FOURTH FIVE-YEAR REVIEW REPORT FOR LOWRY LANDFILL SUPERFUND SITE ARAPAHOE COUNTY, COLORADO

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Prepared by

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Region 8
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Date

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LIST OF ABBREVIATIONS & ACRONYMS

ARAR	Applicable or Relevant and Appropriate Requirement
BTS	Biological Treatment System
CDPHE	Colorado Department of Public Health and Environment
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
CIC	Community Involvement Coordinator
CLLEAN	Citizens for Lowry Landfill Environmental Action Now
COC	Contaminant of Concern
CWM	Chemical Waste Management, Inc.
DADS	Denver Arapahoe Disposal Site
DBF	DADS Blower/Flare
DCA	Dichloroethane
EMSI	Engineering Management Support, Inc.
EPA	United States Environmental Protection Agency
ESD	Explanation of Significant Differences
ft bgs	Feet below ground surface
FTPA	Former Tire Pile Area
FS	Feasibility Study
FS3	Flare Station 3
FYR	Five-Year Review
GAC	Granular Activated Carbon
gpm	Gallons per Minute
GTEP	Gas-to-Energy Plant
GWMP	Groundwater Monitoring Plan
IC	Institutional Control
LFG	Landfill Gas
µg/L	Micrograms per Liter
mg/kg	Milligram per Kilogram
mg/L	Milligram per Liter
NAPL	Non-Aqueous Phase Liquids
NBBW	North Boundary Barrier Wall
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
ND	Not Detected
NPL	National Priorities List
NTES	North Toe Extraction System
O&M	Operation and Maintenance
OU	Operable Unit
PCB	Polychlorinated Biphenyl
PCE	Tetrachloroethylene
POC	Point of Compliance
POTW	Publicly Owned Treatment Works
PQL	Practical Quantitation Limit
PRP	Potentially Responsible Party
RAO	Remedial Action Objective
RD/RA	Remedial Design/Remedial Action
RI	Remedial Investigation
ROD	Record of Decision
RPM	Remedial Project Manager
SIM	Selective Ion Monitoring
SWMP	Stormwater Management Plan
SWRA	Surface Water Removal Action

TCE	Trichloroethylene
TCHD	Tri-County Health Department
UU/UE	Unlimited Use and Unrestricted Exposure
VIAM	Vapor Intrusion Model
VISL	Vapor Intrusion Screening Level
VOC	Volatile Organic Compound
WMC	Waste Management of Colorado, Inc.
WSDs	Work Settling Defendants
WTP	Water Treatment Plant

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 pursuant to the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) Section 121, consistent with the National Contingency Plan (NCP) (40 CFR Section 300.430(f)(4)(ii)), and considering EPA policy.

This is the fourth FYR for the Lowry Landfill Superfund Site (the Site). The triggering action for this statutory review is the completion date of the previous FYR. The FYR has been prepared due to the fact that hazardous substances, pollutants or contaminants remain at the Site above levels that allow for unlimited use and unrestricted exposure (UU/UE).

The Site consists of six operable units (OUs), and all will be addressed in this FYR. A description of each OU is provided below in Table 1.

Table 1: Operable Unit Description

Operable Unit	Description
1	Shallow groundwater and subsurface liquids
2	Landfill solids
3	Landfill gas
4	Soils
5	Surface water and sediments
6	Deep groundwater

The Lowry Landfill Superfund Site FYR was led by Leslie Sims, EPA remedial project manager (RPM). Participants included EPA community involvement coordinator (CIC) Katherine Jenkins; Jeannine Natterman, Doug Jamison and Lee Pivonka of Colorado Department of Public Health and Environment (CDPHE); Lynn Robbio-Wagner (Tri-County Health Department); Chris Carlson (Parsons); Tim Shangraw of Engineering Management Support, Inc. (EMSI); Bruce Peterman and Tim Murphy (Pacific Western Technologies); and Johnny Zimmerman-Ward and Alison Cattani from EPA support contractor Skeo. The review began on 5/20/2016. Documents reviewed in this FYR are listed in Appendix A.

Site Background

The 507-acre Site is located in western Arapahoe County, Colorado, about two miles east of Aurora (Figure C-1). From the mid-1960s until 1980, the city and county of Denver operated the landfill, which accepted liquid and solid municipal and industrial wastes, including sewage sludge disposed of in unlined pits or land application. In 1980, Waste Management of Colorado, Inc. (WMC) took over operation of the landfill. At that time, waste disposal on-Site was restricted to municipal waste and later asbestos waste. Municipal solid waste disposal activities ceased in 1990 and a 4-foot soil cover was installed over the landfill unit. Asbestos disposal occurred northwest of the landfill and is ongoing northeast of the landfill (Figure 1). Landfilling operations contaminated soil, groundwater, surface water and sediment with hazardous substances. Additionally, gases from buried wastes contaminated the air spaces in subsurface soil. The Denver Arapahoe Disposal Site (DADS), an operating municipal solid waste landfill, forms the northern and eastern boundaries of the Site (Figure 1). The City of Denver is the sole owner of the DADS parcels. Current landfilling operations are limited to asbestos disposal activities on the northeastern portion of the Site. Solid waste disposal operations are expected to continue at DADS for the next several decades. Land use in the general area surrounding the Site is changing, with new and

planned residential communities located west and north of the Site and DADS (Figure 2). Road expansions for Gun Club Road and East Quincy Avenue (the southern boundary of the Site) are planned to begin in 2018.

The topography of the Site includes gently rolling hills with a gentle slope on the north half of the Site and a topographic high on the south half of the Site caused by past landfilling activities. The Site is located within the Murphy Creek drainage system. An unnamed tributary to Murphy Creek is present on the Site. This Unnamed Creek is dry and only contains water during significant precipitation or snow melt events. Unnamed Creek extends from the toe of the landfill through the northern portion of the Site. Murphy Creek is located immediately east of the Site (Figure 1). Groundwater exists in two major systems, each with two aquifer zones, and includes (from shallowest to deepest) (Figure C-2):

- Shallow groundwater:
    - Alluvium/weathered Dawson (0-60 feet below ground surface [ft bgs])
    - Unweathered Dawson (30-160 ft bgs)
- Deep groundwater
    - Upper Denver (120-210 ft bgs)
    - Lignite Layer (200-350 ft bgs)

The lower Unweathered Dawson aquifer (OU1) is separated from the Upper Denver (OU6) by the Separation Layer. The Separation Layer is considered an aquitard unless absent or intersected by other geologic structures such as faults. The Lignite Layer is the deepest hydrostratigraphic unit monitored at the Site and the vertical point of compliance (POC). Groundwater flow within the shallow and deep systems is predominantly to the north, although the shallow groundwater system also shows components of flow to the east, west and south. Groundwater rights on-Site and immediately off-Site are owned by the City of Denver, and use is restricted to monitoring or remediation purposes only. Two private residential wells are located about one mile north of the Site, along Jewel Avenue. The wells are screened in the Denver Formation at depths of 200 to 600 ft bgs. The City of Denver samples these wells annually each spring, and no contamination has been observed. See the Data Review section for additional information. The City of Denver conducted a half-mile well survey east, west and south of the Site as well in 2017 and a 5-mile well survey north (downgradient) of the Site in 2014 and 2017. Additional domestic wells were identified north of the Site; information on the most recent 2017 well survey is included in the Institutional Control section of this FYR. A Site chronology table is presented in Appendix B.

FIVE-YEAR REVIEW SUMMARY FORM

SITE IDENTIFICATION		
Site Name: Lowry Landfill		
EPA ID: COD980499248		
Region: 8	**State:** CO	**City/County:** Aurora, Arapahoe County
SITE STATUS		
NPL Status: Final		
Multiple OUs? Yes	**Has the site achieved construction completion?** Yes	
REVIEW STATUS		
Lead agency: EPA		

Author name: Leslie Sims with contractor support provided by Skeo
Author affiliation: EPA Region 8 and Skeo
Review period: 5/20/2016 - 9/28/2017
Date of site inspection: 10/25/2016
Type of review: Statutory
Review number: 4
Triggering action date: 9/28/2012
Due date *(five years after triggering action date)*: 9/28/2017

II. RESPONSE ACTION SUMMARY

Basis for Taking Action

EPA, United States Geological Survey, CDPHE, Denver and WMC conducted various investigations from the mid-1970s to 1984. In 1984, EPA listed the Site on the National Priorities List (NPL).

EPA completed a series of remedial investigations/feasibility studies (RI/FS) in 1993 to determine the nature and extent of contamination. In addition, EPA identified the primary threats to human health and the environment as exposure to and contamination from landfill gas, waste-pit liquids, drums, groundwater and contaminated seepage in the Unnamed Creek drainage. Other threats included contaminated landfill solids, soils and sediments and non-aqueous phase liquids (NAPL). The contaminants of concern (COCs) at the Site include volatile organic compounds (VOCs), semi-volatile organic compounds, metals, pesticides, polychlorinated biphenyls (PCBs), methane and other gases. The COC by media are listed in Table 2.

Table 2: COCs by Media

Landfill gas			
1,1,1-trichloroethane	2-methylnaphthalene	chloromethane	pentachlorophenol
1,1,2,2-tetrachloroethane	acetone	chromium	phenol
1,1,2-trichloroethane	acrylonitrile	cis-1,2-dichloroethene	selenium
1,1-dichloroethane	aniline	dieldrin	styrene
1,1-dichloroethene	arsenic	dioxins/furans	tetrachloroethylene
1,2,4-trichlorobenzene	barium	ethylbenzene	toluene
1,2-dichlorobenzene	benzene	gamma	trans-1,2-dichloroethene
1,2-dichloroethane	beryllium	heptaclor	trichloroethylene
1,2-dichloropropane	cadmium	hexachloride	vanadium
1,4-dichlorobenzene	carbon disulfide	lead	vinyl chloride
1-butanone	carbon tetrachloride	manganese	xylenes
4,4- Dichloro-diphenyltrichloroethane	chlorobenzene	methylene chloride	
	chloroethane	nickel	
2-hexanone	chloroform	PCBs	
Subsurface gas			
1,1,1-trichloroethane	chloroform		
1,1-dichloroethane	ethylbenzene		
1,1-dichloroethene	methane		
1,2-dichloroethane	methylene chloride		
2-butanone	toluene		
benzene	xylenes		
carbon disulfide	vinyl chloride		

Groundwater		
1,1,1-trichloroethane	benzene	iron
1,1,2,2-tetrachloroethane	bromodichloromethane	methylene chloride
1,1,2-trichloroethane	bromoform	naphthalene
1,1-dichloroethane	cadmium	nitrate
1,1-dichloroethene	carbon tetrachloride	nitrite
1,2-dichloroethane	chlorobenzene	tetrachloroethene
1,2-dichloropropane	chloroform	toluene
1,4-dioxane	cis-1,2-dichloroethene	trans-1,2 dichloroethene
acetone	dibromochlormethane	trichloroethylene
arsenic	ethylbenzene	vinyl chloride
Surface soil and surface water		
2,3,7,8-tetrachlorodibenzodioxin	chloroform	mercury
aluminum	chromium	nickel
arsenic	cobalt	PCB-1260
barium	copper	silver
beryllium	cyanide	toluene
cadmium	lead	vanadium
	manganese	zinc

Notes:
COCs are listed in the 1994 Record of Decision (ROD) and the 2012 FYR.

Response Actions

Prior to selecting a final remedy, EPA implemented a number of interim actions at the Site. In 1984, the City of Denver entered into an Administrative Order on Consent with EPA for the design, construction and operation of a groundwater control and treatment system at the northern boundary of the Site, known as the north boundary barrier wall (NBBW). Between 1989 and 1990, EPA conducted a drum removal action at the Site that consisted of re-packaging and removing drums of highly contaminated liquids and solids. In 1990, all municipal solid waste landfill operations stopped and WMC constructed a soil cover over the 200-acre main landfill (Figure 1). In 1991, the City of Denver entered into an Administrative Order on Consent with EPA to construct and operate a surface water removal action (SWRA) that consisted of upgrading the existing groundwater treatment plant (WTP) and constructing a collection system within Unnamed Creek to segregate contaminated groundwater from uncontaminated surface water. The SWRA, completed in 1992, prevents contaminated groundwater from contacting surface water within the Unnamed Creek streambed. Permeable material has been placed beneath the streambed and covered with a clay layer. The permeable material provides a pathway for groundwater to flow to the NBBW without contacting surface water.

In 1994, EPA issued a Unilateral Administrative Order for Remedial Design/Remedial Action (RD/RA) to 34 potentially responsible parties (PRPs). On behalf of all the PRPs, Denver, WMC and Chemical Waste Management, Inc. (CWM) agreed to perform the RD/RA. EPA entered into a Consent Decree with eight responsible parties including the City of Denver, WMC and CWM (the Work Settling Defendants (WSDs) in November 2005. The WSDs agreed to perform the remaining remedial work at the Site.

EPA selected the Sitewide remedy in the 1994 Record of Decision (ROD) with two ROD amendments in 2002 and 2005 and three Explanations of Significant Difference (ESDs) in 1995, 1996 and 2006. EPA identified remedial action objectives (RAOs) for each medium as summarized in Table 3.

Table 3: Remedial Action Objectives

Groundwater
○ Prevention of exposure to humans and the environment (through ingestion, inhalation, or dermal absorption) from liquids (either groundwater or waste-pit liquids) containing contaminants in excess of the performance standards; ○ Prevention of migration of contaminants beyond the compliance boundary in excess of the performance standards; ○ Prevention of horizontal migration of dissolved groundwater contaminants off-Site and to surface waters; ○ Prevention of vertical migration of dissolved groundwater contaminants beyond the lignite layer; ○ Prevention of movement of NAPLs beyond the compliance boundary and minimization of movement of NAPLs; and ○ Minimization of infiltration and leachate production in waste-pit source area.
Landfill solids
○ Protection of human health and the environment from direct contact or ingestion of landfill solids or soils intermingled with landfill solids containing contaminants; ○ Protection of humans from inhalation of volatilized contaminants from landfill solids or soils intermingled with landfill solids, and inhalation of contaminated airborne particulate matter from soils or landfill solids that exceed performance standards; ○ Minimization of the production and migration of leachate, from landfill solids or soils intermingled with landfill solids, to the saturated zone and groundwater; ○ Minimization of the migration of soils intermingled with solids, caused by erosion or entrainment by wind or water; ○ Prevention of off-Site migration of landfill solids and soils intermingled with solids into other media; ○ Protection of human health and the environment from direct contact with or ingestion of leachate that exceeds the performance standards for shallow groundwater and subsurface liquids; and ○ Prevention of off-Site migration of leachate or infiltration into other media.
Landfill gas
○ Protection of human health from inhalation of landfill gases in excess of the performance standards; ○ Protection of human health and the environment from explosion hazards associated with landfill gases; and ○ Prevention of off-Site migration of landfill gas or migration to other media.
Soils, surface water and sediments
○ Protection of human health and the environment from direct contact or ingestion of soils, surface water, and sediments containing contaminants that exceed the performance standards; ○ Protection of human health from inhalation of volatilized contaminants from the soils, surface water, or sediments; and inhalation of contaminated airborne particulate matter from soils or sediments that exceeds performance standards; ○ Minimization of the production and migration of contaminated surface water to the saturated zone and groundwater; ○ Minimization of the migration of soils and sediments by erosion or entrainment by wind or water; and ○ Minimization of migration of contaminated surface water off-Site and into other media.

The remedies consist of a combination of engineered components (slurry wall, groundwater collection trenches and groundwater extraction wells) to remove, contain and/or attenuate migration of COCs from the source area of the Site. If performance standards are not met during implementation or operation, the remedy requires appropriate contingency measures to be implemented. In the ROD, EPA established POCs for the landfill gas remedy and the groundwater remedy at locations inside the Site boundaries. If performance standards are exceeded at these POC locations, contingency measures must be implemented. The selected Sitewide remedy also requires the implementation of on-Site and off-Site institutional controls. The specific remedial action for each OU is listed below in Table 4. No action remedy was selected for soils, surface water and sediments (OU4 and OU5) based on the interim remedial actions already completed at the Site. EPA provided the groundwater and gas performance standard in the 1994 ROD and updated in 2002 minor modification to the ROD. The subsurface gas

performance standards were further revised in the 2015 Landfill Gas Compliance Monitoring Plan. These standards are presented in Appendix G, Table G-1 (groundwater) and Appendix I, Table I-1 (subsurface gas).

After the installation of the SWRA, the contaminant transport to surface water had been eliminated, therefore surface water standards were selected to be applied in the event of a treatment system malfunction and subsequent discharge to surface water. The ROD indicated that periodic surface water runoff sampling was required, but did not specify performance standards. Interim standards were provided in 1996 in the Interim Compliance Monitoring Plan. In 2008, a stormwater management plan (SWMP) replaced the Interim Compliance Monitoring Plan and the performance standards were replaced with stormwater water discharge monitoring requirements, which do not specify performance criteria.

Status of Implementation

A brief summary of the main remedial actions by OU is shown in Table 4 and Figure 1. EPA provided a full description of each remedial action in the 2012 FYR. Institutional controls were implemented as part of the Sitewide remedy to limit access and restrict land use at the Site and prohibit use of water beneath the Site and in the immediate vicinity of the Site. EPA certified construction completion at the Site in September 2006.

Table 4: Remedy Components

Operable Unit	Media	Year of Completion	Remedy Component
1 and 6	Shallow groundwater, subsurface liquids and deep groundwater	1984	NBBW – Composed of a subsurface barrier clay wall, collection drain and sump. A WTP injection trench is positioned approximately 340 feet downgradient (north) of the barrier wall. Groundwater is continuously extracted upgradient of the clay wall and potable water is injected downgradient of the clay wall. The potable injections started in 2001 and are not part of the remedy as described in the ROD.
		1998	Shallow Groundwater Containment, Collection and Diversion (Slurry Wall) – An 8,800-foot subsurface clay/soil wall encloses the west, south and east sides of the main landfill in the southern part of the Site. The slurry wall was designed to deflect or limit the flow of clean weathered Dawson groundwater into the Site from the south and to limit outward flow of potentially impacted groundwater to the east and west of the waste pit sources.
		1998	North Toe Extraction System (NTES) – A groundwater extraction system at the north toe of the main landfill that intercepts groundwater flow beneath the Unnamed Creek drainage at the toe of the landfill and transports it via an underground pipeline to the on-Site WTP. The NTES began operation in 2005.
		2000	WTP – The original WTP was replaced in 2000 and a biological treatment system (BTS) was added in 2004 to treat 1,4-dioxane.
		2002	MW38 Gradient Control Contingency Measure – Two extraction wells were installed to pump contaminated groundwater from the MW38 sand channel (see additional description below).
		Ongoing	Contingency Measures – The 1994 ROD included contingency measures if during operation of the groundwater remedy, contaminant levels exceed performance standards at compliance boundaries. Contingency measures could include additional engineering components, continued monitoring, re-evaluation of remedial technologies, or additional institutional controls. The WSDs are conducting contingency measures at the Site for the following reasons: • To control source associated with the MW38 sand channel;

Operable Unit	Media	Year of Completion	Remedy Component
			• To induce inward hydraulic gradients across the perimeter slurry wall; and • To remove VOCs from groundwater outside the slurry wall. See additional description below.
2	Landfill solids	1990	Landfill Cover – A cover was placed over the landfill mass minimizing infiltration of rainwater and reducing potential leachate and impacts to groundwater.
		1999	North Face Cover – An additional 2-foot cover was installed on the 29-acre north face of the landfill mass.
		1999	Former Tire Pile Area (FTPA) – Surface and subsurface drums and contaminated soils within the middle FTPA waste pit were excavated and disposed of on-Site. The other two FTPA waste pits were covered with an earthen cover, which extends 30 feet beyond the perimeter of the source material.
3	Landfill gas (LFG)	1996	LFG Collection and Treatment System – The system and monitoring wells were installed within the former landfill consisting of 64 vertical extraction wells within the refuse area. Treatment consists of a combination of an enclosed flare, candlestick flare and landfill Gas-to-Energy Plant (GTEP). The GTEP began operation in 2008 and two flare candlesticks were installed: DADS Blower/Flare (DBF) in 2010 and Flare Station 3 (FS3) in 2015.
4 and 5	Soils, Surface Water and Sediment	2005	No Action – Consisted of maintenance on the cover areas, periodic monitoring of surface water runoff, operation and maintenance of the SWRA and NBBW, and construction of 0.87 acre of wetlands.

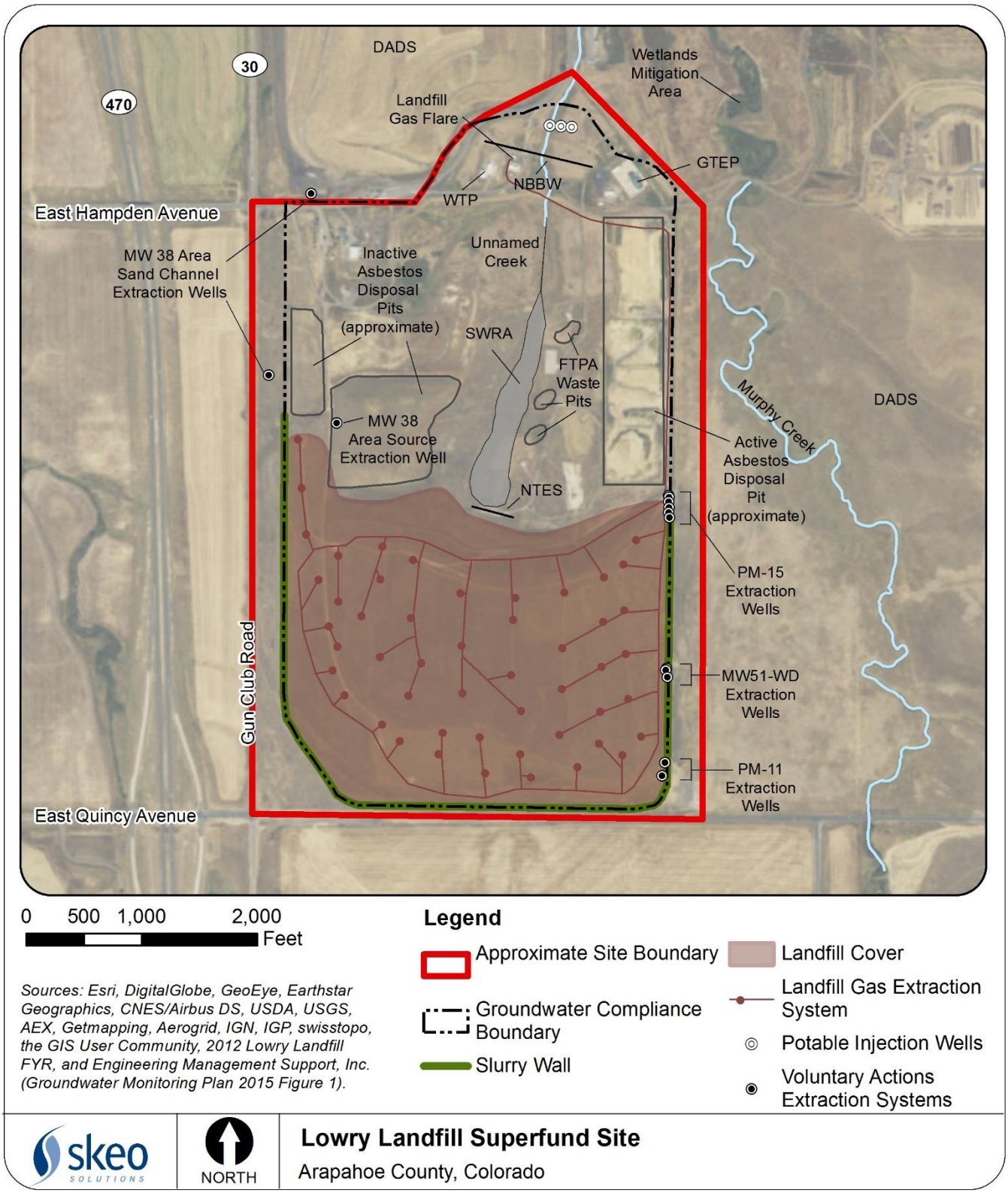
Contingency Measures

The selected remedy for OUs 1 and 6 provides that if, during implementation or operation of the groundwater remedy, contaminant levels exceed performance standards at compliance boundaries, appropriate measures (e.g., pulse pumping or installation of additional extraction wells) shall be taken to prevent and remediate contaminant migration beyond the compliance boundary. Potable water injection is not included in the list of contingency measures in the ROD.

The gradient control measure for the MW38 area, located north of the western portion of the slurry wall, was implemented as a contingency measure in response to groundwater contamination that was detected in the weathered Dawson monitoring well MW38-WD prior to the first FYR for the Site. When it was discovered that groundwater samples from well MW38-WD contained contamination at levels above performance standards, a characterization program was carried out in the second quarter of 2001 until June of 2002. The results indicated that contamination in the sand channel extended from the western Site boundary (but not beyond) to the northern Site boundary. In response to these findings, two extraction wells were installed (consistent with the contingency measures described in the ROD) to pump groundwater from the MW38 sand channel.

The groundwater extraction systems for VOC removal, source and gradient control are at specific Site locations, starting on the west side and progressing counterclockwise around the Site (see Table 5 and Figure 1 and C-3 in Appendix C).

Figure 1: Detailed Site Plan



Disclaimer: This map and any boundary lines within the map are approximate and subject to change. The map is not a survey. The map is for informational purposes only regarding EPA's response actions at the Site.

Table 5: Groundwater Extraction Systems Installed at the Site

System	Type	Description
MW38-WD	Source control	Groundwater extraction from three extraction wells (MW38-1028N-256E, MW38-170S-140W, MW38-825S-445E)
PM-11	Gradient control	Groundwater extraction from two internal wells (PM-11I and BM-11I-100N)
MW51-WD	Gradient control	Groundwater extraction from three internal wells (MW51I-WD-15N, MW51I-WD and MW51I-WD-35S)
	VOC removal outside the wall	Air sparge at one well (MW70-WD)
PM-15	Gradient control	Groundwater extraction from six internal or northern wells
	VOC removal outside the wall	Air sparge at one well (BM-15N5)

Prior to 2000, groundwater extracted from the NBBW area was treated using air stripping and granular activated carbon (GAC). These technologies remove VOCs but not 1,4-dioxane. In 2000, the WSDs brought a new WTP online that treats organic constituents including 1,4-dioxane. Since 2002, the lateral and vertical limits of 1,4-dioxane downgradient of the NBBW have been investigated. Extensive sampling was conducted to assess the nature and extent of 1,4-dioxane in and immediately downgradient of the NBBW.

In 2007, a comprehensive sampling program was conducted downgradient of the NBBW including off-Site to the north in Sections 31, 30, 24, and 19. Results of those investigations showed that 1,4-dioxane occurred above its performance standard in both the NBBW area as well as in groundwater up to 2.4 miles downgradient. As a result of these investigations, the WSDs implemented the North End response actions as a contingency measure both on-Site and north of the Site boundary in response to the discovery of 1,4-dioxane in this area. The WSDs implemented the North End response actions in accordance the contingency procedures outlined in the ROD and the resulting work plans were submitted in 2007, 2008, 2010 and 2013. Extraction wells and associated collection piping in five extraction areas (Areas 1, 2, 3, 4 and 5) and the WTP (Figure C-3 and Figure H-10) comprise the response actions. The operating objectives of the North End response actions are to:

1. Reduce off-Site migration of 1,4-dioxane.
2. Reduce mass of 1,4-dioxane north of the Site.
3. Bring into compliance any monitoring well showing exceedance(s) of performance standard.

Extracted groundwater from the off-Site wells located in Areas 1, 2 and 3 (Figure H-10) is pumped to the WTP, blended with treated effluent from the WTP and pumped to the publicly owned treatment works (POTW) sanitary sewer. Extracted groundwater from the on-Site wells located in Areas 4 and 5 is pumped to the WTP for treatment, blended with untreated off-Site well groundwater and then pumped to the sanitary sewer. The WTP effluent and the North End off-Site groundwater are monitored in accordance with the discharge permit (Industrial Discharge Permit No. 2360-5 issued by Metro). The extraction areas are shown in Figure H-10 in Appendix H.

Institutional Control (IC) Summary

As required by the 1994 ROD, on-Site groundwater and land use is restricted by institutional controls, which include restrictive covenants, zoning and district court water rights (Table 6). Within the Site boundaries, land use is restricted to landfilling and monitoring or remediation activities. Water rights beneath the Site are owned by the City of Denver and restrictive covenants prevent drilling of new wells on-Site except for monitoring or remediation purposes.

On-Site Land Use

On-Site land use is restricted by institutional controls, which include restrictive covenants that run with the land and zoning (Table 6, Figure 2). Within the Site boundaries, the restrictive covenants restrict land use to:

- Landfilling.
- Monitoring or remediation activities.
- Other uses consistent with the selected remediation.

EPA and the CDPHE have the authority to enforce these on-Site land use restrictions.

On-Site Groundwater Use
The City of Denver owns water rights within the Lower Dawson, Denver, Upper and Lower Arapahoe, and Laramie-Fox Hills aquifers beneath the Site. Restrictive covenants that run with the water rights restrict the drilling of any new wells on-Site except for monitoring or remediation purposes necessary for implementation of the remedy (Table 6, Figure 2).

EPA and CDPHE have the authority to enforce these on-Site groundwater use restrictions.

Off-Site Land and Groundwater Use
The City of Denver owns off-Site properties consisting of the remainder of Section 31 that is not part of the Site, Section 32, Township 4 South, Range 65 West (except that portion owned by Waste Management, Inc.), and Section 5, Township 5 South, Range 65 West. Denver placed restrictions on land and groundwater use within that portion of Section 31 that is not part of the Site. The restrictions are in the form of restrictive covenants that run with the land. These restrictive covenants restrict land use to landfilling, monitoring or remediation activities, industrial, commercial, utilities, agricultural, open space, or recreation uses. Denver also owns the water rights within the Dawson, Denver and deeper aquifers Arapahoe, and Laramie-Fox Hills aquifers beneath the remainder of Section 31 that is not part of the Site and the northern three quarters of Section 32 (except that portion owned by Waste Management, Inc.). Groundwater use restrictions preclude drilling new wells for use of groundwater from the Dawson or Denver aquifers except for monitoring or remediation purposes necessary for closure of the landfill located on the property or for implementation of the selected remedy for the Site.

The Lowry Environmental Protection/Cleanup Trust (Trust) owns off-Site properties adjacent to the east, south and west boundaries of the Site. Denver, WMC, and CWM are co-trustees of the Trust. Restrictive covenants that run with the land restrict land use on Trust-owned property to landfilling, monitoring or remediation activities, industrial, commercial, agricultural, transportation, utilities, open space, or recreation uses. These off-Site institutional controls are described in Table 6 and shown as blue hatching on Figure 2.

An Aurora City Ordinance prohibits development or construction of buildings within one quarter mile of the east, south, or west exterior boundaries of Section 6 (green boundary in Figure 2). The prohibition does not apply to buildings used for characterizing or remediating the contamination at the Site, nor does it apply to construction of roadways or public utilities. The ordinance also prohibits drilling, development, or use of any wells in the Dawson aquifer within one-half mile of the exterior boundaries of Section 6 except for wells used for monitoring, extracting groundwater for remediation, or re-injecting treated groundwater (Table 6 and black boundary in Figure 2).

Table 6: Summary of Implemented Institutional Controls (ICs)

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 and Description	Title of IC Instrument Implemented and Date (or planned)
On-Site – groundwater, landfill solids and/or landfill gas	Yes	Yes	Site – Section 6 and portion of Section 31	Restrict land use and water rights	Amended On-Site Restrictive Covenants, Amended Declaratory State of Environmental Covenants
				Restrict land use and land development over closed landfills	Zoning (City of Aurora and Arapahoe County), Certificate of Designation (Arapahoe County)
				Gives prospective purchaser of the property notice of the Superfund Site	Federal Lien
Off-Site – groundwater, landfill solids and/or landfill gas	Yes	Yes	East ½ of Section 36, East ½ of Section 1, North ½ of Section 7, Eastern ¼ of Section 6, Western 1/8 of Section 5, Southern ¼ of Section 32	Restrict land use to landfilling, monitoring or remediation activities, industrial, commercial, utilities, agricultural, open space or recreation uses. Restrict groundwater use from the Dawson and Denver aquifers.	Zoning and Declaratory Statement of Environmental Covenants
			Section 31 (exclusive of Site)	Restrict use of groundwater	Denver water rights, District Court, Water Division I, Colorado (1998)
Off-Site groundwater and land use	No	No	¼ mile (land use) or ½ mile (groundwater uses) of Section 6	Restrict drilling or use of wells and development or construction in the Dawson aquifer. Requires sellers of real property located within ¼ mile of the south or west exterior boundary to give notice to purchasers that the property is located near a Superfund Site.	Aurora Development Restriction (Ordinance No. 93-98, 1993)

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 and Description	Title of IC Instrument Implemented and Date (or planned)
Off-Site groundwater use	Yes	No	Portions of Section 30, 24 and 19	Restrict use of groundwater within 1,4-dioxane plume.	Not planned or implemented

In accordance with the 2002 Institutional Control Plan, the WSDs perform a well survey every five years for wells constructed within one half mile of the Site. The WSDs conducted the most recent one half mile survey in 2017 (Figure 3). Wells that are located within the institutional control area are consistent with previous well surveys and the results will be summarized in the September 2017 Remedial Action/Operation and Maintenance (RA/O&M) Report.

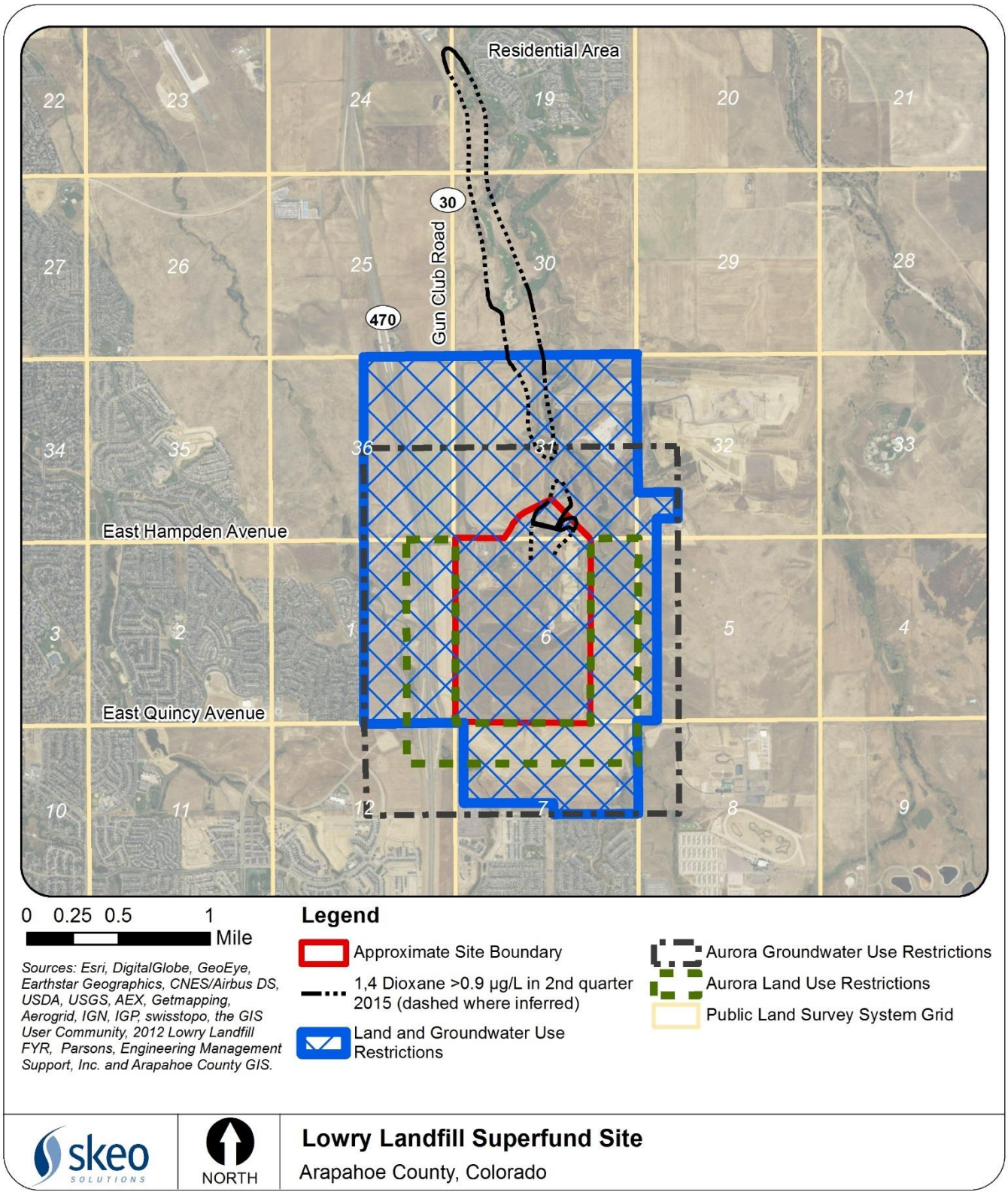
The WSDs extended the 2017 well survey five miles north of the Site along the Murphy Creek drainage basin. Figure 3 shows the locations of these wells, the search area north of the Site and the currently delineated 1,4-dioxane plume. Additional description of the 1,4-dioxane North End Area is provided in the Data Review section. The private and municipal wells located within the drainage basin are listed in Table 7. Four of these wells are located within the footprint of the 1,4-dioxane plume and one well is located immediately adjacent to the plume (Table 7). In order to ensure there is no current human exposure, these wells should be sampled and analyzed for 1,4-dioxane and based on the results, appropriate remedial actions implemented. In addition to the wells located within the drainage, there are domestic wells located approximately 1,000 feet east of the leading edge of the plume, just outside the Murphy Creek Drainage in the Gun Club Estates. An updated plume map and conceptual site model is needed to ensure there is no potential for future exposure in this area. Based on the results, EPA will evaluate the need for a monitoring plan for wells located within the vicinity of the plume edge.

Table 7: Private/Municipal Wells within the Murphy Drainage - Survey Results 2017[a]

ID Number	Use	Aquifer	Owner
1750	Domestic	Unspecified	Superior Sand and Gravel
1795	Domestic	Denver	Private Resident
1807	Domestic	Denver	Private Resident
1819	Domestic	Unspecified	Private Resident
1821	Other	Unspecified	City of Aurora
1867	Domestic	Unspecified	Private Resident
1879	Domestic	Unspecified	Private Resident
1889	Domestic	Unspecified	Private Resident
1890	Domestic	Unspecified	Private Resident
1940	Unspecified	Upper Arapahoe	St. Simeon Cemetery Associations
2000	Stock	Quaternary Alluvium	West Arapahoe Soil Conservation
2001	Stock	Denver	Private Resident
2009	Commercial	Arapahoe	East Creek Valley Water
2014	Commercial	Laramie Fox Hills	East Creek Valley Water
2027[b]	Other	Quaternary Alluvium	City of Aurora
2082[b]	Domestic	Denver	Private Resident
2084[b]	Domestic	Denver	Private Resident
2085[b]	Domestic	Denver	Private Resident
2273[c]	Stock	Unspecified	Buckley Investment Comp
2344	Domestic	Denver	Private Resident
2448	Stock	Lower Dawson	Vincent Murphy Chev Co Inc.

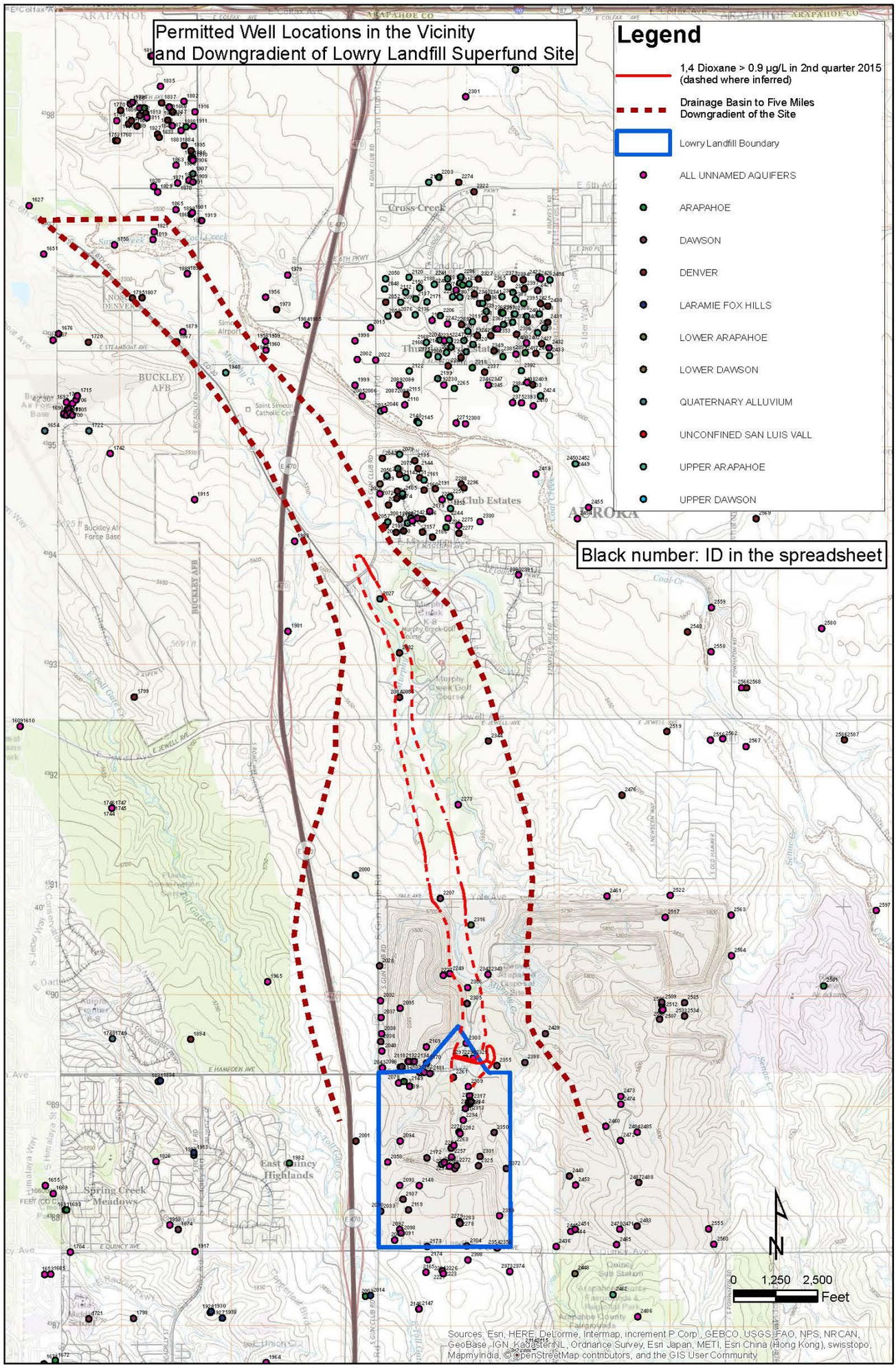
Notes:
a = This table does not include the wells owned by Waste Management or Lowry Trust.
b = Well is located within the footprint of the 2015/2016 delineated 1,4-dioxane plume.
c = Well located outside but adjacent to the footprint of the 2015/2016 delineated 1,4-dioxane plume.

Figure 2: Institutional Control Map



Disclaimer: This map and any boundary lines within the map are approximate and subject to change. The map is not a survey. The map is for informational purposes only regarding EPA's response actions at the Site.

Figure 3: 2017 Permitted Well Location Map



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Systems Operations/Operation & Maintenance

Operation and maintenance (O&M) activities consist of operations and maintenance of the NTES, WTP, groundwater monitoring and extraction wells, LFG collection system and landfill covers. These activities are being performed in accordance with Site O&M plans listed below and in Appendix A:

- Addendum 5, Operation and Maintenance Manual, Water Treatment Plant (EMSI/Parsons, 2015).
- Revision 2, Operations and Maintenance Manual, Groundwater Extraction (EMSI/Parsons, 2015).
- Revision 1, Operations and Maintenance Manual, LFG Remedy (EMSI, 2011).
- Final Operations and Maintenance Manual, Covers and Stormwater (EMSI, 2007).
- Stormwater Monitoring Plan (EMSI, 2008).
- Updated Waste Management Plan (EMSI, 2009).

NTES System

The NTES system consists of the collection trench with a sump located at the low-point of the trench and the conveyance pipeline that extends to the WTP. There are three extraction points located within the collection trench – MPZ-10R, MPZ-11 and the extraction sump. Light Non-Aqueous Phase Liquid (LNAPL) is skimmed from the groundwater surface by timer-activated pneumatic pumps at the extraction points. If the thickness of the LNAPL layer exceeds 0.5 feet, extraction is warranted at that location within the trench. Extraction continues until visual observations of the extracted LNAPL indicate the presence of water, until the LNAPL thickness decreases to less than 0.5 feet, or both.

If LNAPLs are extracted, the extracted fluids are placed in 55 gallon drums located within enclosed double contained storage lockers adjacent to each extraction point. Discharge hoses are also double-contained and will gravity-flow back into the well, sump or drum in the event of a leak of the internal pipe. Full drums are moved to the hazardous waste storage area at the North FTPA Waste Pit and managed in accordance with the Site-wide Updated Waste Management Plan. There was no LNAPL extraction during this FYR period.

WTP

Operations of the WTP during this FYR period included treatment of Site waters from the NBBW, NTES sump, east boundary extraction wells, MW38 extraction wells, on-Site North End response action wells, the decontamination pad at the GTEP complex, LFG condensate, and miscellaneous sources such as purge water and potable water used for plant wash-down. Following treatment and monitoring, all of these waters were discharged to the POTW.

Groundwater from off-Site North End response action wells are routed to the WTP and bypass treatment. Untreated water is blended with treated effluent and then discharged to the POTW. Throughout this FYR period, the WTP operated for about 98 percent of the time. Downtime was attributed to routine maintenance and testing, power interruption as well as other minor issues. There were no major disruptions to the WTP operation during this FYR period, however as a result of the limited capacity of the WTP, high precipitation observed in 2015 and 2016 resulted in the reduction of pumping from multiple extraction systems to accommodate additional water from the NBBW and NTES.

Groundwater Monitoring Wells

The WSDs conduct well inspections as a routine part of the Groundwater Monitoring Plan (GWMP). Routine maintenance was conducted during this FYR period. The following wells were installed during this FYR period:

- MW115-UD (installed in 2013).
- Piezometers NEPZ-100 through NEPZ-103 (installed in 2015).
- MW62-WDR (installed in 2016).

The following wells were abandoned during this FYR period:

- MW143-WD: abandoned in 2012 because it was damaged. It was one of four wells along Gun Club Road and not a primary well so it was not replaced.
- MW95-WD: abandoned in 2013 because it interfered with the northward expansion of DADs asbestos monofill. It was not replaced.
- MPE-N-4: abandoned in 2013 because it was the last well in the north pit area and met closure criteria. It was not replaced.
- MW62-WD: abandoned in 2016 because it was often dry and did not fully penetrate the Weathered Dawson. It was replaced with a deeper well, MW62-WDR.

Landfill Gas Collection System
The WSDs conduct routine maintenance on the LFG collection system including the flares and the GTEP. During this FYR period, all 64 in-ground style gas extraction wells were replaced with above-ground style wellheads. These above-ground style wellheads allow for monthly flow rate measurements to be taken. Replacements occurred from 2012 to 2016. During the most recent reporting period from January through June 2016, the average flow for the Site was 159 standard cubic feet per minute.

Landfill Covers and Stormwater Runoff Monitoring
The WSDs conduct a Sitewide inspection annually and after snow/rain events. Inspections are conducted to identify and repair problems arising from settlement, cover or ditch erosion, sedimentation and damage to security fences and gates. Weed control, mowing and prairie dog mitigation were performed as needed during this FYR period. Minor surface cracking was observed in 2012 and mitigated in 2013. Low areas near the LFG manual traps and wells were filled in 2015 to prevent ponding. Shallow soil-filling in other low areas occurs as needed based on observations during routine inspections.

Stormwater runoff is monitored annually during a precipitation event in accordance with the 2008 SWMP, and results are reported in the semi-annual RA/O&M Status Reports. The runoff is monitored at one location for four parameters: oil and grease, pH, chemical oxygen demand and total suspended solids (Figure H-12). There are no performance criteria for these parameters.

III. PROGRESS SINCE THE LAST REVIEW

This section includes the protectiveness determinations and statements from the last FYR as well as the recommendations from the last FYR and the current status of those recommendations.

Table 8: Protectiveness Determinations/Statements from the 2012 FYR

OU #	Protectiveness Determination	Protectiveness Statement
1 & 6	Protective	The remedy at OUs 1 & 6 is protective of human health and the environment because all engineered components of the containment remedy and north end response actions provide effective containment. The Groundwater Monitoring Plan (GWMP), enforceable under the Consent Decree, is implemented and functioning to mitigate out-of-compliance conditions at ten on-Site wells where one or more contaminants exceed performance standards.
2 & 3	Protective	The remedy for OUs 2 & 3 is protective of human health and the environment because there is no exposure to hazardous waste due to a functioning landfill cap and LNAPL recovery action that prevents exposure to landfill solids and non-aqueous phase liquids. Additionally, there is no exposure to

OU #	Protectiveness Determination	Protectiveness Statement
		hazardous waste due to a functioning landfill gas treatment system that prevents the release of landfill gases into ambient air. The exposure assumptions, toxicity data, cleanup levels and remedial action objectives used at the time of the remedy selection remain valid with the exception of the performance standard for the compound MEK in ambient air and the performance standard for TCE in subsurface gas. Due to EPA's de-listing of MEK as a hazardous air pollutant in 2005, it is no longer considered a contaminant of concern in ambient air. Compliance monitoring for this compound in ambient air is no longer necessary. The performance standard for TCE in subsurface gas has been revised to reflect new toxicity data.
4 & 5	Protective	The remedy at OUs 4 & 5 is protective to human health and the environment because the collection system and soil cap are functioning to eliminate the recharge to shallow groundwater, underlying Unnamed Creek and offsite migration of contaminated seepage, surface water and sediments within Unnamed Creek. Monitoring data indicate surface water runoff meets or exceeds performance standards for surface water as established in the ROD.
Sitewide	Protective	The assessment of this third five-year review is that the remedy for all six operable units is functioning as intended by the decision documents. The exposure assumptions, toxicity data, cleanup levels and remedial action objectives used at the time of the remedy selection remain valid. Additionally, restrictive covenants implemented as part of the remedy provide on-Site and off-Site institutional controls that restrict well installations and land uses. Because the remedy for all six operable units is protective, the Site is protective of human health and the environment. No other information has come to light that could call into question the protectiveness of the remedy.

Table 9: Status of Recommendations from the 2012 FYR

OU #	Issue	Recommendations	Current Status	Current Implementation Status Description	Completion Date (if applicable)
1	5 monitoring wells exceed performance standards for one or more contaminants of concern.	Continue response actions per GWMP for Case 3 groundwater condition. Submit RAWP for EPA approval.	Completed	The WSDs submitted a Remedial Action Work Plan and it is being implemented.	4/4/2013
1	5 compliance wells exceed performance standards for one or more contaminants of concern.	Continue monitoring per GWMP for Case 1 and Case 2 conditions. Initiate appropriate action as required by the GWMP.	Completed	Monitoring for the Case 1 and Case 2 conditions is continuing per the 2015 GWMP. No additional action is required.	3/30/2013
3	A number of original buried wellheads observed to be stressed due to site settlement.	Replace units at/before end of useful lifecycle.	Completed	All buried gas wellheads have been replaced with above-ground systems.	2/29/2016

OU #	Issue	Recommendations	Current Status	Current Implementation Status Description	Completion Date (if applicable)
2	A series of small animal burrows were observed at surface of south waste pit area and cover area used in past construction activity.	Continue monitoring and repair, as necessary.	Completed	The WSDs conduct annual cover inspections and repairs as needed in accordance with the 2007 Final Operations and Maintenance Manual, Covers and Stormwater.	3/30/2013
2	Depressions were observed near south and west slurry wall.	Continue to monitor for ponding and mitigate as necessary to prevent impact to remedy protectiveness.	Completed	Annual cover inspections are conducted. Ongoing repairs and filling are conducted in accordance with the 2007 Final Operations and Maintenance Manual, Covers and Stormwater.	3/30/2013

IV. FIVE-YEAR REVIEW PROCESS

Community Notification, Involvement & Site Interviews

A public notice was made available by a newspaper posting in the *Denver Post* on 10/20/2016, stating that there was a FYR and inviting the public to submit any comments to EPA. The final press notice is included in Appendix E. The results of the review and the report will be made available at the Site's information repository, located at the Aurora Central Library, 14949 E Alameda Pkwy, Aurora, CO 80012.

During the FYR process, interviews were conducted to document any perceived problems or successes with the remedy that has been implemented to date**.** The results of these interviews are summarized below. Interviews were conducted by Katherine Jenkins, the CIC for the Site. All interviewees granted permission to have their responses included in this FYR. Responses are provided in Appendix J.

WSDs Steve Richtel from WMC and Dave Wilmoth from Denver both indicated that the overall remedy at the Site is protective, effective and innovative. They believe the effects on the community surrounding the Site have been neutral or positive with many community members not aware of the Site as a separate entity from the active landfill. Positive effects include working with Arapahoe County to expand roads bordering the Site and allowing for appropriate development in the buffer areas including recreational use. The WSDs indicated they have provided adequate information to the community members and have not received any complaints.

Lynn Robbio Wagner of the Tri-County Health Department (TCHD) indicated the overall remedy is protective of public health and the environment. TCHD believes the remedy components are performing as designed. They are aware of the North End Response Actions to address 1,4-dioxane. TCHD works with the Arapahoe County and the City of Aurora to comment on any new development in the area and indicated they are comfortable with the institutional controls in place at the Site. TCHD would like to see EPA and CDPHE renew their commitment and interest to collaborate with the Lowry Landfill Superfund Site Steering Committee.

State representatives Lee Pivonka, Wendy Naugle, Jeannine Natterman and Doug Jamison believed the remedy for OU1 and OU6 is not effective because performance standards are not being met at the POC. They indicated remedies for the other OUs appear to be effective and protective in the short and long term. They indicated the conceptual site model for the Site should be updated. They made several other recommendations including: revising the GWMP with updated Colorado performance standards and to comply with EPA's 2008 Guidance "A Systematic Approach for Evaluation of Capture Zones at Pump and Treat Systems," stopping the injection of potable water at the NBBW and implementing institutional controls north of the Site in the area of the off-Site groundwater plume.

Former Arapahoe County Commissioner, Rod Bockenfeld, agrees with the CDPHE that additional information is needed to protect the community from the 1,4-dioxane plume and to better understand the contaminants. Mr. Bockenfeld is concerned that the Site contaminants are not being contained and believes another remedy should be investigated. Jeff Baker, current Arapahoe County Commissioner believes the containment part of the remedy may not be working to the extent the community would like. He is interested in knowing if another remedy would be considered. Mr. Baker also believes the Site website should be kept more up to date and the Community Action Group should be started to keep the community more informed. Karen Hancock of the City of Aurora reported that residents living downgradient of the Site have significant concerns about the effectiveness of the groundwater remedy. City staff believe the shallow and deep groundwater contaminant levels have failed to meet RAOs. City staff also would like to see institutional controls extended to include all areas where groundwater contaminant concentrations exceed applicable standards.

The community group Citizens for Lowry Landfill Environmental Action Now (CLLEAN) participated in the interview process. CLLEAN indicated the remedial actions at the Site are inadequate because waste remains in place and groundwater contamination extends off-Site. CLLEAN also questioned the validity of the data collected by the WSDs.

Residents from nearby neighborhoods participated in the interview process as well. All private citizens interviewed are concerned about groundwater contamination and the use of private residential wells. They would like more consistent communication from EPA. They indicated that they would like to know more about the EPA's oversight role and how the investigation of the 1,4-dioxane plume is being conducted.

Data Review

This summary data review is organized by OU. Additional information for each OU is provided in Appendix H.

OU1 – Shallow Groundwater and Subsurface Liquids

The WSDs conducted the performance and compliance groundwater monitoring at the Site in accordance with the July 2015 GWMP. In order to assess whether the RAOs for groundwater are being met, the data collected in the groundwater monitoring program are used to demonstrate compliance with performance standards along the POC, demonstrate the effectiveness of the four engineered components of the groundwater containment remedy (slurry wall, NTES, NBBW and MW38 area) and detect changes in water quality, if any, in deeper bedrock units beneath the Site.

Groundwater monitoring data and evaluations of compliance, effectiveness and vertical migration are presented semi-annually in RA/O&M Status Reports prepared by the WSDs. The semi-annual reports are submitted to EPA and CDPHE in September and March. Reports from September 2012 through September 2016 were reviewed for this FYR. The most recent data are summarized below. Additional information on trends since the previous FYR are provided in Appendix H.

Evaluation of Compliance with Performance Standards

There are 60 wells in the compliance monitoring network, located along the POC boundary (Figure C-3 and Figure C-4 in Appendix C). Based on 2016 data, there are 13 monitoring wells that contain one or more compliance parameters that exceed or potentially exceed the performance standard (based on the compliance evaluation and decision tree [Figure H-1] and the reduced analyte list and performance standards [Table H-1]). Five parameters, including 1,4-dioxane, trichloroethylene (TCE), chloroform, nitrate and iron exceeded the performance standards (Table H-2). Generally, wells out of compliance are located in the NBBW area and east of the Site, with some in the south and the MW38 area to the west (Figure H-3). These areas have remained consistent since the previous FYR (Figure H-2), however, three additional wells now have exceedances. The NBBW area had exceedances for 1,4-dioxane and nitrate. The concentrations of 1,4-dioxane have declined since the previous FYR; however, results indicate concentrations are still three to 11 times the current Practical Quantification Limit (PQL)-based standard (which was updated from 5 to 0.9 micrograms per liter [µg/L] in July

2015) (Table H-3). The response actions are to be implemented until concentrations are restored to below performance standards. The continued effectiveness of these response actions should be assessed.

In the MW38 area, concentrations of 1,4-dioxane, TCE and chloroform exceeded their respective performance standards at MW38-830N-230E. Based on the WSDs statistical evaluation, there is no significant trend in concentrations, however the most recent concentration reported in 2016 was an order of magnitude lower than in 2015 (Table H-5). One southeast location was out of compliance for TCE although the concentration is close to the performance standard with no significant trend over time based on the statistical analysis conducted by the WSDs. The most recent 2016 concentration was below the performance standard. The VOC exceedances in the MW38 area and along the slurry wall to the south and east are being addressed by contingency response actions currently implemented in these areas.

Iron exceedances were observed to the east and south. The iron exceedances may be attributed to background levels of iron in the unweathered Dawson. As reported in the RA/O&M Status Reports, the performance standard for iron is currently based on the background concentration in the weathered Dawson. The applicability and implementability of this performance standard to wells screened in the unweathered Dawson should be further assessed.

Containment Effectiveness

Containment effectiveness is monitored at the perimeter slurry wall, the NTES, the NBBW and the MW38 area.

Perimeter Slurry Wall

The effectiveness of the perimeter slurry wall is assessed by the presence of an inward hydraulic gradient across the slurry wall. If the outward hydraulic gradient is observed at a particular location along the wall, water quality data obtained from outside the wall are used to assess the effectiveness of the slurry wall at containing Site contaminants. Using data from 2014 to 2016, an outward gradient is present at four locations: PM-3, PM-6, PM-13 and PM-14. These perimeter monitoring wells have no exceedances and concentrations are not increasing for indicator chemicals. Based on the procedure to assess effectiveness, the slurry wall is effective at all 15 well pairs used for the evaluation (Table H-6 and Figure H-4 in Appendix H). However, it is important to note that 1,4-dioxane is not analyzed in any of these well pairs since it was not initially a COC at the Site. Given the high concentrations of 1,4-dioxane on-Site, 1,4-dioxane should be added to the monitoring scheme for these wells.

NTES

Effectiveness of the NTES is demonstrated based on hydraulic monitoring. The results indicate that trench water levels remained below the base of the alluvium through the reporting period (Figure H-5 in Appendix H). Therefore, the NTES is effective at capturing some contaminated groundwater emanating from the toe of the landfill. During this FYR period, no LNAPL extraction was necessary from the three extraction points based on monitoring the thickness of the LNAPL layer, which did not exceed 0.5 feet. Visual inspection of the groundwater pumped from the NTES to the WTP indicated no LNAPL or dense NAPL (DNAPL) were present in the extracted groundwater during this FYR period. The effectiveness of this system should be determined based on Capture Zone Analysis, as described in EPA 2008 Guidance "A Systematic Approach for Evaluation of Capture Zones at Pump and Treat Systems."

NBBW

The containment area created by the NBBW systems is defined by the weathered Dawson potentiometric surface in the NBBW area. As presented in the RA/O&M Status Report, due to the presence of the groundwater divide and associated containment area (highlighted in yellow in Figures H-6), contaminated groundwater to the south of the groundwater divide does not appear to flow off-Site to the north. Three potable injection wells (highlighted green in Figure H-6) are being used to maintain hydraulic control north of the wall. The potable water injections are not part of the remedy for the NBBW. There is a potential that these injections are negatively affecting the containment in this area of the Site by interfering with interpretation of water quality data in areas near the injection points and by possibly increasing the volume and mobility of 1,4-dioxane. EPA will discontinue the

potable water injections and conduct an optimization study of the groundwater containment remedy to assess changes in water levels, capture zones and water chemistry.

MW38 Gradient Control Contingency Measure
Groundwater is extracted from wells MW38-170S-140W and MW38-1028N-256E located in the MW38 channel sand to control the gradient in this area. The presence of convergent flow into the MW38 channel indicates that the channel effectively prevents shallow contaminated groundwater within the channel from migrating outside of the sand channel (Figure H-8).

Contingency Measures – MW38 and Perimeter Systems
The WSDs are conducting contingency measures at the Site (Figure H-1): 1) for source control associated with the MW38 sand channel; 2) to induce inward hydraulic gradient across the perimeter slurry wall; and 3) to remove VOCs from groundwater outside the slurry wall. The systems are located along the west, south and east slurry wall (PM-11, MW51-WD and PM-15 (Figure C-3)). Perimeter system MW38-WD is located north of the slurry wall.

As described above, monitoring results at the perimeter slurry wall indicate groundwater extraction is effectively maintaining inward hydraulic gradient (Figure H-4). Compliance monitoring in these areas still shows exceedances (Figure H-3) for VOCs, nitrate and iron. The effectiveness of these contingency measures should be assessed using a Capture Zone Analysis and other potential response actions should be evaluated, such as in-situ treatment.

Air sparging from MW70-WD in the MW51-WD area was terminated in March 2013 when VOC concentrations decreased below performance standards. Air sparging was restarted at MW70-WD in December 2014 when tetrachloroethylene (PCE) increased to 5.1 µg/L. PCE and TCE were not detected in MW70-WD in June 2016. Compliance well MW60-WD, located downgradient from MW70-WD, has not had any PCE or TCE detections since April 2000.

North End Response Actions
The North End response actions include monitoring and/or extractions for Sections 31, 30, 19 and 24 (Figure H-9). North End groundwater levels and quality are monitored in accordance with North End GWMP (*2007 North End Groundwater Monitoring Plan and the 2008 North End Groundwater Monitoring Plan Update No.1*).

Extraction Activities
A total of 5.64 million gallons of groundwater was pumped from response action wells during the first half of 2016 and about 84 million gallons were pumped since the inception of the response actions. This corresponds to a total of 14 pounds of 1,4-dioxane removed (0.2 pounds of which were removed during the first half of 2016).

Monitoring Results
The WSDs conducted the most recent sampling event in the second quarter 2016 and included monitoring wells and overland surface water sampling locations (Figure H-9). One well, B-326-WD, shows an increasing trend for 1,4-dioxane. Concentrations increased from 7.2 to 12 µg/L in 2015 and then decreased to 6.9 µg/L in second quarter 2016 (Figure H-9). This may be the result of decreased pumping from NBBW extraction wells due to limited capacity of the WTP due to high precipitation in 2015 and 2016. During the most recent sampling event in 2016, EPA collected split samples with the WSDs. For all 1,4-dioxane results, EPA samples were consistently lower in concentration than those collected and analyzed by the WSDs. This is most likely attributable to the final analytical methodologies used. The EPA laboratory ultimately used method EPA 8270 Selective Ion Monitoring (SIM) which utilized 1,4-dioxane-d8 as a surrogate and 1,4-dichlorobenzene-d4 as an internal standard. The WSDs' laboratory used method EPA 8260 SIM which utilized Isotopic Dilution using 1,4-dioxane-d8 as the internal standard. The WSDs' laboratory followed the Site-specific requirements and validated analytical methods as presented in the most current Lowry Landfill PQL Study completed in 2015. The EPA laboratory selected a less conservative laboratory method to analyze for 1,4-dioxane. A technical review of the 1,4-dioxane results from the 2016 split sampling event was conducted. The validation confirmation of the data from both the EPA and

WSDs were found to be accurate and reported correctly in terms of the analytical methods employed. The differences observed is due to the variability inherent in the sample analyses.

EPA also reported iron exceedances at four wells (MW126-WD, MW129-WD, MW138-WD and MW145-WD) (Table H-7). The WSDs-reported iron results in the RA/O&M Status Report were all well below the performance standard. See Appendix H for additional discussion on these results.

Two private domestic wells along East Jewel Avenue are sampled annually in the spring for 1,4-dioxane. The wells are screened in the Denver formation. The most recent sampling event was in May 2016. 1,4-Dioxane has never been detected in either well above the performance standard of 5 (or 0.9 µg/L since the change in analytical procedure in July 2015).

The 1,4-dioxane plume north of the Site has been delineated based on data collected in 2015 and 2016 and the current performance standard of 0.9 µg/l, however, in many areas, the boundary is inferred. In addition, the contaminant transport pathways in this area are not well understood.

As indicated above, the effectiveness of the extraction wells should be assessed with a Capture Zone Analysis and potable water injections discontinued in order to optimize the containment remedy in this area of the Site.

GTEP Area Response Actions

Pumping has occurred from the GTEP extraction well MW170-EW-1 (Area 5) since 2012. In May 2015, pumping was decreased due to limited capacity of the WTP. Since 2015, pumping rates have been increased intermittently when possible. A cone of depression still existed in this area during the first half of 2016, although it was reduced due to the lowered extraction rates. VOC concentrations show decreasing or stable trends for all COCs including 1,4-dioxane.

Water Treatment Plant

Compliance monitoring is required at two locations, MP-001 (WTP effluent) and MP-004 (North End off-Site groundwater) in accordance with the discharge permit. Monthly results show that all discharge standards were met at both locations during this FYR period as reported in the RA/O&M Status Reports.

Early warning monitoring is also conducted from five individual influent sources (Raw Water Storage Tanks, NBBW, MW38, North End on-Site and NTES and LFG condensate water) and analyzed for VOCs. A sample is also collected from a composite of these sources for all other parameters. Monitoring results during this FYR period showed VOCs (1,1-dichloroethene, 1,4-dioxane and benzene) are the only influent compounds that exceed discharge limits; however, the WTP is able to treat these parameters to below discharge limits. Although technically not a VOC, 1,4-dioxane is included in the laboratory VOC target analyte list.

OU2 – Landfill Solids

No data collected are associated with the landfill solids.

OU3 – Landfill Gas

LFG monitoring consisted of collecting gas composition samples at the GTEP inlet, flare sampling locations DBF and FS3, and POC probes located outside the slurry wall to provide detection of any releases of LFG from the Site. POC probe locations are shown in Figure H-11. COC sampling is performed biennially. The last event was performed in February 2015. The results show that most results are not detected above the laboratory reporting limits and the detected concentrations are well below the POC subsurface gas performance standards. The POC probes are also sampled quarterly for methane. All concentrations were below the methane performance standard of 5 percent by volume.

OU4 – Soils

No data collected are associated with soils.

OU5 – Surface Water and Sediment
No data collected are associated with on-Site surface water and sediment.

OU6 – Deep Groundwater
Vertical migration wells, B-504A, B-712-LD, C-702P3 and GW-113 are sampled biannually. Monitoring well B-712-LD is screened in the unweathered Dawson. The other vertical migration wells are screened in the upper Denver. These wells are located on the POC boundary and data are used to assess the effectiveness of the compliance monitoring network. Monitoring frequency is biennial for the unweathered Dawson well and every five years for the upper Denver.

The maximum concentrations for all compounds for each well have been less than their respective performance standards with the exception of a single detected value for 1,4-dioxane of 0.95 µg/L in well B-712-LD in 2007. The most recent 1,4-dioxane result was less than the PQL, 0.9 µg/L and there were no other detected concentrations of 1,4-dioxane.

No significant trends were identified for any of the COCs in these wells with the exception of increasing trends for 1,2-dichloroethane (DCA) and iron in B-712-LD and iron and nitrate in GW-113. The COC 1,2-DCA has been detected in each of the 10 most recent samples, however in each case, the reported results were less than the laboratory reporting limit. As discussed above, iron may be naturally occurring at the Site. Nitrate in GW-113 not been detected since November 2006. These increasing trends are the result of minor fluctuations in very low estimated concentrations and not indicative of vertical migration. The vertical migration well data for this FYR period is summarized in the January through June 2016 RA/O&M Status Report, Table C-5.1.

The WSDs will continue biannual sampling and trend analysis. Overall, the data indicate that vertical migration from the shallow groundwater zone on-Site is not occurring. However, there are no vertical migration wells located north of the Site within the 1,4-dioxane plume to assess if 1,4-dioxane contamination is confined to the shallow units.

Site Inspection
The Site inspection took place on 10/25/2016. The following participants were in attendance:

- Les Sims, EPA RPM.
- Katherine Jenkins, EPA CIC.
- Johnny Zimmerman-Ward and Alison Cattani, Skeo.
- Bruce Peterman and Tim Murphy, Pacific Western Technologies.
- Tim Shangraw, EMSI.
- Chris Carlson, Parsons.
- Lynn Wagner, TCHD.
- Jeannine Natterman, Doug Jamison and Lee Pivonka, CDPHE.

The purpose of the inspection was to assess the protectiveness of the remedy. Chris Carlson presented a health and safety briefing to the group prior to the start of the Site inspection. Tim Shangraw from EMSI, contractor to the WSDs, led a discussion of the remedy components and their current status. Site inspection participants then observed Unnamed Creek, the SWRA and the three waste pits associated with the FTPA. The remedial activities are completed in all three waste pits and NAPL is being recovered as needed. Covers were all well vegetated and in good condition. Site inspection participants then observed the NTES and the associated monitoring wells, cleanouts and pump station. From the NTES, participants drove along the slurry wall, observing the extraction systems along the perimeter of the Site. The wells were all secure and above-ground pipes were in good condition. A new Colorado Interstate Gas plant was observed adjacent to the southeast boundary of the Site.

The landfill cover was well vegetated and in good condition. Site inspection participants observed the gas collection wells located on the landfill. These wells were replaced with above-ground wells in accordance with WMC's standard protocol. In 2016, shallow areas on the cover were filled in and revegetated and gas collection

pipes were pulled up to address ponding around the gas extraction wells. Tim Shangraw indicated future plans to expand Quincy Avenue and Gun Club Road, south and west of the Site, respectively. Site inspection participants observed the Excel Energy Plant located south of the Site, immediately adjacent to the Lowry Trust-owned land.

Site inspection participants then observed the MW38 source control well and extraction system, followed by the WTP. Tim Shangraw informed Site inspection participants that the WTP discharges 30 gallons per minute (gpm). The NBBW and NTES are pumped continuously. The other extraction systems are pumped as needed. The MW38 extraction system is pumped when there is sufficient capacity in the WTP. The WTP consists of two buildings. Building 1 consists of the GAC filters and the UV/Oxidation system. Building 2 consists of the BTS. Tim Shangraw presented an overview of the BTS. From the WTP, Site inspection participants toured the GTEP and were informed that 1,200 cubic feet per minute was currently being pumped to the GTEP and 1,100 cubic feet per minute was being routed to the flare. Site inspection participants then observed the North End response extraction wells and the wetlands mitigation area, which was well vegetated. Chris Carlson indicated the wetlands have endured several storm events and are holding up well.

Alison Cattani and Johnny Zimmerman-Ward visited the Site repository, located at the Aurora Central Library. They located the previous two FYRs and the 1997 ESD. The Site inspection checklist and photos are included in Appendix D and F.

V. TECHNICAL ASSESSMENT

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

Question A Summary:

OU1 – Shallow Groundwater and Subsurface Liquids

No, the remedy is not functioning as intended by the decision documents because the original remedy has been substantially augmented by the contingency response measures that started in 2007. Even with these additional responses in operation for 10 years, contaminant concentrations at the POC continue to exceed performance standards.

The remedy consists of containment and source control via engineered components and compliance monitoring along the POC boundary. The WSDs added contingency extraction systems along the slurry wall and north of the MW38 area and NBBW to induce inward hydraulic gradient and reduce localized contaminant source areas and northern migration of groundwater contamination. The extracted groundwater from on-Site is pumped and treated at the WTP and discharged at 30 gpm to the POTW pipeline in accordance with the ROD. The off-Site groundwater bypasses the treatment system and discharges with the on-Site water to the POTW.

The containment portion of the remedy is monitored along the POC boundary to confirm an inward hydraulic gradient is maintained. Areas that do not exhibit an inward gradient are monitored for contaminant migration outside of the Site boundary, however 1,4-dioxane is not included as part of the perimeter effectiveness monitoring. Based on the high concentrations of 1,4-dioxane on-Site, this COC should be added to the containment effectiveness monitoring program. Most on-Site POC monitoring wells are meeting the groundwater performance standards; however, several wells continue to exceed the performance standards in the northern, eastern and southern portions of the Site. Contaminants include organic chemicals such as 1,4-dioxane, chloroform and TCE as well as nitrate and iron. These areas are being addressed through contingency measures using the protocols outlined in the ROD and the GWMP, however the effectiveness of these systems is unclear since exceedances are persisting in some areas. The areas with out-of-compliance wells are generally unchanged since the previous FYR, however three additional wells now exceed performance standards. Compliance wells MW62-WD and B-326-WD exhibit increasing concentrations of 1,4-dioxane, which were attributed in part to limited capacity of the WTP during times of high precipitation in 2015 and early 2016. The effectiveness of the

contingency measures in source control and organic chemical removal and the need for WTP capacity upgrades will be evaluated by the WSDs. The WSDs will conduct a Capture Zone Analysis in accordance with EPA's 2008 Guidance "A Systematic Approach for Evaluation of Capture Zones at Pump and Treat Systems" and subsequent optimization study to ensure that extraction systems are meeting performance standards at the POC. The NBBW area specifically has several wells out of compliance and the 1,4-dioxane plume extends north of the NBBW off-Site into the North End response area. The hydraulic containment in the NBBW area is augmented by the injection of potable water at three injection wells. There is a potential that these injections are negatively affecting the containment in this area of the Site by interfering with interpretation of water quality data in areas near the injection points and by possibly increasing the volume and mobility of 1,4-dioxane. The WSDs will discontinue the potable water injections and perform an optimization study of the groundwater containment remedy to assess changes in water levels, capture zones and water chemistry.

Iron is out of compliance in several unweathered Dawson wells and appears to be attributable to background (based on a lack of other COCs in these wells). The performance standard for iron is based on background levels established in the ROD. This background performance standard is based on concentrations in the weathered Dawson formation, which may not be appropriate for the unweathered Dawson wells. The groundwater performance standard for iron should be further evaluated by the WSDs to deduce if it is attainable in the unweathered Dawson wells.

Institutional controls are in place to prevent use of and exposure to contaminated groundwater in the area immediately north of the Site, but these controls do not cover the downgradient part of the 1,4-dioxane plume in Sections 19, 24 and 30 (Figure 2). The need for additional institutional controls for groundwater affected by the 1,4-dioxane plume north of the Site should be evaluated and implemented by the WSDs, as determined necessary.

Institutional controls are in place on-Site and in the area immediately off-Site to the north, west, south and east. These controls are adequate to prevent the use of and exposure to contaminated groundwater in these areas.

OU2 – Landfill Solids

Yes, the remedy is functioning as intended by the decision documents. A cover was placed over the landfill mass. Surface and subsurface drums and contaminated soils within the middle FTPA pit were excavated. The other pits were covered and monitoring and NAPL recovery is ongoing. The landfill and FTPA areas are well vegetated and regular maintenance is conducted to ensure the cover remains intact. During this FYR period, low areas were filled and maintenance is adequate to ensure protectiveness. LNAPL and DNAPL are collected as needed from the waste pit areas, although neither of these liquids were observed during this FYR period. Institutional controls are in place and adequate to prevent disturbance of landfill solids on-Site.

OU3 – Landfill Gas

Yes, the remedy is functioning as intended by the decision documents. The LFG collection and treatment system consists of 64 vertical extraction wells within the landfill area. Treatment consists of a combination of an enclosed flare, candlestick flare and landfill GTEP. The treatment system is operating appropriately and performance standards are being met. Regular maintenance is conducted and the extraction wells were all replaced during this FYR period with above-ground wells that allow for more efficient monitoring.

OU4 – Soils

Yes, the remedy is functioning as intended by the decision documents. The no action remedy consists of continued maintenance on the cover areas. Regular maintenance is conducted to ensure the covers remain intact.

OU5 – Surface Water and Sediment

Yes, the remedy is functioning as intended by the decision documents. The no action remedy consists of periodic surface water runoff monitoring, continued O&M of the SWRA and NBBW and construction of the wetlands located northeast of the Site. Stormwater monitoring, which replaced surface water monitoring, is conducted annually during precipitation events and O&M is conducted regularly at both the SWRA and NBBW. The wetlands appeared to be in good condition during the Site inspection.

OU6 – Deep Groundwater

No, the remedy is not functioning as intended by the decision documents. The remedy consists of monitoring the deep groundwater in the unweathered Dawson (biennial) and Denver aquifers (every five years). Water quality data collected from four monitoring wells installed in the unweathered Dawson and Denver aquifers located in the interior of the Site indicate that there is no vertical migration of contaminated groundwater. However, there are no vertical migration wells located north of the Site within the 1,4-dioxane plume to assess if 1,4-dioxane contamination is confined to the shallow units. The need for additional vertical migration wells north of the Site within the 1,4-dioxane plume to assess if this contaminant, as well as any others, is confined to the shallow units should be evaluated by the WSDs and addressed, as determined necessary.

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?

Question B Summary:

OU1 – Shallow Groundwater and Subsurface Liquids

Yes, the exposure assumptions and RAOs used at the time of the remedy selection are still valid. 1,4-Dioxane was added as a COC after the remedy was implemented and the WTP was amended to address it. The groundwater performance standards from the ROD and the GWMP (which include 1,4-dioxane) were compared to the current MCLs and the 2016 CDPHE groundwater standards. The results are provided in Appendix G, Table G-1. While there have been changes in toxicity and groundwater standards, these changes do not affect the protectiveness of the current groundwater performance standards. There are several standards for which the MCL or CDPHE standard is less than the PQL or Reporting Limit for that COC. The reporting limits and PQLs are reevaluated annually and updated accordingly. This is specifically crucial for 1,4-dioxane. There is no MCL for 1,4-dioxane and the current PQL (0.9 µg/L) is greater than the standard set by CDPHE (0.35 µg/L). The PQL for 1,4-dioxane will continue to be reevaluated annually until an MCL is established.

The RAOs for groundwater are still valid and include prevention of human and environmental exposure, migration beyond the compliance boundary and off-Site and prevention of vertical migration. In instances where the performance standards are not being met at the compliance boundary, contingency measures are being implemented to maintain hydraulic gradient and meet performance standards. Despite the implementation of several contingency measures, several wells remain out of compliance north of the Site, as well as east, west and south as described in the previous section.

OU2 – Landfill Solids

Yes, the exposure assumptions, toxicity data, cleanup levels and RAOs used at the time of the remedy selection are still valid. There have been no changes in exposure assumptions, toxicity data or RAOs. There are no cleanup levels for landfill solids. The RAOs are being met because landfill solids are covered and the covers remain intact.

OU3 – Landfill Gas

Yes, the exposure assumptions and RAOs used at the time of the remedy selection are still valid. The LFG subsurface performance standards were provided in the 2002 minor modification to the ROD and then updated in 2007 and 2012 using EPA's Vapor Intrusion Model (VIAM). This model is undergoing updates to reflect EPA's June 2015 final vapor intrusion guidance. To determine if the performance standards remain valid, EPA's Vapor Intrusion Screening Level (VISL) calculator, which reflects updated toxicity values, was used as a screening tool. Results are provided in Appendix I, Tables I-1 and I-2. Several performance standards were outside EPA's acceptable risk range of $1x10^{-6}$ to $1x10^{-4}$ (cancer risk) or had a hazard quotient greater than 1 (non-cancer risk), however the screening values are not based on-Site-specific inputs. Using the maximum detected concentrations at the POC wells indicated that all detected concentrations were below or within EPA's acceptable risk range for cancer and below a hazard quotient of 1. The LFG performance standards should be reevaluated by the WSDs utilizing the updated toxicity values and Site-specific inputs to ensure future protectiveness.

OU4 – Soils

Yes, the exposure assumptions, toxicity data, cleanup levels and RAOs used at the time of the remedy selection are still valid. There have been no changes in exposure assumptions, toxicity data or RAOs.

OU5 – Surface Water and Sediment

Yes, the exposure assumptions, toxicity data, cleanup levels and RAOs used at the time of the remedy selection are still valid. There have been no changes in exposure assumptions, toxicity data or RAOs.

OU6 – Deep Groundwater

While the performance standards are still protective as described above for OU1, the exposure assumptions and RAOs used at the time of the remedy selection are not still valid. Monitoring activities indicate that the RAO to "prevent vertical migration of dissolved groundwater contaminants" is being met on-Site because performance standards are being achieved in the Denver aquifer wells, however, as described in question A above, there are no vertical monitoring wells north of the Site to monitor vertical migration of the 1,4-dioxane plume. As indicated in question A, the need for additional vertical migration wells north of the Site within the 1,4-dioxane plume to assess if this contaminant, as well as any others, is confined to the shallow units should be evaluated by the WSDs and addressed, as determined necessary.

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

Yes, the WSDs conducted a well survey in 2017 that extended five miles downgradient of the Site along the Murphy Creek Drainage. There were several private or municipal wells located within the drainage. Four of these wells are located within the footprint of the 1,4-dioxane plume and one well is located immediately adjacent to the plume (Figure 3 and Table 7). In order to ensure there is no current human exposure, these wells should be sampled and analyzed for 1,4-dioxane and based on the results, appropriate remedial actions implemented. In addition to the wells located within the drainage, there are domestic wells located approximately 1,000 feet east of the leading edge of the plume, just outside the Murphy Creek Drainage in the Gun Club Estates. An updated plume map and conceptual site model is needed to ensure there is no potential for future exposure in this area. Based on the results, EPA will evaluate the need for a monitoring plan for wells located within the vicinity of the plume edge.

VI. ISSUES/RECOMMENDATIONS

Issues/Recommendations
OU(s) without Issues/Recommendations Identified in the FYR:
OU2 – Landfill Solids *OU4 – Soils* *OU5 – Surface Water and Sediment*

Issues and Recommendations Identified in the FYR:

OU(s): 1	**Issue Category: Remedy Performance**			
	Issue: The potable water injections are not part of the remedy for the NBBW and the effectiveness or potential impact to the water balance and contaminant transport north of the NBBW has not been evaluated by EPA.			
	Recommendation: Discontinue potable water injections and conduct an optimization study of the groundwater containment remedy to assess changes in water levels, capture zones and water chemistry.			
Affect Current Protectiveness	**Affect Future Protectiveness**	**Party Responsible**	**Oversight Party**	**Milestone Date**
No	Yes	PRP	EPA	9/30/2018

OU(s): 1	**Issue Category: Remedy Performance**			
	Issue: The capacity of the WTP was limited during times of high precipitation in 2015 and early 2016.			
	Recommendation: Evaluate and upgrade the WTP capacity.			
Affect Current Protectiveness	**Affect Future Protectiveness**	**Party Responsible**	**Oversight Party**	**Milestone Date**
No	Yes	PRP	EPA	9/30/2019

OU(s): 1	**Issue Category: Remedy Performance**
	Issue: Numerous compliance wells continue to exceed the performance standards for 1,4-dioxane, chloroform, iron and nitrate in the northern, eastern, western and southern portions of the Site.
	Recommendation: Conduct a Capture Zone Analysis in accordance with EPA's 2008 guidance. Based on the results of the Capture Zone Analysis, optimize the remedial extraction systems on-Site and off-Site to ensure the remedy is meeting remedial action objectives.

Affect Current Protectiveness	Affect Future Protectiveness	Party Responsible	Oversight Party	Milestone Date
No	Yes	PRP	EPA	9/30/2019

OU(s): 1	Issue Category: Remedy Performance			
	Issue: Private or municipal wells are located within the Murphy Drainage downgradient of the Site. Four of these wells are located within the footprint of the 1,4-dioxane plume and one well that is located immediately adjacent to the plume.			
	Recommendation: Sample these wells and analyze for 1,4-dioxane. Based on the results, implement appropriate remedial actions.			
Affect Current Protectiveness	**Affect Future Protectiveness**	**Party Responsible**	**Oversight Party**	**Milestone Date**
Yes	Yes	PRP	EPA	9/30/2018

OU(s): 1	Issue Category: Monitoring			
	Issue: The containment effectiveness monitoring at the perimeter slurry wall does not monitor for 1,4-dioxane.			
	Recommendation: Add 1,4-dioxane to the monitoring plan for perimeter wells.			
Affect Current Protectiveness	**Affect Future Protectiveness**	**Party Responsible**	**Oversight Party**	**Milestone Date**
No	Yes	PRP	EPA	9/30/2018

OU(s): 1	Issue Category: Monitoring			
	Issue: The performance standard for iron is based on background concentrations in the weathered Dawson. Several wells that are screened in the unweathered Dawson are out of compliance for iron.			
	Recommendation: Reevaluate the performance standard for iron.			
Affect Current Protectiveness	**Affect Future Protectiveness**	**Party Responsible**	**Oversight Party**	**Milestone Date**
No	Yes	PRP	EPA	9/30/2018

OU(s): 1	Issue Category: Institutional Controls
	Issue: The 1,4-dioxane plume extends off-Site to the north. No institutional controls are in place in this area and there are private wells located within the footprint and the vicinity of the plume. In addition, there are domestic drinking water wells located approximately 1,000 feet east of the leading edge of the plume, just outside the Murphy Creek Drainage in the Gun Club Estates.
	Recommendation: Develop an updated plume map and conceptual site model to ensure there is no potential for future exposure in this area. Based on the results, evaluate the need for a monitoring plan for wells located within the vicinity of the

	plume edge. Also, assess the need for additional institutional controls for the 1,4-dioxane plume area.			
Affect Current Protectiveness	**Affect Future Protectiveness**	**Party Responsible**	**Oversight Party**	**Milestone Date**
No	Yes	PRP	EPA	9/30/2019

OU(s): 3	**Issue Category: Monitoring**			
	Issue: Several LFG performance standards may not be stringent enough based on current toxicity values.			
	Recommendation: Reevaluate the LFG performance standards utilizing updated toxicity values and Site-specific input data (as opposed to default values) in the Johnson-Ettinger model.			
Affect Current Protectiveness	**Affect Future Protectiveness**	**Party Responsible**	**Oversight Party**	**Milestone Date**
No	Yes	PRP	EPA	9/30/2018

OU(s): 6	**Issue Category: Monitoring**			
	Issue: There are no vertical migration wells located north of the Site within the 1,4-dioxane plume area to assess if 1,4-dioxane contamination is confined to the shallow aquifer units.			
	Recommendation: Review the vertical migration compliance well network and evaluate the need for an additional vertical migration compliance well in the 1,4-dioxane plume area.			
Affect Current Protectiveness	**Affect Future Protectiveness**	**Party Responsible**	**Oversight Party**	**Milestone Date**
Yes	Yes	PRP	EPA	9/30/2019

OTHER FINDINGS

In addition, the following are recommendations that were identified during the FYR, but do not affect current and/or future protectiveness:

- *Update the GWMP with current Colorado performance standards and to comply with EPA's 2008 Guidance "A Systematic Approach for Evaluation of Capture Zones at Pump and Treat Systems.*
- *The 2016 EPA and WSDs split sampling results for some analytes including 1,4-dioxane were different as reported yet each sample report was validated for the respective result and method. Consider using the same laboratory methodologies and internal standard for future split sampling efforts.*
- *Update Site repository with decision documents and other recent Site documents.*

VII. PROTECTIVNESS STATEMENTS

Protectiveness Statements		
Operable Unit: 1	*Protectiveness Determination:* Protectiveness Deferred	*Planned Addendum Completion Date:* 9/30/2018
Protectiveness Statement: A protectiveness determination of the OU1 remedy cannot be made at this time until further information is obtained. Further information will be obtained by sampling and analyzing the wells located within the footprint of the plume for 1,4-dioxane. Based on the results, appropriate measures will be taken to prevent exposure to contaminated groundwater. It is expected these actions will take approximately 1 year to complete, at which time a protectiveness determination will be made.		

Operable Unit: 2	*Protectiveness Determination:* Protective
Protectiveness Statement: The remedy at OU2 is protective of human health and the environment because there are no completed exposure pathways to landfill solids.	

Operable Unit: 3	*Protectiveness Determination:* Short-term Protective
Protectiveness Statement: The remedy at OU3 currently protects human health and the environment because there is no exposure to hazardous waste due to a functioning landfill gas treatment system that prevents the release of landfill gases into ambient air. The LFG subsurface performance standards were provided in the 2002 minor modification to the ROD and then updated in 2007 and 2012 using EPA's VIAM. This model is undergoing updates to reflect EPA's June 2015 final vapor intrusion guidance. In order for the remedy to be protective in the long-term, the LFG performance standards should be revised utilizing EPA's updated toxicity values and Site-specific input data.	

Operable Unit: 4	*Protectiveness Determination:* Protective
Protectiveness Statement: The remedy at OU4 is protective of human health and the environment because the ongoing maintenance of the cover areas prevents direct contact, ingestion and inhalation of soil contaminants as well as minimizes the migration of soil by erosion by wind or water.	

Operable Unit: 5	*Protectiveness Determination:* Protective
Protectiveness Statement: The remedy at OU5 is protective of human health and the environment because the operation and maintenance of the SWRA effectively prevents contamination from migrating to on-Site surface water and sediments.	

Operable Unit:	*Protectiveness Determination:*	*Planned Addendum Completion Date:*
6	Protectiveness Deferred	9/30/2018

Protectiveness Statement:
A protectiveness determination of the OU6 remedy cannot be made at this time until further information is obtained. Further information will be obtained by installing additional vertical migration wells north of the Site within the 1,4-dioxane plume to assess if this contaminant, as well as any others, are confined to the shallow units. It is expected these actions will take approximately 1 year to complete, at which time a protectiveness determination will be made.

Sitewide Protectiveness Statement

Protectiveness Determination:	*Planned Addendum Completion Date:*
Protectiveness Deferred	9/30/2018

Protectiveness Statement:
Because a protectiveness determination cannot be made for the OU1 and OU6 remedies at this time until further information is obtained, a protectiveness determination cannot be made for the Site. Further information for OU1 will be obtained by sampling and analyzing the wells located within the footprint of the plume for 1,4-dioxane. Based on the results, appropriate measures will be taken to prevent exposure to contaminated groundwater. For OU6, further information will be obtained by installing additional vertical migration wells north of the Site within the 1,4-dioxane plume. It is expected these actions will take approximately 1 year to complete, at which time a protectiveness determination will be made.

VIII. NEXT REVIEW

The next FYR Report for the Lowry Landfill Superfund Site is required five years from the completion date of this review.

APPENDIX A – REFERENCE LIST

Addendum 5 to Final Operation and Maintenance Manual Water Treatment Plant, Lowry Landfill Superfund Site, Operations and Maintenance. Prepared for City and County of Denver, Chemical Waste Management, Inc. and Waste Management of Colorado, Inc. Prepared by EMSI. Reviewed and approved by EPA. August 2015.

Amendment to the Record of Decision, Lowry Landfill Superfund Site, Arapahoe County, Colorado. EPA Region 8. August 2005.

Explanation of Significant Differences, Lowry Landfill Superfund Site, Arapahoe County, Colorado. EPA Region 8. August 1995.

Final Institutional Controls Plan, Lowry Landfill Superfund Site, Arapahoe County, Colorado. EPA Region 8. September 2002.

Five-Year Review Report, Third Review for Lowry Landfill Superfund Site, Arapahoe County, Colorado. EPA Region 8. September 2012.

Groundwater Containment Remedy Technical Considerations, Lowry Landfill Superfund Site, Arapahoe County, Colorado. CDPHE. February 2015.

Minor Modification of the March 10, 1994 Record of Decision, Lowry Landfill Superfund Site, Arapahoe County, Colorado. EPA Region 8. March 1996.

Minor Modification of the March 10, 1994 Record of Decision, Lowry Landfill Superfund Site, Arapahoe County, Colorado. EPA Region 8. October 2002.

Minor Modification of the Selected Remedy, Lowry Landfill Superfund Site, Arapahoe County, Colorado. EPA Region 8. July 2006.

Record of Decision, Lowry Landfill Superfund Site, Arapahoe County, Colorado. EPA Region 8. March 1994.

Remedial Action and Operations and Maintenance Status Report, January through June 2012, Lowry Landfill Superfund Site. Prepared for City and County of Denver, Chemical Waste Management, Inc. and Waste Management of Colorado, Inc. Prepared by EMSI. Reviewed and approved by EPA. September 2012.

Remedial Action and Operations and Maintenance Status Report, July through December 2012, Lowry Landfill Superfund Site. Prepared for City and County of Denver, Chemical Waste Management, Inc. and Waste Management of Colorado, Inc. Prepared by EMSI. Reviewed and approved by EPA. March 2013.

Remedial Action and Operations and Maintenance Status Report, January through June 2013, Lowry Landfill Superfund Site. Prepared for City and County of Denver, Chemical Waste Management, Inc. and Waste Management of Colorado, Inc. Prepared by EMSI. Reviewed and approved by EPA. September 2013.

Remedial Action and Operations and Maintenance Status Report, July through December 2013, Lowry Landfill Superfund Site. Prepared for City and County of Denver, Chemical Waste Management, Inc. and Waste Management of Colorado, Inc. Prepared by EMSI. Reviewed and approved by EPA. March 2014.

Remedial Action and Operations and Maintenance Status Report, January through June 2014, Lowry Landfill Superfund Site. Prepared for City and County of Denver, Chemical Waste Management, Inc. and Waste Management of Colorado, Inc. Prepared by EMSI. Reviewed and approved by EPA. September 2014.

Remedial Action and Operations and Maintenance Status Report, July through December 2014, Lowry Landfill Superfund Site. Prepared for City and County of Denver, Chemical Waste Management, Inc. and Waste Management of Colorado, Inc. Prepared by EMSI. Reviewed and approved by EPA. March 2015.

Remedial Action and Operations and Maintenance Status Report, January through June 2015, Lowry Landfill Superfund Site. Prepared for City and County of Denver, Chemical Waste Management, Inc. and Waste Management of Colorado, Inc. Prepared by EMSI. Reviewed and approved by EPA. September 2015.

Remedial Action and Operations and Maintenance Status Report, July through December 2015, Lowry Landfill Superfund Site. Prepared for City and County of Denver, Chemical Waste Management, Inc. and Waste Management of Colorado, Inc. Prepared by EMSI. Reviewed and approved by EPA. March 2016.

Remedial Action and Operations and Maintenance Status Report, January through June 2016, Lowry Landfill Superfund Site. Prepared for City and County of Denver, Chemical Waste Management, Inc. and Waste Management of Colorado, Inc. Prepared by EMSI. Reviewed and approved by EPA. September 2016.

Response Action Work Plan, B-326-UD and B-313 Areas, Lowry Landfill Superfund Site, Operations and Maintenance. Prepared for City and County of Denver, Chemical Waste Management, Inc. and Waste Management of Colorado, Inc. Prepared by EMSI. April 2013.

Response Action Work Plan to Extract Additional Groundwater from Upgradient of MW77-WD, Lowry Landfill Superfund Site, Remedial Action/Operations and Maintenance. Prepared for City and County of Denver, Chemical Waste Management, Inc. and Waste Management of Colorado, Inc. Prepared by EMSI. November 2011.

Review of Draft Final Report entitled *Groundwater Containment Remedy Technical Considerations – Lowry Landfill Superfund Site, Arapahoe County, Colorado* dated January 2013. EPA Region 8. August 2013.

Revised Groundwater Monitoring Plan, Lowry Landfill Superfund Site, Arapahoe County, Colorado. Prepared for City and County of Denver, Chemical Waste Management, Inc. and Waste Management of Colorado, Inc. Prepared by EMSI. July 2015.

Revised North End Initial Response Action (IRA) Work Plan Addendum, and North End Monitoring Data, Lowry Landfill Superfund Site, Arapahoe County, Colorado. Prepared for EPA Region 8. Prepared by EMSI. February 2008.

Revision 2 Operations and Maintenance Manual Groundwater Extraction, Lowry Landfill Superfund Site, Operations and Maintenance. Prepared for City and County of Denver, Chemical Waste Management, Inc. and Waste Management of Colorado, Inc. Prepared by EMSI. April 2015.

Revision 2, Updated Compliance Monitoring Plan, Landfill Gas Remedy, Lowry Superfund Site, Remedial Action/Operations and Maintenance. Prepared for City and County of Denver, Chemical Waste Management, Inc. and Waste Management of Colorado, Inc. Prepared by EMSI. February 2015.

Sampling Activities Report, 2016 Sampling Events Final, Lowry Landfill Superfund Site, Arapahoe County, Colorado. Prepared for EPA Region 8. Prepared by TechLaw. November 2016.

Second Explanation of Significant Differences, Lowry Landfill Superfund Site, Arapahoe County, Colorado. EPA Region 8. October 1997.

Stormwater Monitoring Plan, Lowry Landfill Superfund Site, Arapahoe County, Colorado. Prepared for EPA Region 8. Prepared by EMSI. April 2008.

Work Plan to Assess Northern Extent of 1,4-Dioxane in Shallow Groundwater (North of Well MW144-WD). Prepared for EPA. Prepared by EMSI. November 2014.

APPENDIX B – SITE CHRONOLOGY

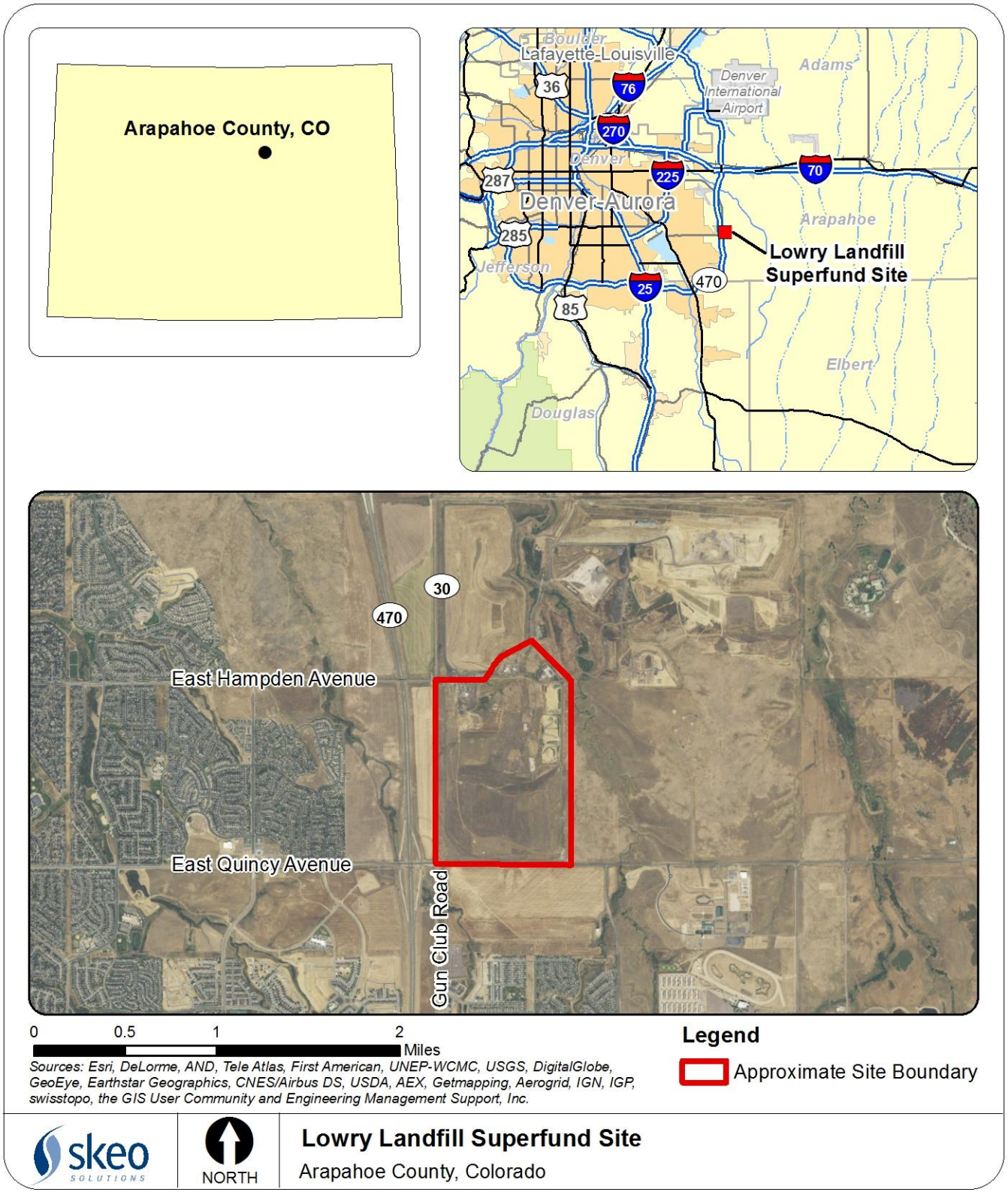
Table B-1: Site Chronology

Event	Date (Month Year)
City of Denver operated Lowry Landfill as a municipal and industrial landfill	1965-1980
Citizens issued complaints about the Lowry Landfill to regulatory authorities. EPA, the CDPHE and Denver engaged in an ongoing process to identify contamination problems and modify operational practices.	1971-1979
Initial discovery	October 1, 1978
EPA, United States Geological Survey and CDPHE conducted various investigations at the Site	Mid 1970s-1984
WMC took over operation of the landfill under a contract with Denver	1980
EPA conducted a Preliminary Assessment for the Lowry Landfill	June 1, 1980
EPA conducted a Site inspection	August 1, 1982
EPA placed Lowry Landfill on NPL. Denver implemented an interim remedial measure consisting of subsurface groundwater drain backed by a compacted clay barrier wall (NBBW) and a WTP.	September 21, 1984
EPA completed the Drum Removal Action	October 1990
PRPs comprising the Lowry Coalition completed the RI for OU1	March 1994
PRPs completed the RI for OU6	
Denver, WMC and CWM performed the RI for OU2 and OU3	
The PRPs conducted the RI for OU4	
EPA issued the ROD	March 10, 1994
EPA issued the Unilateral Administrative Order for Remedial Design/Remedial Action (RD/RA) to 34 PRPs. Respondents Denver, WMC, and CWM agreed to perform the RD/RA on behalf of themselves and 31 other PRPs.	November 18, 1994
Respondents constructed the Landfill Gas Collection and Treatment System	1996
Respondents completed the North Toe Extraction System and East/South/West Barrier Wall	1998
Respondents completed FTPA Middle Waste Pit excavation	February 1999
Respondents completed North Face Landfill Cover	1999
Respondents completed the new WTP	2000
EPA conducted the first FYR	September 2001
EPA issued the ROD Amendment for FTPA remedy	August 2005
Respondents constructed the BTS at the WTP	2005
Respondents implemented the MW38 Area Gradient Control Contingency Measure	
EPA certified the completion of construction of groundwater monitoring network	
EPA approved the Final Interim Closeout Report, Middle Waste Pit Remediation and Construction of the Treatment Cell, FTPA Waste Pit Remedy	
EPA certified completion of the SWRA, MW38 Area Gradient Control Contingency Measure and new WTP	
EPA certified construction completion for Sitewide remedy	September 2006
EPA issued a third ESD modifying the treatment component of the landfill gas remedy by adding a new on-Site landfill gas to energy facility	July 2007

Event	Date (Month Year)
EPA conducted the second FYR	September 2007
EPA approved the Final Remedial Action Completion Report for the South Waste Pit portion of the FTPA	2010
EPA approved Addendum 1 to the Final Construction Closeout Report for the GTEP	2011
EPA conducted the third FYR	September 2012
EPA completed Final Remedial Action Report for North Waste Pit and Former Tire Pile Area	September 2013

APPENDIX C – SITE MAPS

Figure C-1: Site Vicinity Map



Disclaimer: This map and any boundary lines within the map are approximate and subject to change. The map is not a survey. The map is for informational purposes only regarding EPA's response actions at the Site.

Figure C-2: Generalized Stratigraphic Column of Geologic Units and Aquifer Designations

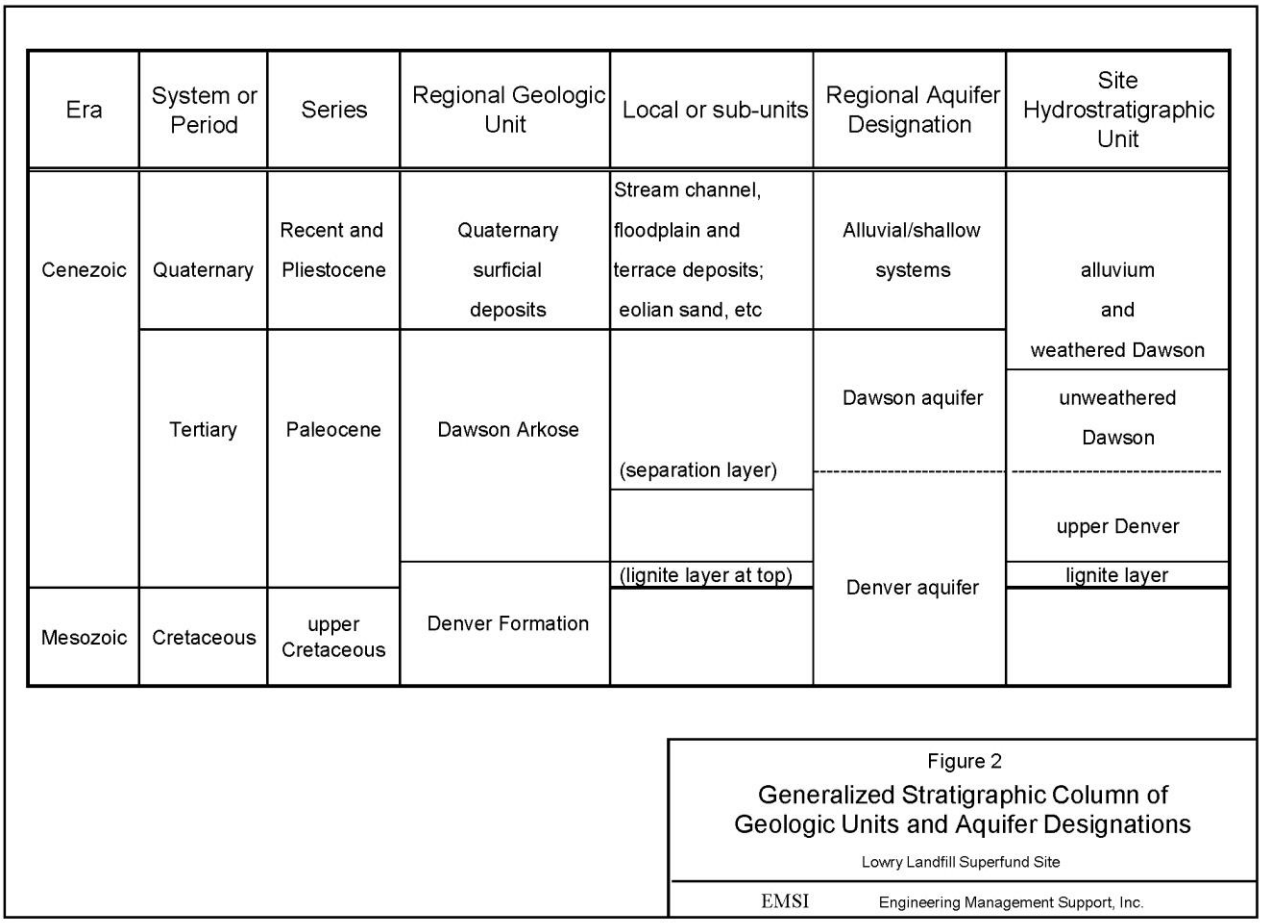


Figure C-3: Groundwater Remedy Components and Point of Compliance Boundary

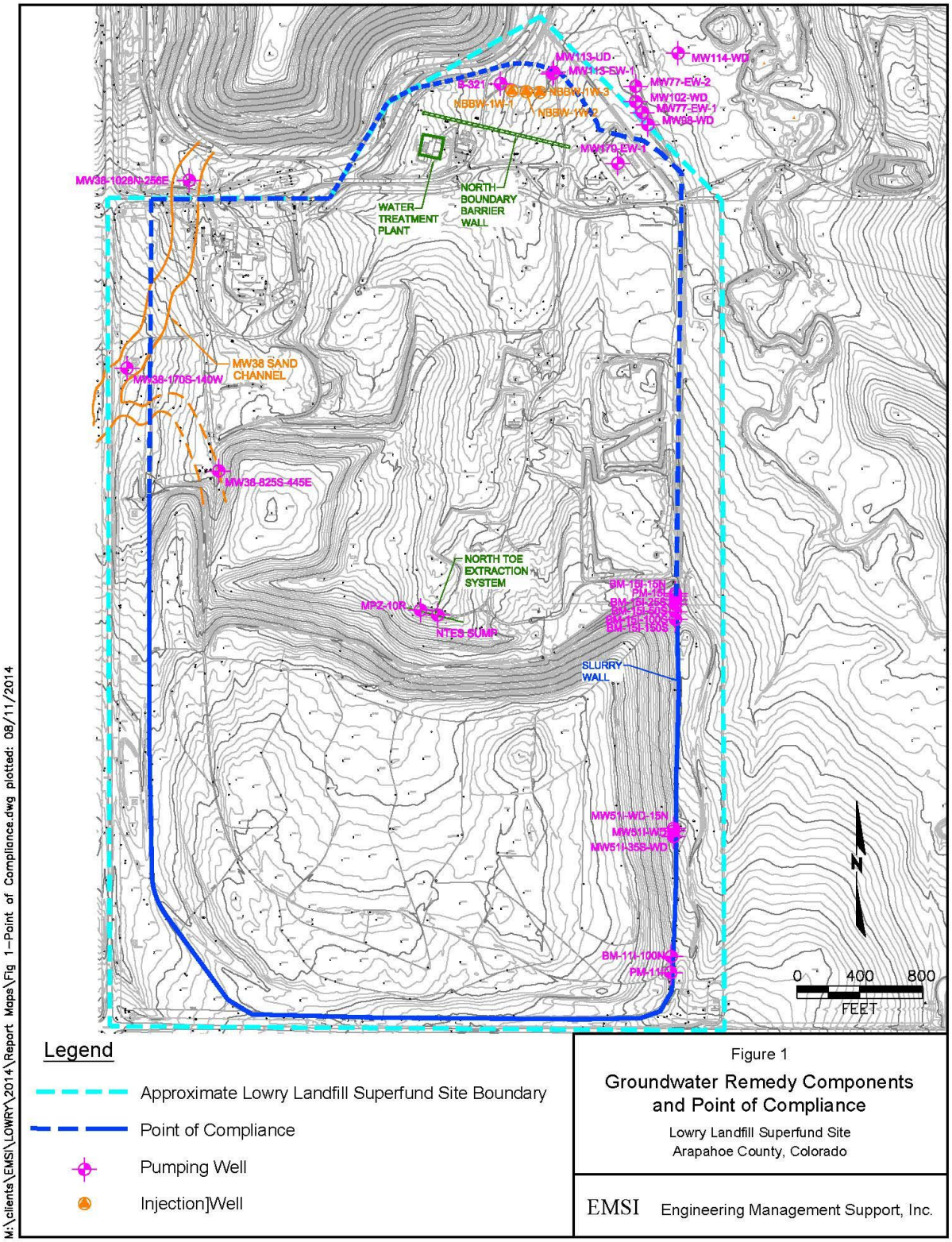
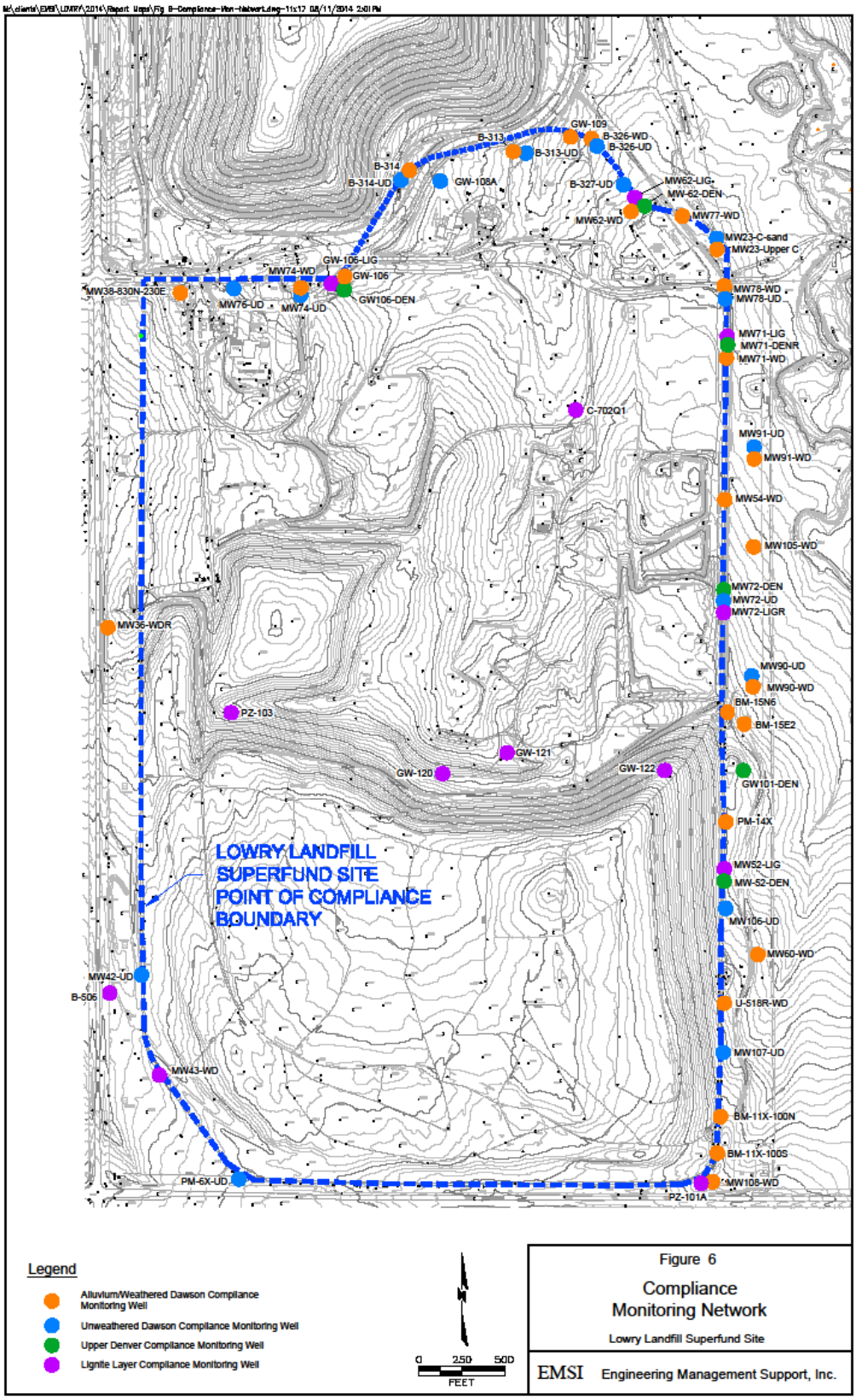


Figure C-4: Compliance Monitoring Network



APPENDIX D – SITE INSPECTION CHECKLIST

FIVE-YEAR REVIEW SITE INSPECTION CHECKLIST

I. SITE INFORMATION

Site Name: LOWRY LANDFILL	**Date of Inspection:** 10/25/2016
Location and Region: Aurora, Colorado 8	**EPA ID: COD980499248**
Agency, Office or Company Leading the Five-Year Review: EPA	**Weather/Temperature:** Partly Cloudy, mid-50's

Remedy Includes: (Check all that apply)

- ☒ Landfill cover/containment
- ☒ Access controls
- ☒ Institutional controls
- ☒ Groundwater pump and treatment
- ☐ Surface water collection and treatment
- ☒ Other: Gas to Energy Plant
- ☐ Monitored natural attenuation
- ☒ Groundwater containment
- ☒ Vertical barrier walls

Attachments: ☐ Inspection team roster attached ☐ Site map attached

II. INTERVIEWS (check all that apply)

1. **O&M Site Manager** Steve Richtel, WMI and Dave Wilmoth, Denver (Name) _____ (Title) 10/27/2016 (Date)
   Interviewed ☐ at site ☐ at office ☒ by phone Phone: _____
   Problems, suggestions ☐ Report attached: _____

2. **O&M Staff** _____ (Name) _____ (Title) _____ (Date)
   Interviewed ☐ at site ☐ at office ☐ by phone Phone: _____
   Problems/suggestions ☐ Report attached: _____

3. **Local Regulatory Authorities and Response Agencies** (i.e., state and tribal offices, emergency response office, police department, office of public health or environmental health, zoning office, recorder of deeds, or other city and county offices). Fill in all that apply.

   Agency CDPHE
   Contact Lee Pivonka, Wendy Naugle, Jeannine Natterman and Doug Jamison _____ (Title) 11/18/2016 (Date) _____ (Phone No.)
   Problems/suggestions ☐ Report attached: _____

   Agency City of Aurora
   Contact Karen Hancock (Name) _____ (Title) 2/28/2017 (Date) _____ (Phone No.)
   Problems/suggestions ☐ Report attached: _____

   Agency Arapahoe County
   Contact Jeff Baker (Name) County Commissioner (Title) 4/11/2017 (Date) _____ (Phone No.)
   Problems/suggestions ☐ Report attached: _____

   Agency Arapahoe County
   Contact Rod Bockenfed (Name) Former Arapahoe 2/28/2017 (Date) _____ (Phone No.)

		County Commissioner Title			
	Problems/suggestions ☐ Report attached: _____				
	Agency TCHD				
	Contact Lynn Robbio Wagner Name	_____ Title	6/6/2017 Date	_____ Phone No.	
	Problems/suggestions ☐ Report attached: _____				
4.	**Other Interviews** (optional) ☐ Report attached: _____				
Bonnie Rader, President, CLLEAN					
President, Thunderbird Estates Homeowners Association					
III. ON-SITE DOCUMENTS AND RECORDS VERIFIED (check all that apply)					
1.	**O&M Documents**				
	☒ O&M manual	☒ Readily available	☒ Up to date	☐ N/A	
	☒ As-built drawings	☒ Readily available	☒ Up to date	☐ N/A	
	☒ Maintenance logs	☒ Readily available	☒ Up to date	☐ N/A	
	Remarks: _____				
2.	**Site-Specific Health and Safety Plan**	☒ Readily available	☒ Up to date	☐ N/A	
	☒ Contingency plan/emergency response plan	☒ Readily available	☒ Up to date	☐ N/A	
	Remarks: _____				
3.	**O&M and OSHA Training Records**	☒ Readily available	☒ Up to date	☐ N/A	
	Remarks: _____				
4.	**Permits and Service Agreements**				
	☒ Air discharge permit	☒ Readily available	☒ Up to date	☐ N/A	
	☒ Effluent discharge	☒ Readily available	☒ Up to date	☐ N/A	
	☐ Waste disposal, POTW	☐ Readily available	☐ Up to date	☒ N/A	
	☐ Other permits: _____	☐ Readily available	☐ Up to date	☒ N/A	
	Remarks: _____				
5.	**Gas Generation Records**	☒ Readily available	☒ Up to date	☐ N/A	
	Remarks: _____				
6.	**Settlement Monument Records**	☐ Readily available	☐ Up to date	☒ N/A	
	Remarks: _____				
7.	**Groundwater Monitoring Records**	☒ Readily available	☒ Up to date	☐ N/A	
	Remarks: _____				
8.	**Leachate Extraction Records**	☐ Readily available	☐ Up to date	☒ N/A	
	Remarks: _____				
9.	**Discharge Compliance Records**				
	☒ Air	☒ Readily available	☒ Up to date	☐ N/A	

☒ Water (effluent) ☒ Readily available ☒ Up to date ☐ N/A

Remarks: _____

10. **Daily Access/Security Logs** ☒ Readily available ☒ Up to date ☐ N/A

Remarks: _____

IV. O&M COSTS

1. **O&M Organization**

☐ State in-house ☐ Contractor for state

☐ PRP in-house ☒ Contractor for PRP

☐ Federal facility in-house ☐ Contractor for Federal facility

☐ _____

2. **O&M Cost Records**

☐ Readily available ☐ Up to date

☐ Funding mechanism/agreement in place ☒ Unavailable

Original O&M cost estimate: _____ ☐ Breakdown attached

Total annual cost by year for review period if available

From: _____ Date	To: _____ Date	_____ Total cost	☐ Breakdown attached
From: _____ Date	To: _____ Date	_____ Total cost	☐ Breakdown attached
From: _____ Date	To: _____ Date	_____ Total cost	☐ Breakdown attached
From: _____ Date	To: _____ Date	_____ Total cost	☐ Breakdown attached
From: _____ Date	To: _____ Date	_____ Total cost	☐ Breakdown attached

3. **Unanticipated or Unusually High O&M Costs during Review Period**

Describe costs and reasons: _____

V. ACCESS AND INSTITUTIONAL CONTROLS ☒ Applicable ☐ N/A

A. Fencing

1. **Fencing Damaged** ☐ Location shown on-Site map ☒ Gates secured ☐ N/A

Remarks: In excellent condition.

B. Other Access Restrictions

1. **Signs and Other Security Measures** ☐ Location shown on-Site map ☐ N/A

Remarks: In excellent condition.

C. Institutional Controls (ICs)

1. **Implementation and Enforcement**

Site conditions imply ICs not properly implemented ☐ Yes ☒ No ☐ N/A

Site conditions imply ICs not being fully enforced ☐ Yes ☒ No ☐ N/A

Type of monitoring (e.g., self-reporting, drive by): Daily on-Site presence

Frequency: _____

Responsible party/agency: WSDs

Contact _____ _____ _____ _____

Name Title Date Phone no.

Reporting is up to date ☐ Yes ☐ No ☒ N/A

Reports are verified by the lead agency ☐ Yes ☐ No ☒ N/A

Specific requirements in deed or decision documents have been met ☒ Yes ☐ No ☐ N/A

Violations have been reported ☐ Yes ☒ No ☐ N/A

Other problems or suggestions: ☐ Report attached

2. **Adequacy** ☒ ICs are adequate ☒ ICs are inadequate ☐ N/A

Remarks: Additional ICs may be needed north of the Site.

D. General

1. **Vandalism/Trespassing** ☐ Location shown on-Site map ☒ No vandalism evident

Remarks: _____

2. **Land Use Changes On-Site** ☒ N/A

Remarks: _____

3. **Land Use Changes Off-Site** ☐ N/A

Remarks: Plans for road expansion and increased development in that part of Arapahoe County.

VI. GENERAL SITE CONDITIONS

A. Roads ☒ Applicable ☐ N/A

1. **Roads Damaged** ☐ Location shown on-Site map ☒ Roads adequate ☐ N/A

Remarks: _____

B. Other Site Conditions

Remarks: _____

VII. LANDFILL COVERS ☒ Applicable ☐ N/A

A. Landfill Surface

1. **Settlement** (low spots) ☐ Location shown on-Site map ☒ Settlement not evident

Area extent: _____ Depth: _____

Remarks: Applies to waste pit covers and landfill cover.

2. **Cracks** ☐ Location shown on-Site map ☒ Cracking not evident

Lengths: _____ Widths: _____ Depths: _____

Remarks: Applies to waste pit covers and landfill cover.

3.	**Erosion**	☐ Location shown on-Site map	☒ Erosion not evident
	Area extent: _____		Depth: _____
	Remarks: Applies to waste pit covers and landfill cover.		
4.	**Holes**	☐ Location shown on-Site map	☒ Holes not evident
	Area extent: _____		Depth: _____
	Remarks: Applies to waste pit covers and landfill cover.		
5.	**Vegetative Cover**	☒ Grass	☒ Cover properly established
	☒ No signs of stress	☐ Trees/shrubs (indicate size and locations on a diagram)	
	Remarks: Applies to waste pit covers and landfill cover.		
6.	**Alternative Cover** (e.g., armored rock, concrete)		☒ N/A
	Remarks: _____		
7.	**Bulges**	☐ Location shown on-Site map	☒ Bulges not evident
	Area extent: _____		Height: _____
	Remarks: _____		
8.	**Wet Areas/Water Damage**	☒ Wet areas/water damage not evident	
	☐ Wet areas	☐ Location shown on-Site map	Area extent: _____
	☐ Ponding	☐ Location shown on-Site map	Area extent: _____
	☐ Seeps	☐ Location shown on-Site map	Area extent: _____
	☐ Soft subgrade	☐ Location shown on-Site map	Area extent: _____
	Remarks: Applies to waste pit covers and landfill cover.		
9.	**Slope Instability**	☐ Slides	☐ Location shown on-Site map
	☒ No evidence of slope instability		
	Area extent: _____		
	Remarks: Applies to waste pit covers and landfill cover.		
B. Benches		☐ Applicable	☒ N/A
	(Horizontally constructed mounds of earth placed across a steep landfill side slope to interrupt the slope in order to slow down the velocity of surface runoff and intercept and convey the runoff to a lined channel.)		
1.	**Flows Bypass Bench**	☐ Location shown on-Site map	☐ N/A or okay
	Remarks: _____		
2.	**Bench Breached**	☐ Location shown on-Site map	☐ N/A or okay
	Remarks: _____		
3.	**Bench Overtopped**	☐ Location shown on-Site map	☐ N/A or okay
	Remarks: _____		
C. Letdown Channels		☐ Applicable	☒ N/A
	(Channel lined with erosion control mats, riprap, grout bags or gabions that descend down the steep side slope of the cover and will allow the runoff water collected by the benches to move off of the landfill cover without creating erosion gullies.)		

1. **Settlement** (Low spots) ☐ Location shown on-Site map ☐ No evidence of settlement
Area extent: _____ Depth: _____
Remarks: _____

2. **Material Degradation** ☐ Location shown on-Site map ☐ No evidence of degradation
Material type:_____ Area extent: _____
Remarks: _____

3. **Erosion** ☐ Location shown on-Site map ☐ No evidence of erosion
Area extent: _____ Depth: _____
Remarks: _____

4. **Undercutting** ☐ Location shown on-Site map ☐ No evidence of undercutting
Area extent: _____ Depth: _____
Remarks: _____

5. **Obstructions** Type: _____ ☐ No obstructions
☐ Location shown on-Site map Area extent: _____
Size: _____
Remarks: _____

6. **Excessive Vegetative Growth** Type: _____
☐ No evidence of excessive growth
☐ Vegetation in channels does not obstruct flow
☐ Location shown on-Site map Area extent: _____
Remarks: _____

D. Cover Penetrations ☒ Applicable ☐ N/A

1. **Gas Vents** ☒ Active ☐ Passive
☐ Properly secured/locked ☒ Functioning ☒ Routinely sampled ☒ Good condition
☐ Evidence of leakage at penetration ☐ Needs maintenance ☐ N/A
Remarks: Locked wellhead vaults with buried wellheads being replaced with above-groundwater wellheads that are not locked.

2. **Gas Monitoring Probes**
☐ Properly secured/locked ☐ Functioning ☐ Routinely sampled ☐ Good condition
☐ Evidence of leakage at penetration ☐ Needs maintenance ☒ N/A
Remarks: _____

3. **Monitoring Wells** (within surface area of landfill)
☒ Properly secured/locked ☒ Functioning ☒ Routinely sampled ☒ Good condition
☐ Evidence of leakage at penetration ☐ Needs maintenance ☐ N/A
Remarks: _____

4. **Extraction Wells Leachate**
☐ Properly secured/locked ☐ Functioning ☐ Routinely sampled ☐ Good condition

☐ Evidence of leakage at penetration ☐ Needs maintenance ☒ N/A

Remarks: _____

5. **Settlement Monuments** ☐ Located ☐ Routinely surveyed ☒ N/A

Remarks: _____

E. Gas Collection and Treatment ☒ Applicable ☐ N/A

1. **Gas Treatment Facilities**

☒ Flaring ☒ Thermal destruction ☒ Collection for reuse

☒ Good condition ☐ Needs maintenance

Remarks: _____

2. **Gas Collection Wells, Manifolds and Piping**

☒ Good condition ☐ Needs maintenance

Remarks: _____

3. **Gas Monitoring Facilities** (e.g., gas monitoring of adjacent homes or buildings)

☐ Good condition ☐ Needs maintenance ☒ N/A

Remarks: _____

F. Cover Drainage Layer ☐ Applicable ☒ N/A

1. **Outlet Pipes Inspected** ☐ Functioning ☐ N/A

Remarks: _____

2. **Outlet Rock Inspected** ☐ Functioning ☐ N/A

Remarks: _____

G. Detention/Sedimentation Ponds ☐ Applicable ☒ N/A

1. **Siltation** Area extent: _____ Depth: _____ ☐ N/A

☐ Siltation not evident

Remarks: _____

2. **Erosion** Area extent: _____ Depth: _____

☐ Erosion not evident

Remarks: _____

3. **Outlet Works** ☐ Functioning ☐ N/A

Remarks: _____

4. **Dam** ☐ Functioning ☐ N/A

Remarks: _____

H. Retaining Walls ☐ Applicable ☒ N/A

1. **Deformations** ☐ Location shown on-Site map ☐ Deformation not evident

Horizontal displacement: _____ Vertical displacement: _____

Rotational displacement: _____

Remarks: _____

2. **Degradation** ☐ Location shown on-Site map ☐ Degradation not evident

Remarks: _____

I. Perimeter Ditches/Off-Site Discharge ☒ Applicable ☐ N/A

1. **Siltation** ☐ Location shown on-Site map ☒ Siltation not evident

Area extent: _____ Depth: _____

Remarks: _____

2. **Vegetative Growth** ☐ Location shown on-Site map ☐ N/A

☒ Vegetation does not impede flow

Area extent: _____ Type: _____

Remarks: _____

3. **Erosion** ☐ Location shown on-Site map ☒ Erosion not evident

Area extent: _____ Depth: _____

Remarks: _____

4. **Discharge Structure** ☐ Functioning ☒ N/A

Remarks: _____

VIII. VERTICAL BARRIER WALLS ☒ Applicable ☐ N/A

1. **Settlement** ☐ Location shown on-Site map ☒ Settlement not evident

Area extent: _____ Depth: _____

Remarks: _____

2. **Performance Monitoring** Type of monitoring: Head differential

☐ Performance not monitored

Frequency: Quarterly ☐ Evidence of breaching

Head differential: _____

Remarks: Applies to NBBW, NTES, Barrier/Slurry Wall, Voluntary Extraction Systems

IX. GROUNDWATER/SURFACE WATER REMEDIES ☒ Applicable ☐ N/A

A. Groundwater Extraction Wells, Pumps and Pipelines ☒ Applicable ☐ N/A

1. **Pumps, Wellhead Plumbing and Electrical**

☒ Good condition ☒ All required wells properly operating ☐ Needs maintenance ☐ N/A

Remarks: _____

2. **Extraction System Pipelines, Valves, Valve Boxes and Other Appurtenances**

☒ Good condition ☐ Needs maintenance

Remarks: _____

3. **Spare Parts and Equipment**

☒ Readily available ☒ Good condition ☐ Requires upgrade ☐ Needs to be provided

Remarks: _____

B. Surface Water Collection Structures, Pumps and Pipelines ☐ Applicable ☒ N/A

1. **Collection Structures, Pumps and Electrical**

☐ Good condition ☐ Needs maintenance

Remarks: _____

2. **Surface Water Collection System Pipelines, Valves, Valve Boxes and Other Appurtenances**

☐ Good condition ☐ Needs maintenance

Remarks: _____

3. **Spare Parts and Equipment**

☐ Readily available ☐ Good condition ☐ Requires upgrade ☐ Needs to be provided

Remarks: _____

C. Treatment System ☒ Applicable ☐ N/A

1. **Treatment Train** (check components that apply)

☒ Metals removal ☐ Oil/water separation ☒ Bioremediation

☐ Air stripping ☒ Carbon adsorbers

☒ Filters: _____

☒ Additive (e.g., chelation agent, flocculent): _____

☒ Others: UV/Oxidation

☒ Good condition ☐ Needs maintenance

☒ Sampling ports properly marked and functional

☒ Sampling/maintenance log displayed and up to date

☒ Equipment properly identified

☒ Quantity of groundwater treated annually: 30 gpm

☐ Quantity of surface water treated annually: _____

Remarks: _____

2. **Electrical Enclosures and Panels** (properly rated and functional)

☐ N/A ☒ Good condition ☐ Needs maintenance

Remarks: _____

3. **Tanks, Vaults, Storage Vessels**

☐ N/A ☒ Good condition ☒ Proper secondary containment ☐ Needs maintenance

Remarks: _____

4. **Discharge Structure and Appurtenances**

☐ N/A ☒ Good condition ☐ Needs maintenance

Remarks: _____

5. **Treatment Building(s)**

☐ N/A ☒ Good condition (esp. roof and doorways) ☐ Needs repair

☐ Chemicals and equipment properly stored

Remarks: _____

6. **Monitoring Wells** (pump and treatment remedy)

☒ Properly secured/locked ☒ Functioning ☒ Routinely sampled ☒ Good condition

☐ All required wells located ☐ Needs maintenance ☐ N/A

Remarks: _____

D. Monitoring Data

1. **Monitoring Data**

☒ Is routinely submitted on time ☒ Is of acceptable quality

2. **Monitoring Data Suggests:**

☐ Groundwater plume is effectively contained ☐ Contaminant concentrations are declining

E. Monitored Natural Attenuation

1. **Monitoring Wells** (natural attenuation remedy)

☐ Properly secured/locked ☐ Functioning ☐ Routinely sampled ☐ Good condition

☐ All required wells located ☐ Needs maintenance ☐ N/A

Remarks: _____

X. OTHER REMEDIES

If there are remedies applied at the site and not covered above, attach an inspection sheet describing the physical nature and condition of any facility associated with the remedy. An example would be soil vapor extraction.

XI. OVERALL OBSERVATIONS

A. Implementation of the Remedy

Describe issues and observations relating to whether the remedy is effective and functioning as designed. Begin with a brief statement of what the remedy is designed to accomplish (e.g., to contain contaminant plume, minimize infiltration and gas emissions).

The final selected remedy utilized containment, collection, treatment and monitoring to address contamination at the Site. Contamination is mostly contained on-Site with the exception of the North End 1,4-dioxane plume, which extends off-Site to the north. The capacity of the WTP is limited. During high precipitation events, multiple extraction systems are shut off to accommodate additional water from the NBBW and NTES.

B. Adequacy of O&M

Describe issues and observations related to the implementation and scope of O&M procedures. In particular, discuss their relationship to the current and long-term protectiveness of the remedy.

O&M procedures are adequate.

C. Early Indicators of Potential Remedy Problems

Describe issues and observations such as unexpected changes in the cost or scope of O&M or a high frequency of unscheduled repairs that suggest that the protectiveness of the remedy may be compromised in the future.

There are no early indicators of potential remedy problems.

D. Opportunities for Optimization

Describe possible opportunities for optimization in monitoring tasks or the operation of the remedy.

The WTP has limited capacity, which results in some systems not pumping. Operation involves two treatment trains – BTS and GAC. Updating the WTP to streamline the operation and allow for all extraction systems to run may be appropriate. Currently, potable water is being injected downgradient of the NBBW. Potable water injection could potentially interfere with the interpretation of water chemistry data in areas near injection points and because of the volume of water that has been injected, may have increased the volume and mobility of the 1,4-dioxane plume. As a result, EPA will conduct an optimization study of the groundwater containment remedy and discontinue potable water injections. Once potable water injection is discontinued, then a study of changes in water levels, capture zones and water chemistry shall be conducted.

APPENDIX E – PRESS NOTICE

Lowry Landfill Superfund Site

The U.S. Environmental Protection Agency and the Colorado Department of Public Health and Environment Announce the Fourth Five-Year Review

Colorado Department of Public Health and Environment

The U.S. Environmental Protection Agency (EPA) is conducting a Five-Year Review of the remedy for the Lowry Landfill Superfund site (the Site) in Araphahoe, Colorado. The purpose of the Five-Year Review is to make sure that selected cleanup actions effectively protect human health and the environment. The site's long-term remedy, selected in 1994, uses containment, collection, treatment and monitoring to address the contamination. Remedy construction began in 1996 and finished in 2006. Operation and maintenance activities and monitoring are ongoing. The National Contingency Plan requires review of remedial actions that result in any hazardous substances, pollutants or contaminants remaining at the Site above levels that allow for unlimited use and unrestricted exposure every five years to ensure the protection. This is the fourth Five-Year Review for the Site. It will be completed by September 2017.

As part of the Five-Year Review process, EPA staff members are available to answer any questions about the Site. Community members who have questions about the Site or the Five-Year Review process, or who would like to participate in a community interview, are asked to contact or attend an open house on October 27th from 5-7 PM at the Aurora Municipal Center.

Leslie Sims, Remedial Project Manager
Phone: 303-312-6224
Email: sims.leslie@epa.gov

Mailing Address:
U.S. EPA Region 8 (EPR-SR)
1595 Wynkoop Street
Denver, CO 80202-1129

Katherine Jenkins, Community Involvement Coordinator
Phone: 303-312-6351
Email: jenkins.katherine@epa.gov

On October 27, 2016 from 5-7 PM, EPA staff members will also be hosting an open house to conduct in-person interviews at the Aurora Municipal Center (15151 E Alameda Pkwy, Aurora, CO 80012).

Site information is also available at Aurora Central Library (14949 East Alameda Parkway, Aurora, Colorado 80012) and EPA's Superfund Records Center (1595 Wynkoop Street, Denver, Colorado 80202-1129), and online at https://cumulis.epa.gov/supercpad/cursites/csitinfo.cfm?id=0800186&msspp=med.

APPENDIX F – SITE INSPECTION PHOTOS

Water treatment plant

Unnamed Creek looking north

Outside slurry wall wells at PM15 cluster looking east

Landfill from North Waste Pit Area looking south

NTES Area looking east

Above-ground gas well

MW38 area looking north

NBBW area looking west

Generators at GTEP

North End extraction wells looking north

Wetland area looking northeast

Asbestos disposal area, northeast of landfill cover

APPENDIX G – DETAILED GROUNDWATER ARARs REVIEW TABLE

Table G-1: Groundwater ARARs Review

Analyte	Performance Standard based on Minor Modification (dated 9/30/02) to ROD (dated 3/10/94)	2016 MCLs[a]	Current Colorado Basic Standard for Groundwater[b]	Current Performance Standard[c]		Units
				Value	Basis	
1,1,1-Trichloroethane	200	200	14,000 or 200	200	MCL	µg/L
1,1,2,2-Tetrachloroethane	0.055	NA	0.18	1	Reporting Limit	µg/L
1,1,2-Trichloroethane	3	5	2.8 – 5[d]	5	MCL	µg/L
1,1-Dichloroethane	990	NA	NA	990	noncarcinogenic risk-based	µg/L
1,1-Dichloroethene	7	7	7	7	MCL	µg/L
1,2,4,5-Tetrachlorobenzene	2	NA	2.1	10	Reporting Limit	µg/L
1,2,4-Trichlorobenzene	70	70	70	70	MCL	µg/L
1,2-Dibromo-3-chloropropane	0.2	0.2	0.2	2	Reporting Limit	µg/L
1,2-Dibromoethane	0.05	NA	0.018	1	Reporting Limit	µg/L
1,2-Dichlorobenzene	600	600	600	600	MCL	µg/L
1,2-Dichloroethane	0.4	5	0.38 – 5[d]	5	MCL	µg/L
1,2-Dichloropropane	0.56	5	0.52 – 5[d]	5	MCL	µg/L
1,2-Diphenylhydrazine	0.05	NA	0.044	10	Reporting Limit	µg/L
1,3-Dichlorobenzene	620	NA	94	94	CO GW Std	µg/L
1,4-Dichlorobenzene	75	75	75	75	MCL	µg/L
1,4-Dioxane	8	NA	0.35	0.9	PQL	µg/L
2,3,7,8-Tetrachlorodibenzodioxin	0.00000022	0.00003	0.00000022 – 0.00003[d]	0.00001	Reporting Limit	µg/L
2,4,5-TP	50	50	50	50	MCL	µg/L
2,4,6-Trichlorophenol	2	NA	3.2	10	Reporting Limit	µg/L
2,4-Dichlorophenoxyacetic acid	70	70	70	70	MCL	µg/L
2,4-Dichlorophenol	21	NA	21	21	CO GW Std	µg/L
2,4-Dinitrophenol	14	NA	14	50	Reporting Limit	µg/L
2-Butanone	1,904	NA	NA	1,904	non-carcinogenic risk based	µg/L

Analyte	Performance Standard based on Minor Modification (dated 9/30/02) to ROD (dated 3/10/94)	2016 MCLs[a]	Current Colorado Basic Standard for Groundwater[b]	Current Performance Standard[c]		Units
				Value	Basis	
2-Chlorophenol	0.1	NA	35	35	CO GW Std	µg/L
2-Methylnaphthalene	0.0031	NA	NA	10	Reporting Limit	µg/L
4,4'-DDE	0.1	NA	0.1	0.1	CO GW Std	µg/L
4,4'-DDT	0.1	NA	0.1	0.1	CO GW Std	µg/L
4-Methyl-2-pentanone (MIBK)	158	NA	NA	158	non-carcinogenic risk based	µg/L
Acetone	1,600	NA	6,300	1,600	NA	µg/L
Alachlor	2	2	2	2	MCL	µg/L
Aldicarb	3	NA	7	7	CO GW Std	µg/L
Aldicarb Sulfone	2	NA	7	7	CO GW Std	µg/L
Aldicarb Sulfoxide	4	NA	7	7	CO GW Std	µg/L
Aldrin	0.002	NA	0.0021	0.05	Reporting Limit	µg/L
Alpha - BHC	0.006	NA	0.0056	0.05	Reporting Limit	µg/L
Alpha, Gross	15	NA	15	55.4	Background	pCi/L
Aluminum	5,000	200	5,000	5,000	CO Agri. Std	µg/L
Americium-241	0.46	NA	0.15	0.15	CO GW Std	pCi/L
Antimony	6	6	6	770	Background	µg/L
Aroclor 1260	0.005	0.5	0.0175 – 0.5[d]	1	Reporting Limit	µg/L
Arsenic	50	10	10	52.18	Background	µg/L
Asbestos	30,000	7,000,000	7,000,000	7,000,000	MCL	fibers/L
Atrazine	3	3	3	3	MCL	µg/L
Barium	1,000	2,000	2,000	2,000	MCL	µg/L
Benzene	5	5	5	5	MCL	µg/L
Benzidine	0.0002	NA	0.00015	100	Reporting Limit	µg/L
Benzo(a)anthracene	0.1	NA	0.0048	10	Reporting Limit	µg/L
Benzo(a)pyrene	0.01	0.2	0.0048 – 0.2	10	Reporting Limit	µg/L
Beryllium	4	4	4	5	Reporting Limit	µg/L
Beta, Gross	80	4 millirem per year = 80 pCi/L (site-specific)	4 millirem per year = 80 pCi/L (site-specific)	80	MCL	pCi/L
Bis(2-Chloroethyl)Ether	0.03	NA	0.032	10	Reporting Limit	µg/L

Analyte	Performance Standard based on Minor Modification (dated 9/30/02) to ROD (dated 3/10/94)	2016 MCLs[a]	Current Colorado Basic Standard for Groundwater[b]	Current Performance Standard[c]		Units
				Value	Basis	
Bis(2-Ethylhexyl)adipate	400	400	400	400	MCL	µg/L
Bis(2-Ethylhexyl)phthalate	4.8	6	2.5 – 6[d]	10	Reporting Limit	µg/L
Boron	750	NA	750	750	CO Agri Std	µg/L
Bromodichloromethane	0.3	NA	0.56	1	Reporting Limit	µg/L
Bromoform	4	NA	4	4	CO GW Std	µg/L
Cadmium	5	5	5	5.48	Background	µg/L
Carbofuran	36	40	35 – 40[d]	40	MCL	µg/L
Carbon Tetrachloride	0.3	5	0.5 – 5[d]	5	MCL	µg/L
Cesium-134	80	NA	80	80	CO GW Std	pCi/L
Chlordane	0.03	2	0.10 – 2[d]	2	MCL	µg/L
Chloride	250,000	250,000	250,000	1,000,000	Background	µg/L
Chlorobenzene	100	100	100	100	MCL	µg/L
Chloroform	6	NA	3.5	3.5	CO GW Std	µg/L
Chromium	50	100	100	100	MCL	µg/L
Chromium (hexavalent)	50	NA	NA	83.47	Background	µg/L
cis-1,2-Dichloroethene	70	70	14 – 70[d]	70	MCL	µg/L
Cobalt	50	NA	50	50	CO Agri Std	µg/L
Coliform (total)/ 100 ml	1	TT	2.2	TT	CO GW Std	%
Color, color units	15	15	15	15	CO GW Std	color units
Copper	200	1,000 (drinking water) & 1,300 (action level)	200	200	CO Agri Std	µg/L
Corrosivity	non-corrosive	non-corrosive	non-corrosive	non-corrosive	CO GW Std	µg/L
Cyanide	200	200	200	200	MCL	µg/L
Dalapon	200	200	200	200	MCL	µg/L
Di(2-ethylhexyl)adipate	400	400	400	400	MCL	µg/L
Dibromochloromethane	0.42	NA	14	14	CO GW Std	µg/L
Dieldrin	0.002	NA	0.002	0.05	Reporting Limit	µg/L
Dinoseb	7	7	7	7	MCL	µg/L
Diquat	20	20	15 – 20[d]	20	MCL	µg/L

Analyte	Performance Standard based on Minor Modification (dated 9/30/02) to ROD (dated 3/10/94)	2016 MCLs[a]	Current Colorado Basic Standard for Groundwater[b]	Current Performance Standard[c]		Units
				Value	Basis	
Endothall	100	100	100	100	MCL	µg/L
Endrin	0.2	2	2	2	MCL	µg/L
Endrin Aldehyde	0.2	NA	2.1	2.1	CO GW Std	µg/L
Ethylbenzene	680	700	700	700	MCL	µg/L
Fluoranthene	188	NA	280	280	CO GW Std	µg/L
Fluoride	2,000	4,000	4,000	50,000	Background	µg/L
Foaming Agents	500	500	500	500	CO DW Std	µg/L
Gamma - BHC	0.2	NA	0.2	0.2	MCL	µg/L
Glyphosate	700	700	700	700	MCL	µg/L
Heptachlor	0.008	0.4	0.008 – 0.4[d]	0.4	MCL	µg/L
Heptachlor Epoxide	0.004	0.2	0.004 – 0.2[d]	0.2	MCL	µg/L
Hexachlorobenzene	1	1	0.022-1.0[d]	10	Reporting Limit	µg/L
Hexachlorobutadiene	1	NA	0.45	1	Reporting Limit	µg/L
Hexachlorocyclopentadiene	50	50	42 – 50[d]	50	MCL	µg/L
Iron	300	300	300	2060.4	Background	µg/L
Isophorone	40	NA	140	140	CO GW Std	µg/L
Lead	15	15	50	50	CO GW Std	µg/L
Lead-210	0.037	NA	NA	0.037	carcinogenic risk	pCi/L
Malathion	2,500	NA	140	140	CO GW Std	µg/L
Manganese	50	50	50	1,620	Background	µg/L
Mercury	2	2	2	2	MCL	µg/L
Methoxychlor	40	40	35 – 40[d]	40	MCL	µg/L
Methylene chloride	5	5	5.6 or 5[d]	5	MCL	µg/L
Naphthalene	6.2	NA	140	140	CO GW Std	µg/L
Nickel	2	NA	100	100	CO GW Std	µg/L
Nitrobenzene	3.5	NA	14	10	Reporting Limit	µg/L
Nitrogen, Nitrate	10,000	10,000	10,000	28,000	Background	µg/L
Nitrogen, Nitrate plus Nitrite	10,000	NA	10,000	34,000	Background	µg/L
Nitrogen, Nitrite	1,000	1,000	1,000	1,000	MCL	µg/L
Oxamyl	200	200	175 – 200[d]	200	MCL	µg/L

Analyte	Performance Standard based on Minor Modification (dated 9/30/02) to ROD (dated 3/10/94)	2016 MCLs[a]	Current Colorado Basic Standard for Groundwater[b]	Current Performance Standard[c]		Units
				Value	Basis	
Pentachlorobenzene	6	NA	5.6	10	Reporting Limit	µg/L
Pentachlorophenol	1	1	0.088-1.0[d]	50	Reporting Limit	µg/L
pH	6.5 – 8.5	6.5 – 8.5	6.5 – 8.5	6.5 – 8.5	CO DW Std	µg/L
Phenanthrene	0.0031	NA	NA	10	Reporting Limit	µg/L
Phenol	300	NA	2,100	300	CO GW Std	µg/L
Picloram	500	500	490	500	MCL	µg/L
Plutonium-238	0.15	NA	0.15	0.15	CO GW Std	pCi/L
Plutonium-239	0.15	NA	0.15	0.15	CO GW Std	pCi/L
Plutonium-239/240	0.15	NA	0.15	0.15	CO GW Std	pCi/L
Plutonium-240	0.15	NA	0.15	0.15	CO GW Std	pCi/L
Potassium-40	1.9	NA	NA	1.9	carcinogenic risk	pCi/L
Radium-226	5	NA	5	5	CO GW Std	pCi/L
Radium-226/228	5	5	5	5	MCL	pCi/L
Radium-228	5	NA	5	5	CO GW Std	pCi/L
Selenium	10	50	50	371.98	Background	µg/L
Silver	50	100	50	50	CO GW Std	µg/L
Simazine	4	4	4	4	MCL	µg/L
Strontium-90	8	NA	8	8	CO GW Std	pCi/L
Styrene	100	100	100	100	MCL	µg/L
Sulfate	250,000	250,000	250,000	2,400,000	Background	µg/L
Tetrachloroethene	5	5	17 or 5[d]	5	MCL	µg/L
Thallium	2	2	2	10	Reporting Limit	µg/L
Thorium-228	0.16	NA	NA	0.16	carcinogenic risk	pCi/L
Thorium-230 + 232	60	NA	60	60	CO GW Std	pCi/L
Toluene	1,000	1,000	560 – 1,000[d]	1,000	MCL	µg/L
Toxaphene	0.03	3	0.032 – 3[d]	5	Reporting Limit	µg/L
trans-1,2-Dichloroethene	100	100	140 or 100[d]	100	MCL	µg/L
trans-1,3-Dichloropropene	87	NA	NA	87	--	µg/L
Trichloroethene	5	5	5	5	MCL	µg/L
Tritium	20,000	NA	20,000	20,000	CO GW Std	pCi/L

Analyte	Performance Standard based on Minor Modification (dated 9/30/02) to ROD (dated 3/10/94)	2016 MCLs[a]	Current Colorado Basic Standard for Groundwater[b]	Current Performance Standard[c]		Units
				Value	Basis	
Uranium-234	30	30	16.8 – 30[d]	30	MCL	pCi/L
Uranium-235	30	30	16.8 – 30[d]	30	MCL	pCi/L
Uranium-238	30	30	16.8 – 30[d]	30	MCL	pCi/L
Vanadium	100	NA	100	100	CO Agri Std	µg/L
Vinyl chloride	2	2	0.023 – 2[d]	2	MCL	µg/L
Xylenes, Total	10,000	10,000	1,400 – 10,000[d]	10,000	MCL	µg/L
Zinc	2,000	5,000	2,000	2,000	CO Agri Std	µg/L

Notes:

a = EPA National Primary Drinking Water Regulations MCL: https://www.epa.gov/sites/production/files/2016-06/documents/npwdr_complete_table.pdf (accessed 11-30-2016)

b = CDPHE Water Quality Control Commission, Basic Standards for Groundwater: https://www.colorado.gov/pacific/sites/default/files/41_2016%2806%29hdr.pdf (accessed 12-29-2016)

c = Table 1, 2015 GWMP

d = Per CDPHE Water Quality Control Commission, Basic Standards for Groundwater: whenever a range of standards is listed and referenced to this footnote, the first number in the range is a strictly health-based value, based on the Commission's established methodology for human health-based standards. The second number in the range is a MCL, established under the federal Safe Drinking Water Act that has been determined to be an acceptable level of this chemical in public water supplies, taking treatability and laboratory detection limits into account. The Commission intends that control requirements for this chemical be implemented to attain a level of ambient water quality that is at least equal to the first number in the range except as follows:

- Where groundwater quality exceeds the first number in the range due to a release of contaminants that occurred prior to September 15, 2012, (regardless of the date of discovery or subsequent migration of such contaminants) cleanup levels for the entire contaminant plume shall be no more restrictive than the second number in the range or the groundwater quality resulting from such release, whichever is more protective.
- Wherever the Commission has adopted alternative, site-specific standards for the chemical, the site-specific standards shall apply instead of these statewide standards.

pCi/L = picoCuries per liter
µg/L = micrograms per liter
TT = treatment technique
CO GW std = Colorado groundwater standard
DW std = drinking water standard
Agri std = agricultural standard

Analyte	Performance Standard based on Minor Modification (dated 9/30/02) to ROD (dated 3/10/94)	2016 MCLs[a]	Current Colorado Basic Standard for Groundwater[b]	Current Performance Standard[c]		Units
				Value	Basis	
NA = Standard not available -- = basis not identified						

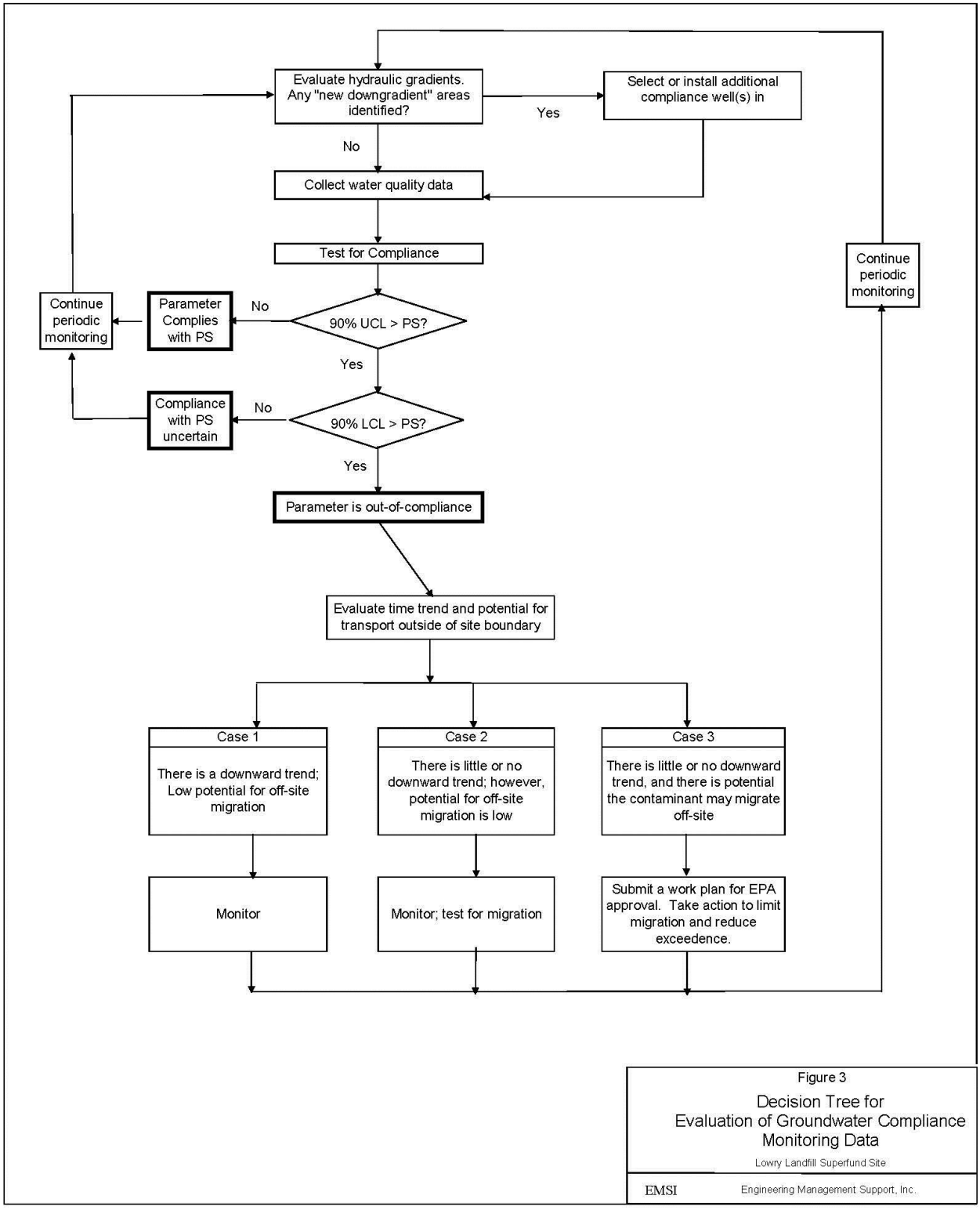
APPENDIX H – DETAILED DATA ANALYSIS

OU1 – Shallow Groundwater and Subsurface Liquids

Evaluation of Compliance with Performance Standards

There are 60 wells in the compliance monitoring network. Wells are located along the POC boundary (Figure C-3 and Figure C-4 in Appendix C). Compliance is assessed by comparing the long-term average concentration (90 percent upper confidence limit) for each COC at each location to the respective performance standard. Additional details on the procedures used to calculate the 90 percent upper confidence limit is provided in Appendix C of the GWMP. The compliance evaluation includes a requirement for contingency measures in cases where performance standards are not met and there is potential for off-Site migration (referred to as Case 3 condition). The decision tree for performing compliance evaluations is illustrated in Figure H-1.

Figure H-1: Compliance Evaluation Decision Tree



EPA established performance standards in the 1994 ROD and the 2002 minor modification to the ROD. In accordance with the 2005 Consent Decree, the WSDs assess the PQL for each COC as compared to the groundwater performance standards. The PQL for 1,4-dioxane was updated from 5 to 0.9 µg/L in July 2015. As a result, some wells that were previously in compliance are now out of compliance.

Based on 2016 data and the statistical protocols outlined in the GWMP and the RA/O&M Status Report, there are 13 monitoring wells that contain one or more compliance parameters that exceed or potentially exceed the performance standard. The locations and parameters that exceeded or potentially exceed the performance standard are listed in Table H-2. Exceedances and parameters from 2011 and 2016 are shown in Figures H-2 and H-3. The status of these exceedances and their associated contingency measures are described below. Generally, the areas with out of compliance wells are the same since the previous FYR, however three additional wells now exceed respective performance standards (see Figures H-2 and H-3 below). Trends were assessed in accordance with the GWMP protocols.

Table H-1: Compliance/Performance Monitoring Water Quality Reduced Analyte List and Standards

Analyte	Current Performance Standard[a]		Units
	Value	Basis	
1,1,1-Trichloroethane	200	MCL	µg/L
1,1,2,2-Tetrachloroethane	1	Reporting Limit	µg/L
1,1,2-Trichloroethane	5	MCL	µg/L
1,1-Dichloroethane	990	noncarcinogenic risk-	µg/L
1,1-Dichloroethene	7	MCL	µg/L
1,2-Dichloroethane	5	MCL	µg/L
1,2-Dichloropropane	5	MCL	µg/L
1,4-Dioxane	0.9	PQL	µg/L
Acetone	1,600	NA	µg/L
Arsenic	52.18	Background	µg/L
Benzene	5	MCL	µg/L
Bromodichloromethane	1	Reporting Limit	µg/L
Bromoform	4	CO GW Std	µg/L
Cadmium	5.48	Background	µg/L
Carbon Tetrachloride	5	MCL	µg/L
Chlorobenzene	100	MCL	µg/L
Chloroform	3.5	CO GW Std	µg/L
cis-1,2-Dichloroethene	70	MCL	µg/L
Dibromochloromethane	14	CO GW Std	µg/L
Ethylbenzene	700	MCL	µg/L
Iron	2,060.4	Background	µg/L
Methylene chloride	5	MCL	µg/L
Naphthalene	140	CO GW Std	µg/L
Nitrogen, Nitrate	28,000	Background	µg/L
Nitrogen, Nitrite	1,000	MCL	µg/L
Tetrachloroethene	5	MCL	µg/L
Toluene	1,000	MCL	µg/L
trans-1,2-Dichloroethene	100	MCL	µg/L
Trichloroethene	5	MCL	µg/L
Vinyl chloride	2	MCL	µg/L

Notes:
a = Table 1, 2015 GWMP

Table H-2: Compliance Monitoring Evaluation (January through June 2016)

Well	COC	Compliance Decision	Trend[a]
NBBW			
B-313	1,4-Dioxane	Out of compliance	No Trend
	Nitrate	Out of compliance	No Trend
B-326-UD[b]	1,4-Dioxane	Out of compliance	Decreasing
B-326-WD[b]	1,4-Dioxane	Out of compliance	Increasing
GW-109[b]	1,4-Dioxane	Potentially out of compliance	Decreasing
MW62-WD	1,4-Dioxane	Potentially out of compliance	Increasing
	Nitrate	Out of compliance	No Trend
MW77-WD	1,4-Dioxane	Potentially out of compliance	Decreasing
	Nitrate	Out of compliance	No Trend
BM-15N6	Nitrate	Out of compliance	No Trend
POC Boundary			
MW106-UD	Iron	Out of compliance	No Trend
PM6X-UD	Iron	Out of compliance	Decreasing
MW90-UD	Iron	Out of compliance	No Trend
MW76-UD	Iron	Potentially out of compliance	Increasing
BM-11X-100N	TCE	Potentially out of compliance	No Trend
MW38 Channel			
MW38-830N-230E	1,4-Dioxane	Out of compliance	No Trend
	TCE	Out of compliance	No Trend
	Chloroform	Out of compliance	No Trend

Notes:

a. Trend determined by Mann-Kendall trend test analysis. When there is an increasing or decreasing trend, least squares regression analysis is used to determine the upper confidence limit and lower confidence limit.

b. Potentially impacted by potable water injections.

Source: Table 4.6, Remedial Action and Operations & Maintenance Status Report, September 2016.

Figure H-2: 2011 Groundwater Compliance

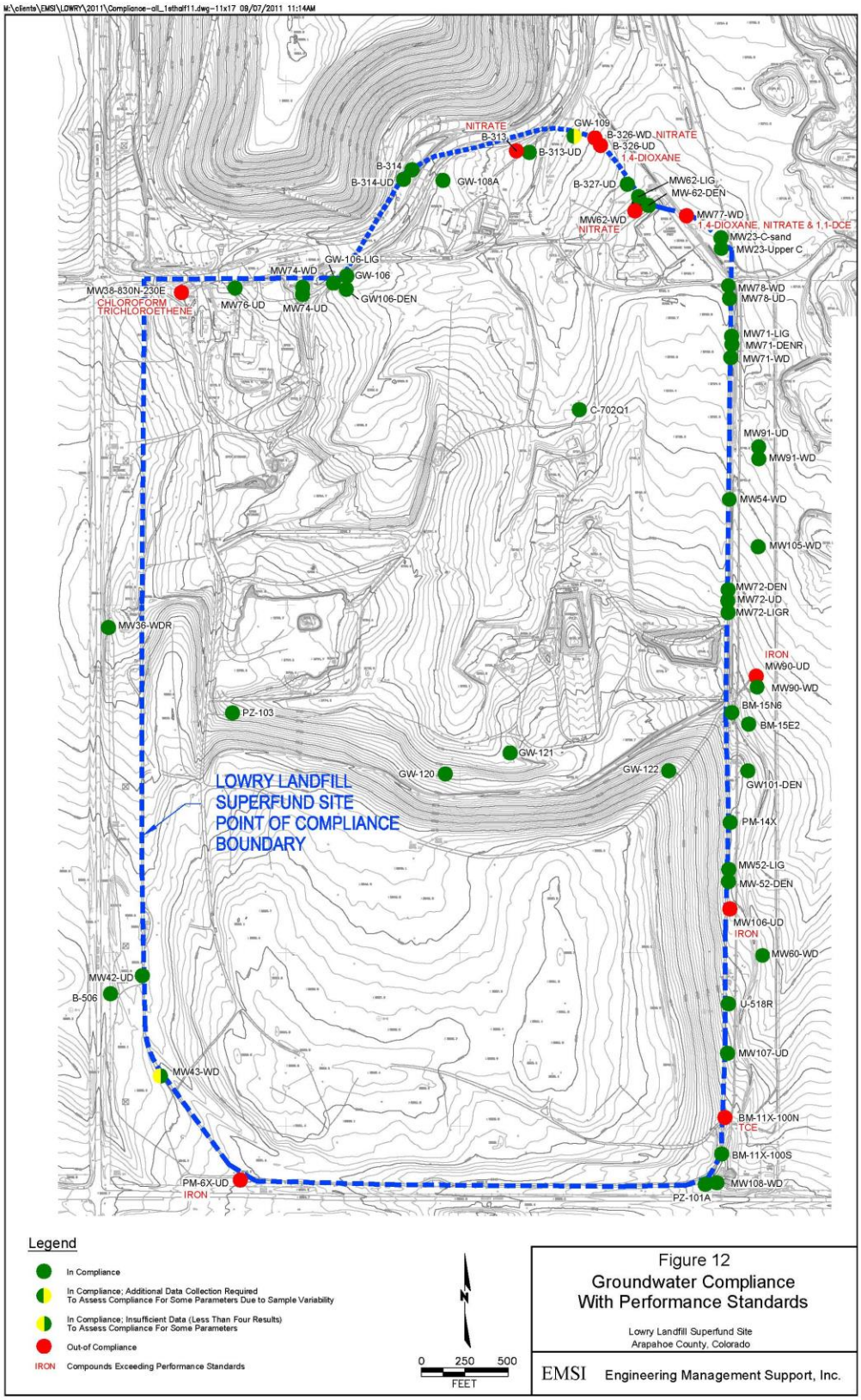
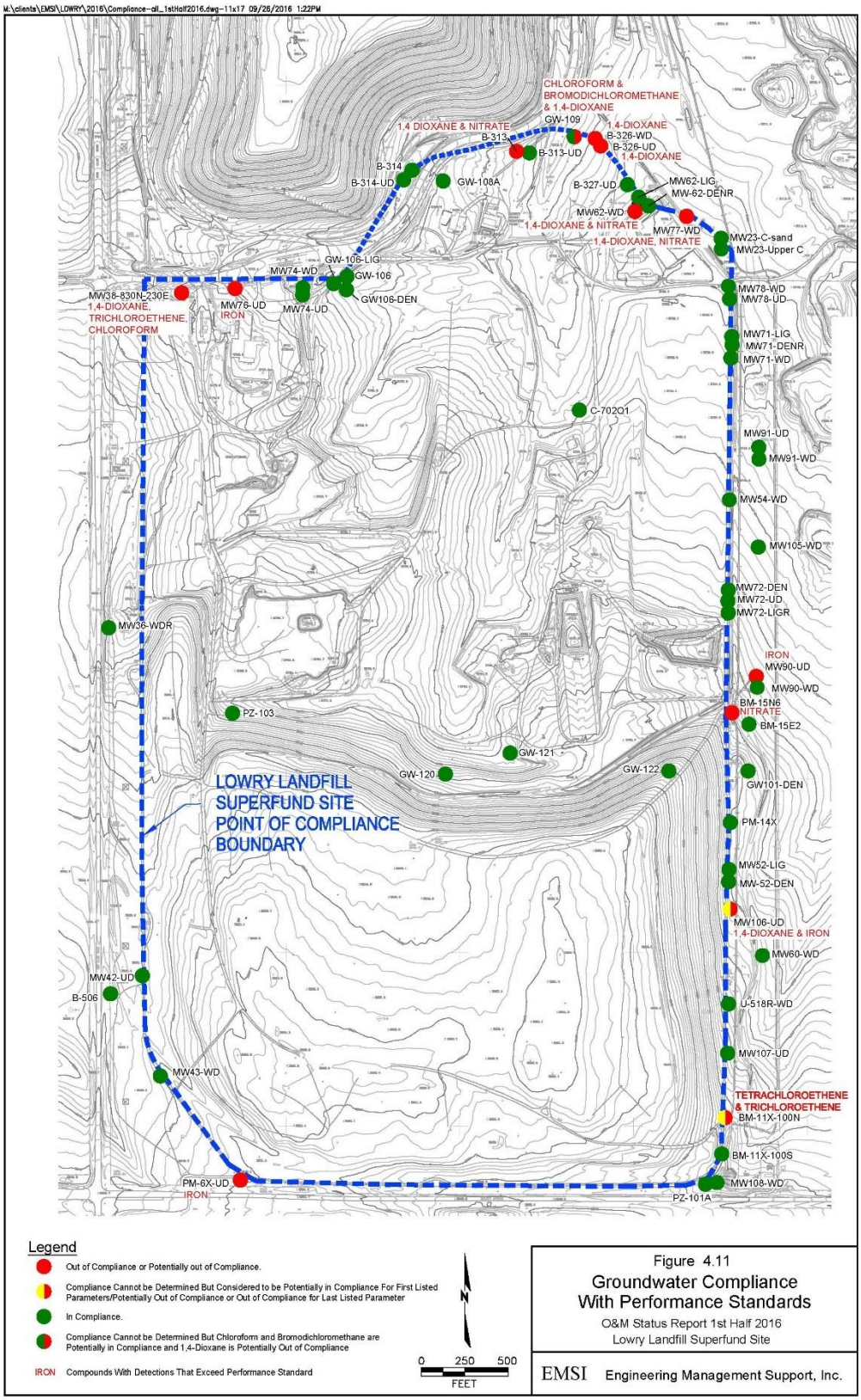


Figure H-3: 2016 Groundwater Compliance



NBBW Area

1,4-Dioxane and nitrate statistically exceed their performance standards in the NBBW area. Response actions to address the 1,4-dioxane exceedances are being implemented in this area in accordance with the following remedial action work plans:

- *Response Action Work Plan, B-326-UD and B-313 Areas* (EMSI 2013)
- *Response Action Work Plan to Extract Additional Groundwater from Upgradient of MW77-WD* (EMSI, 2011)

These Response Action Workplans include groundwater extraction from MW-113-EW-1, MW113-UD, MW170-EW-1 and B-321. Due to abnormally high precipitation in 2015 and the spring of 2016, extraction from these systems was reduced due to capacity limitations at the WTP, possibly resulting in increased concentrations and trends noted in Table H-2. The concentrations of 1,4-dioxane have decreased in all wells since the previous FYR (Table H-3). Continued pumping from the extraction wells and increased pumping from MW113-EW-1 and MW170-EW-1 was recommended in the 2016 RA/O&M Status Report. While concentrations are decreasing in these wells, results indicate concentrations are still three to 11 times the current PQL-based standard of 0.9 µg/L. The effectiveness of these response actions should be assessed.

Table H-3: Maximum 1,4-Dioxane Concentrations 2011-2016 in NBBW Area

Well	2011	2012	2013	2014	2015	2016
B-313	42	62	39	34	18	17
B-326-UD	34	26	21	8.4	6.2	6.9
B-326-WD	16	18	3.9 J	10	12	11
GW-109	15	12	2.5	5.1	1.8	2.1
MW62-WD*	14	7.8	NA	NA	4.9	4.3
MW77-WD	41	29	27	23	15	3.5

Notes:
*Well was abandoned and replaced by MW62-WDR in 2016.
All concentrations are shown as µg/L.
J = Estimated concentration
NA = not analyzed
Source: Appendix C-6.1, Remedial Action and Operations & Maintenance Status Report, September 2016.

Nitrate exceeds the performance standards in wells located along the northern boundary of the Site. Monitoring wells located north of the Site in Section 31 were sampled and analyzed as part of the North End Sampling Plan. There were no detections above the performance standards for nitrate. These results indicate that nitrate exceedances are limited to the central and eastern portion of the NBBW area. The groundwater extraction from the North End wells should capture any potential migration of nitrate from the NBBW area if northern migration were to occur.

BM-11X-100N

The average TCE concentration in well BM-11X-100N is 5.36 µg/L compared to the performance standard of 5 µg/L. The hydraulic gradient in this area is inward and there is no discernable trend in concentration. The WSDs previously completed an evaluation of this well and results indicated that is unlikely that TCE will migrate across the Site boundary and concentrations are likely to attenuate over time.

Table H-4: Maximum COC Concentrations 2011-2016 at BM-11X-100N

COC	Performance Standard	2011	2012	2013	2014	2015	2016
TCE	5	7.2	5.4	5.2	4.7	6.9	5.9

Notes:
All concentrations are shown as µg/L.
Source: Appendix C-3.1, Remedial Action and Operations & Maintenance Status Report, September 2016.

MW38 Channel

Concentrations of 1,4-dioxane, TCE and chloroform exceed their respective performance standards at MW38-830N-230E. Statistically, concentrations are stable, however, since 2015, concentrations have decreased. Extraction occurs at two locations, including a location approximately 200 feet north of MW38-830N-230E. The results represent concentrations within the sand channel, however the area is hydraulically contained.

Table H-5: Maximum COC Concentrations 2011-2016 at MW38-830N-230E

COC	Performance Standard	2011	2012	2013	2014	2015	2016
1,4-Dioxane	0.9	29	22	20	27	22	7.7
TCE	5	10	6.2	7.1	8.5	5.7	3.6
Chloroform	3.5	14	11	11	13	9.1	5

Notes:
All concentrations are shown as µg/L.
Source: Appendix C-3.1, Remedial Action and Operations & Maintenance Status Report, September 2016.

POC Iron Exceedances

Iron exceeds or potentially exceeds performance standards at four locations. Wells MW76-UD, MW90-UD and MW106-UD are located along the eastern, downgradient portion of the POC and well PM-6X-UD is located along the upgradient, southern boundary of the Site. Concentrations of other COCs in these wells are generally non-detect. Based on the lack of other source related contamination, iron in these wells may be naturally occurring. The performance standard for iron is based on background data from the weathered Dawson wells and may not be reflective of the background conditions in the unweathered Dawson formation. The WSDs will continue monitoring, recognizing that the groundwater performance standard for iron may not be applicable to the unweathered Dawson wells.

Containment Effectiveness

Containment effectiveness is monitored at the perimeter slurry wall, the NTES, the NBBW and the MW38 area.

Perimeter Slurry Wall

The effectiveness of the perimeter slurry wall is assessed by the presence of an inward hydraulic gradient across the slurry wall. In the event an outward hydraulic gradient is observed at a particular location along the wall, water quality data obtained from outside the wall are used to assess the effectiveness of the slurry wall at containing Site contaminants. The gradients are determined by reviewing water level measurements from weathered Dawson wells located in pairs inside and outside the slurry wall. Fifteen well pairs (PM-1 through PM-15) are used for this assessment. Table H-6 provides a summary of the results using the maximum head difference from 2014 to 2016. Figure H-4 shows the hydrographs for each well pair.

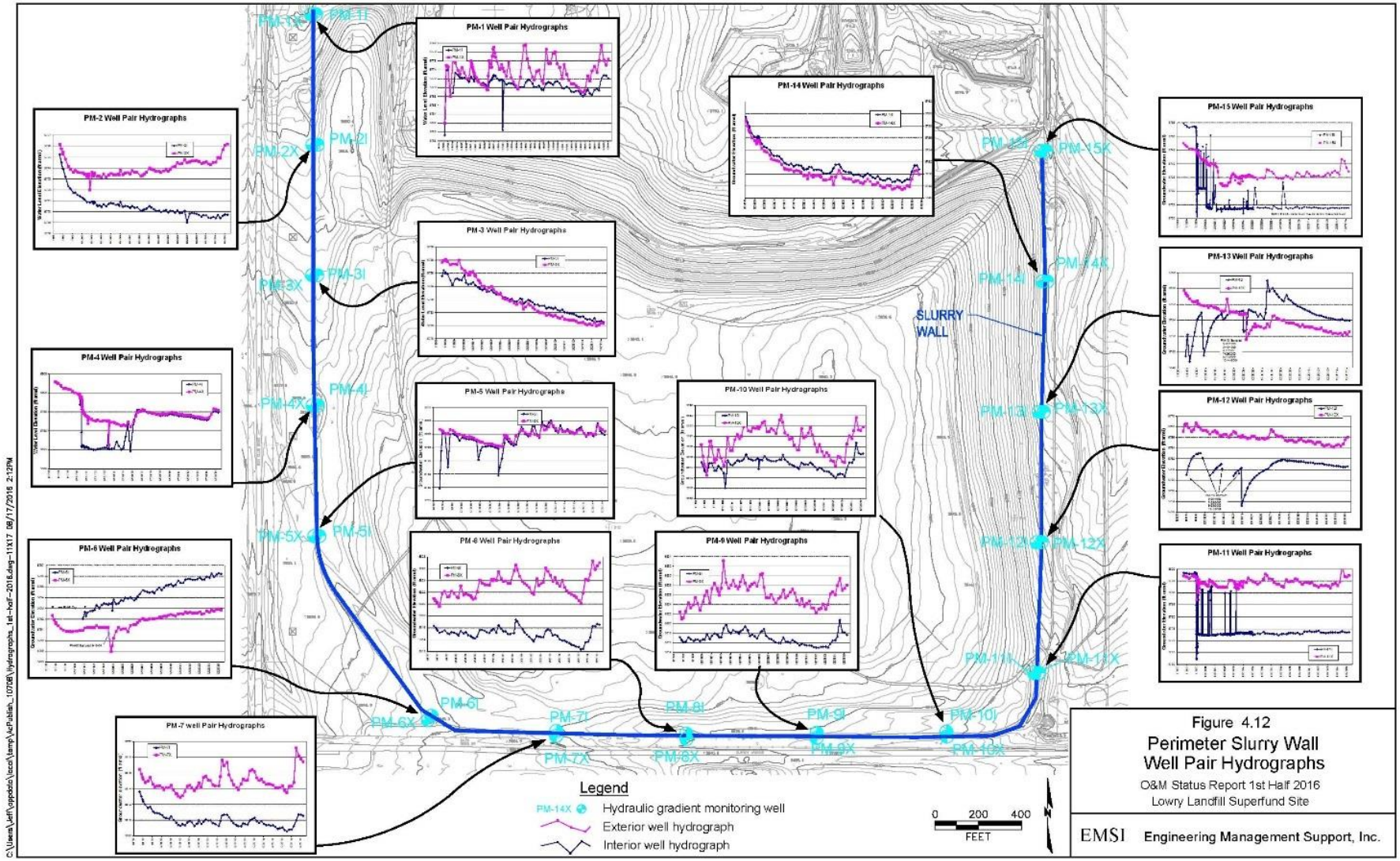
Table H-6: Summary of Slurry Wall Gradient Conclusions

Well Pair	Mean Head Difference (ft)	Gradient	Conclusion
PM-1	-4.831	Inward	Wall is effective
PM-2	-5.597	Inward	Wall is effective
PM-3	**0.574**	Outward	No exceedances, no increasing trends; wall is effective
PM-4	-0.45	Inward	Wall is effective
PM-5	-0.39	Inward	Wall is effective.
PM-6	**3.25**	Outward	No detections; wall is effective
PM-7	-6.53	Inward	Wall is effective
PM-8	-10.27	Inward	Wall is effective
PM-9	-9.72	Inward	Wall is effective
PM-10	-4.92	Inward	Wall is effective
PM-11	-22.41	Inward	Wall is effective
PM-12	-4.19	Inward	Wall is effective
PM-13	**1.72**	Outward	No exceedances, no increasing trends; wall is effective
PM-14	**1.05**	Outward	No exceedances, no increasing trends; wall is effective
PM-15	-14.36	Inward	Wall is effective

Notes:
Bold = Outward gradient exists
Source: Table 4.8, Remedial Action and Operations & Maintenance Status Report, September 2016.

When the water level data indicate the presence of an outward gradient, the effectiveness of the slurry wall is assessed using water quality data for four indicator VOCs (1,1,1-trichloroethane, 1,1-dichloroethane, TCE and PCE) from the wells outside of the slurry wall. The presence of no trend or a decreasing trend indicates the slurry wall is effective, while the presence of an increasing trend indicates the slurry wall may not be effectively containing Site contaminants. Based on the procedure to assess effectiveness, the slurry wall is effective at all well pairs.

Figure H-4: Perimeter Slurry Wall Well Pair Hydrographs



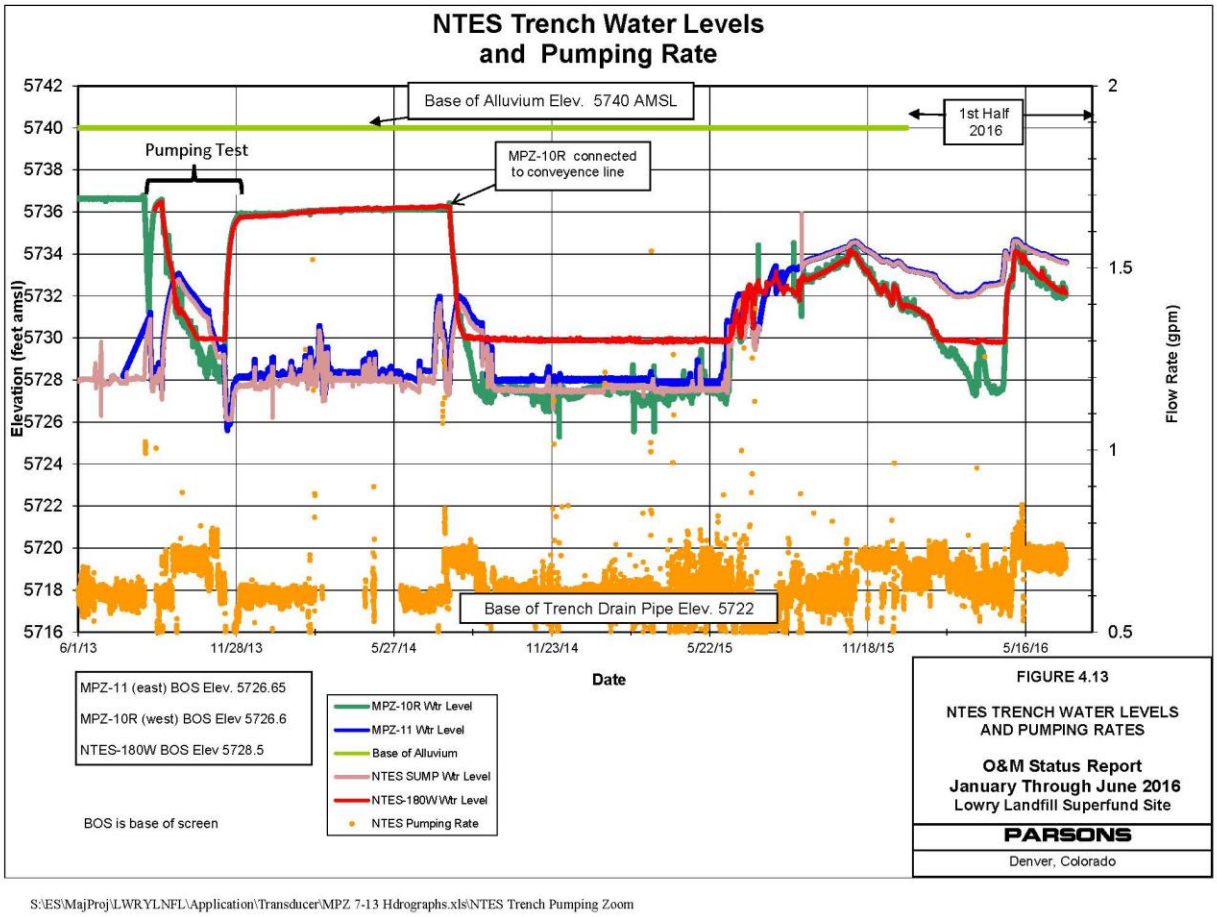
NTES

Effectiveness of the NTES is demonstrated based on hydraulic monitoring alone if either of the following conditions occurs:

- Pumping from the NTES results in continuous decline of trench water levels based on hydrographs for MPZ-10R, NTES-180W and MPZ-11, or
- Trench water levels at MPZ-10R, NTES-180W and MPZ-11 remain below the base of alluvium (elevation of 5,740 above mean sea level).

Figure H-5 shows the water level data from these wells and the extraction sump. The results indicate that trench water levels remained below the base of the alluvium through the reporting period. Therefore, the NTES is effective at capturing contaminated groundwater emanating from the toe of the landfill.

Figure H-5: NTES Trench Water Levels



S:\ES\MajProj\LWRYLNFL\Application\Transducer\MPZ 7-13 Hdrographs.xls\NTES Trench Pumping Zoom

NBBW

The containment area created by the NBBW systems is defined by the weathered Dawson potentiometric surface in the NBBW area. Water level measurements are collected quarterly from all monitoring wells and potentiometric maps are created for the weathered and unweathered Dawson. The most recent potentiometric maps are provided in Figure H-6 and H-7.

Figure H-6: Weathered Dawson Potentiometric Map – April 2016

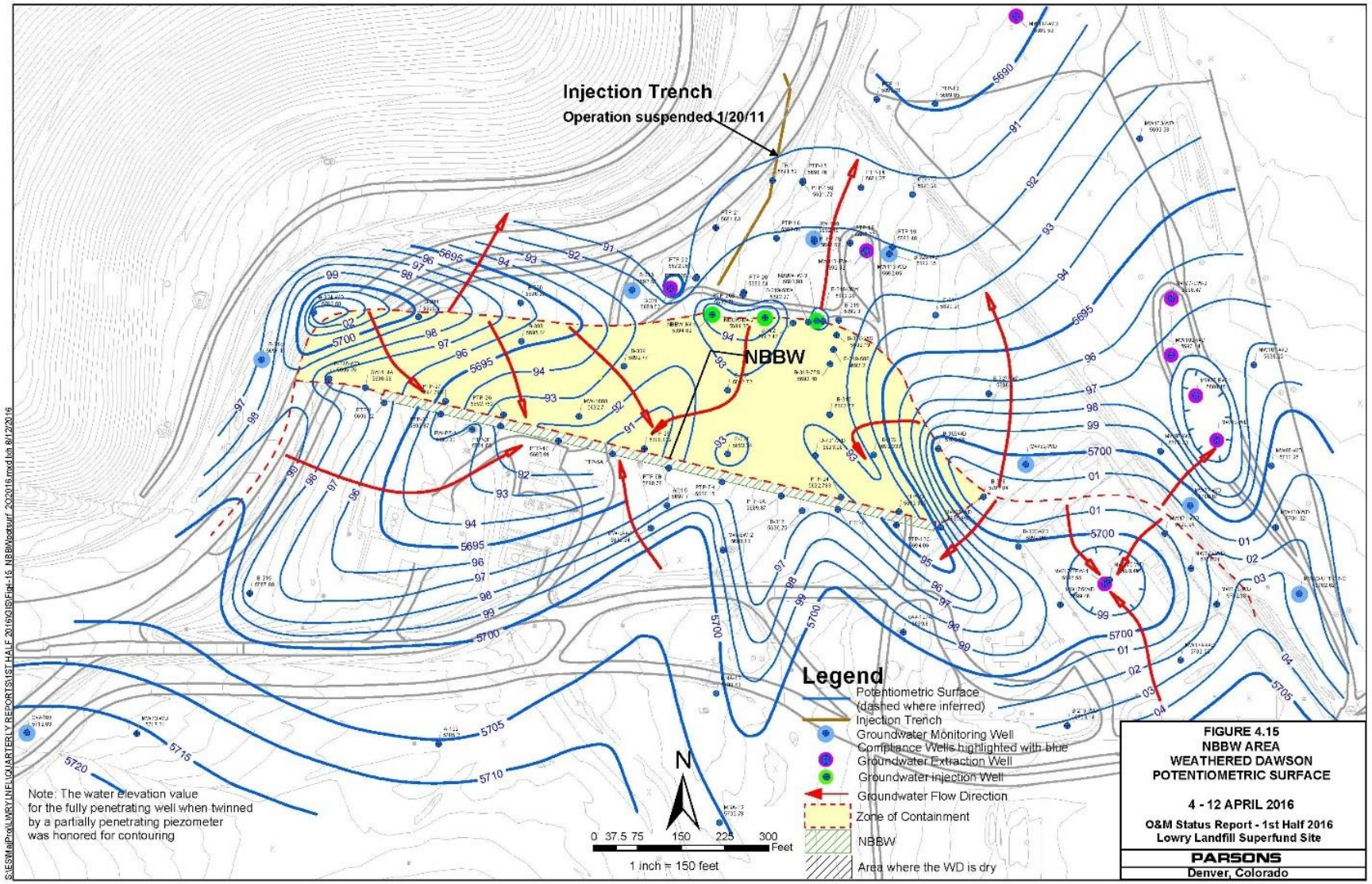
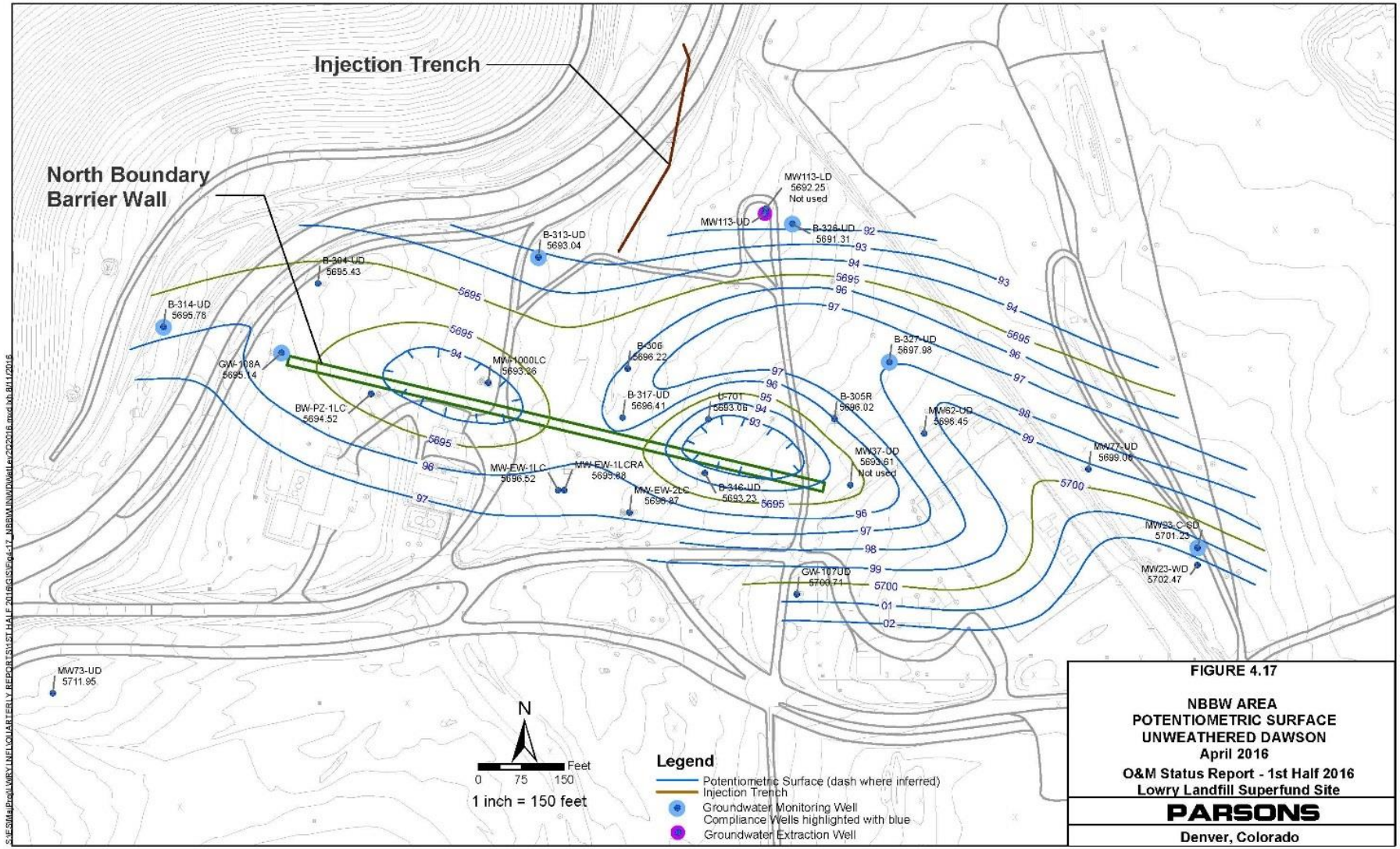


Figure H-7: Unweathered Dawson Potentiometric Map – April 2016

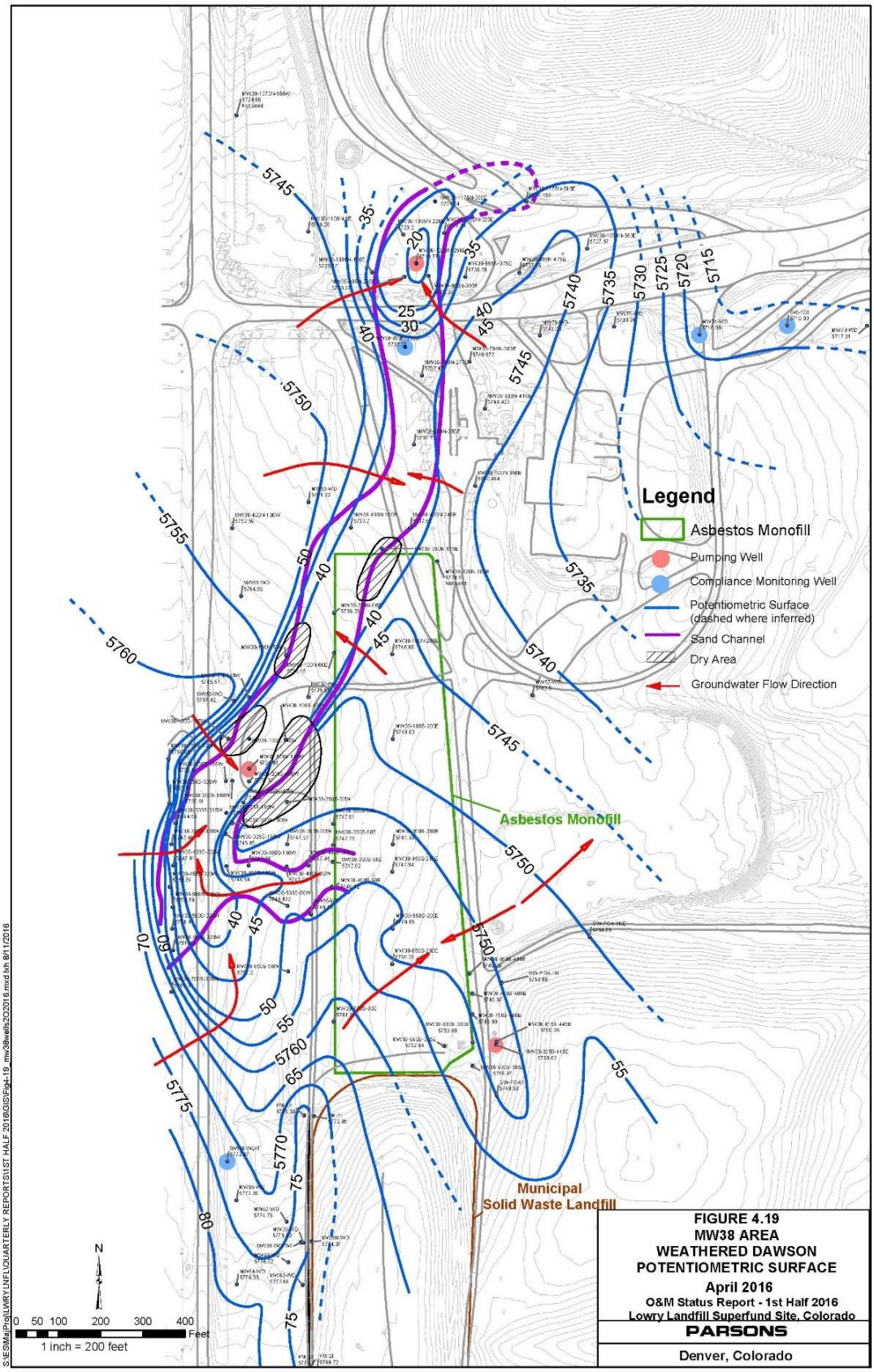


Based on the presence of the groundwater divide and associated containment area (highlighted in yellow in Figures H-6), contaminated groundwater to the south of the groundwater divide does not flow off-Site to the north. However, EPA has not evaluated the vertical extent of capture. Three potable injection wells (highlighted green in Figures H-6) are being used to maintain hydraulic control north of the wall.

MW38 Gradient Control Contingency Measure

Groundwater extraction occurs from wells MW38-170S-140E and MW38-1028N-256E located in the MW38 channel sand. Pumping is performed to maintain an inward hydraulic gradient toward the sand channel. Pumping occurs intermittently because the area gets dewatered and it takes several days to accumulate enough water to activate pumping. Water level monitoring is used to demonstrate hydraulic containment and effectiveness. In addition, WSDs voluntarily pump from source control well MW38-825S-445E, which is positioned upgradient of the MW38 sand channel. Figure H-8 provides the most recent potentiometric map of the MW38 channel. The presence of convergent flow into the MW38 channel indicates that the channel effectively prevents shallow contaminated groundwater within the channel from migrating out of the sand channel.

Figure H-8: MW38 Area Weathered Dawson Potentiometric Map



Contingency Measures – MW38 and Perimeter Systems

The WSDs are conducting contingency measures at the Site: 1) for source control associated with the MW38 sand channel; 2) to induce inward hydraulic gradient across the perimeter slurry wall; and 3) to remove VOCs from groundwater outside the slurry wall. The systems are located in the following areas, starting on the west side and progressing counterclockwise around the Site:

- MW38-WD – voluntary groundwater extraction from upgradient well (source control);
- PM-11 – groundwater extraction from two internal wells (gradient control);
- MW51-WD – groundwater extraction from three internal wells (gradient control) and air sparge at one well (VOC removal outside the wall); and
- PM-15 – groundwater extraction from six internal or northern wells (gradient control) and air sparge at one well (VOC removal outside the wall).

MW38-WD

The WSDs conducts intermittent voluntary pumping from source control well MW38-825S-445E. This well has remained inactive during the spring of 2015 and most of the first half of 2016 due to a lack of capacity at the WTP. Approximately 386 gallons were pumped from this well during the first half of 2016 and about 3.77 million total gallons have been removed.

The primary constituents detected in the pumped water during June 2016 were 1,2-DCA at 38,000 µg/L; 1,1-DCA at 2,500 µg/L; and 1,4-dioxane at 2,400 µg/L. This action has resulted in a contaminant mass removal during this reporting period of 0.122 pounds of 1,2-DCA; 0.0068 pounds of 1,1-DCA; and 0.0077 pounds of 1,4-dioxane. Cumulative mass removed from this well is 2,883 pounds of 1,2-DCA; 148 pounds of 1,1-DCA; and 145.5 pounds of 1,4-dioxane.

The WSDs will evaluate other response actions such as in-situ treatment of the MW38 source area should long-term treatment capacity at the WTP remain an issue.

PM-11

Groundwater is extracted from wells PM-11I and BM-11I-100N. The combined extraction rate from the two wells was 332 gallons per day and about 60,000 gallons of water were transferred to the WTP during the reporting period.

MW51-WD

Groundwater extraction continued from extraction wells MW51I-WD-15N, MW51I-WD and MW51I-WD-35S which are all within the perimeter slurry wall. The combined extraction rate from the three wells was 71,000 gallons or 392 gallons per day.

Air sparging from MW70-WD began in May 2002 and ended in March 2013 because four quarterly sampling events confirmed no VOC detections above the performance standards. In November 2014, PCE increased to 5.1 µg/L so air sparging was resumed in December 2014. PCE and TCE were not detected in MW70-WD in June 2016. Compliance well MW60-WD, located downgradient from MW70-WD, has not had any PCE or TCE detections since April 2000.

PM-15

Contingency measures in the PM-15 area include groundwater extraction from six wells: PM-15I, BM15I-25S, BM-15I-50S, BM-15I-100S, BM-15I-150S (interior wells) and BM-15I-15N (15 feet north of the end of the slurry wall). A total of 17,000 gallons was transferred to the WTP during the first half of 2016. Groundwater extraction has maintained an inward hydraulic gradient across the northeast end of the slurry wall (see Figure H-4).

The WSDs conducted air sparging from BM-15N5 since 2003 to remove low-level VOCs from groundwater north of the slurry wall in PM-15 area. This air sparge well is located downgradient of PM-15X. The WSDs will continue air sparging in this well to remove residual VOCs from groundwater that may be migrating north from the PM-15X area.

North End Response Actions

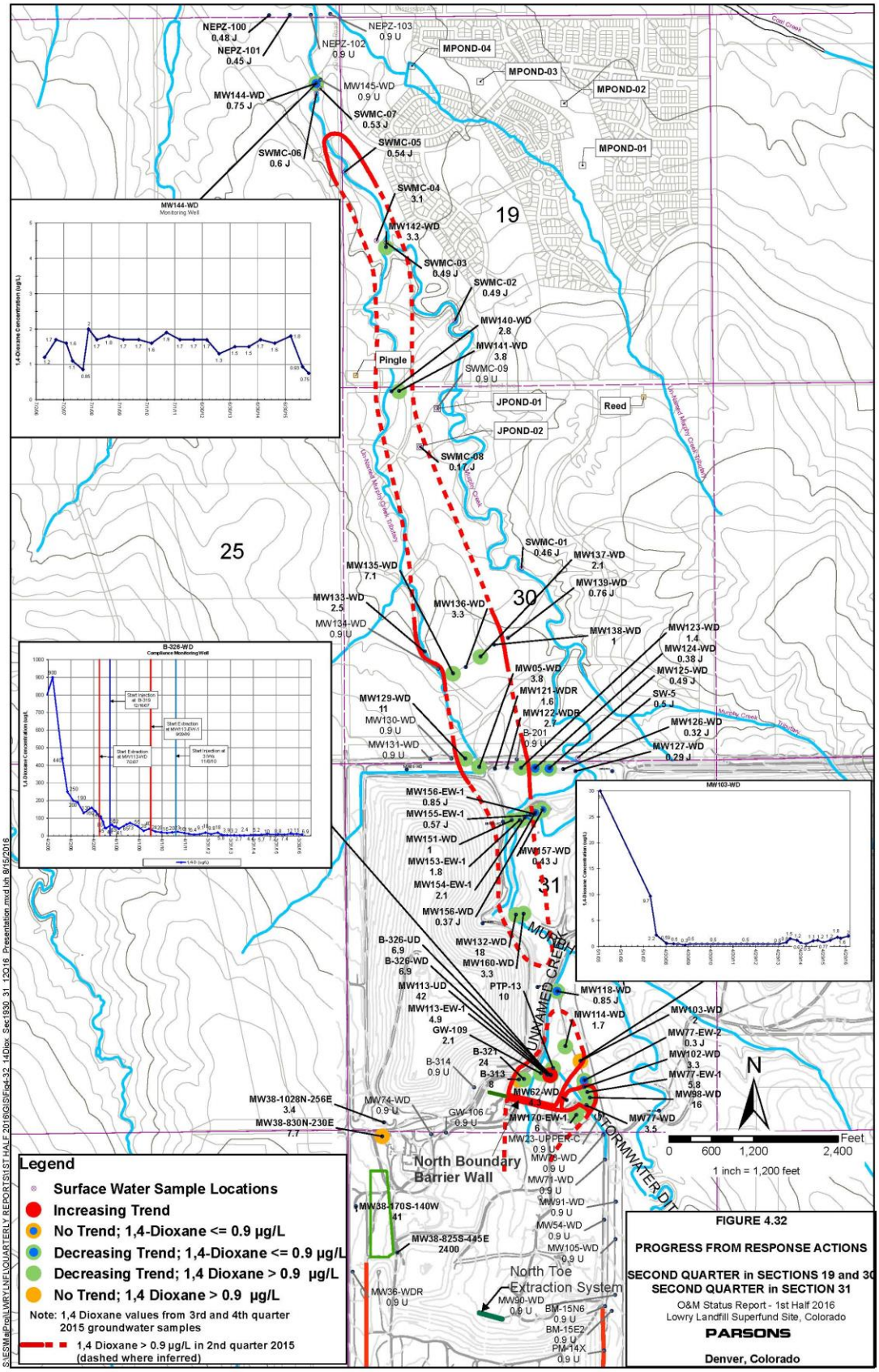
The North End response actions include monitoring and extraction for Sections 31 and monitoring for Sections 30, 19 and 24. North End groundwater levels and quality are monitored in accordance with North End GWMP (2007 North End Groundwater Monitoring Plan and the 2008 North End Groundwater Monitoring Plan Update No.1).

Monitoring Activities and Results

There are 31 monitoring wells and four compliance wells that are utilized to monitor groundwater quality in the North End area. Section 31 wells are sampled quarterly and Section 19 and 30 wells are sampled semi-annually in accordance with the North End GWMP. Current and historical analytical results are provided in Appendix C-6 of the September 2016 RA/O&M Status Report. Trend results for the 35 monitoring wells are shown in Figure H-9. One well, B-326-WD, shows increasing concentrations. Concentrations increased from 7.2 to 12 µg/L in 2015 and then decreased to 6.9 µg/L in second quarter 2016. This may be the result of decreased pumping from NBBW extraction wells due to limited capacity of the WTP.

Additional delineation work was conducted in 2015 and 2016 to determine the lateral and northern extent of 1,4-dioxane in the North End area. These results were summarized in the 2015 and 2016 RA/O&M Status Reports. Four piezometers were installed along Mississippi Avenue to determine the northern extent of 1,4-dioxane. Figure H-9 shows the results from these wells, which were all below the performance standard of 0.9 µg/L.

Figure H-9: North End 1,4-Dioxane Extent – Second Quarter 2016



In accordance with the 2016 Work Plan to Sample North End Wells, Piezometers and Surface Water, North End wells and surface water samples were collected and analyzed for 1,4-dioxane, VOCs, metals, nitrate and nitrite. As part of this work plan, EPA collected split samples at all locations. The WSDs-collected sample results indicated only 1-4-dioxane exceeded the respective performance standard. Thirteen groundwater locations and one surface water location had 1,4-dioxane concentrations exceeding the performance standard of 0.9 µg/L. EPA split sample results showed exceedances for iron and 1,4-dioxane. Iron exceedances were observed at the following locations: MW 126-WD, MW 129-WD, MW 138-WD and MW 145-WD. The iron results from the WSD collected samples were well below the iron performance standard at these same wells. EPA results indicated 12 groundwater locations and one surface water location had 1,4-dioxane concentrations above the performance standard. These reported exceedances were the observed at the same locations with the exception of MW138-WD. The WSDs-collected result from MW138-WD exceeded the performance standard with a value of 1.0 µg/L, while the EPA split sample at this location was 0.56 µg/L. See Table H-7 for a comparison between the WSDs and EPA collected split sample results.

Table H-7: 1,4-Dioxane Exceedances – Split Sample Results

Sampling Location	1,4-dioxane (WSD collected)[a]	1,4-dioxane (EPA collected)[b]
Groundwater		
MW05-WD	3.8	1.9
MW121-WDR	1.6, 1.6	0.9[c]
MW122-WDR	2.3, 2.7	1.2
MW123-WD	2.9, 1.4	1
MW129-WD	11, 11	5.8
MW133-WD	2.5	1.4
MW135-WD	7.1	3.7
MW136-WD	3.3	1.6
MW137-WD	2.1	0.9
MW138-WD	1	0.56
MW140-WD	2.8	1.1
MW141-WD	3.8	2.3
MW142-WD	3.3	1.1
Surface Water		
SWMC-04	3.1	1.4

All concentrations are shown as µg/L.
Performance Standard = 0.9 µg/L
All results analyzed via method 8260 SIM.
a = 1st Half 2016 RA/O&M PDF page 44
b = EPA Sampling Activities Report 2016 Sampling Events, Table 2.3-9
c = Duplicate Result. Parent result was 0.63 µg/L.

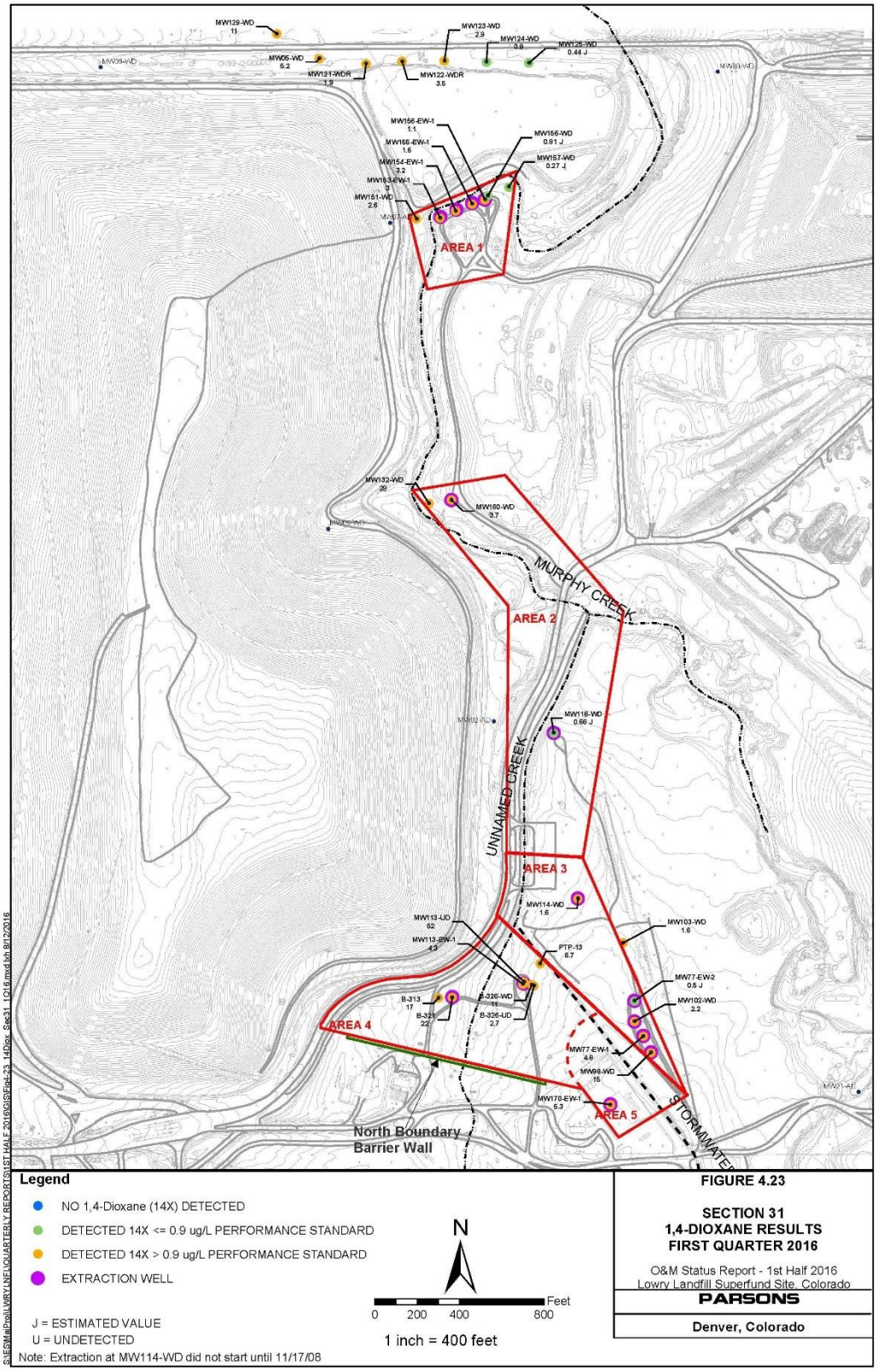
For all 1,4-dioxane results, EPA samples were consistently lower in concentration. This is most likely attributable to the final analytical methodologies used. The EPA laboratory ultimately used method EPA 8270 Selective Ion Monitoring (SIM) which utilized 1,4-dioxane-d8 as a surrogate and 1,4-dichlorobenzene-d4 as an internal standard. The WSDs' laboratory used method EPA 8260 SIM which utilized Isotopic Dilution using 1,4-dioxane-d8 as the internal standard. The WSDs' laboratory followed the Site-specific requirements and validated analytical methods as presented in the most current Lowry Landfill Practical Quantitation Limit (PQL) Study completed in 2015. The EPA laboratory selected a different laboratory method to analyze for 1,4-dioxane. A technical review of the 1,4-dioxane results from the 2016 split sampling event was conducted. The validation confirmed the data from both the EPA and WSDs were accurate and reported correctly in terms of the analytical methods employed.

Extraction Activities

Groundwater extraction occurs from the four areas indicated on Figure H-10. Area 1 extraction has occurred from three wells (MW153-EW-1, MW154-EW-1 and MW155-EW-1) since August 2013 at a combined rate of 6-6.4 gpm in 2016. In Area 2, one well, MW160-WD, was pumped continuously at a rate between 0.5 and 0.6 gpm. In Area 3 (MW77 area), three wells (MW102-WD, MW77-EW-1 and MW98-WD) were pumped at a combined rate of 1.16 to 1.27 gpm. Area 4 (NBBW area) extraction occurs at MW113-UD and B-321. Area 5 is the GTEP area. Extraction occurs from well MW170-EW-1. Groundwater from the North End extraction wells are pumped to the WTP. On-Site North End water is treated, while off-Site water is routed to the back end of the plant without treatment.

A total of 5.64 million gallons of groundwater was pumped from response action wells during the first half of 2016 and about 84 million gallons have been pumped since the inception of the response actions which corresponds to 14 pounds of 1,4-dioxane removed (0.2 pounds of which were removed during the first half of 2016).

Figure H-10: North End Extraction Areas



Two private domestic wells, which are located along East Jewel Avenue are sampled annually in the spring for 1,4-dioxane. The wells are screened in the Denver formation. The most recent sample was collected in May 2016. 1,4-dioxane has never been detected in either well above the method detection limit of 0.5 or 0.15 µg/L.

GTEP Area Response Actions

Pumping has occurred from the GTEP extraction well MW170-EW-1 (Area 5) since 2012. In May 2015, pumping was decreased from 14 gpm to 8 gpm due to limited capacity of the WTP. Since 2015, pumping rates have been increased intermittently when possible. In June 2016, the rate was 7.3 gpm. About 2.75 million gallons were pumped during the reporting period and 26.4 million gallons have been extracted since the start of pumping. A cone of depression still existed in this area during the first half of 2016, although it was reduced due to the lower extraction rates. VOC concentrations show decreasing or stable trends for all COCs including 1,4-dioxane.

Water Treatment Plant

Compliance monitoring is required at two locations, MP-001 (WTP effluent) and MP-004 (North End off-Site groundwater) in accordance with the discharge permit. Results are reported monthly in Periodic Compliance Reports to Aurora, EPA, CDPHE, TCHD and CLLEAN. All discharge standards were met at both locations during this FYR period as reported in the Status Reports and the semi-annual Remedial Action and Operations & Maintenance Status Reports prepared by the WSDs.

Early warning monitoring is also required in accordance with the 2008 *Updated Early Warning Monitoring Plan* (EWMP) and the 2015 *Metro Letter of Understanding*. Samples are collected from five individual influent sources (RWSTs, NBBW, MW38, North End on-Site and NTES and LFG condensate water) and analyzed for VOCs. A sample is also collected from a composite of these sources for all other parameters. Monitoring results during this FYR period showed VOCs are the only influent compounds that exceed discharge limits. The WTP is able to treat these parameters to below discharge limits.

OU3 – Landfill Gas

Landfill Gas Collection and Treatment System

The current LFG extraction, collection and treatment system consists of the following components: 64 vertical gas extraction wells, header and lateral piping, three automatic and nine manual condensate traps, two flares and the GTEP. Under normal circumstances, the FS3 or DBF operates concurrently with the GTEP to stabilize vacuum in the Lowry and DADS collection systems (i.e., the FS3 and DBF do not operate at the same time with the GTEP). However, in the rare event of a full shutdown of the GTEP for more than several hours, the FS3 and DBF stations may operate together to treat gas flows from the Lowry and DADS well fields. The LFG extraction, collection and treatment system operated continuously during the reporting period.

Monitoring activities during the reporting period consisted of collecting gas composition samples at the GTEP inlet, FS3 and DBF and POC probes. The GTEP inlet and flare sampling locations FS3 and DBF are analyzed for methane, carbon dioxide, oxygen and balance gas monitoring. Subsurface LFG POC monitoring locations are located outside the slurry wall to provide detection of any releases of LFG from the Site. POC probe locations are shown in Figure H-11. COC sampling is performed biennially. The last event was performed in February 2015. The results were provided in the September 2015 RA/O&M Status Report. There were no exceedances of the POC subsurface gas performance standards and concentrations were generally not detected or very low (orders of magnitude below the performance standards). The POC probes are also sampled quarterly for methane. All concentrations were below the methane performance standard of 5 percent by volume.

Figure H-11: Gas Monitoring Locations

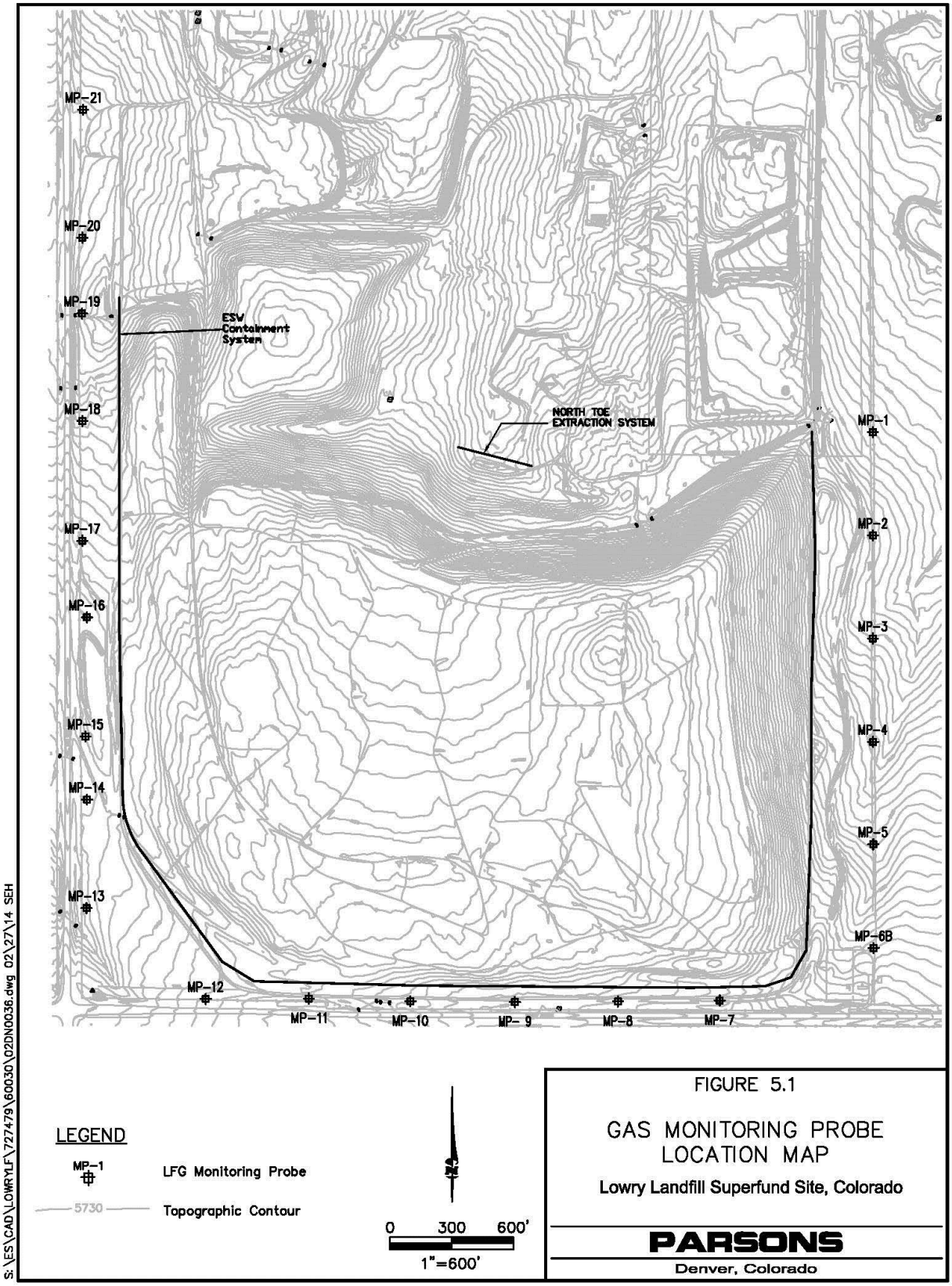
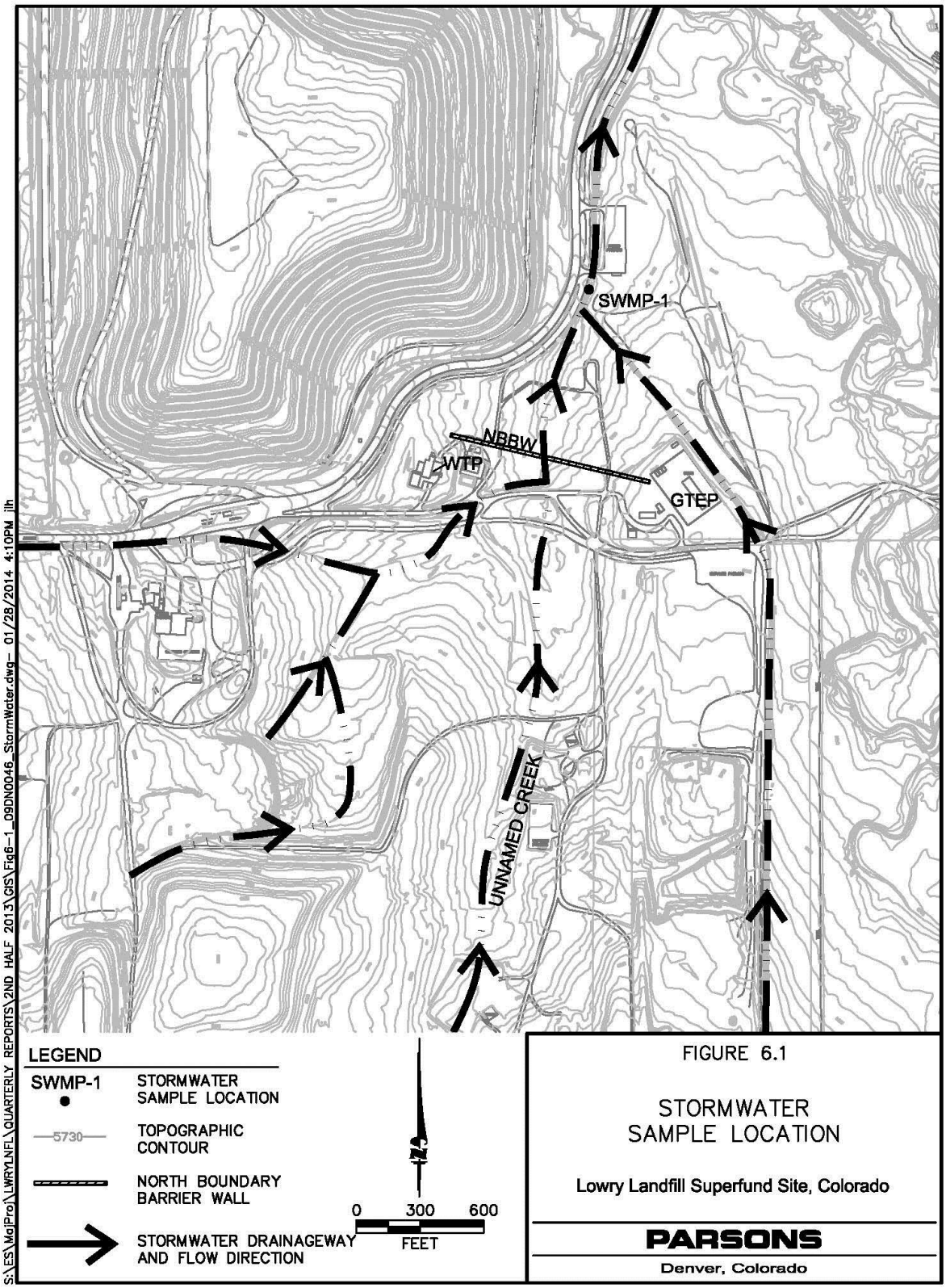


Figure H-12: Stormwater Sample Location



OU 6 – Deep Groundwater

Evaluation of Vertical Migration

Vertical migration wells, B-504A, B-712-LD, C-702P3 and GW-113 are sampled biannually. Monitoring well B-712-LD is screened in the unweathered Dawson. The other vertical migration wells are screened in the upper Denver. These wells are located on the POC boundary and data is used to assess the effectiveness of the compliance monitoring network. Monitoring frequency is biennial for the unweathered Dawson well and every five years for the upper Denver.

The most recent sampling event occurred in July 2015. Results were consistent with historic monitoring results and below the groundwater performance standards. The maximum concentrations for all compounds for each well have been less than their respective performance standards with the exception of a single detected value for 1,4-dioxane of 0.95 µg/L in well B-712-LD in 2007. The most recent 1,4-dioxane result was less than the PQL, 0.9 µg/L. Trend analyses performed on the dataset indicate increasing concentrations of 1,2-DCA and iron in B-712-LD and iron and nitrite in GW-113. The most recent sampling event in July 2015 showed decreased iron and nitrite concentrations in GW-113, stable iron and decreased 1,2-DCA in B-712-LD.

APPENDIX I – DETAILED TOXICITY REVIEW

The 1994 ROD established LFG performance standards to be achieved at the POC boundary (Figure H-11). The LFG PS were based on ambient air quality standards but later revised in the 2002 minor modification to the ROD to reflect standards based on subsurface soil vapor. The 2002 standards were derived based on EPA's vapor intrusion model and Site-specific assumptions based on a risk level of $1x10^{-6}$ (cancer risk) or Hazard Quotient of 1 (non-cancer risk). These standards have been revised twice, in 2007 and 2012, using EPA's Region 8 VIAM to reflect changes in toxicity values. Due to recent changes in methods for evaluating vapor intrusion, EPA's VIAM is undergoing updates to reflect EPA's June 2015 final vapor intrusion guidance. The updated VIAM was not available for this FYR. To determine if the LFG PS remain valid since the previous FYR, the 2012 LFG PS were evaluated using EPA's VISL calculator which reflect toxicity values as current as May 2016. The VISL does not accommodate input of Site-specific information thus, the VISL is conservative assuming rapid transport of subsurface vapors into indoor air. The LFG PS were compared to the soil gas screening levels in the VISL calculator assuming a commercial land use consistent with previous assessments using the VIAM. Table I-1 shows the LFG PS that exceed the cancer risk of $1x10^{-6}$ (cancer risk) or Hazard Quotient of 1 (non-cancer risk).

Table I-1: Vapor Intrusion – Landfill Gas Subsurface Performance Standard Toxicity Review

COC	Subsurface Gas Performance Standard ($\mu g/m^3$)[a]	Future Commercial Worker Vapor Intrusion	
		Carcinogenic Risk[b]	Hazard Quotient[b]
Acetone	1,688	No IUR	<0.01
Benzene	730	**$1.4x10^{-5}$**	0.17
Bromodichloromethane	41	**$3.7x10^{-6}$**	No RfC
Bromoform	53	$1.4x10^{-7}$	No RfC
Bromomethane	803,000	No IUR	**1100**
Carbon Disulfide	79,700,000	No IUR	**780**
Carbon Tetrachloride	4,059	**$6.0x10^{-5}$**	0.28
Chlorobenzene	8,815	No IUR	**1.2**
Chloroform	349	**$2.0x10^{-5}$**	0.02
Chloromethane	696,000	No IUR	**53**
Dibromo-3-chloropropane, 1,2-	12	**$1.8x10^{-4}$**	0.41
Dibromoethane, 1,2-	17	**$2.5x10^{-5}$**	0.01
Dichlorobenzene, 1,2-	24,319	No IUR	0.83
Dichlorodifluoromethane	31,000,000	No IUR	**2123**
Dichloroethane, 1,1-	152,200	**$6.0x10^{-4}$**	No RfC
Dichloroethane, 1,2-	126	**$8.0x10^{-6}$**	0.12
Dichloroethylene, 1,1-	5,311	No IUR	0.18
Dichloropropane, 1,2-	357	**$8.7x10^{-6}$**	0.61
Dichloropropene, 1,3-	13,000	**$1.3x10^{-4}$**	**4.5**
Dioxane, 1,4-	1.2	$1.5x10^{-8}$	<0.01
Ethylbenzene	128,777	**$7.9x10^{-4}$**	0.88
Methyl Ethyl Ketone (2-Butanone)	2,752	No IUR	<0.01
Methyl Isobutyl Ketone (4-methyl-2-pentanone)	518	No IUR	<0.01
Methylene Chloride	307	$7.5x10^{-9}$	**<0.01**
Styrene	6,309	No IUR	0.04
Tetrachloroethane, 1,1,2,2-	7.9	**$1.1x10^{-6}$**	No RfC
Tetrachloroethylene	2,224	**$1.4\ x10^{-6}$**	0.38
Toluene	164,359	No IUR	0.23
Trichloro-1,2,2-trifluoroethane, 1,1,2-	4,520,000,000	No IUR	**1032**
Trichloroethane, 1,1,1-	91,728	No IUR	0.13

COC	Subsurface Gas Performance Standard ($\mu g/m^3$)[a]	Future Commercial Worker Vapor Intrusion	
		Carcinogenic Risk[b]	Hazard Quotient[b]
Trichloroethane, 1,1,2-	110	**4.3 x10^{-6}**	**3.8**
Trichloroethylene	1,321	**1.3 x10^{-5}**	**4.5**
Vinyl Chloride	1,706	**1.8 x10^{-5}**	0.12
Xylenes	1,190,064	No IUR	**81.5**

Notes:
a = Table 3.1, Updated Landfill Gas Compliance Monitoring Plan Revision 2, February 2015
b = Calculated based on commercial use using the VISL calculator, version 3.5.1: https://www.epa.gov/vaporintrusion/vapor-intrusion-screening-levels-visls (accessed 11-30-2016)
IUR = Inhalation Unit Risk
RfC = Reference Concentration
$\mu g/m^3$ = micrograms per cubic meter
Bold = Exceeds cancer risk of 1x10^{-6} or Hazard Quotient of 1

To determine if the LFG performance standards remain valid, the subset of COCs with performance standards that exceeded 1x10^{-6} (cancer risk) or Hazard Quotient of 1 (non-cancer risk) for commercial worker exposure were further evaluated. To determine if the maximum detected values observed in the monitoring data collected since the last FYR pose risks above 1x10^{-6} and hazard quotient of 1 (Table I-2) the concentrations were entered into the VISL calculator assuming a future commercial land use. Table I-2 shows that only one constituent exceeded 1x10^{-6} risk level, chloroform. The risk level at the maximum concentration was within the EPA acceptable risk range of 1x10^{-6} to 1x10^{-4}. These results indicate that the LFG PS remain valid, as long as the monitoring data are evaluated in a vapor intrusion calculator or model using current toxicity data to demonstrate that the remedy continues to be protective for the future vapor intrusion exposure pathway.

Table I-2: Screening-Level Risk Evaluation of Maximum Detected Subsurface Gas Concentrations

COCs with Performance Standards above a risk of 1x10^{-6} and hazard quotient >1	Maximum Detected Concentration 2013-2015[a] $\mu g/m^3$	Future Commercial Worker Vapor Intrusion	
		Carcinogenic Risk[b]	Hazard Quotient[b]
Benzene	1.8	3.4 x10^{-8}	<0.01
Bromodichloromethane	0.72 J	6.5 x10^{-8}	No RfC
Carbon Disulfide	7.6	No IUR	<0.01
Chloroform	100	**5.6 x10^{-6}**	<0.01
Chloromethane	10	No IUR	<0.01
Dichlorodifluoromethane	740	No IUR	0.1
Dichloroethane, 1,1-	69	2.7 x10^{-7}	No RfC
Tetrachloroethylene	32	2.0 x10^{-8}	<0.01
Trichloro-1,2,2-trifluoroethane, 1,1,2-	15	No IUR	<0.01
Trichloroethylene	20	2.0 x10^{-7}	0.1
Vinyl Chloride	4	4.3 x10^{-8}	<0.01
Xylenes	6.9	No IUR	<0.01

Notes:
a = POC sampling is conducted biannually. Maximum concentrations listed are from 2013 and 2015 sampling results (RA/O&M Status Report, January through June 2013 [Appendix D-3] and RA/O&M Status Report, January through June 2015 [Appendix D-6])

b = VISL calculator, version 3.5.1: https://www.epa.gov/vaporintrusion/vapor-intrusion-screening-levels-visls (accessed 11-30-2016)
$\mu g/m^3$ = micrograms per cubic meter
Bold = Exceeds cancer risk of $1x10^{-6}$ or Hazard Quotient of 1
J = Estimated concentration
IUR = Inhalation Unit Risk
RfC = Reference Concentration

APPENDIX J – INTERVIEW FORMS

LOWRY LANDFILL Superfund Site Five-Year Review Interview Form

Site Name:	**LOWRY LANDFILL**	**EPA ID No.:**	**COD980499248**
Interviewer Name:	**Katherine Jenkins**	**Affiliation:**	**EPA**
Subject Name:	**Steve Richtel (Waste Management) and Dave Wilmoth (Denver)**	**Affiliation:**	**WSD**
Subject Contact Information:			
Time:	**3:00 p.m.**	**Date:**	**10/27/2016**
Interview Location:			

Interview Format (circle one): **In Person** **Phone** **Mail** **Other: Email**

Interview Category: **Work Settling Defendants (WSDs)**

1. What is your overall impression of the remedial activities at the Site?

Steve: Thorough. Precise. Well-documented. Effective. We've done some pretty innovative things and we should be recognized for that. Running the bio treatment plant to remove 1,4-dioxane. We have done several voluntary actions above what remedy required. We've gone beyond protective. In response to a CLLEAN request we installed 10 LFG extraction wells screened only at bottom of landfill to try to remove gas deep in landfill. Not required by EPA or regulation. It was a good faith gesture to CLLEAN. We also installed an EW at MW38 sand channel headwaters and it still runs today. We were way ahead of agency of the north end plume investigations.

Dave: The remedy overall is functioning as intended, and is protective and effective as the past FYRs have found. Regarding innovative actions that Denver and WM have implemented, I would include the landfill gas-to-energy plant. It was the first plant in Colorado and takes a waste and creates a beneficial use out of it. Not just treating the gas, but provides electricity to the community. Denver and WM's acquisition of the buffer property went above and beyond to control the land uses surrounding the Superfund site. We didn't want residential neighborhoods up against the landfill. It was a community relations issue and not required by the Site's Record of Decision. We also acquired the groundwater rights around the site so that the groundwater flow regime within area was controlled. A groundwater user can't put in a well that could cause groundwater to change course. It's an additional step that Denver and WM felt was an appropriate protective measure to ensure the remedy is protective.

2. What have been the effects of this Site on the surrounding community, if any?

Dave: What we found is that the community at large is not aware of Lowry Landfill. It's just a grassy field with signs and fencing, but it's adjacency to DADS makes it seem it's part of the modern-day landfill. Some have memories of going to landfill to throw away trash but most people are relatively new to the area. In the past, there were small farms and ranchettes, but these have been replaced with new residential subdivisions in the past 20 years. I don't think there are any impressions of negative effects in the public's mind and that there is a relatively low level of basic knowledge of the site. I think that residents are generally aware that it's a Superfund site, EPA and CDPHE are involved, and it's been cleaned up. Whether know or not, I think much of the public is positively affected. We are working with Arapahoe County for expansion of the Gun Club Rd and Quincy intersection to improve traffic flow and mitigate growing congestion. Arapahoe County is beginning construction next year to ease traffic congestion in the area (purchasing a portion of the buffer properties). Xcel is expanding its substation south of the Superfund site on buffer property. This new substation will be an entry point for electricity from a wind farm in eastern Colorado. Just a couple years ago, we sold buffer property to Arapahoe Parks and Rec District (a special district) which they plan to build a regional park facility with baseball fields and a recreation center to expand recreational opportunities in the community. They're raising funds to do the improvements. Right now it has public access as part of a trail system. We're looking at these types of things to address

community needs and public benefits. Our goal with the buffer properties are to protect the remedy first, but it doesn't mean all land uses are prohibited on the properties. We look at the proposed use and how its compatible with the protectiveness of site and the public's need, such as a need for regional park facilities. Impact is positive as we're working with community and giving back.

Steve: It has a big impact on land use in area. Residential use has not occurred very close to the Site because of the Trust buffer property. We work with other impacted stakeholders who are involved in infrastructure. The Superfund site has provided jobs, economic development in purchasing of goods and services. We've tried to do a really good job with reaching out to the public and keeping them informed. Water quality issues are not in the front of minds in community because of what work we've done there. Eventually it will be a very large piece of land that needs to be worked back into functional use.

3. What is your assessment of the current performance of the remedy in place at the Site?

Steve: The remedy is extremely effective. I know that community group points to excursions outside of established compliance zone as remedy failure, but it's not remedy failure. The zone was set up by EPA in known areas of contamination. The monitoring plan includes mechanisms to deal these issues. We're pulling back plumes, they're shrinking and contaminants are being reduced.
Our teams have been effective at dealing with regulatory change. We quickly adjusted before 1,4-dioxane levels changed.

Dave: Lowry has a long history and there is an abundance of site information. The information tells you that the site has functioned well. The slurry wall that's been in operation since 1997 has shown itself to be very effective at both preventing groundwater contamination as well as containing the high levels of contamination in the landfill mass. Denver and WM have been on the forefront of 1,4-dioxane as an emerging contaminant through the development of newer analytical methods and innovative treatment technologies. Academic and professional case studies and peer-reviewed papers include work we have done at Lowry on addressing the contaminant. In Colorado we've been well out front of other Colorado sites that are just now beginning to address 1,4-dioxane.

4. Are you aware of any complaints or inquiries regarding environmental issues or the remedial action from residents since implementation of the cleanup?

Dave: Other than CLLEAN, I'm not.
Steve: We have reached out time and time again to residents in area to inform them and we haven't received any complaints. We once had a meeting with residents potentially most impacted by offsite groundwater, and residents wanted to talk about Gun Club Rd traffic and odor off DADS, etc. We have had inquiries from high schools, elementary schools, etc. There is interest in the process and we provide tours and education. CU Denver, as well as Metro State, college students are interested in the bioplant. We've given tours to boy scouts of America and scientists have written papers on this remedy.

5. Do you feel the community is well-informed regarding the Site's activities and remedial progress? If not, how might EPA convey site-related information in the future?

Steve: We have a website we keep current, we've done mailers, we've done community meetings, community events, booths as Arapahoe County fairground, HOA Meetings etc. We're active members of Tri-County Steering committee which informs the community through government. The frequency of outreach has decreased as is natural for a site that's 20 years in O&M.

Dave: The Tri-County Health Department's steering committee affords an opportunity for stakeholders throughout the community (City, County, Plains Conservation, etc.) to talk about things going on in the area like development plans and traffic congestion, and how we can collaborate. It's not just about groundwater flow and contamination, but bigger picture issues. The meetings also allow stakeholders to stay informed and can collaborate to find solutions to bigger picture community issues. Keeping lines of communication open between

local governments, EPA, Denver, and WM is critical. Communication used to be an issue, but that's no longer the case. Our experience has been that the feedback we get during outreach is not Superfund related, rather related to other community issues outside of our realm of influence.

6. Do you have any comments, suggestions or recommendations regarding the management or operation of the Site's remedy?

Dave: I do not.

Steve: Regarding EPA's management of the Site, it has been a difficult site for the agency to deal with. We're on our 7th or 8th RPM in 20 years. Given the complexity of understanding the hydrogeology of the Site, it is difficult to get up to speed. We don't want it to be a training ground for future RPMs. Given the active citizens group, it's no place for people afraid of those types of situations. There is a certain level of maturity and skill set to deal with it. EPA should be proud of itself. This was a highly contentious and dangerous site in 60s and 70s and it is not anymore. It's a well-managed, contained, understood site and PRPs, Denver, Waste, EPA has a lot to be proud of.

LOWRY LANDFILL Superfund Site Five-Year Review Interview Form

Site Name:	**LOWRY LANDFILL**	**EPA ID No.:**	**COD980499248**
Interviewer Name:	**Katherine Jenkins**	**Affiliation:**	**EPA**
Subject Name:	**Lee Pivonka, Wendy Naugle, Jeannine Natterman and Doug Jamison**	**Affiliation:**	**Colorado Department of Public Health and Environment, Hazardous Materials and Waste Management Division (the Division)**
Time:		**Date:**	**November 18, 2016 (Amended December 13, 2016)**

Interview Format (circle one): In Person Phone **Mail** Other:

1. What is your overall impression of the project, including cleanup, maintenance and reuse activities (as appropriate)?

   The Division's overall impression of the project is that:

   a) with regard to "cleanup" the remedy for Operable Unit 1 (OU1) and OU6 still does not meet performance standards and the Division has concerns about remedy effectiveness;

   b) with regard to maintenance, the remedial systems at the site are operated and maintained in the manner required by EPA; and

   c) with regard to reuse, the Division is unaware of any reuse activities at the Site.

2. What is your assessment of the current performance of the remedy in place at the Site?

   The remedies for OUs 2 through 5 (Landfill Solids, Landfill Gas, Soil, and Surface Water and Sediments, respectively) appear effective, with ongoing maintenance and operation, and they are protective in both the short- and long-terms. This assessment is consistent with the Division's positions during the past two five-year reviews (CDPHE, 2007 and 2012).

   In contrast, the remedy for OU1 (Shallow Groundwater and Shallow Subsurface Liquids) and OU6 (Deep Groundwater) appears ineffective and its long-term protectiveness may be compromised. The OU1 and OU6 remedy has failed to achieve the Remedial Action Objectives (RAOs) after more than three decades of active groundwater extraction operations. This assessment of remedy performance is consistent with the Division's positions during the past two five-year reviews and with other documents and/or comments submitted to EPA. (See CDPHE, 2003, 2007, 2012, 2015a, 2015b and CDPHE and EPA, 2007).

3. Are you aware of any complaints or inquiries regarding site-related environmental issues or remedial activities from residents in the past five years?

   Yes. Recent examples of complaints/inquiries from residents include, but are not limited to CLLEAN correspondence to EPA (CLLEAN, 2016a and 2016b). CLLEAN has also provided multiple technical white papers to EPA during the past four years, that include complaints and inquiries about remedial activities at the site. The Honorable Rod Bockenfeld (Arapahoe

County Commissioner) has also inquired about remedial activities at the Site and the ongoing technical disagreements regarding the OU1 and OU6 remedy effectiveness.

4. Has your office conducted any site-related activities or communications in the past five years? If so, please describe the purpose and results of these activities.

   Yes. The Division conducted an independent analysis of site-specific factors influencing groundwater containment remedy effectiveness because of concerns about the on-going persistence of groundwater contamination beyond the point of compliance. This analysis is summarized in a white paper titled "Groundwater Containment Remedy Technical Considerations" dated February 2015 (CDPHE, 2015a). The white paper includes multiple conclusions and recommendations. The primary issues identified during this review are as follows:

   - **A structural feature has been identified north of the site that is likely continuous both north and south of where it was identified. The growth fault represents a possible mechanism for contaminant transport beyond the point of compliance.**
   - **Two predominant hydraulic gradients prevail at the Site, northward and downward. A three-dimensional analysis of hydraulic gradients and conductivities demonstrates that the nominal resultant groundwater flow vector is northward and 20 degrees downward. Data collection and analysis in three dimensions is critical to properly assessing remedy effectiveness and attainment of remedial action objectives.**
   - **The conceptual site model for the Site should be updated to reflect the complex interrelationships between geology and groundwater contaminant migration.**
   - **The remedy does not appear to completely capture and contain the groundwater contaminant plume. Supplemental actions taken north of the point of compliance have been unsuccessful in fully eliminating what was considered to be residual contamination of limited extent.**
   - **The injection of potable water near point of compliance wells interferes with the evaluation of remedy effectiveness and increases the volume and mobility of the off-Site groundwater contaminant plume.**
   - **The Groundwater Monitoring Plan (GWMP) is still in need of revision. Subsequent to the Division's 2015 white paper, the GWMP was revised, however, the changes did not address many of the fundamental problems identified by the Division, both in the white paper and in comments on the GWMP itself (CDPHE, 2015b). The plan does not comply with EPA's 2008 Guidance "A Systematic Approach for Evaluation of Capture Zones at Pump and Treat Systems" and does not allow for the unbiased evaluation of remedy effectiveness compared to performance standards.**

5. Are you aware of any changes to state laws that might affect the protectiveness of the Site's remedy?

   Yes. Colorado Basic Standards for Groundwater, Regulation 41 has been amended several times since the March 22, 2005 version currently utilized as a basis for "Site Wide Groundwater Performance Standards" as depicted in Table 1 of the Revised Monitoring Plan, dated July 13, 2015 (EMSI in association with Parsons, 2015).

   Specifically, Regulation 41 was amended in January 2008, October 2009, September 2012 and May 2016. The most recent version has an effective date of June 30, 2016 and can be located at:

   https://www.colorado.gov/pacific/sites/default/files/41_2016%2806%29hdr.pdf

Specific standards in need of revision are as follows (please refer to Regulation 41 for an explanation of the ranges of values in the standards):

- **1,1,1-Tichloroethane should be 14,000 or 200 micrograms per liter (µg/L)**
- **1,2-Dibromethane should be 0.018 µg/L**
- **Acetone should be 6,300 µg/L**
- **Arsenic should be 10 µg/L**
- **Biphenyl should be added with a standard of 4.4 µg/L***
- **Gross Alpha should be 15 picocuries per liter (pCi/L)**
- **Aroclor, 1260 should be 0.0175 to 0.5 µg/L**
- **Carbon Tetrachloride should be 0.5 to 5 µg/L**
- **cis,1,2-Dichloroethene should be 14 to 70 µg/L**
- **Coliform, should be expressed as "Coliform (total)" (not Coliform (total)/100 ml) and the units should be "organisms per 100 ml" the correct standard is 2.2**
- **Methanol should be added with a standard of 14,000 µg/L***
- **Methylene Chloride should be 5.6 or 5 µg/L**
- **Pentachlorophenol should be 0.088 to 1.0 µg/L**
- **Phenol should be 2,100 µg/L**
- **Tetrachloroethene should be 17 or 5 µg/L**
- **Tetrahydrofuran should be added, with a standard at 6,300 µg/L***
- **Thorium 230 and 232 have a combined standard of 60 pCi/L, not separate standards, as is currently indicated**
- **Toluene should be 560 to 1000 µg/L**
- **Trans-1,2-Dicholoroethene should be 140 or 100 µg/L**

The chemical Bis (2-Chloroethyl) Ether is listed on Table 1 in the monitoring plan. This chemical name is sometimes synonymous with Bis (chloromethyl) ether (BCME). Both chemicals are listed in Regulation 41 with different CAS numbers and different groundwater standards. We are uncertain which chemical is referred to in the monitoring plan, so we cannot determine which standard is applicable. It would be very helpful if the monitoring plan were to also identify contaminants of concern using CAS numbers. EPA should confirm which chemical is a COC at the site and then verify that the correct value from Regulation 41 is being applied.

***new contaminants that were added to Regulation 41 in 2016. It is possible that there are other standards in Regulation 41 that have been added since 1994 that we have missed in this review. We encourage EPA to conduct a comprehensive review of the groundwater and surface water standards to determine if all standards currently being used at the site for OUs 1, 5, and 6 are up to date.**

The final issue is that standards being applied at the site are not always the actual ARAR from the regulation. In some cases, a reporting limit or background value was applied in lieu of the actual standard. The basis for these decisions, some of which were made many years ago, should be reviewed for both representativeness and protectiveness in the context of this Five-Year Review. For example, performance standards that were established based on a

reporting limit in 2005 may not be protective given improvements in analytical methods in the past 10 years. In addition, performance standards that were established using background data, should also be revisited if there is a possibility that the original data used to represent background were not appropriate (for example, the Division has long argued that use of downgradient well data to establish background is inappropriate).

6. Are you comfortable with the status of the institutional controls at the Site? If not, what are the associated outstanding issues?

   No. The environmental covenant (HMCOV0016) that is the primary Institutional Control for the site covers only the site itself. Since there is a substantial off-Site groundwater contaminant plume that has NO institutional controls, the ICs for the site are inadequate and not protective. ICs should be extended to include all areas where groundwater contaminant concentrations exceed ARARs or applicable standards

7. Are you aware of any changes in projected land use(s) at the Site?

   No. Although the Division is aware of some changes and future possible changes in land uses adjacent to the Site, the Division is unaware of any changes in projected land use(s) at the Site, proper.

8. Do you have any comments, suggestions or recommendations regarding the management or operation of the Site's remedy?

   Yes. Please see the response to Question 4, above, in addition, we recommend reading the Division's White Paper (CDPHE, 2015a) and the Division's comments on the 2014 draft Groundwater Monitoring Plan (CDPHE, 2015b) in their entirety.

9. Question A: Is the remedy functioning as intended by the decision document?

   No (OU1 and OU6).

   Yes (OUs 2 through 5).

   The OU1 and OU6 remedy is not functioning as intended because the RAOs have not been achieved after more than three decades of continuous operation and supplemental actions taken north of the point of compliance have been unsuccessful in fully eliminating what was considered to be residual contamination of limited extent.

10. Question B: Are the exposure assumptions, toxicity data, cleanup levels, and RAOs used at the time of the remedy selection still valid?

    No. The exposure assumptions, toxicity data, cleanup levels/performance standards for OUs 1 and 6 contaminants have changed since the last five-year review in 2012.

    With regard to exposure assumptions, it was previously assumed that the off-Site groundwater plume posed no risk because there were no known completed exposure pathways. This assumption is no longer valid as shallow privately owned drinking water wells have been identified near the off-Site contaminant plume.

It is very important to note that each EPA Five-Year Review provides an inventory of privately owned wells within a 1-mile radius of the site, which makes no sense when groundwater contamination is currently monitored at least three (3) miles downgradient of the site. In order to fully determine protectiveness of the remedy with regard to potential off-Site private wells, the well inventory radius MUST be expanded based on-Site-specific conditions. For example, 1-mile from the down-gradient terminus of the plume, would be more appropriate. If this analysis had been conducted correctly during the last two Five-Year Reviews (EPA, 2007 and EPA, 2012), private wells potentially impacted by the plume would have been identified and sampled in a timely manner.

Changes in toxicity data have resulted in modification of the State's Basic Standards for Groundwater, as indicated in response to Question 5 above. However, it is unclear how these changes to the standards may impact protectiveness at the site. In particular, it is important to note that many of these contaminants of concern are no longer monitored at the site. Therefore, there may be no data available to compare to the updated standards.

Most importantly, since the full extent of the off-Site groundwater contaminant plume has not been defined in a comprehensive synchronous sampling event, at an appropriate PQL, it is impossible to know where the plume boundaries are in relation to off-Site private wells, especially in three dimensions.

Yes. The RAOs for OUs 1 and 6 remain valid.

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

Yes. With respect to the OU1 and OU6 remedy, two types of new information have become available since the last Five-Year Review as follows:

- **In April 2014, CLLEAN provided the Division and EPA with information regarding the location of shallow off-Site privately owned wells; and**
- **In 2015 the Division provided its white paper to EPA (CDPHE, 2015a). The white paper contains new information regarding a growth fault north of the site, in addition to other important technical observations regarding remedy effectiveness.**

References Cited

CDPHE, 2015a: Colorado Department of Public Health and Colorado Environment, Hazardous Materials and Waste Management Division, 2015a. Groundwater Containment Remedy Technical Considerations, Lowry Landfill Superfund Site, Arapahoe Colorado, February 2015, Final, also known as "the Division white paper."

CDPHE, 2015b: Colorado Department of Public Health and Colorado Environment, Hazardous Materials and Waste Management Division, 2015b. CDPHE Comments to EPA dated February 5, 2015 on the "August ##, 2014" document entitled "Revised Groundwater Monitoring Plan," Lowry Landfill Superfund Site, Arapahoe County, Colorado.

CDPHE, 2012: Colorado Department of Public Health and Colorado Environment, Hazardous Materials and Waste Management Division, 2012. CDPHE Comments to EPA on the Draft Third Five-Year Review Report, Lowry Landfill Superfund Site, provided as Attachment 7 to EPA, 2012

CDPHE, 2007: Colorado Department of Public Health and Colorado Environment, Hazardous Materials and Waste Management Division, 2007. CDPHE Comments to EPA on the November 3, 2006 Draft Second Five-Year Review Report, Lowry Landfill Superfund Site, provided as Attachment 3 to EPA, 2007

CDPHE, 2003: Colorado Department of Public Health and Environment, Hazardous Materials and Waste Management Division, 2003. Lineaments at Lowry Landfill Superfund Site? identifying the Division's lineament hypothesis as it may relate to groundwater monitoring and containment at Lowry Landfill Superfund Site, Preliminary Draft: January 24, 2003.

CDPHE and EPA, 2007: Colorado Department of Public Health and Environment, Hazardous Materials and Waste Management Division and the Environmental Protection Agency (EPA), Region VIII, 2007: Powerpoint presentation entitled "Lowry Landfill North End 1,4-Dioxane Plume" provided as part of Attachment 1 to CDPHE, 2015b.

CLLEAN, 2016a: Citizens for Lowry Landfill Environmental Action Now (CLLEAN), 2016a. Letter to Mr. Shaun McGrath, Regional Administrator EPA Region 8 and Mr. Martin Hestmark Assistant Regional Administrator of Ecosystems regarding "EPA Region Oversight of the Lowry Landfill Superfund Site," dated September 12, 2016.

CLLEAN, 2016b: Citizens for Lowry Landfill Environmental Action Now (CLLEAN), 2016b. Response to Martin Hestmark, EPA Region 8 Assistant Regional Administrator, CLLEAN letter dated September 12, 2016 – EPA Region 8 Oversight of the Lowry Landfill Superfund Site, dated October 13, 2016.

EPA, 2012: Environmental Protection Agency (EPA), Region VIII, 2012. Five-Year Review Report, Third Review for Lowry Landfill Superfund Site, Arapahoe County, Colorado, February 14, 2012.

EPA, 2007: Environmental Protection Agency (EPA), Region VIII , 2007. Five-Year Review Report, Second Review for Lowry Landfill Superfund Site, Arapahoe County, Colorado, February 7, 2007.EMSI in association with Parsons, 2015: Engineering Management Support, Inc. in association with Parsons, 2015. Revised Groundwater Monitoring Plan, Lowry Landfill Superfund Site, dated July 13, 2015 and approved by EPA on July 21, 2015.

(1)

LOWRY LANDFILL Superfund Site **Five-Year Review Interview Form**

Site Name: LOWRY LANDFILL **EPA ID No.:** COD980499248
Interviewer Name: Katherine Jenkins **Affiliation:** EPA
Subject Name: BONNIE RADER **Affiliation:** CITIZENS FOR LOWRY LANDFILL ENVIRONMENTAL ACTION NOW
Time: **Date:**

1) **Are you aware of the former environmental issues at the Site and the cleanup activities that have taken place to date?**

Yes, we are aware. There have been **no** cleanup activities in the deep pits to date. The 138 million gallons of chemical waste remain buried under a 100' lift of clay and trash, making it more difficult to reach the pits to remediate.

2) **What is your overall impression of the project, including cleanup, maintenance and reuse activities (as appropriate)?**

Included is a copy of CLLEAN's comments during the 2012 5 Year Review. Not one of CLLEAN's concerns in the 2012 5 Year Review have been addressed. The project is not being cleaned up, the Record of Decision for the Lowry Site requires Containment. The Site cannot be reused. The chemicals are at least 2.5 miles off-site and probably more. Which proves that the Site is not In Compliance – containment has not been achieved. Operable Units 1 and 6 (shallow groundwater) have not performed as required. The LLSF Site is not meeting the ARARs. EPA is not enforcing the ROD at the LLSF Site.

3) **What have been the effects of this Site on the surrounding community, if any?**

Before the pits were covered, the chemicals traveled in the air for at least 8 miles. Many people had problems with nose bleeds, headaches, tingling hands and feet, heart issues and Bronchial Pneumonia with no fever. Once the pits were covered, those symptoms went away. At that time, residents knew when they were being impacted by chemicals from the pits at Lowry because of the odors and the oily film that covered their skin.

Now, the threat is more insidious, because the residents cannot smell or feel the chemicals from the pits. The chemical contamination that remains in the Lowry Landfill Superfund Site threatens to pollute the underground aquifers that serve the entire Front Range of Colorado, and our private domestic wells. Within a five-mile radius of the Site, there are four developments, all of which rely on groundwater for their domestic use. People are no longer worried about health impacts from the air, they are worried that the water they use will make them sick, and they won't know why until it is too late. Many are worried about how having chemicals in the groundwater under their homes will affect their property values. When the City of Denver and Waste Management say they have no intention of cleaning up the off-site plume, and EPA Region 8 concurred, this causes even more anxiety.

4) **Have there been any problems with unusual or unexpected activities at the Site, such as emergency response, vandalism or trespassing?**

Yes. The Contractor for the City of Denver and Waste Management has been manipulating the data from the LLSF Site to make it look like the Site is In Compliance. EPA, has not scientifically reviewed the data produced by the Contractor, or taken split samples to validate that the data from sampling by the Contractor is accurate, has been approving the Contractor's conclusions that the LLSF Site is In Compliance, when in reality, it is not In Compliance. In the meantime, the contamination from the LLSF Site has traveled north in the groundwater and onto private property.

5) **Has EPA kept involved parties and surrounding neighbors informed of activities at the Site?**

No. The last public meeting EPA held in the neighborhoods where the 1,4-dioxane plume has traveled was in 2006. It was a public meeting at which EPA announced the existence of an off-site plume and stated that the off-site plume posed no danger to the public because everyone uses City of Aurora Water. EPA refused to discuss that there are residents in the area who have private domestic wells, and do not use City of Aurora Water. At the meeting, EPA RPM Bonita Lavelle told the residents that EPA would keep them up-dated on a regular basis. The next update from EPA was 7 years later, 2013, when the EPA released a new Fact Sheet. The new Fact Sheet had a number of statements that CLLEAN did not want included because they were misleading to a public who was not directly involved in the Site. EPA released the Fact Sheet to the public with the misleading information.

The City of Denver, Waste Management and their PR Firm, Intermountain Public Affairs, began a concerted effort to prevent CLLEAN from participating in the process. The EPA Public Involvement Coordinator did not object on behalf of CLLEAN, even though CLLEAN is a TAG recipient and it is EPA's mandate, under SARA, to include impacted stakeholders in the entire process.

a) **Do you feel well-informed regarding the Site's activities and remedial progress?**

Yes, by our own persistence, we are well informed.

As no-one is remediating at the Site, there is no remedial progress.

If anything, the Site is in worse condition because the EPA has not acted as a Lead Agency and EPA has blindly accepted the City of Denver and Waste Management's manipulated data, which says the Site is In Compliance. CLLEAN data proves that the Site is not In Compliance and EPA Washington, D.C. Headquarters Scientists agree with CLLEAN.

b) **How can EPA best provide site-related information in the future?**

By providing regular updates to CLLEAN who will use their current outreach email and flyer distribution list to reach the community.

LOWRY LANDFILL Superfund Site **Five-Year Review Interview Form**

Site Name:	**LOWRY LANDFILL**	**EPA ID No.:**	**COD980499248**
Interviewer Name:	**Katherine Jenkins**	**Affiliation:**	**EPA**
Subject Name:		**Affiliation:**	[redacted] Pres. TBE / HOA
Time:		**Date:**	

1. Are you aware of the former environmental issues at the Site and the cleanup activities that have taken place to date?

   Yes

2. What is your overall impression of the project, including cleanup, maintenance and reuse activities (as appropriate)?

   Very concerned that containment ~~maintenance~~ is failing.

3. What have been the effects of this Site on the surrounding community, if any?

   lots of concern in the Thunderbird Estates every home (90 in number) has a well. We already are worried about the water table dropping and additionally fracking and disposal wells within a mile.

4. Have there been any problems with unusual or unexpected activities at the Site, such as emergency response, vandalism or trespassing?

   Not to my knowledge

5. Has EPA kept involved parties and surrounding neighbors informed of activities at the Site? How can EPA best provide site-related information in the future? No not really.

   Regular newsletter to email addresses.

6. Do you own a private well in addition to or instead of accessing city/municipal water supplies? If so, for what purpose(s) is your private well used?

   Yes All our water needs.

7. Do you have any comments, suggestions or recommendations regarding any aspects of the project?

1. Are you aware of the former environmental issues at the Site and the cleanup activities that have taken place to date?

[redacted] I have reviewed the EPA website and few the documents that are available. I was unable to review a history, current community involvement, and EPA approved responses to understand former or current environmental issues at the site.

3. What is your overall impression of the project, including cleanup, maintenance and reuse activities (as appropriate)

[redacted] EPA has not provided adequate information for the public to determine the current status of the site. Community involvement is lacking. EPA states there is no interest? If the site has had no community interest EPA has not been effective in communicating the outstanding issues.

5. What have been the effects of this Site on the surrounding community, if any?

[redacted] comment: No information has been provided by EPA to determine the effects of the site and surrounding community.

6. Have there been any problems with unusual or unexpected activities at the Site, such as emergency response, vandalism or trespassing?

[redacted] comment: No information has been provided by EPA.

8. Has EPA kept involved parties and surrounding neighbors informed of activities at the Site? How can EPA best provide site-related information in the future?

[redacted] comment: No information has been provided by the EPA to validate EPA's oversite.

10. Do you own a private well in addition to or instead of accessing city/municipal water supplies? If so, for what purpose(s) is your private well used?

[redacted] comment: NO.

11. Do you have any comments, suggestions or recommendations regarding any aspects of the project?

[redacted] comments:

1. EPA has not provided the public with adequate community involvement tools or provided public meetings.
2. A local citizens group has requested a meeting with the Regional Administrator and follow-up answers to their questions and EPA has not provided this opportunity or specifically answered their questions.
3. The EPA LEAD did not return my phone calls to follow-up on questions re the citizens group.
4. The local citizen group CLLEAN received TAG grants and the information is not posted to the EPA website.

5. CDPHE submitted written concerns to EPA in 2015. There has been no EPA response posted. In the recent 2016 Superfund report to the Colorado legislature the CDPHE concerns have not been addressed. EPA has not responded to CDPHE and the issues have not been posted for public review?
6. EPA should "promote" a Citizen's Advisory Group. EPA should have public meetings. The prior CIP reports do not address citizen concerns.
7. The local citizen group CLLEAN requested EPA test offsite contamination. EPA has not responded. Why?
8. A Lowry Landfill steering committee was formed and the local citizens' group was not invited to participate? Why?
9. Why is there no update regarding the 1,4 dioxane north of the Lowry Landfill site?

[redacted]

www.lowrylandfillinfo.com

"Although it poses no public health risk, dioxane has been detected in groundwater monitoring wells up to 2.4 miles north of the Lowry Landfill site."

www.epa.gov/region8/superfund/co/lowry

https://www.epa.gov/sites/production/files/documents/DioxaneJul06.pdf

EPA will take steps to prevent
potential exposure to 1,4-dioxane at levels that could present
unacceptable health risks,
prevent further migration of
contaminants, and restore water quality to performance
standards.

www.cdphe.state.co.us/hm/rplowry.htm

Lowry dioxane fact sheet

- There is and has been a surface water standard for 1,4 - dioxane since 2005.
- The facility is currently working to delineate the groundwater plume extent.

- www.tchd.org

http://www.tchd.org/documentcenter/view/1749

‘‘may leach readily from soil to groundwater, migrates rapidly in groundwater and is relatively resistant to biodegradation in the subsurface.

Classified by the EPA as “likely to be carcinogenic to humans” by all routes of exposure

https://www.epa.gov/sites/production/files/documents/LowryDioxaneFactSheet.pdf

1,4-Dioxane In Shallow Groundwater
Lowry Landfill Superfund Site
March 2008

Why is there no updated Fact Sheet regarding the Dioxane plume?

“This fact sheet provides information about the plume of 1,4-dioxane found in the shallow ground water north of the Lowry Landfill Superfund site. The plume is under investigation because 1,4-dioxane has been classified as a probable human carcinogen”.

Site Name:	**LOWRY LANDFILL**	**EPA ID No.:**	**COD980499248**
Interviewer Name:	**Katherine Jenkins**	**Affiliation:**	**EPA**
Subject Name:	**Rod Bockenfeld**	**Affiliation:**	
Time:	**Phone Interview**	**Date:**	**Feb. 28, 2017**

1. Are you aware of the former environmental issues at the Site and the cleanup activities that have taken place to date?

   I have been a County Commissioner for past 12 years and am familiar with the site based on my role as County Commissioner and having the Site be in my district. I have toured the Site frequently and have been part of conversations over the years. I find it concerning that EPA and Tri County Health are on the other side of the State of Colorado on the issue containment and not agreeing to the statistics of the site. There seems to be different plans established on how the community is to be protected from the 1,4 dioxane plume moving and what information is needed to better understand the contaminants. I believe the State is more accurate about site than EPA.

2. What is your overall impression of the project, including cleanup, maintenance and reuse activities (as appropriate)?

   I am worried that the Site contaminates are not being contained.

3. What have been the effects of this Site on the surrounding community, if any?

   I am familiar with CLLEAN monitoring the interest and being vocal in the community about the concerns surrounding the plume of 1,4 dioxane moving towards the wells in the surrounding subdivision. I would like to know that due diligence has been done on the investigation of the plume.

4. Have there been any problems with unusual or unexpected activities at the Site, such as emergency response, vandalism or trespassing?

   No unusual problems or unexpected activities. However, I am concerned about liner and worried about movement from the site with groundwater plume and flowing in other directions that have not been detected.

5. Has EPA kept involved parties and surrounding neighbors informed of activities at the Site? How can EPA best provide site-related information in the future?

   Think they have had meetings and kept people informed. However, the mitigation measures to contain the plume have not been effective.

6. Do you own a private well in addition to or instead of accessing city/municipal water supplies? If so, for what purpose(s) is your private well used?

   I do not have any wells in the area, however I am familiar with the Gun Club Estates and Thunderbird Estates neighborhoods that do have wells. It was my understanding that if those wells get tested and are contaminated there are plans to connect them to public water.

7. Do you have any comments, suggestions or recommendations regarding any aspects of the project?

   I think there needs to be an investigation to look at another remedy.

Site Name:	**LOWRY LANDFILL**	**EPA ID No.:**	**COD980499248**
Interviewer Name:	**Katherine Jenkins**	**Affiliation:**	**EPA**
Subject Name:	**Jeff Baker**	**Affiliation:**	
Time:	**Phone Interview**	**Date:**	**April 11, 2017**

8. Are you aware of the former environmental issues at the Site and the cleanup activities that have taken place to date?

   Yes, I am familiar with things that are ongoing now and former activities.

9. What is your overall impression of the project, including cleanup, maintenance and reuse activities (as appropriate)?

   Overall impression of the cleanup is that containment (part of the ROD) may not be working to the extent that the community would like. I would like to know if containment is the best method. Would a new remediation be considered?

   I have no concerns on the maintenance of the Site.

   I am glad that there are resuse features such as the gas to energy plant are being used.

10. What have been the effects of this Site on the surrounding community, if any?

    I know that the residents from Murphy Creek, Gun Club, Traditions, Dove Hill, Thunderbird Estates, Adonea, and other housing areas to the north believe that the chemicals are in a plume heading north.

11. Have there been any problems with unusual or unexpected activities at the Site, such as emergency response, vandalism or trespassing?

    No.

12. Has EPA kept involved parties and surrounding neighbors informed of activities at the Site? How can EPA best provide site-related information in the future?

    I haven't heard anything about EPA communication on this project and I think that the website needs to be updated regularly. I worry that the current website could be misinforming individuals. I would like to see the start of a Community Advisory Group and think that group could be used to help get the most updated information to the community.

13. Do you own a private well in addition to or instead of accessing city/municipal water supplies? If so, for what purpose(s) is your private well used?

    No wells.

14. Do you have any comments, suggestions or recommendations regarding any aspects of the project?

    I appreciate the complexity of the site and the effort by EPA to be forthcoming and honest in dealings with the community and county.

    I agree with the November 2016 CDPHE letters.

LOWRY LANDFILL Superfund Site		**Five-Year Review Interview Form**	
Site Name:	**LOWRY LANDFILL**	**EPA ID No.:**	**COD980499248**
Interviewer Name:	**Katherine Jenkins**	**Affiliation:**	**EPA**
Subject Name:	**Lynn Robbio Wagner, Environmental Health Field Supervisor**	**Affiliation:**	**Tri-County Health Department, Greenwood Village, Colorado**
Time:		**Date:**	**May 31, 2017**

Interview Format (circle one): In Person Phone Mail Other: **Email**

1. What is your overall impression of the project, including cleanup, maintenance and reuse activities (as appropriate)?

   Tri-County Health Department's (TCHD) overall impression of the project is that the Lowry Landfill Superfund Site remediation activities are protective of public health and the environment. The site is in operation and maintenance. This is the 4th Five Year Review. The Responsible Parties have been very responsive to TCHD and local governmental concerns. TCHD works cooperatively with the United States Environmental Protection Agency (USEPA), Colorado Department of Public Health and Environment (CDPHE), Arapahoe County and the City of Aurora, and the Responsible Parties to inform developers, adjacent landowners, citizens and other interested parties about site progress.

   TCHD leads the Lowry Landfill Superfund Site Steering Committee and samples private wells closest to the site. TCHD works with all home owners to provide information on private well water testing. In 2014 TCHD implemented a program called "Is Your Well Well?" that provided residences with information to test their private wells annually and to have their septic tanks pumped.

   Currently there is not a reuse plan for Lowry Landfill Superfund Site and there are Institutional Controls and Environmental Convents/Deed Restrictions to restrict building and water use both on and under the site.

2. What is your assessment of the current performance of the remedy in place at the Site?

   TCHD believes the remedy components are preforming as designed. TCHD reviews most all technical documents for the Lowry Landfill including, but not limited, to the following: The bi-annual Remediation Action and Operations and Maintenance Status Reports, the monthly Periodic Compliance Report for Industrial Wastewater Discharge Permit No. 2360-5-1A, and Addendum 5a to Final Operations and Maintenance Manual Water Treatment Plant and the updates to the Groundwater Monitoring Plan.

   TCHD is aware of the North End Response Actions to address 1,4-dioxane that was detected off site and north of the site. 1,4-Dioxane is a chemical of concern that has significantly decreased in concentration and continues to show a decreasing trend since the removal action began.

TCHD and the Responsible Parties (RP's) sample two private domestic wells located along East Jewell Avenue for general field parameters such as nitrate, fluoride, hardness and specific conductance. These private wells have been sampled annually each spring since 2006 for 1,4-dioxane by the RP's. TCHD observes that all sampling is conducted in accordance with the North End Groundwater Monitoring Plan and sampling results are provided to the homeowners. Sampling of these wells is to provide assurances to the well owners that are proximal to the shallow groundwater plume that their drinking water does not contain 1,4-dioxane above detection limits. The private wells sampled have been non-detection (ND) for 1,4-dioxane.

3. Are you aware of any complaints or inquiries regarding site-related environmental issues or remedial activities from residents in the past five years?

   TCHD is aware of environmental community concerns raised by Citizens for Lowry Landfill Environmental Action Now (CLLEAN). CLLEAN is a former recipient of an USEPA Technical Assistance Grant (TAG). CLLEAN was awarded a TAG in 1996 which allowed them to hire technical assistance to help understand the complexities of the site and technical data over the years. CLLEAN continues to write letters to the USEPA and the City and County of Denver to express their concerns.

4. Has your office conducted any site-related activities or communications in the past five years? If so, please describe the purpose and results of these activities.

   See No. 2- TCHD and the RP's sample two private domestic wells located along East Jewell Avenue for general field parameters such as nitrate, fluoride, hardness and specific conductance. These private wells have been sampled annually each spring since 2006 for 1,4-dioxane by the RP's. TCHD observes that all sampling is conducted in accordance with the North End Groundwater Monitoring Plan and sampling results are provided to the homeowners. Sampling of these wells is to provide assurances to the well owners that are proximal to the shallow groundwater plume that their drinking water does not contain 1,4-dioxane above detection limits. The private well sampled have been non-detection (ND) for 1,4-dioxane.

   TCHD routinely organizes Lowry Landfill and Denver Arapahoe Disposal Site tours for interested parties and incoming TCHD staff. TCHD staff will accompany USEPA and CDPHE during site wide inspections and/or remediation oversight activities.

5. Are you aware of any changes to state laws that might affect the protectiveness of the Site's remedy?

   At this time TCHD does not know of any state laws that might affect the protectiveness of the site's remedy. The last known regulation change for groundwater was the Colorado Basic Standards for Groundwater, Regulation No. 41, most recently amended in 2015. This affected the site's 1,4 dioxane standard which changed from a site wide protection standard of 200 parts per billion to 0.35 micrograms per liter as adopted by the CDPHE.

   The Colorado Air Quality Commission is in the process of updating the Colorado Air Quality Control Commission State Implementation Plan in regards to ozone and sulfur dioxide. This includes revisions to Regulation no. 6, Part A, to incorporate by reference changes the

USEPA made to its New Source Performance Standard Rules (NSPS), Regulation 7, and Regulation No. 8 Parts A & E for Hazardous Air Pollutants Rule. Most revisions will reflect current operation practices for the oil and gas control techniques guidelines but it is anticipated major source categories will be affected in the effort to reduce ozone precursor emissions to improve and reduce ozone concentrations. It is unknown at this time if any changes will affect the Air Pollution Control Division Air Pollutant Emission Standards for the Gas to Energy Plant.

6. Are you comfortable with the status of the institutional controls at the Site? If not, what are the associated outstanding issues?

   TCHD is comfortable with the institutional controls on the site. Current restrictive covenants restrict land use to landfilling, monitoring or remediation activities and uses that are consistent with this purpose. No structures or excavation shall be conducted on the property except as necessary to support the site activities. All groundwater is restricted by deed. The site owns buffer property to the north and west of the site. The City and County of Denver owns the property to the north of the site that is operated by Waste Management as a landfill.

   TCHD works with the Arapahoe County and City of Aurora Planning Departments to make comments on any new development in the area. TCHD worked with Copperleaf developers to write a Notice to Purchasers in Proximity to Lowry Landfill Superfund Site which notifies all purchasers of property within Copperleaf Filings 2 and 3 that are with a ¼ mile radius of the site are notified of restrictions to develop occupied residential and non-residential uses. Additionally, TCHD continues to works with the Arapahoe County and City of Aurora Planning Departments to include information in their comprehensive plans on the Lowry Landfill Superfund Site. There is a Landfill Proximity Notice for the Murphy Creek Subdivision for the Denver Arapahoe Disposal Site. These sites are distantly different but residents living in the area have a hard time distinguishing the difference in their operations.

   TCHD will continue to work with local developers and Home Owners Associations in the area. In addition, the USEPA concluded that 1,4-dioxane is not vaper intrusive but TCHD will continue to work with all developers that may be located north of the site. This area is expected to increase growth as the economy strengthens.

7. Are you aware of any changes in projected land use(s) at the Site?

   See No. 6. We do anticipate an increase of growth surrounding the site but it is consistent with the currently land use development that has been approved by the local government.

8. Do you have any comments, suggestions or recommendations regarding the management or operation of the Site's remedy?

   TCHD would like to see the USEPA and CDPHE renew their original commitment and interest to collaborate with the Lowry Landfill Superfund Site Steering Committee. The committee was formed to increase information sharing about the site and how it affects land use and the areas surrounding the site. It is important to build a framework for developing and maintaining factual and effective communication in the surrounding community. TCHD should be involved with all technical meetings and be updated on the site on a routine basis.

TCHD should be included in all USEPA correspondences. TCHD is a partnering agency that strongly encourages transparency.

LOWRY LANDFILL Superfund Site **Five-Year Review Interview Form**

Site Name:	**LOWRY LANDFILL**	**EPA ID No.:**	**COD980499248**
Interviewer Name:	**Katherine Jenkins**	**Affiliation:**	**EPA**
Subject Name:	**Karen Hancock**	**Affiliation:**	**City of Aurora, Colorado**
Time:		**Date:**	

Interview Format (circle one): In Person Phone Mail Other: **Email**

1. What is your overall impression of the project, including cleanup, maintenance and reuse activities (as appropriate)? **Residents living downgradient from the landfill continue to have significant concerns about the effectiveness of the groundwater remedy.**

2. What is your assessment of the current performance of the remedy in place at the Site**?**

   City staff concurs with the response provided by CDPHE. Shallow and deep groundwater contaminant levels have failed to meet Remedial Action Objectives.

3. Are you aware of any complaints or inquiries regarding site-related environmental issues or remedial activities from residents in the past five years?

   City staff has been copied on correspondence from CLLEAN and CDPHE a number of times over the past 15 years indicating their dissatisfaction with the performance the groundwater remedy.

4. Has your office conducted any site-related activities or communications in the past five years? If so, please describe the purpose and results of these activities.

   No.

5. Are you aware of any changes to state laws that might affect the protectiveness of the Site's remedy?

   City staff became aware of changes to regulations as a result of this Five-Year review, identified in comments provided by CDPHE.

6. Are you comfortable with the status of the institutional controls at the Site? If not, what are the associated outstanding issues?

   City staff concurs with the response provided by CDPHE:
   "No. The environmental covenant (HMCOV0016) that is the primary Institutional Control for the site covers only the site itself. Since there is a substantial off-site groundwater contaminant plume that has NO institutional controls, the ICs for the site are inadequate and not protective. ICs should be extended to include all areas

where groundwater contaminant concentrations exceed ARARs or applicable standards."

7. Are you aware of any changes in projected land use(s) at the Site?

   No.

8. Do you have any comments, suggestions or recommendations regarding the management or operation of the Site's remedy?

   CDPHE provided a comprehensive response indicating that the Department has significant issues with the OU1 and OU6 remedy. CLLEAN has provided multiple written communications to EPA that address technical discrepancies and complaints about the groundwater remedy. City staff would like to be copied on EPA's response to these concerns.