FIFTH FIVE-YEAR REVIEW REPORT FOR RAMAPO LANDFILL SUPERFUND SITE ROCKLAND COUNTY, TOWN OF RAMAPO, NEW YORK

Prepared by

U.S. Environmental Protection Agency
Region 2
New York, New York

Eric Wilson, Acting Director
Superfund and Emergency Management Division

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Date

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LIST OF ABBREVIATIONS & ACRONYMS

BMP	Best Management Practices
CFR	Code of Federal Regulations
DCR&EE	Declaration of Restrictive Covenants and Restrictions and Environmental Easement
EC	Emerging Contaminant
EPA	United States Environmental Protection Agency
FYR	Five-Year Review
gpy	Gallons Per Year
HA	Health Advisory
HHRA	Human Health Risk Assessment
HI	Hazard Index
ICs	Institutional Controls
MCL	Maximum Contaminant Level
MDL	Method Detection Limit
µg/L	micrograms per liter
mg/kg	Milligrams per Kilogram
NPL	National Priorities List
NYSDEC	New York State Department of Environmental Conservation
OM&M	Operation and Maintenance Manual
OU	Operable Unit
PFAS	polyfluoroalkyl substances
POTW	Publicly-Owned Treatment Works
RAO	Remedial Action Objective
RD	Remedial Design
RI/FS	Remedial Investigation and Feasibility Study
ROD	Record of Decision
SMP	Site Management Plan
UU/UE	Unlimited Use/Unrestricted Exposure
VOC	Volatile Organic Compound

I. INTRODUCTION

The purpose of a five-year review (FYR) is to evaluate the implementation and performance of a remedy to determine if the remedy is and will continue to be protective of human health and the environment. The methods, findings, and conclusions of reviews are documented in FYR reports such as this one. In addition, FYR reports identify issues found during the review, if any, and document recommendations to address them.

The U.S. Environmental Protection Agency (EPA) is preparing this FYR review pursuant to the Comprehensive Environmental Response, Compensation, and Liability Act Section 121, consistent with the National Contingency Plan (40 CFR Section 300.430(f)(4)(ii)), and considering EPA policy.

This is the fifth FYR for the Ramapo Landfill Superfund site. The triggering action for this statutory review is the completion date of the previous FYR, which was February 26, 2015. The FYR has been prepared because hazardous substances, pollutants, or contaminants remain at the site above levels that allow for unlimited use and unrestricted exposure (UU/UE).

The site is being addressed as a single operable unit (OU), which is the subject of this FYR.

This FYR was conducted by EPA remedial project manager George Jacob. Participants included Julie McPherson, EPA risk assessor; Rachel Griffiths, EPA hydrogeologist; Cecelia Echols, EPA community involvement coordinator; and Payson Long of the New York State Department of Environmental Conservation (NYSDEC).

Site Background

The Ramapo Landfill site is located at 250 Torne Valley Road in the Village of Hillburn, Town of Ramapo, Rockland County, New York. See Figures 1 and 2.

The landfill, which is situated on a 96-acre tract, occupies approximately 60 acres. The landfill consists of two major lobes (northern and southern) and slopes steeply toward the west with grades ranging from less than one percent to greater than 30 percent. Both landfill lobes contain mixed refuse. Substances reportedly disposed of in the landfill include industrial sludge and other wastes from a pharmaceutical company, sewage sludge, municipal refuse, asbestos, construction and demolition debris, yard debris, paint sludge (presumably from an automotive plant), and liquid wastes from a paper company. Utility corridors lie on three sides of the site, high voltage power transmission lines are located to the east and west, and a high pressure gas line is situated to the south. A power substation is located just north of the site. The Ramapo Police Department currently uses a portion of the site for a shooting range.

In the 1950s and 1960s, portions of the site were excavated as a source of gravel. In 1971, the Rockland County Department of Health granted a permit to the Town of Ramapo for the operation of a sanitary landfill. At that time, the site was owned by the Ramapo Land Company and the contract-operator was the Torne Mountain Sand and Gravel Co., Inc.

Municipal waste was accepted in the landfill until 1984 and construction and demolition debris was accepted until 1989.

Appendix A, attached, summarizes the documents utilized to prepare this FYR. Appendix B, attached, provides a chronology of site events. Appendix C, attached, summarizes the site's topography and geology/hydrogeology. For more details related to background, physical characteristics, geology/hydrogeology, land/resource use, and history related to the site, please refer to www.epa.gov/superfund/ramapo-landfill.

FIVE-YEAR REVIEW SUMMARY FORM

SITE IDENTIFICATION		
Site Name: Ramapo Landfill Superfund Site		
EPA ID: NYD000511493		
Region: 2	**State:** NY	**City/County:** Town of Ramapo/Rockland County

SITE STATUS	
NPL Status: Final	
Multiple OUs? No	**Has the site achieved construction completion?** Yes

REVIEW STATUS
Lead agency: State ***[If "Other Federal Agency", enter Agency name]*:**
Author name (Federal or State Project Manager): George Jacob
Author affiliation: EPA
Review period: 2/27/2015 - 2/13/2020
Date of site inspection: 10/28/2019
Type of review: Statutory
Review number: 5
Triggering action date: 2/26/2015
Due date *(five years after triggering action date)*: 2/26/2020

II. RESPONSE ACTION SUMMARY

Basis for Taking Action

In September 1983, the Ramapo Landfill site was placed on the Superfund National Priorities List. Between 1980 and 1988, NYSDEC and the Town of Ramapo entered into four Orders on Consent to effect phasing out landfill operations, constructing a surface water and groundwater diversion system and a leachate collection and transport system, conducting a remedial investigation and feasibility study (RI/FS), and designing and constructing the remedy that was to be ultimately selected. The Town also received a Title 3, Environmental Bond Act grant to assist it in performing the remedial activities.

The results of the RI revealed the presence of volatile organic compounds (VOCs) in three known waste locations (landfill material and paint sludge); VOCs were not detected in surface soil samples. Semivolatile organic compounds, including polycyclic aromatic hydrocarbons, were detected in waste samples and surface soil samples. Antimony, barium, beryllium, cadmium, calcium, chromium, copper, lead, selenium, and zinc were detected in surface soil and waste samples at concentrations exceeding background by an order of magnitude. NYSDEC Water Quality Standards and Guidance Values (T.O.G.S. 1.1.1) and/or EPA Maximum Contaminant Levels (MCLs) were exceeded for arsenic, chromium, iron, lead, magnesium, manganese, mercury, sodium, benzene, chlorobenzene, and di-n-octyl phthalate in on-site groundwater monitoring wells. No federal or state drinking water standards were exceeded in groundwater samples collected from the nearby public or private water supply wells during the RI.

The baseline human health risk assessment (HHRA) identified five potential exposure pathways by which the public may be exposed to contaminant releases at the site under current and future land-use conditions. These pathways included ingestion of soil, dermal contact with soil, inhalation of vapors from the landfill, ingestion of groundwater, and inhalation of vapors during showering. Under current land-use conditions, unacceptable non-carcinogenic risks were identified for workers and child trespassers. Under future land-use conditions, unacceptable risks were identified for adult and child residents living on the site and workers. The primary chemical contributors to noncarcinogenic health risks were xylenes (total) and chlorobenzene for inhalation of vapors from the landfill, and manganese and arsenic for ingestion of groundwater.

For known or suspected carcinogens, under current land-use conditions, the risk characterization showed that cancer risks for all receptors evaluated (*i.e.,* adults, children, and workers) were less than or within the acceptable cancer risk range . Under future land-use conditions, cancer risks for children and workers were within the acceptable range. However, the sum of future cancer risks for all exposure pathways assessed for adults were marginally outside the range. Arsenic and benzene were the chemicals responsible for the highest carcinogenic risks from groundwater ingestion and inhalation of vapors, respectively.

Surface water and sediment samples collected from site water features indicated some impacts from site-related contaminants.

An ecological assessment was conducted to evaluate exposure risks to aquatic life. A comparison of the results obtained from sediment samples with NYSDEC sediment cleanup criteria indicate that contaminant concentrations do not exceed the cleanup criteria. Therefore, sediments are not expected to pose a risk to aquatic life. In reviewing the surface water contaminant concentrations, aquatic surface water standards were exceeded for copper, iron, lead, mercury, sulfide and zinc, however, they do not pose unacceptable risk for ecological receptors. The ecological studies also indicated that there are no federally-listed threatened or endangered species identified at the site. The landfill is in the historical range of a subspecies of the Eastern Woodrat, Neotoma floridana magister, listed by NYSDEC as endangered in New York State. However, because the species' habitat is within rock outcrops or boulder fields, it is unlikely to occur on or in the immediate vicinity of the landfill. No other NYSDEC rare, threatened or endangered species or critical habitats are known to occur within the vicinity of the landfill.

Response Actions

The Town of Ramapo, under NYSDEC oversight, constructed a leachate collection system along the downgradient edge of the landfill from 1984 to 1985. The collected leachate was conveyed to a wastewater treatment pond at the site's southwest corner. After aeration and settling in the pond, the water was discharged to the Ramapo River. In 1990, the collected leachate was discharged to the Village of Suffern Wastewater Treatment Plant via a 7,900-foot sewer line.

Based upon the results of the RI/FS, the following remedial action objectives (RAOs) were established: 1) prevent inhalation of vapors from the landfill; 2) prevent human and animal contact with contaminated soil from the landfill surface; 3) prevent erosion of contaminated surface soil through surface-water runoff; 4) minimize the infiltration of rainfall or snow melt into the landfill, thus reducing the quantity of water percolating through the landfill materials and leaching out contaminants; and 5) reduce the movement and toxicity of the contaminated landfill leachate into groundwater and the subsequent downgradient migration of contaminants.

In March 1992, EPA signed a Record of Decision (ROD) for the site. The selected remedy included:

- Installation of a cap on the top of the landfill using a multimedia system, including layers of fill material, a gas-venting system and an impermeable membrane. The landfill side slopes would be capped using a multimedia system without an impermeable membrane if confirmatory studies demonstrated that this approach met the RAOs. Should the confirmatory studies indicate that the overall remedy's effectiveness would be significantly reduced by not including an impermeable barrier in the multimedia cap on the side slopes, then an impermeable barrier was to be included in the cap on some or all of the side slopes of the landfill.
- Installation of groundwater extraction wells to supplement the existing leachate collection system.
- Installation of a perimeter drain around the sections of the cap containing the impermeable membrane to collect and divert surface water runoff.
- Collection and diversion of leachate seeps to the existing leachate collection system.

- Conveyance of the collected leachate and contaminated groundwater via the sewer system to a local wastewater treatment facility.
- Imposition of property deed restrictions which would include measures to prevent the installation of drinking water wells at the site, and restrict activities which could affect the integrity of the cap.
- Performance of a maintenance and sampling program upon completion of closure activities. The monitoring program will provide data to evaluate the effectiveness of the remedial effort. Additional monitoring points would be established as needed to detect any future movement of site contaminants toward drinking water sources off-site.
- Development of a contingency plan for rapid implementation of additional measures to protect nearby residents and users of groundwater if those measures are determined to be necessary.[1]

Status of Implementation

The Town of Ramapo retained URS Consultants, Inc. to conduct the remedial design (RD), solicit and obtain bids for the landfill closure, and provide construction administration and resident engineering.

As was noted above, the ROD stated that an impermeable barrier would be placed on the landfill's side slopes if confirmatory studies indicated that the remedy's overall effectiveness would be significantly enhanced. The confirmatory studies indicated that the exclusion of an impermeable barrier from the landfill cap on the side slopes would result in increased infiltration of rainfall through the cap. This would cause the generation of greater quantities of contaminated groundwater, which would result in greater operational costs to collect and treat a larger volume of contaminated groundwater and leachate. In addition, it was determined that either a thicker soil cover or an impermeable barrier would be needed on the side slopes to provide adequate control of landfill gases. The impermeable barrier was found to be the less costly of the two options. Therefore, based upon the results of the confirmatory studies, it was concluded that a cap with an impermeable barrier on the landfill's side slopes would be more protective and more cost-effective than a cap without an impermeable barrier on the side slopes. An Explanation of Significant Differences was issued on November 26, 1997 to document these findings.

The RD was approved by NYSDEC in 1992. The RD not only included the plans and specifications for the construction of the landfill cap, installation of groundwater extraction wells to supplement the existing leachate collection system and installation of a perimeter drain, but also included a preliminary design (contingency plan) for the connection of nearby residents to the Pothat Water Company water line should groundwater monitoring indicate that groundwater standards are being contravened.

[1] The contingency plan would include a preliminary design for an alternate water supply. If drinking water standards are significantly exceeded for site-related parameters in residential wells, or in the same aquifer in the closest monitoring wells to the residential wells, and detected concentrations are confirmed by subsequent sampling, residents would immediately be provided with bottled water and/or an acceptable point-of-use treatment system as an interim measure until an alternate water supply could be constructed.

A construction contract was awarded to Geo-Con, Inc., in 1993. Construction of the remedy was performed from 1994 to 1997.

Institutional Controls Summary Table

Table 1, below, summarizes the status of the institutional controls.

Table 1: Summary of Planned and/or Implemented Institutional Controls

Media, engineered controls, and areas that do not support UU/UE based on current conditions	ICs Needed	ICs Called for in the Decision Documents	Impacted Parcel(s)	IC Objective	Title of IC Instrument Implemented and Date (or planned)
Landfill property & groundwater	Yes	Yes	Landfill property	To prevent the installation of drinking water wells at the site and restrict activities which could affect the integrity of the cap	Declaration of Restrictive Covenants and Restrictions and Environmental Easement (DCR&EE) August and October 2012

Systems Operations/Operation & Maintenance

An Operation and Maintenance Manual (OM&M) covering post-landfill cap construction inspection and maintenance was submitted and approved by NYSDEC as part of the RD. The inspections called for in the OM&M are to document the condition of the landfill cover system, groundwater extraction system, leachate collection system, monitoring wells, gas venting system and access roads. During the first year following the landfill cap construction, the site was inspected quarterly and following major storm events. For the subsequent years, the site has been inspected on an annual basis as follows:

- The site is inspected for debris, litter, waste and vandalism;
- The landfill cap is inspected for vegetation loss due to erosion or poor grass growth. Annual ground inspections notes stressed or undesirable species of vegetation on the landfill surface and side slopes;
- The landfill property is visually inspected for leachate outbreaks (precipitates on the ground surface, intermittent seeps, or soft spots);
- The leachate collection system inspection includes manholes, pipes, the valve control panel and tank level controls;
- The landfill cap is inspected for cracks, settlement, erosion and deposition, ponding, and animal borrows;
- The gas venting pipes are inspected for damage;
- The site access gate and fence are inspected for operational locks and vandalism;
- The culverts, drainage ditches, and settlement gauges are inspected for sediment buildup or erosion;

- The groundwater monitoring wells are inspected for operational locks, damage, and vandalism; and
- The extraction wells, leachate collection system, and leachate seep diversion system are inspected to ensure their integrity.

An annual Periodic Review Report submitted by the Town includes a summary of the findings of the above-noted inspection along with a certification that remedy-related operation and management is being performed.

Contaminated groundwater from the site is currently pumped from seven extraction wells. Trend analyses are used to optimize and update the groundwater capture from the site.

Consistent with NYSDEC requirements associated with effecting a DCR&EE, the Town prepared a Site Management Plan (SMP), which was finalized in 2017. The SMP incorporates an Institutional/Engineering Control Plan, Inspection and Monitoring Plan, and OM&M to provide for the continual post-closure monitoring and maintenance of the landfill.

The groundwater monitoring includes shallow overburden monitoring wells (UP-OS, 1-OS, 2-OS, 4-OS, 7-OS, 8-OS, 9-OS, and 10-OS), intermediate overburden monitoring wells (UP-I, 3-OS/I, 8-I, 9-I, and 10-I) and bedrock monitoring wells (UP-R, 8-R, 9-R, and 10-R). Private water supply wells (PW-1 and PW-2) and Suez North America municipal supply wells partnered with Spring Valley Water Company (SVWC-93, 94, 95, and 96) located to the west of the site are monitored. See Figure 3 for the locations of the above-noted monitoring wells and water supply wells.

Because contamination was detected in the "upgradient" monitoring well MW-5 cluster, a new monitoring well cluster (UP-OS/I/R) was installed in October 2016.

The monitoring program originally called for the sampling of the groundwater monitoring wells and drinking water wells three times a year. In 2003, due to the relative stability of the sampling results, the groundwater and drinking water well monitoring frequency was changed to every five quarters to consider potential seasonal effects. More frequent sampling (*i.e.,* quarterly) is performed for the private and public water supply wells because of past MCL exceedances and given their close proximity to the landfill.

In May 2017, flow meters were installed on each extraction well and a notification system was installed to provide alerts if any malfunctions occur.

Potential site impacts from climate change have been assessed, and the performance of the remedy is currently not at risk due to the expected effects of climate change in the region and near the site.

III. PROGRESS SINCE THE LAST REVIEW

The protectiveness determinations from the last FYR are summarized in Table 2, below.

Table 2: Protectiveness Determinations/Statements from the 2015 FYR

OU	Protectiveness Determination	Protectiveness Statement
01	Short-term Protective	The remedy protects human health and the environment in the short-term because the remedies have interrupted exposure of humans and ecological receptors to landfill wastes and institutional controls to prevent the installation of drinking water wells at the site and to restrict activities which could affect the integrity of the cap are in place. In order for the remedy to be protective in the long-term, the following activities need to take place: an investigation into the source of the contamination in the current "upgradient" monitoring well cluster MW5 should be performed and, if appropriate, corrective measures taken; a new upgradient monitoring well cluster should be installed at a location that is not impacted by historic disposal operations; a determination as to whether the landfill is the source of iron, manganese and other metals detected in groundwater monitoring wells, including an assessment of background conditions; and a capture zone analysis of the leachate collection system should be conducted
Sitewide	Short-term Protective	The remedy protects human health and the environment in the short-term because the remedies have interrupted exposure of humans and ecological receptors to landfill wastes and institutional controls to prevent the installation of drinking water wells at the site and to restrict activities which could affect the integrity of the cap are in place. In order for the remedy to be protective in the long-term, the following activities need to take place: an investigation into the source of the contamination in the current "upgradient" monitoring well cluster MW5 should be performed and, if appropriate, corrective measures taken; a new upgradient monitoring well cluster should be installed at a location that is not impacted by historic disposal operations; a determination as to whether the landfill is the source of iron, manganese and other metals detected in groundwater monitoring wells, including an assessment of background conditions; and a capture zone analysis of the leachate collection system should be conducted.

The previous FYR had several recommendations and suggestions. The status of the recommendations and suggestions are summarized in Tables 3 and 4, below.

Table 3: Status of Recommendations from the 2015 FYR

OU	Issue	Recommendations	Current Status	Current Implementation Status Description	Completion Date (if applicable)

01	Contamination was detected in the "upgradient" monitoring well MW5 cluster.	An investigation into the source of the contamination in monitoring well MW5 cluster should be performed. If appropriate, corrective measures need to be taken.	Completed	A new upgradient well cluster was constructed to replace the MW-5 cluster (because contamination was detected). Concentrations of aluminum, antimony, iron, nickel, and sodium were detected above their respective MCLs, implying that these metals are naturally-occurring.	10/28/2016
01	Because contamination was detected in the "upgradient" monitoring well MW5 cluster, a new "upgradient" monitoring well cluster is needed.	A new monitoring well cluster should be installed at an upgradient location that is not impacted by historic disposal operations. The screened elevations should be similar to the monitoring well MW5 cluster.	Completed	A new upgradient well cluster was constructed and sampled.	10/28/2016
01	It is unknown whether the landfill is the source of iron, manganese and other metals detected in downgradient groundwater monitoring wells.	The background levels of iron, manganese, and other metals in native soils and bedrock should be researched and compared with local sampling data to determine the potential range of groundwater levels that are related to the landfill operations and the current uses of the property.	Completed	It has been concluded these metals are naturally-occurring.	10/28/2016
01	Extraction well capture efficacy cannot be determined	Evaluate leachate collection capture.	Addressed in next FYR	Potentially responsible party response to the recommendation not acceptable to EPA and NYSDEC.	Incomplete

Table 4: Status of Suggestions from the 2015 FYR

OU	Comment	Suggestions	Current Status	Current Implementation Status Description	Completion Date (if applicable)
01	In accordance with best management practices (BMP) of outdoor shooting ranges, berms should be covered by a roof to prevent erosion of the berm and increased lead mobility. During the five-year review site inspection, it was observed that a roof was not present and expended bullet casings were present and accumulating on the ground. The Town submitted a draft Plan for BMP and a draft preliminary roof design on October 30, 2014. The drafts are currently under review by the Agencies.	The review of the BMP of outdoor shooting ranges and draft preliminary roof design should be completed by the Agencies and appropriate recommendations should be carried out.	Completed	Construction of Eco-bond lead stabilization approach by MT-2 (which includes lead abatement and backstop berm reconstruction) in lieu of the covering of backstop berm completed in 2018 per work plans and design approved by EPA and NYSDEC. The Ramapo Police strongly objected to the covering of the berm and presented the Eco-bond alternative currently in use at other police facilities as a BMP of outdoor shooting ranges.	4/15/2018
01	Several intermediate and bedrock monitoring wells were not sampled in the review period. The number of groundwater monitoring wells, parameters and	All of the monitoring wells and piezometers in the network need to be sampled consistent with the long-term monitoring plan for the site.	Addressed in Next FYR	Incomplete	Incomplete

	frequency of sampling need to be enhanced				
01	The monitoring of each groundwater extraction point needs to include pumping records using separate flow meters to obtain operating flows.	Flow meters need to be installed in each groundwater extraction well. The monitoring of each groundwater extraction point should include pumping records using separate flow meters.	Completed	New flowmeters were installed. They are, however, currently inoperable.	5/15/2017
01	Enhanced alarm and communication systems to monitor operation of each groundwater extraction point should be considered to monitor performance and improve reliability of the extraction system.	A mechanism should be put into place on each groundwater extraction point to alert personnel of problems with extraction well operations.	Completed	All pump stations are equipped with an amber signal light to alert Town personnel of a high level alarm condition.	10/28/2016
01	A remedial system optimization program is needed to address alternate diversion and disposal of surface water runoff from the site if monitoring determines there is no reason to require treatment at a publicly-owned treatment works (POTW).	A remedial system optimization program should be conducted to address alternate diversion and disposal of surface water runoff from the site if monitoring determines there is no reason to require treatment at a POTW.	Not applicable	Literature review conducted. Because surface water runoff is not currently treated at a POTW, an optimization program is not necessary at this time.	Not applicable
01	Landfill caps can provide nesting	Evaluate and adjust the mowing schedule to reduce	Completed	The awareness of mowing to improve nesting bird habitat and	5/15/2017

	habitat for grassland birds.	potential impacts to birds that may nest on the site, especially in the spring.		preventing rattlesnake inhabitation has been included in the revised SMP. The SMP outlines a mowing plan to balance the enhancement of use of the landfill by wildlife, but also prevent deep rooted plants from damaging the cover system.	

IV. FIVE-YEAR REVIEW PROCESS

Community Notification, Involvement & Site Interviews

On October 1, 2019, EPA Region 2 posted a notice on its website indicating that it would be reviewing site cleanups and remedies at Superfund sites in New York, New Jersey, Puerto Rico and the US Virgin Islands including the Ramapo Landfill Superfund site. The announcement can be found at the following web address: https://www.epa.gov/superfund/R2-fiveyearreviews.

In addition to this notification, a notice of the commencement of the FYR was sent to local public officials. The notice was provided to the Town of Ramapo by email on December 5, 2019, with a request that the notice be posted in public areas in the town hall. The purpose of the public notice was to inform the community that EPA would be conducting a FYR to ensure that the remedy implemented at the site remains protective of public health and is functioning as designed. In addition, the notice included contact information, including addresses and telephone numbers, for questions related to the FYR process or the site.

Once the FYR is completed, the FYR report will be made available online (www.epa.gov/superfund/ramapo-landfill) and at the site information repositories. The information repositories are maintained at the Finkelstein Public Library, 24 Chestnut Street, Spring Valley, New York, Suffern Free Public Library, Washington and Maple Avenues, Suffern, New York and the EPA Region 2 Superfund Records Center, 290 Broadway, 18th Floor, New York, New York.

Data Review

Upgradient Monitoring Well Sampling Results

An upgradient monitoring well cluster (installed in 2016) has been sampled three times. Maximum concentrations of aluminum at 1,540 micrograms per liter (µg/L) at UP-1 in 2018 (MCL of 200 µg/L), antimony at 3.82 µg/L (MCL of 3 µg/L), iron at 3,230 µg/L (New York State groundwater

standard of 300 µg/L), nickel at 154 µg/L(New York State groundwater standard of 100 µg/L), and sodium at 24,800 µg/L (New York State groundwater standard of 20,000 µg/L) were detected.

Downgradient Monitoring Well Sampling Results

Data collected during the review period from monitoring wells located downgradient of the landfill indicate relatively consistent detections of iron and manganese above their respective MCLs. These constituents are present in the regional aquifer and are likely being mobilized due to the typically reducing and acidic geochemistry of landfills. Less consistent detections include chromium, magnesium, nickel, and sodium above their respective MCLs. Nickel and sodium are present in upgradient monitoring wells.

While historic trends for chromium (since 1999) have shown increasing concentrations at several monitoring wells, most of these locations exhibited decreasing or stable trends during the review period (*e.g.,* monitoring wells 1-OS, 4-OS, and 8-OS). Chromium was detected above its MCL of 50 µg/L at sentinel monitoring location 10-R during the May 2018 sampling event at 181 µg/L. Prior to this sampling event, the maximum concentration was 7.9 µg/L.

Magnesium was detected at 35,900 µg/L (above its MCL of 35,000 µg/L) at monitoring well 8-R during the review period. With the exception of monitoring well 5-OS on two occasions, this has been the only location with exceedances since 1999.

Concentrations of nickel exceeding its New York State groundwater standard were observed at monitoring wells 1-OS, 2-OS, 3-OS, 10-R, and UP-I during the review period. The detections at monitoring wells UP-I and 10-R are the first exceedance at either location. The maximum concentration detected during the review period was 1,044 µg/L at 3-OS/I in 2019. Nickel has been detected more frequently at monitoring wells 1-OS, 2-OS, and 3-OS in which concentrations have been relatively stable or decreasing since 2005. The concentration of nickel detected in monitoring well 3-OS in 2019 was a significant increase from the prior concentrations during the review period which were in the range of 300-400 µg/L

Sodium exceeded its MCL of 20,000 µg/L at the majority of monitoring locations. Concentration trends for sodium show a generally increasing trend since 1999, but most locations show decreasing trends since 2015.

Leachate Collection and Groundwater Extraction System

The efficacy of the leachate collection and groundwater extraction system has improved significantly since 2011, when the total extracted volume was less than 10 million gallons per year (gpy). Since 2012, the average extracted volume is approximately 13 million gpy; the extracted volume was approximately 17 million gpy in 2017. The increased extraction volume correlates to decreasing contaminant trends.

Water Supply Well Sampling Results

Groundwater samples from both the private (PW-1 and PW-2) and public (SVWC-93, SVWC-94, SVWC-95, and SVWC-96) wells are collected and compared to state and EPA MCLs. A sporadic exceedance of secondary drinking water standards for iron and manganese was noted at SVWC-95 in the July 2015 sampling event. During the review period, sodium (naturally-occurring) was detected above its MCL of 20 milligrams per liter in all the water supply wells except PW-2. Based on the sampling results, the potable water supplies are not being impacted by site-related contaminants.

Emerging Contaminants

In response to a request from NYSDEC, in July 2019, select groundwater samples were analyzed for emerging contaminants (ECs)--1,4-dioxane and per- and polyfluoroalkyl substances (PFAS). The results are summarized below.

1,4-Dioxane

Groundwater samples were collected and analyzed for 1,4-dioxane from monitoring wells UP-OS, UP-I, UP-R, 9-OS, 9-I, 9-R, 10-OS, 10-I, and 10-R and public water supply wells SVWC-94 and SVWC-95. The proposed Maximum Contaminant Level (MCL) for 1,4-dioxane in groundwater is 1 ppb; 1,4-dioxane was not detected above the laboratory method detection limit (MDL) in groundwater samples collected from monitoring wells UP-OS, UP-I, UP-R, 9-OS, 9-I, 10-OS, 10-I, and 10-R. It was, however, detected at 3.16 µg/L, 0.0576 µg/L, and 0.36 µg/L in samples collected from monitoring well 9-R and public water supply wells SVWC-94 and SVWC-95, respectively. (See Tables 4 and 5).

Per- and Poly-Fluoroalkyl Substances

Groundwater samples were collected for PFAS analysis from monitoring wells UP-OS, UP-I, UP-R, 9-OS, 9-I, 9-R, 10-OS, 10-I, and 10-R and public water supply wells SVWC-94 and SVWC-95. PFAS were not detected above the laboratory MDL in groundwater samples collected from monitoring wells UP-I and 10-OS. The EPA Health Advisory (HA) level is 0.070 µg/L for perfluorooctanoic acid (PFOA) and perfluorooctanesulfonic acid (PFOS), individually and combined. The sum of PFOA and PFOS in monitoring wells UP-OS, UP-R, 9-OS, 9-I, 9-R, 10-I, and 10-R and from public water supply wells SVWC-94 and SVWC-95 ranged from 0.000483 µg/L (monitoring well 10-I) to 0.034 µg/L (monitoring well 9-OS). The EPA HA level was not exceeded at any of the monitoring locations for individual or combined results. Additionally, the screening value of 0.040 µg/L from the December 19, 2019 "Interim Recommendations to Address

Groundwater Contaminated with Perfluorooctanoic Acid and Perfluorooctanesulfonate (OLEM Directive No 9283.1-47)," was not exceeded.

The State of New York is in the process of finalizing the MCLs for 1,4-dioxane, PFOA and PFOS. EPA will continue to work with NYSDEC to determine whether further sampling at this site is necessary.

Site Inspection

The inspection of the site was conducted on October 28, 2019. In attendance were George Jacob from EPA, Jeffrey Dyber and Payson Long from NYSDEC, Vance Pleski from the Ramapo Police Department, and Ted Dzurinko, Paul Gdanski, and Glenn Zahlmann from the Town of Ramapo. The purpose of the inspection was to assess the protectiveness of the remedy.

During the inspection, it was noted that deep-rooted plants and trees are growing along some sections of the landfill's cover on the drainage swales. This vegetation could compromise the integrity of the landfill cover.

V. TECHNICAL ASSESSMENT

QUESTION A: Is the remedy functioning as intended by the decision documents?

The implemented remedy included the installation of a cap with an impermeable membrane, installation of groundwater extraction wells to supplement the existing leachate collection system, and collection and diversion of leachate to the leachate collection system for off-site treatment. The cap is currently being maintained by the Town as part of the New York State Part 360 closure requirements. NYSDEC inspects and assesses the integrity of the cap annually, as does the Town of Ramapo during periodic mowing of the grass. Currently, leachate and extracted groundwater are treated off-site by the Rockland County Sewer District. Sampling results of the public and private drinking water wells revealed no contamination of concern from the Ramapo Landfill. A new sentinel well cluster has been installed and sampled, which verifies the limit of impacted groundwater associated with the site. As required by the ROD, a DCR&EE was recorded in 2012 to prevent the installation of drinking water wells at the site and to restrict activities that could affect the integrity of the cap.

Iron and manganese both downgradient and upgradient of the landfill continue to exceed their secondary MCLs. The installation of a new upgradient well cluster to determine the source of these contaminants and establish regional and site-specific levels confirms the presence of the naturally-occurring inorganic constituents at the site. However, the existing groundwater extraction wells need to be individually monitored and a capture zone analysis of the extraction network conducted. Based on the fluctuating iron and manganese levels in multiple downgradient wells, the capture zone analysis will help determine the source of these exceedances (landfill versus naturally-occurring background) and assist in determining capture efficacy of the leachate collection system.

QUESTION B: Are the exposure assumptions, toxicity data, cleanup levels, and remedial action objectives (RAOs) used at the time of the remedy selection still valid?

Although some exposure assumptions have changed and several exposure pathways were not evaluated in the 1991 HHRA, the need to take a remedial action remains valid. The toxicity values for several contaminants of concern have changed since the RI. To account for changes in toxicity values since the RI, the maximum detected concentrations of these contaminants in monitoring wells during the review period were compared to their respective MCLs. Several site-related contaminants were identified as exceeding their respective MCLs or New York State groundwater standards. However, institutional controls prevent the installation of drinking water wells. The groundwater use on-site is not expected to change in the future. Additionally, the data analysis shows that private and public supply wells downgradient are not impacted by the landfill. It is recommended that the private and public water supply wells continue to be monitored.

The implemented remedy has met the objectives of the ROD of eliminating the exposure pathway to site-related contaminants via the soil exposure pathway and reducing the risk to human health and the environment due to contaminants leaching from the landfill mound.

The ROD evaluated potential threats to ecological receptors from sediment and surface water at the site. At that time, sediment contaminant concentrations were below the cleanup criteria, while inorganic contaminants exceeded aquatic surface water criteria. As part of the remedy, the leachate holding pond was excavated, and all leachate is treated off-site. Therefore, the potential for exposure to ecological receptors has been eliminated.

The RAOs established in the ROD are valid at this time.

QUESTION C: Has any other information come to light that could call into question the protectiveness of the remedy?

No.

Technical Assessment Summary

Based upon the results of the FYR, it has been concluded that:

- The cap and vegetative cover are intact and in good condition.
- The fence around the cap within the site is intact and in good repair.
- The monitoring wells are in good condition and are properly locked.
- The Town implemented BMPs for the shooting range in 2018.
- The groundwater and leachate collection system is fully functional.
- The flow meters that were installed on each extraction well in 2017 are not functional.
- The existing groundwater extraction wells need to be individually monitored and a capture zone analysis of the extraction network conducted. Based on the fluctuating iron and manganese levels in multiple downgradient wells, a study needs to be conducted to determine the source of these exceedances (landfill versus naturally-occurring background) and assist in determining capture efficacy of the leachate collection system.

VI. ISSUES/RECOMMENDATIONS

Table 4, below, presents a recommendation and follow-up action for this FYR.

Table 4: Issue and Recommendation

Issues/Recommendations				
OU(s) without Issues/Recommendations Identified in the Five-Year Review:				
OU1				
Issues and Recommendations Identified in the Five-Year Review:				
OU(s): **OU1**	**Issue Category: Remedy Performance**			
	Issue: Extraction well capture efficacy cannot be determined			
	Recommendation: A capture zone analysis of the leachate collection system needs to be conducted.			
Affect Current Protectiveness	**Affect Future Protectiveness**	**Party Responsible**	**Oversight Party**	**Milestone Date**
No	Yes	PRP	EPA/State	1/31/2021

OTHER FINDINGS

1. ECs sampling for 1,4-dioxane and PFAS were conducted during this review period. Upgradient monitoring wells, downgradient sentinel wells, and two public supply wells were sampled. EPA will continue to work with NYSDEC to determine whether further sampling at this site is necessary.
2. The flow meters for the extraction wells are not functional. The flow meters need to be replaced.
3. Deep-rooted plants and trees are growing on the landfill's cover on the drainage swales in various areas at the top of the landfill. Because this vegetation could compromise the integrity of the landfill cover, it should be removed.
4. Several bedrock monitoring wells were not sampled during the last five years. Chromium has been detected above its criteria in overburden and intermediate monitoring wells and also exceeded its respective criteria in historical bedrock monitoring wells. All monitoring wells should be included in the future sampling events and analyzed for site-related Target Compound List/Target Analyte List.

VII. PROTECTIVENESS STATEMENT

Table 5, below, presents the operable unit and sitewide protectiveness statements.

Table 5: Protectiveness Statements

Protectiveness Statement(s)		
Operable Unit: OU1	*Protectiveness Determination:* Short-term Protective	*Planned Addendum Completion Date:* Click here to enter a date
Protectiveness Statement: The remedy protects human health and the environment in the short-term because the remedy has interrupted exposure of humans and ecological receptors to landfill wastes and institutional controls to prevent the installation of drinking water wells at the site and to restrict activities which could affect the integrity of the cap are in place. For the remedy to be protective in the long-term, extraction well capture efficacy must be determined.		
Sitewide Protectiveness Statement		
Protectiveness Determination: Short-term Protective		*Planned Addendum Completion Date:* Click here to enter a date
Protectiveness Statement: The remedy protects human health and the environment in the short-term because the remedies have interrupted exposure of humans and ecological receptors to landfill wastes and institutional controls to prevent the installation of drinking water wells at the site and to restrict activities which could affect the integrity of the cap are in place. For the remedy to be protective in the long-term, extraction well capture efficacy must be determined.		

VIII. NEXT REVIEW

The next FYR report for the Ramapo Landfill Superfund site is required five years from the completion date of this review.

APPENDIX A – DOCUMENTS, DATA, AND INFORMATION REVIEWED IN COMPLETING FIVE YEAR REVIEW

Documents, Data, and Information Reviewed in Completing Five-Year Review	
Remedial Investigation and Feasibility Study Report, URS Consultants, Inc.	1991
Record of Decision, EPA	1992
Final Design Analysis Report, URS Greener, Inc.	1994
Explanation of Significant Differences, EPA	1997
Preliminary Close-Out Report, EPA	1997
Operation and Maintenance Monitoring Manual, URS Greener, Inc.	1998
Construction Monitoring Report Ramapo Landfill Remediation, URS Greiner, Inc.	1998
Five Year Review Report, EPA	1999
Second Five-Year Review Report, EPA	2004
Addendum to the Second Five-Year Review report.	2005
Third Five-Year Review Report, EPA	2009
Revised Draft SMP, Sterling Environmental Engineering	2014
Plan for Best Management Practices & Preliminary Roof Design for shooting range, Town of Ramapo	2014
Work Plan, Installation report and sampling results for the new downgradient sentinel well cluster	2014
Fourth Five-Year Review Report, EPA	2015
Work Plan, Installation report and sampling results for the new upgradient monitoring well cluster	2017
DCR & EE	2012
Periodic Review Reports, Sterling Environmental Engineering	2014-2019

APPENDIX B: CHRONOLOGY OF SITE EVENTS

Event	Date
Commencement of operation of the Ramapo Landfill	1950
NYSDEC and Town of Ramapo enter into three Orders on Consent related to phasing out operation of landfill, determining extent of leachate movement and feasibility of leachate collection, and constructing surface-water and groundwater-diversion system, leachate-collection system, and system capable of transporting or treating collected leachate	1980 1986
Site placed on National Priorities List	1983
Town enters into fourth Order on Consent with NYSDEC under which a remedial investigation and feasibility study is performed.	1988
Record of Decision signed	1992
Remedial Design	1992-1994
Remedial Action	1994-1997
Explanation of Significant Differences	1997
First Five Year Review conducted.	1999
Preliminary Site Close Out Report.	2002
Second Five-Year Review conducted.	2004
Addendum to the Second Five-Year Review report.	2005
Third Five-Year Review conducted.	2009
Installation of new downgradient sentinel well cluster	2014
Commencement of operation of the Ramapo Landfill	1950
NYSDEC and Town of Ramapo enter into three Orders on Consent related to phasing out operation of the landfill, determining extent of leachate movement and feasibility of leachate collection, and constructing a surface-water and groundwater-diversion system, leachate-collection system, and system capable of transporting or treating the collected leachate	1980 1986
Site is placed on National Priorities List	1983
Town enters into fourth Order on Consent with NYSDEC under which a remedial investigation and feasibility study is performed.	1988
Record of Decision signed	1992
Remedial Design	1992-1994
Remedial Action	1994-1997
Explanation of Significant Differences	1997
First Five Year Review conducted.	1999
Preliminary Site Close Out Report.	2002
Second Five-Year Review conducted.	2004
Addendum to the Second Five-Year Review report.	2005
Third Five-Year Review conducted.	2009

Implementation of Institutional Controls	2012
Installation of new downgradient sentinel well cluster	2014
Fourth Five Year Review conducted	2015
Installation of new UP well cluster	2017
BMP for outside firing range EcoBond MT-2 construction	2018

APPENDIX C: SITE TOPOGRAPHY, GEOLOGY, AND HYDROGEOLOGY

Site Geology/Hydrogeology

The main surface waters in the vicinity of the site are the Ramapo River, Torne Brook and Candle Brook. The Ramapo River, located approximately 300 feet from the southwest corner of the site, is a New York State Department of Environmental Conservation (NYSDEC) Class "A" water, which may be used as a source of water supply for drinking, culinary, or food-processing purposes. Torne Brook, which flows near the western boundary of the site, and Candle Brook, a tributary of Torne Brook, are NYSDEC Class "B" waters, suitable for primary contact recreation and any other use, except as a source of water supply for drinking, culinary, or food-processing purposes. The United States Geological Survey has identified an area of less than ten acres near the headwaters of Candle Brook as a wetland.

The site is underlain by a sequence of glacially derived unconsolidated sediments that overlie bedrock, which is comprised of granitic and biotite gneiss. The bedrock geology is structurally complex with numerous fault systems in the area. A fracture trace analysis identified a number of lineaments in the vicinity of the site, the most obvious one being the Ramapo fault (approximately 1.25 miles southeast of the site), which strikes northeast and dips steeply southeast. Two other lineaments observed within the immediate area of the landfill include one that lies adjacent to the west side of the landfill and trends northeast. This lineament may represent faulting or other subsurface structures controlling deflections in Torne Brook. The second lineament trends east-west and appears to cross the central portion of the landfill.

The shallow aquifer is comprised of permeable sediments consisting of a grey to brown, very loose to loose sand or sandy gravel with some silt with a hydraulic conductivity on the order of 1×10^{-4} centimeters per second (cm/sec) and a medium-dense to very dense silty sand or gravelly sand with abundant boulders and cobbles with hydraulic conductivity values ranging from 5.1×10^{-5} to 1.4×10^{-4} cm/sec. Below these sand units is a thin weathered rock zone ranging in thickness from a few inches to nearly five feet with hydraulic conductivity values ranging from 4×10^{-5} to 1.5×10^{-3} cm/sec. Underlying the weathered rock zone is a granitic and biotite gneiss bedrock aquifer. In some locations, highly fractured zones were found within the bedrock suggesting faulting. Hydraulic conductivity values for the bedrock aquifer ranged from 8.9×10^{-5} to 1×10^{-2} cm/sec.

Past investigations found that shallow (water-table aquifer) groundwater generally flows toward Torne Brook and the Ramapo River with Torne Brook acting as the discharge area for the water-table aquifer, and that groundwater in the bedrock aquifer likely flows beneath Torne Brook. Vertical flow measurements indicate that groundwater generally flows downward.

Land and Resource Use

The Town subdivided the property north of the limit of waste and sold it to the Rockland County Solid Waste Management Authority in August 1998. The Rockland County Solid Waste Management Authority currently operates a garbage transfer facility at this location.

A pistol range utilized by the Town of Ramapo Police Department since May 1997 is located in the northeastern area of the site. Immediately adjacent to it (south of the pistol range), the Rockland County Solid Waste Management Authority constructed a leaf composting facility in 2007.

Groundwater is withdrawn from the area south and west of the site for residential use. Ten water supply wells, operated by the Spring Valley Water Supply Company and serving a population of over 200,000, are located along the Ramapo River both upstream and downstream of the site. Four of these wells are located within 1,600 feet of the landfill, the nearest being 750 feet from the landfill. The closest private well is located approximately 450 feet west of the site on the west bank of the Ramapo River at the Torne Brook Estate, a residential apartment complex of 25 units. A two-unit apartment building maintains a well about 1,200 feet from the landfill.

Figure 1: Site Location Map

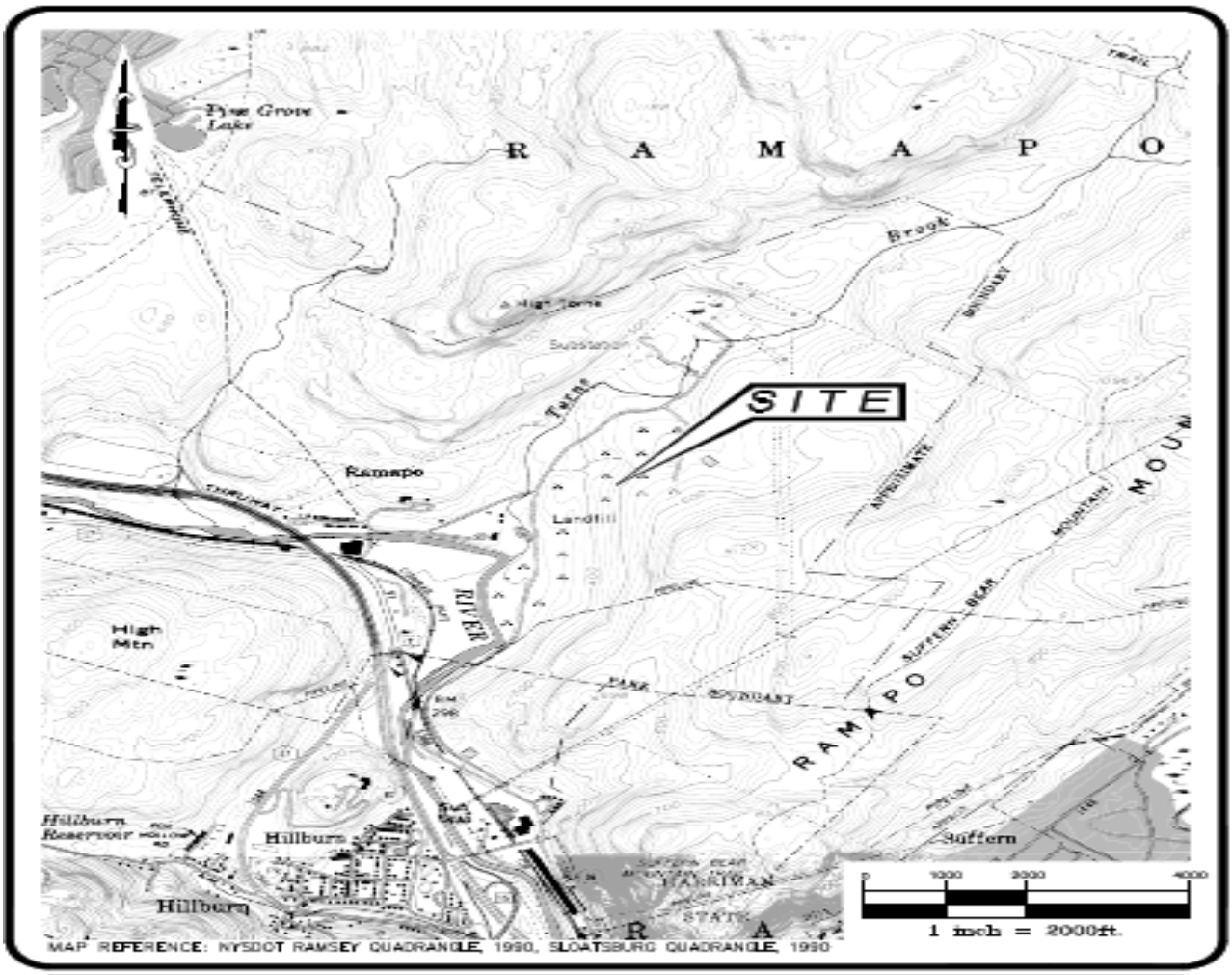

Figure 2: Site Boundary Map

Figure 3: Groundwater monitoring locations