**TULSA DISPOSAL, LLC**

**TULSA, OKLAHOMA**

**TAB XIII**

**CORRECTIVE MEASURES**

In Compliance With

40 CFR 270.14 (c)

Revised October 2015

**TABLE OF CONTENTS**

**Section Page**

13.1. INTRODUCTION 2

13.2.1. Former Facility Operations 2

13.2.2. Initial Investigations 3

13.2.3. RCRA Facility Investigation 5

13.2.4 Interim Measure Field Investigations 6

13.2.5 Interim Measure Installation 7

13.2.6. Site-Specific Target Levels (SSTLs) 7

13.3. CORRECTIVE MEASURE 9

13.3.1. System Objectives And Overview 9

13.3.1.1. System Operational Controls 10

13.3.2. Corrective Measure Monitoring Program 12

13.3.2.1. Groundwater Sampling 14

13.3.2.2. Corrective Measure Operation and Maintenance 14

13.4. DEMONSTRATION OF ADEQUACY OF CORRECTIVE MEASURE 15

13.4.1. Trench Hydraulics 15

13.4.2. Groundwater Analytical Results 16

13.4.3. Groundwater Pumping and VOC Recovery 16

13.4.4. In-Situ Biological Reactor (isbr) 16

13.4.5. Summary 17

13.5. ATTAINMENT OF CORRECTIVE MEASURES OBJECTIVES 18

13.5.1. Attainment of On-Site Target Levels 18

13.5.2. Attainment of Off-Site Target Levels 19

13.5.3. Decommissioning of Corrective Measure 19

13.5.4. Summary 19

**13.0 - CORRECTIVE MEASURES**

**ODEQ Item Numbers B-22 to B-28**

**40 CFR 270.14(c)**

# 13.1. INTRODUCTION

Corrective measures at the Tulsa Disposal, LLC facility, the Facility, while approved separately from this permit, are herein described including a detailed description of the approved Corrective Measure that has been implemented. The Corrective Measure is designed to contain volatile organic compounds (VOCs) on-site and to reduce contaminant mass in the saturated clay-clayey shale unit at Solid Waste Management Unit 1 (SWMU 1).

The Corrective Measure Study, Appendix 3, Attachment 9, was approved by the Oklahoma Department of Environmental Quality (ODEQ) in an October 13, 1998 letter to Safety-Kleen (Tulsa), Inc. Approval was granted separately from this permit thereby allowing the Corrective Measure, in its entirety, including sampling locations, frequency, and analytes, to be amended based on the written consent of the ODEQ and the Facility without a permit modification being required.

Tab XIII has been prepared in accordance with 40 CFR 270.14(c)(1-8). It presents:

1. A summary of environmental investigations at the Facility;
2. A description of the ODEQ-approved groundwater site-specific target levels and Corrective Measure including objectives;
3. A discussion of effectiveness of the Corrective Measure; and
4. A discussion of the criteria for determining when Corrective Measure objectives have been achieved.

**13.2. SITE HISTORY**

## 13.2.1. Former Facility Operations

The Facility (Appendix 2, Figure 9) began operations in 1979 as Hydrocarbon Recyclers, Inc. (HRI) to recycle waste oil. Waste solvent storage and recycling operations were added in 1983. In 1987, a new processing plant for waste oil was completed. Processing activities were conducted in two separate plant areas until June 3, 1996, when operations ceased. On May 30, 1997, the Facility underwent a name change. The company name was changed from Hydrocarbon Recyclers, Inc. to Laidlaw Environmental Services (Tulsa), Inc. to reflect the acquisition of the Facility by Laidlaw. The Facility underwent a second name change on July 2, 1998, when the name was changed to Safety-Kleen (Tulsa), Inc. to reflect the merger between Safety-Kleen, Inc. and Laidlaw. The name of the facility was changed to Tulsa Disposal, LLC to reflect the acquisition by Clean Harbors, Inc. on September 6, 2002.

Past activities at the Facility have included the solvent operations in the solvent recycling plant, waste oil treatment in the waste oil plant, and, when waste oil treatment operations were discontinued, non-hazardous industrial wastewater treatment in the former waste oil plant. Three major types of waste streams have historically been managed by these activities:

1. chlorinated solvents;
2. non-chlorinated solvents (including paint and lacquer thinners); and
3. waste oils.

Laidlaw submitted a partial closure plan to the ODEQ on April 18, 1996; the plan was approved by ODEQ on April 19, 1996. The Facility ceased waste handling operations on June 3, 1996, and partial closure in accordance with ODEQ requirements was certified by ODEQ on March 17, 1997.

## 13.2.2. Initial Investigations

Numerous investigations have been conducted at the Facility in accordance with the corrective action conditions of the existing Part B Permit. A *RCRA Facility Assessment (RFA) Preliminary Review and Visual Site Inspection (PR/VSI) Report* dated May 1988 was prepared by Science Application International Corporation (SAIC) for EPA Region VI. In the PR/VSI, a total of 53 SWMUs were identified, but no areas of concern were identified. The 53 SWMUs were subsequently consolidated into six SWMUs by the Oklahoma State Department of Health (OSDH) and the Facility.

Discolored water was recovered from beneath the concrete secondary containment liner of the solvent processing area on August 21, 1991. On August 22, 1991, HRI, the operator at the time, notified OSDH of a potential release from the solvent recycling plant at the Facility. Volatile organic compounds (VOCs) were detected in the groundwater immediately below the secondary containment liner.

After the discovery of the potential release, OSDH requested a preliminary investigation, in a September 10, 1991 letter to HRI, to identify any immediate threats to human health or the environment resulting from the potential release. HRI issued the results of the preliminary investigation to OSDH in two letters dated October 10 and November 8, 1991. These included analytical results of samples collected from three locations below the concrete containment pad for the solvent recycling plant. VOCs were detected in the three samples. The VOCs detected included components of materials managed in the recycling plant. However, the source of the contamination discovered below the solvent recycling plant could not be determined at that time. There was no visual evidence to indicate that contamination existed outside the limits of the concrete secondary containment pad for the solvent recycling plant.

On December 24, 1991, OSDH issued a letter to HRI requesting additional information regarding a potential release of solvents from the solvent plant. OSDH stated additional information was necessary to identify any immediate threats to human health and the environment related to the potential release. OSDH requested the following additional information:

* The groundwater flow direction and velocity in the area of solvent recycling plant;
* Additional data to determine whether the solvents were isolated beneath the solvent recycling plant’s concrete secondary containment; and
* Additional data to estimate the potential for contaminant migration to sanitary sewers, and subsequent migration along the sewer lines.

HRI retained USPCI Remedial Services, now Cameron-Cole, LLC, to gather the additional information requested by OSDH in the December 24, 1991, letter. In February USPCI submitted a document titled *Workplan Outline Site Investigation HRI Tulsa Facility* to OSDH for approval. OSDH approved the workplan, and USPCI conducted the field work from May 14 to 16, 1992. The objective of the investigation was to determine if an immediate threat to human health and the environment existed. The investigation consisted of drilling and collecting soil samples from six soil borings (HR-1 through HR-6), constructing groundwater monitoring wells in five of the borings, well development, surveying, and collection of groundwater samples from the newly constructed wells (MW-1 and MW-3 through MW-6). Soil boring and monitor well locations are shown on Appendix 2, Figure 9. The investigation also included identification of potential receptors, migration pathways, and an ecology survey.

Sample results indicated that the concentrations of individual VOCs detected in soil samples ranged from less than 0.005 milligrams per kilogram (mg/kg) to 0.45 mg/kg. The range in the concentration of VOCs detected in soil samples was not indicative of a surface spill in the source area.

VOCs were detected in groundwater samples collected from wells installed in the shallow clay layer and an underlying weathered clayey shale zone within approximately 20 feet of ground surface. Concentrations of individual VOCs detected in monitoring wells east of the solvent recycling plant ranged from less than 0.005 parts per billion (ppb) to 60 ppb. The groundwater flow direction in the clay and clayey shale zones was to the northwest.

The results of the additional preliminary investigation demonstrated that soil and groundwater at the Facility had been impacted by VOCs. However, USPCI concluded that an immediate threat to human health and the environment was not present based on the following:

1. VOC impacts to surface soil were negligible;
2. Groundwater within a one-mile radius of the Facility was not used as a source of potable water supply;
3. No surface water bodies were present at the Facility to support biota; and
4. The Facility ecology survey identified no federally listed endangered or threatened fauna of plant species occurring on the Facility.

Based upon the results of the preliminary investigations, USPCI, with the concurrence of OSDH, recommended a RCRA Facility Investigation (RFI) at the Facility.

## 13.2.3. RCRA Facility Investigation

The goal of the RFI, presented in a USPCI (1993) workplan, was to characterize the Facility hydrogeology and the distribution of VOCs in soil and groundwater. Specifically, the RFI developed site-specific data necessary to characterize the nature and extent of any potential releases of VOCs associated with the following six solid waste management units (SWMUs) (Appendix 2, Figure 9):

1. SWMU 1 - Solvent Recycling Plant;
2. SWMU 2 - Former Waste Oil Process Area;
3. SWMU 3 - Heat Vapor Recovery System;
4. SWMU 4 - Stormwater Storage Tank 1;
5. SWMU 5 - Stormwater Storage Tank 2; and
6. SWMU 6 - Former Drum Storage Area.

The field investigation was conducted at the Facility from August 1993 through July 1994. The investigation included the installation of soil borings HR-2 and HR-15 through HR-18, installation of groundwater monitoring wells MW-1 through MW-25 (Appendix 2, Figure 9), water quality sampling and analyses, and data interpretation. Quarterly groundwater monitoring, which began in November 1993 as part of the RFI, was continued beyond the submittal date of the RFI through December 1994.

Results of the soil-quality investigation indicated that soil in the vicinity of SWMU 1 has been impacted with VOCs. SWMU 1 roughly encompasses the entire width of the property north of the southern edge of the former solvent recycling plant, including the north drum pad and the office building as shown in Appendix 2, Figure 9. The distribution of VOCs in vadose zone soils and in groundwater suggested that releases of VOCs to the unsaturated portions of the near surface clay unit have been principally confined to the solvent recycling and drum storage areas of SWMU 1. The principal source area of the VOCs was believed to be within the limits of the solvent recycling plant (SWMU 1). Soil in the vicinity of SWMU 2 through SWMU 6 was not impacted with VOCs.

Results of the RFI indicated that groundwater beneath and downgradient of SWMU 1 had been impacted by VOCs. The solvent recycling plant encompassing SWMU 1 was identified as the probable source area for the VOCs detected in groundwater. The groundwater sample analytical results from the RFI and more recent sampling events in 1994 indicated that the lateral extent of dissolved VOCs was reasonably well defined. Trichloroethylene was the most prevalent and elevated VOC detected in groundwater samples.

## 13.2.4 Interim Measure Field Investigations

Based on the results of the RFI, an Interim Measure investigation and implementation program was initiated. Laidlaw submitted an *Interim Measure Plan* for field investigation and Interim Measure installation activities at SWMU 1. The plan was accepted by the Oklahoma Department of Environmental Quality (ODEQ) in their May 25, 1995, letter.

Interim Measure field investigations were conducted at SWMU 1 and off-site between June 5 and 11, 1995, and between October 30 and November 3, 1995, to further characterize the Facility hydrogeology and lateral distribution of VOCs in groundwater preparatory to selecting interim measures. The investigations included the completion of the tasks listed below:

* Constructing eighteen permanent groundwater monitoring wells (MW-26 through MW-43), seven temporary wells (TW-1 through TW-7), and one soil boring (SB-1);
* Collecting soil samples and analyzing for selected physical properties, including horizontal specific permeability to air, vertical hydraulic conductivity and intrinsic permeability, total and effective porosity, volumetric water content, dry and wet bulk density, and total organic carbon content;
* Developing the groundwater monitoring wells, including surveying and collecting initial groundwater-level measurements;
* Sampling groundwater and analyzing for VOCs and general inorganic cations and anions; and
* Conducting an aquifer pumping test and vacuum test.

As a result of the field investigations, the horizontal extent of VOC contamination in the clay-clayey shale unit was well defined. The results indicated the presence of elevated concentrations of VOCs, defined as greater than 1 ppm, in two main areas of the Facility. The first was along the northern portion of the solvent recycling plant (in the area of wells MW-1, MW-26, MW-27, and MW-29). The second was to the north of the north drum pad area (in the area of wells MW-32 and MW-40). Previous results from MW-9 and MW-32 had demonstrated that the concentrations were higher at the top of the clayey shale than they are in the upper portion of the saturated portion in the clay zone.

## 13.2.5 Interim Measure Installation

The Interim Measure was installed in June and July 1996 (final completion on July 2) and became operational on October 9, 1996. The Interim Measure consisted of a perimeter containment trench and a source area recovery trench at SWMU 1. The trenches were designed to remove groundwater containing VOCs. The hydrostratigraphic zones addressed by the measure are the clay and clayey shale units encountered at shallow depth beneath the Facility. Appendix 2, Figure 9 shows a plan view of the trenches.

The trench recovery system consists of a 70-foot long recovery trench near the northwest corner of the recycling plant and a 540-foot long containment trench along the north and west edges of the Facility property boundary. The recovery trench is located immediately downgradient of the contaminant source. Its purpose is to reduce the levels of contaminants migrating toward the containment trench. The containment trench is located downgradient at the property boundary to recover dissolved VOCs in groundwater and to prevent the further off-site migration of contaminants. Both trenches are completed to a depth below the contact of the clayey shale and shale interface to insure the collection of any contaminants perched on the shale. Groundwater is extracted from the trenches and stored on-site in a 500,000 gallon storage tank, Tank V-69. The collected groundwater is treated through carbon adsorption by the Facility prior to permitted discharge to the City of Tulsa Publicly Operated Treatment Works (POTW) on a batch basis after treatment. A more detailed discussion of the system is provided in Section 13.3.

## 13.2.6. Site-Specific Target Levels (SSTLs)

On July 12, 1996, Laidlaw submitted a report to the ODEQ entitled *Groundwater Site-Specific Target Level Assessment, Treatment and Recovery Services, Tulsa, Oklahoma, Volumes I and II*. This document proposed site-specific groundwater target levels for the groundwater in the clay-clayey shale units at the Facility and a technical rationale for the SSTLs. The SSTLs were determined for eight chemicals of concern both on-site (which included the Facility and the immediately surrounding property owned by the Facility) and off-site (non-Facility-owned property).

Laidlaw received approval with modifications for the SSTL report in the ODEQ's letter dated February 24, 1997. A revised SSTL document and cover letter were prepared, both dated May 8, 1997, that incorporated the ODEQ modifications. Laidlaw received a draft letter dated December 16, 1997 from the ODEQ allowing for the establishment of SSTLs for chemicals of concern both on-site and off-site from the Laidlaw Facility. On March 20, 1998, Laidlaw prepared a letter to the ODEQ requesting clarification of the SSTLs listed in the draft letter.

On August 5, 1998, Safety-Kleen (as successor to Laidlaw) received approval from the ODEQ for the SSTLs proposed in Table 9 of the revised SSTL document (1997). The approved SSTLs are set at ten times the maximum concentration levels (MCLs) for the off-site chemicals of concern (COCs) and tens to several tens times drinking water MCLs for the on-site COCs. The off-site SSTLs approved by the ODEQ are:

* Benzene 0.05 mg/L
* 1,1-Dichloroethylene 0.07 mg/L
* 1, 4-Dioxane 0.03 mg/L
* Methylene Chloride 0.05 mg/L
* Tetrachloroethylene 0.05 mg/L
* 1,1,1-Trichloroethane 2.0 mg/L
* Trichloroethylene 0.05 mg/L
* Vinyl chloride 0.02 mg/L

These are the VOC concentrations in groundwater that are acceptable to the ODEQ for an off-site receptor on the non-company owned property surrounding the Facility. The values for off-site COCs represent ten times their MCLs, with the exception of the value for 1,4-dioxane, for which a target level concentration of ten times the calculated RCRA Subpart-S Screening Level was used.

The on-site SSTLs are:

* Benzene 0.50 mg/L
* 1,1-Dichloroethylene 2.4 mg/L
* 1, 4-Dioxane 0.12 mg/L
* Methylene Chloride 0.25 mg/L
* Tetrachloroethylene 3.9 mg/L
* 1,1,1-Trichloroethane 37 mg/L
* Trichloroethylene 0.90 mg/L
* Vinyl chloride 0.14 mg/L

**13.2.7. Corrective Measures Study**

Following implementation of the Interim Measure, Laidlaw conducted and completed a Corrective Measures Study (CMS). On August 25, 1998, a *Corrective Measures Study (CMS) Report,* Appendix 3, Attachment 9, was submitted to the ODEQ. The report evaluated eight Corrective Measure alternatives for addressing the VOC contamination identified and delineated during the RFI and Interim Measures work. These measures included:

1. Slurry trenches;
2. Vertical recovery wells;
3. Vertical dual-phase recovery wells;
4. Horizontal recovery wells;
5. A trench recovery system;
6. Enhanced liquid bioremediation;
7. Air sparging;
8. Reaction wall technology; and
9. Continued operation of the Interim Measure.

The Corrective Measures were evaluated based on the following criteria:

1. Protection of human health and environment;
2. Ability to attain Corrective Measures objectives (i.e. SSTLs);
3. Control of sources of release;
4. Compliance with applicable waste management standards;
5. Long-term reliability and effectiveness;
6. Reduction in toxicity, mobility, and volume of waste;
7. Short-term effectiveness; and
8. Cost-effectiveness.

The alternative which best met the Corrective Measure objectives was the continued operation of the Interim Measure. The Interim Measure was designed to hydraulically contain the VOCs in groundwater on-site and to remediate the saturated zone in the clay-clayey shale unit to the ODEQ-approved site-specific target levels. Consequently, it was recommended in the CMS Report that the existing Interim Measure be used as the final remedy for addressing the VOCs in the clay-clayey shale unit. This recommended approach was approved by the ODEQ in an October 13, 1998 letter to Safety-Kleen (Tulsa), Inc.

# 13.3. CORRECTIVE MEASURE

## 13.3.1. System Objectives And Overview

The Corrective Measure objectives as presented in the CMS include:

* Containing the contaminant, and
* Removing contaminant mass to the greatest extent practicable.

The Corrective Measure consists of one containment trench along the north and west perimeter of the Facility and one recovery trench near the VOC source area at SWMU 1. The conceptual design of the Corrective Measure was presented in the ODEQ-approved *Interim Measure Plan* dated March 1995. The groundwater extraction trenches were completed on July 2, 1996 and began operating on October 9, 1996. The locations of the containment trench and recovery trench are presented in Appendix 2, Figure 9.

The containment trench is 540 feet in length and is located downgradient of the probable on-site source areas at the property boundary. It recovers dissolved VOCs in groundwater to prevent the further off-site migration of contaminants. The containment trench consists of 10 trench-observation wells (TOW-A through TOW-J), filter media, perforated conduit at the bottom of the trench, three recovery sumps (RS-1, RS-2, and RS-3), mechanical and operational controls, and double-containment discharge piping. The trench observation wells are used to monitor groundwater levels in the trench during the course of groundwater extraction.

The recovery trench is 70 feet in length and is located immediately downgradient of the probable source area in the former solvent recycling plant. Its purpose is to reduce the levels of contaminants migrating toward the containment trench. The recovery trench consists of four trench-observation wells (TOW-K through TOW-N), filter media, perforated conduit at the bottom of the trench, a recovery sump (RS-4), mechanical and operational controls, and double containment discharge piping. Each of the four recovery sumps consists of a recovery sump and an immediately adjacent piezometer for measuring groundwater levels.

To capture perched contaminants, both trenches are completed to a depth below the contact of the clayey-shale and shale interface where the pooling of contaminants would be expected. Contaminated groundwater is recovered by operating the submersible total-fluids recovery pumps in each recovery sump. The relatively porous filter media, perforated conduit, and trench bottoms with slopes directed toward each of the four sumps allow groundwater to flow toward each recovery sump within both trenches.

The groundwater is pumped from the trenches to a 500,000-gallon on-site storage tank, Tank V-69. The collected groundwater is treated through carbon adsorption, and the treated water is discharged to the City of Tulsa Publicly Operated Treatment Works (POTW). The groundwater is discharged in compliance with the POTW discharge permit obtained from the City of Tulsa Public Works Department, Industrial Pretreatment Section.

### 13.3.1.1. System Operational Controls

The recovery system is equipped with process controls to operate the recovery pumps and notify maintenance personnel when alarm conditions exist. The pump controls and alarm notification device are installed in the control panel near the northwest corner of the former solvent recycling plant (see Appendix 2, Plate 2). Pump controls and safety interlocks are processed by a programmable logic controller (PLC), which is housed in the control panel. The PLC can be programmed for different operational configurations which allows the groundwater recovery system to be modified or upgraded with relative ease.

A pressure sensor controls operation of the recovery pump in each well. The pressure sensor has an operating range of approximately 12 inches. When the water level increases in the recovery sump the pressure sensor monitors the pressure caused by the water level above the pressure sensor. When the water

level increases above the actuation pressure of the pressure sensor, a signal is sent to the PLC. The PLC then turns the recovery pump “ON”. When the water levels drop below the operating range of the pressure sensor, the PLC turns the pump “OFF”. To minimize cavitation, and provide adequate pressure head for priming the recovery pumps, the lower operating range of the pressure sensor in each recovery sump has been placed several inches above the intake of each pump.

Five alarm conditions are monitored on the recovery system:

* Loss of electrical power;
* High fluid level in any recovery well;
* High fluid level in vaults RS-1 and RS-3;
* High fluid levels in vaults RS-2 and RS-4; and
* High water pressure in the discharge piping.

Alarm conditions are monitored via an automatic telephone dial-up system which notifies maintenance personnel when one of the alarm conditions exists. In the event of a power outage, the phone monitoring system will switch to an alternate power source and notify maintenance personnel that the power is off.

If a recovery pump should fail to operate properly or a discharge line becomes clogged, the high level alarm in the recovery well will be activated. This alarm will allow the recovery pump to continue operating, but will notify maintenance personnel that this alarm condition exists.

A high fluid level alarm condition from either recovery vault RS-1 or RS-3 indicates that rainwater may have collected in one of the vaults. This alarm will notify maintenance personnel, but will allow all of the recovery pumps to continue operating.

A high fluid level alarm condition from vault RS-2 or RS-4 indicates that rainwater has collected in these vaults or that a discharge line has ruptured. Since a ruptured discharge line would eventually cause the recovered water to overfill the double containment system, an alarm from RS-2 or RS-4 disrupts power to the recovery pumps and the phone monitoring system notifies maintenance personnel that this alarm condition exists.

Groundwater recovered by the system is pumped by the recovery pumps to a 500,000-gallon storage tank (Tank V-69). The storage tank is equipped with a high-level shut-off valve. When the shut-off valve is actuated, the recovery pumps create an increase of water pressure in the discharge piping. In recovery vault RS-4, a pressure sensor, mounted on the discharge piping, detects an increase in pressure. When a high-pressure signal is detected, the PLC shuts off the recovery pumps and starts a 1-hour timer. After one hour has elapsed, the pumps will re-start. If high pressure does not develop in the discharge line, the pumps will continue to operate until another high pressure event occurs. If eight or more high-pressure events occur in a ten-hour period, then the recovery pumps will be turned off and an alarm will be sent to the maintenance personnel. The pumps will not re-start until the PLC is manually reset.

## 13.3.2. Corrective Measure Monitoring Program

The Corrective-Measure monitoring program at the Facility was approved by ODEQ separately from the permit on October 13, 1998. It consists of measuring flow volumes from the two groundwater extraction trenches, measuring groundwater levels, collecting groundwater samples, analyzing the groundwater samples for VOCs, and performing operation and maintenance activities related to the groundwater extraction system. Prior to the start-up of the Interim Measure extraction system on October 9, 1996, baseline groundwater monitoring was conducted between June 24 and 29, 1996. These data were collected to document the pre-pumping groundwater surface and VOC distribution in groundwater.

Groundwater-level and analytical data were collected quarterly between June 1996 and December 1998. Pursuant to the approval of Mr. Greg Garber of the ODEQ in April 1999, the monitoring schedule has been changed to semi-annually. The semi-annual reports will be submitted in July and January of each calendar year, covering the first half and second half of the year, respectively.

In the CMS and subsequent monitoring reports, it has been demonstrated that the containment and recovery trenches maintain hydraulic control of the on-site portion of the VOC plume and effectively remove significant VOC mass from groundwater. As demonstrated by the monitoring events since the start-up of the trench recovery system in June 1996, the VOC plume has steadily and consistently decreased in area and concentration compared to the June 1996 plume. This indicates that the trench recovery system is hydraulically controlling the migration of the VOC plume and recovering significant contaminant mass, as presented in greater detail in Section 13.4.

The monitoring well network is part of the ODEQ-approved Corrective Measure and consists of 37 wells and associated sumps and recovery trench wells. These wells were originally installed for site investigation purposes. The well network is currently sampled and monitored in accordance with the ODEQ-approved Corrective Measure using on-site and off-site monitoring wells to observe system performance and attainment of the SSTLs. The wells have been selected based on their location relative to the groundwater plume, current and past VOC concentrations, and groundwater gradient under pumping and pre-pumping/static conditions. To monitor the continued effectiveness of the Corrective Measure system to hydraulically contain the impacted groundwater at the site, all of the existing monitoring wells will be monitored for fluid-levels during each semi-annual monitoring event. In addition, groundwater samples will be collected from on- and off-site wells.

Off-Site (Outside Facility Fenceline) Corrective Action Monitoring Wells

The following wells will be used as off-site monitoring points: MW-20, MW-23, MW-24, MW-25, MW-36, MW-37, MW-38, MW-39, MW-40, MW-41, MW-42, and MW-43. These wells are located downgradient and off-site of the containment recovery trench. The wells will be used to demonstrate attainment of the off-site SSTLs, and the containment of the VOC plume.

On-Site (Inside Facility Fenceline) Corrective Action Monitoring Wells

The following wells will be used as on-site monitoring points: MW-1, MW-3, MW-5, MW-8, MW-10, MW-11, MW-12, MW-13, MW-14, MW-21, MW-22, MW-26, MW-28, MW-29, MW-30, MW-31, MW-32, MW-33, MW-34, and MW-35. These wells are located on-site and upgradient of the containment recovery trench and include the wells with the historically highest total VOC concentrations (e.g. well MW-29), in addition to wells with intermediate to low concentrations located between the source recovery trench and the containment trench. The selected wells will provide an accurate depiction of the VOC plume on a semi-annual basis, and will allow demonstration of progress toward the on-site SSTLs.

ODEQ granted permission on March 4, 204 to plug and abandon monitoring wells MW-7 and MW-9 thus permanently eliminating them from the monitoring program. These wells would be decommissioned, plugged, and abandoned in accordance with the ODEQ standards. The rationale for eliminating these two wells from the semi-annual monitoring program is presented below:

Decommissioning of Deep Monitoring Well MW-7

Tulsa Disposal, LLC proposed that MW-7, screened within the Coffeyville Shale, be abandoned to remove the potential for preferential vertical VOC migration from the upper clay and clayey shale units into the underlying bedrock shale unit. Of special concern was the possibility that VOCs could enter the well and migrate down into the hydraulically separate Coffeyville Shale. It was proposed that MW-7 be decommissioned, plugged, and abandoned in accordance with ODEQ requirements to prevent this well from potentially serving as a conduit from the shallow clay-clayey shale unit into the underlying shale. Although MW-7 showed a decreasing VOC trend (see the total VOC concentration vs. time plot for this well in Appendix 2), Tulsa Disposal, LLC felt that the well may be detrimental to the on-site cleanup. Based on the one-sided Mann-Kendall statistical test for trends, a downward trend was evident from March 1994 through March 2003 with a statistical significance greater than 95%. The well underwent abandonment procedures in July 2005.

Decommissioning of Shallow Monitoring Well MW-9

The Facility also proposed that MW-9 be decommissioned, plugged, and abandoned. Installed early in the site characterization process, it was completed to only 10 feet below ground surface and contains groundwater only sporadically, generally during summer sampling events. MW-9 has historically been gauged for groundwater level, but it has not been sampled since June 1995 since it produces inadequate sample volumes. Moreover, well MW-9 is immediately adjacent to a newer well, MW-32, which was completed to the shale and thus yields representative water samples on a consistent basis. During the sampling events in which it has been possible to analyze the groundwater from the MW-9, the concentration of constituents were in all cases non-detectable, while MW-32 has generally shown total VOC concentrations greater than 10 mg/l. MW-9 was plugged and abandoned in July 2005 and replaced by MW-32.

Appendix 3, Attachment 3 provides the detailed groundwater Sampling and Analysis Plan (SAP) presenting the field methodologies implemented during the semi-annual events as part of the Corrective Measure. As with all aspects of the Corrective Measure, the SAP can be amended without requiring modification of the permit. However, the SAP is provided for informational purposes.

The sections below provide only a general overview of the monitoring program as a preliminary to the discussion of the demonstration of adequacy of the Corrective Measure and the program for the attainment of site-specific target levels presented in Sections 13.4 and 13.5, respectively. For specifics, reference is made to the SAP.

###

### 13.3.2.1. Groundwater Sampling

Groundwater samples are collected in accordance with the SAP. Prior to sampling, the depth to groundwater is measured in all applicable on-site and off-site wells, in each of the fourteen trench observation wells (TOW-A through TOW-N), and in the four trench-sump observation wells (RS-1 through RS-4). Prior to sampling, a minimum of three casing volumes are purged from each well except in those wells in which water recovery is extremely slow.

The samples are to be analyzed for VOCs by EPA Method 8260, at an ODEQ-certified analytical testing laboratory. Quality Assurance/Quality Control (QA/QC) samples are also collected and analyzed in accordance with the SAP.

### 13.3.2.2. Corrective Measure Operation and Maintenance

The operation and maintenance program, Appendix 3, Attachment 10, consists of collecting flow and volume readings, routine maintenance of the system, and groundwater treatment and discharge in accordance with regulatory agency requirements. Cumulative flow readings of the volumes of groundwater pumped from the trenches are collected as part of program. Flow meters are positioned at the discharge point of each recovery sump and in the discharge line after the flow from all sumps is combined. The groundwater recovered from the two trenches is pumped to Tank V-69. The facility is responsible for managing the recovered groundwater pumped to the storage tank. The groundwater pumped from the trenches is treated through the carbon adsorption system prior to discharge to the POTW. When collecting flow readings, the amount of water stored in the tank is also recorded.

Details regarding monthly maintenance and monitoring are included in each semi- annual report prepared for the Facility.

# 13.4. DEMONSTRATION OF ADEQUACY OF CORRECTIVE MEASURE

This section presents a summary of the adequacy of the Corrective Measure at achieving CMS objectives. As discussed in detail below, the containment and recovery trenches continue to maintain hydraulic control of the on-site portion of the VOC plume and to effectively remove significant VOC mass from groundwater. The results from the groundwater monitoring program underscore the significant reduction in VOC mass in the water-bearing zone beneath the Facility since the trench recovery system began full-time operation in October 1996. Since this time, the VOC plume has steadily and consistently decreased in area and concentration while the system has recovered significant contaminant mass.

## 13.4.1. Trench Hydraulics

Appendix 2, Figure 10 presents a contour map of the pre-pumping (June 1996) groundwater surface at the Facility. The direction of natural groundwater flow under non-pumping conditions for the shallow, unconfined aquifer is predominantly to the west along the western portion of SWMU 1 and to the north-northwest in the north portion of the solid waste management unit. Appendix 2, Figure 11 presents the groundwater surface at the Facility and off-site in April 2015, the first semi-annual monitoring event for 2015. In Appendix 2, Figures 10 and 11, it is apparent that the regional groundwater flow direction and hydraulic gradient are significantly affected by groundwater pumping from the two trenches.

In April 2015, the groundwater elevation difference between trench observation wells TOW-K through TOW-N and the monitor wells adjacent to the recovery trench (MW-6, MW-26, and MW-27) was approximately 11 feet. This result indicates that the hydraulic gradient towards the recovery trench is extremely steep.

The differences in groundwater elevations between the containment trench and adjacent monitoring wells are less dramatic than those at the recovery trench, but are still significant. The differences in the groundwater elevations between the containment trench and adjacent wells MW-10, MW-11, MW-12, and MW-32 ranged from approximately 2 to 10 feet in April 2015 (Appendix 2, Figure 11). The results indicate relatively steep hydraulic gradients towards the containment trench.

## 13.4.2. Groundwater Analytical Results

The comprehensive groundwater analytical results indicate that the VOC plume at SWMU 1 has not migrated off-site at levels above SSTLs for individual VOCs along the western property line or western edge of SWMU 1. Prior to installation of the recovery system, the plume had, however, migrated beyond 46th Street South approximately 150 feet north of SWMU 1, at levels above SSTLs for selected VOCs. Since the June-1996 baseline sampling event, the trench recovery system has been effective in minimizing and reducing further migration of the leading edge of the plume, and containing the plume on company property as well. This is illustrated in Appendix 2, Figures 12 and 13, which present the distribution of total VOCs in shallow groundwater at SWMU 1 and off-site in June 1996 (baseline sampling event) and April 2015, respectively. The analytical results indicate that the Corrective Measure trenches are significantly reducing chemical concentrations in groundwater.

## 13.4.3. Groundwater Pumping and VOC Recovery

To estimate the amount of contaminants recovered by each of the four recovery sumps, groundwater volume readings are collected on a weekly basis and groundwater samples are collected from each recovery sump discharge on a semi-annual basis. Groundwater volume readings and cumulative groundwater recovery estimates are compiled semi-annually along with VOC mass recovery of the individual contaminants based on samples collected from sample ports of RS-1, RS-2, RS-3, and RS-4. Between full-time system start-up in October 1996 and June 2015, a total of 213 Kg of VOC contaminant mass was recovered. The amount of mass recovered calculates to an annual recovery rate of approximately 11.4 Kg per year. The cumulative amount of groundwater recovered from the Corrective Measure recovery trenches for the above time period has been approximately 20,600,000 gallons.

## 13.4.4. In-Situ Biological Reactor (isbr)

To expedite attainment of SSTLs and closure of the site, an in-situ biological reactor (ISBR) pilot-scale system was proposed to ODEQ in the In*-Situ Field Treatability Study and Bioplug Testing Workplan* dated March 1, 2007. An ISBR is a patented immobilized microbial bioreactor used for in-situ bioremediation of impacted soil and groundwater. The pilot system, consisting of two ISBR wells, was installed and the results of the study were presented in the *2009 First Semi-Annual (January – June) Groundwater and Corrective Measure Monitoring, and In-Situ Biological Reactor Pilot Test Summary Report*. An *Addendum to Corrective Measures Study* (CMS) *Report: Bioaugmentation of Groundwater Trench Recovery System Using In-Situ Biological Reactors* was submitted to ODEQ on August 20, 2010. The CMS addendum proposed augmenting the trench recovery system with additional ISBR wells in the primary source area to address the impacted groundwater at the site. The CMS addendum was approved by the ODEQ in its October 4, 2010 letter to Clean Harbors.

In response to an ODEQ request, Clean Harbors submitted a Class 1 Permit Modification, dated July 8, 2014, to the ODEQ for the planned ISBR Interim Measure system that will be used to augment the existing groundwater Corrective Measure at SWMU 1. The permit modification was submitted in accordance with Code of Federal Regulations (CFR) 270.42(d)(1) and pursuant to the ODEQ’s request in its May 8, 2014, letter to Clean Harbors addressing the implementation of the ISBR Interim Measure. The permit modification included a description of the planned ISBR Interim Measure system and a general implementation schedule. The permit modification was based on the ODEQ-approved CMS Addendum.

Between August 3 and 14, 2015 and September 7 through 10, 2015, a total of 35 ISBR wells were installed and developed at the site, in accordance with the Class I Permit Modification. The ISBR system will augment the existing trench recovery system and remediate soil and groundwater impacted by the full suite of COCs in the source area beneath the North Drum Pad, Former Solvent Recycling Plant, and other areas of the site exceeding groundwater SSTLs. The design of the full-scale system was based on the operational and performance data gathered during the pilot scale demonstration. The 35-well ISBR system is scheduled to undergo startup testing in November 2015 and become fully operational in December 2015, augmenting the existing groundwater trench recovery system.

## 13.4.5. Summary

Based on years of site monitoring, it is concluded that the system is operating effectively and meeting the CMS objectives of source removal and hydraulic containment while protecting human health and the environment. The trenches are maintaining hydraulic control of the on-site portion of the VOC plume in groundwater. The results from the hydraulic steady-state capture zone modeling in the CMS show that the containment and recovery trenches together intercept the entire VOC plume on the Facility property and most of the plume off the boundary. The results from the monitoring program indicate decreasing VOC trends in most of the monitoring wells at the Facility.

The containment and recovery trenches continue to effectively remove significant VOC mass from groundwater. During the sampling events, the VOC plume has steadily and consistently decreased in area and concentration compared to the June 1996 plume. This indicates that the trench recovery system is hydraulically controlling the migration of the VOC plume and recovering significant contaminant mass. The addition of the ISBR system should further reduce the Chemicals of Concern to site specific target levels.

# 13.5. ATTAINMENT OF CORRECTIVE MEASURES OBJECTIVES

This section presents a discussion of the criteria to be used to demonstrate that corrective action is complete. In as much as the Corrective Measure was approved separately from the permit, operation of individual components of the Corrective Measure may be modified and/or ceased, with ODEQ approval and without requiring a permit modification, to optimize the system performance. Thus, the recovery trench might remain in operation longer than the containment trench, or vice versa. In addition, the operating components of the system may be shut down for periods of time to determine if rebound of COC concentrations occur. However, termination of the corrective action program will be determined based on:

* The verification of attainment of the ODEQ-approved SSTLs, or
* When it can be demonstrated that further reducing contaminant mass is no longer feasible, or
* Receipt of a “no further action” letter from ODEQ.

The Corrective Measures objectives (Subsection 13.3.1) are currently being met by the recovery system. The Corrective Measure objectives target both the VOC source and the solute-phase contaminants, while at the same time providing for the protection of human health and the environment and complying with waste management standards. The SSTLs provide thresholds to be met and verified to determine that the corrective action program can be terminated unless it can be demonstrated that reducing contaminant mass is no longer feasible or ODEQ issues a “no further action” letter.

As with all aspects of the Corrective Measure, the determination that Corrective Measures objective have been met are not part of this permit and can be made separate from it with ODEQ approval.

## 13.5.1. Attainment of On-Site Target Levels

The Corrective Measure at the Facility will continue to operate until all wells in the groundwater monitoring program are below the on-site SSTLs listed in Subsection 13.2.6 for two consecutive groundwater monitoring events, when it can be demonstrated that reducing contaminant mass is no longer feasible, or ODEQ issues a “no further action” letter. The first monitoring event providing evidence of contaminant concentrations below SSTLs will be considered preliminary until the second event verifies that the on-site SSTLs have been attained for all eight of the chemicals of concern. At that time the recovery and containment trench recovery system will be shut-off. The system will not be decommissioned, however, until further groundwater monitoring verification has been completed, as presented below.

## 13.5.2. Attainment of Off-Site Target Levels

Once the on-site target levels have been attained and the Corrective Measure has been turned off, natural attenuation will be employed to reduce contaminant levels to below off-site SSTL concentrations. Natural attenuation, resulting from the combined effects of dispersion, retardation, and decay due to biodegradation, takes advantage of nature's ability to intrinsically remediate or degrade VOCs. From the SSTL document, the receptor was a hypothetical irrigation water supply well located 107 meters (351 feet) downgradient from SWMU 1. Thus, once cleanup to the on-site target levels was achieved, chemical concentrations are required to be below off-site groundwater target level concentrations before reaching this hypothetical worst-case receptor. The VOC concentrations in groundwater that were acceptable to the ODEQ for the hypothetical off-site receptor are presented in Subsection 13.2.6.

To provide field verification that the concentrations of the chemicals of concern do not exceed the target concentrations downgradient of SWMU 1, it is proposed that the on and off-site monitoring wells be monitored semi-annually for two years after completion of active remediation and shutdown of the system. This monitoring could be completed as part of the post-closure monitoring for the Facility. The wells will comprise a sentinel well network to verify that off-site target levels are not being exceeded. If the off-site target levels presented in Subsection 13.2.6 above are exceeded in any of these wells, then appropriate contingency action would be taken with the concurrence of ODEQ. In this case, the Corrective Measure could be turned back on or the risk assessment reevaluated to determine what concentrations would be considered acceptable at this distance from the hypothetical closest future receptor. The ODEQ would be contacted in the event of an off-site SSTL exceedance and discussions pursued to determine appropriate contingency action.

## 13.5.3. Decommissioning of Corrective Measure

If after two years, there was no exceedance of an off-site SSTL in any one of the wells presented above, when it can be demonstrated that reducing contaminant mass is no longer feasible or ODEQ issues a “no further action” letter, then the Corrective Measure system would be decommissioned permanently, and closed in accordance with the Closure Plan in Tab XI.

## 13.5.4. Summary

In summary, the Corrective Measure approach presented above is consistent with EPA guidance and is protective of public health and the environment. It does not pose any unacceptable potential health risks to future potential irrigation water well receptors in the area. The approach provides a level of protection of human health and the environment that is consistent with anticipated future land use and does not inappropriately exceed the level of protection required. It incorporates a monitoring system that can provide early warning if levels potentially exceed those that could be expected downgradient of the Facility. This will provide sufficient time to design contingent response action, should such action be necessary.