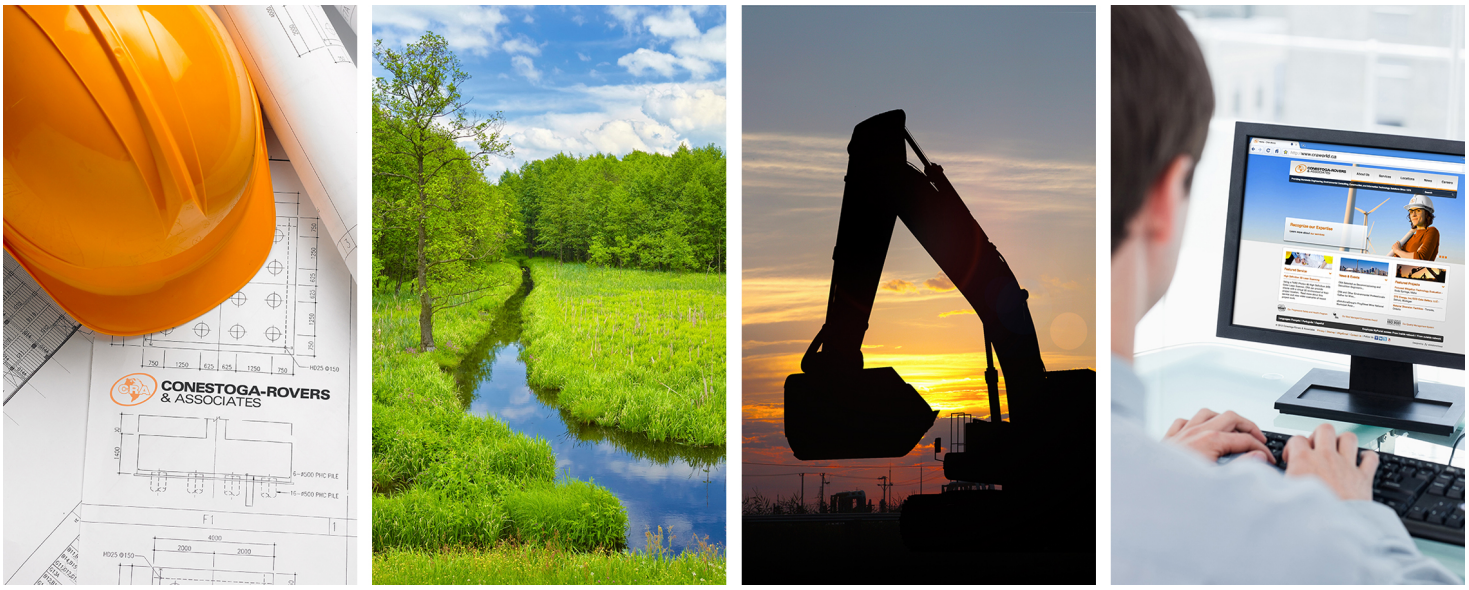
ABRIDGED to fit size requirements for Web Page Refer to Document Repository for Complete Version

CRA Infrastructure & Engineering, Inc.

www.CRAworld.com



Final Engineering Report

Frontier Chemical Site
Niagara Falls, New York

Prepared for: Frontier Chemical Royal Avenue Site PRP Group
(an unincorporated association)

CRA Infrastructure & Engineering
285 Delaware Avenue, Suite 500
Buffalo, New York 14202

April 2014 • 047392 (15)

Partners in Sustainability

CERTIFICATION

I, Robert G. Adams, am currently a registered professional engineer licensed by the State of New York. I certify that the Remedial Action was implemented and that construction activities were completed in substantial conformance with the Department-approved Remedial Design Report.

I certify that the data submitted to the Department with this Final Engineering Report demonstrates that the remediation requirements set forth in the Remedial Design Report and in applicable statutes and regulations have been or will be achieved in accordance with the time frames, if any, established in for the remedy.

I certify that use restrictions, Institutional Controls, Engineering Controls, and/or any operation and maintenance requirements applicable to the Site are contained in an environmental easement created and recorded pursuant to ECL 71-3605 and that affected local governments, as defined in ECL 71-3603, have been notified that such easement has been recorded.

I certify that a Site Management Plan has been submitted for the continual and proper operation, maintenance, and monitoring of Engineering Controls employed at the Site, including the proper maintenance of remaining monitoring wells, and that such plan has been approved by Department.

I certify that documents generated in support of this report have been submitted in accordance with the DER's electronic submission protocols and have been accepted by the Department.

I certify that data generated in support of this report have been submitted in accordance with the Department's electronic data deliverable and have been accepted by the Department.

I certify that all information and statements in this certification form are true. I understand that a false statement made herein is punishable as a Class "A" misdemeanor, pursuant to Section 210.45 of the Penal Law. I, Robert G. Adams, of CRA Infrastructure & Engineering, 285 Delaware Avenue, Buffalo New York, am certifying as the Owner's Designated Site Representative and I have been authorized and designated by the site owners to sign this certification for the site.

Robert G. Adams

Robert G. Adams, P.E.
CRA Infrastructure & Engineering, Inc.
New York License Number 064918

APRIL 15, 2014

Date

Table of Contents

Page

List of Figures
(Following Text)

List of Tables
(Following Text)

List of Appendices

List of Drawings
(Following Appendices)

Drawing 1	Final Base of Excavation Area Contours
Drawing 2	Elevation of Top of Non-Source Soil Backfill Contours
Drawing 3	Elevation of Top of Treated Source Soil Backfill Contours
Drawing 4	Elevation of Top of Crushed Concrete/Imported Stone Contours
Drawing 5	Cross-Section Location
Drawing 6	Cross-Section of Excavated and Backfill Areas

List of Acronyms and Abbreviations

ARAR	Applicable or Relevant and Appropriate Requirement
ASTM	American Society for Testing and Materials
BMP	Best Management Practice
btu	British thermal unit
cm/sec	Centimeters per Second
CRA	CRA Infrastructure & Engineering, Inc.
COC	Contaminant of Concern
cy	Cubic Yard
ESA	Environmental Services Associates, Inc.
ESC	Erosion and Sediment Control
eV	electron volt
feet bgs	Feet Below Ground Surface
Frontier Group	Frontier Chemical Royal Avenue Site PRP Group
FFS	Focused Feasibility Study
GAC	Granular Activated Carbon
HASP	Health and Safety Plan
ISCO	ISCO Chemical Company
NAPL	Non-Aqueous Phase Liquid
MCL	Maximum Contaminant Level
mg/kg	Milligrams per Kilogram
NYCRR	New York Codes, Rules and Regulations
NYSDEC	New York State Department of Environmental Conservation
NYSDOT	New York State Department of Transportation
OM&M	Operation, Maintenance, and Monitoring
PID	Photoionization Detector
ppm	parts per million
RA	Remedial Action
RAOs	Remedial Action Objectives
RCRA	Resource Conservation and Recovery Act
RD	Remedial Design
RI	Remedial Investigation
RI/FS	Remedial Investigation and Feasibility Study
ROD	Record of Decision

List of Acronyms and Abbreviations

Site	Frontier Chemical Site
TCLP	Toxicity Characteristic Leaching Procedure
TENORM	Technically Enhanced Naturally Occurring Radiological Material
TSD	Treatment, Storage and Disposal
U.S. EPA	United States Environmental Protection Agency
VOCs	Volatile Organic Compounds
SIU	Significant Industrial User

Section 1.0 Introduction

1.1 General

CRA Infrastructure & Engineering, Inc. (CRA), on behalf of the Frontier Chemical Royal Avenue Site PRP Group (Frontier Group) (an unincorporated association), has prepared this Final Engineering Report (FER) for submittal to the New York State Department of Environmental Conservation (NYSDEC) for the Frontier Chemical Site (NYSDEC Index # 89-0571-00-01) (Site). This FER has been prepared in accordance with NYSDEC guidance for documenting the implementation of the Site remedy as specified in the Remedial Design Report (CRA - February 2013) and in the Order on Consent & Administrative Settlement executed on March 27, 2013 (see Appendix A). The Site remedy includes the source area soil component and the Site conditions (i.e., Site cover) component, both of which have been completed. The Site conditions remedy is consistent with the Record of Decision (ROD) (see Appendix B) requirement to maintain the existing concrete/asphalt cap over the Site to the extent possible, and to cover any soil cap areas with 1 foot of clean material. The remaining component of the Site remedy involves the groundwater, which is an ongoing activity.

In the ROD issued for the Site in 2006, the selected soil remedy consisted of excavation, trucking, and off-Site treatment/disposal of source area soil at a permitted waste facility. Between 2008 and 2010, the Frontier Group performed pre-design investigation activities associated with the soil remedy, resulting in an improved understanding of Site conditions compared with that available at the time the ROD was issued. In the years leading up to the implementation of the soil remedy, considerable improvements in remedial technologies for soil were developed that had been implemented at many locations. Based upon an improved understanding of Site conditions and upon improved remedial technologies for soil, it was determined that remedial alternatives other than the ROD-selected "dig and haul" remedy may be more suitable for the Site. Consequently, the NYSDEC requested that the Frontier Group re-evaluate the soil remediation alternatives for the Site. This re-evaluation was performed and a Focused Feasibility Study (FFS) outlining the results of the re-evaluation was submitted to the NYSDEC in November 2011. The FFS concluded that the remedial alternative consisting of excavation and on-Site thermal treatment of source area soil was a superior remedy to the ROD-selected remedy. In addition, the excavation and on-Site treatment of source area soil remedy was more consistent with New York's green remedy mandate (NYSDEC DER-31/Green Remediation), and therefore a more appropriate remedial alternative.

Given this determination and NYSDEC approval, the Frontier Group prepared a Remedial Design Report providing details of the various components of the updated Site remedy, including excavation and on-Site treatment of the source area soil. The Remedial Design Report presented the measures necessary to meet the Remedial Action Objectives (RAOs) for the Site and provided the technical requirements in sufficient detail to allow the implementation of the soil remedy to proceed. Additional final details of the soil treatment remedy were provided by the remediation contractor as the remedy progressed.

In addition, the Remedial Design Report provided the information necessary to implement the groundwater component of the remedy. The shallow groundwater remedy for the Site has been implemented in accordance with the remedy selected in the ROD. A Significant Industrial User Permit has been obtained from the Niagara Falls Water Board to accept and treat shallow groundwater from the Site. A study of the deep bedrock groundwater (designated OU2) was completed in accordance with the Supplemental Soil Characterization and Pilot Test Work Plan (CRA, November 2007). The study determined that a remedy consisting of Monitored Natural Attenuation is the appropriate remedy for deep bedrock groundwater and the remedy was adopted in the OU2 ROD issued in March, 2011.

The combination of these three components of the remedy (source area soil, Site conditions, and groundwater) constitutes the entire Site remedy.

1.2 Remedial Action Objectives

RAOs were identified in the 2006 ROD and are still valid. The RAOs for the source area soil (the areal extent of which was determined by subsequent investigations and negotiation with the NYSDEC) are summarized as follows:

- Eliminate to the extent practicable the potential for direct contact with the contaminated subsurface soil
- Reduce the risk of further contamination of the groundwater by reducing the potential for leaching of contaminants into the groundwater
- Eliminate to the extent practicable the potential for human exposures to organic vapors in Site buildings, structures, and subsurface utilities

In conjunction with the implementation of institutional controls, the excavation and on-Site treatment of source area soil best achieves these RAOs. Further, this remedy also enhances and complements the remedial components selected for the Site groundwater and other Site conditions.

The remediation goals for groundwater include the following:

- Eliminate, reduce, or control to the extent practicable the off-Site migration of VOCs and SVOCs within the overburden groundwater and within the bedrock groundwater zones of concern
- Attain to the extent practicable the ambient groundwater quality standards

The groundwater remedy selected in the ROD for the shallow groundwater properly and sufficiently meets these goals. Further, the groundwater remedy selected for the deep bedrock groundwater properly and sufficiently meets these goals.

1.3 Purpose of Report and Report Organization

The purpose of this FER is to document the remedy that was implemented at the Site. The final remedial design (Remedial Design Report – CRA - February 2013 that was attached to the Order on Consent & Administrative Settlement – March 2013) was based on the results of the Supplemental Remedial Investigation (Ecology & Environment Engineering, P.C., 2002); Feasibility Study (FS) (Ecology & Environment Engineering P.C., 2004); Remedial Pre-Design Investigation (CRA, September, 2010) and Focused Feasibility Study (FFS) (CRA, November 2011).

The content of this FER follows the requirements specified in the NYSDEC DER-10 Technical Guidance for Site Investigation and Remediation. The remainder of this Report is organized as follows:

Section 2.0	Project Description
Section 3.0	Summary of the Remedy
Section 4.0	Remedial Pre-Design Investigation Results
Section 5.0	Remedy Elements
Section 6.0	Institutional Controls/Engineering Controls
Section 7.0	Modifications to the Approved Remedial Design
Section 8.0	Final Site Conditions
Section 9.0	Operation, Maintenance, and Monitoring Requirements
Section 10.0	Summary
Section 11.0	References

Section 2.0 Project Description

The following subsections present a brief description of the Site, its history of operation, and the selected remedy for the source area soil, groundwater, and Site conditions. Additional Site background and project details can be found in the previously mentioned reports.

2.1 Site Description

This former permitted Treatment, Storage and Disposal (TSD) Site is an inactive 9-acre parcel located at 4626 Royal Avenue within the industrial area of the City of Niagara Falls, New York (see Figure 2.1). The Niagara River lies about 1 mile south of the Site.

The Site is bordered to the north by property identified as owned by Sentry Metals, to the northwest and west by property identified as owned by Norampac, to the south by Royal Avenue, beyond which is Elkem Metal Company, and to the east by 47th Street, beyond which is an industrial site (Strator).

The property had historically been the site of a chemical manufacturing facility and then later became a NYSDEC TSD-permitted facility, storing and treating chemical wastes from 1974 until December 1992, when the facility closed. When in operation, approximately 25,000 tons of chemical wastes were treated each year.

2.2 Site History

The Site was originally developed in 1906 by ISCO Chemical Company (ISCO) as a caustic-chlorine plant. During World War II, the International Minerals and Chemicals Corporation bought the Site and operated the facility as a caustic soda/potash and chlorine plant. In 1977, the Frontier Chemical Company, which provided hazardous and non-hazardous chemical treatment, moved their operations to the Site from Pendleton, New York. Frontier Chemical expanded its on-Site operations, which included wastewater treatment, fuels blending, and bulking chemicals for off-Site disposal. The Site held a NYSDEC permit.

In 1985, Frontier Chemical and a sister company, BLT Services, Inc., became wholly owned subsidiaries of Environmental Services Associates, Inc. (ESA). In February 1990, ROE Consolidated Holdings assumed operational control of ESA, which had operational control of the Site. The current Site owner is 5335 River Road, Inc.

The facility ceased operations in December 1992. Beginning in 1999, most of the Site's buildings were demolished to grade leaving some rubble behind on Site. In 2012, the Frontier Group demolished the remaining buildings and disposed of the debris (including the debris from the previous rubble pile) at a permitted disposal facility. To the extent practicable, the concrete and brick from the demolition of the buildings and from the former debris pile have been retained on Site, crushed, and used as part of the Site's final cover. The Site remains a vacant industrial property and is secured with a perimeter fence.

2.3 Subsurface Conditions

The overburden thickness ranges from 14.7 feet to 17.1 feet. It consists of up to 2 feet of fill material (topsoil, silt, sand, and gravel with some cinder blocks, glass, wood, slag, bricks, crushed stone, concrete, and asphalt) followed by 12 feet to 15 feet of silty clays overlying the bedrock. The natural soils encountered generally consist of brown to red to green silty clays or fine sand and silt, with trace gravel at most localities.

Bedrock underneath the Site is classified as Lockport Dolomite.

2.4 Nature and Extent of Source Area Soil

Due to the long history of industrial activities at the Site, there were a variety of contaminants detected in the subsurface (soil and groundwater). The nature and extent of source area soil were originally determined through the remedial investigations that were performed on the Site in the 1990s and early 2000s. Additional delineation was performed as part of the pre-design work for the final remedy. This work expanded the understanding of the nature and extent of source area soil and groundwater impact. The additional investigation and pre-design were implemented pursuant to NYSDEC-approved work plans.

Although there are a variety of contaminants present on the Site, Volatile Organic Compounds (VOCs) are the primary contaminants of concern with regard to the soil and groundwater remediation. This was determined in the 2004 Feasibility Study based on the following factors:

- Historic operations at the Site included treatment and storage of chemical wastes that primarily included a variety of VOCs
- VOCs were the contaminants detected most frequently and at the highest concentrations
- In general, other types of contamination detected were located proximate to the areas significantly contaminated with VOCs

Consequently, VOCs were used in the Supplemental Remedial Investigation (2002) to delineate the source area soil that required remediation. That report used the analytical data from 29 soil samples that had been collected and analyzed for chemical presence to delineate the extent of contamination in the soil. NYSDEC used this initial delineation to select the remedy for the source area soil in the ROD.

As part of the remedial pre-design investigation performed by the Frontier Group between 2008 and 2010, an additional 174 samples were collected and analyzed. This work vastly improved the delineation of the nature and extent of the source area soil in both the horizontal and vertical direction. This delineation of the source area soil was approved by the NYSDEC on October 13, 2010 as part of the approval of the Remedial Pre-Design Investigation Report (CRA September 2010) and as specified in the Order on Consent & Administrative Settlement (March 2013).

Using all of the available soil data, a set of figures depicting the source area soil approved for remediation is presented on Figures 2.2 through 2.9. Each successive figure presents a 2-foot interval of the soil horizon, starting with the interval at the ground surface and descending to the bottom interval overlying the top of bedrock, which is located at a depth of approximately 16 feet below ground surface (bgs). As can be seen on the figures, there were considerable discontinuities in the adjoining and overlying/underlying areas that were considered source area soil. This is indicative of a multi-release site.

This delineation of source area soil extended beyond the vertical and horizontal limits of the soil that exceeds the cleanup criteria in 6 NYCRR Part 375-6, regulations that were promulgated after the ROD was issued. Although the 6 NYCRR Part 375-6 criteria would require considerably less soil to be defined as source area soil requiring remediation, the NYSDEC and Frontier Group established the horizontal and vertical delineation of the source area soil to constitute the remediation area identified through the NYSDEC-approved remedial pre-design investigation. This delineation is consistent with the remedial objectives of the 2006 ROD.

The pre-design investigations performed by the Frontier Group also provided information on the deep bedrock groundwater beneath the Site. The deep bedrock (identified as Zones C through E), which encompasses the depths of 30 feet through 90 feet below the top of bedrock, was investigated through the installation of three deep bedrock well nests. The sampling of these wells identified the following:

- There is minimal chemical presence in the deep bedrock zones
- There is a continual upward vertical gradient that extends from the E Zone to the D Zone to the C Zone to the B Zone. This upward gradient restricts downward groundwater and chemical migration from the Site

Section 3.0 Summary of the Remedy

This section describes the major components of the remedy as defined in the ROD and its subsequent modifications. Most of the remedial components had previously been implemented, although a few, such as the institutional controls, are currently being implemented by the property owner as part of the final remediation implementation. All of the remedial components are briefly discussed in this section to demonstrate that the combined effect will eliminate any significant threats to public health and the environment, and will ensure continued protection of human health and the environment.

The remedial components consist of the following:

- Physical Controls

  Fencing and warning signs are being used to restrict access to the facility to deter vandalism and control trespasser exposure. Those areas of the Site that were disturbed by the soil remedy's excavation have been capped with 1 foot of clean material (crushed concrete/asphalt/demolition debris or imported quarried stone). All existing soil-exposed surfaces across the Site were similarly capped with 1 foot of clean material. The remainder of the Site is covered with concrete or asphalt and will remain with these hard surface covers.

- Institutional Controls

  Institutional controls have been put in place to reduce the potential for exposure to the residual contaminants of concern. The Site will remain as an industrial zoned property and an environmental easement (See Appendix C) and title notices have been put in place by the property owner to document appropriate precautions for any residual constituents that will remain on Site.

  The NYSDEC regulates the installation of new groundwater extraction projects in New York State and therefore, in conjunction with the institutional controls, is in a position to confirm that groundwater beneath the Site is not inappropriately extracted or diverted from its current flow path without proper precautions being taken. The institutional controls ensure that future Site buildings incorporate appropriate vapor control measures to protect indoor air quality. The owners of the property will allow and monitor all appropriate institutional controls placed upon the Site.

- Groundwater Remedies

  The overburden and shallow bedrock groundwater beneath the Site is hydraulically controlled by the bedrock sewer tunnels along 47th Street and Royal Avenue. These tunnels draw all of the shallow groundwater in the area (including from beneath the Frontier Site) toward them. The groundwater, once having infiltrated the tunnels, flows to the City of Niagara Falls wastewater treatment plant where it is treated. A Significant Industrial User Permit has been issued to the Frontier Group by the Niagara Falls Water Board to allow this infiltration and treatment of Site groundwater to occur under proper authorization.

  While the Niagara Falls Water Board has closed a portion of the Falls Street Tunnel along Royal Avenue, the closure does not include the entire portion of the tunnel adjacent to the Frontier Site. The closure caused the groundwater elevation in the bedrock immediately adjacent to the closed portion of the tunnel to rise in elevation by a few feet. Since the 47th Street Tunnel and a portion of the Falls Street Tunnel adjacent to the Site remain open, the groundwater in the shallow bedrock beneath the Site changed from its previous southeasterly flow direction to a more easterly flow path, but is still intercepted by the open sections of the tunnels. The groundwater flow conditions continue to be monitored under the Significant Industrial User Permit.

  The deep bedrock groundwater was investigated during the remedial pre-design and determined to be protected from the chemicals on the Site by upward hydraulic gradients that prevent any aqueous phase chemical from reaching the deep bedrock groundwater flow regime. While there are some chemicals present in the deep bedrock groundwater, their concentrations are low and they do not pose a significant environmental risk. A monitored natural attenuation remedy has been selected for the deep bedrock groundwater and has been incorporated in the OU2 ROD (March 2011).

- Site Conditions

  Most of the Site buildings/structures were demolished in 1999 or shortly thereafter. The remaining buildings and structures were demolished in 2012. The Site is currently vacant, but plans are being

prepared to use the Site in the near future as a vehicle parking area. This use would be in compliance with the industrial zoning for the Site.

- Site Cap

  Most of the current surface area on the Site is hard surface cover consisting of asphalt or concrete. This surface prevents contact with Site contaminants. Smaller areas of the Site have soil cover and the implemented soil remediation (excavation and on-Site treatment of source area soil) created additional soil covered areas. Upon completion of the soil remedy, the soil cover areas were capped with 1 foot of clean material. Based on the expectation that the Site will be used as a vehicle parking area in the near future, the most practical material to use as the cover material was the crushed concrete/asphalt/demolition debris from the soil remediation project. To the extent necessary, the crushed concrete asphalt/demolition debris was supplemented with imported quarried stone to complete the capping of the soil covered areas. This material is capable of supporting truck traffic that may traverse the Site if used as a vehicle parking area. Figure 3.1 shows the final cover areas following the completion of the soil remediation.

- Long-Term Operation, Maintenance, and Monitoring

  With the source area soil having been treated, there is no need for ongoing operation, maintenance, and monitoring (OM&M) activities associated with the remaining soil. However, it is noted that the groundwater remedies will require some OM&M activities, primarily groundwater sampling. The only other physical remedial component at the Site will be the fence (portions of which may be moved to locations remote from the Site's boundary to match future use of the Site) and appropriate signage that will provide for the continued security of the Site. All other long term remedial components are institutional in nature. This includes restrictions and guidelines associated with potential future use or activity at the Site. These restrictions and guidelines are defined by the institutional controls established for the Site and are provided in the Site Management Plan, which is provided as Appendix D.

Section 4.0 Remedial Pre-Design Investigation Results

Remedial pre-design investigation activities, as outlined in the Supplemental Soil Characterization and Pilot Test Work Plan (CRA 2007), were conducted between 2008 and 2010 to obtain additional data required for the Remedial Design and to address known and potential challenges related to the major components of the ROD-selected remedy. The following sections summarize the remedial pre-design investigation activities that were completed to assist in developing the Remedial Design and performing the Remedial Action.

4.1 Source Area Soil Delineation

A total of 33 additional boreholes were drilled during the remedial pre-design investigation to supplement the chemical concentration and soil stratigraphy information that was generated in the previous investigations. The results of the previous investigations were presented in the Supplemental Remedial Investigation report by Ecology & Environment P.C. (2004). The additional boreholes drilled during the remedial pre-design investigation provided 174 additional chemical samples to augment the 29 taken during the remedial investigation phase. This information vastly improved the delineation of the nature and extent of the source area soil in both the horizontal and vertical direction. This delineation of the source area soil was approved by the NYSDEC on October 13, 2010 as part of the approval of the Remedial Pre-Design Investigation Report (CRA 2010) and the Order on Consent & Administrative Settlement (March 2013). Using all of the available soil data, a set of figures depicting the source area soil approved for remediation is presented on Figures 2.2 through 2.9. Each successive figure presents a 2-foot interval of the soil horizon starting with the interval at the ground surface and descending to the bottom interval overlying the top of bedrock which is located at a depth of approximately 16 feet bgs. As can be seen on the figures, there are considerable discontinuities in the adjoining and overlying/underlying areas that are considered source area soil. This is indicative of a multi-release site.

Based upon this approved delineation, it was determined that there was on the order of 15,000 cubic yards of source area soil. Since the source area soil was interspersed throughout the soil horizon and surrounded by soil that does not require remediation, considerable additional soil had to be excavated in order to access the source area soil. Based on the available information, it was expected that on the order of 32,000 cubic yards of non-source area soil would have to be excavated in order to access the 15,000 cubic yards of source area soil. Only the source area soil was required to be thermally treated prior to placement back into the excavation.

4.2 Remedial Alternative Re-Evaluation

In recent years, there was a dramatic advancement in soil remediation technology with regard to thermal treatment. This advancement was particularly pronounced for sites where VOCs are the targeted contaminants of concern. While it has been known for a long time that VOCs can be readily removed from soil through the application of heat, it has only recently become commercially viable to do so. Mobile thermal treatment units are now available for conditions such as existed at the Site. Further, there is documentation from numerous sites across New York and the rest of the country demonstrating the effectiveness of these mobile units. The technology has advanced to the point that mobile thermal treatment can be performed as an economically viable option (including considerations of vapor controls, destruction efficiency, etc.).

In addition to the technological advancements, New York State has implemented a process for evaluating remedial alternatives that includes consideration of the overall impact of a remedy's

implementation. This includes consideration of the remedy's impact with respect to its environmental footprint, sustainability, and the use of "green technologies". In essence, all of the environmental aspects of the remedy are now being evaluated in the remedy selection process, not just the specific impacts on human health and the environment.

The Frontier Group, as a result of discussions with the NYSDEC, researched the possibility of implementing a thermal treatment option for the source area soil. Through discussions with the NYSDEC, it was agreed that it would be appropriate to re-evaluate the Site's soil remedy factoring in these advances in remedial options. As a result, the Frontier Group completed a FFS comparing the ROD-selected excavation, trucking, and off-Site treatment/disposal alternative against an excavation and on-Site thermal treatment alternative.

The FFS was submitted in November 2011 and concluded that the excavation and on-Site thermal treatment alternative ranked higher in the feasibility study evaluation factors and higher in the sustainability/green concept evaluation than the ROD-selected alternative. Overall, the alternative re-evaluation showed that excavation and on-Site thermal treatment was the highest ranked alternative. Coupled with the fact that on-Site thermal treatment has been proven through application at multiple Sites, successfully meets the RAOs, and has a smaller environmental footprint than the ROD-selected remedy, it became the preferred remedy for this Site.

4.3 Summary

Based upon the results of the remedial pre-design investigation and FFS, it was determined that a remedy consisting of excavation and on-Site thermal treatment of source area soil was the appropriate remedy for the Remedial Action. The defined source area soil consisted of approximately 15,000 cubic yards of soil. Treating this volume of soil far exceeds the current regulatory cleanup requirements for the Site, but is consistent with the remedial objectives of the 2006 ROD and was therefore agreed upon between the NYSDEC and Frontier Group as the appropriate performance goal for the remediation that was implemented.

Section 5.0 Remedy Elements

The Remedial Design of the soil remedy for the Site was developed through discussions with the NYSDEC and input from experienced thermal remediation contractors in addition to CRA's remediation experience. Each of the components of the Site's remedy is presented in the following subsections. The Frontier Group retained Clean Harbors Environmental Services, Inc. as the primary contractor for implementing the soil remedy. Figure 5.1 provides the layout of the Site features that were used to complete the soil remediation project.

The following documents were developed to govern the implementation of the remediation for the Site:

- Remedial Design Report
- Site Specific Health and Safety Plan
- Construction Quality Assurance Plan
- Citizen Participation Plan
- Work Plan for Radiological Material Handling
- Community Air Monitoring Plan
- Erosion and Sediment Control and Storm Water Management Plan

5.1 Erosion and Sediment Control and Storm Water Management

The Site is primarily flat and about 80 percent of the surface is covered with asphalt or concrete. Areas where soil was previously exposed at the ground surface were vegetated with scrub shrubs and grasses. Given that all of the surfaces on the Site were either hard cover or soil areas with vegetative cover, there was no sediment erosion concern under the conditions that existed prior to the soil remediation.

The implemented soil remediation involved the excavation of a large area of the Site (approximately 2.6 acres) which resulted in soil with Site contaminants of concern being exposed during remedial activities. The exposed soil was in two settings: either in the excavation itself or being handled on a portion of the remaining surface area of the Site. All water was handled in accordance with plans to ensure that Site contaminants of concern did not migrate off Site. The following surface water handling practices were implemented to meet this requirement:

Within the Excavation Area

All precipitation that fell within the excavation was considered impacted. All such water was retained within the excavation and managed in an appropriate manner. The water that did not infiltrate or evaporate was pumped to a 21,000-gallon Frac tank that was set up at the southeast corner of the Site. The Frac tank was used as a secondary sedimentation basin (the excavation itself acted as the primary sedimentation basin), allowing sediment to decant from the accumulated water. The water was then filtered through a bag filter system to remove additional sediment prior to its discharge to the sanitary sewer system in compliance with the Site's Significant Industrial User Permit that was issued by the Niagara Falls Water Board.

Peripheral to the Excavation Area

Precipitation was prevented from leaving the impacted soil handling areas that encircled the excavation through the construction of a perimeter clean soil berm that encompassed the entire source area soil

excavation area and the impacted soil handling areas. Precipitation falling in the peripheral areas outside the berms was allowed to continue to drain as it had in the past.

Soil Handling Area

All soil removed from the excavation was placed into specific storage areas within the perimeter berm system. The pathways used by trucks and equipment that handled or transported soil on Site was similarly encompassed within the surface water control berms. All precipitation falling within the surface water control area was retained within the area and managed accordingly. The retained water was either allowed to evaporate, directed into the excavation, or if necessary, was pumped to the sanitary sewer in compliance with the Site's Significant Industrial User Permit (via the Frac tank system).

The location of the area within the water control berms is shown on Figure 5.2.

Sediment Control

By providing surface water control in the designated storage and transfer areas, sediment was also controlled. Equipment working within the surface water control area was required to undergo appropriate decontamination procedures before leaving the controlled area.

Trucks and vehicles making deliveries to the Site were required to remain outside of the surface water control area and on hard surfaces to avoid tracking any soil off Site.

5.2 Site Preparation

A series of tasks were performed to prepare the Site for the soil remediation. These tasks included the following:

Personnel and Equipment Decontamination Facilities

Any person or piece of equipment that entered the surface water control area had to be decontaminated prior to exiting the area. All other areas on the Site were deemed as clean areas, within which decontamination was not required. The decontamination facilities for personnel consisted of a temporary station that was set up along the eastern surface water control berm, adjacent to the Site trailers. The station was equipped and maintained in accordance with the procedures specified in the Health & Safety Plan.

One equipment decontamination station consisting of a concrete pad complete with curb and sump was set up along the eastern surface water control berm, adjacent to the Site trailers. The equipment decontamination water was discharged to the sanitary sewer via the Frac tank in compliance with the

Site's Significant Industrial User Permit. All accumulated soil removed from the equipment was placed back into the excavation.

Site Trailers

Mobile trailers were set up on the Site to provide appropriate accommodation for the following functions:

- Lunch/break room for workers
- Lockers for on-Site workers
- Contractor office
- Engineer office
- NYSDEC office
- Meeting room

The trailers were equipped with running water, washrooms, and electricity.

Building Demolition

All of the buildings/structures on the Site have been demolished and the debris sent to a permitted waste disposal facility. The concrete and brick from the demolition were sampled to confirm they were suitable for use as clean cover material that was spread over exposed soil areas. The results of this sample effort are summarized in Table 5.1.

Foundation, Slab, and Pavement Demolition

The surface area within the footprint of the source area soil excavation included areas covered with concrete slabs from former buildings, asphalt pavement areas, and soil-covered areas.

The areas covered with concrete are mostly the floor slabs of former buildings and tank farms. The concrete floor slab areas were typically encircled with foundations that extended below grade and were comprised of reinforced concrete. The concrete was broken up using a hoe-ram and removed from the excavation, where appropriate. The concrete was pulverized to 2-inch-minus size and stockpiled for reuse as final cover over the excavation area. Six samples of the crushed concrete were collected and sent to a New York State Department of Health certified laboratory (TestAmerica) for analysis for VOCs, SVOCs, Pesticides/PCBs, and metals. The results of this sampling were compared to the Part 375 Table 6.B criteria for fill material. All of the samples were approved for use as clean cover by the NYSDEC on January 6, 2014. The sample results are summarized in Table 5.2.

The reinforcing steel from within the crushed concrete was separated and shipped off Site for salvage. More than 80 tons of scrap metal were recovered and recycled.

The areas covered with asphalt (within the excavation area) were removed with a backhoe and blended with the crushed concrete for use as part of the final cover. The asphalt was included in the previously mentioned concrete sampling plan.

The surface areas on the Site that consisted of soil cover were excavated (to the extent necessary so that the final surface elevations match the perimeter surface grades) and placed into the source area soil excavation as backfill. All soil covered surface areas on the Site were covered with 1 foot of crushed concrete/asphalt/demolition debris (supplemented with 5,480 tons of imported quarried stone).

Utilities

A connection to the existing watermain on 47th Street was made to provide a potable water service for the Site. The connection to the water service was installed above ground on the Site to eliminate the need for any additional excavation. The water service provided potable water to the Site trailers, personnel and equipment decontamination stations, the air scrubber on the thermal treatment unit, and for dust control application on the haul roads. At the conclusion of the soil remediation project, the water service was disconnected from the City's watermain.

Arrangements were made with the local electrical utility (Niagara Mohawk) to provide electrical service to the Site for the remediation project. Two service connections were made, both from the local grid on 47th Street. One service was a direct connection to the Site trailers. The other connection was installed above grade on temporary power poles to connect to the thermal treatment unit and the temporary enclosure where the source area soils were stored. At the conclusion of the soil remediation project, the electrical services were disconnected from the grid and the temporary power poles removed.

Arrangements were made with the local natural gas provider (National Fuel) to supply a large volume natural gas feed to the thermal treatment unit from the gas main on 47th Street. The service was installed in a shallow trench (approximately 18 inches below grade). At the conclusion of the soil remediation project, the gas connection to the main on 47th Street was disconnected.

Arrangements were made with the Niagara Falls Water Board to install a connection to the sanitary sewer to handle sanitary discharge, air scrubber water, and impacted surface water control discharges from the Site. The discharges were managed under the Site's Significant Industrial User Permit. The results of the wastewater samples collected during the course of the soil remediation were reported monthly to the Niagara Falls Water Board. Summaries of the analytical results and wastewater

discharge volumes from the Site are provided in Table 5.3. During the remediation project, a total of 987,000 gallons of water was discharged to the sanitary sewer for treatment.

Site Clearing

The Site had been previously cleared of all vegetative overgrowth. Other miscellaneous debris, as encountered during the soil remediation project, was either backfilled in the source area soil excavation or sent off Site for disposal at a sanitary landfill or recycled, as appropriate.

Monitoring Well Closures

Monitoring wells located within the excavation area and in the soil stockpile/treatment area were decommissioned by grouting in place in accordance with NYSDEC's CP-43: Groundwater Monitoring Wells Decommissioning Policy. To the extent that the wells were in the source area soil excavation area, the encountered portions of the grouted wells were also removed. Efforts were made to preserve wells currently included in the Site's long-term OM&M Plan and that are used for the Site's Significant Industrial User Permit discharge compliance monitoring program. The following wells were decommissioned during the soil remediation project:

MW-88-2AR	MW-7R
MW-88-2B	MW-88-7B
MW-88-3A	MW-88-7BR
MW-88-3AR	MW-11
MW-88-3B	MW-88-14A
MW-87-4BR	MW-88-14B
MW-88-5B	
MW-88-6A	
MW-88-6B	
MW-88-6ob	

5.3 Excavation of Source Area Soil

The estimated limits of source area soil were delineated during the remedial pre-design investigation to preliminarily define the limits of the excavation area. The actual limits of the soil excavation were defined in the field using hand held instruments. Within the excavation area, the field protocol relied upon the results of the soil characterization investigations that were performed to guide the excavation of soil and to distinguish between source area soil and non-source area soil. Because the source area soil was interspersed amongst soil intervals that did not require treatment, it was necessary to devise a simple and reliable method for separating the excavated soil into the two categories as the excavation progressed. While visual evidence of staining did provide some indication of source area soil, it could

not identify all of the source area soil. Consequently, another method of segregating the soil into the two categories was developed.

During the remedial pre-design investigation, each 2-foot soil sample interval from the boreholes included in the soil characterization program was screened with a photoionization detector (PID). A sample of each 2-foot interval was also submitted to a New York State Department of Health certified laboratory for VOC analysis using precision analytical laboratory instruments. As noted in the Remedial Pre-Design Investigation report (CRA 2010), a comparison of the results from these two analytical methods showed good correlation. The evaluation showed that, in general, the soil samples that had confirmed laboratory concentrations in excess of 100 parts per million (ppm), also registered as having concentrations in excess of 100 ppm on the PID. While there were some outlier samples (where one method measured a concentration greater than 100 ppm but the other did not), the basic trend was that the results matched. The outliers were as follows:

- Twenty of the 109 soil intervals that upon analysis were below 100 ppm in the laboratory results, exceeded 100 ppm using the PID
- Thirteen of the 62 soil intervals that upon analysis were above 100 ppm in the laboratory results, were below 100 ppm using the PID

In both cases, about 20 percent of the samples were inaccurately characterized. It is noted that most (8 of the 13) of the soil intervals for which the PID measurements showed a concentration less than 100 ppm, the laboratory result was in the 100 to 200 ppm range. Another two were in the 200 to 300 ppm range, two in the 300 to 400 ppm range, and one in the 600 to 700 ppm range. The complete set of comparative results is presented in Table 5.4. While the PID method did underestimate the actual laboratory confirmed result in these 13 samples, all of these samples met the current regulatory cleanup criteria as promulgated in 6 NYCRR Part 375-6. As a result, the PID provided conservatively accurate results in identifying source area soil according to current regulations. The fact that the PID method identified 20 soil samples that were not categorized as source area soil by the laboratory analysis indicates that this method for identifying source area soil is conservative. The net result is that more soil would have been designated as source area soil using the PID than was actually confirmed by laboratory analysis as exceeding current regulatory criteria.

Based upon this comparison, it was evident that the PID would be suitably accurate to be used as the field tool to determine whether the soil being excavated from a specific layer and area was source area soil. This conclusion is based upon the following:

- The clean-up criteria used in the ROD for selecting the soil remedy was more restrictive than the current Part 375 regulatory soil clean up criteria for an industrial site

- The Frontier Group agreed to remediate the source area soil within the more restrictive limits delineated during the pre-design investigation, and recognized that this results in the treatment of more soil than would be required under the current regulations as applied to an industrial site
- In those cases in which the PID inaccurately determined that the soil being examined was not source area soil, the soil would still meet the current promulgated regulations, and therefore would not have required treatment
- The PID reliably and conservatively identifies soils that should be included as source area soil

Based upon the above factors, a PID was used as the screening tool during the soil excavation to segregate the soil into two distinct categories: source area soil and non-source area soil. The PID was equipped with a 10.6 eV lamp; consistent with the one used during the pre-design investigations. All exposed surfaces within the excavation were scanned to determine into which stockpile the next excavated layer was to be placed.

Prior to using soil placed in the non-source area stockpile as backfill for the excavation, confirmatory samples were collected to confirm that the soil met the 100 ppm total VOC concentration criteria. One confirmatory sample was collected from every 2,500 cubic yards and analyzed at a New York State Department of Health certified laboratory for VOC analysis. The sample was collected as a five-point composite selected from a depth of approximately 2 feet below the surface of the stockpile. If the laboratory analysis was 100 ppm or less, the 2,500-cubic-yard batch of soil was available for reuse in the excavation as backfill. A total of 15 samples of non-source soils were collected from the non-source stockpiles. There were two cases in which the laboratory analysis of the stockpiled material was greater than 100 ppm (although one of these cases was later determined to be a laboratory reporting error). In the remaining case, further delineation was performed using the PID to remove additional soil from the stockpile and place it in the source area soil stockpile for treatment. Subsequent retesting of the stockpile following this removal confirmed that the remaining portion of the 2,500 cubic yard batch met the 100 ppm criteria. A summary of the results of the non-source area soil confirmation sampling is provided in Table 5.5.

As the limits of the previously identified source area soil areas were reached, the PID was also used to finalize the horizontal and vertical limits of the excavation. The confirmatory sampling procedure for defining the excavation limit was performed as follows:

Excavation sidewalls were tested in 30-foot lateral sections. Each section consisted of the entire soil horizon from ground surface to the base of the excavation. From each section:

- A minimum of six individual samples of the excavation face were collected to a depth of 2 inches in from the face using a hand trowel.

- At least one sample was collected from each distinctly identified soil interval. A typical testing pattern included two samples from the first 5 feet of the sidewall closest to the surface, two samples from the center of the sidewall section, and two samples from the bottom 5 feet of the sidewall.
- The samples were collected from each geographic segment of the exposed excavation face on an area-proportion basis.
- Each sample was placed into its own poly bag and sealed.
- The samples were allowed to equilibrate to outdoor air temperature and then analyzed using the PID.
- The results of the PID readings were recorded.
- The average concentration of the samples collected in each section was compared to 100 ppm.
  - If the average concentration was 100 ppm or less, the limits of the excavation face were confirmed to be defined and no further excavation was required.
  - If the average concentration exceeded 100 ppm, the Frontier Group's field representative directed the remediation contractor to excavate additional soil as appropriate. The additional excavation focused on the particular soil interval(s) that had the highest individual concentration(s). In some cases it was decided to extend the excavation of the entire face. In the cases where additional excavation was performed, the additionally excavated area was resampled and new PID readings were taken and used in calculating the revised average concentration.

The base of the excavation was removed in lifts of 1 to 2 feet, consistent with the thickness of individual soil horizons and the known VOC concentrations. In all areas, the historic data from the soil characterization program chemically identified a soil horizon that was below the ROD's 100 ppm criteria or identified the top of bedrock as the underlying layer. Therefore, confirmatory laboratory-generated analytical data were already available across the source area soil excavation limits. Nonetheless, the base of the excavation was tested and analyzed using the PID to confirm that the vertical limits of the excavation were met. A total of six individual soil samples were collected from each 2,500 square feet of excavation base. The analysis by PID, comparison to the 100 ppm criteria, and subsequent further actions were the same as those used for the sidewall assessment. The samples were hand cored to a depth of 6 inches to collect each sample from the exposed base. In areas where the excavation reached the top of bedrock (typically at 14 to 15 feet bgs), no confirmatory testing was required.

The PID results of the confirmation sampling for the excavation sidewalls and base are provided in Table 5.6.

Since radioactive material was found on a property adjacent to the Frontier Site, the Frontier Group performed a radiation survey of the Site prior to the implementation of the soil remedy. Some

radioactive slag material, similar to that found on the adjacent property, was also found on the Site. The material was identified as Technically Enhanced Naturally Occurring Radioactive Material (TENORM). During the excavation of the source area soil, the exposed surfaces were continuously visually examined for evidence of slag. In addition, a radiological scanning meter was used to determine whether any radioactive material was present in any of the fill layers that were excavated. Where identified, the TENORM was carefully segregated from the surrounding soil and placed into a separate soil storage area, where it was kept covered and secured within a temporary fenced-in area. A total of approximately 933 cubic yards (1,500 tons) of TENORM was identified and removed from the excavation. Further details of the handling of the radioactive materials are provided in Section 5.10.

The final horizontal and vertical limits of the excavation are shown on Figure 5.3. In summary, the excavation consisted of the following:

Total excavation volume	49,400 cubic yards
Total source area soil excavated	25,500 cubic yards
Total source area soil treated	22,200 cubic yards (42,500 tons)
Volume of boulders/cobbles in source area soil	3,300 cubic yards
Volume of non-source area soil excavated	19,000 cubic yards
Volume of TENORM excavated	930 cubic yards
Volume of concrete/asphalt excavated	4,000 cubic yards

5.4 Soil Stockpiles

Following characterization of the soil layers using the PID, the soil was transported by truck to either the source area soil stockpile or the non-source area soil stockpile, as appropriate. The non-source area soil stockpile was located within the surface water control berm that was constructed to control impacted soil and water. The non-source area soil was available for reuse as backfill as soon as the confirmatory sampling of each 2,500 cubic yard portion was completed and approved. Care was taken to keep each 2,500 cubic yard segment separate until the confirmatory sample data were available.

The primary locations of the non-source area stockpiles were along the eastern and western limits of the excavation, although other areas were also occasionally used for stockpiling as the project proceeded and according to the availability of space and operating conditions.

All of the excavated source area soil was immediately placed in storage within an enclosed fabric structure that was assembled along the northern property boundary of the Site. The metal framed structure was on the order of 15,000 square feet in size. The structure was sized to accommodate the remediation contractor's expected rate of excavation and treatment, with the primary consideration

being to ensure that a steady feed of source area soil could be supplied to the thermal treatment unit. The enclosure was encircled with a soil berm to control surface water and sediment.

Within the enclosure for the source area soil, the remediation contractor prepared the soil for treatment. The preparation involved the blending of soil with varying moisture contents and chemical concentrations to provide as consistent a feed stock to the thermal treatment unit as possible. Due to the fine-grained nature of the soil requiring treatment, some mechanical manipulation of the soil was also required. The soil was passed through a screen to reduce the size of any soil clumps to less than 3 inches, the size most suitable for the thermal treatment unit.

Part way into the excavation project, it was found that some of the source area soil layers also contained rocks. In order to separate the rocks from the source area soil, an additional mechanical screen was brought to the Site. To the extent necessary, the soil/rock material was screened through the additional screen to separate the rocks from the soil. The rocks, once separated, were passed through the screen multiple times (up to 9 times) to remove any residual soil adhering to the rock surfaces. The screened rocks were allowed to dry out between some of the passes to improve the soil removal from the rock surfaces on the subsequent passes through the screen. Nine samples of the rock material were submitted to a New York State Department of Health certified laboratory to confirm that the VOC concentrations of the rock material met the definition of non-source soil. Upon confirmation, and with NYSDEC approval (which was provided on November 1, 2013), the rocks were blended with other non-source soil and used as backfill in the excavation. An estimated 3,300 cubic yards of rock were separated from the source area soil in this manner. The analytical results from the laboratory confirmation samples of the rock materials are provided in Table 5.7.

The enclosed fabric structure was equipped with air purification equipment to protect workers and to manage the vapors emitted from the source area soil as it was handled within the enclosure. The air within the enclosure was captured and passed through activated carbon to remove airborne contaminants prior to release from the enclosure. The air purification system operated at a capacity of four air turnovers per hour within the enclosure. The air quality within the enclosure was monitored to determine the level of respiratory protection required by workers entering the enclosure. In most cases, supplied air was required and access to the enclosure was restricted to only those workers who needed to enter the enclosure to deliver or remove source area soil.

Treated soil was stockpiled in 200-cubic-yard piles in the northern half of the Site, wherever space permitted. Confirmation sampling of the treated soil was performed by collecting one five-point composite sample from each pile. A total of 124 samples of treated source soil were collected during the soil remediation project. The samples were submitted to a New York State Department of Health certified laboratory for VOC analysis. The sample results were compared to the 100 ppm total VOC criteria. All samples easily met the criteria with the average total VOC concentration of the treated soil samples being 0.34 ppm, with the maximum result being 5.7 ppm. A summary of the complete list of

treated soil sample results is presented in Table 5.8. Upon receipt of confirmation that each 200-cubic-yard pile met the criteria, the pile was released for use as backfill in the excavation. In many cases, after receipt of the sample data, the piles were consolidated into larger stockpiles to improve space management. Due to the minimal VOC presence following the thermal treatment of the source area soil, the Frontier Group requested permission from the NYSDEC in November to reduce the frequency of confirmatory testing for the remainder of the project. This permission was granted and the confirmatory sampling of the treated soil was reduced to one sample per 1,000 cubic yards after November 5, 2013.

5.5 Soil Vapor & Particulate Management

Since the excavated soil was impacted with VOCs, vapor and dust management controls were provided throughout the working area to protect Site workers and the surrounding community. The components of the vapor and dust management plan included the following:

Within the Excavation

Best management practices were employed within the excavation to minimize the generation of soil vapors and dust. These practices included:

- The size of the excavation was maintained at the smallest size possible, consistent with the practical need of reasonably being able to access the remaining source area soil
- The sequence of soil excavation to the various depths was planned to minimize the size of the excavation open at any given time
- Areas excavated to final depth were backfilled with non-source area soil or treated source area soil as soon as practicable
- Odiferous exposed surfaces were covered with polyethylene sheeting
- Water was applied to surface areas to control vapor and dust generation

Non-Source Area Soil Stockpile

On days when vapors or odors were noticeable, the non-source area soil stockpile was covered with polyethylene sheeting to minimize VOC volatilization and dust generation. The sheeting was left in place during the daily advance of the excavation and stockpiling process to the extent practicable.

Source Area Soil Stockpile

The area within the enclosure for the source area stockpile was under negative pressure with air constantly being evacuated from the interior. The rate of air exchange was four times per hour. The

evacuated air was passed through carbon adsorption units to remove the VOCs from the airstream prior to discharge to the atmosphere. Carbon change outs were scheduled in accordance with calculations using influent and effluent sampling data to predict breakthrough of the various VOCs and to ensure that VOC concentrations did not exceed air quality criteria, consistent with appropriate air quality management practices.

Treated Soil Stockpile

Once treated, the source area soil no longer contained any appreciable VOCs. Consequently, no vapor controls were required with regard to the treated soil stockpile.

5.6 Air Monitoring

The excavation and handling of Site soil resulted in the generation of dust and the volatilization of some chemicals. While best management practices were used to minimize uncontrolled volatilization, some occurred nonetheless. To ensure that there was no adverse risk to the Site workers, the public, or the environment, particulate and vapor monitoring were performed during all soil excavation activities. The results of the air monitoring program were used to maintain air quality compliance with New York State criteria.

Air monitoring was performed around the active soil management area and on the Site perimeter (as part of the Community Air Monitoring Program) using handheld PIDs and dust particulate monitoring equipment. Background (upwind) air quality was compared to downwind air quality to determine the effect of Site operations. The measurement stations were established daily based upon climatological conditions and repositioned as necessary throughout the day. Measurements were made on a continuous basis while actively excavating the soil and transferring to the stockpiles.

With only a few minor temporary exceptions, the soil management practices employed at the Site were able to maintain the air quality compliance required. On those days that an exceedance was observed sometime during the day, additional preventative measures (such as additional application of water on soiled surfaces) were employed to bring the daily operations back into compliance. On two days, operations were temporarily suspended as high winds were creating dust complaints from neighboring properties, even though the allowable air limits were not being exceeded.

A summary of the daily average and maximum air monitoring results is provided in Table 5.9.

5.7 Backfilling of Excavation

The backfilling of the excavation was sequenced to match as closely as possible with the excavation operation. As soon as practicable, once an area of the excavation had reached the maximum depth required to remove the delineated source area soil, the backfilling of that area began.

The backfill material was taken either from the treated source area soil stockpile (upon receipt and acceptance of confirmation testing) or from the non-source area soil stockpile. The soil was placed in the excavation in layers not exceeding 6 inches in thickness and was compacted with a minimum of five passes with a 10-ton roller.

The soil and material was placed back into the excavation in the following sequence. An orange filter fabric was placed over the exposed slopes of the excavation and over the exposed bottom surfaces of the excavation that had reached the limits of the source area soil. The purpose of the orange filter fabric was to act as a demarcation feature for future reference so that the limits of the excavation would be identifiable in the field. Filter fabric was not placed over the exposed bedrock surface. Once the filter fabric was in place, the deepest portion of the excavation was backfilled with non-source area soil. In some areas, the rock material that had been separated from the source area soil was blended into the backfill layer of non-source area soil as the backfilling progressed. Upon completion of the placement of the non-source area soil in a specific area, this material was also covered with an orange filter fabric for demarcation purposes. The remainder of the excavation, to within 1 foot of the surrounding concrete and asphalt surfaces, was backfilled with the treated source area soil. The final foot of the excavation was backfilled with either the crushed concrete/asphalt that had been excavated from the Site, the crushed select demolition debris, or with imported quarried stone. The quarried stone was new material provided from the Lafarge pit in Niagara Falls, New York. A total of 5,480 tons (3,300 cubic yards) of quarried stone had to be imported to supplement the volume of crushed concrete, asphalt, and demolition debris necessary to complete the 1 foot of clean cover over all of the exposed soil cover areas. This included some areas that were outside the limits of the soil remediation excavation but had soil covers that were required to be covered with 1 foot of clean material as well. The elevations of the base of the final excavation, the top of the backfill layer of non-source area soil, the elevation of the top of the backfill layer of source area soil, and the final top of the crushed concrete/asphalt/demolition debris/imported stone are presented on Figures 5.3, 5.4, 5.5, and 5.6, respectively.

The TENORM that was not shipped off Site for disposal was placed in the separate on-Site disposal area that was approved by the NYSDEC. The location of the TENORM disposal area is shown on Figure 5.7. The TENORM was placed on top of a layer of non-source area soil and covered with a layer of treated source area soil. The entire TENORM deposit was enveloped in orange filter fabric for demarcation purposes. As required, the top of the TENORM deposit is set more than 4 feet bgs to minimize the potential for future contact. Two cross sections of the excavation area and the backfilling sequence are provided on Figure 5.8. The locations of the cross sections are shown on Figure 5.9.

In summary, the backfilling consisted of the following:

Volume of source area soil backfilled	22,200 cubic yards
Volume of boulders/cobbles backfilled	3,300 cubic yards
Volume of non-source area soil backfilled	19,000 cubic yards
Volume of TENORM backfilled	608 cubic yards
Volume of crushed concrete/asphalt backfilled	4,000 cubic yards
Volume of imported stone backfilled	3,300 cubic yards

All standing water was removed from the excavated areas prior to placement of the backfill material.

The final elevation of the top of the backfill material in the soil excavation area was left 1 foot below the elevation of the surrounding surface areas. In accordance with the ROD, this final foot of material was backfilled with clean material. In consideration of the expected use of this Site as a vehicle parking area, the final foot was backfilled with crushed concrete/asphalt, select crushed demolition debris from the Site, or imported quarried stone. The on-Site material was crushed to 2-inch-minus in size and was confirmed to be clean through the collection and analysis of samples.

The concrete slabs and foundations removed during the source area soil remediation were used as part of the final foot cap of clean material over the excavation areas. In preparation for the reuse of the concrete as part of the clean cover, the concrete surfaces that were in contact with soil were scraped to remove any adhering soil. While some thin film of soil may have remained adhered to the concrete surfaces, there was no residual VOC concentrations of concern, as confirmed by the analytical testing that was performed.

Only authorized personnel were allowed in the excavation and their entry was limited to an as-needed basis. To the extent practical, work was directed from perimeter areas outside the excavation. High visibility vests were worn by all individuals entering the excavation and procedures were set up to maintain appropriate separation distances between individuals and equipment.

5.8 Groundwater Handling

Minimal groundwater was encountered in the excavation. The groundwater that was encountered was either pumped to a separate excavation area/sump area where it was allowed to infiltrate back into the surrounding groundwater flow regime or was pumped to the sanitary sewer under the Site's Significant Industrial User Permit.

5.9 NAPL

No NAPL was encountered during the performance of the remedial action.

5.10 Radiological Material

Due to the presence of TENORM, all of the exposed excavation surfaces within the layer of soil determined to be fill (or at least disturbed soil) was scanned for radiological activity. The Frontier Group retained the services of MJW Corporation, Inc., an experienced radiation safety and radiological operations contractor, to perform all of the radiological monitoring and management for the project. A representative of MJW Corporation, Inc. was on Site during all activities in which TENORM could be encountered or handled. This included all excavation activities within the fill layer of soil, which is the limit within which the TENORM could be encountered.

During the excavation, a handheld meter (typically a scaler/rate meter coupled with a 2-inch Nal scintillation detector) was used to detect the gamma radiation emanating from the TENORM. The encountered TENORM was segregated from the surrounding soil and placed into a separate fenced stockpile area. The TENORM stockpile was placed on a polyethylene sheet and kept covered with polyethylene at all times. All of the TENORM encountered was low level material with the highest gamma radiation measurement being 200,000 counts per minute. Most of the TENORM had less than 20,000 counts per minute. A total of 933 cubic yards of TENORM was removed and separated during the excavation program.

In accordance with the approved Remedial Design and the Order on Consent & Administrative Settlement (March 2013), 520 tons of the TENORM (approximately 325 cubic yards) was shipped off Site to a secure permitted disposal facility. The Environmental Quality Company's Wayne Disposal Site in Belleville, Michigan was selected for this purpose. The TENORM with the highest gamma radiation counts was the material that was shipped off Site, leaving only the low level material on Site. Six samples of the TENORM that was to be shipped off Site were collected and submitted for waste characterization in support of EQ Landfill's disposal requirements. Table 5.10 summarizes the TENORM results. The TENORM was shipped in December 2013, filling 22 trucks. The remainder of the TENORM (608 cubic yards) was placed back into the excavation in the location approved by the NYSDEC as shown on Figure 5.7. The top of the TENORM was placed more than 4 feet bgs and the entire TENORM deposit was enveloped in orange filter fabric for demarcation. The waste manifests for the TENORM shipments are presented in Appendix E.

All on Site workers received radiation training prior to being deployed on the Site to ensure that they were familiar with the procedures to be followed due to the presence of TENORM on the Site.

All equipment that was in contact with the TENORM (i.e., backhoe and trucks) was scanned after the specific activities associated with handling the TENORM were complete. Each piece of equipment that

was used on the Site was also scanned for radiation and cleared prior to its final release from the Site. Similarly, the area used for the temporary storage of the TENORM was scanned for radiation and cleared once the TENORM had been removed.

5.11 Thermal Treatment

The source area soil was treated in an on-Site thermal treatment unit designed to heat the soil to temperatures above the boiling point of the contaminants of concern. Table 5.11 provides the boiling points of the contaminants of concern. The contaminants were desorbed from the soil and became airborne, which allowed them to be captured in the off-gas from the thermal treatment unit. The off-gases were then treated by passing through a thermal oxidation unit that further heated the gases to temperatures that break the chemical bonds of the contaminants, thereby destroying the contaminants and converting them into innocuous breakdown components. A schematic of the thermal treatment unit provided by the retained subcontractor (Midwest Soil Remediation Inc.) (MSR) is shown on Figure 5.10. The off-gas from the thermal oxidation unit was scrubbed to meet New York State air emission concentrations. The thermal treatment unit operated under an air equivalency permit issued by the NYSDEC. The permit required compliance with the substantive requirements of all applicable regulations including those contained in Part 375-1.12. The NYSDEC provided air equivalency parameters to govern the operation of the thermal treatment unit, the requirements of which included the recommendations contained in the ITRC guidance document entitled "Technical Requirements for On-Site Thermal Desorption of Solid Media Contaminated with Hazardous Chlorinated Organics" dated September 18, 1997.

Each of the components of the treatment process is further described in the following subsections.

Soil Preparation

As described in Section 5.4, the soil was processed within a fabric enclosed building that housed the source area soil to prepare it for thermal treatment. The contractor established working piles within the enclosure that allowed the excavated soil to be separated according to the following criteria, as appropriate for the treatment process:

- Moisture content
- Chemical concentrations
- Soil characteristics
- Adhesive characteristics

The soil preparation also took into consideration the BTU value of the source area soil to prevent "flash" burning of the soil within the thermal treatment unit and/or overheating of the thermal treatment unit.

Working from these piles, MSR blended the available soil from the working piles to create as consistent a feedstock as possible to the thermal unit. The soil was processed through two screening systems to reduce the size of soil clumps to 3-inch-minus and to remove/separate irregular objects and gravel. To improve the soils workability (break down the clayey soil and reduce moisture content), the soil was initially amended with calciment, which also helped neutralize the soil. After a few weeks, quick lime pellets were used instead of the calciment, as a more effective additive. Approximately 680 tons of calciment/quick lime was used to amend the soil.

Soil Transfer to the Thermal Unit

The blended soil was transferred to the thermal treatment unit with a bucket loader. The soil was deposited into the feed hopper/screen of the thermal treatment unit.

Thermal Treatment Unit

The thermal treatment unit used at the Site was a direct fired system where the combustion gases come in direct contact with the soil. Natural gas from the local supplier was used to fire the unit. The thermal treatment unit was a rotary dryer that was affixed to and shipped to the Site on a tractor trailer bed. The thermal treatment unit had a processing throughput of about 15 tons of source area soil per hour.

Following the set-up of the thermal treatment unit, a start-up plan was implemented to test all of the components of the unit. Following confirmation that the unit was operating properly, the thermal treatment unit was incrementally brought up to its operating capacity, initially operating one shift per day. The first treated soil passed through the treatment unit on July 3, 2013. Upon demonstrating that the unit was operating as designed, the NYSDEC approved 24-hour operation in mid-July. Full 24-hour 7-day per week operation began on July 27, 2013. Routine maintenance was performed weekly during a regularly scheduled shut down shift, or as needed when repairs were required.

The thermal treatment process involved heating the soil to well above the boiling point of all of the VOC contaminants of concern. Based on the boiling points listed in Table 5.11, the temperature required had to be greater than approximately 450°F. Once the soil approached this temperature, the VOCs readily desorbed from the soil. In order to achieve this temperature using the least amount of fuel, it was preferred that the incoming soil have a moisture content less than 18 percent. Over the course of the soil treatment, the average moisture content of the incoming soil was 16.4 percent. Soil blending, the addition of lime, and care taken at the time the soils were excavated were the primary methods used to control the moisture content of the incoming soil.

The test burns were performed as part of the thermal treatment unit approval process following set up of the equipment on the Site. During the test burn, all of the operating parameters were fine-tuned and

appropriate minimums and maximums set. The off-gas and soil treatment concentrations were confirmed through monitoring and sampling.

The soil exiting the thermal unit was required to be treated to a total VOC concentration of less than 100 ppm. In fact, the soil was all treated to total VOC concentrations of less than 5.72 ppm. The average total VOC concentration of the treated soil was 0.34 ppm. Of the 124 samples that were collected of the treated soil, only 13 had total VOC concentrations of more than 1 ppm.

The soil exiting the thermal treatment unit was cooled and rehydrated with water to a moisture content in the range of 5 to 26 percent (with the goal of 9 to 13 percent) to facilitate good compaction when the soil was backfilled into the excavation. The soil was processed through an auger as part of the rehydrating process to further prepare the soil for use as backfill material.

5.12 Off-Gases from Thermal Treatment

The off-gas from the thermal treatment unit was hot and contained the desorbed VOCs and dust. The off-gases were treated by thermal destruction.

The off-gas from the rotary desorber of the soil treatment unit was filtered through a bag house to capture dust particles. Gas exiting the baghouse was further heated using an afterburner to raise the temperature of the off-gas to on the order of 1700°F. This additional heating broke the chemical bonds of the VOCs and converted them to their innocuous breakdown components. Following the afterburner, a direct contact water quench chamber lowered the gas temperature down to less than 450°F. The dust captured by the baghouse was mixed with the treated soil and placed back into the excavation. Due to the presence of hydrogen and chlorine in the treated off-gas, it was necessary to pass the off-gas through a scrubber unit to remove these compounds. The scrubber used about 150 gallons of re-circulation water per minute. The scrubber also served to quench the off-gas to an acceptable discharge temperature. The scrubbing generated salt water which was discharged to the sanitary sewer under the Significant Industrial User Permit at a rate of about 4 gallons per minute.

5.13 Proof of Performance

Proof of Performance tests (trial burns) were used to confirm the thermal desorption unit was operating in compliance with applicable regulations and set operating limits that ensured continued compliance. Prior to Proof of Performance testing, shakedown operations were conducted to determine the envelope of operational parameters which would achieve the soil cleanup objective in a cost effective and technically implementable manner. Operating parameters quantified during shakedown included:

- Temperature ranges
- Feed stock rate

- Air flow rates
- Pretreatment amendments and soil preparation requirements
- Treated soil analytical results
- Continuous emission monitoring of CO and O2

Prior to performance of the trial burns, a Proof of Performance Test Plan dated April 29, 2013, was submitted to the NYSDEC and subsequently approved on May 15, 2013. The Test Plan was designed to meet the air equivalency requirements provided by the NYSDEC. The Test Plan provided emissions estimates, control technology parameters, air dispersion modeling results, and comparisons of emission rates and concentrations with State and Federal air emission limitations. Following the test burns, which were performed August 14 and 15, 2013, MSR compiled the data taken during the tests and submitted the Proof of Performance Test Report to the NYSDEC on October 17, 2013. The NYSDEC approved the report on November 5, 2013.

Following system optimization that resulted from shakedown operations, three trial burns were conducted at worst case conditions, which included:

1. Soil with high VOC concentrations
2. Operating the thermal treatment unit at the highest possible production rate

The trial runs were performed at the operating conditions required to comply with regulatory limits. The following operating parameters were monitored and recorded during the test burns and during operation of the unit:

1. Treated soil exit temperature
2. Baghouse pressure drop, or drop in liquid/gas ratio
3. Waste feed rate, VOC concentrations, and moisture content
4. Exit air temperature from the desorption chamber and thermal oxidizer
5. Stack gas velocity
6. Flow rate and pH of acid gas scrubber liquor
7. Treated soil analytical results
8. BTU value

During the test burns and for the operating phase of the soil remediation project, the thermal treatment unit operated under waste feed cutoff or system shutdown conditions. Typical shutdown conditions are provided below. The listed conditions would trigger an automatic shutdown of the waste feed.

Condition	*Initiate Waste Feed Cutoff/Shutdown*
Primary Burner Failure	Instantaneous
Outlet waste temperature falls below set point which is based on type and amount of contamination, waste type, and test burns	10 minute delay
Afterburner temperature (if applicable) falls below set point used in test burns	2 minute delay
Blower failure or positive pressure at the desorber	1 minute
Bag house pressure drop, , or drop in liquid/gas ratio (if applicable) outside the operating set point	1 – 10 minute
Carbon monoxide in exhaust gas (afterburner units only)	10 minute delay
Waste feed rate exceeds approved limit	10 minute delay
An appropriate indicator of significant change outside the operating parameter for gas velocity through secondary treatment device	.5 minute delay

To the extent that stack testing was required as part of the permit/approval process, the initial stack testing parameters included:

- Contaminants of concern
- Hydrochloric acid (if applicable)
- Other acid gas (if applicable)
- Total hydrocarbons
- Particulates
- Visible emissions
- Carbon monoxide
- Oxygen

Section 6.0 Institutional Controls/Engineering Controls

Institutional controls have been implemented to ensure the integrity of the Remedial Action for the Site. The institutional controls also prevent or eliminate the frequency of trespassers onto the Site and prevent potable use of impacted groundwater. The following is a listing of the institutional controls:

1. An Environmental Easement and title notices remain in effect until NYSDEC, or their successor(s) approve modifications or rescission of the restrictions. A copy of the Environmental Easement and title notices shall be provided to all future owners, heirs, successors, lessees, assigns, and

transferees by the person transferring the interest. A copy of the Environmental Easement is provided in Appendix C.

2. A Site Management Plan has been developed for the Site and requires that:
   a. Any development of the Site will comply with the Site Management Plan
   b. Any development of the Site is done in such a manner that does not interfere with subsurface features associated with the remedy
   c. Any development of the Site be protective of the remedy and ensures the long-term reliability of the controls
   d. Any building constructed on the Site incorporates vapor intrusion prevention design features
   e. The consumption or otherwise use of the groundwater underlying the Site absent NYSDEC approval is prohibited

Engineering controls have also been implemented to ensure the integrity of the Remedial Action for the Site. The following is a listing of the engineering controls:

1. To the extent possible, the existing concrete and asphalt surfaces were left in place. All areas with soil cover have been covered with an additional foot of clean material (crushed concrete/asphalt/demolition debris or imported quarried stone).
2. The shallow groundwater beneath the Site is intercepted by the Falls Street Tunnel and the 47th Street Tunnel. This groundwater is subsequently treated by the City of Niagara Falls wastewater treatment plant.
3. A security fence is in place along the applicable boundaries of the Site.

Section 7.0 Modifications to the Approved Remedial Design

During the implementation of the Site remedy, the encountered field conditions resulted in the need to modify the Site operations under certain circumstances to address the conditions. The modifications were as follows:

1. On occasion, the discharge of the treated soil from the thermal treatment unit resulted in the generation of dust. Modifications were made to the discharge including: i) additional and improved rehydration procedures; ii) modifications to the auger drive system that transferred the soil from the treatment unit; and iii) the installation of additional shielding with fabricated metal sheets and tarps; to reduce the dust generation. On two particularly windy occasions, the processing of source area soil through the thermal treatment unit and all on-Site soil handling activities were temporarily suspended until the winds subsided. This suspension occurred even though the air monitoring program confirmed that the air quality objectives were being met.

2. Part way into the excavation project, it was found that some of the source area soil layers also contained rocks. In order to separate the rocks from the source area soil, an additional mechanical screen was brought to the Site. To the extent necessary, the soil/rock material was screened through the additional screen to separate the rocks from the soil. The rocks, once separated, were passed through the screen multiple times (up to 9 times) to remove any residual soil adhering to the rock surfaces. The screened rocks were allowed to dry out between some of the passes to improve the soil removal from the rock surfaces on the subsequent passes through the screen. Nine samples of the rock material were submitted to a New York State Department of Health certified laboratory to confirm that the VOC concentrations of the rock material met the definition of non-source soil. Upon confirmation, and with NYSDEC approval (which was provided on November 1, 2013), the rocks were blended with other non-source soil and used as backfill in the excavation. An estimated 3,300 cubic yards of rock were separated from the source area soil in this manner. The analytical results from the laboratory confirmation samples of the rock materials are provided in Table 5.7.
3. Due to the minimal VOC presence following the thermal treatment of the source area soil, the Frontier Group requested permission from the NYSDEC in November to reduce the frequency of confirmatory testing of treated soil for the remainder of the project. This permission was granted and the confirmatory sampling of the treated soil was reduced from one sample per 200 cubic yards to one sample per 1,000 cubic yards after November 5, 2013.

Section 8.0 Final Site Conditions

The soil remediation project was successfully completed in accordance with the Remedial Design Report and the Order on Consent. The implementation of the soil remedy resulted in the treatment of more than 95 percent of the VOCs present on the Site based upon the data collected during the remedial investigations. Although areas of the industrial site have historic fill materials left in place under the Site cover, this historic fill and any residual impacts are addressed through the filing of the Environmental Easement and through the implementation of the Site Management Plan. The conditions that remain below the Site cover consist of the following:

a. Within the Soil Remedy's Excavation Area

i) Non-source area soil that contains total VOC concentrations of less than 100 ppm

ii) Source area soil that contains total VOC concentrations averaging 0.34 ppm

iii) 608 cubic yards of TENORM material within the designated backfill area, enveloped in orange filter fabric

The areal and horizontal boundaries of the storage areas containing these materials are presented on Figures 5.3 through 5.7.

b. Outside the boundaries of the Soil Remedy's Excavation Area

i) Non-source area soil that contains total VOC concentrations of less than 100 ppm

ii) TENORM

The concentrations of VOCs in the soils outside the boundaries of the soil remedy's excavation area are presented in Appendix F. These analytical data are from the boreholes completed during the Remedial Investigation and Pre-Design Investigations. A figure showing the location of these boreholes is also included in Appendix F.

Copies of the radiological surveys performed prior to the implementation of the soil remedy are provided in Appendix G to show the locations of possible TENORM across the remainder of the Site.

Section 9.0 Operation, Maintenance, and Monitoring Requirements

There are no future OM&M requirements specifically associated with the Site soil. However, the Site Management Plan (which includes an OM&M Plan) does provide the restrictions and limitations that must be followed in maintaining security at the Site and for any future development of the Site. OM&M will include routine inspection and any necessary repairs to the Site cover system and security system. In addition, the OM&M Plan also specifies the monitoring that is required in conjunction with the groundwater remedies for the Site.

Section 10.0 Summary

This FER details the Remedial Action that has been performed for the Site and the ongoing Operation, Maintenance, and Monitoring that will be performed into the future. All of the work was performed in accordance with the Remedial Design Report and the modifications approved by the NYSDEC during the implementation of the Remedial Action.

Section 11.0 References

Ecology & Environment Engineering, P.C., 2002. *Supplemental Remedial Investigation.*

Ecology & Environment Engineering, P.C., 2004. *Feasibility Study.*

Conestoga-Rovers & Associates, 2010. *Remedial Pre-Design Investigation*.

Conestoga-Rovers & Associates, 2011. *Focused Feasibility Study*.

Conestoga-Rovers & Associates, 2013, *Remedial Design Report*.

MSR, 2013, Proof of Performance Test Report.

New York State Department of Environmental Conservation, March 2006. *Record of Decision*. Frontier Chemical Royal Avenue Site - Operable Unit No. 1 - City of Niagara Falls, Niagara County, New York - Site Number 9-32-110.