Analysis of the Current Groundwater Protection Monitoring Program with Recommendations for Improvement
Permit No. CO-13-03-15-01
EPA ID No. COD991300484

PREPARED FOR:

CLEAN HARBORS DEER TRAIL, LLC.
108555 EAST HIGHWAY 36, HCR-1
DEER TRAIL, COLORADO 80105

PREPARED BY:

Cameron-Cole, LLC
5777 Central Ave, Suite 200
Boulder, Colorado 80301

September 2013

Executive Summary

RCRA Permit No. CO-13-03-15-01, issued March 15, 2013, mandates a compliance schedule in Section I.J. which requires an analysis of the current groundwater monitoring program. This report includes this analysis along with recommendations for improvement as proposed changes to the program. The recommended revised plan meets all regulatory requirements for groundwater monitoring expressed in 6CCR 1007-3, part 264, subpart F, for RCRA landfills and permitted units and those of 6CCR 1007-1, Part 14, for Licensed Land Disposal.

Clean Harbors Deer Trail, LLC (Site) first began accepting waste in 1991, and initiated a monitoring program for background groundwater chemistry parameters in January of 1986. Since 1986, data collected on monthly, quarterly, semi-annual, and annual schedules has produced a robust database of hydrogeologic and hydrogeochemical data. This data set characterizes aspects of both temporal and spatial variability at the site and justifies a reevaluation of the Site's Groundwater Protection Program. This evaluation has been completed using the data collected and previous reports prepared regarding environmental conditions at the Site. The proposed modifications address three (3) areas of the Groundwater Protection Program: 1) monitoring frequency and operations, 2) monitoring of immiscible liquids levels and organic vapors and 3) statistical analysis methods. Minor modifications include revising out-dated text, updating the regulatory timeframes to be consistent with one another and updating quality assurance methods during sampling.

Potential modifications to the monitoring frequency at the Site have been evaluated based on migration potential and the requirement of sample independence. The Facility currently gauges fluid levels, collects groundwater samples for Radiochemistry constituents, and the F039 parameter list for operational landfills on a quarterly basis. Groundwater samples for the detection monitoring program are collected on a semi-annual schedule. Based on low groundwater flow rates at the Site, a semiannual sampling schedule for Radiochemistry constituents and the active landfill leachate sumps is proposed.

Monitoring program components and other requirements have been revised to increase clarity in the monitoring program, align the program with current regulations and increase the efficiency of the sampling and analysis program. The requirement to remove three casing volumes from high yield wells was revised with low flow sampling techniques in order to keep all the sampling techniques consistent at the Site. Additionally, based on historical field observations and data analysis, the requirements to monitor for organic vapors in the well head and immiscible liquids

on the groundwater surface have been removed. Field personnel will continue to verify that immiscible liquids are not present during all monitoring activities.

Statistical methods for analysis of fluid level and laboratory chemical results have been evaluated based on the objectives of minimizing the frequency of false positives and improving sensitivity to increases in parameter concentrations. The low flow rates and lack of a well defined groundwater gradient indicate an intrawell approach for sample to background comparisons at the Site. A Shewhart-CUSUM control chart approach, coupled with descriptive statistics is proposed.

TABLE OF CONTENTS

1 INTRODUCTION 1

2 PREVIOUS WORK COMPLETED 2

3 ENVIRONMENTAL SETTING 3

3.1 LOCATION 3

3.2 SURROUNDING LAND USE 3

3.3 CLIMATE 3

3.4 GEOLOGICAL SETTING 4

3.4.1 REGIONAL GEOLOGY 4

3.4.1.1 Structural Geology 4

3.4.1.2 Stratigraphy 5

3.4.2 SITE GEOLOGY 6

3.4.2.1 Site Geomorphology 6

3.4.2.2 Site Stratigraphy 6

3.5 HYDROLOGIC SETTING 8

3.5.1 REGIONAL HYDROLOGY 8

3.5.2 SITE HYDROLOGY 9

3.5.2.1 Surface Water Hydrology 9

3.5.2.2 Hydrogeology 9

3.5.2.2.1 Hydrostratigraphic Units 10

3.5.2.2.2 Hydraulic Characteristics 12

4 SECURE CELL DESIGN, OPERATION AND SETTING 15

4.1 LAND DISPOSAL RESTRICTIONS 15

4.2 LINER DESIGN 15

4.3 SECURE CELL LAYOUT 15

5 GROUNDWATER PROTECTION PROGRAM 17

5.1 MONITORING PROGRAM DESCRIPTION 17

5.1.1 PERFORMANCE MONITORING 17

5.1.1.1 Leachate Collection System Monitoring 18

5.1.1.2 Secure Cell Leak Detection System Monitoring 18

5.1.1.3 Permanent Sump Monitoring 18

5.1.2 INSPECTION MONITORING 19

5.1.3 DETECTION MONITORING 19

5.2 DATA EVALUATION 19

5.2.1 FLUID LEVEL EVALUATION 19

5.2.2 CHEMICAL DATA EVALUATION 20

5.2.3 BACKGROUND DATABASE 20
6 PROPOSED MODIFICATIONS 21
6.1 MONITORING FREQUENCY AND OPERATIONS 21
6.1.1 PERFORMANCE MONITORING 21
6.1.1.1 Active Secure Cell Leachate Collection Systems 22
6.1.2 INSPECTION MONITORING 22
6.1.3 DETECTION MONITORING 24
6.2 MONITORING OF IMMISCIBLE LIQUIDS LEVELS AND ORGANIC VAPORS 26
6.3 MONITORING AND SAMPLING OPERATIONS 27
6.4 STATISTICAL METHODS 28
6.4.1 INDICATOR PARAMETER ANALYSIS 28
7 REFERENCES 30

LIST OF PLATES

PLATE 1 SITE BASE MAP AND MONITORING LOCATIONS
PLATE 2 L3 ZONE QUARTERLY WATER LEVEL ELEVATIONS - 2012
PLATE 3 L4 AND L4A ZONE QUARTERLY WATER LEVEL ELEVATIONS - 2012
PLATE 4 L5 AND L6 ZONE QUARTERLY WATER LEVEL ELEVATIONS - 2012

LIST OF APPENDICES

APPENDIX A CONCENTRATION VS TIME PLOTS FOR RADIOCHEMISTRY DATA
APPENDIX B REVISED MONITORING WELL FIELD FORMS
APPENDIX C CONTROL CHARTS

LIST OF ABBREVIATIONS

CCR	CODE OF COLORADO REGULATIONS
CDPHE	COLORADO DEPARTMENT OF PUBLIC HEALTH AND ENVIRONMENT
CFR	CODE OF FEDERAL REGULATIONS
CH	HIGH PLASTICITY CLAY (USCS)
CHDT	CLEAN HARBORS DEAR TRAIL, LLC
CL	LOW TO MEDIUM PLASTICITY CLAY (USCS)
CM/S	CENTIMETERS PER SECOND
GPP	GROUNDWATER PROTECTION PROGRAM
H	CUSUM CONTROL LIMIT
K	CUSUM PARAMETER

L3	LEVEL 3
L4	LEVEL 4
L4A	LEVEL 4A
L5	LEVEL 5
L6	LEVEL 6
LCS	LEACHATE COLLECTION SYSTEM
LDR	LAND DISPOSAL REGULATIONS
LDS	LEAK DETECTION SYSTEM
PCB	POLYCHLORINATED BIPHENYLS
RCRA	RESOURCE CONSERVATION AND RECOVERY ACT
RML	RADIOACTIVE MATERIALS LICENSE
SCL	SHEWHART CONTROL LIMIT
USCS	UNIFIED SOIL CLASSIFICATION SYSTEM
USEPA	UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

1 INTRODUCTION

This Analysis of the Current *Groundwater Protection Program with Recommendations for Improvement* is being submitted by Clean Harbors Deer Trail, LLC (CHDT), for their property located at 108555 East Highway 36 in Deer Trail, Colorado (Site, Facility). The purpose of this report is to present analyses performed and conclusions reached regarding proposed updates to the Groundwater Protection Program, as defined in the Site's Resource Conservation and Recovery Act (RCRA) Hazardous Waste Permit last renewed in April of 2013, Permit No. CO-13-03-15-01.

The proposed modifications presented below are suggested for the purpose of refining Part 7 and Attachment 8 in the current Permit for the Groundwater Protection Program. Proposed modifications will improve the efficiency of the monitoring program and data analysis, while maintaining the existing integrity of the groundwater monitoring network. Proposed changes include a making the monitoring and analysis frequencies consistent throughout the site, updating statistical analysis methods, and updating corrective action triggers.

2 PREVIOUS WORK COMPLETED

A large inventory of hydrogeological and hydrogeochemical data exists for this site. Initial investigations of the Site date back to the early nineteen-eighties (BFI 1981). Approximately one-hundred and sixty (160) borings have been drilled on-site to depths up to 439± feet. Groundwater quality analysis at site wells dates back to 1986, which includes quarterly fluid level inspections and ongoing quarterly and semiannual laboratory analyses of groundwater and leachate samples. This data has been compiled and summarized in numerous characterization and monitoring reports throughout the Facility's history. These reports, in conjunction with the monitoring data collected, constitute the material analyzed to develop the program modifications. In general, previous field investigations, studies and characterization reports consist of three (3) groups:

- Investigations, studies, and reports conducted in the early 1980s that were part of the site selection process and the application for a Certificate of Designation from Adams County. A two-volume draft and final report developed by the initial owners, Browning-Ferris Industries, Inc., Chemical Waste Treatment/Solidification & Disposal Facility Plan, summarizes or references these reports (BFI 1981 and 1982).

- Investigations, studies, and reports that pertained to the development of the Resource Conservation and Recovery Act Part B Permit Application for a hazardous waste treatment, storage, and/or disposal facility. These reports developed in the mid to late 1980s, provided baseline data for groundwater, surface water, soils, and air. Examples include an evaluation by the Colorado Geologic Survey (CGS 1986) and an analysis of pertinent weather factors for the Site (Crow 1987).

- Routine and non-routine monitoring reports developed to demonstrate compliance with applicable Hazardous Waste Facility Permit condition(s). Examples include *Groundwater Protection Program Design and Rationale* by McCulley, Frick and Gillman (MFG 1997), and the *Annual Ground Water Monitoring Reports* (Cameron-Cole 2003-2012).

3 ENVIRONMENTAL SETTING

This section, Environmental Setting, describes Site characteristics such as location, land use, geology, and hydrology. The text has been adapted from Volume 2, Chapter 2 of the 2005 RML Application. Environmental setting is described in terms of both the local and regional environment. The local environment is confined to an approximate 50 mile radius from the Facility. The regional environment encompasses the Great Plains area of Colorado.

3.1 LOCATION

The Facility is located on the north side of Highway 36, approximately 70 miles east of Denver, in Adams County, Colorado. The general location of the Site can be referenced on Figure 1: *Site Location*. The property consists of approximately 5,760 acres, of which 325± acres comprise the Deer Trail Facility. The remaining property outside of the Facility is designated as a buffer zone, with the facility centered in the buffer zone. Reference to the Site will herein refer to the 325± acres comprising the Deer Trail Facility.

3.2 SURROUNDING LAND USE

The property surrounding the Site is used for non-irrigated production of dry land wheat, sunflowers, and grasslands for grazing cattle. There are no residential areas, industrial areas, schools, colleges, hospitals, convalescent homes, or day care centers within a 1.0 mile radius of the Facility (RML Application, 2005). According to the Eastern Adams County Zoning Map, the property is zoned as A-3.

3.3 CLIMATE

The climate of the eastern plains of Colorado is classified as continental steppe, characterized by cold winters, hot summer days and cool nights, abundant sunshine, and low but variable precipitation. On average, the spatial distribution of temperature on the eastern plains tends to be fairly consistent with little annual variation between locations within 50 miles of each other. However, because more than 60.0 percent of the annual precipitation occurs during late spring and summer as thunderstorms, spatial variations in precipitation exist between neighboring locations. The precipitation regime is influenced by two (2) major features. Air masses moving across Colorado from the southwest and the northwest lose a large portion of their moisture over the Rocky Mountains. Conversely, air masses entering Colorado from the south or southeast can

transport moisture from the Gulf of Mexico. The influence of moisture from the Gulf region produces the largest amounts of spring and summer precipitation with thunderstorms.

The temperature and precipitation averages at the Facility are typical for eastern Colorado. The average annual temperature is 48.4°F, with an annual monthly average range of 25.0°F in January to 73.4°F in July. Average maximum temperatures range from 37.6°F in January to 89.0°F in July, while average minimum temperatures range from 12.5°F in January to 57.8°F in July. Average monthly precipitation ranges from 0.33 inches in February to 3.06 inches in May, with a total of annual average of approximately 16 inches.

3.4 GEOLOGICAL SETTING

Multiple geologic investigations have described and classified the geology in the Deer Trail area. Several of these studies are summarized in two reports by Browning- Ferris Industries, Inc., both named *Chemical Waste Treatment/Solidification & Disposal Facility Plan. Volume I - Technical Report* (BFI 1981 and 1982). Other notable reports include an evaluation conducted by the Colorado Geologic Survey (CGS 1986) and the 2004 *Permit Renewal Report* (CHDT 2004). The following sections summarize some of the information in these documents. For more information, refer to these documents in Volumes 2 through 6 the RML Application.

3.4.1 REGIONAL GEOLOGY

This section describes the Site's regional geologic setting. A focus is placed on the structural geology and stratigraphy of the Deer Trail area. This information is summarized from the Browning- Ferris Industries, Inc. Technical Reports (BFI 1981 and 1982).

3.4.1.1 Structural Geology

The Facility is situated on the eastern flank of a large structural basin, the Denver Basin, which encompasses northeastern Colorado, southeastern Wyoming, and southwestern Nebraska. The Denver Basin is a broad asymmetrical north-south trending structure east of the Front Range; the axis of the basin is approximated by a line from Cheyenne, Wyoming, to Denver, Colorado. It is characterized by a steeply dipping western limb truncated by the uplifted Rocky Mountains. The basin rises steeply immediately east of Denver, and more gently with eastward extent. Bedrock beneath the Facility dips at approximately 1± degree to the west.

Faulting associated with the Rocky Mountain uplift occurs in the western portions of the basin. Faulting in the eastern portion of the basin is rare to nonexistent (CGS 1986). Results from

geologic site characterization activities at the Facility have not revealed evidence of structural deformation inside the Facility Permit boundary. Regional bedrock geology in the Basin includes Precambrian Eon rocks and marine and non-marine deposits originating from the Pennsylvanian through Upper Cretaceous Periods. Basement materials consist of Precambrian Eon igneous and metamorphic rocks, primarily gneiss and granite, which occur at depths ranging from 8,000± to 10,000± feet. Cretaceous-age bedrock occurs at depths ranging from 2,000± to 4,000± feet in the western portion of the Basin, and at or near the surface in the eastern portion. The majority of rocks that outcrop at the surface are Upper Cretaceous age or younger. Additional information on the structural geology is available in the report by the Colorado Geologic Survey (CGS 1986).

3.4.1.2 Stratigraphy

No bedrock units outcrop within a 6-mile radius of the Facility. Surficial geology in the vicinity of the Site consists of (1) non-alluvial clay and silt deposits (i.e., loess) and (2) sandy clays and clayey sands, both of Quaternary origin. The loess, apparently deposited during the most recent glacial period, covers a large portion of the Facility area, and consists mainly of massive, well sorted silt, with occasional medium-grained fluvial sands in the bottom foot of the deposit. Discontinuous alluvial deposits are present within intermittent drainages in the vicinity of the Site; the composition of the alluvial deposits is a direct function of the parent rocks (BFI 1982).

The uppermost bedrock unit underlying the Facility, the Pierre Shale, is a gray to black, silty, fossiliferous shale, approximately 4,300 feet thick. Inside the Site boundary, the Pierre Shale occurs at depths ranging from 15 to 30 feet below the ground surface. The Pierre Shale is underlain by the gray, calcareous shale of the Niobrara Formation, which contains limestone and bentonite interbeds. The Niobrara Formation is approximately 500 feet thick, and contains two (2) major members, the Smokey Hill Shale and the Fort Hayes Limestone. The Niobrara Formation has produced natural gas in portions of the Denver Basin, but is not known to contain significant natural gas under the Facility.

The Niobrara Formation is underlain by the Benton Group, which includes the Carlisle Shale, the Greenhorn Limestone, and the Graneros Shale. The Carlisle Shale includes approximately 80 feet of gray, non-calcareous siltstone with occasional limestone interbeds. The Greenhorn Limestone consists of gray limestone with gray to black clayey shale, and is approximately 80 feet thick. The Graneros Shale, which is gray, clayey shale with interbedded siltstones, comprises the bottom 220 feet of the Benton Group (BFI 1982).

The Dakota Group, including the 'D' and 'J' Sandstones, underlies the Benton Group at an approximate depth of 5,000 feet below the ground surface. Regionally, both sandstones, characterized by 10 to 20 feet of medium-grained quartz sandstone, contain commercial quantities of oil and gas. Several other Mesozoic and Paleozoic Era deposits occur between the Dakota Group and the Precambrian basement rocks. Because these deposits are quite deep, and bear no significance to the permitting or operation of the facility, this report does not discuss them.

3.4.2 SITE GEOLOGY

This section discusses Site geomorphology and the shallow geologic units underlying the Site. The subsurface geology in the Site vicinity is relatively simple due to a limited number of stratigraphic horizons, and the lack of significant secondary structural processes that could have affected either surficial or bedrock units (CGS 1986). The shallowest bedrock formation of significant importance with regard to the permitting and operation of the Facility is the Pierre Shale. Due to their extreme depth, this application does not discuss the units underlying the Pierre Shale further.

3.4.2.1 Site Geomorphology

The Site vicinity is characterized by broadly rolling topography. The surface slope of the Facility ranges from flat to about 6 percent. Topographic relief in the Site vicinity results from erosional drainages, such as Beaver Creek (east of the Facility), and Wetzel Creek (on the west), and their tributaries, that are incised in the highly erodible clay-loam soils. The Site is topographically higher than the surrounding land.

3.4.2.2 Site Stratigraphy

Early field activities provided information on the stratigraphy of the deposits underlying the Facility to depths of more than 400 feet. Those activities included test borings, in-situ permeability tests, laboratory permeability tests (on retrieved core), and a seismic refraction investigation. Browning- Ferris Industries, Inc. summarizes the detailed analysis of those data (BFI 1982), and evaluates other regional information (i.e., regional geology, seismic information, and information from oil and gas wells).

Additional investigations by the Colorado Geological Survey (CGS 1986) provided information related to specific geologic and hydrologic characteristics of the Site. Based on analysis of the

previous investigations, McCulley, Frick, and Gilman presented the most detailed classification of surficial deposits and weathered and unweathered Pierre Shale (MFG 1997).

The subsurface geology includes 1± to 2± feet of silty clay topsoil sequentially underlain by three (3) stratigraphic units: 1) unconsolidated Quaternary sediments, including nonalluvial clay/silt deposits (Silty Clay Unit or Level 4A (L4A) Zone) and sandy clays and clayey sands (Level 3 (L3) Zone), 2) weathered Pierre Shale (Level 4 (L4) Zone), and 3) unweathered Pierre Shale (Level 5 (L5) Zone).

The unconsolidated sediments (comprising the Silty Clay) have been classified (MFG 1997) as wind-blown loess deposits (presumably originating from the northern and western portions of the Denver Basin) consisting of calcareous clayey silt and silty clay. A portion of the clay composition may be derived, in part, from in-place weathering of the Pierre Shale. The clay content of this unit, classified as CL (Low to Medium Plasticity Clay) according to the Unified Soil Classification System (USCS), increases with depth (MFG 1997). Inside the Facility boundary, this unit typically occurs between the ground surface and depths of 9 to 32 feet below the ground surface.

Alluvial deposits in the intermittent drainages outside the Facility boundary typically consist of fine silt and sand, and weathered clays originating from the Pierre Shale. The average sand content in these deposits is less than 3.0 percent. These sediments do not occur inside the Facility boundary; however, monitoring wells have been installed in these deposits.

A linear sand body has been defined in the Silty Clay Unit beneath the eastern portion of the Facility. This sand body, referred to as the L3 Zone, consists of sandy clays and clayey sand. The L3 Zone varies in width from 350 to 700 feet, and trends north-northeast to south-southwest across the Facility. Where present, this unit generally varies in thickness from 3 to 5 feet; the maximum documented thickness underlying the Site is 10.0 feet. Stratigraphically, the unit becomes fine with decreasing depth, and has a gradational upper contact with the Silty Clay Unit.

Weathered Pierre Shale, commonly encountered between 10.0 and 30.0 feet below the ground surface and typically 15 to 35 feet thick, is classified as CH (High Plasticity Clay) in the USCS. This unit is characterized by gray-brown to yellow-brown, silty, medium to hard, moist shale, with occasional low-angle fractures filled with gypsum and stained with iron. Occasional lenses of massive, gray calcite-cemented siltstone, approximately 3 to 5 feet thick and 2 to 12 feet long, occur in the weathered shale (MFG 1997).

The contact between the L3 Zone (where present) and the underlying weathered Pierre Shale is often distinct, but can be gradational. The contact between the unconsolidated deposits and the weathered shale is characterized by bedding planes and tight fractures, usually occurring over a 1 to 2 foot interval. The contact between the unconsolidated deposits and the weathered shale is classified as the L4A hydrostratigraphic unit.

Between depths of 40.0 to 55.0 feet, the weathered shale grades to unweathered shale of gray to dark gray, silty, laminated slightly calcareous, hard shale. The contact between the unweathered and weathered shale is termed the L4 zone. The shale is thinly laminated and interbedded with silt and traces of very fine sand. Hard, dry calcareous silt beds occur intermittently, ranging in thickness from about 2.0 inches to 1.5 feet. The silt beds appear to be discontinuous, because they cannot be correlated from one well to another. Rare, low-angle fractures in the silt are typically filled with gypsum and stained with iron. The unweathered shale typically grades from blocky structure, hard, and slightly moist near the top to uniform structure with depth (CGS 1986).

The weathered shale is distinguished from the unweathered shale by brown color and less massive structure. The thickness of the gradational contact between the weathered and unweathered shale varies from 10 to 20 feet; in some areas this transition zone comprises the majority of the weathered shale unit (MFG 1997). The unweathered Pierre Shale has engineering and hydrologic characteristics similar to those of the weathered Pierre Shale, except it is generally unfractured.

3.5 HYDROLOGIC SETTING

The surface water and groundwater hydrology of the Facility has been studied extensively. Detailed information on this hydrology is contained in the Browning- Ferris Industries, Inc. Technical Reports (BFI 1981 and 1982). The following sections summarize surface water and groundwater hydrology information derived from these documents.

3.5.1 REGIONAL HYDROLOGY

Regionally, the Denver Basin encompasses several groundwater aquifers located stratigraphically above the Pierre Shale. The principal aquifers in the western and central portions of the Basin are the Fox Hills Sandstone, Arapahoe/Denver Formation, and Dawson Formation. The Denver-area aquifers are recharged by precipitation and infiltration at outcrops in the extreme western portion of the Basin. The Ogallala Formation is recharged at outcrops extending over eastern Colorado, southwestern Nebraska, and western Kansas. Ground-water flow in the regional aquifers is

generally to the east. These geologic units have been eroded away at the Site location; the nearest Denver-area aquifer outcrop (the Fox Hills Sandstone) is approximately 10 miles west of the Facility. The Ogallala Formation is the primary aquifer east of the Site. The Site is approximately 20 miles from the western-most outcrop of the Ogallala Formation. Because all regional shallow aquifers have been eroded away, the Facility is hydraulically isolated.

3.5.2 SITE HYDROLOGY

This section presents a hydrologic characterization of the stratigraphic units discussed under Site Geology (Section 3.4.2). Covered is a description of both groundwater and surface water characteristics at the Site. Material for this section is based on previous reports and Facility monitoring data.

3.5.2.1 Surface Water Hydrology

There are no perennial streams, rivers, or surface water impoundments (other than stock tanks/ponds) near the Site. Because the Facility is topographically above the surrounding land, little or no potential for drainage onto the Site exists (i.e., there are no upstream drainage areas). Downstream drainage basins include the Wetzel and Beaver Creek drainages, which ultimately discharge to the South Platte River approximately 30 miles north of the Site.

Surface water drainage on the Site is controlled with a system of surface water drainage ditches and all Site surface water runoff is diverted to either a retention pond in the south, or a rainwater basin in the north. In addition, a floodplain analysis was performed for the confluence of the Beaver and Wetzel Creek drainages. Results of that study, based on a 100-year flood depth of 22± feet above the average stream elevation at the confluence, indicate that the lowest part of the Facility is at least 93.0 feet above the predicted floodplain elevation.

Due to the lack of perennial streams and shallow groundwater aquifers, groundwater/surface water interaction in the vicinity of the Facility is limited. Because there are no perennial streams near the Facility, few data regarding the quality of surface waters are available. One sample collected from a stock pond near the Facility was reported to contain a total dissolved solids concentration of 385.0 milligrams per liter (CGS 1986).

3.5.2.2 Hydrogeology

Groundwater occurrence in the vicinity of the Site is based on information from exploratory and Site characterization activities over the life of the Facility, information from the Colorado State

Engineer's Office, and the ongoing Facility groundwater monitoring program. Existing hydrostratigraphic units underlying the Facility are classified in accordance with the geologic stratigraphy presented in Section 3.4.2.2., and consistent with the nomenclature used for the current groundwater monitoring program.

Due to the unique geological setting in the vicinity of the Facility, the underlying deposits are hydraulically isolated from the regional aquifers. Therefore, there are no conventional groundwater aquifers in either the unconsolidated surficial deposits or the underlying bedrock (the Pierre Shale) in the vicinity of the Site. Further, groundwater supply wells in the vicinity are limited; all potable water is trucked to the Site.

The Facility is generally underlain by roughly 150 to 175 feet of unsaturated materials (through which the potential for infiltration is negligible). Beneath the Pierre Shale, potential water-bearing zones underlying the Facility are limited to the 'D' and 'J' Sandstones of the Dakota Group, which are approximately 5,000± feet below the ground surface at the Site location. Both sandstones are primarily oil and gas production zones; the water quality is poor due to naturally occurring concentrations of total dissolved solids and hydrocarbons. No other identifiable water-bearing zones occur between the Dakota Group and the Pierre Shale.

Naturally occurring groundwater does occur in discontinuous perched zones underlying the Facility. These isolated saturated zones are the focus of the discussion in the following section. In addition, disposal of produced water from an onsite oil well (the Jolly-Axtell #2) to a pond (referred to as the "brine pond") in the northern portion of the Facility has resulted in the presence of shallow groundwater beneath a small part of the Facility. In 1988, Triegel & Associates evaluated the relationship between the pond operation and groundwater quality with respect to RCRA groundwater monitoring requirements. The Jolly-Axtell well and another oil well inside the property boundary (Zexco-State #1-36), were plugged and abandoned in 1986 and 1984, respectively, in accordance with Colorado Oil and Gas Commission regulations. The brine pond was closed in 1986.

3.5.2.2.1 Hydrostratigraphic Units

Based on historical characterization activities at the Facility and the current groundwater monitoring program, the hydrostratigraphic units underlying the Facility have been classified into five (5) different zones (MFG 1997).

- The L3 Zone (the sand lens occurring in the surficial Silty Clay Unit);

- The L4A Zone (the interface between the surficial Silty Clay Unit and the underlying weathered Pierre Shale);
- The L4 Zone (the interface between the weathered Pierre Shale and the unweathered Pierre Shale);
- The L5 Zone (the uppermost water-bearing unit beneath the facility; defined as the uppermost saturated portion of the unweathered Pierre Shale); and
- The L6 Zone (the first occurrence of saturated conditions in the alluvial drainages outside the compliance boundary).

The L3 Zone is defined as the discrete lenticular sand body that occurs infrequently in the surficial silty clay unit. Monitoring wells were historically installed at 50 foot intervals along the compliance boundary and in those areas where the L3 Zone is present. However, in a previous Class 2 Modification to the Part B Permit, the approach to the number and location of new L3 Zone wells was modified; new L3 wells are located along potential fluid migration pathways in the L3 Zone. L3 wells are screened from approximately 9 to 36 feet below the ground surface, with water being detected in only one of the thirty-nine (39) L3 wells throughout facility history. During the construction of future cells at the Facility, a large part of the L3 Zone will be removed. In addition, the cell construction specifications require the removal of L3 Zone and replacement with an engineered clay barrier (minimum hydraulic conductivity of 1.0×10^{-8} centimeters per second (cm/s)) of sufficient thickness to provide a 1,000-year travel time barrier to any migration of fluids from the secure cell to the remaining L3 Zone.

The L4A Zone is defined as the interface between the Surficial Silty Clay Unit and the underlying weathered Pierre Shale. Monitoring wells are installed at 100-foot intervals in areas where the L4A Zone is (or historically was) saturated. L4A wells are screened from 12 to 19 feet below the ground surface. Saturated conditions in the L4A Zone occur only along the northern compliance boundary in the vicinity of a former oil-field brine pond near well L4-33.

The L4 Zone is defined as the interface between the weathered Pierre Shale and the underlying unweathered Pierre Shale. L4 Zone wells are screened from 32 to 64 feet below the ground surface. The typical depth of the weathered/unweathered shale contact is approximately coincident with the proposed depths of the landfill cells. Monitoring wells are installed at 300 foot intervals along the compliance boundary except in areas where the L4 Zone is (or historically was) saturated, where closer (100 foot) spacings are required.

The saturated conditions requiring tighter spacing of L4 wells occur only along portions of the northern compliance boundary in the vicinity of the former brine pond and along the western compliance boundary in the vicinity of Cells 1 and 2 (See Figure 6: *Potentiometric Surface Map L4 Zone*). The occurrence of saturated conditions adjacent to Secure Cell 2 results from recharge of incident precipitation through the base of the Cell 2 excavation, which was unlined from about August 1989 to July 1995. During this time, water apparently seeped into the weathered portion of the Pierre shale that was exposed in the base and walls of the unlined excavation and slowly moved along the weathered/unweathered Pierre Shale interface.

The L5 Zone represents the uppermost water-bearing unit at the Facility and is defined as the uppermost saturated portion of the unweathered Pierre Shale. The L5 wells are screened in the silt lenses that occur at various depths in the unweathered Pierre Shale, ranging from approximately 250 to 415 feet below the ground surface.

The L6 Zone is defined as the first occurrence of saturated conditions in the alluvial drainages outside the compliance boundary. Focused recharge in offsite drainages results in limited areas of saturation that occur in shallow alluvial materials. Three (3) L6 Zone wells are in the vicinity of the Facility. The wells are screened in silt and fine sand units overlying the weathered Pierre Shale, and in the unweathered Pierre Shale. Depth to groundwater in the L6 Zone wells ranges from 10± to 50± feet below the ground surface.

3.5.2.2.2 Hydraulic Characteristics

Discussion of hydraulic characteristics (i.e., groundwater flow direction and velocity) is somewhat misleading because it implies the presence of a conventional aquifer system, which is not the case for the Site. However, groundwater does exist in discrete perched systems. The L5 Zone, characterized by thin laminated beds of silt and clay, is likely recharged by fracture flow (MFG 1997) and flow through thin, silty partings. The L4A and L4 Zones exhibit precipitation dominated recharge. Due to the significance of precipitation recharge to the L4 and L4A Zones, surface drainage and runoff patterns are reflected in the location and elevation of groundwater within these zones.

The initial investigations conducted to complete the RCRA Part B Permit application thoroughly evaluated the hydraulic properties of current or potential hydrostratigraphic units in the vicinity of the Site. Testing included thirty (30) in situ standpipe permeability tests, thirty-one (31) packer tests, two (2) hydraulic stress tests, and ten (10) laboratory analyses on undisturbed and remolded

samples. A summary of the packer and standpipe permeability tests are summarized in the Browning-Ferris Industries, Inc. technical report (BFI 1982).

Based on the results of the standpipe and packer tests, the saturated hydraulic conductivity of the units underlying the Facility varies from 5.1×10^{-4} to less than 2.3×10^{-8} cm/s. Because the extent of saturation in the L4 and L4A Zones is limited, and the L5 Zone wells yield so little water, the performance of long-term multiwell pumping tests at the Facility has not been possible. Therefore, no estimates of formation storativity are available.

June 2010 conditions in the L4 Zone yielded a maximum hydraulic gradient of 1.7 percent (wells L4-33 and L4-32E). Maximum expected linear groundwater velocities have been calculated for the L4 Zone at 4± feet/year. This value is based on an effective porosity of 0.1, an average hydraulic conductivity of 1.8×10^{-5} cm/sec, and a maximum expected groundwater gradient of 2.1 percent (current maximum plus 25.0 percent). Depending on moisture content, the unsaturated flow velocity can be several orders of magnitude lower than saturated flow velocities (MFG 1997).

Because hydrogeologic conditions at the Facility result in limited areas of saturation in shallow hydrostratigraphic zones and there is no definable hydraulic gradient in the L5 Zone, presentation of potentiometric surface maps to assess groundwater flow direction in each zone is not warranted. However, the following general statements can be made about groundwater flow beneath the Facility:

- Of the one location at which groundwater has been detected in the L3 zone, well L3-42, flow is expected to be vertically downward at this location because groundwater here is perched in a depression at the base of the L3 Zone. In the event that saturated conditions were to occur above the critical elevation of this isolated depression, groundwater would travel down dip along the base of the L3 Zone.

- As indicated by the vertical head differences in adjacent wells completed in the upper L4A Zone and in the lower L4 Zone, the primary groundwater flow direction here is vertical, with the residual water in the surficial silty clay unit draining vertically into the underlying Pierre shale.

- The low hydraulic conductivity of the hydrostratigraphic units at the Facility limits the amount of groundwater inflow to wells between sampling events. Lateral flow in the L4 Zone is predominantly the result of groundwater gradients imposed during the sampling process.

- The L5 Zone represents the “uppermost aquifer” at the Facility, as that term is used in the regulatory context (40 CFR §260.10). In a conventional hydrogeologic sense, the L5 Zone is not an aquifer, as evidenced by low yield wells and very slow recovery rates following purging and sampling. Saturated zones monitored by the L5 Zone wells are hydraulically isolated silt lenses recharged by secondary permeability.

- Groundwater in the L6 Zone is assumed to flow horizontally along the offsite drainages, with a small amount of vertical leakage to the underlying geologic units.

Plates 1 through 4 present the Facilities groundwater monitoring network and quarterly groundwater elevations from 2012.

4 SECURE CELL DESIGN, OPERATION AND SETTING

This section briefly describes the design of the secure cells and operational activities as it relates to control of leachate within the secure cells. The intention is to provide a background for how the monitoring program is designed and what potential migration pathways exist in the event of release from a Secure Cell. A detailed description of these program components can be found in the RCRA Part B Permit.

4.1 LAND DISPOSAL RESTRICTIONS

Land Disposal Regulations (LDRs) are established by the United States Environmental Protection Agency (USEPA) in 40 CFR Part 268, and by the Colorado Department of Public Health and Environment (CDPHE) in 6 CCR 1007-3, Part 268. These LDRs restrict the types and amounts of materials that can be landfilled at the Site. Treatment standards are established for restricted hazardous wastes established under RCRA. Each waste stream entering the Facility is analyzed prior to receipt to screen the waste composition against the LDR limits specified in 40 CFR 268. If needed, the waste is treated to meet the LDR limits prior to disposal in the Secure Cell.

4.2 LINER DESIGN

The landfill cells are designed with double liners, leachate collection and removal systems (LCSs), and leachate detections systems (LDSs). The liner systems are designed to meet the performance objectives set forth by EPA (40 CFR 264.100). These performance objectives are designed to prevent hazardous constituents from migrating out of a cell through the end of post closure care.

The double liner system consists of primary and secondary composite clay liners separated by an LDS. An LCS is located above the primary liner, which is overlain by a protective soil layer. Below the secondary liner is a permanent sump (PS). This sump collects naturally occurring vadose zone water. In the improbable event that leakage should occur, this sump would allow for detection and removal of leachate that had migrated through the collection systems.

4.3 SECURE CELL LAYOUT

A plan view layout of the existing and proposed secure cells can be seen in Figure 7: *Cell Design*. The bottom of the secure cells is designed to be roughly corresponding with the contact between

the weathered and unweathered Pierre Shale (L4 Zone). For cells planned to be constructed within the L3 Zone, the L3 Zone material will be removed adjacent to the cell and replaced with a barrier that has a hydraulic travel time equal to that of a 100.0 foot thick clay with a hydraulic conductivity of 1.0×10^{-7} cm/s (RCRA Part B Permit Attachment 10.1, Section 02119).

5 GROUNDWATER PROTECTION PROGRAM

The primary objective of the Groundwater Protection Program (GPP) at the CHDT Facility is to detect a release of contaminants to Site groundwater with for the purpose of satisfying the requirements of 6CCR 1007-3 Part 264, Subpart F. Monitoring of permitted units at the site is also included in this program. The successful accomplishment of this objective requires that representative groundwater samples be collected from the detection monitoring well network with a regular frequency. The data must then be evaluated using appropriate analytical and statistical methodologies in order to identify a potential release. The specific methods and tools employed by the Facility to accomplish this objective, including proposed revisions, are addressed in the following sections.

5.1 MONITORING PROGRAM DESCRIPTION

The current GPP is described in Part VII and Attachment 8 of the 2013 Part B State RCRA Permit, Clean Harbors Deer Trail, LLC (Permit). The GPP has been divided into three (3) main components: 1) Performance Monitoring, 2) Inspection Monitoring, and 3) Detection Monitoring. Performance monitoring involves fluid level and chemical monitoring in the Secure Cell LCSs and LDSs, the Treatment Building LDS, and the Permanent Sumps. Inspection monitoring involves fluid level monitoring in Facility wells. Detection monitoring involves chemical monitoring in Facility wells. Each of these components is discussed in detail in the following sections.

5.1.1 PERFORMANCE MONITORING

Performance Monitoring involves monitoring for fluid levels and water quality at the Secure Cells and the Treatment Building Surface Impoundment. The locations of monitoring include the LCSs, LDSs, and Permanent Sumps. LCS monitoring is designed to collect data for characterization of the chemical composition of leachate within the primary liner of the Secure Cells. LDS and Permanent Sump monitoring is designed to collect data for the purpose of evaluating the performance of Secure Cell leachate containment. The design and rationale of monitoring at the LCSs, LDSs, and Permanent Sumps is described below.

5.1.1.1 Leachate Collection System Monitoring

As described in Section 4.2: *Liner Design*, the LCS is contained within the primary liner of the secure cells. LCS monitoring involves the collection and analysis of leachate levels and chemical composition within these Secure Cells. Leachate is the primary potential source of releases to groundwater at the site. Characterization of the leachate composition provides an understanding of what potential impacts there may be in the event of a release from the Secure Cell. Additionally, this characterization provides a unique identifier, or "fingerprint", to aid in determining the location of the source of contamination in the event that it is detected in a Facility monitoring well.

5.1.1.2 Secure Cell Leak Detection System Monitoring

Each Secure Cell, as well as the Treatment Building Impoundment, contains an LDS. As described in Section 4.2: *Liner Design*, the LDS is located between the primary and secondary liners. LDSs are monitored to detect the presence of leachate outside of a primary liner, which would indicate potential failure of that liner. This is accomplished through the application of two approaches: 1) monitoring for increased fluid levels in the LDSs, and 2) monitoring the fluids in the LDSs for parameters that are unique to the composition of the secure cell or impoundment leachate.

Fluid levels in the LDSs are monitored weekly. In the event that weekly measurements indicate an increase in fluid levels, the measurements will be evaluated to determine a potential cause of the increase (Permit Attachment 3). If the evaluation indicates a release from the regulated unit pursuant to Permit Attachment 3 (*Inspection Plan),* then the Contingency Plan (Permit Attachment 4, Sections II.B.1 and II.B.2) will be implemented. Monitoring the chemical composition of fluids in the LDSs constitutes a secondary measure to detect the presence of leachate outside of the primary liner. In the event that the constituents analyzed for as listed in Table VII-3 of the Permit are detected and verified within the LDS, the Contingency Plan will be implemented (Permit Attachment 4, Section II.B.1).

5.1.1.3 Permanent Sump Monitoring

As described in Section 4.2: *Liner Design*, each cell is underlain by a Permanent Sump. Fluids within the permanent sumps are monitored for fluid level and chemical composition. Sampling and laboratory analysis of groundwater in the Permanent Sumps is used to evaluate the performance of the Secure Cells. Chemical monitoring in these sumps supplements the performance monitoring conducted in the LDSs. In the unlikely event that a breach in the liner

system occurs and is not identified through hydraulic or chemical monitoring of the LDS fluids, the Permanent Sumps are monitored to detect contaminants or leachate outside of the Secure Cell liners. Identification of contaminants or leachate within a Permanent Sumps will trigger implementation of the Contingency Plan (Permit Attachment 4, Sections II.B.1 and II.B.2).

5.1.2 INSPECTION MONITORING

Inspection Monitoring requires the measurement of fluid levels at Facility groundwater wells to determine the potentiometric head at each monitoring location. These head values are utilized in the characterization of the Site's hydrogeologic environment. Spatial distributions of potentiometric head are used to determine the direction of movement and spatial distribution of groundwater. Temporal changes in the potentiometric head are used to identify temporal changes in the hydrologic environment.

5.1.3 DETECTION MONITORING

Detection Monitoring consists of groundwater sampling and laboratory analysis of groundwater samples collected from Facility monitoring wells. Chemical data collected at facility wells are analyzed to detect the presence of contaminants within the hydrogeologic environment beneath the Facility. This sampling and analysis process supplements the Secure Cell and Surface Impoundment Performance Monitoring in monitoring for a release of contaminants from the secure cells to the subsurface environment.

5.2 DATA EVALUATION

Data evaluation involves quality control/quality analysis (QAQC) of monitoring data, as well as analysis of that data for indications of contaminant releases to the subsurface environment. Monitoring data includes fluid level and chemical monitoring results collected from site monitoring wells, LDSs, and Permanent Sumps. Data evaluation processes applied to monitoring data is briefly described below. For detailed more detailed description of data evaluation procedures, please refer to Permit Section VII.C: *Data Evaluation* and Permit Attachment 8, Appendix 8.

5.2.1 FLUID LEVEL EVALUATION

Data evaluation is completed for groundwater levels at facility monitoring wells on a quarterly basis, and for fluid levels at LCSs and LDSs on a weekly basis (Permit Section VII.C.1).

Groundwater levels at all facility wells are screened for statistically significant increases in groundwater elevation by comparing the current value to a statistical limit calculated for that well. This limit is computed as the mean plus two standard deviations from the historic groundwater elevation at that well.

5.2.2 CHEMICAL DATA EVALUATION

Evaluation of groundwater quality results are completed semiannually (Permit Table VII-1). This evaluation consists of three (3) primary components capable of triggering a programmatic change: 1) determination of a significant increase over the background value for inorganic Detection Monitoring Parameters (Permit Section VII.C.3.a.), 2) determination of an organic constituent detection above the reportable detection limit in any detection monitoring well or leak detection system (Permit Section VII.C.3.b.), and 3) determination of a significant trend variation for General Groundwater Quality Parameters (Permit Section VII.C.3.c.).

Prior to initiation of the above evaluation components, descriptive statistics are completed to characterize the background datasets and to select appropriate statistical methods (Permit Section VII.C.4.a.). Trend analyses are performed for each dataset with ten (10) or more points to identify any temporal changes (Permit Sections VII.C.4.b., VII.C.6. and VII.C.8.d.). Outlier tests are performed to detect anomalous data that should be further evaluated. Data evaluation methods include box and whisker plots, Dixon's test, Rosner's test, and ASTM E178-94. The cases for which these tests are performed are described in Permit Attachment 8, Appendix 8.

Duplicate samples are evaluated to test the consistency of the laboratory analyses. Duplicate samples are screened for a relative percent difference of 20.0%. Laboratory quality assurance and quality control analyses also screen the data through analysis of trip blanks, equipment blanks, method blanks, matrix spikes, laboratory control samples and surrogate spikes. (Permit Attachment 8, Appendix 8)

5.2.3 BACKGROUND DATABASE

A background database is defined in the Permit as all groundwater monitoring data collected prior to waste acceptance at the Facility from the monitoring wells, and all data that meets the criteria specified in Permit Section VII.C.9.c. Data that do not meet the specified criteria is reanalyzed or resampled to verify the monitoring results (Permit Section VII.C.9.c.i.). Data that do not meet the specified criteria will be included in the background database if they are proven to represent natural Site conditions (Permit Section VII.C.9.c.iii.).

6 PROPOSED MODIFICATIONS

An evaluation has been completed in support of the proposed revisions to the Groundwater Protection Program at the Site. There is sufficient data to justify a reevaluation of the methods employed in the Site's Groundwater Protection Program. This evaluation has been completed using the data collected and previous reports prepared regarding environmental conditions at the Site. The proposed modifications address three (3) areas of the Groundwater Protection Program: 1) Monitoring frequency and Operations, 2) Monitoring of immiscible liquids levels and organic vapors and 3) statistical analysis methods. Minor modifications include revising outdated text, updating certain submittal deadlines to be consistent in relation to one another, and updating quality assurance methods during sampling.

6.1 MONITORING FREQUENCY AND OPERATIONS

Monitoring frequency describes the intervals over which the collection of chemical and fluid level data from Facility monitoring points is conducted. Inspection monitoring is currently conducted quarterly and detection monitoring is conducted semiannually at all program monitoring wells. Performance monitoring for fluid levels is conducted weekly. Sampling and laboratory analysis is conducted semiannually at all Secure Cell Permanent Sumps, Secure Cell LDSs, and the Treatment Building LDS. Sampling and laboratory analysis is conducted quarterly at the active Secure Cell LCS and annually at closed Secure Cell LCSs.

Monitoring frequency has been evaluated for each of the three (3) main program components (Performance, Inspection, and Detection Monitoring). There are no proposed changes for the frequency of hydraulic measurements associated with performance monitoring. Changes are proposed for the frequency of sampling and laboratory analyses associated with performance monitoring, inspection monitoring, and monitoring for radiochemistry parameters.

6.1.1 PERFORMANCE MONITORING

Changes are proposed for one (1) area of sampling and laboratory analysis associated with Performance Monitoring at the Active Secure Cell LCS, which is discussed below.

6.1.1.1 Active Secure Cell Leachate Collection Systems

As described in Section 6.1.1, sampling and laboratory analysis at the LCSs is conducted for the purpose of identifying potential impacts in the event of a release from a secure cell and the source of contamination detected. The current Performance Monitoring Program as described in Section 5.1.1 entails weekly inspections and fluid levels from the primary, secondary, and tertiary sumps for active cells. Data is collected and evaluated on a weekly basis to monitor any changes in leachate volumes that may be an indication of a release from the cell. In addition, the permit requires annual updates to the list of detection monitoring parameters based on the composition of the secure cell leachate. Because statistical analysis of short term trends are not performed on leachate composition results, quarterly chemical monitoring of this system is not warranted. As such, semiannual sampling is sufficient for the active Secure Cell Leachate. This semiannual frequency will continue to provide adequate evaluation of potential modifications to the list of detection monitoring parameters. Therefore, it is suggested that the frequency of sampling and laboratory analysis at active Secure Cell LCSs be modified to a semiannual sampling schedule.

6.1.2 INSPECTION MONITORING

As described in Section 5.1.2, Inspection Monitoring is intended to aid in characterization of the hydraulic properties of the hydrogeologic environment beneath the Facility. Fluid levels in groundwater wells and leachate sumps have been measured at the Facility since the monitoring program began in 1986. The last twenty-six (26) years of groundwater-specific fluid levels provide a comprehensive and robust data set that incorporates both the temporal and spatial aspects of hydrogeologic conditions at the site and effectively characterizes the site hydrology. Approximately 20,000 fluid level readings have been recorded at the site since 1986, which also includes the readings that indicate the well was dry. It is estimated that at least 12,000 of these fluid level readings are associated with the current groundwater monitoring program. An approximate breakdown based on Permit-defined stratigraphic zones is as follows:

- The Level 3 Zone is defined as the discrete lenticular sand body that occurs within the surficial Silty Clay Unit. Thirty-three wells were installed in this hydro-stratigraphic unit and with the exception of L3-42, this zone has historically been dry. There are approximately 100 water levels associate with L3-42. All wells in this zone are gauged quarterly with the majority of them being historically dry. See Attachment 1 for the historical groundwater elevation versus time hydrograph of L3-42.

- The Level 4A and 4 Zones are defined as the interface between the surficial Silty Clay unit and the underlying weathered Pierre Shale for the 4A zone and the interface between the weathered Pierre Shale and the underlying unweathered Pierre Shale. Combined there are currently sixty monitoring wells within these two zones; and thirty-four of these wells have exhibited groundwater elevations since the zone 4 and 4A wells were installed. There are at least 2200 groundwater elevations associated with the wells in these zones since the wells were installed. See Attachment 1 for the historical groundwater elevation versus time hydrographs for the L4 and L4A zone wells.

- The Level 5 Zone is defined as the uppermost saturated, water producing, portion of the unweathered Pierre Shale. There are eight wells within this hydro-stratigraphic zone and all eight wells have exhibited a groundwater elevation every quarter since these wells were installed. There have been at least 900 groundwater elevations associated with the zone 5 wells since 1986. See Attachment 1 for the historical groundwater elevation versus time hydrographs from the Level 5 wells.

- Level 6 Zone is defined as the first occurrence of saturated conditions in the alluvial drainages outside the Compliance Boundary. There are three wells within this hydro-stratigraphic unit. All three of these wells have exhibited groundwater elevations in the past, however, two of these wells are have been dry for the majority of the historical gauging events and do not yield enough groundwater to continuously collect groundwater samples. One of these wells (L6-3A) consistently exhibits measurable groundwater. There have been at least 400 groundwater level measurements associated with these wells since they were installed. See Attachment 1 for the historical groundwater elevation versus time hydrographs from the Level 6 wells.

A review of quarterly water levels for this 26-year period has shown normal temporal fluctuations across the site. These fluctuations for the shallow wells (primarily Zone 4 wells) appear to coincide with site precipitation patterns based on their generally water-producing nature and related hydrographs. Fluid level exceedances that have been identified have been evaluated using both hydrogeological and hydrogeochemical methods and determined to not be related to a release from a regulated unit on site.

The current monitoring well network at the Site is a system of one-hundred and ten (110) groundwater monitoring wells (see Plate 1: *Site Basemap and Monitoring Locations*). The network monitors hydrogeologic and hydrogeochemical conditions in five (5) hydrostratigraphic units (see Section 3.5.2.2: *Groundwater Hydrology* for a description of these units). Thirty-eight

(38) monitoring wells are screened in the L3 Zone, fifty-three (53) monitoring wells are screened in the L4 Zone, seven (7) monitoring wells are screened in the L4A Zone, eight (8) monitoring wells are screened in the L5 Zone, and three (3) monitoring wells are screened in the L6 Zone. Each of these wells is currently used to monitor hydrogeologic conditions; and when samples are collected, hydrogeochemical conditions. As per Permit Attachment 8 (Ground Water Sampling Plan), Section III.A.5, a well "classification" event shall be performed during the first sampling event of each year. During this event, all monitoring wells that have water above the top of the sump are purged dry and recharge is measured. Depending on rate of recharge, each well purged is then classified as "rapidly recovering, low yield, or no-yield wells. Historical field observations indicate that thirty-seven (37) out of 38 L3 Zone wells, thirty (30) out of 53 L4 Zone wells, one L4A, and one L6 Zone well are physically dry and classification cannot be performed on these wells. Additionally, multiple wells, including at least one L4A and three L4 wells cannot be classified due to water levels that are consistently below the bottom of the screen.

Based on the 26 years worth of quarterly monitoring data in existing wells, coupled with the lack of groundwater in more than sixty percent of the Sites' monitoring locations, quarterly fluid level measurements do not provide additional useful information to the existing hydrogeologic database. Therefore, it is proposed that the historically dry wells be gauged on an annual schedule for three years; after which the frequency is reduced to a triennial (every three years) gauging schedule. It is additionally proposed that the forty-one (41) wells that do exhibit groundwater be gauged annually during the second quarter well classification event to coincide with detection monitoring. The wells that classify for the current sampling year will continue to be gauged during the proposed regularly scheduled sampling events (semiannual). In the event that groundwater is observed in a dry well, guidelines set forth in the Final Permit will be followed. Continued fluid level monitoring will focus on the collection of data for the purpose of tracking long term trends in the hydrogeologic environment. This proposed frequency will continue to provide the data necessary to evaluate temporal and spatial variability across the site and provide current conditions and information to CDPHE, while bringing the inspection and detection monitoring frequencies into sync with each other.

6.1.3 DETECTION MONITORING

As described in Section 5.1.3, detection monitoring is the required sampling and analysis of groundwater chemistry at Facility monitoring wells. Detection monitoring at the Site occurs on a quarterly schedule for analyses of radiochemistry parameters and on a semiannual basis for parameters listed in Table VII-3 of the permit (which also includes radiochemistry parameters).

Since 1986, Over 6,000 samples have been collected and over 200,000 analytical results reported and are currently stored in the site database. Currently, both the Groundwater Protection Program and the Radioactive Materials License (CDPHE License Number Colo. 1102-01) require monitoring for the same radiochemistry parameters. This redundancy introduces confusion into the sampling plan. Monthly background sampling for an extended background list of radiological parameters occurred from April 2005 through March 2006. Since March 2006, quarterly sampling for radiological parameters has been conducted. This has resulted in a background data set for radiological parameter of more than 40 data points for each regularly-sampled analyte.

Background radiochemistry data from the time period April 2005 – March 2006 have been compiled, and historical concentration vs time (C vs T) graphs, histograms, and scatter plots have been evaluated. This evaluation indicates the following:

- Scatter plots reveal no strong seasonal correlation to the data set;
- A reasonably strong correlation appears to exist between radionuclide activity and stratigraphic units. The weathered bedrock (Pierre Shale) of the L4 unit has much higher radionuclide activity than the unweathered Pierre Shale bedrock unit. The L4 unit has multiple exceedances to the EPA Drinking Water Standards including gross alpha, uranium, and Radium-226/228. This is not uncommon for groundwater originating from the Eastern Colorado Plains;
- Uranium radionuclides are found at the highest concentrations in the weathered Pierre Shale bedrock, specifically at locations L4-16, L4-32WA, and L4-32EA. Elevated gross alpha is found at the same locations. The contribution to gross alpha from Uranium is not counted toward the 15 pCi/L maximum contaminant level (MCL). Gross alpha concentrations are typically well below the 15 pCi/L MCL in the L5 bedrock unit where Uranium radionuclide values are also low;
- Gross beta concentrations greater than 50 pCi/L have the potential to emit energy greater than 4 millirems per year (mrem/yr). At the Facility, the weathered Pierre Shale bedrock and LCS samples are typically much greater than 50 pCi/L. Potassium-40 from the cement kiln dust and fly ash is a likely source of the beta emissions in the LCS samples. Decay products of Th-232 and Uranium also emit beta particles and could contribute to the beta activity in the shallow bedrock (L4 wells).

Upon review of radiochemistry data over this time, little variance from event-to-event has been observed. In the atypical event where a small increase or spike was observed, the concentrations generally increased within the same order of magnitude and the concentration returned to "normal" (compared to background levels) within one – two sampling events. The C vs. T plots that were evaluated can be found in Appendix A.

Therefore, it is proposed that the sampling frequency for radiochemistry parameters as part of the detection monitoring program be revised to a semiannual sampling frequency, coinciding with the frequency of the Groundwater Protection Program.

It is also proposed that semi-annual detection monitoring events be rescheduled to take place during April (2nd quarter) and October (4th quarter). Currently, the events occur in June (2nd quarter) and December (4th quarter) and are frequently delayed by weather issues. Additionally, an updates to Appendix 2, 3 and 4 of the Groundwater Sampling Plan is proposed. A revised set of forms for Monitoring Well Inspection and Fluid Level Collection, a Monitoring Well Classification and Evacuation Field Log, and a Monitoring Well Sampling Field Log are presented in Appendix B.

6.2 MONITORING OF IMMISCIBLE LIQUIDS LEVELS AND ORGANIC VAPORS

The permit currently requires measuring of immiscible liquid elevations in wells prior to measuring the groundwater surface elevation. Because light, non-aqueous phase liquids (LNAPLs) have historically not been detected in LDS or the permanent sumps, it is unlikely that immiscible liquids would be present in the groundwater monitoring network. If LNAPLs were to be released, it would be detected in the Secure Cell sampling and/or LDS sampling prior to being observed in groundwater wells. Based on lack of historic LNAPL detections coupled with the intact monitoring system at the Secure Cell and LDS levels, it is proposed that the requirement to use an interface probe for fluid levels be removed from the permit. In the event LNAPL compounds are noted in the analytical data at any LDS sampling points or monitoring wells, this interface probe requirement shall be re-imposed on the target well and any immediately adjacent monitoring wells.

A review of historic organic vapor monitoring (OVM) data collected as part of the inspection monitoring program shows that organic vapors have not been detected above background levels, nor have ever prompted any remedial action due to increased OVM reading. After a review of historic readings recorded on field data sheets, OVM readings greater than 1.0 parts per million (ppm) above background have not been observed. OVM readings typically range between 0.0

and 0.5 ppm. Based on this review, the source of any organic vapors would most likely be from the Secure Cells and organic constituent-causing vapors would likely be detected at leachate sampling locations prior to monitoring well locations. Based on these conditions, it is proposed that this organic vapor monitoring requirement at sampling locations be removed from the permit.

6.3 MONITORING AND SAMPLING OPERATIONS

The Groundwater Sampling plan requires that the monitoring wells be classified annually in order to determine if the well is a high yield, low yield, or no yield well. According to the Permit and the Groundwater Sampling Plan, high yield wells recover at least 90 percent of their initial water level within 12 hours of being purged, low yield wells are defined as wells that take longer than 12 hours to recover to at least 90% of the initial water level prior to purging, and no yield wells do not recover 90 percent of the initial water level within 36 to 48 hours. Logistically, the collection of groundwater levels at the 12-hour mark is not feasible and would require personnel to remain on-site for 24 hours. Therefore, it is recommended that the 12-hour measurement requirement be increased to 24 hours. Field observations have shown that the number of wells classified as high, low or no yield will not significantly change over the course of 24-hour measurement cycle. The wells that have been assessed annually as high-yield wells show little variability in terms of overall yield. Basically, the high-yield wells tend to consistently repeat as high-yield wells. Similarly, those wells classified as low-yield or dry wells also exhibit minimal variability. It is has been noted that between 0 – 3 wells annually vary between low yield and dry yield wells. Based on this information, sampling locations within the monitoring network will remain consistent regardless of 12-, 24-, or 36-hour recharge measurements.

Furthermore, high yield wells must be purged prior to sampling by removing three casing volumes or until field parameters have stabilized. Low yield wells are purged according to the procedures in *Groundwater Sampling Procedure for Low Stress (Low Flow) Purging and Sampling* (EPA 1998). Low-Flow Purging and Sampling is becoming increasingly accepted within the environmental monitoring community for numerous reasons including minimizing the drawdown and total purge volume, reducing the stress placed on the aquifer, and decreasing the mixing of stagnant casing water with formation water. Based on the above criteria, it is proposed that Low-Flow procedures for purging and sampling be utilized at all classified monitoring wells, with the exception of the deep L5 wells. The deep L5 Zone wells each have a dedicated electric pump system to purge and conduct sampling.

Other general language modifications and updates pertaining to the Permit and Groundwater Sampling Plan are also proposed. These updates, which are based on both field observations and

historical annual reports, should help facilitate the overall flow and understanding of the Groundwater Protection Program. Specifically, in the Groundwater Sampling Plan, updating the Facility name from *Highway 36* to Clean Harbors Deer Trail (Section III.C, X.A and X.B) in the Groundwater Sampling Plan, removing references of Table VII-4 (leftover from 2005 Permit) and updating Section V.C (equipment blanks) as well as updates to outdated Groundwater Monitoring Logs and other field forms. Suggested updates to Section VII.C. of the Permit are proposed in order to clarify and streamline the data evaluation process as well as modifying Table VII-1 to include previously discussed changes and other general document updates.

6.4 STATISTICAL METHODS

The objective of statistical analysis of groundwater data is to identify statistically significant changes in the groundwater quality. Identification of these changes in groundwater quality will aid in the early detection of a release from a regulated unit at the Facility. A robust statistical approach will maximize the potential for release detection while minimize the frequency of false positive results. The design of the statistical methods aims to characterize the natural background properties of the hydrogeologic system from which groundwater samples are to be compared. A background dataset is defined for each monitoring parameter at each monitoring well, and consists of data obtained prior to waste acceptance at the Facility (or waste acceptance into each individual secure cell) and data obtained after waste acceptance that passes the prescribed statistical tests. Proposed changes to the statistical analysis methods concern the analysis of indicator parameters, as described in the following section. The selection of the combined Shewhart-CUSUM Intrawell control chart removes aspects of spatial variability from the analysis and allows for detection of both rapid and subtle changes in groundwater quality. Control Charts can be found in Appendix C.

6.4.1 INDICATOR PARAMETER ANALYSIS

A combined Shewhart-CUSUM control chart approach (Lucas, 1982) is recommended for statistical analysis of indicator parameters at the Site. This will replace the current Tolerance and Prediction Limit approaches. Shewhart-CUSUM control charts are sensitive to detection of both gradual increases in parameter concentrations as well as spikes in parameter concentrations. This approach also serves to reduce the frequency of false positives as additional samples are added to the background database.

Statistically significant evidence of an increase in analyte concentration occurs when the plotted Shewhart or CUSUM value exceeds its respective limit. The default upper Shewhart and

CUSUM control limits (SCL and h) are set to 4.5 and 5.0, respectively, and the CUSUM parameter (k) is set to 1.0. Combined Shewhart-CUSUM control charts will be plotted for each sampling event. The background dataset will be updated every two (2) years, defining a "control period" of duration two (2) years.

A set of control charts has been completed for data collected through June of 2010 (available in Appendix C: Control Charts). Due to the fact that control chart limits are calibrated as data is added to the background, the false positive rates will be highest in the beginning of the comparison history. The failures detected in these control charts are primarily due to the limited background data for these failure points and irregularities in the sampling history.

7 REFERENCES

(BFI 1981) Browning-Ferris Industries, Inc. *Chemical Waste Treatment/Solidification & Disposal Facility Plan. Volume I - Technical Report*. Highway 36 Land Development Company, Adams County, Colorado, Draft for Review and Comment.

(BFI 1982) Browning-Ferris Industries, Inc. *Chemical Waste Treatment/Solidification & Disposal Facility Plan. Volume I - Technical Report*. Highway 36 Land Development Company, Adams County, Colorado, Revised October 1982.

(CHDT 2004) Clean Harbors Deer Trail, LLC. *Permit Renewal Report for Incorporation of a Geosynthetic Clay Liner (GCL) in the Liner Section for Secure Cells 3 Through 7 and in the Cover Section for Secure Cells 1 Through 7.*

(CGS 1986) Colorado Geological Survey. 1986. *Candidate Area Evaluation Report, Low-Level Radioactive Waste Disposal, Colorado*. Open File 86-7.

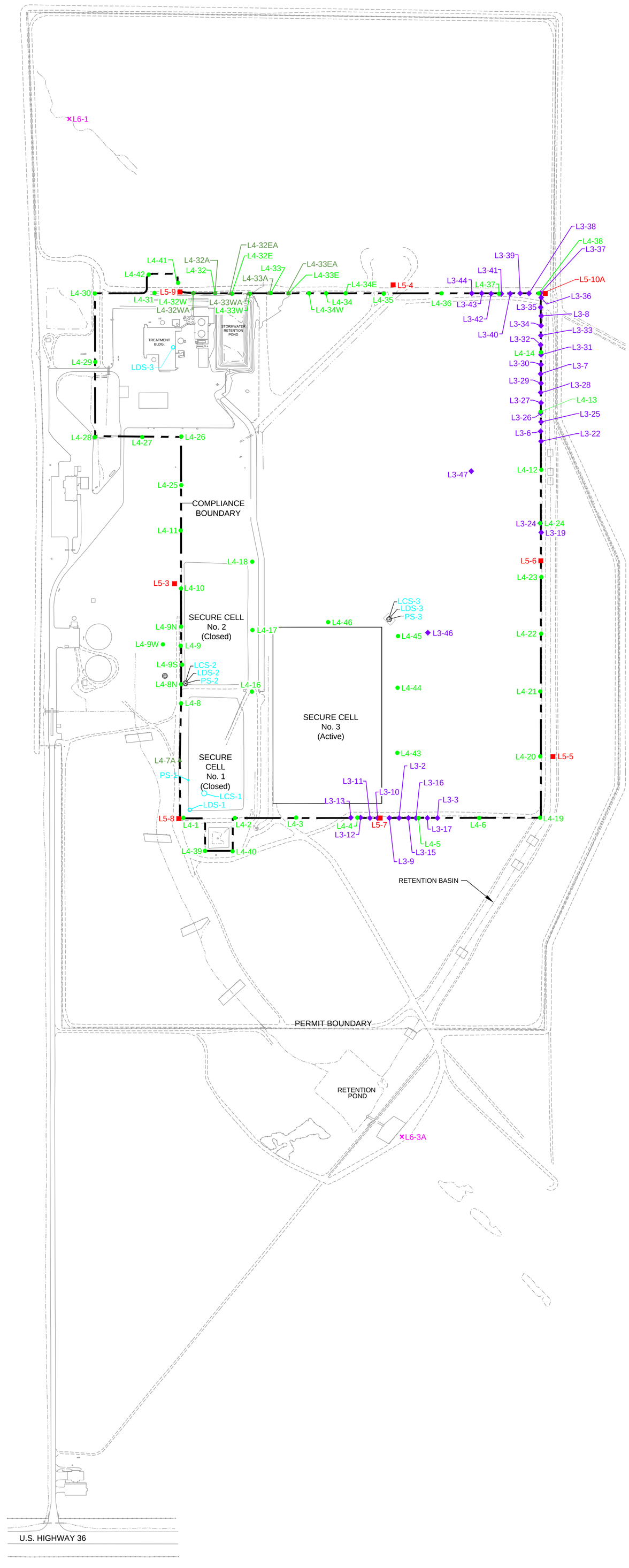
(Crow, 1987) Crow, L. W. 1987. *Analysis of Pertinent Weather Factors Related to the Permit Application for Proposed Highway 36 Waste Management Facility.* Prepared for Morrison-Knudsen Engineers, Inc., Denver, Colorado.

(Lucas, 1982) Lucas, J.M., 1982. *Combined Shewart-CUSUM Quality Control Schemes*. Journal of Quality Technology. Vol. 14. Pp.51-59.

(MFG 1997) McCulley, Frick, and Gilman, Inc. *Highway 36 Facility Groundwater Protection Program Design and Rationale*. Prepared for the Highway 36 Land Development Company, Deer Trail, Colorado.

(USEPA 1999) U.S. Environmental Protection Agency, Office of Research and Development. *Partition Coefficients for Metals in Surface Water, Soil, and Waste.*

PLATES



N

0 300 600

SCALE: 1" = 300'

LEGEND

GROUNDWATER MONITORING WELLS

WELL SYMBOL	ZONE
◆	L3
▲	L4A
●	L4
■	L5
×	L6

STORMWATER DRAINAGE DITCH

UNIMPROVED ROAD

LEACHATE COLLECTION SYSTEM (LCS)
LEAK DETECTION SYSTEM (LDS)
PERMANENT SUMP (PS)

CleanHarbors®
ENVIRONMENTAL SERVICES, INC.

	BY	DATE
DRAWN	DMC	1/23/09
CHECKED		
REVISED	JGM	2/4/13
APPROVED		
APPROVED		
APPROVED		

Cameron-Cole
5777 CENTRAL AVENUE, SUITE 200
BOULDER, COLORADO 80301
PHONE: (303) 938-5500
FAX: (303) 938-5520
http://www.cameron-cole.com

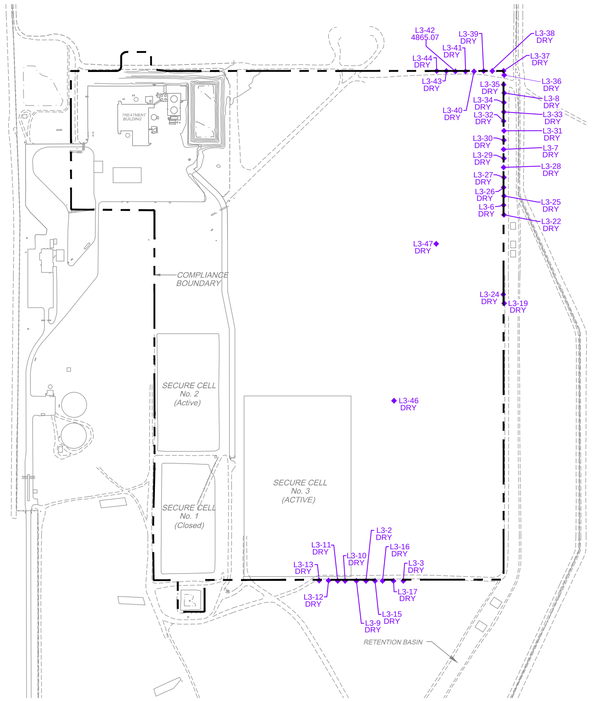
PLATE 1

CLEAN HARBORS (DEER TRAIL), LLC.
MONITORING LOCATIONS FOR GROUNDWATER & LEACHATE
2012 GROUNDWATER REPORT

SCALE: 1" = 300'

DWG. NO.: 1600

M:\clients\Cameron-Cole\1600-DeerTrail\2012\Plate 1-2012 LAYOUT: 24 X 36



FIRST QUARTER 2012

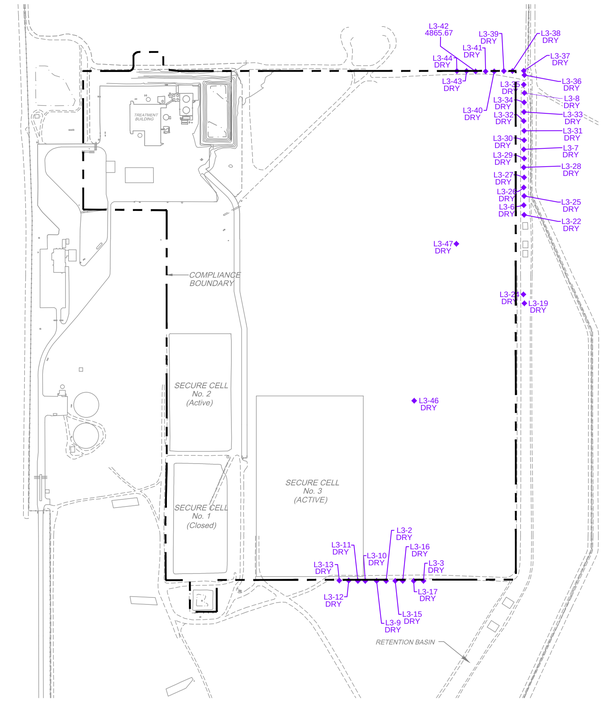
NORTH

0 250 500
FEET

LEGEND

◆ L3 ZONE MONITORING WELL

4865.07 L3 ZONE WATER LEVEL ELEVATION (FEET ABOVE MSL.)



SECOND QUARTER 2012

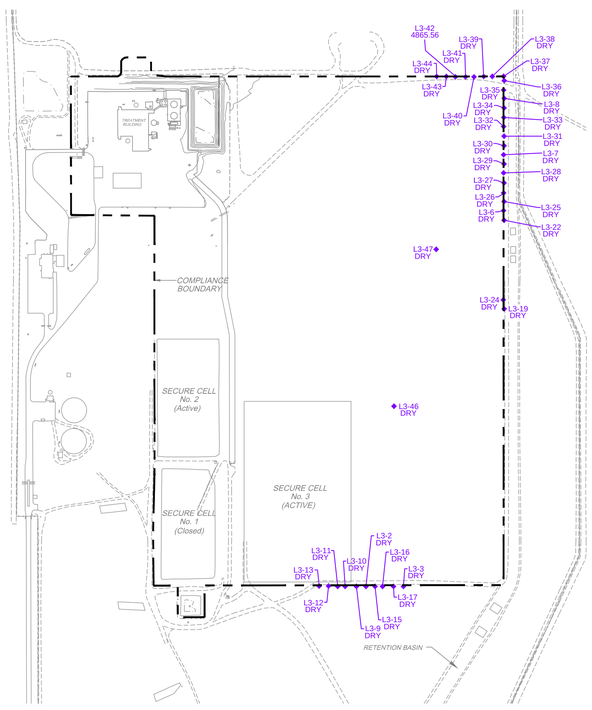
NORTH

0 250 500
FEET

LEGEND

◆ L3 ZONE MONITORING WELL

4865.67 L3 ZONE WATER LEVEL ELEVATION (FEET ABOVE MSL.)



THIRD QUARTER 2012

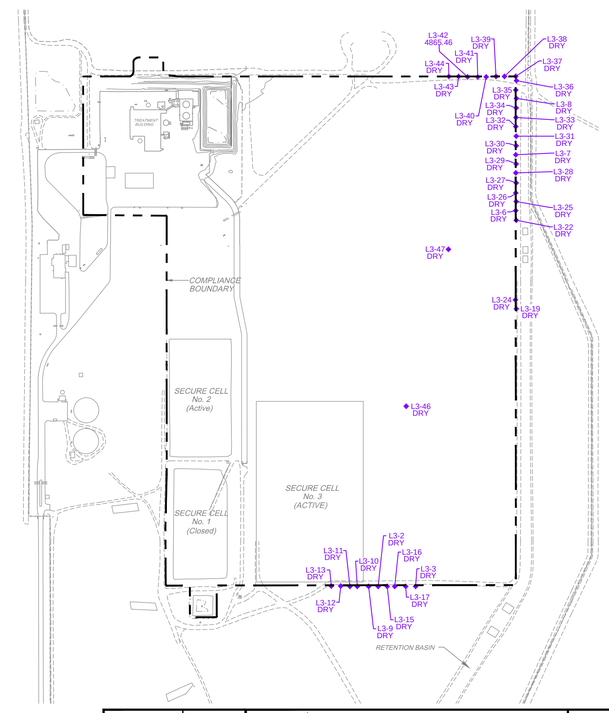
NORTH

0 250 500
FEET

LEGEND

◆ L3 ZONE MONITORING WELL

4865.56 L3 ZONE WATER LEVEL ELEVATION (FEET ABOVE MSL.)



FOURTH QUARTER 2012

NORTH

0 250 500
FEET

LEGEND

◆ L3 ZONE MONITORING WELL

4865.46 L3 ZONE WATER LEVEL ELEVATION (FEET ABOVE MSL.)

	BY	DATE
DRAWN	DB	1/25/08
CHECKED		
REVISED	JGM	2/4/13
APPROVED		
APPROVED		
APPROVED		

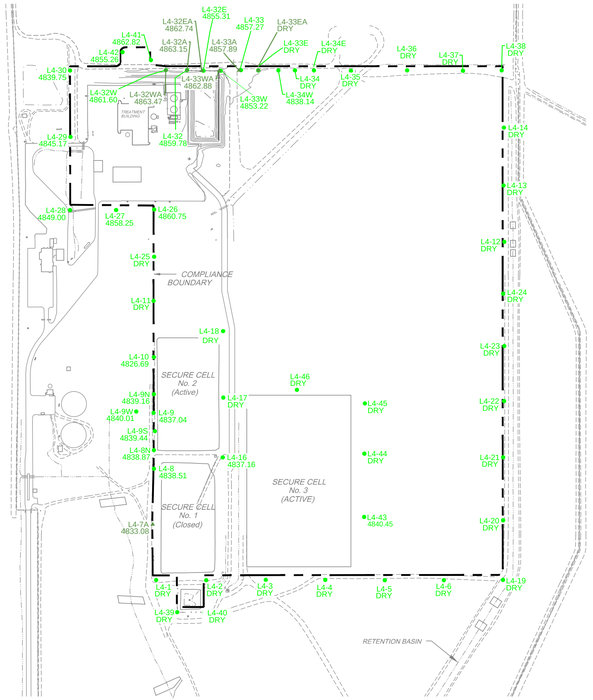
Cameron-Cole
5777 CENTRAL AVENUE, SUITE 200
BOULDER, COLORADO 80301
PHONE: (303) 938-5500
FAX: (303) 938-5520
http://www.cameron-cole.com

PLATE 2

CLEAN HARBORS DEER TRAIL, LLC
L3 ZONE QUARTERLY WATER LEVEL ELEVATIONS

SCALE:	REPORT REF.:	PROJECT NO.:
1" = 500'	2012 ANNUAL GROUNDWATER REPORT	1600

M:\clients\Cameron-Cole\1600-DeerTrail\2012\2012Zone L3 LAYOUT, LAYOUT1



FIRST QUARTER 2012

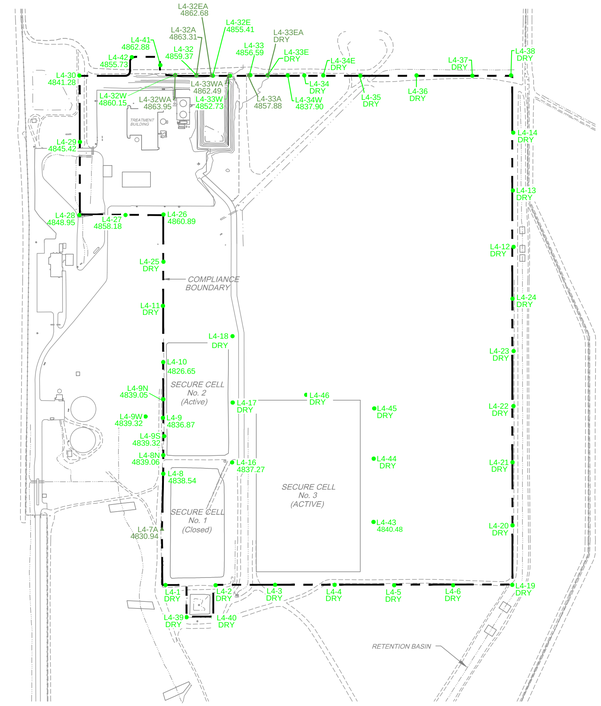
NORTH

0 250 500
FEET

LEGEND

▲ L4A ZONE MONITORING WELL
4862.74 L4A ZONE WATER LEVEL ELEVATION (FEET ABOVE MSL.)

● L4 ZONE MONITORING WELL
4838.51 L4 ZONE WATER LEVEL ELEVATION (FEET ABOVE MSL.)



SECOND QUARTER 2012

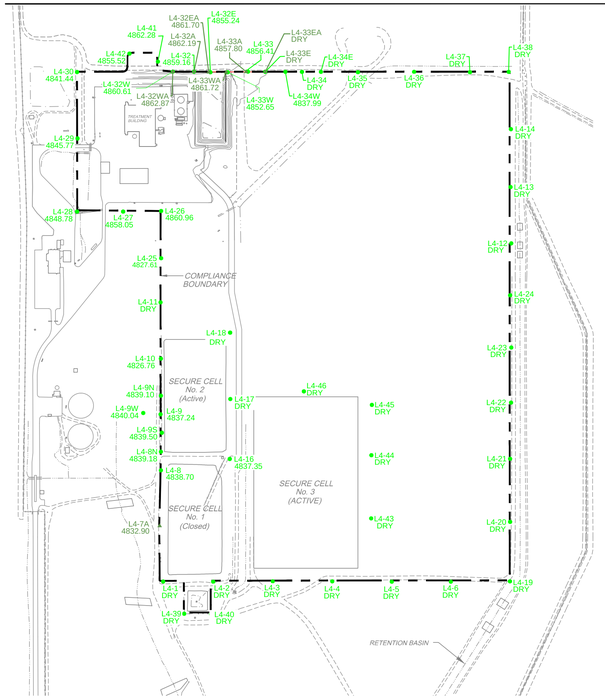
NORTH

0 250 500
FEET

LEGEND

▲ L4A ZONE MONITORING WELL
4863.95 L4A ZONE WATER LEVEL ELEVATION (FEET ABOVE MSL.)

● L4 ZONE MONITORING WELL
4837.27 L4 ZONE WATER LEVEL ELEVATION (FEET ABOVE MSL.)



THIRD QUARTER 2012

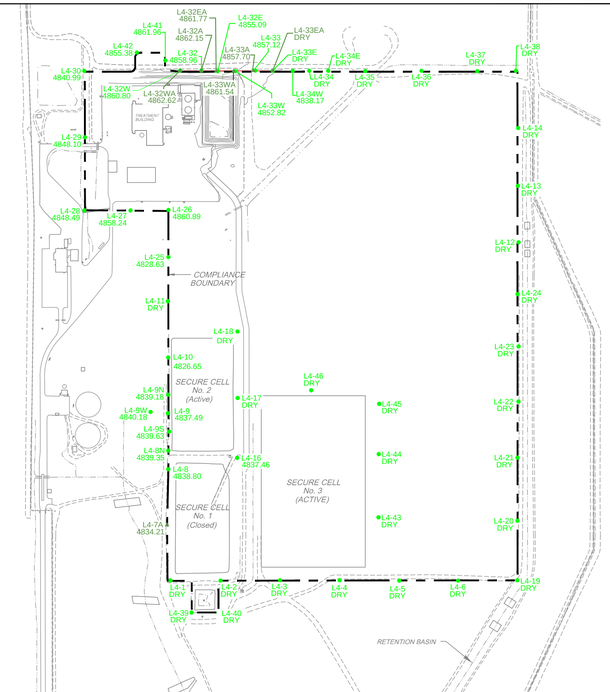
NORTH

0 250 500
FEET

LEGEND

▲ L4A ZONE MONITORING WELL
4861.70 L4A ZONE WATER LEVEL ELEVATION (FEET ABOVE MSL.)

● L4 ZONE MONITORING WELL
4839.18 L4 ZONE WATER LEVEL ELEVATION (FEET ABOVE MSL.)



FOURTH QUARTER 2012

NORTH

0 250 500
FEET

LEGEND

▲ L4A ZONE MONITORING WELL
4861.77 L4A ZONE WATER LEVEL ELEVATION (FEET ABOVE MSL.)

● L4 ZONE MONITORING WELL
4837.46 L4 ZONE WATER LEVEL ELEVATION (FEET ABOVE MSL.)

	BY	DATE
DRAWN:	PO	3/23/07
CHECKED		
REVISED	JGM	2/4/13
APPROVED		
APPROVED		
APPROVED		

Cameron-Cole
5777 CENTRAL AVENUE, SUITE 200
BOULDER, COLORADO 80301
PHONE: (303) 938-5500
FAX: (303) 938-5520
http://www.cameron-cole.com

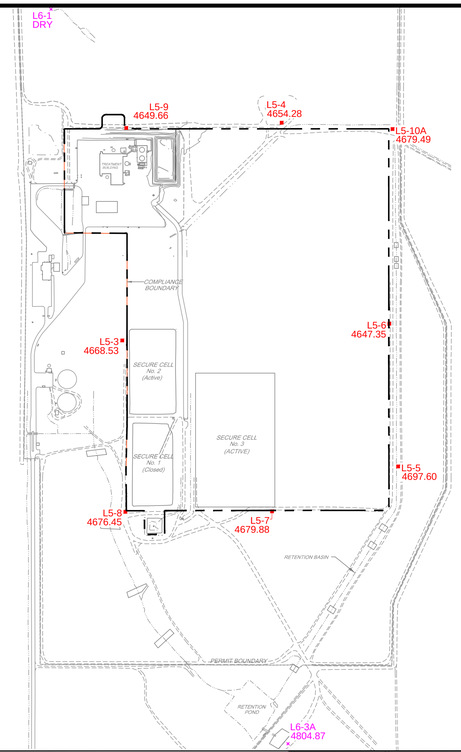
PLATE 3

CLEAN HARBORS DEER TRAIL, LLC

L4 AND L4A ZONE QUARTERLY WATER LEVEL ELEVATIONS

SCALE:	REPORT REF.:	PROJECT NO.:
1" = 500'	2012 ANNUAL GROUNDWATER REPORT	1600

M:\clients\Cameron-Cole\1600-DeerTrail\2012\2012Zone L4_L4A LAYOUT: LAYOUT1



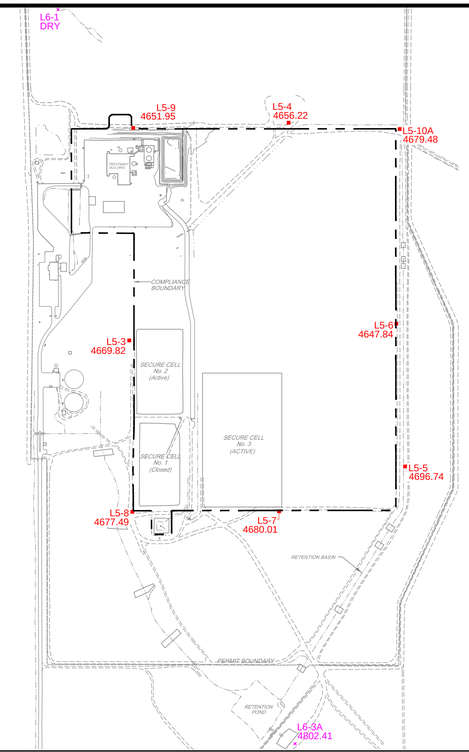
FIRST QUARTER 2012

NORTH
0 600
FEET

LEGEND

■ L5 ZONE MONITORING WELL
4668.53 L5 ZONE WATER LEVEL ELEVATION (ABOVE MSL.)
x L6 ZONE MONITORING WELL
4730.44 L6 ZONE WATER LEVEL ELEVATION (ABOVE MSL.)

L6-2*
4730.44



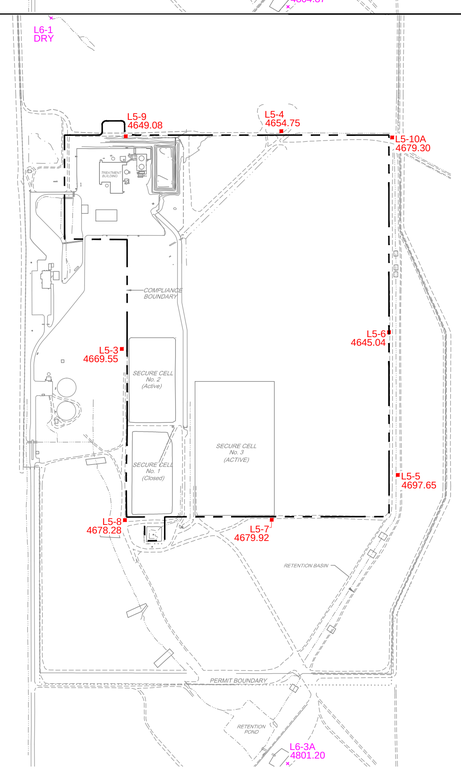
SECOND QUARTER 2012

NORTH
0 600
FEET

LEGEND

■ L5 ZONE MONITORING WELL
4669.71 L5 ZONE WATER LEVEL ELEVATION (ABOVE MSL.)
x L6 ZONE MONITORING WELL
4830.43 L6 ZONE WATER LEVEL ELEVATION (ABOVE MSL.)

L6-2*
4730.40



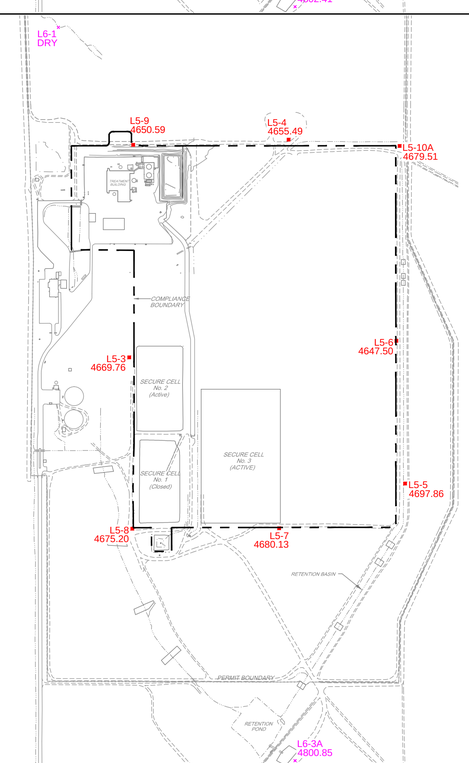
THIRD QUARTER 2012

NORTH
0 600
FEET

LEGEND

■ L5 ZONE MONITORING WELL
4669.55 L5 ZONE WATER LEVEL ELEVATION (ABOVE MSL.)
x L6 ZONE MONITORING WELL
4729.68 L6 ZONE WATER LEVEL ELEVATION (ABOVE MSL.)

L6-2*
4729.68



FOURTH QUARTER 2012

NORTH
0 600
FEET

LEGEND

■ L5 ZONE MONITORING WELL
4669.76 L5 ZONE WATER LEVEL ELEVATION (ABOVE MSL.)
x L6 ZONE MONITORING WELL
4730.36 L6 ZONE WATER LEVEL ELEVATION (ABOVE MSL.)

L6-2*
4730.36

	BY	DATE
DRAWN	DB	1/25/08
CHECKED		
REVISED	JGM	2/4/13
APPROVED		
APPROVED		
APPROVED		

Cameron-Cole
5777 CENTRAL AVENUE, SUITE 200
BOULDER, COLORADO 80301
PHONE: (303) 938-5500
FAX: (303) 938-5520
http://www.cameron-cole.com

PLATE 4

CLEAN HARBORS DEER TRAIL, LLC
L5 AND L6 ZONE QUARTERLY WATER LEVEL ELEVATIONS

SCALE:	REPORT REF.:	PROJECT NO.:
1" = 600'	2012 ANNUAL GROUNDWATER REPORT	1600

M:\clients\Cameron-Cole\1600-DeerTrail\2012\2012Zone L5_L6 LAYOUT: LAYOUT1