between Francis Street and Stone Road. A total of 820 soil and 32 sediment samples were collected from 208 locations and analyzed for arsenic, including samples from the 0- to 3-inch, 3- to 6-inch, 6- to 12-inch, 12- to 18-inch, and 18- to 24-inch depth intervals at each of the soil sampling locations (unless refusal was encountered), and from the 0- to 3-inch depth interval at each of the sediment sampling locations. In addition, 40 of the soil samples and two of the sediment samples were analyzed for lead and 22 of the soil samples and one of the sediment samples were analyzed for chlorinated pesticides. Further, one of the sediment samples was analyzed for TOC. The data were presented in the report titled "Draft 2002 Sampling Program Report" (CRA and GMX 2003a). The sampling locations are identified as "T#S," "T#W#," "T#E#," "C#S," "C#W#," or "C#E#" on Figures 3.4 to 3.8.

3.8 2003-2004 Middleport Environmental Exposure Investigation

From November 2003 through January 2004, FMC collected composite surface soil samples (0- to 3-inch, 0- to 6-inch or 0- to 12-inch depth intervals) as part of a Middleport residents' biomonitoring and exposure study. A total of 17 composite samples at eight properties were collected within the Tributary One South Study Area and analyzed for arsenic. The locations and arsenic concentrations of the samples collected within the Tributary One South Study Area are indicated on Figure 3.9 and in Table B.9 in Appendix B. The results of the investigation are presented in the report titled "Middleport Environmental Exposure Investigation" (Exponent 2004). The composite soil sampling and analysis activities performed as part of this study were not reviewed or approved by the Agencies. It should be noted that these composite

sample arsenic results are not directly comparable to grab sample arsenic results since they do not represent arsenic concentrations at specific sample locations, and that these composite results were not required by the Agencies nor used in the evaluation of site-related arsenic extent.

3.9 2004-2006 Soil Arsenic Bioavailability Studies

In 2004, Exponent, under contract to FMC, implemented an arsenic bioavailability study that included both laboratory (*in vitro*) and animal (*in vivo*) testing to supplement the findings of previous studies and to provide an estimate of the relative oral arsenic bioavailability in Middleport soil. Nine soil samples collected at six locations along the flood plain of Tributary One South were included in the soil samples used in this study. The sampling locations were selected based on the arsenic results reported from the 2002 RFI Sampling Program. Additional soil sample volume was collected for the bioavailability study at the following locations: T2E1 (0-3 inches), T2E1 (6-12 inches), T5E3 (0-3 inches), T5E3 (6-12 inches), T12E1 (0-3 inches), T13E4 (0-3 inches), T13E4 (6-10 inches), T15E4 (0-3 inches), and T16E2 (6-12 inches). All of the samples were used in the *in vitro* measurement of arsenic bioaccessibility, and two of the surface (0-3 inches) samples (T5E3 and T15E4) were also used in the *in vivo* testing in cynomolgus monkeys as part of a larger research study of oral bioavailability. A summary of the results was presented in a Technical Memorandum prepared by Exponent and submitted to the Agencies in September 2007 (Exponent 2007) (see Appendix 3D of RFI Volume I). It should be noted that the soil sampling results from these studies were not required by the Agencies nor used in the evaluation of site-related arsenic extent, and that the Agencies have not approved (or disapproved) the studies' performance or results.

3.10 2004 RFI Sampling Program for Tributary One South and Culvert 105 – Phase I

By letter dated November 14, 2003, the Agencies approved the sampling and analysis portions of the October 2003 document titled "Tributary One South of Pearson/Stone Roads & Culvert 105 North of the Erie Canal RFI/CMS Work Plan" (CRA and GMX 2003b), and directed FMC to implement the approved work. Implementation began in December 2003, with sample collection conducted in March and April 2004.

The sampling locations extended farther laterally from the stream along the 2002 transects, along additional transects, and at "remote borehole" locations not aligned with the transects. Soil samples were collected from the same depth intervals as the 2002 sampling program and from deeper samples in many of the boreholes if refusal was not encountered. The boring log information is summarized in Appendix D.

A total of 1,052 soil samples were collected at 208 locations and 16 sediment samples were collected at four locations within the Tributary One South Study Area and analyzed for arsenic. In addition, three of the soil samples were analyzed for lead and 20 of the soil samples were analyzed for chlorinated pesticides. The validated data

were provided to the Agencies on June 22, 2004 and July 8, 2004, and were approved by the Agencies on October 27, 2004.

3.11 2004 RFI Sampling Program for Tributary One South and Culvert 105 – Phase II

Based on the preliminary findings of the investigation activities conducted through May 2004, FMC submitted Addendum No. 2 to the RFI/CMS Work Plan (BBL and GMX 2004b) to the Agencies. This Addendum proposed additional sampling and analysis intended to:

- Collect soil samples for arsenic analysis outward from previously sampled transect locations
- Where possible, collect soil samples for arsenic analysis near previously proposed sample locations where access permission was not granted

Following receipt of approval, FMC collected a total of 316 soil samples at 57 locations and seven sediment samples at four locations in the fall of 2004, and analyzed the samples for arsenic. The samples were collected at the same depth intervals as employed in the 2004 RFI Phase I sampling event. The boring log information is summarized in Appendix D. The validated data were provided to the Agencies on July 12, 2005, and were approved by the Agencies on August 25, 2005.

3.12 2005 RFI Sampling Program for Tributary One South and Culvert 105 – Phase III

By letter dated September 21, 2005, the Agencies determined that additional investigation was needed along some of the transects and requested additional sampling and analysis. By cover letter dated October 27, 2005, FMC submitted Addendum No. 3 to the RFI/CMS Work Plan (BBL 2005) to the Agencies. By letter dated November 2, 2005 the Agencies approved Addendum No. 3, and directed FMC to implement the approved work. Implementation of the approved work began in November 2005, with sample collection conducted in November and December 2005.

A total of 69 soil samples were collected at 13 locations and were analyzed for arsenic, with 14 of the samples also analyzed for lead and 13 of the samples also analyzed for chlorinated pesticides. Samples were collected at the same depth intervals as employed in the 2004 RFI sampling events. The boring log information is summarized in Appendix D. The validated data were provided to the Agencies on March 9, 2006, and were approved by the Agencies on May 31, 2006.

4. Presentation of Tributary One South Study Area Data Sets

From 1986 through 2005, a total of 2,286 soil, 78 sediment and 5 surface water "combined" (refer to Section 4.1 below) arsenic results were obtained for samples collected by FMC and/or the Agencies (in some cases both FMC and the Agencies sampled the same location) within the Tributary One South Study Area. Duplicates and/or split samples were analyzed for approximately five percent of these samples for quality assurance/quality control (QA/QC) purposes. In addition, eight sediment samples and three surface water samples were collected from upstream areas to represent background conditions. Sub-sets of the samples were analyzed for lead, chlorinated pesticides, other metals, chlorinated herbicides, organophosphate pesticides, phenolic compounds, furans, and methyl carbamates.

Table 4.1 summarizes the number of soil, sediment, and surface water samples collected by FMC and the Agencies within the Tributary One South Study Area and analyzed for each group of constituents. Table 4.2 summarizes the number of these samples analyzed for arsenic during each sampling program.

The following sections discuss the combination of the data in each of the soil, sediment, and surface water data sets, and evaluate the data usability.

4.1 Combined Results

In this and other volumes of the RFI Report, analytical results for soil and sediment samples at a given unique sampling location and depth interval with more than one primary result (e.g., splits, duplicates) were combined to produce a single "combined" result for that sampling location/depth interval. The approach used to present the data and produce the combined results is as follows:

- If a single analytical result was present for a sampling location/depth interval, that value was used to represent the combined result.
- If multiple analytical results (e.g., splits, duplicates) were reported for a sampling location/depth interval, the arithmetic average of all results for that sample was used as the combined result.
- If an analytical result was reported as not detected (ND), then a value of one-half the reported laboratory detection limit was used in the calculations.
- For the few cases where a sampling location/depth interval was later re-sampled, the later results were treated as a separate sample, except as described in specific cases presented in Section 4.2.

4.2 Usability of Data

The existing soil, sediment, and surface water data for the Tributary One South Study Area are acceptable to use for the purpose of evaluating the nature and delineation of the extent of constituents, with the following limitations:

1. Duplicates of soil samples collected at location T4W1 and of a sediment sample collected at location T4S in early 2004 did not exhibit consistent arsenic concentrations. These locations were re-sampled in late 2004, and only the later results are used.

2. Changes over time are expected to occur within the stream environment, and hence older data are less likely to represent current conditions.

3. Elevated concentrations were reported for dichlorodiphenyltrichloroethane (DDT) and dichlorodiphenyldichloroethane (DDD) in a duplicate of sediment sample SD-7 that was collected in 1992 during the OSI, and are considered suspect. The concentrations for the sample duplicate are two orders of magnitude higher, indicating poor analytical precision. Also, the elevated concentrations reported for the duplicate are inconsistent with results for other upstream or downstream samples. Therefore, only the lower reported concentrations are used.

4. Soil samples collected in the 2004 Environmental Exposure Investigation (17 samples designated as “Y0##”) are composite soil samples. The data are valid and usable, but are not used in the delineation of the extent of arsenic presented in Section 8 because discrete samples are available in the data set that were collected from the same depths at nearby locations of properties included in the RFI Study Area.

5. Evaluation of Constituents in Surface Water

As described in Section 3.4 of this Volume V, surface water samples were collected from Tributary One as part of the OSI in 1990-1993. The locations of surface water samples collected from Tributary One South (T3 to T7) and from upstream background sections of Tributary One (T1 and T2) and the Erie Canal (E1) are shown on Figure 3.10.

No detectable levels of chlorinated pesticides, chlorinated herbicides, organo-phosphate pesticides, phenolic compounds, furans, or methyl carbamates were detected in any of the five Tributary One South surface water samples (see Table 3.2). Note that for several of the organochlorine pesticides, the detection limit was above the respective surface water quality criteria, and hence the lack of detection does not necessarily equate to lack of impact.

Six metals (arsenic, aluminum, iron, manganese, sodium, and zinc) were the only constituents identified at detectable levels in the surface water samples. These metals occur naturally in surface water as well as in soil and sediment. The detectable surface water results for the Tributary One South samples are compared in Table 3.2 to the concentrations observed in the upstream background samples and to the NYS Class C Surface Water Quality Standards (6NYCRR Part 703). The only metals that were identified at a concentration above the Surface Water Quality Standards were aluminum and iron. However, the concentrations of these metals were within the range observed in the background samples.

Arsenic was detected in only one of the five surface water samples, at a concentration of 16 ug/L, which is below the applicable Surface Water Quality Standard of 150 ug/L.

6. Identification of Soil and Sediment Background Concentrations and Screening Values

Soil and sediment samples collected in the Tributary One South Study Area have been tested for a wide range of constituents, including all constituents on the Off-Site Parameter List (refer to Table 3.3). This section identifies background concentrations and screening values for these constituents in soil and in sediment in the Tributary One South Study Area.

6.1 Background Concentrations of Metals in Soil

Arsenic, lead, and other metals occur naturally in soil, and may also be present due to a range of anthropogenic sources, such as the use of pesticides and fertilizers, use of coal and depositing of coal ash, use of pressure-treated wood, use of lead-based paint, disposal of household wastes, vehicle exhaust emissions, and the use of fill of unknown origin for excavation projects and grading.

From 1985 to 2003, several sampling and analysis studies were conducted by FMC and/or the Agencies to characterize background arsenic concentrations in Middleport soil (refer to Section 6 of Volume I of the RFI Report for a more detailed review of these studies). The most recent and comprehensive study was the 2001-2003 Gasport background study, proposed by the Agencies in the Background Study Work Plan (Agencies 2001). To implement this program, FMC collected surface soil samples from orchards, agricultural fields, undeveloped wooded properties, public properties, and residential properties (approximate locations of properties shown on Figure 6.1) in the nearby Village of Gasport, which was selected based on its similar soil geology and similar pattern of historical land uses to those found in Middleport, and its location outside any area that would have been affected by releases from the FMC Facility. The results of the 2001-2003 Gasport background study were presented in the report titled Development of Arsenic Background in Middleport Soils (CRA 2003), which was approved by the Agencies in June 2003. For ease of reference, the data collected in the 2001-2003 Gasport background study are provided in Table 6.1a and summarized in Table 6.1b, organized by type of land use (e.g., orchard, residential).

The 2001-2003 Gasport data were used in conjunction with the proportionate total area of historical land use types within a defined study area in the Village of Middleport (called the “Middleport Study Area”) to calculate an overall background level of arsenic in soil. This evaluation was used by the Agencies to identify a background concentration of arsenic in Middleport Study Area soil of 20 mg/kg for delineation purposes. Further discussion of this analysis is provided in Section 6 of RFI Volume I.

The background sampling programs conducted from 1985 to 1993 also included the analysis of soil samples for metals other than arsenic. The combined results for the other metals in soil samples collected at various locations approximately 0.5 to 2.0

miles east of the Facility and approximately 2.5 to 5.0 miles west of the Facility (locations shown on Figure 6.2) are presented in Table 6.2a.

6.2 Background Concentrations in Sediment

A total of 16 samples of sediment were collected from Tributary One at locations upstream (south) of Francis Street or from the Erie Canal upstream of its overflow to Tributary One (see Figure 6.3 for locations). These samples were collected at locations upstream of the Tributary One South Study Area and represent background conditions for sediment in Tributary One South. These background samples were analyzed for arsenic, with eight of the samples also analyzed for other constituents.

The analytical data for the background sediment samples are provided in Table 6.2b. All nine of the metals (including arsenic and lead) and five of the ten chlorinated pesticide constituents that were detected in sediment samples collected from the Tributary One South Study Area were also detected in the background samples.

6.3 Soil and Sediment Screening Values

As agreed with the Agencies and shown in Tables 6.3a to 6.3e for five sections of Tributary One South, respectively, the soil and sediment samples collected in the Tributary One South Study Area were assigned to one of three categories for comparison to the following screening values:

1. Residential Soil Screening Levels (SSLs) and residential Soil Cleanup Objectives (SCOs), with a sub-set of these samples also compared to the industrial SSLs and SCOs where applicable, for screening of potential human contact with flood plain soil

2. Ecological SCOs for screening of potential ecological receptors to flood plain soil

3. Sediment screening criteria for screening of potential ecological receptors to sediment in the stream and to stream bank soil and flood plain soil with potential to become sediment in the future

In 1996, the USEPA published a document entitled “USEPA Soil Screening Guidance: Technical Background Document,” which included Soil Screening Levels (SSLs) for some constituents and a health-based methodology for determining SSLs for other constituents. For each constituent, there is a SSL for residential property and a SSL for industrial property. SSLs applicable to FMC-related constituents were used in comparison to site data to develop soil sampling programs, and were presented in the 1999 Draft RFI Report (CRA 1999a). For constituents other than arsenic (which is compared to the background value of 20 mg/kg), the residential SSL values are provided in Table 6.4 and the industrial SSL values are provided in Table 6.5.

In 2006, the NYSDEC promulgated regulations which included Soil Cleanup Objectives (SCOs) for a wide variety of constituents, with each constituent having a number of SCOs in consideration of property type/usage, and both potential human and ecological receptors. The SCOs were developed from human health and ecological-based criteria, and in some cases, from a state-wide background database. The Agencies have indicated that the SCOs, presented in 6 NYCRR Subpart 375-6.8(b) of the NYSDEC regulations, are appropriate for use as comparison criteria in the RFI. For constituents other than arsenic (which is compared to the background value of 20 mg/kg), the residential SCO values are provided in Table 6.4 and the industrial SCO values are provided in Table 6.5. The ecological SCO values, including that for arsenic, are provided in Table 6.6.

The NYSDEC sediment screening guidance (1999) provides screening criteria for constituents (or groups of constituents) in sediment to evaluate potential impacts to human health and ecological receptors. For metals (including arsenic), the guidance includes two categories of screening criteria for benthic (sediment dwelling) organisms: the Lowest Effect Level (LEL) and the Severe Effect Level (SEL). For chlorinated pesticides and other synthetic organic constituents, the guidance includes three categories of screening criteria: Benthic Aquatic Life (both Acute and Chronic Toxicity), Wildlife Bioaccumulation (from bioaccumulation in ingested aquatic organisms), and Human Health Bioaccumulation (from bioaccumulation in ingested aquatic organisms). Each of these categories of criteria is included in this sediment evaluation. The screening criteria for each category are provided in Table 6.7.

7. Comparison of Soil and Sediment Analytical Data to Screening Values

Arsenic data define the horizontal and vertical limits of potential Site-related impacts in soil and sediment of the Tributary One South Study Area. The extent of other constituents at concentrations above soil and sediment screening values is within the extent of arsenic above background concentrations, however they should be considered during the performance of the CMS. This section documents the basis for this finding, while Section 8 provides an evaluation of the extent of arsenic in soil and sediment in the Tributary One South Study Area.

7.1 Comparison to Residential Soil Screening Values

The non-arsenic analytical data associated with applicable flood plain soil sample locations identified in Tables 6.3a to 6.3e are compared to the residential SSLs in Table C.1 of Appendix C and to the residential SCOs in Table C.2. A statistical summary of these data and a summary of the comparisons are presented in Table 7.1 for residential SSLs and Table 7.2 for residential SCOs.

The analyses included 853 samples for arsenic, 36 samples for chlorinated pesticides, 36 samples for lead, 10 samples for other metals and 3 samples for chlorinated herbicides, organophosphate pesticides, phenolic compounds, furans and methyl carbamates. Constituents detected in these soil samples included metals and chlorinated pesticides. No detectable concentrations of chlorinated herbicides, organophosphate pesticides, phenolic compounds, furans or methyl carbamates were identified. A total of eight samples contained a metal or a chlorinated pesticide at a concentration above the applicable residential SSL or SCO value. A summary of these constituents and samples is provided in the table below.

Constituents	Samples Above Residential SSL or SCO
DDT, DDE and DDD	T7W2 (12-18”)
Alpha- and Gamma-Chlordane and Heptachlor epoxide	BB8-3 (0-3”)
Lead	T7W2 (12-18”) and T9E3 (6-12”)
Iron	DOH-SS11 (0-3”), DOH-SS13 (0-3”), DOH-SS15 (0-3”) and DOH-SS17 (0-3”)
Manganese	S8 (0-6”)
Barium	DOH-SS17 (0-3”)
Chromium	DOH-SS17 (0-3”)

The presence of DDT, DDE, DDD and lead in sample T7W2 (12- to 18-inches) might not be attributable to FMC-related constituents via the Tributary One surface water pathway, based on the observed distribution of these constituents. This sample contains the highest concentrations of DDT, DDE, DDD and lead of any soil or

sediment samples collected from the Tributary One South Study Area, including samples located upstream of location T7W2. The concentrations of DDT, DDE and DDD in this sample are at least an order of magnitude higher than the concentrations detected in any other sample. While this sample was reported to contain elevated arsenic (118 mg/kg), the concentration is more than an order of magnitude below the highest levels identified in the Tributary One South Study Area.

The presence of alpha-chlordane, gamma-chlordane and heptachlor epoxide at location BB8-S3 might not be attributable to FMC-related constituents via the Tributary One surface water pathway for the following reasons. Sample location BB8-S3 is situated approximately 300 feet distant from and uphill of Tributary One (at Property BB8 in Reach T1). Numerous other samples from locations between this sample location and the stream exhibited non-detectable or significantly lower concentrations of these constituents. Further, in areas of known FMC impacts (i.e., along FMC's former outfall sewer that was remediated by FMC in 2003), chlordane and heptachlor epoxide were not typically detected at concentrations higher than DDT, DDD, and DDE, as is the case for sample BB8-S3.

The presence of the elevated levels of metals, other than possibly lead, might not be attributable to FMC-related constituents via the Tributary One surface water pathway for the following reasons. The metals lead, iron, manganese, barium and chromium are all naturally occurring in soil, and lead in particular is ubiquitous in soil in developed areas due to many common anthropogenic sources (e.g., historical usage in lead-based paint and as a gasoline additive). The maximum concentrations of iron and manganese are within the range for the background soil samples (Table 6.2a). Barium and chromium are not identified on the Off-Site Parameter List (Table 3.3). Further, the low frequency of noncontiguous observations of the metals above the residential SSLs or SCOs is not consistent with the distribution of arsenic in soil.

Arsenic data define the horizontal and vertical limits of potential Site-related impacts in soil/sediment in the Study Area. The extent of other constituents at concentrations above the soil screening values is within the extent of soil arsenic above background concentrations.

7.2 Comparison to Industrial Soil Screening Values

Three properties within the Tributary One South Study Area are zoned for industrial use (see Figure 2.4). As identified in Tables 6.3a and 6.3b, flood plain soil samples collected at 39 locations on these three properties were also compared to the industrial SSL and SCO values, in addition to the residential SSL and SCO values. These comparisons are made in Tables C.1 and C.2 in Appendix C, and are summarized in Table 7.3. Non-arsenic analyses at these locations included 2 samples for lead and 1 sample for other metals. None of the non-arsenic results for these applicable soil samples collected in the Tributary One South Study Area exceeds its industrial SSL or SCO value.

7.3 Comparison to Ecological SCOs

For applicable flood plain soil sample locations identified in Tables 6.3a to 6.3e, the arsenic and non-arsenic analytical data are compared to the ecological SCOs in Table B.2 of Appendix B and Table C.3 of Appendix C, respectively. A statistical summary of these data and a summary of the comparisons are presented in Table 7.4.

The analyses included 1,040 samples for arsenic, 18 samples for chlorinated pesticides, 22 samples for lead, 8 samples for other metals and 3 samples for chlorinated herbicides, organophosphate pesticides, phenolic compounds, furans and methyl carbamates. Constituents detected in these soil samples included metals and chlorinated pesticides. No detectable concentrations of chlorinated herbicides, organophosphate pesticides, phenolic compounds, furans or methyl carbamates were identified.

Arsenic was detected in these samples at concentrations ranging from 0.8 to 1,050 mg/kg, with 469 of the 1,040 samples (approximately 45%) containing more than its 13 mg/kg ecological SCO value. Lead was detected in these samples at concentrations ranging from 3.0 to 515 mg/kg, with 13 of the 22 samples (approximately 59%) containing more than its 63 mg/kg ecological SCO value. Other metals detected above the respective ecological SCO value include 3 of 3 samples for chromium, 6 of 8 samples for copper, 4 of 8 samples for mercury and 6 of 6 samples for zinc.

With respect to chlorinated pesticides, only DDT, DDE, DDD and dieldrin were detected in more than a few samples. The detected concentrations were above the ecological SCO value in approximately 80% of samples for DDT and DDE and approximately 20% of the samples for DDD and dieldrin. Note that in most cases for these constituents, the detection limit for samples reported as non-detect was above the ecological SCO value, which is typical for the analytical method used for these constituents.

The extent of non-arsenic constituents at concentrations above the ecological SCO values is within the extent of arsenic above its ecological SCO value and background concentration.

7.4 Comparison to Sediment Screening Criteria

As shown in Tables 6.3a to 6.3e, both sediment within the stream as well as stream bank soil and flood plain soil with potential to become sediment in the future were compared to the NYSDEC sediment screening criteria. For applicable sediment and soil sample locations identified in Tables 6.3a to 6.3e, the arsenic and non-arsenic analytical data are compared to the sediment screening criteria in Table B.3 of Appendix B and Tables C.4 to C.5c of Appendix C, respectively. A statistical summary of these data and a summary of the comparisons are presented in Table 7.5 for arsenic, lead and other metals, and in Tables 7.6 and 7.7 for pesticides.

The analyses included 454 samples for arsenic, 38 samples for lead, 20 samples for other metals, 43 samples for chlorinated pesticides, 16 samples for chlorinated herbicides and organophosphate pesticides, and 11 samples for phenolic compounds, furans and methyl carbamates. No detectable concentrations of chlorinated herbicides, organophosphate pesticides, phenolic compounds, furans or methyl carbamates were identified. The following is a discussion of the comparison for detected constituents.

7.4.1 Arsenic

Arsenic was detected in each of the 454 applicable soil and sediment samples, at concentrations ranging from 1.4 mg/kg to 4,090 mg/kg. Of these 454 results, 393 are above the LEL screening criteria of 6.0 mg/kg, and 271 are above the SEL screening criteria of 33.0 mg/kg. Arsenic was detected in each of the 16 background sediment samples, with concentrations ranging from 2.2 to 18.0 mg/kg. Eight of the background results are above the LEL screening criteria, and none are above the SEL.

7.4.2 Lead

Lead was detected in each of the 38 applicable soil and sediment samples, at concentrations ranging from 5.5 mg/kg to 276 mg/kg. Of these 38 results, 31 are above the LEL screening criteria of 31 mg/kg, and 11 are above the SEL screening criteria of 110 mg/kg. Lead was detected in 7 of 8 background sediment samples, with concentrations ranging from non-detect to 128 mg/kg. Four of the background results are above the LEL screening criteria and one result is above the SEL.

7.4.3 Other Metals

The following metals (other than arsenic and lead) were identified in at least one of the applicable soil or sediment samples at a concentration above the respective LEL screening criteria: cadmium, copper, iron, manganese, mercury, and zinc. Each of these metals was also observed at a concentration above its LEL at a similar frequency in the background sediment samples. Metals identified in at least one sample at a concentration above its SEL include copper and zinc in the Tributary One South samples and manganese and zinc in the background samples.

7.4.4 Chlorinated Pesticides

A summary of the comparison of the chlorinated pesticide data to the various categories of applicable sediment screening criteria is provided below. The screening criteria for some chlorinated pesticides are for groups of compounds or isomers (e.g., total chlordane). Further, the comparison requires a conversion of the data from the dry weight concentration in soil/sediment, as reported by the laboratory, to a total organic carbon (TOC)-adjusted concentration. This conversion was made using either a TOC measurement if available for that sample, or using an average value of all samples of 3.1 percent if a measurement was not available for that sample. Where the average

TOC value was used in this conversion, the TOC-adjusted results should be regarded as “estimated” values. Note that for many of these constituents, the detection limit is above the sediment screening criteria.

Benthic Aquatic Life: Five of the nine chlorinated pesticide constituents or groups with a benthic aquatic life sediment screening criteria were detected in at least one of the applicable samples at a concentration above the respective chronic toxicity screening criteria: DDT, total BHC, total chlordane, endosulfan I and total heptachlor and heptachlor epoxide. DDT was detected at a concentration above its chronic toxicity screening criteria in a background sediment sample. DDT and endosulfan I were detected at a concentration above the respective acute toxicity screening criteria.

Wildlife Bioaccumulation: Each of the seven chlorinated pesticide constituents or groups with a wildlife bioaccumulation sediment screening criteria had at least one applicable sample with a detected concentration above the screening criteria: total DDT, DDD, and DDE; total BHC; total chlordane; total aldrin and dieldrin; endrin and total heptachlor and heptachlor epoxide. Total DDT, DDD, and DDE and total aldrin and dieldrin were detected at concentrations above their wildlife bioaccumulation screening criteria in background sediment samples.

Human Bioaccumulation: Seven of the eight chlorinated pesticide constituents or groups with a human bioaccumulation sediment screening criteria had at least one applicable sample with a detected concentration above the screening criteria: total DDT, DDD, and DDE; total BHC; total chlordane; dieldrin; total aldrin and dieldrin; endrin and total heptachlor and heptachlor epoxide. Total DDT, DDD, and DDE, dieldrin, and total aldrin and dieldrin were detected at concentrations above their human bioaccumulation screening criteria in background sediment samples.

According to the NYSDEC sediment screening guidance, “it is not necessary in all cases and at all times to achieve these criteria through remediation efforts. Risk assessment, risk management, and the results of further biological and chemical tests and analyses are vital tools for managing sediment contamination.” Further, the guidance states that if the screening criteria are exceeded, then “a site-specific evaluation procedure must be employed to quantify the level of risk, establish remediation goals, and to determine the appropriate risk management actions.” The site-specific evaluation might include (for example), sediment toxicity testing or macroinvertebrate community surveys. These types of studies were conducted as part of the OSI (see Section 7.5), and in FMC’s opinion, significant impact to benthic aquatic life was not identified. It should be noted that the Agencies have advised that they have not accepted this conclusion and further that the 1993 results may not be indicative of current stream conditions. However, the Agencies believe that additional sediment bioassays or other field study of the sediment in the Tributary One Study Area is not necessary for completion of the RFI.

7.5 Review of 1993 Ecological Assessment

An ecological assessment was conducted as part of the OSI by ICF Kaiser Engineers (1993). The ecological assessment included a fish and wildlife impact analysis, which was performed in accordance with NYSDEC-approved work plans. Habitat and stream surveys, including a benthic macroinvertebrate community survey, were performed to identify various habitats and potential ecological receptors. In addition, sediment toxicity testing was performed on sediment samples collected from Tributary One. The results of the ecological assessment are presented in Appendix O of the 1993 OSI Report (CRA 1993).

The benthic macroinvertebrate survey included the collection of samples to identify the type and number of benthic invertebrates at locations both within and upstream of Tributary One South. The inventory obtained from this survey is provided in Table 7.6 of this Volume V (replicated from Table 4 of Appendix O of the OSI Report). According to the survey, there was no apparent trend in the number of benthic invertebrates found in the upstream and downstream samples, and intolerant organisms (e.g., mayflies, stoneflies, and caddis flies) were found in the downstream samples. The exceptions were lower numbers and less intolerant organisms were observed at sample locations immediately downstream of the Middleport Wastewater Treatment Plant.

Sediment bioassays were conducted for nine sediment samples (SD-3 to SD-11) from the Tributary One South Study Area and two upstream (background) sediment samples (SD-1 and SD-2). The bioassays were conducted using the amphipod *Hyalella azteca* and the dipteran *Chironomus tentans*. The results of this sediment toxicity testing are provided in Table 7.7 (replicated from Tables 9 and 10 of Appendix O of the OSI Report). For *H. azteca*, survival and growth in the Tributary One South sediment samples were consistent with the upstream samples, with the exception that survival was significantly lower for samples SD-10 and SD-11 (collected downstream of the Village Wastewater Treatment Plant), and growth was significantly lower for sample SD-5. For *C. tentans*, survival and growth in the Tributary One South sediment samples were consistent with the upstream samples, with the exception that survival was significantly lower for sample SD-10, and growth was significantly lower for samples SD-4 and SD-5.

Based on the results of the sediment chemistry, macroinvertebrate community survey, and sediment bioassays, FMC's OSI Report concluded that the benthic aquatic community of Tributary One was not significantly impacted by constituents in the sediments upstream of the Middleport Sewage Treatment Plant. It should be noted that the Agencies have not accepted the conclusions of this report and that the 1993 results may not be indicative of current stream conditions. However, the Agencies believe that additional sediment bioassays or other field study of the sediment in the Tributary One Study Area is not necessary for completion of the RFI.

8. Evaluation of Extent of Arsenic in Soil and Sediment

This section presents an evaluation of the horizontal and vertical extent of potentially Site-related arsenic in soil and sediment in the Tributary One South Study Area and demonstrates that the extent of arsenic has been sufficiently characterized for the purposes of the RFI in accordance with the terms and conditions of the AOC and Attachment 1 to the AOC. This evaluation includes the presentation of tables and figures that show the horizontal and vertical distribution of the soil and sediment arsenic data sets (Section 8.1), and a discussion of potential non-Site-related sources of arsenic in the Tributary One South Study Area (Section 8.2). Based on this evaluation, a summary of observations regarding the horizontal and vertical distribution of arsenic in soil and sediment is provided in Section 8.3.

8.1 Presentation of the Soil and Sediment Arsenic Data Set Distributions

Figure 8.1 is a frequency plot of the percentage of soil samples exhibiting a particular arsenic concentration for each of the 0- to 3-inch, 3- to 6-inch, 6- to 12-inch, 12- to 18-inch, 18- to 24-inch, and 24- to 30-inch depth intervals. These distributions indicate that arsenic concentration decreases with depth, with approximately 90 percent of the soil samples collected from the 24- to 30-inch depth interval exhibiting arsenic concentrations less than 20 mg/kg.

Table 8.1 presents the statistics of the soil arsenic data set, organized by transect or remote borehole locations within each reach. The statistics include the number of samples, minimum concentration, maximum concentration, arithmetic mean concentration for all sample depths, arithmetic mean concentration for all samples collected deeper than 12 inches, average concentration for samples collected from the upper 12 inches of soil, and average concentration for samples collected from the 12- to 24-inch depth interval.

The statistics that are provided in Table 8.1 are shown on Figures 8.2a through 8.2d for the transects versus distance downstream from Francis Street. Figure 8.2a shows the average concentrations for the upper 12 inches of soil. Figure 8.2b shows the average concentrations for soil samples collected from the 12- to 24-inch depth intervals. Figure 8.2c provides a side-by-side comparison of the 0- to 12-inch and 12- to 24-inch depth intervals. Figure 8.2d shows the maximum concentration for soil at all depths.

The statistics for the sediment arsenic data set are presented in Table 8.2, organized by reach. The average concentration in sediment versus distance downstream of Francis Street is shown on Figure 8.3a. The maximum concentration in sediment versus distance downstream of Francis Street is shown on Figure 8.3b.

The horizontal distribution of average arsenic concentrations, organized by reach of the stream, is shown on Figures 8.4 to 8.8, respectively, for the upper 12 inches of soil and on Figures 8.9 to 8.13 for the 12- to 24-inch depth interval. The horizontal distribution of

maximum arsenic concentrations, organized by reach of the stream, is shown on Figures 8.14 to 8.18, respectively, for the upper 12 inches of soil, Figures 8.19 to 8.23 for the 12- to 24-inch depth interval, and Figures 8.24 to 8.28 for soil deeper than 24 inches. The sample locations on these figures are color-coded based on the applicable average or maximum arsenic concentration in the associated depth interval at each location.

Cross-sections depicting the vertical distribution of the soil and sediment arsenic data at each location along each of the 41 sampling transects are provided in Appendix E.

The horizontal and vertical distribution figures show the extent of the 100-year flood plain for Tributary One as identified on FEMA flood insurance rate maps. As discussed in Section 2, FEMA is in the process of revising the flood plain mapping for this region of New York State.

8.2 Discussion of Potential Non-Site-Related Sources of Arsenic

Potential sources of arsenic that may exist within or adjacent to the Tributary One South Study Area not related to past Facility operations include:

- Application of arsenic-containing pesticides at historical orchards and in the treatment of trees
- Application of arsenic-containing pesticides, fertilizers, and lawn care and horticultural products (e.g., lime, potting soil, chicken manure) at agricultural fields, along railroad tracks, and landscaping activities
- Use of arsenic-containing wood treatment products and/or pressure-treated lumber for decks, play sets, docks, sheds, utility poles, fences, and other structures
- Storage of coal and depositing of coal ash
- Placement of arsenic-containing fill materials

References for these sources include http://pubs.usgs.gov/fs/2005/3152/, http://www.atsdr.cdc.gov/csem/arsenic/exposure_pathways.html, and http://www.dnrec.state.de.us/dnrec2000/Divisions/AWM/SIRB/Arsenic/.

One or more of these sources may have been associated with properties that contributed surface water runoff to the Tributary One South Study Area prior to commencement of investigation activities in the mid-1980s. Historical land uses at properties in the Tributary One South drainage area, including former orchards, agricultural land, coal-handling locations, and manufacturing operations, are presented on Figure 2.2, based on historical aerial photographs, Sanborn fire insurance maps, and information from property owners. Arsenic-containing pesticides were commonly used in Western New York in fruit orchards and for other agricultural purposes (Merwin

et al 1994, Bishop and Chisholm 1961, Peryea 2004, Dragun and Chiasson 1991, Woolson 1975, Gianessi and Phillips 1994, Woolson et al 1971). The presence of a potential non-FMC related arsenic source of contamination or arsenic source does not necessarily indicate the absence of FMC-related arsenic at these properties.

8.3 Summary of Extent of Arsenic

Review of the figures and tables referenced in Section 8 shows the following regarding the distribution of arsenic in soil and in sediment in the Tributary One South Study Area:

- The concentrations of arsenic in soil and sediment are highest within and along Tributary One, with concentrations decreasing with distance laterally from Tributary One. In areas where the flood plain rises in elevation more steeply, the concentrations in soil decrease within a shorter distance laterally from the stream.

- The horizontal extent of arsenic in flood plain soil has been adequately evaluated. Arsenic concentrations in the soil sampling locations situated the farthest laterally from Tributary One are below or approach 20 mg/kg for each transect, except in locations where access permission could not be obtained (transects T14.5, T15, T17.5, T21, C11, C12 and C13).

- The vertical extent of arsenic in stream bank soil and flood plain soil has been adequately delineated. The highest concentrations of arsenic are found in the upper 12 inches of soil for approximately 80% of sampling locations with data available to a depth of at least 18 inches. The vertical extent of impact greater than 20 mg/kg arsenic is primarily limited to the upper 24 inches of soil, with less than 10 percent of soil samples collected from the 24- to 30-inch depth interval containing greater than 20 mg/kg arsenic. In some places, bedrock is present within the upper 24 inches of soil.

- The horizontal and vertical extent of arsenic in sediment has been adequately delineated. Many portions of the Tributary One South stream bed do not contain any sediment or only trace amounts of sediment overlying bedrock. In sections of Tributary One South that do contain sediment, samples could only be collected deeper than 6 inches in a few places. In these locations, the shallowest depth interval of sediment frequently contains a lower arsenic concentration than deeper sample intervals.

- The extent of arsenic in soil and sediment along Tributary One downstream of Stone Road will be addressed in separate RFI volumes.

9. Proposed Corrective Measures Study Area

This section presents the basis for the selection of the areas described in this Volume V of the RFI Report to be included in the CMS for the Tributary One South Study Area. Areas proposed for inclusion in the CMS are highlighted green on Figure 9.1 for the entire Tributary One South Study Area and on Figures 9.2 to 9.6, respectively, by dividing the study area into five sections of the stream. The proposed CMS area includes all or portions of 62 properties.

The extent of the proposed CMS Area (as shown in green on Figures 9.1 to 9.6) was delineated based on the soil and sediment arsenic data distribution, surface topography, stream and surface water drainage hydrology and historical land use.

Discrete soil and/or sediment samples were collected from 60 properties included in the RFI study area for Tributary One South. Of these 60 properties, 10 properties are proposed for exclusion from the CMS Area, as listed below:

- BB8, BC5, BC7, BC8, BC9, BC10, BG2, BJ8, BK2 and BK3

The locations of these properties are shown by a yellow outline on Figures 9.1 to 9.6, and Table 9.1 shows the range of soil arsenic concentrations and the basis for exclusion for each property. The soil arsenic concentration data collected at these properties are consistent with the Gasport background soil data for residential properties, with consideration given to normal data variability, with the exception of a couple samples where a potential non-FMC related source was noted.

Based on the interpolation between data points, areas at 16 properties are proposed for inclusion in the CMS Area, but either no discrete soil arsenic data exist because sampling was not proposed as part of the RFI study (10 properties), no samples were collected from the property due to lack of access permission (2 properties), or only a portion of the proposed sampling at that property was completed due to limited access permission (4 properties). These areas are shown as black hatch lines on Figures 9.1 to 9.6, and the corresponding properties are listed below:

- BD3, BD4, BD5, BE3, BE4, BH8, BH10, BH11, BH12, BH13, BH14, BI1, BI2, BJ5, AK1 and BO2

Additional soil sampling and analysis in these areas may be conducted during the CMS or Corrective Measures implementation, if access can be obtained.

10. Findings

A review of the analytical data collected from the Tributary One South Study Area yields the following findings:

1. Flood plain soil, stream bank soil, and stream bed sediment in the Tributary One South Study Area have been adequately evaluated for constituents that were historically manufactured, formulated, handled, or used at the Facility. The data set includes arsenic results for 2,286 soil samples and 78 sediment samples, with split and/or duplicate analyses conducted on approximately five percent of these samples for QA/QC purposes. Sub-sets of the samples were analyzed for lead, other metals, chlorinated pesticides, chlorinated herbicides, organophosphate pesticides, phenolic compounds, furans, and methyl carbamates.

2. The constituent most frequently detected above background levels in soil and sediment was arsenic. To a lesser extent, lead and some chlorinated pesticides were detected. No detectable levels of chlorinated herbicides, organophosphate pesticides, phenolic compounds, furans, or methyl carbamates were identified.

3. Arsenic defines the extent of potential Site-related impacts to soil and sediment in the Tributary One South Study Area. The limits of any other potential FMC-related constituents are within the delineated limits of arsenic presence above 20 mg/kg.

4. The horizontal and vertical extent of arsenic has been sufficiently delineated to 20 mg/kg in the Tributary One South Study Area flood plain soils, except for areas where access permission could not be obtained for sampling.

5. In 1993, surface water analysis indicated that arsenic was not present at concentrations above the applicable Class C surface water quality standard, even in areas where elevated concentrations of arsenic were found in soil and sediment. Other constituents detected in soil and sediment (lead, chlorinated pesticides) were not detected in surface water in 1993. Notwithstanding, potential migration of soil and sediment containing elevated concentrations of FMC-related constituents via erosion and surface water migration will be further evaluated in the CMS.

Based on the above findings, it is concluded that there are sufficient and usable analytical data to support the development of the CMS and to identify and evaluate corrective measures alternatives.

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