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Final Environmental Assessment for the Proposed City of Billings Class II Landfill Expansion Project Billings, Montana

December 17, 2018

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1 PURPOSE AND NEED FOR ACTION

1.1 SUMMARY

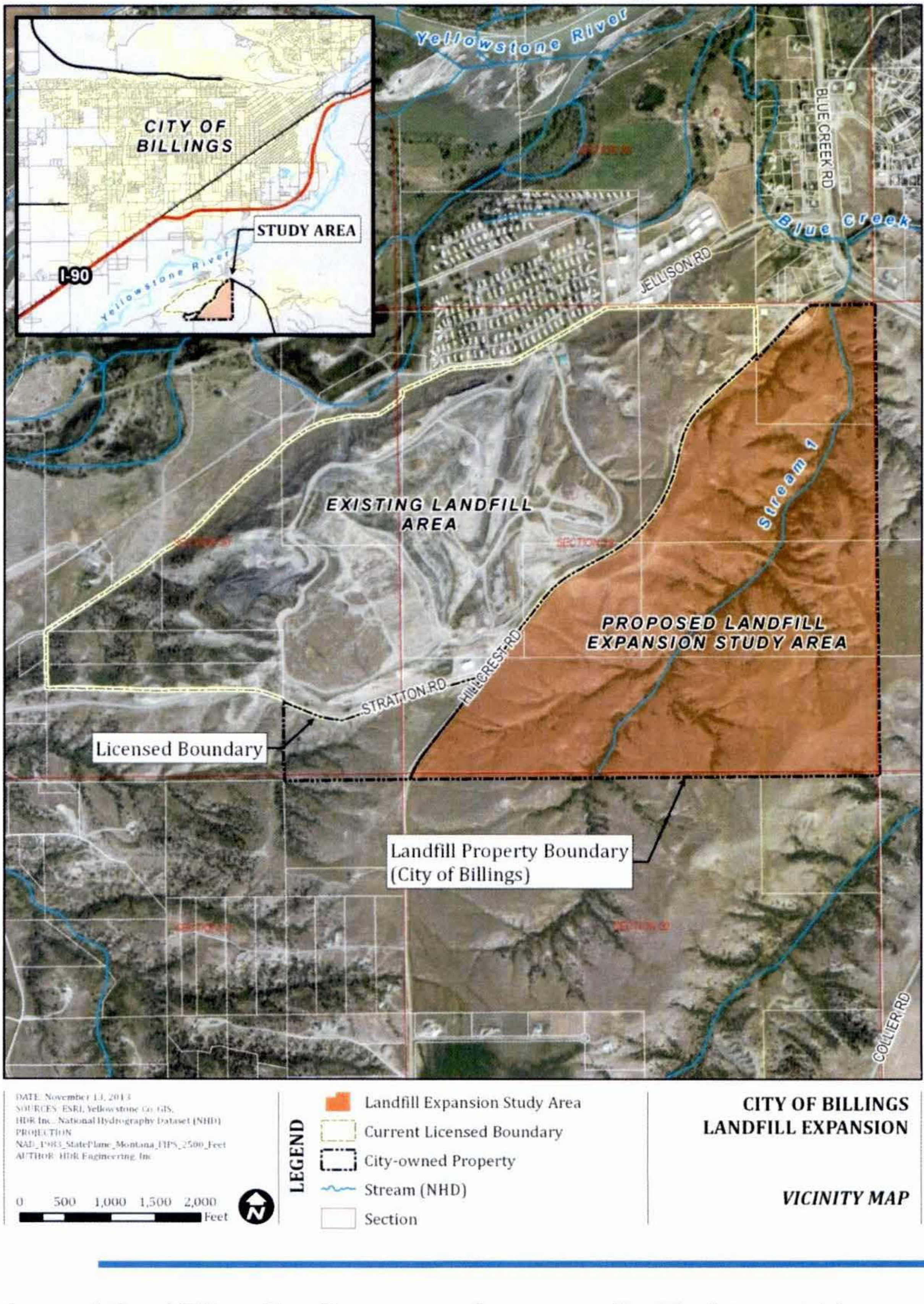
The City of Billings (COB) is currently licensed to operate a Class II Solid Waste Management System (SWMS) for the management of solid wastes. A Class II SWMS is a system that controls the storage, treatment, recycling, recovery, and/or disposal of Group II, III, and IV solid wastes. In Montana, wastes are grouped based upon their physical and chemical characteristics which determine the degree of care required in their handling and disposal, and the potential of the wastes to cause environmental degradation or public health hazards. Group II wastes include decomposable wastes and mixed solid wastes containing decomposable materials but exclude regulated hazardous waste. Group III wastes include clean wood wastes and other clean non-water soluble or inert solids. This category includes, but is not limited to, brick, rock, dirt, concrete, unpainted and unglued wood materials, and tires. Group IV wastes include construction and demolition wastes and asphalt but exclude regulated hazardous wastes. A Class II facility design requires the most stringent and protective features to ensure the protection of human health and the environment.

On April 27, 2015, the COB submitted a SWMS license application to the Montana Department of Environmental Quality (DEQ) Solid Waste Program (SWP) for the expansion of their current facility license boundary. The proposed expansion would allow the City to continue to provide solid waste services for residents of the City and of Yellowstone County once the current landfill reaches final capacity.

The proposed expansion area encompasses 350 acres of city-owned property. The project area is located south of the currently licensed and operating City of Billings Class II Landfill facility in portions of Section 29, Township 1 South, Range 26 East, Montana Principal Meridian (Figure 1.1). Of the 350 acres proposed for the expansion, the project would result in a disturbance total of 293 acres for landfill disposal units, storm water and leachate retention ponds, roads, and buildings during the entire life cycle of the facility. The landfill disposal units would disturb a total of 232 acres and the remaining 61 acres for the construction of the ponds, roads, buildings and ditches. The landfill disposal units would be partially closed when it reaches final grade and the maximum open area during operations would be 119 acres.

The proposed expansion area would include four separate landfill units that would be developed in seven phases over the life of the facility; the four landfill units would consist of two Class II and two Class IV disposal units.

Figure 1.1 – General Location of Proposed COB Class II Facility Expansion
*(Source: Great West Engineering, Billings Landfill Expansion Application, 2015 (*not to scale))*



The expansion would provide for the disposal of an estimated additional 12,101,100 tons (18,656,200 cubic yards) of Group II waste and 4,220,000 cubic yards of Group IV waste. The total on-site waste tonnage at closure is estimated to be 13,392,580 tons. Based upon the municipal solid waste density, the waste acceptance rate, and the projected growth rate in the Billings area, the proposed COB expansion would extend the life of the COB Class II Landfill by approximately 48 years once the current facility nears capacity.

COB would relocate the composting operations that are currently conducted along the southern boundary of the active landfill to the expansion area within one to five years. Compostable wastes would continue to be received and stockpiled at the current landfill; COB will transport the blended compostable materials to the expansion area for management. Construction of new disposal units and associated appurtenances within the proposed expansion area is not expected to commence for another 20 to 25 years. Prior to the construction of future disposal units, COB would be required to submit updated construction documents to DEQ for approval that demonstrate compliance with existing regulations.

1.2 PURPOSE AND NEED

COB applied to DEQ for expansion of their current Class II solid waste management facility. DEQ's purpose and need is to take action on COB's application to expand its SWMS by constructing Class II and Class IV landfill units as described in its application. The proposed expansion would provide for the disposal of 12, 101,100 ton of Group II waste and 4,220,000 cubic yards of Group IV waste and extend the life of the COB landfill by 48 years. DEQ's action must be consistent with the Solid Waste Management Act, the Clean Air Act, and the Water Quality Act. The applicant's purpose and need of the proposed action is the construction and operation of the solid waste management system as proposed. The proposed action is a result of COB's long-range planning efforts to ensure they can continue to manage solid wastes for residents of the City of Billings and Yellowstone County.

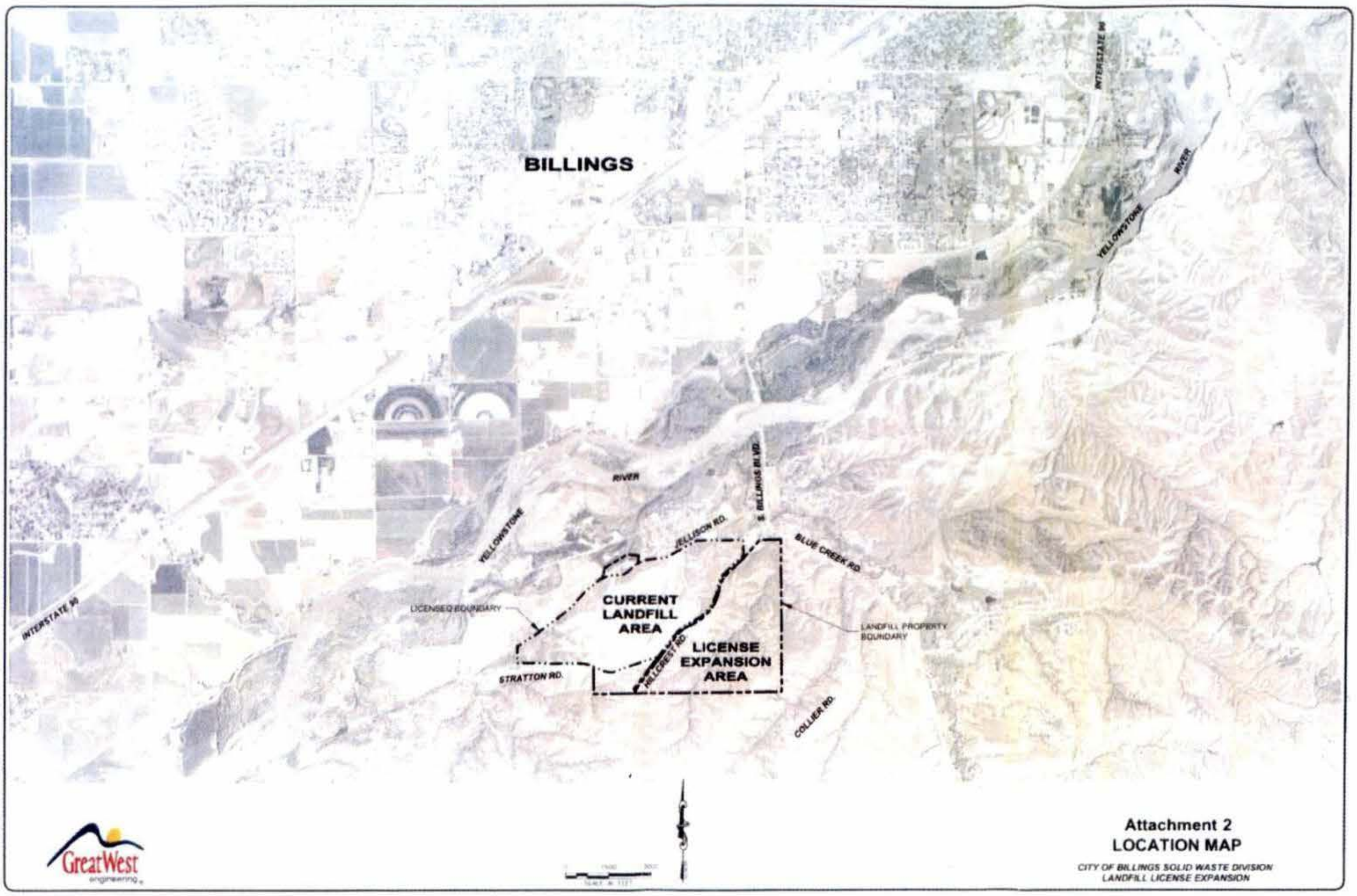
DEQ's Solid Waste Program received an application for licensure of the proposed facility. DEQ is required under the Montana Environmental Policy Act (MEPA) to disclose the potential impacts to the human environment that may result from the agency action. A MEPA document does not result in a certain decision, but rather serves to identify the potential effect of a state action within the confines of the existing regulations governing such proposed activities so that agencies make balanced decisions. MEPA does not provide regulatory authority beyond the authority explicitly provided in existing regulations. This final environmental assessment (EA) document incorporates DEQ's responses to the comments received on the draft EA during the public comment period.

1.3 PROJECT LOCATION AND STUDY AREA

The proposed landfill expansion area is located south of the current COB Class II landfill across Hillcrest Road, directly south of the intersection of Hillcrest Road and Highway 416 (Blue Creek Road) in Yellowstone County, Montana (Figure 1.2). The proposed landfill expansion area is in Section 29, Township 1 South, Range 26 East, Montana Principal Meridian.

The proposed landfill expansion property is owned by COB. The site of the proposed expansion area is zoned agricultural property that is used occasionally for livestock grazing. There are no local restrictions that prohibit the location of the facility at the site the applicant selected. Adjacent land uses include residential, agricultural, light industrial, and recreational.

Figure 1.2 – Proposed COB Class II Facility Expansion Vicinity Map



*(Source: Great West Engineering, Billings Landfill Expansion Application, 2015 (*not to scale))*

1.4 AUTHORIZING ACTION

DEQ's Solid Waste Section (SWS) is responsible for ensuring activities proposed under the Solid Waste Management Act, the Integrated Waste Management Act, the Septage Disposal Licensure Act, and the Motor Vehicle Disposal & Recycling Act comply with current regulations. The SWS is a part of DEQ's Waste Management and Remediation Division, Waste and Underground Tank Management Bureau. The Solid Waste Management Act (Title 75, Chapter 10, Part 2 Montana Code Annotated (MCA)) and the Administrative Rules of Montana (ARM), Title 17, Chapter 50 provide the necessary authority for the SWS to license and regulate SWMS's in the state of Montana.

DEQ is also responsible for protecting air quality under the Clean Air Act of Montana (Title 75, Chapter 2, Parts 1 through 4, MCA), and water quality and quantity under the Montana Water Quality Act (Title 75, Chapter 5, Parts 1-11, MCA). The options that DEQ has for decision-making upon completion of the EA are (1) denying the application if the proposed operation would violate SWMA, the Clean Air Act, or the Water Quality Act; (2) approving the application as submitted; (3) approving the application with agency mitigations; or (4) determining the need for further environmental analysis to disclose and analyze potentially significant environmental impacts. Table 1.1 provides a listing of agencies and their respective permit/authorizing responsibilities.

Table 1.1: Regulatory Responsibilities

ACTION	REGULATORY AGENCY
Solid Waste Management System License	DEQ – Waste and Underground Tank Management Bureau
Air Quality Permitting	DEQ – Air Quality Bureau
General Permit for Storm Water Discharge Associated with Industrial Activity	DEQ-Water Protection Bureau
Montana Pollutant Discharge Elimination System Permit (MPDES)	DEQ – Water Protection Bureau
SWMS License Validation by County Health Officer	Yellowstone County Health Officer
County Road Construction, Maintenance, and Land Use, Weed Plan Approval	Yellowstone County
Encroachment Permit for State Highway modifications	Montana Department of Transportation

DEQ's evaluation of the proposed COB Class II Landfill expansion application is based upon the current regulations and the site-specific characteristics of the location selected by the City as it relates to the proposed facility design and operation. The site location was selected by the applicant.

1.5 PUBLIC PARTICIPATION

DEQ, as the lead agency, prepared a draft EA that presented the analysis of possible environmental consequences related to the proposal. The draft EA, published on

December 16, 2016, was distributed to adjacent landowners and interested persons for review. DEQ held a public meeting to accept public comments on this proposal on January 10, 2016, in the gymnasium at the Blue Creek School. Oral and written comments were received at the public meeting. Prior to the completion of the comment period ending on January 30, 2017, DEQ received numerous requests to extend the public comment period; as a result, the comment period was extended to March 16, 2017. In addition to the oral comments received during the meeting, written comments were accepted during the comment period.

1.6 ISSUES AND CONCERNS

DEQ has identified potential issues and concerns related to the proposed action. The issues and concerns are discussed in Section 3.

2 DESCRIPTION OF ALTERNATIVES

2.1 INTRODUCTION

This chapter summarizes alternatives to the proposed plan including the No Action alternative required by MEPA. MEPA requires the evaluation of reasonable alternatives to the Proposed Action. Reasonable MEPA alternatives are those that are achievable under current technology and are economically feasible as determined solely by the economic viability for similar projects having similar conditions and physical locations and determined without regard to the economic strength of the specific project sponsor. Section 75-1-220, MCA, states that for a project that is not a state-sponsored project, an alternatives analysis does not include an alternative facility or an alternative to the proposed project itself. Therefore, DEQ only considered alternatives applicable to the proposed facility at the proposed location.

2.1.1 ALTERNATIVES CONSIDERED BUT DISMISSED

In addition to the action proposed as presented in the COB's application for expansion, COB evaluated three other alternatives for site configuration. The evaluation of the alternatives was presented in the COB's February 2014 Solid Waste Alternatives Analysis document (Appendix A). COB's analysis of each alternative considered the benefits of each alternative based on site conditions, soil balance, landfill waste capacity, expansion cost, closure cost, and cost per ton.

According to the evaluation, COB's Alternative 1 consisted of the construction of one large waste disposal unit designed to maximize the volume of waste in the disposal unit. This alternative would provide for the disposal of approximately 43,621,000 cubic yards of waste in a 214-acre landfill unit and would have a projected life of 123 years. This alternative requires the removal of the current central drainage that runs from the southwest towards the northeast on the site of the proposed expansion. COB would construct a perimeter drainage ditch adjacent to Hillcrest Road to divert storm water run on entering the site and direct it towards the natural drainages in the southwest and the northeast portions of the site. The maximum depth of the waste unit would be 30 to 40 feet and, once filled, would rise 200 to 300 feet above current site elevations in the center of the proposed expansion area. The COB determined that Alternative 1 was impracticable due to the presence of large quantities of hard rock that would require excavation for construction of the landfill disposal unit. Alternative 1 would require significant capital costs to construct the landfill unit and large perimeter storm water ditch. As a result, COB determined that Alternative 1 did not meet the purpose and need of the expansion proposal.

As indicated above, an alternatives analysis under MEPA does not include an alternative facility or an alternative to the proposed project itself. The construction of one large waste disposal unit under COB's Alternative 1 is an alternative facility or an alternative to COB's proposed project itself. Therefore, DEQ considered but dismissed Alternative 1 without detailed analysis.

COB's Alternative 2 consisted of a landfill design that overlaps the existing COB Class II Landfill. This alternative would provide for the disposal of approximately 50,482,100 cubic yards of waste in a 196-acre landfill unit and would have a projected life of 142 years. This alternative would require the removal of Hillcrest Road, but would capitalize on the volume of space available for landfilling by overlapping into the existing fill. COB would either utilize and improve Collier Road or provide a new access off Blue Creek Road for the current users of Hillcrest Road. This alternative requires the removal of the current central drainage that runs from the southwest towards the northeast on the site of the proposed expansion. COB would construct a perimeter drainage ditch on the south and east side of the expansion property. Selection of this alternative would require COB's acquisition of additional property for the replacement of Hillcrest Road. The COB determined that Alternative 2 was impracticable due to the presence of large quantities of hard rock that would require excavation and construction of the landfill unit and large perimeter storm water ditch. Selection of this alternative would maximize the capacity available for waste disposal, but would add significant capital costs to the project due to property acquisition, road reconstruction and hard rock excavation. COB determined that this alternative would not meet the purpose and need of the expansion proposal.

As indicated above, an alternatives analysis under MEPA does not include an alternative facility or an alternative to the proposed project itself. The construction of a landfill design that overlays the existing COB landfill under COB's Alternative 2 is an alternative facility or an alternative to COB's proposed project itself. Therefore, DEQ considered but dismissed Alternative 2 without detailed analysis.

COB's Alternative 3 consisted of a standalone facility. However, due to its configuration, the design resulted in a reduced capacity and lifespan, as compared to the other alternatives. Since there would be a reduced capacity and lifespan, this alternative would not meet the purpose and need as stated above in Section 1.2.

As indicated above, an alternatives analysis under MEPA does not include an alternative facility or an alternative to the proposed project itself. The construction of a standalone facility under COB's Alternative 3 is an alternative facility or an alternative to COB's proposed project itself. In addition, Alternative 3 would result in a landfill that has a reduced capacity and life span. Thus, it does not meet the purpose and need. Therefore, DEQ considered but dismissed Alternative 2 without detailed analysis.

DEQ considered a modification of the proposed liner design and the final cover design as alternatives to the design proposed by the COB.
According to ARM 17.50.1204, two options exist for Class II landfill units: a prescriptive design that utilizes a composite liner and a leachate collection and removal system designed and constructed to maintain less than a 12-inch (30-cm) depth of leachate over the liner; or a design based upon liner performance that ensures that the concentration of ARM 17.50.1204 Table 1 constituents will not be exceeded at the relevant point of compliance in the uppermost aquifer. The list of Table 1 constituents is provided in Appendix B.

According to ARM 17.50.1403, two options exist for Class II landfill final cover systems. The first option is a prescriptive design that utilizes a liner equivalent to the base landfill liner that is covered by an 18-inch infiltration layer topped with an erosion layer that consists of at least six inches of topsoil. The second option is a design based upon performance that does not require the liner, but includes an infiltration layer equivalent to the prescriptive design and an erosion layer equivalent to six inches of topsoil.

DEQ considered the prescriptive landfill liner design as an alternative to the performance-based liner design submitted by COB. The prescriptive liner design consists of two components: an upper 30-mil flexible membrane liner (FML) installed in direct contact with a lower two-foot barrier of compacted soil. The applicant proposes a liner design that consists of a 60-mil FML made of high-density polyethylene (HDPE) and re-compaction of the uppermost native subgrade clay material into an in-place six-inch barrier.

DEQ considered the prescriptive final cover system design as an alternative to the performance based final cover system design submitted by COB. The prescriptive final cover system consists of a 30-mil FML, covered by 18 inches of earthen material and six inches of topsoil. COB proposes to utilize a performance based alternative final cover (AFC) system for closure of all four landfill units in the proposed expansion area, matching the AFC closures for the currently licensed active COB Class II Landfill facility.

DEQ's evaluation of the requirements for Class II liner and final cover system design, as discussed in Sections 2.4.3 and 2.4.8, determined that the performance-based design proposed by COB was equivalent to the prescriptive design. The current COB landfill has successfully implemented the performance-based design since the facility 2008. To date, the alternative performance-based liner and final cover design has functioned as designed; no releases to groundwater have been detected. Incorporation of the performance-based liner and final cover design demonstration report into the proposed expansion application documents is justified because (i) all site investigations confirm that the geologic conditions beneath the expansion area correspond with the reported data, and (ii) the proposed liner is identical to the liner in the demonstration report. Therefore, DEQ's alternative for the prescriptive design was dismissed from further evaluation.

2.2 ALTERNATIVE 1 - NO ACTION ALTERNATIVE

Under the No Action Alternative, the proposed landfill expansion would not be approved by DEQ and could not be built by COB. The continued disposal of waste after closure of the existing landfill would have to occur at another approved landfill facility.

2.3 ALTERNATIVE 2 - PROPOSED ACTION

The Proposed Action is the expansion of COB's currently licensed solid waste management system. The Proposed Action would consist of a landfill system as depicted on Figure 2.1 and as described below. Table 2.1 provides the information on the volume of earthen materials excavated along with the soil and waste balance budget. The proposed expansion would require the excavation of a total of 293 acres that includes 232 acres for the landfill disposal units and 61 acres for the construction of ponds, roads, buildings and ditches.

2.3.1 Landfill Features

The design features and layout of the proposed COB landfill expansion are depicted in Figure 2.1. The proposed landfill expansion design and operations will include construction of the following components: (i) the gatehouse and scale, (ii) landfill maintenance building, (iii) facility access road, (iv) controlled point of entry, (v) interior roads, (vi) waste disposal units, (vii) leachate collection, removal, and conveyance system, (viii) leachate ponds, (ix) alternative final cover system, and (x) storm water control system.

Two lined Class II landfill units would be developed in five phases (Phases 1 through 5); the first three phases of the Class II disposal unit will be located south of the central ravine that bisects the current proposed expansion area, and the last two phases will be located north of this central ravine. An interior road will be constructed along this central ravine. A continuous final cover will be constructed that, at final closure, will tie together phases one through three of the south disposal unit; another continuous final cover will be constructed that will tie together phases four and five of the north disposal unit after filling over the liner has been completed. The construction of the disposal units will generally develop downslope on the western and eastern margins of the central coulee progressing from the southwest to the northeast.

2.3.2 Soils Excavation and Budget

The proposed expansion will require the excavation of 232 acres for the landfill disposal units, plus preparation for ponds, roads, and ditches after the excavation of the soil and rock from the coulee and slopes. Approximately 7,718,800 total cubic yards of excavated soil will be used for daily cover, final cover, liners, ponds, and other elements and will leave a net soil surplus of approximately 1,169,980 cubic yards. Table 2.1 provides the summary of the total soil volume available on site, as well as the fill and soil volumes required during each phase of construction and operation within the expansion area.

2.3.3 Landfill Liner Design

According to the Administrative Rules of Montana (ARM) 17.50.1204, a new Class II landfill unit must be designed to protect the uppermost aquifer from landfill contaminants. The regulations provide two design options to meet these requirements: (1) utilizing a composite liner and leachate collection and removal system that is designed and constructed to maintain less than a 30-cm depth of leachate over the liner; or (2) by submitting a design that ensures that the concentration of ARM 17.50.1204 Table 1 constituents will not be exceeded at the relevant point of compliance in the uppermost aquifer. The prescribed standard composite liner must be comprised of two components: an upper flexible synthetic membrane liner (FML) installed in direct contact with a lower two-foot barrier of compacted soil. The applicant proposes an alternative liner that consists of a 60-mil FML made of high-density polyethylene (HDPE), thereby matching the synthetic membrane standard and re-compaction of the uppermost native subgrade material into an in-place six-inch barrier that would substitute for the lower soil component, as depicted in Figures 2.2 and 2.3.

An alternative liner demonstration was previously approved by DEQ for compliance with the composite liner design requirements and the contaminant migration standards for the currently active, licensed Class II landfill. Incorporation of this previous demonstration report into the proposed expansion application documents is justified because (i) all site investigations confirm that the geologic conditions beneath the expansion area correspond with the reported data, and (ii) the proposed liner is identical to the liner in the demonstration.

HDPE is a very low permeability, flexible, synthetic membrane (geomembrane) that is widely used to contain or control liquid and gas migration in an engineered project, structure, or system. Also, HDPE pipe commonly conveys water or wastewater for many municipal systems. When properly installed and tested during landfill construction, HDPE geomembrane liners are highly impermeable barriers which prevent the contamination of soil and groundwater from chemicals in liquids that may be derived from the solid waste. The lower, compacted, in-place native component of the proposed composite liner will function as a secondary liner to enhance the primary upper geomembrane providing further protection by retarding seepage and landfill gas diffusion as noted.

Figure 2.2 depicts the applicant's proposed alternative base liner and leachate collection and removal system (LCRS) elements for the landfill floor. The anchor trench design is provided in Figure 2.3. The base liner elements consist of the following components, from top to bottom:

- LCRS gravel drainage layer
- Non-woven geotextile cushion
- Double-textured HDPE geomembrane (FML)
- Compacted uppermost native clay subgrade material

As shown in Figure 2.4, the slope liner system and LCRS elements consist of the following components, from top to bottom:

- Protective cover soil
- Non-woven geotextile cushion
- HDPE geomembrane (FML)
- Compacted uppermost native clay subgrade material

Figure 2.1 – Proposed COB Class II Facility Expansion Area Features
*(Source: Great West Engineering, Billings Landfill Expansion Application, 2015 (*not to scale))*

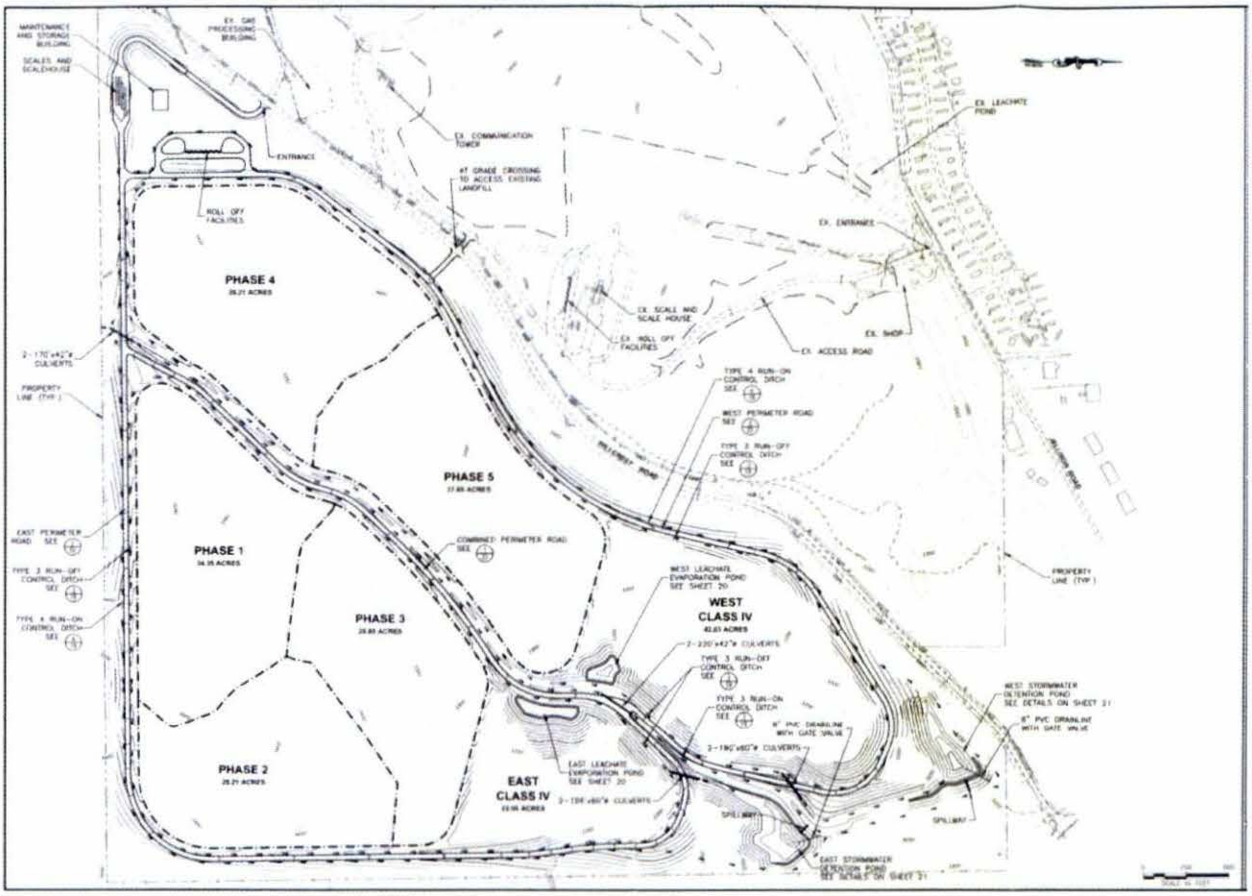


Table 2.1: Soil and Waste Balance Table

(Source: Great West Engineering, Billings Landfill Expansion Application, 2015)

Phase	Total Airspace (yds³)	Waste Volume (yds³)	Daily Cover (yds³)	Final Cover (yds³)	Total Soil Required (yds³)	Total Fill Required for Construction (yds³)	Total Excavation (yds³)	Acres	Tonnage	Life (years)	Soil Balance (yds³)
Roads, ponds, ditches						487,900	1,181,900	*61*		48	694,000
Phase 1	3,811,400	3,042,800	608,500	160,100	768,600	100,620	852,600	34.35	1,977,820	8	-16,620
Phase 2	3,514,800	2,818,100	563,300	133,100	696,700	12,000	795,500	28.21	1,831,800	7	86,800
Phase 3	6,296,800	4,973,000	994,500	329,300	1,323,800	5,000	887,700	28.85	3,232,400	13	-441,100
Phase 4	4,852,600	3,869,100	773,800	209,700	983,500	42,800	949,000	39.21	2,515,000	10	-77,300
Phase 5	5,078,800	3,953,200	790,600	335,000	1,125,600	14,700	986,100	37.55	2,569,600	10	-154,200
Total Class II	*23,554,400*	*18,656,200*						*168.17*	*12,126,620*	*48*	
West Class IV	3,626,000	2,985,200	298,500	342,300	640,800	0	1,356,200	42.03	895,560	26	715,400
East Class IV	1,581,600	1,234,800	123,500	223,300	346,800	0	709,800	22.00	370,400	11	363,000
Total Class IV	*5,207,600*	*4,220,000*						*64.03*	*1,265,960*	*37*	
TOTAL	*28,762,000*	*22,876,200*	*4,153,000*	*1,732,800*	*5,885,800*	*663,020*	*7,718,800*	*293.2*	*13,392,580*		*1,169,980*

Notes:

1. *The site will retain the central drainage.*
2. *There will be two separate waste fill areas.*
3. *The average cut depth will be 20 feet.*
4. *The waste to soil ratio is 5:1 for Class II and 10:1 for Class IV.*
5. *The assumed waste density for Class II waste is 1,300 #/yd³*
6. *The assumed waste density for Class IV waste is 600 #/yd³.*
7. *The final fill slopes will be 3:1.*
8. *The top deck elevation is 3565.0 feet.*
9. *The life is based on 250,000 tons/yr for Class II.*
10. *The life is based on 35,000 tons/yr for Class IV.*

Figure 2.2 – Base Liner Design Details

(Source: Great West Engineering, Billings Landfill Expansion Application, 2015)

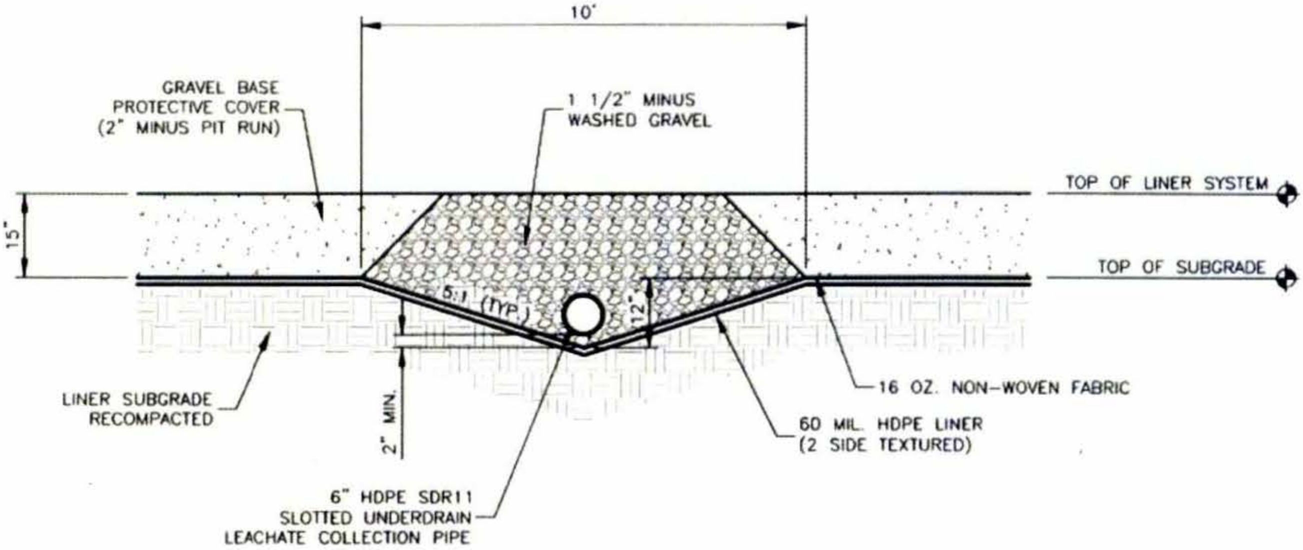


Figure 2.3 – Anchor Trench Details

(Source: Great West Engineering, Billings Landfill Expansion Application, 2015)

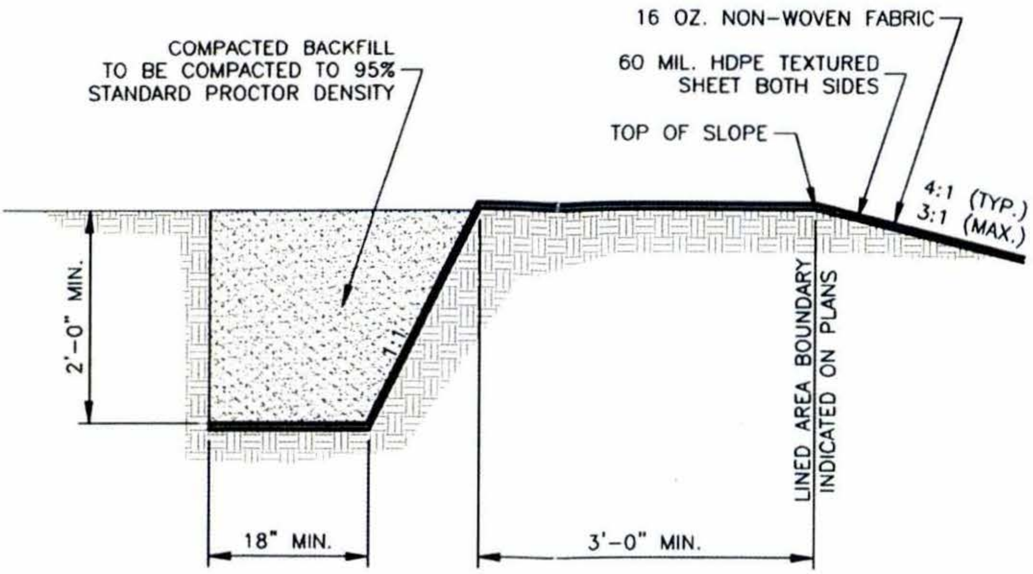
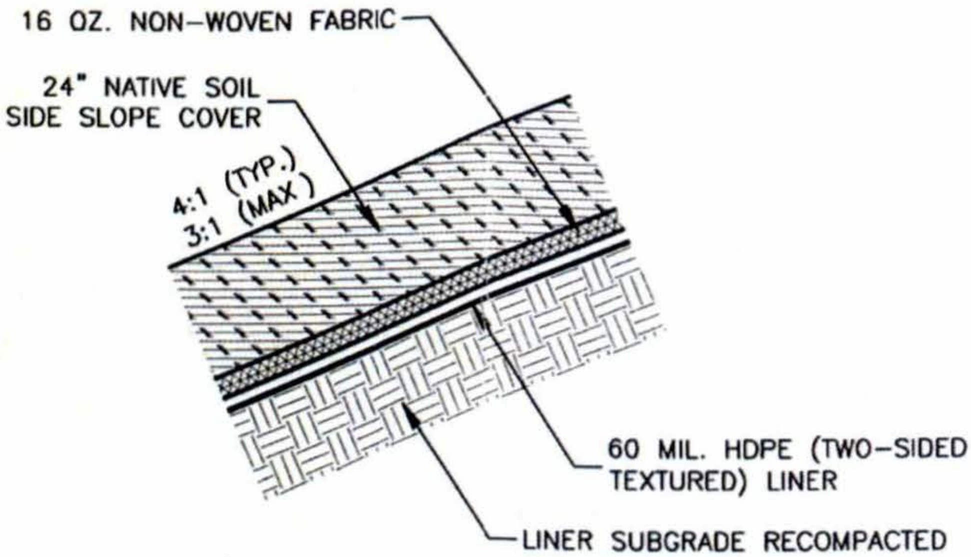


Figure 2.4 – Slope Liner Design Details
(Source: Great West Engineering, Billings Landfill Expansion Application, 2015)



2.3.4 Landfill Unit Construction

The proposed liner system described above will be installed during construction of the east and west landfill units according to DEQ's approval and the manufacturer's guidelines for each component. Each component of the liner system will be tested for conformance with the design based on the DEQ-approved Construction Quality Assurance and Construction Quality Control (CQA/CQC) Plan.

The proposed landfill expansion is comprised of two separate Class II landfill units and two separate Class IV units, each of the pairs separated by the central road as shown in Figure 2.1. As illustrated by the Phase 1 plans (Figure 2.5), the complex base grades in each phase will be built following local bedrock topography, maintaining at least a two-percent minimum slope on the liner towards a network of lateral leachate collection pipes. These laterals mostly connect to headers that slope towards the leachate mains that follow the central road. Some laterals will connect along gradient directly to the mains. All leachate pipe joints will be heat fusion welded. The liner slopes will vary in degree and aspect but will not exceed 4:1 (Horizontal: Vertical) slopes; such variations are caused by hardness of bedrock at depth. The maximum waste fill thickness will be approximately 200 feet. Maximum utilization of the designed landfill capacity will provide for the minimum disposal of 12,101,100 tons (18,656,200 cubic yards) of Group II waste when the daily and final cover soil volume is subtracted from the total fill volume (Table 2.1).

Excavation of the native soils to a depth of 25 feet below the existing natural grade within the landfill footprint will remove a total 7,718,800 cubic yards of soil that will be used for daily, intermediate, and final covers. During construction, the lower clay soil component of the Class II liner will be compacted in one six-inch lift. The native subgrade will be wetted, compacted, and tested to ensure that it meets the compaction specifications; the complete compacted surface of the six-inch soil barrier layer will be rolled and inspected for adequate smoothness before the HDPE geomembrane liner is installed. This geomembrane liner will then be placed in direct and uniform contact with the compacted soil layer with a three- to six-inch overlap on each unrolled panel that will be heat fusion welded along each edge to form a double seam. Located along the steeper eastern flank of the disposal area (Figure 2.1), the Class IV units will be excavated to base grade in shallow bedrock and will provide for the disposal of 4,220,00 cubic yards of Group IV waste.

2.3.5 Leachate Collection and Removal System (LCRS) and Leachate Pond Construction

An LCRS and leachate pond will be installed for the east and west Class II landfill units according to all DEQ-approved design plans and CQA/CQC requirements during each phase of construction. All leachate will be collected over the lined base of each Class II landfill unit within the granular drainage layer and will flow into a network of perforated HDPE leachate collection pipes bedded in gravel (*e.g.* Phase 1, Figure 2.5). Numerical models of leachate generation indicate that leachate levels will remain less than 12 inches over the liner as required over a range of rainfall intensity beyond normal averages.

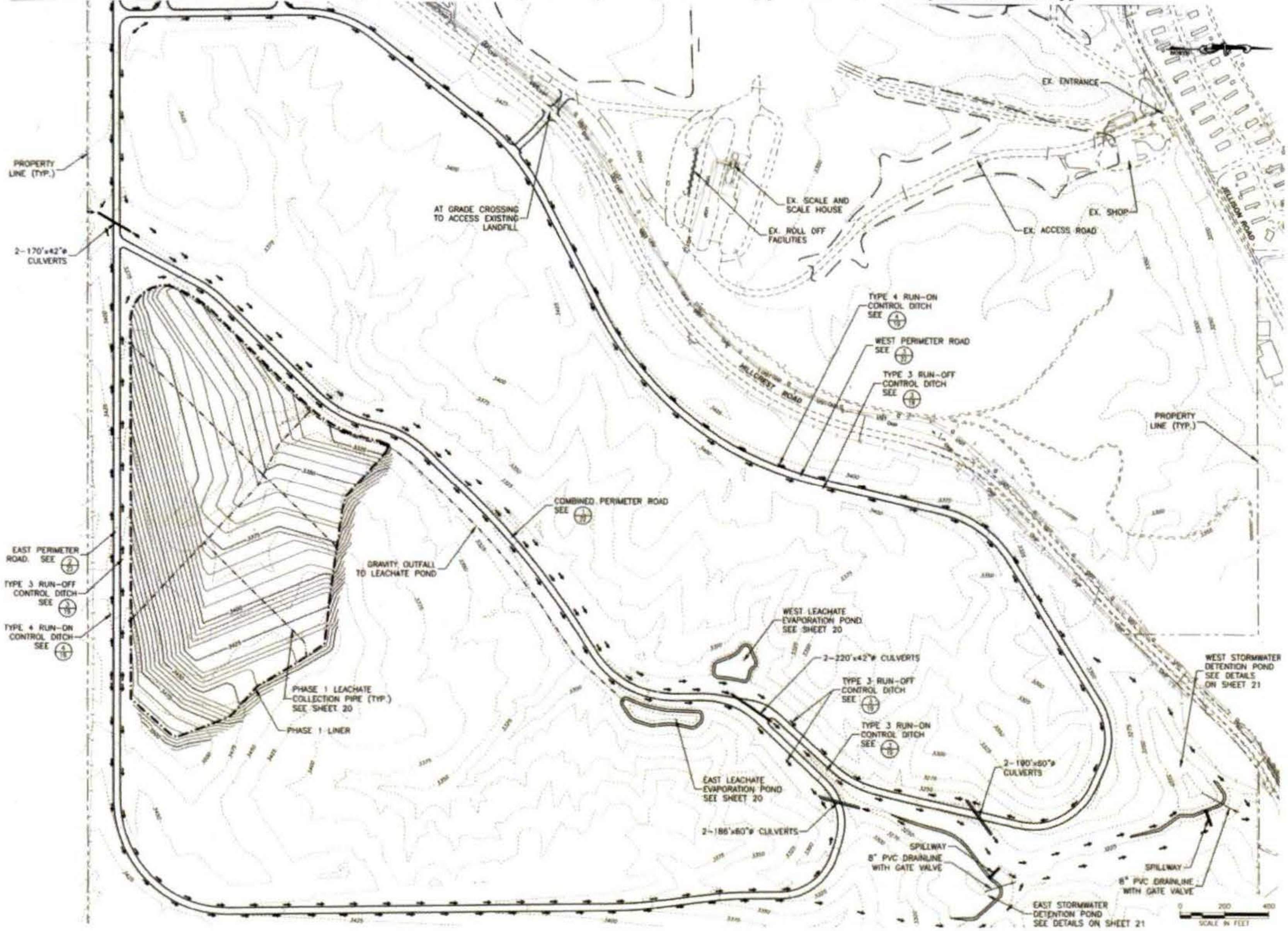
The LCRS design will provide two configurations to account for the difference in base and slope liner stability. For each waste disposal unit base, the granular leachate collection layer and lateral leachate collection pipe trenches will be constructed with at least two-percent slope following changes in grade to convey leachate from the outer edge of the floor towards a central perforated leachate collection header. In the south landfill unit, a leachate divide separates the Phase 1 and Phase 2 pipe networks, but Phase 3 parallels those prior slopes toward the toe. The headers connect downslope from each phase to a single leachate collection main that follows the toe of each unit flanking the central road along the axis of the expansion area.

The LCRS elements placed over the liner at the base of each unit will consist of the following components from top to bottom (Figure 2.6):

- Leachate collection gravel layer
- Outer coarse gravel filter (trench)
- Inner perforated leachate collection pipe (trench)
- Non-woven geotextile cushion.

Figure 2.5 – Phase 1 Design Plan

*(Source: Great West Engineering, Billings Landfill Expansion Application, 2015 (*not to scale))*



On the side slopes of the waste disposal units, the LCRS will consist of a geotextile cushion over the textured geomembrane. Leachate from the side slopes will percolate through the protective cover soil to be carried downslope by gravity drainage through the nonwoven geotextile and lateral collection pipes into the base LCRS network and headers. Each lateral collection pipe will be joined to a solid riser pipe that is extended to the surface on the uphill side-slope berms to allow for cleanout access.

All leachate will be directed to the leachate pond via gravity flow through an external buried, double-walled HDPE leachate conveyance pipe. The temporary liner penetrations installed during Phase 1, 2, and 4 operations (Figure 2.7) will be replaced by permanent penetrations at the toe of Phases 3 and 5 where the main pipes exit the collection sump and connect to the buried conveyance pipes for the east and west Class II landfill units (Figure 2.5). These double-walled HDPE (8-inch carrier pipe inside a 16-inch outer sleeve) leachate conveyance pipes will transport leachate by gravity along both sides of the central road and discharge into the east and west leachate ponds via dissipation manholes.

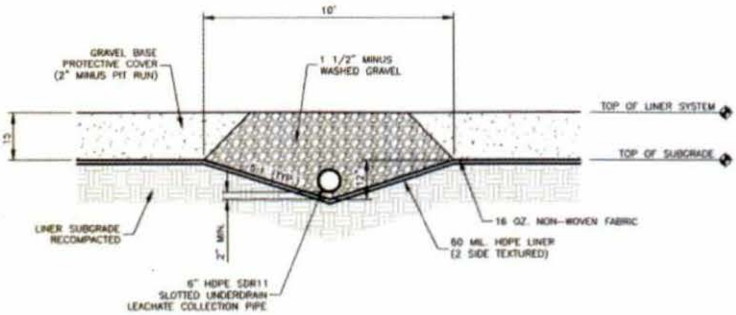
Leachate will be managed largely by evaporation from the leachate pond, but may be applied over the lined active waste disposal areas (areas that are not under final or intermediate cover) for dust control, if needed. This management allows the pond to be emptied faster to assure that there is sufficient capacity available at all times.

Separate leachate ponds will be constructed for each of the east and west Class II landfill units with double composite liner components from top to bottom as follows (Figure 2.8):

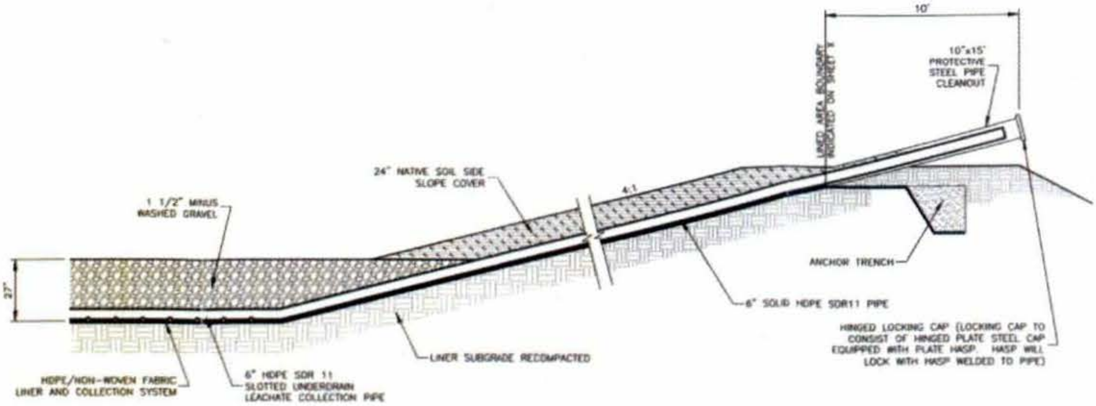
- Primary HDPE geomembrane (FML)
- Geonet composite
- Slotted HDPE collector and riser pipe (monitors leakage)
- Geonet composite rub sheet
- Secondary HDPE geomembrane (FML)
- Geosynthetic Clay Liner (GCL), doubled below monitoring sump
- Compacted subgrade.

Each pond bottom will slope 1% toward the detection sump with maximum 3:1 (Horizontal: Vertical) side slopes. The double composite liners for the leachate ponds will be installed in a manner equivalent to the landfill base liner according to all DEQ-approved design plans and CQA/CQC requirements.

Figure 2.6 – Leachate Collection and Removal System Design Detail
(Source: Great West Engineering, Billings Landfill Expansion Application, 2015)



TYPICAL BASE LINER/LEACHATE COLLECTION LATERAL CROSS SECTION
NOT TO SCALE



LEACHATE CLEANOUT SECTION
NOT TO SCALE

2.3.6 Scale House and Equipment Building

The new gatehouse, scales, maintenance building, and roll-off zee-wall will be accessed by the controlled entrance built off Hillcrest Road, located across from the existing methane gas processing facility near the northwest corner of the proposed expansion area.

2.3.7 Soil Stockpiles

The soil removed as each waste disposal unit is excavated for construction will either be stockpiled in the Class IV unit areas, or will be placed on top of fill in available active or closed landfill cells. Stockpiled soil can be utilized for daily or intermediate cover operations when needed, or placed for use during phased closure of any waste management area that has reached final grade.

2.3.8 Final Closure

The landfill final cover will be constructed in phases. Each unit will be partially closed when it reaches final grade in a progression that follows the sequence of construction (Table 2.1). The maximum open area at any one point in time will be 119 acres. The overall barrier performance characteristics for the composite final cover must at least match that of the base composite liner system, as discussed in Liner Design, Section 1.5.1. Once the outer portions of each phase have been filled to final grade, those areas will be closed. The intermediate soil cover over each of the east and west units will be tied together and capped as a single, mounded disposal unit by a continuous final cover (Figure 2.9). Both Class IV units will be covered in the same manner using the same type of final cover.

COB proposes to utilize a performance based AFC system for closure of all four landfill units in the proposed expansion area, matching the AFC closures for the active landfill. The AFC demonstration was previously approved by DEQ for compliance with the AFC design requirements and the standards for infiltration reduction, erosion, and revegetation at the currently licensed facility. Incorporation of this previous AFC demonstration report into the proposed COB expansion application documents is adequately justified given the proposed base liner properties and performance as shown by the alternative liner demonstration (Appendix C).

The proposed AFC is designed to provide an engineered soil-plant system that will attain similar water-balance equilibrium as that reached in the surrounding natural soil ecosystem. Consequently, optimal plant growth is supported by the natural storage of yearly precipitation in the soil cover for the timely release to the plants and evaporation during the growth season. Numerical models based on testing of site soils predict that the proposed AFC performance will approach an upper limit of 1 mm/year (0.05 inch/year) average annual drainage through the cover. Such percolation rates fall within the range required for equivalence to the base liner.

Figure 2.7 – Leachate Collection and Removal System Design During Phased Expansions
(Source: Great West Engineering, Billings Landfill Expansion Application, 2015)

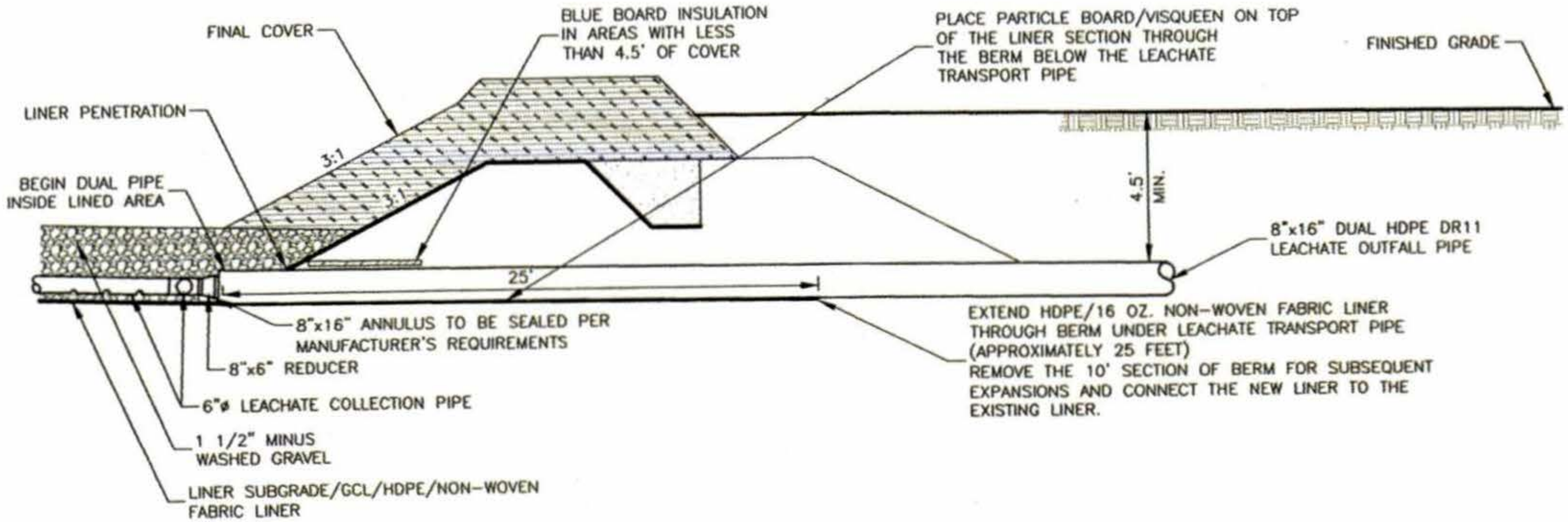


Figure 2.8 – Leachate Pond Design Detail
(Source: Great West Engineering, Billings Landfill Expansion Application, 2015)

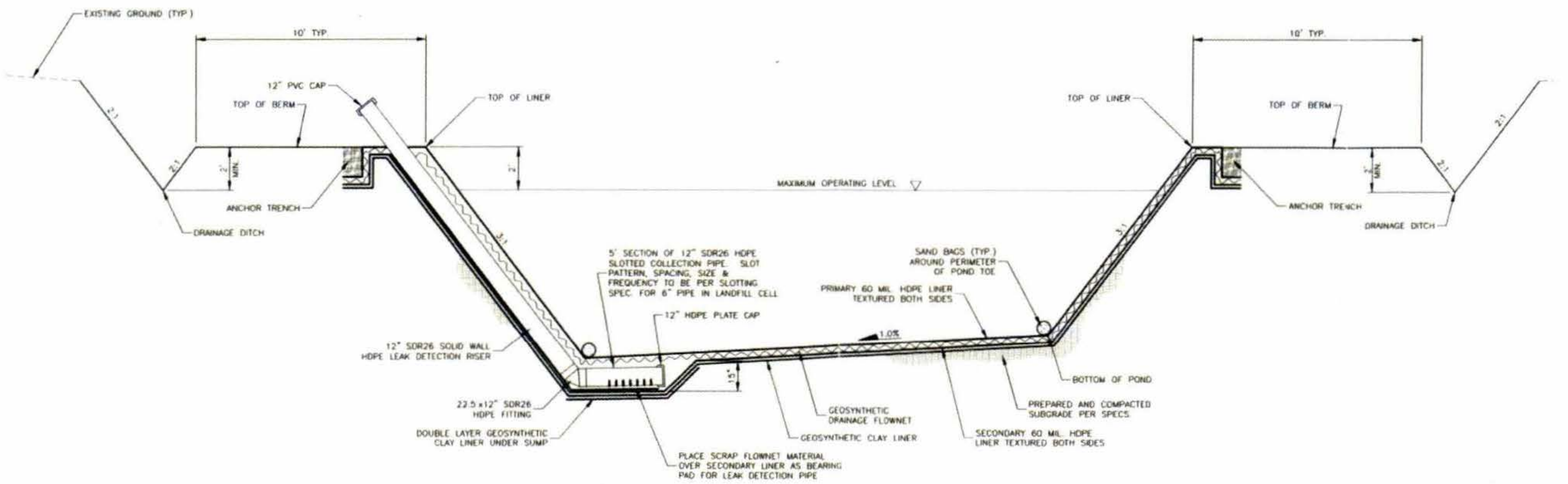
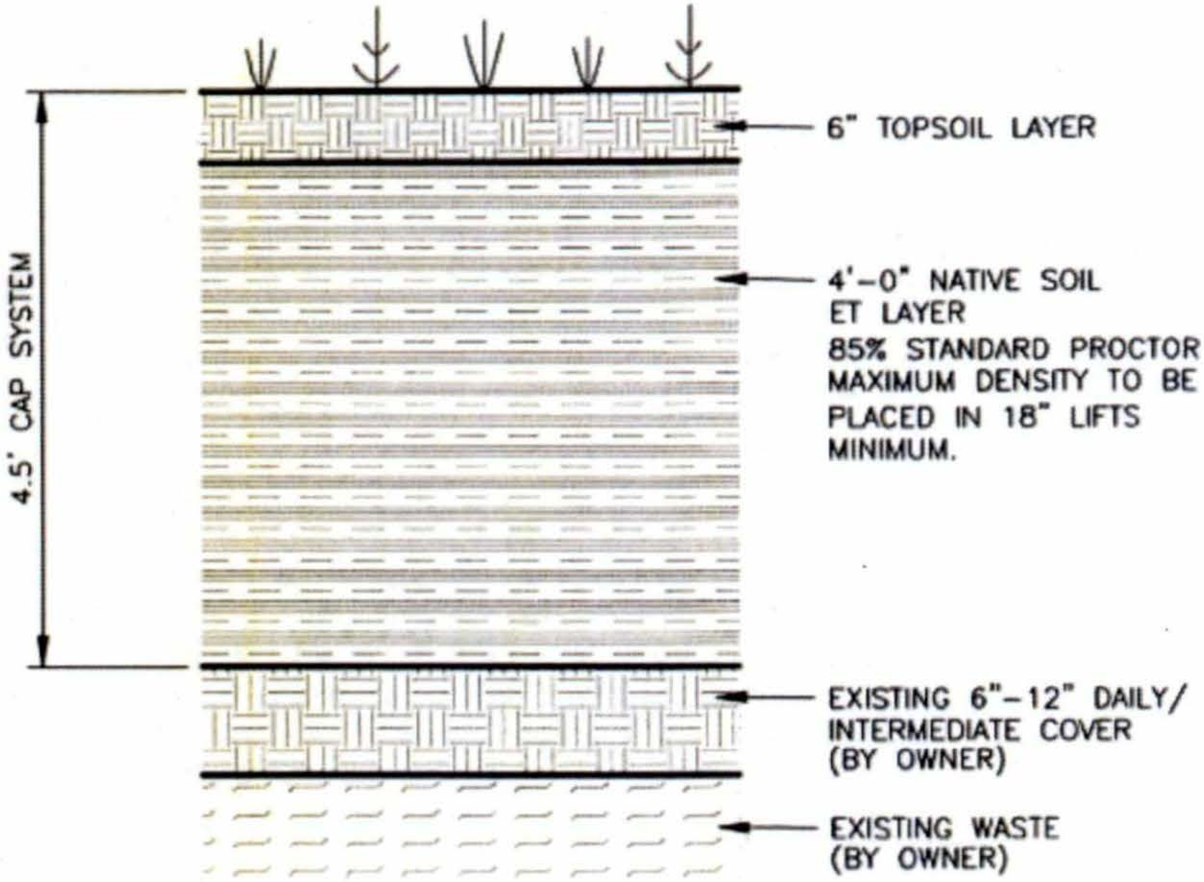


Figure 2.9 – Alternative Final Cover Design Profile



(Source: Great West Engineering, Billings Landfill Expansion Application, 2015)

The monolithic AFC profile (Figure 2.9) for the proposed expansion area landfill will consist of the following field-tested components, from top to bottom:

- Healthy stand of select native local vegetation
- Minimum 6-inch thick topsoil layer
- Minimum 48-inch thick storage layer of select tested and approved soil.

The daily or intermediate covered waste will provide the base for the final cover system. This surface will be prepared smooth and firm. The 48-in monolithic, evapotranspiration (ET) layer will be constructed in one or two continuous lifts compacted to a maximum of 85% standard proctor. The permeability of the ET layer will be verified by a combination of field and laboratory testing. The top layer will consist of six inches of loose topsoil and will be fertilized and seeded in accordance with the recommendations described in the AFC Demonstration and Vegetation Plan. The AFC will be installed according to all methods and testing based on conformance with the DEQ approved Closure Plan specifications and CQA/CQC requirements.

Both west and east Class-II landfill units will reach a final elevation of 3565 feet above mean sea level and relief will not exceed 265 feet above the lowest surrounding grade in the central coulee (Figure 2.10). The final cover top deck will not exceed 3-5% slope and will attain maximum side slopes not to exceed a 3:1 grade. Side slope ditches for storm water control will be constructed to intercept runoff at 50-feet vertical intervals and route flow at approximately 5% percent into grouted downchutes that discharge to the perimeter rip-rap ditches adjacent to the central road.

2.3.9 Operation and Maintenance Plan

The COB Landfill facility will continue to operate as a licensed Class II SWMS and follow a DEQ-approved Operation and Maintenance (O&M) Plan. The facility O&M Plan will be updated at least every five years, and as necessary prior to commencing operations in the proposed expansion area and as on-site conditions change. The facility must comply with applicable requirements of the SWMA and associated administrative rules, including the payment of fees and submittal of an annual application for renewal. Failure to operate the facility according to these requirements could result in enforcement actions, license revocation, or denial of an application for renewal.

2.3.10 Personnel

The proposed expansion area will continue to be operated by COB employees. Site personnel will inspect incoming loads, review incoming waste load records, operate landfill equipment, and apply the necessary soil cover.

2.3.11 Operating Hours

The current City of Billings landfill is open Monday through Saturday from 8:00 a.m. to 5:30 p.m. From May through October, the facility is also open on Sunday from noon to 5:00 p.m. The facility is closed on New Year's Day, Memorial Day, July 4th, Labor Day, Thanksgiving Day, and Christmas Day.

2.3.12 Access Control

Planned access to the landfill expansion will be provided by Hillcrest Road from South Billings Boulevard. Access into the facility will be controlled through a lockable entrance gate and perimeter fence around the landfill facility. All landfill users will enter the expansion area through the main facility gate. Scale house personnel will continue to control all access through this existing landfill entrance.

2.3.13 Acceptable Wastes

The proposed expansion area will be licensed as a Class II SWMS and continue to accept Group II, III, and IV wastes, as is the current practice at the existing COB Class II Landfill facility. Group II wastes include decomposable wastes and mixed solid wastes containing decomposable materials but exclude regulated hazardous waste. Group III wastes include wood wastes and other clean non-water soluble or inert solids. This category includes, but is not limited to, brick, rock, dirt, concrete, unpainted and unglued wood materials, and tires. Group IV wastes include construction and demolition wastes and asphalt but exclude regulated hazardous wastes.

2.3.14 Waste Screening and Prohibited Wastes

The landfill staff would perform random load inspections to assure landfill compliance with regulations prohibiting the disposal of regulated hazardous waste and polychlorinated-biphenyls (PCB) in solid waste landfills. The landfill operator will monitor each load of incoming wastes at the scale house. Waste screening procedures, including random and targeted load inspections, would continue to be implemented to prevent prohibited wastes from entering the COB Class II Landfill Facility. If unacceptable wastes are discovered at the scale house, the facility would reject the load and instruct the customer to dispose of it at an appropriate facility. Any unacceptable waste discovered by the equipment operators at the working face would be segregated in the waste disposal unit for handling and disposal by a qualified consultant. The facility operator would notify DEQ's Solid Waste Program within 24-hours when prohibited wastes are discovered at the facility or when incoming loads are rejected during the on-site waste screening activities.

The following prohibited wastes would not be accepted for disposal at the COB Class II Landfill Facility: regulated quantities of hazardous waste; listed hazardous wastes; explosives; regulated quantities of polychlorinated biphenyls (PCBs); bulk liquids; highly flammable or volatile substances; septic tank pumpings; and infectious waste as defined by 75-10-1003, MCA.

If questionable wastes that do not fall into the above categories are discovered during operations, these wastes would not be incorporated into the active disposal areas but would be placed outside the area of daily operation for further evaluation. Temporarily stored wastes would be segregated from other wastes in the landfill and protected from wind and water dispersion and leaching as may be appropriate for the type of waste. The hauler responsible for the waste would be determined and would be asked to identify the source of the waste. The waste will then either be removed from the site by the hauler, or the characteristics of the waste identified by the generator to confirm that the waste is acceptable. If the hauler cannot be identified, the COB would have the waste characterized by a private laboratory. In the event that the waste is determined to be prohibited, handling and disposal would be in accordance with the requirements of the appropriate regulatory authorities. The COB would notify DEQ within 24-hours of discovery that prohibited waste has been delivered to the landfill.

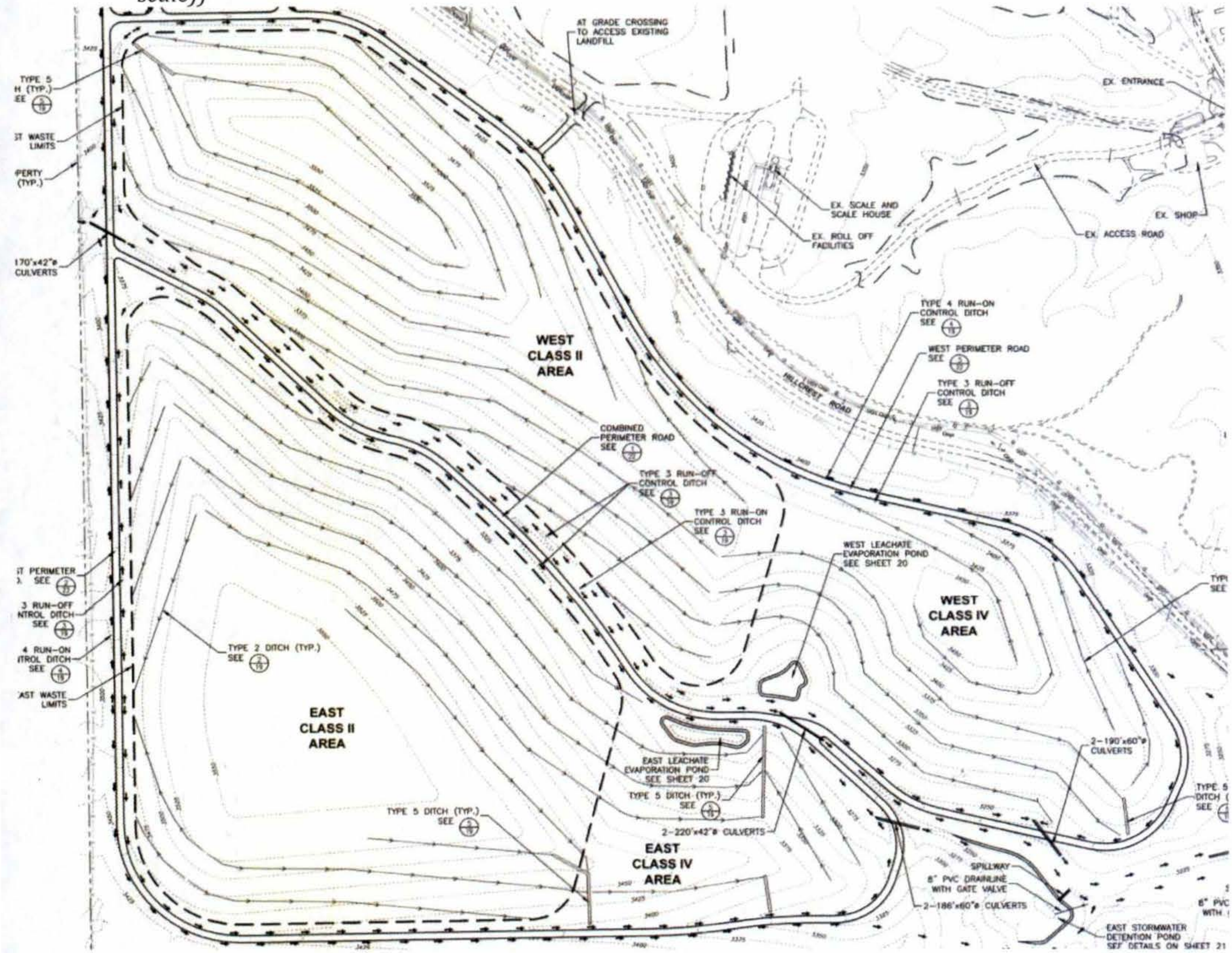
2.3.15 Landfill Equipment

Equipment to be used at the landfill during operations includes:

- Dozers;
- Loaders;
- Compactors;
- Graders;
- Water Truck;
- Vacuum Truck;
- Excavator; and
- Roll-off Trucks.

Figure 2.10 – Landfill Final Grading Design

*(Source: Great West Engineering, Billings Landfill Expansion Application, 2015 (*not to scale))*



The facility also has an assortment of pick-up trucks, dump trucks, and a welding/service truck that will be available for site operations.

The following equipment will be used during landfill construction:

- Dozers;
- Loaders;
- Rollers;
- Graders;
- Water Truck;
- Scrapers; and
- Excavators.

2.3.16 Daily Landfill Operations

The scale operator will continue to be the first point of contact for vehicles entering the landfill and will direct vehicles to the appropriate waste management areas based upon the type of material being disposed. Trained landfill personnel will continue to maintain control over the area used for discharging wastes. Shipments of special waste with unique disposal requirements, such as friable asbestos or dead animals, would also be directed to their respective disposal areas. Since wastes will be brought to the landfill in a variety of vehicles, the scale operator will direct the individual haulers to areas of the working face apart from the larger commercial vehicles or to roll-off containers located near the scale. Large household appliances and metals will continue to be unloaded at a separate drop-box container.

As refuse is being unloaded at the containers or working face, landfill staff will inspect the loads for recyclable or prohibited materials. Unacceptable waste identified by landfill staff will continue to be separated for proper treatment and disposal or rejected and returned to the customer. As appropriate, customers with recyclable or salvageable materials will continue to be directed to a licensed off-site recycling facility.

2.3.17 Severe Weather Operations

All-season roads will be constructed by re-compacting the subgrade materials within the facility boundary to ensure that facility operations are not hindered during inclement weather. Asphalt may also be used to construct permanent roads in areas that will be used during the life of the facility. The location of the public drop-off area may be adjusted as necessary during muddy conditions. During windy weather, the operators will utilize temporary litter fences that can be moved to strategic areas of the landfill to catch blowing litter. The working face may also be moved to lower elevations, or operations may be shut down temporarily during extremely windy conditions.

2.3.18 Litter Control

Wastes will continue to be compacted and covered as required in the active waste disposal unit as soon as possible after deposition to reduce the possibility of blowing litter. Whenever possible, the active working face will be oriented to the downwind side of prevailing winds and kept to the smallest practical area to minimize exposure and help reduce blowing litter. Landfill personnel will continue to regularly patrol the landfill perimeter and pick up litter blown from the working face on a daily basis. Additionally, portable litter fences may be placed downwind of the working face. Litter caught on the fences is removed daily, or as necessary. All loads require tarps placed over open truck loads.

2.3.19 Dust Control

The operator is required to control dust on the interior facility roads. Water will be applied as a dust suppressant on an as-needed basis using a water truck. Application of water as a dust suppressant will not cause runoff, erosion, or water/waste interaction. The water will be applied to the road any time the operator observes dust beginning to circulate into the air more than about three feet, where visibility of the drivers could be obstructed. In windy conditions, the operator shall be prepared to implement dust control measures to prevent dust generation. If the operator is unable to control dust generation, the site manager may temporarily halt operations to mitigate dust generation.

To minimize dust generation in the lined active waste disposal units, the facility may use leachate generated from the waste unit as a dust suppressant within the unit. Leachate will only be applied within the active waste disposal unit as-needed to achieve the desired results.

2.3.20 Leachate Control

According to the solid waste regulations, moisture that contacts waste is considered leachate. Leachate generated from the landfill disposal units will be managed by evaporation. The COB will construct two separate leachate evaporation ponds, a 1.5-acre East Leachate Pond and a 1.0-acre West Leachate Pond. Both leachate evaporation ponds will be constructed with at least two-feet of freeboard. The evaporation pond design will provide a maximum capacity sized for variations based on historic annual precipitation models and the peak flows experienced at the active landfill. The leachate ponds have no outlet and leachate may not be released from the leachate pond or landfill units, although leachate may be recirculated over the active Class II landfill unit for land application or infiltration over the composite liner. Solid waste regulations prohibit more than 12 inches of leachate over the liner. Leachate collected in the ponds will be monitored and recorded regularly in the facility operating record.

2.3.21 Storm Water Control

Storm water is water that originates during precipitation events and snow and ice melt. Storm water can soak into the ground, be held on the surface to evaporate, or run off towards downstream surface water bodies. Two storm water ponds will be constructed to retain storm water for sediment control. During routing, this storm water runoff will be managed using standard best management practices (BMP's). Storm water BMP's are control measures used to manage changes in the quality and quantity of storm water runoff. BMP's are designed to reduce the volume, peak flows, and/or quality of storm water through evaporation, infiltration, detention, and filtration. BMP's, including erosion control mats, screens, wattles, or berms, ditches, and ponds will be constructed according to the facility Storm Water Pollution Prevention Plan (SWPPP).

Perimeter ditches will surround the facility to intercept natural runoff from outside the facility, prevent it from flowing onto the site, and route it away from the facility into adjacent natural drainages. Perimeter rip-rap ditches will also be constructed to convey runoff from areas on the interior side of the facility perimeter road, but outside the waste disposal units, toward a central ditch to the ponds. The central ditch will be constructed in the current drainage (Stream 1 – Section 3.4.2) that flows 1.5 miles north-northeast through the proposed area. The ditches are designed to carry the maximum 25-year 24-hour storm flow volume as required (3.25-inches/day) to control site erosion during large storm events. The pond inlets and outlets will be constructed with riprap plunge pools to further minimize erosion impacts. The 127-acre west drainage basin drains into the 2.5-acre west storm water pond. The west storm water pond is designed to hold 9.1 million gallons (28 acre-feet); the discharge calculated from a 25-year, 24-hour storm event for the area captured by the west basin is 22.7 acre-feet, or 7.4 million gallons. The 123-acre east drainage basin drains into the 3-acre east storm water pond. The east storm water pond is designed to hold 7.2 million gallons (22 acre-feet); the discharge calculated from a 25-year, 24-hour storm event for the area captured by the east basin is 21.5 acre-feet, or 7.0 million gallons.

Effective erosion control BMP's, such as revegetation, may allow clean runoff from some areas to also be routed to the central coulee and naturally discharged offsite. The existing general storm water industrial discharge permit issued by the DEQ Water Protection Bureau for the current Class II Landfill facility will be extended prior to operations in the proposed expansion area. The COB will also acquire the necessary storm water construction permits prior to any landfill unit construction/expansion activities.

The BMP's, including the establishment and maintenance of vegetation on closed areas as well as on the soil stockpiles, will be implemented as necessary. Areas receiving final cover would be contoured for positive drainage so that surface runoff would be routed away from the active disposal area. Runoff from fully re-vegetated and closed areas of the landfill final cover may discharge naturally off-site.

2.3.22 Contingency Planning

The O&M Plan for the active COB Class II Landfill facility has current contingency plans for unusual situations beyond typical screening procedures. The expanded facility will follow similar updated detailed response plans for fire protection and notifications during emergencies. Presently, all emergency operations will be managed under the Incident Command System with one designated Incident Commander. Initial response will be the responsibility of the Landfill Supervisor or any landfill employees present as the mechanism to get the most appropriate emergency response personnel to the site as soon as possible. The Solid Waste Superintendent will assume the lead role in coordinating all contingency plans beyond the initial response phase. In the absence of the Solid Waste Superintendent, the Landfill supervisor and Environmental Compliance Coordinator, in that order, will assume the role of Incident Commander unless replaced by a more appropriate person. The O&M Plan is reviewed at least every five years and as part of the review, the contingency plan will be updated as necessary for DEQ review and approval.

2.3.23 Financial Assurance

In accordance with ARM 17.50.540, all Class II landfills must provide and maintain a Financial Assurance (FA) mechanism to cover costs associated with facility closure and post-closure care. FA ensures that work associated with facility closure and post-closure care is completed in the event the operator cannot or will not do so on his own accord. Financial assurance is already required for the active COB Class II Landfill facility.

The amount of FA required is based upon the proposed maximum costs associated with third-party closure of the maximum exposed landfill area and the performance of post-closure care activities. If the proposed facility expansion is approved, the current total cost estimate for FA is $7,059,470 and includes projected closure costs of $5,798,870 and $1,260,600 for the 30-year post-closure care period.

The existing COB Class II Landfill FA mechanism is a trust fund. The regulations require that the trust fund be funded prior to the initial placement of waste in the proposed expansion area. DEQ will be the fund beneficiary and control all release of money from the trust fund. The minimum annual payment required to cover the cost of closure and post-closure care is based upon the size of the projected largest open area of the landfill units. The projected largest open area is 119 acres. The FA cost based upon this is currently estimated to be $178,864 accumulated over the first 38 years (Phases 1-4). A payment of $26,263 would be required annually thereafter based on projected 10-year remaining life until closure. The regulations require all Class II facilities to update the FA cost estimates, including adjustments for inflation, and payments to the approved FA mechanism on an annual basis to ensure that the approved FA mechanism is adequately funded.

2.3.24 Post-Closure Care

The Post-Closure Plan identifies the inspection, maintenance, and monitoring activities to be completed during the 30-year post-closure care period, and identifies the frequency for conducting these activities. The final proposed use of the facility is rangeland.

According to the Post-Closure Plan, detailed inspections of the closed landfill facility will be conducted yearly during the post-closure care period and will include:

- Evaluation of the final cover for settlement, erosion and quality of vegetation;
- Inspection of leachate collection, monitoring, and evaporation systems for damage or degradation;
- Inspection of drainage control facilities (berms, ditches, catch basins, piping, manholes, outlets and ponds) for erosion, damage, blockage or accumulation of sediment;
- Condition and functionality of groundwater and methane monitoring wells,
- General site conditions (gates, locks, fencing, survey monuments, etc.); and
- Evaluation of the FA.

The leachate collection pipes will also be cleaned as necessary. If damage or degradation to the final cover, drainage control facilities, monitoring systems or general site features is noted, maintenance will be completed by the owner on a timely basis. Such maintenance activities will be described in the Post-Closure Plan, will follow manufacturer's specifications as necessary, and meet all approved CQA/CQC procedures. The nature of the maintenance completed will be noted on the inspection form, which will be added to the operating record.

A report describing the inspections, conditions observed, corrective actions, maintenance activities, monitoring activities performed, and annual FA adjustments needed in connection with the closed facility will be submitted to DEQ annually and entered into the operating record. Routine groundwater or methane monitoring will be performed by the owner during the post-closure care period in accordance with the DEQ-approved Groundwater or Methane Monitoring Plans.

3 AFFECTED ENVIRONMENT AND ENVIRONMENTAL CONSEQUENCES BY RESOURCE

3.1 INTRODUCTION

Section 3 describes resources that could be affected by the Proposed Action and discusses the environmental consequences of the Proposed Action and the No Active Alternative.

3.2 LOCATION DESCRIPTION AND STUDY AREA

The project location and associated study area for the Proposed Action include all lands and resources in the proposed Project Area, plus those additional areas identified by technical disciplines as "resource analysis areas" that are beyond the Project Area. Resource analysis areas are identified for each technical discipline.

3.3 TERRESTRIAL AND AQUATIC LIFE AND HABITATS

3.3.1 ANALYSIS AREA AND METHODS

The analysis area for wildlife and aquatic life is the proposed COB Class II Landfill facility expansion site. The analysis methods included DEQ's research of the Natural Resource Heritage Program database to determine the presence of threatened, listed, and/or endangered plant and animal species. DEQ also reviewed the United States Geological Survey topographic maps to determine existing water resources in the area.

3.3.2 AFFECTED ENVIRONMENT

The proposed landfill expansion area is in an upland plain that is dissected by a secondary drainage that flows to Blue Creek. Blue Creek is a tributary of the Yellowstone River. The expansion area is currently used intermittently for livestock grazing.

The tract is currently dominated by various grasses, sage, and cacti that may be used as forage by transient local wildlife such as mule deer. Large areas of similar vegetation are found adjacent to the proposed expansion area. The landscape is not unique and does not contain any specially designated or unique wildlife habitat features.

Wetland and stream delineations were conducted within the area of the proposed expansion. (Appendix D). During the investigation, 14 wetlands, occupying a total of approximately 2.41 acres, were identified. These wetlands were distinguished from the abutting uplands by the presence of wetland indicators, including hydric soils (soils that are saturated, flooded or ponded long enough during the growing season to create anaerobic conditions), and hydrophytic vegetation (plants that grow in the water, or areas deficient in oxygen due to excess water).

The proposed expansion area is located in the Blue Creek Watershed. There are 22 unnamed first-order intermittent streams that discharge into a large second-order intermittent stream (where 2 or more first-order streams join). These 22 unnamed intermittent streams do not carry water year-round, but only exhibit seasonal flow when runoff exceeds the rate of infiltration. The large second-order intermittent stream identified as Stream 1 is located in the center of the proposed expansion area. Seasonal flow occurs in Stream 1 when runoff exceeds the rate of infiltration. Stream 1 starts just south of the proposed area and runs 1.5 miles north-northeast through the proposed area. Discharges from Stream 1 flow into Blue Creek through the culverts constructed under Blue Creek Road. During springtime weather events, it is expected that this area would generate low-gradient riffles. However, the resulting shallow, coarse-bedded intermittent streams with slow flows, but high turbulence, do not provide fish habitat.

3.3.3 ENVIRONMENTAL CONSEQUENCES

3.3.3.1 No Action Alternative

Under this alternative, because the site would not be developed, there would be no additional impacts to terrestrial and aquatic life and habitats.

3.3.3.2 Proposed Action

The primary impact anticipated due to the construction and operation of the landfill within the expansion area will be the displacement of terrestrial and avian species that may currently occupy the site. The COB application for expansion was received before January 1, 2016. Therefore, compliance with the Sage Grouse Executive Order is not required. However, DEQ consulted maps of sage grouse habitat available from the Montana Sage Grouse Conservation Program to determine whether sage grouse habitat is present in the proposed expansion area. The result of the habitat map review indicated that sage grouse habitat is not present in the proposed expansion area.

A search of the Montana Natural Heritage Program database indicated that there are no threatened or endangered terrestrial or avian species, nor Species of Concern or Special Status species, identified in Township 1 South, Range 26 East. The displacement of other wildlife habitat from construction and operation of the facility may alter the movement of local wildlife. Current populations of transient wildlife that may inhabit portions of the proposed expansion area site would move to other areas of similar habitat. Not all disposal areas within the proposed expansion area would be open at any one time; a maximum of 119 acres of landfill units would be open at any one time. This would leave undisturbed areas available for grazing and bedding. Once the current COB landfill reaches capacity, the disposal units would be closed, capped, and revegetated. Existing wildlife would likely migrate away from disturbances in the proposed expansion area and move into the closed landfill where interactions with humans, vehicles, and heavy equipment would be minimal. Therefore, the impacts from landfill construction and operation on wildlife habitat would be minor due to the abundance of surrounding similar habitats in the vicinity to accommodate any terrestrial or avian species that may be forced to relocate.

3.4 HYDROLOGY

3.4.1 ANALYSIS AREA AND METHODS

The analysis area for hydrology is the proposed COB Class II Landfill facility expansion site and the drainage area one mile downstream of Blue Creek to the Yellowstone River. A discussion of regional geology, based upon published reports, is also provided herein. The analysis methods for hydrology included reviewing on-site drilling information, publications of the Montana Bureau of Mines and Geology, and published topographic maps of the area.

3.4.2 AFFECTED ENVIRONMENT

3.4.2.1 Surface Water

The proposed COB Class II expansion site is located approximately 0.8 mile south of the Yellowstone River, the main drainage mapped on the United States Geological Survey (USGS) Billings East MT 1:24,000 quadrangle. Generally, surface water drains from the surrounding upland areas to the north and east via several seasonal first order drainages to large seasonal second order drainage to Blue Creek and into the Yellowstone River.

As part of the proposed expansion project, COB's consulting engineers conducted a wetland and stream delineation study in October 2012. The investigation was conducted using methods described in the Corps of Engineers Wetland Delineation Manual, as updated by the Regional Supplement to the Corps of Engineers Wetland Delineation Manual: Great Plains Region. The field investigation identified 14 wetlands with a cumulative area of 2.41 acres in the study area. The proposed expansion area also contains 22 unnamed first-order streams that discharge into a large second-order stream (where 2 or more first-order streams join). The large second-order intermittent stream, identified as Stream 1, runs through the center of the proposed expansion area. Stream 1 starts just south of the proposed area and runs 1.5 miles north-northeast through the proposed area, and discharges into Blue Creek through the culverts constructed under Blue Creek Road. In the week prior to the October 2012 stream delineation investigation, Billings had 1.5 inches of rain and temperatures were generally in the normal range for early October. None of the intermittent streams, including Stream 1, contained surface water flow in any part of the channel during the October 2012 field investigation. Due to the intermittent nature of these drainages identified within the proposed expansion area, none of these drainages contribute a large amount of flow to Blue Creek.

3.4.2.2Ground Water

The distribution and physical properties of the underlying geologic units affect the availability, movement, and quality of ground water. The proposed expansion site is located within the Yellowstone River valley which lies between the sandstone cliffs to the north and rolling hills underlain by a thick sequence of shale to the south. The cliffs are locally known as the "Rims" and are composed of the Eagle Sandstone and the Telegraph Creek Formation, both of which are Cretaceous in age. The sandstone formations dip gently to the north and are not present in the valley beneath the river. Within the Yellowstone River valley, the Yellowstone River has cut down into a thick sequence of Cretaceous aged shale. The shale sequence is on the order of 2,000 feet thick and is widely exposed in the hills south of Billings, as evidenced in the proposed landfill expansion area hydrogeological and soils investigation.

The two geological units within the proposed landfill expansion property are the Belle Fourche unit and the Quaternary-aged (Pleistocene) deposit. The Belle Fourche shale underlies the entire site, exposed either at the surface or near the surface, and consists of a fine-grained sedimentary rock of upper Cretaceous age. The unit is thinly-laminated, dark bluish-gray, and consists almost entirely of silt- and clay-sized particles. The Quaternary-aged (Pleistocene) deposit consists of silt, sand and gravel that underlie the center of the easternmost part of the expansion area property; it is expressed as a flat, non-eroded prairie and is obvious on the land east of the expansion area property. Several faults were identified in the proposed expansion area. None of the faults are active and the proposed landfill expansion area does not lie within any seismic impact zone.

Within the Yellowstone River valley, ground water generally occurs in gravel deposits ranging from 0 to 30 feet thick and lying beneath these terraces. Saturated thickness beneath the terraces is approximately 15 feet and the individual terraces do not appear to be hydraulically connected. There is up to 100 feet of silty clay or clayey sand above the saturated gravel units that acts as a confining layer in some areas.

Ground water in the proposed expansion area was encountered in at least two of the four deeper borings and monitoring wells were established at these two locations (B8 and B16). In general, the lower depths of the weathered Belle Fourche shale, perhaps as deep as 45 feet below ground surface, appear capable of transmitting small quantities of groundwater. Ground water also migrates on top of thicker bentonite beds. Due to the lack of consistency in the occurrence of ground water, the generally shallow depths at which it was conclusively detected and apparently low yields of the water-bearing formations, the hydrogeological regime appears to consist of locally recharged perched aquifers. Conditions documented during the hydrogeological and soils study support the assertion that groundwater is not contiguous, is locally recharged, and occurs as isolated, perched water-bearing zones. These are the same conditions that are dominant at the existing landfill, which is immediately adjacent to the proposed expansion area.

Locations of nearby ground water wells, including public water supply wells, within one-mile of the proposed expansion area boundary were identified by a search of the Montana Bureau of Mines and Geology's (MBMG) Groundwater Information Center (GWIC) database. The GWIC database lists 46 water-supply wells within a one-mile radius of the proposed expansion area. Because the GWIC database locates wells by section, all wells in the section containing the proposed expansion area were included in this analysis. Table 3.1 summarizes the well information by section. The data used to create this table are collected from well drillers' records and are not verified for accuracy. The wells identified by GWIC nearest to the proposed expansion site are greater than 20 feet deep and have static water levels greater than 7 feet below ground surface. Most of those wells are concentrated within the southeast quarter of Section 20, Township 1 South, Range 26 East. All but four of the wells are set in alluvial aquifers related to Blue Creek or the Yellowstone River. The remaining four wells appear to penetrate aquifers within the Mowry shale. The Mowry shale underlies the Belle Fourche formation found at the landfill

3.4.3 ENVIRONMENTAL CONSEQUENCES

3.4.3.1 No Action Alternative

Under this alternative, because the site would not be developed, there would be no additional impacts to surface water or ground water.

3.4.3.2 Proposed Action

3.4.3.2.1 Surface Water

Surface water at the proposed site consists of the natural flow of water discharged when the excess water generated by rain or snowfall, melting of accumulated snow, or seepage from groundwater springs flows freely over the land surface into the intermittent drainages.

Surface water flow may occur over bare rock or ice, when the soil is saturated and ponding capacity is exceeded, when precipitation falls more quickly than the soil can absorb it, or more typically when a combination of all these conditions exists. Storm water runoff can cause erosion and may transport sediments some distance from their source depending upon the intensity of the runoff, vegetative cover, soil characteristics, and topography.

The current regulations require licensed solid waste management systems to control storm water. As discussed in the facility design section, the overall design of the proposed COB Class II Landfill facility includes the construction of two perimeter ditches and a central ditch and berms that would prevent upgradient storm water from entering any waste disposal area.

Perimeter rip-rap ditches would also be constructed to convey runoff from areas on the interior side of the facility perimeter road, but outside the waste disposal units, toward a central ditch to the ponds. The interior perimeter ditches are designed to carry the maximum 25-year 24-hour storm flow volume as required (3.25-inches/day) to control site erosion during large storm events. Storm water flow in the interior perimeter ditches would be conveyed to one of two storm water detention ponds. The detention ponds are designed to settle the solid particles in the storm water and retain at a minimum the total volume of water from the 25-year, 24-hour storm event in accordance with State and Federal requirements. The pond inlets and outlets would be constructed with riprap plunge pools to further minimize erosion impacts. The 127-acre west drainage basin drains into the 2.5-acre west storm water pond. The pond is designed to hold 9.1 million gallons (28 acre-feet); the discharge calculated from a 25-year, 24-hour storm event for the area captured by the west basin is 22.7 acre-feet, or 7.4 million gallons. The 123-acre east basin drains into the 3-acre east storm water pond. The east storm water pond is designed to hold 7.2 million gallons (22 acre-feet); the discharge calculated from a 25-year, 24-hour storm event for the area captured by the east basin is 21.5 acre-feet, or 7.0 million gallons.

The COB would operate and maintain the detention ponds and ditches in accordance with the SWPPP and General Industrial MPDES Permit throughout the life of the facility. As required by the regulations, the storm water retention pond is designed at a minimum to contain a surge of storm water generated from a 25-year, 24-hour rainfall with adequate freeboard on pond inlets and berms. Any necessary discharges from the ponds would be routed to the natural drainage that flows to Blue Creek. If a discharge is necessary, COB must first sample the ponds for total dissolved solids and total iron before any storm water is released into the central coulee to become state waters and flow downstream into Blue Creek and the Yellowstone River. These actions are required according to the facility's MPDES Permit requirements regulated by DEQ's Water Protection Bureau to ensure that a discharge does not deposit sediment downstream.

The COB landfill staff would be responsible for maintenance of all on-site drainage structures and ditches. Maintenance would include the implementation of Best Management Practices (BMPs) to control erosion and sediment transport.

Construction of landfill units and associated features of the proposed expansion area would remove the 2.41 acres of existing wetlands identified on site. The wetlands and bodies of water that would be affected by the expansion currently have direct contact to Blue Creek, which flows into the Yellowstone River via the second order drainage (Appendix D - Wetlands Delineation Report) The United States Army Corps of Engineers (USACE) has elected the Yellowstone River as Traditional Navigable Water, or TNW. Thus, all impacted wetlands and bodies of water are subject to jurisdiction under Section 404 of the Clean Water Act. COB must also obtain a 401 certification from DEQ's Water Quality Bureau prior to any construction activity. The USACE is accountable for Section 404 determinations. The COB must obtain a 404 permit from the USACE prior to any wetland disturbance.

With the removal of these wetlands, the construction of mitigated wetlands is required. Wetland mitigation must occur prior to construction. The minimum wetland mitigation requirement would be a 1:1 ratio to achieve 2.41 acres of wetland, or 2.41 mitigation credits. However, mitigation could require at least a 2:1 ratio, depending on project timing and if mitigation wetlands are likely to provide the same or better quality of habitat. Actual mitigation requirements would be determined prior to 404 permitting in a Wetland Mitigation Plan. Additional mitigation credits would be required if mitigation is not completed before construction.

Table 3.1: Nearby Well Information
(Source: Montana Bureau of Mines and Geology, GWIC database)

Gwic Id	Twn	Rng	Sec	Q Sec	Type	Total Depth	Static water level	Yield	Date	Use
179454	01S	26E	19	DADA	WELL	19	10	17.5	12/22/1999	PUBLIC
179455	01S	26E	19	DADA	WELL	20	10	75	12/23/1999	PUBLIC
94160	01S	26E	19	DD	WELL	30	10		8/12/1977	DOMESTIC
94161	01S	26E	19	DD	WELL	30	10		8/12/1977	DOMESTIC
144866	01S	26E	20		WELL	22	12	20	6/20/1988	DOMESTIC
94163	01S	26E	20		WELL	32	7	20	10/9/1967	DOMESTIC
94164	01S	26E	20		WELL	29	13	20	4/20/1978	DOMESTIC
94165	01S	26E	20		WELL	35	14	10	11/28/1977	DOMESTIC
94166	01S	26E	20		WELL	35	14	10	11/29/1977	DOMESTIC
199219	01S	26E	20		WELL	29	18.5	50	8/6/2002	DOMESTIC
94170	01S	26E	20	D	WELL	32	12	10	3/28/1968	DOMESTIC
94171	01S	26E	20	D	WELL	29	14	25	12/16/1974	DOMESTIC
94172	01S	26E	20	D	WELL	32	15	20	12/16/1974	DOMESTIC
94173	01S	26E	20	D	WELL	36	16	8	9/28/1977	DOMESTIC
94174	01S	26E	20	D	WELL	34	15	8	11/7/1979	DOMESTIC
94181	01S	26E	20	D	WELL	35	25	15	1/1/1954	DOMESTIC
143913	01S	26E	20	D	WELL	31	11	20	10/3/1989	DOMESTIC
94176	01S	26E	20	DA	WELL	30	18		5/10/1962	DOMESTIC
94177	01S	26E	20	DA	WELL	33	8	12	9/12/1963	DOMESTIC
280024	01S	26E	20	DA	WELL	29	13	8	8/21/2014	DOMESTIC
280024	01S	26E	20	DA	WELL	29	13	8	8/21/2014	DOMESTIC
94178	01S	26E	20	DAA	WELL	29	15	30	11/14/1969	DOMESTIC
94162	01S	26E	20	DACA	WELL	36	19	8	10/16/1976	DOMESTIC
144867	01S	26E	20	DACB	WELL	29	16	24	10/15/1990	DOMESTIC
94179	01S	26E	20	DD	WELL	35	7	15	6/19/1978	DOMESTIC
94180	01S	26E	20	DD	WELL	32	14	20	10/15/1986	UNKNOWN
143914	01S	26E	20	DD	WELL	27	9	20	6/23/1989	DOMESTIC
187038	01S	26E	20	DD	WELL	33	13.8	33	5/15/2000	IRRIGATION
184287	01S	26E	20	DDB	WELL	110	31	2.5	8/8/2000	DOMESTIC
705319	01S	26E	20	DDDA	WELL	22			7/1/1978	DOMESTIC
270054	01S	26E	21	DB	WELL	15			8/14/2012	MONITORING
94189	01S	26E	28		WELL	55	14	25	8/25/1975	DOMESTIC
94191	01S	26E	28	ABBD	WELL	30	10	5	11/26/1984	DOMESTIC
181372	01S	26E	28	ACDB	WELL					
6978	01S	26E	28	ACDB	WELL	25	12.7			DOMESTIC
143915	01S	26E	28	BA	WELL	45	11	1.5	8/5/1991	DOMESTIC
94192	01S	26E	28	BA	WELL	25	18	20	1/1/1895	DOMESTIC
218551	01S	26E	28	BAA	WELL	20	0		11/6/2003	TEST WELL
705320	01S	26E	28	BACD	WELL	40				DOMESTIC

160975	01S	26E	28	DCC	WELL	65	24	6	8/27/1996	DOMESTIC
94190	01S	26E	28		WELL	35	7	28	7/12/1977	DOMESTIC
Gwic Id	**Twn**	**Rng**	**Sec**	**Q Sec**	**Type**	**Total Depth**	**Static water level**	**Yield**	**Date**	**Use**
230197	01S	26E	30	DB	WELL	35			9/29/2006	DOMESTIC
94193	01S	26E	31	BB	WELL	1,291.00			1/1/1961	STOCK
176733	01S	26E	33	DDC	WELL	245	75	0.5	8/9/1999	
94197	01S	26E	33	DDDA	WELL	32	9	20	7/12/1982	UNUSED
162939	01S	26E	33	BDD	WELL	50	28	30	2/28/1997	IRRIGATION

The wetland delineation report identified other potentially jurisdictional waterbodies, including Stream 1, a seasonal tributary to Blue Creek, and several intermittent tributaries to Stream 1. As discussed in Section 2.3.21, the central ditch would be constructed in Stream 1 to divert storm water runoff in the facility to one of two storm water detention ponds. The construction of the proposed expansion would be considered one project, so all impacted wetlands and jurisdictional water bodies would require mitigation even if construction is completed in phases and only disturbs a portion of the waterbodies at any given time.

Due to the small size of the watershed in the proposed expansion area, the low precipitation the area receives, the perimeter ditches, and the proposed storm water controls including the storm water ponds, the impacts to surface water from the construction and operation of the facility are expected to be minor. The controlled release of storm water from the storm water detention pond would not contain the suspended sediments that is currently contained in runoff that occurs presently during heavy precipitation or snowmelt events.

3.4.3.2.2 Ground Water-No Migration Determination

The hydrogeological and soils investigations were conducted during March and April of 2013 and then again during September 2014. The 2013 field work consisted of the drilling and excavation of 10 exploratory borings and 17 test pits. During September 2014, an additional 21 test borings and 40 test excavations were completed. Of the 31 test borings, 28 terminated in the Belle Fourche shale, ranging in depth from 17 to 300 feet below ground surface (bgs). The 57 test pits were excavated to a depth of approximately 12 feet bgs. Figure 3.1 provides a map of the location of soil borings and test pits.

The subsurface profile in the exploratory borings generally consisted of a thin layer of topsoil overlying interbedded layers of alluvial clay, sand, and gravel which extended to depths ranging from approximately 0.5 to 50.5 feet bgs.

The profile encountered in the test pits generally consisted of a thin layer of topsoil overlying interbedded layers of alluvial clay, sand, and gravel which extended to depths ranging from approximately 1.5 feet bgs to beyond the excavated depth of approximately 12 feet bgs. The Belle Fourche shale bedrock was encountered below the alluvial soil deposits and extended beyond the maximum depth of the test pits in 42 of the 57 test pits.

The Belle Fourche shale in the area is reported to be at least 350 to 400 feet thick, and is documented in a well log to be from 1,200 to 1,300 feet thick in one well located approximately 1.5 miles to the west of the expansion area. The shallowest groundwater proximal to the proposed expansion area is at the current COB Class II Landfill, where previous investigations suggest that the groundwater is locally recharged within discontinuous zones of the Belle Fourche, the overlying Greenhorn shale and a Quaternary-aged landslide. Groundwater was not encountered in any of the drilled borings at the time of the field investigation, other than in minimal quantities in isolated zones. Two of the borings drilled during the site investigation (B8 and B16) were completed as monitoring wells at depths of 48 feet and 55 feet bgs, respectively. Since construction, these two wells have been monitored for water levels. Groundwater will not be intercepted in the areas excavated for construction of the disposal units. In addition, slug tests have been performed to determine the hydraulic conductivity properties. The results of the slug test conducted on well BRLX-B8 indicated a hydraulic conductivity of 35 feet per day; while the slug test performed on well BRLX-B16 indicated indicate a hydraulic conductivity of 0.07 feet per day. These conflicting results demonstrate the lack of a laterally continuous aquifer at the site. The result from well BRLX-B8 indicates a possible, localized infiltration to that well, which may be a response from fractures in the clay rich bedrock.

The water level monitoring has indicated very limited quantities of groundwater. The slug tests recharge rates validate the absence of a viable aquifer. To further determine the source and response of groundwater recharge to the aquifer, a pressure transducer was installed in the monitoring well completed in boring B-8 (MW-BRLX-B-8). Transducers are used to measure and log static water level data to record changes in water levels in wells over longer periods of time. The overall conclusion based upon the transducer data collected from November 2015 to August 2016 was that there no direct connection between precipitation events and ground water recharge of the localized aquifer. Several significant precipitation events that occurred during this time period did not result in an increase in water levels, confirming that precipitation is not a source of recharge.

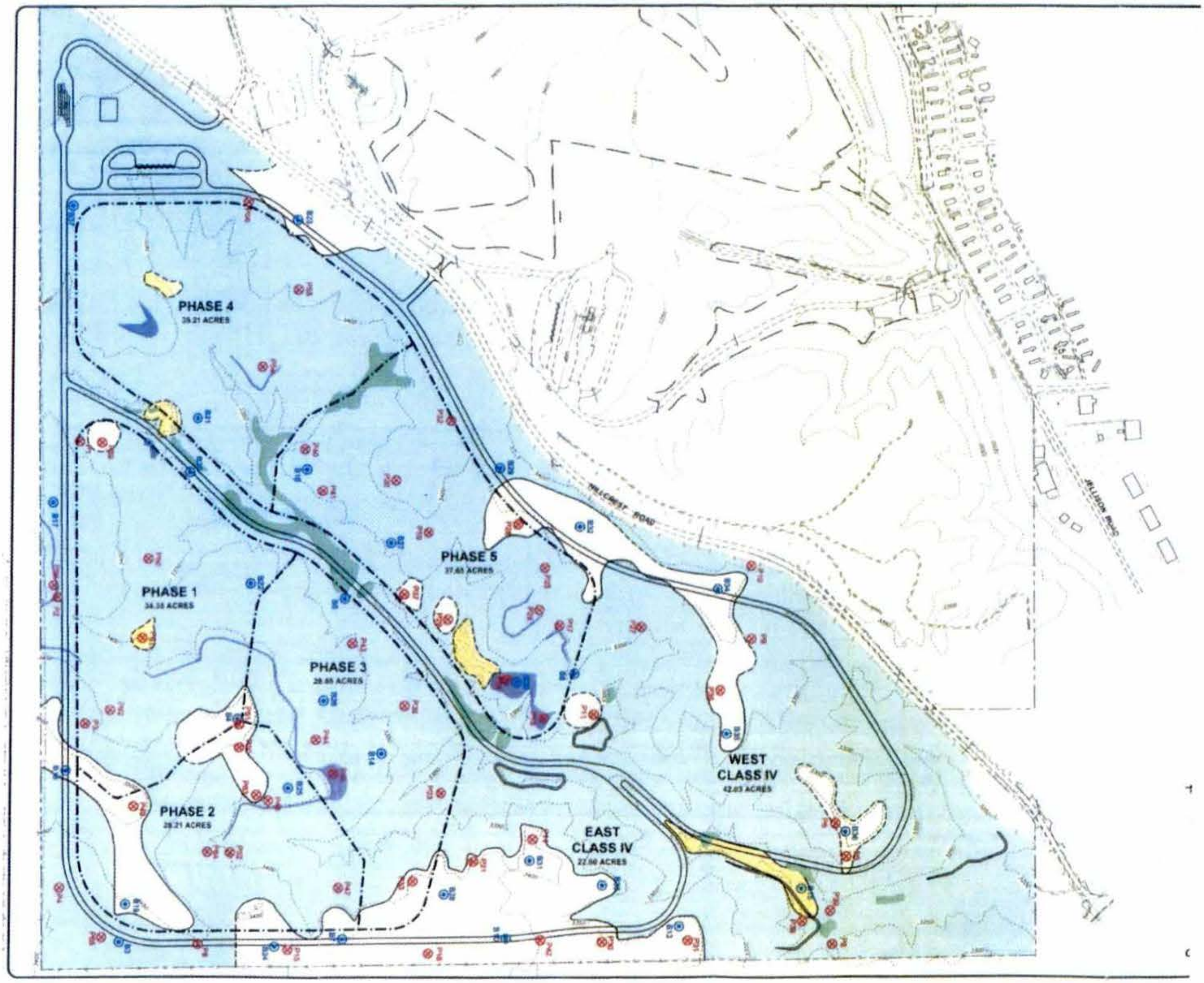
Another indication of the lack of recharge in the area from precipitation is radiocarbon dating analysis performed in 1997. Three samples were collected from monitoring wells located at the existing COB landfill monitoring network for Carbon-14 (C-14) dating. The results of the C-14 dating, after dilution factors were applied, indicated that groundwater ages in the area ranged from present to 2,700 years before present (BP) in monitoring well DH-M-1; a mid-range of 2,400 to 6,700 years BP in monitoring well DH-18; and from 18,700 to 23,000 years BP at monitoring well DH-16.

The overall conclusion from the investigation is that the property and surrounding upland areas do not present an identifiable connecting groundwater system that would allow for the placement of either background wells or downgradient wells. These conditions also exist to the immediate south and west of the expansion area and are apparent by the fact that homes built in this area do not have wells, but have cisterns and potable water is hauled in due to the lack of available groundwater. Therefore, developing a groundwater monitoring network and plan would be impractical for the facility.

The speed of movement of leachate migration and landfill gas diffusion within the shale located beneath the adjacent Phase V of the existing landfill was calculated using the POLLUTE version 7.11 model software. The model has a 15-year history, and functions on the integration of data to develop rates of flow and contaminant concentrations based on diffusion. The model assumes, as a conservative input, that there is no liner and that there is no attenuation, both of which are not the circumstance at the proposed expansion area; the landfill units will be lined and natural attenuation occurs. The minimum possible estimate from the model output of migration time of the leachate and landfill gas to the uppermost aquifer was 150 years. This estimate is well beyond the expected life of the expansion plus the required 30-year post closure period.

No continuous uppermost aquifer was found upon drilling to 300-ft maximum depth below ground surface during site investigations. Any leachate seepage would not reach this depth for 2900 years (or probably longer) after potential release into the natural subsurface shales. Additionally, the attenuating natural subgrade also meets the standards for landfill gas diffusion (*e.g.* any vinyl chloride component) to depths likely not more than 25 feet for a period of at least 100 years after closure.

Figure 3.1 – Location of Site Characterization Test Pits and Borings
*(Source: Great West Engineering, Billings Landfill Expansion Application, 2015 (*not to scale))*



The log for the well located approximately 1.5 miles west of the expansion area, drilled to a depth below the Belle Fourche (1,291 feet bgs), reports the well is under artesian pressure. An artesian aquifer is a confined aquifer that contains ground water under positive pressure. When a well is completed in a confined aquifer, the water level in the well rises above the height of the surrounding water table until it reaches hydrostatic equilibrium. Considering that leachate and landfill gas would have to first migrate through the HDPE liner and 300 feet of the very low permeability shale, the leachate would then have to overcome artesian pressure of the deep aquifer, a phenomenon which is very unlikely. The most likely estimate for migration to the deep aquifer is at least several hundred years for the vertical seepage of fluid or gas through a minimum 300-foot thick section of consolidated Belle Fourche shale.

Finally, the combination the 60-mil HDPE liner and the alternative 6-inch barrier of re-compacted native (in-place) subgrade for the lower soil component, along with the highly impermeable Belle Fourche shale would provide an exceptional barrier to the potential migration of leachate. This would also, in all probability, prevent the lateral and vertical migration of contaminants to points of potential impact for a period well beyond the active and post-closure period of the proposed facility. The extreme length of the most probable migration times for leachate exceeds the estimated life of the facility and the 30-year post closure care period. Additionally, the landfill design consists of the composite liner designed to impede the flow of liquids. The clay component of the liner system has a hydraulic conductivity of not more than $1.0x10^{-7}$ cm/sec, meaning that any liquids passing through the clay liner would pass through at a rate of 0.0000001 cm/sec or 0.10346 inches per year. Therefore, wells in the area will not be impacted by construction and operation of the proposed landfill expansion.

DEQ has found that the COB has adequately demonstrated that there is no potential for migration of constituent's indicative of landfill contamination to the uppermost aquifer during the proposed 48-year operational life and 30-year post-closure period of the proposed landfill expansion area.

3.5 GEOLOGY AND SOILS

3.5.1 ANALYSIS AREA AND METHODS

The analysis area for geology is the proposed COB Class II Landfill facility expansion site. Some discussion of regional geology, based upon published reports, is also provided herein. The analysis methods for geology included reviewing on-site drilling information, publications of the Montana Bureau of Mines and Geology, the U.S. Geological Survey, and the U.S. Department of Agriculture's Natural Resource Conservation Service, along with their associated geology and soil maps and drawings.

3.5.2 AFFECTED ENVIRONMENT

The proposed expansion is located within the Yellowstone River valley which lies between the sandstone cliffs to the north and rolling hills underlain by a thick sequence of shale to the south. The cliffs are locally known as the "Rims" and are composed of the Eagle Sandstone and the Telegraph Creek Formation, both are Cretaceous in age. The sandstone formations dip gently to the north and are not present in the valley beneath the river.

Within the Yellowstone River valley, the Yellowstone River has cut down into a thick sequence of Cretaceous aged shale. The shale sequence is on the order of 2,000 feet thick and is widely exposed in the hills south of Billings, as evidenced in the proposed landfill expansion area hydrogeological and soils investigation. Two geological units are exposed within the proposed landfill expansion property: The Belle Fourche unit and the Quaternary-aged (Pleistocene) deposit. The Belle Fourche shale underlies the entire site, either at the surface or near the surface. The unit is a fine-grained sedimentary rock of upper Cretaceous age. The unit is thinly-laminated, dark bluish-gray, and consists almost entirely of silt- and clay-sized particles. As discussed above, the Belle Fourche shale in the area is reported to be at least 350 to 400 feet thick, and is documented in a well log to be from 1,200 to 1,300 feet thick in one well located approximately 1.5 miles to the west of the expansion area. The Quaternary-aged (Pleistocene) deposit consists of silt, sand and gravel that underlie the center of the easternmost part of the expansion area property; it is expressed as a flat, non-eroded prairie and is obvious on the land east of the expansion area property.

The predominant soil type at the proposed COB expansion are the Lismas Clay (map unit "Ln"), 15 to 35 percent slopes (Figure 3.2). These soils are characterized as shallow, well-drained, moderately steep clay soils on upland, with a low to moderately high capacity to transmit water. The secondary soil types are the Pierre-Lismas clays (map unit "Pl"), moderately steep clay soils and well-drained soil, with a low capacity to transmit water. A typical profile from top to bottom show the Lismas clay soils consist of 0 to 2 inches of clay, 2 to 10 inches of clay, and 10 to 60 inches bedrock. A typical profile of the Pierre-Lismas clays, from top to bottom, consists of 0 to 31 inches of clay and 31 to 60 inches of bedrock.

The minor soil types are Maginnis channery clay loam (Map unit "Mc"), which is classified as well drained with a low capacity to transmit water, and the Danvers silty clay loam (Map unit "Da") which is classified as well drained with a high capacity to transmit water. A typical profile from top to bottom shows the Maginnis channery clay loam consists of 0 to 10 inches of clay loam and 10 to 60 inches of bedrock. A typical profile from top to bottom of Danvers silty clay loam consists of 0 to 6 inches of silty clay loam, 6 to 13 inches of silty clay, and 13 to 60 inches of clay loam.

The subsurface cores collected during the site investigation were submitted for laboratory testing to measure the average vertical hydraulic conductivity, moisture content, grain size distribution and critical water contents (shrinkage, plastic limit and liquid limit). Laboratory test results indicate that the soils above the Belle Fourche shale generally contain a small percentage of fine gravel with some limited areas containing cobble size alluvial and fluvial deposits. The sand fraction ranged from 3.99% to 46.6%, and the silt and clay fractions ranged from 21.3% to 65.7%. The measured hydraulic conductivities provided by the laboratory analysis of the soil borings ranged from 2.21×10^{-9} cm/sec to 5.31×10^{-9} cm/sec. This range is typical for clays and silts.

The result of the hydrogeological and soils investigation was generally consistent with published technical studies of the region.

3.5.3 ENVIRONMENTAL CONSEQUENCES

3.5.3.1 No Action Alternative

Under this alternative, because the site would not be developed, there would be no additional impacts to site geology and soils.

3.5.3.2 Proposed Action

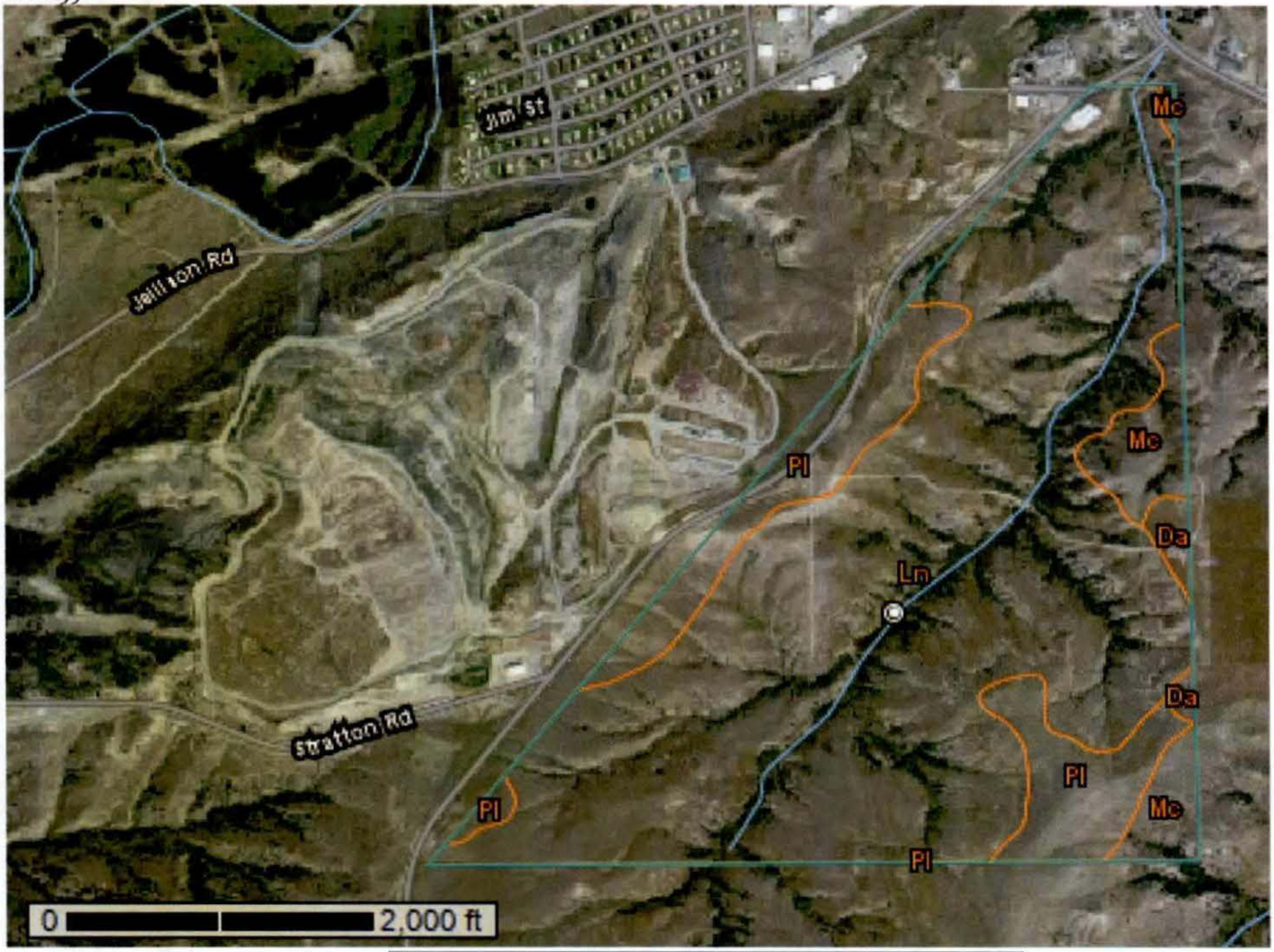
The site would be excavated to accommodate the proposed landfill disposal units. Additionally, general site grading would be necessary to facilitate the storm water control features. Excavation of the existing ground to a maximum depth of 25 feet below natural grade to establish the landfill footprints for the MSW and Class IV would yield 7,718,800 cubic yards of loose soil and rocky subsurface material. These materials would be used to (i) provide subgrade fill to establish base elevations for the landfill units, and (ii) construct the compacted soil component of the landfill, final cover, and leachate pond liners.

The weathered, bentonitic marine shale found beneath the base of all areas within the proposed expansion planned for the landfill excavation provides a good in-situ source of cohesive, clay-rich, natural liner material that would be scarified and re-compacted in place to form a six-inch soil barrier.

Construction and operation of the facility would result in the disturbance of 293-acres for the entire life of the facility. The native soil and subgrade materials would be stockpiled on site and used to construct vegetated berms, landfill liner components, landfill cover, and in on-site road construction.

All long-term soil stockpiles would be seeded to prevent wind or water erosion and airborne dust. The rocky soils and bedrock layers are not good substrate for agriculture. Because these soils are well drained, construction and operation of the proposed facility would not result in an extensive amount of soil erosion or the substantial loss of viable topsoil through appropriate placement of berms, ditches, and other previously identified storm water BMPs minimizing erosion (see Section 2.3.2.1). Additionally, the landfill design consists of the composite liner designed to impede the flow of liquids.

Figure 3.2: Map of the soil types in the expansion area
*(Source: U.S. Department of Agriculture, Natural Resources Conservation Service (*not to scale))*



SOIL KEY
Ln: Lismas Clay
Pl: Pierre-Lismas clays
Mc: Maginnis channery clay loam

3.6 VEGETATION

3.6.1 ANALYSIS AREA AND METHODS

The analysis area is the site of the proposed COB Class II Expansion Landfill. The analysis method for vegetation consisted of published reports from the Montana Natural Heritage Program, the U.S. EPA, and Yellowstone County.

3.6.2 AFFECTED ENVIRONMENT

The site of the proposed COB Class II Landfill is identified as Big Sagebrush Steppe and Great Plains Mixedgrass Prairie. The more common species occupying this area include Wyoming big sagebrush, western wheatgrass, thickspike wheatgrass, green needlegrass, blue grama, and needle and thread. In grazing areas, the predominant species include Kentucky bluegrass, smooth brome, and Japanese brome. Along Stream 1, there are areas identified as Great Plains Ponderosa Pine Woodland and Savanna, Great Plains Wooded Draw and Ravine, and Great Plains Riparian. Vegetation in these areas include ponderosa pine uphill from drainages, Rocky Mountain juniper in valleys and ravines, and both narrowleaf cottonwood and Plains cottonwood in the floodplains.

3.6.3 ENVIRONMENTAL CONSEQUENCES

3.6.3.1 No Action

Under this alternative, the site would not be developed, and there would be no impacts to existing vegetation on site.

3.6.3.2 Proposed Action

A search of the Montana Natural Heritage Program website revealed that there are no records of plant Species of Concern, Potential Species of Concern, or Special Status Species in the proposed footprint of the disturbance and area surrounding the proposed COB Class II Landfill expansion site. During facility construction, vegetation would be removed from areas of the site for establishing the proposed landfill disposal units, roads, buildings, and storm water control features. Some soils removed during excavation of each landfill unit may be stockpiled in the area of the subsequent unit and would be used as-needed for daily, intermediate, or final soil cover. Ground disturbance activities could increase the potential for noxious weeds on the facility. COB would be required to obtain and implement a County-approved noxious weed plan during all stages of the project.

The existing vegetation at the location of the proposed expansion is not unique or limited, considering the extensive amount of similar land with similar vegetation around the proposed expansion area. Further, at final closure, the final cap would be fully revegetated with native plant species. To ensure vegetative success, the upper six inches of the final cover must be comprised of a top soil capable of supporting vegetation. In addition, the seed mix used for revegetation must be approved by the Natural Resource Conservation Service (NRCS) to ensure the vegetation is adapted to the local climate.

3.7 AIR QUALITY

3.7.1 ANALYSIS AREA AND METHODS

The area for the air quality analysis is the proposed expansion site adjacent to the current COB Landfill. The analysis method considers the information provided by the applicant and DEQ's professional experience with other major Class II landfill facilities. All facilities are required to comply with applicable air quality rules.

3.7.2 AFFECTED ENVIRONMENT

The proposed expansion site is along the south-east border of the active COB landfill. The COB owns the property. Power transmission lines cross the property and several dirt roads exist across the property. There is limited activity occurring on the land. Air quality impacts from use of the dirt roads within the property includes fugitive road dust.

3.7.3 ENVIRONMENTAL CONSEQUENCES

3.7.3.1 No Action Alternative

Under this alternative, because the site would not be developed, there would be no additional impacts to existing air quality beyond the current activities on the property.

3.7.3.2 Proposed Action

Air Quality impacts associated with landfill activity typically include fugitive dust generated from construction, excavation, vehicle traffic, day-to-day operations, and closure activity. Landfill gas emissions cause another air quality impact that is generated from the biological breakdown of waste. Landfill gas is mainly a mixture of methane and carbon dioxide, but can also include nitrogen dioxide, oxygen, ammonia, sulfides, hydrogen, and other volatile organic compounds released within each cell of a MSW landfill. Landfill gas is generated as soon as waste is deposited in the landfill. Gas continues to be generated through the operation of the landfill and after the landfill is closed, until all the waste is degraded. Although rare, another source of air quality impacts comes from landfill fires. The COB attempts to prevent landfill fires through waste inspections and proper landfill waste deposits.

Fugitive dust is created from disturbing the ground, moving dirt, and vehicle activity during construction and excavation activities. Blowing winds increase fugitive dust from these activities and can pick up additional material from stockpiles and the daily cover over the waste. If fugitive dust from construction, excavation and placement of cover material becomes a problem, dust control measures, such as watering the work surfaces before commencing working shall be initiated. Watering work surfaces is required during construction activities such as road construction. During closure of the landfill, more cover material is placed on the waste pile which generates fugitive dust from the movement of the material and vehicles used to place the cover material. The COB intends to control dust at the working face of the landfill using the following measures:

- carefully moving dusty wastes and soils,
- promptly covering light, powdery wastes with other wastes,
- minimizing earthwork activities during windy periods, and
- apply vegetative seeding to intermediate cover.

Dirt roads can generate fugitive dust emissions, particularly during dry and windy times. Dirt can be carried onto paved roads from vehicles leaving dirt roads. Once this dirt becomes dry on the paved roadway, it may be entrained into the air from vehicles driving over it and when strong winds occur. The COB plans to have a high capacity paved access road to the scale and public roll-off container site. The proposed scale house is to be located in an area that allows ample space for queuing of commercial haul trucks and public customers on a paved road. This paved road is the main access road into the landfill expansion site from Hillcrest Road from South Billings Boulevard, which would reduce fugitive emissions generated from vehicle traffic near the access road. There should be less carry-over dirt deposited on the Hillcrest Road as a result of paving the main access road.

Internal access roads within the landfill parcel will be graveled roads maintained by landfill staff. These roads are planned to be accessible year-round for access to all operational areas. Other roads will be dirt roads and will be used strictly for soil transportation by large equipment and will also be maintained by landfill staff.

Fugitive dust can be controlled through the application of water or chemical dust suppressants on roadways, storage piles, and cover material. The COB plans to grade fine soils from roads during wet periods to reduce fugitive road dust as well as control vehicle speeds and clean dirt from asphalt roads leading to the front entrance after wet periods. COB will clean dirt from the asphalt road leading to the front entrance after wet periods and will use water or a chemical dust suppressant on non-paved road surfaces. Water or a chemical dust suppressant would be applied at a rate that would not cause runoff, erosion, or water/waste interaction. The COB may halt material handling operations to mitigate fugitive dust emissions if the operator is unable to control emissions. All long-term soil stockpiles would be seeded to minimize the generation of fugitive dust and water erosion. Vegetation on these soil stockpiles should be established within one year of seeding. Fugitive dust levels are expected to remain similar to those at the current landfill with any increase being representative of Billing's population growing.

The impact of fugitive dust is affected by local meteorological conditions. Meteorological data is collected by the National Weather Service at the Billings/Logan International Airport. This meteorological station is about 5 miles northwest of the landfill. The data as shown in Figure 1, shows wind in the area generally blows from the southwest. The average wind speed is 10.8 mph with gusts well above 25 mph at times. Temperature and precipitation data also collected by the National Weather Service at the airport from 2000 through 2017 is shown in Tables 1 and 2. This weather data indicates the warmest temperatures occur in the summer during July and August. Precipitation rates are above 1 inch for the spring months of April, May and June and then again in the fall months of September and October. Winter months experience some of the lowest levels of rainfall. The average annual rainfall for Billings is 13.5 inches. The warm dry summers are likely to be the time when fugitive dust is highest. Windy conditions during dry periods can generate the most fugitive dust if control methods are not applied. Application of water and chemical dust suppressant could reduce the fugitive dust emissions by up to 50 to 80 percent if correctly applied.

Figure 1 - Billings, MT - Wind Rose, 2013 - 2017

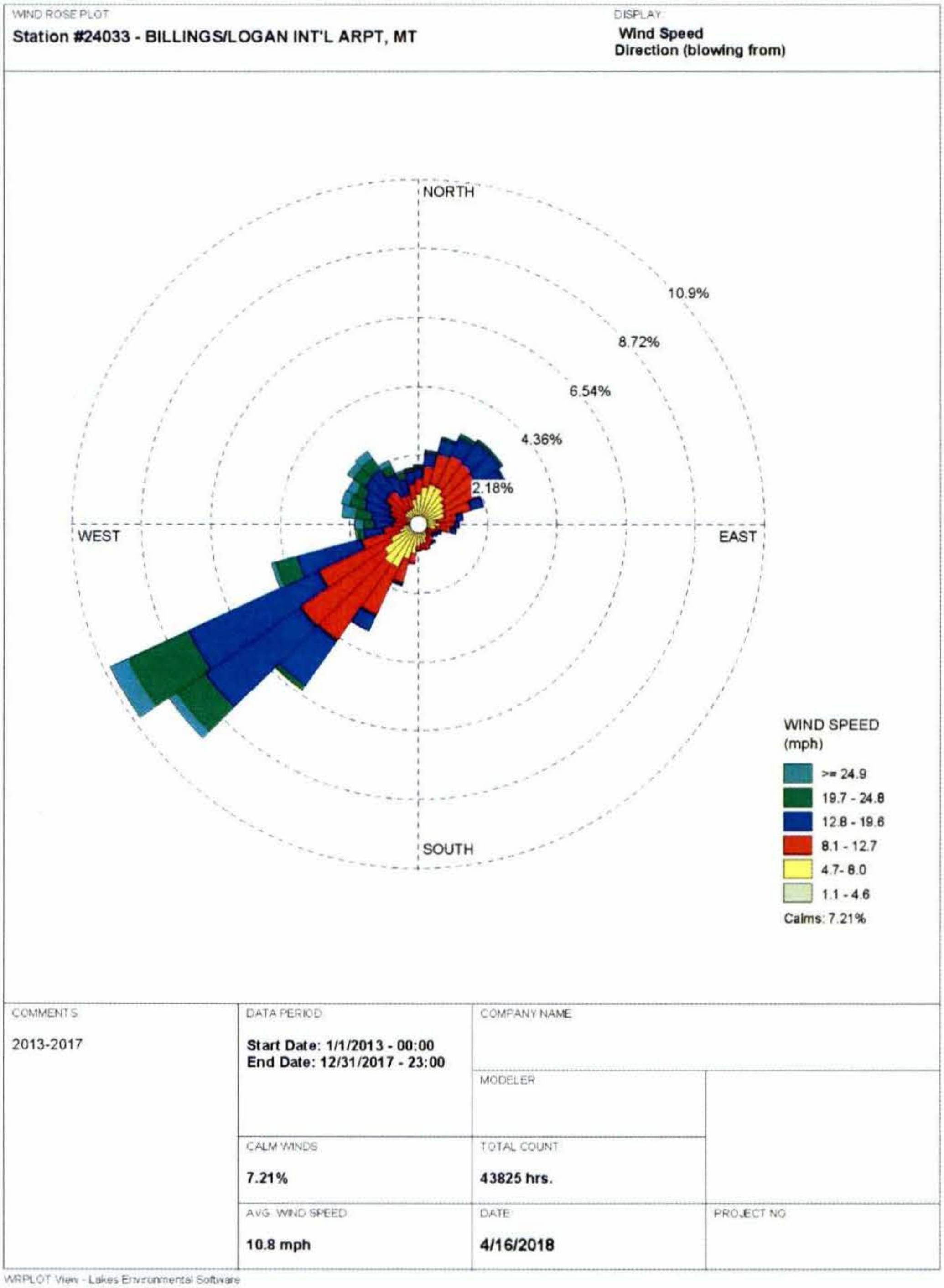


Table 1- Billings, MT Temperature Data, 2000 - 2017

Monthly Mean Average Temperature (degrees Fahrenheit)													
Year	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Annual**
2000	27.6	31.3	40.8	47.2	56.3	64.3	75.7	73.6	59.8	47.4	26.8	20.1	47.6
2001	30.2	20.6	38.6	46.3	58.9	63.5	74.2	75.2	63.6	47.8	41.2	27.8	49.0
2002	27.9	32.8	24.7	40.8	52.2	65.4	76.8	66.6	61.4	41.2	39.3	31.5	46.7
2003	31.1	25.2	34.0	49.5	55.2	63.7	78.4	77.1	60.3	53.5	30.6	31.5	49.2
2004	23.6	32.3	44.4	49.4	53.4	61.6	72.2	68.9	59.8	48.8	39.4	32.9	48.9
2005	22.4	34.4	40.6	46.2	52.7	63.3	74.2	69.7	61.8	49.7	39.3	26.3	48.4
2006	37.9	30.0	34.7	49.8	58.1	68.6	78.0	71.4	59.6	44.4	35.7	31.6	50.0
2007	25.3	26.1	44.6	44.5	56.5	66.0	79.1	71.9	61.3	50.1	36.5	27.8	49.1
2008	24.9	32.3	37.7	43.8	54.8	63.6	73.9	72.6	58.5	48.3	42.2	19.2	47.7
2009	29.7	33.7	33.8	45.3	57.3	61.7	71.2	70.2	66.7	41.2	41.7	16.5	47.4
2010	25.3	26.3	44.0	46.5	51.7	63.8	71.5	70.5	59.7	53.6	30.3	24.7	47.3
2011	25.7	20.2	35.5	42.7	50.0	62.4	74.7	73.5	64.5	51.9	35.3	30.8	47.3
2012	30.5	30.1	47.0	50.4	54.9	68.6	78.3	73.8	64.9	46.1	40.2	27.3	51.0
2013	28.0	33.2	37.6	41.7	57.4	65.6	74.4	74.9	64.4	44.7	36.0	22.1	48.3
2014	30.5	18.7	33.6	46.7	55.7	62.3	74.5	70.1	60.6	54.0	30.5	29.9	47.3
2015	29.8	33.4	46.8	47.7	53.8	70.0	72.5	71.0	65.4	53.5	34.4	29.2	50.6
2016	29.9	41.0	43.0	49.5	56.0	70.7	73.7	70.5	61.2	50.3	44.1	18.7	50.7
2017	19.0	29.9	41.6	47.6	57.3	67.0	78.3	71.3	60.2	48.6	35.9	24.4	48.4
2018	26.8	15.8	33.1	M	M	M	M	M	M	M	M	M	25.2
Mean	27.7	28.8	38.7	46.4	55.1	65.1	75.1	71.8	61.9	48.6	36.6	26.2	47.4
Max	37.9 2006	41.0 2016	47.0 2012	50.4 2012	58.9 2001	70.7 2016	79.1 2007	77.1 2003	66.7 2009	54.0 2014	44.1 2016	32.9 2004	51.0
Min	19.0 2017	15.8 2018	24.7 2002	40.8 2002	50.0 2011	61.6 2004	71.2 2009	66.6 2002	58.5 2008	41.2 2002	26.8 2000	16.5 2009	25.2

Note: M means missing data.

Table 2 – Billings, MT Precipitation Data, 2000 – 2017

Monthly Total Precipitation (inches)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
2000	0.55	1.30	0.78	1.32	1.64	1.30	0.51	0.06	1.85	0.54	0.49	0.34	10.68
2001	0.30	0.60	0.79	1.51	0.22	4.11	1.05	0.01	1.06	0.76	0.37	0.17	10.95
2002	0.37	0.23	0.25	2.09	1.09	1.41	0.55	0.67	1.23	1.12	0.04	0.25	9.30
2003	0.40	0.81	0.83	1.40	1.89	1.79	T	0.03	0.15	1.38	0.30	0.76	9.74
2004	0.25	0.78	0.11	1.51	0.81	1.95	2.27	0.23	1.19	1.67	0.06	0.25	11.08
2005	0.25	0.25	0.67	3.31	1.78	2.35	1.77	0.30	0.83	1.97	1.39	0.44	15.31
2006	0.05	0.11	2.67	1.50	1.14	0.49	0.40	0.42	2.73	2.22	0.86	0.38	12.97
2007	0.34	0.56	1.37	2.51	3.93	1.12	1.63	0.07	1.73	2.48	0.43	0.28	16.45
2008	0.35	0.07	0.42	0.20	4.83	0.31	0.77	1.18	2.44	1.82	0.27	1.23	13.89
2009	0.43	0.37	1.36	1.83	0.64	1.55	0.61	1.20	0.65	1.45	0.17	0.65	10.91
2010	1.09	0.39	0.43	1.24	1.92	5.10	1.70	2.78	0.63	0.63	1.89	0.95	18.75
2011	0.24	0.71	0.68	1.82	9.54	1.46	0.93	1.71	0.12	1.66	0.46	0.21	19.54
2012	0.61	0.24	0.70	0.64	1.96	0.24	0.39	0.30	T	1.14	0.64	0.27	7.13
2013	0.59	0.29	0.26	1.02	4.28	0.88	0.67	0.19	3.63	2.57	0.34	1.98	16.70
2014	1.02	2.06	1.32	1.18	2.25	1.75	0.34	1.97	0.57	0.16	0.74	0.67	14.03
2015	1.09	0.21	0.37	1.57	2.43	1.60	1.66	0.91	0.27	1.80	0.48	0.57	12.96
2016	0.44	0.09	1.55	1.28	2.04	0.23	0.45	1.67	1.58	3.51	0.38	1.67	14.89
2017	0.63	0.83	2.22	3.34	1.61	2.31	0.13	0.17	2.74	0.49	1.35	1.81	17.63
2018	0.60	1.66	0.70	M	M	M	M	M	M	M	M	M	M
Mean	0.51	0.61	0.92	1.63	2.44	1.66	0.88	0.77	1.30	1.52	0.59	0.72	13.50
Max	1.09 2010	2.06 2014	2.67 2006	3.34 2017	9.54 2011	5.10 2010	2.27 2004	2.78 2010	3.63 2013	3.51 2016	1.89 2010	1.98 2013	19.54 2011
Min	0.05 2006	0.07 2008	0.11 2004	0.20 2008	0.22 2001	0.23 2016	T 2003	0.01 2001	T 2012	0.16 2014	0.04 2002	0.17 2001	7.13 2012

Note: T means trace amount.
M means missing data.

Some landfills request air quality burn permits which allows for the burning of untreated wood waste that reduces the volume of material to be landfilled. The COB's application did not mention plans for open burning at the facility.

The Administrative Rules of Montana (ARM) require that all facilities comply with applicable air quality requirements. These include restrictions on particulate matter emissions to not exceed an opacity of 20 percent or more averaged over 6 consecutive minutes, whether from fugitive dust sources or from combustion sources, per ARM 17.8.304 and ARM 17.8.308. ARM 17.8.308 also requires that facilities take reasonable precautions to control emissions of airborne particulate matter from the production, handling, and storage of any material and to apply reasonable precautions to any street, road or parking lot. As described above, COB proposes to control fugitive dust at the landfill using applications of water and/or chemical dust suppressant on roadways, and cleaning paved roadways. Watering of roads is an effective method for reducing fugitive dust emissions during construction and operations.

Federal Prevention of Significant Deterioration regulations have classified states and local areas to let state's plan for local land use. Each classification allows for different amounts of development and changes to the ambient air quality. Areas designated Class I are the most restrictive and allow for the least amount of change to the ambient air. Class II areas can accommodate normal, well-managed industrial growth. Areas designated as Class I include our national parks, several of the wilderness areas and certain native American Indian reservations. All other areas in the region are Class II areas, which includes Billings and the area of the existing landfill and proposed expansion. The nearest Class I area to the proposed project site is the Northern Cheyenne Indian Reservation in southeastern Montana. The reservation is about 75 miles to the east-southeast. As described earlier, winds generally blow from the southwest. Air quality impacts are not expected from the COB landfill 75 miles away at the Northern Cheyenne Indian Reservation.

DEQ operates a regulatory monitor on Coburn Road in Billings that monitors sulfur dioxide and meteorology. Coburn Road is on the southeast side of Billings. DEQ also operates a regulatory monitor east of Billings in Lockwood, MT that monitors PM2.5 and meteorology. Additional non-regulatory monitoring of volatile organic compounds, nitrogen oxides, and ozone occurs at the Lockwood site. Billings and the project area meet the current Montana and national ambient air quality standards for all regulated pollutants. PM2.5 monitoring in Lockwood has typically shown the highest PM2.5 daily averages during the warmer summer months of July, August, and September as shown in Table 3. Any time an area experiences warm weather with minimal precipitation, emissions of fugitive dust can increase.

Table 3 - PM2.5 Average Monthly 24-hour Value ($\mu g/m^3$)

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
5.8	5.0	4.7	3.8	5.0	5.3	9.1	10.3	8.3	6.3	6.0	6.8

Montana has several areas that are designated as nonattainment areas by EPA, which meaning they have experienced air quality impacts above the national ambient air quality standards (NAAQS). Although many areas have not exceeded the NAAQS in year, they still carry the nonattainment designation. The nearest nonattainment area is Laurel, MT. Laurel is 11 miles southeast of the COB landfill and is designated 'nonattainment' for the sulfur dioxide NAAQS. Lame Deer, MT is the nearest nonattainment area for particulate matter. Lame Deer is 90 miles east-southeast of Billings. Air quality impacts from the COB landfill would not reach these communities given their distance from the landfill.

The ARM 17.8.743 requires a facility to obtain a Montana air quality permit (MAQP) before installing an incinerator (landfill flare) or constructing a facility that has the potential to emit 25 tons per year (tpy) of a regulated air pollutant. The COB Landfill currently does not hold an MAQP because it does not operate an incinerator nor exceed the emissions threshold limit. The COB will only need an MAQP if any change to the landfill includes the construction of a landfill gas flare (incinerator) or the facility has the potential to emit 25 tpy of a regulated air pollutant.

The COB has recently request a Title V operating permit. Title V operating permits are required for major sources of air pollution and are state and federally enforceable. At this time, a draft version of Title V operating permit (OP5176-00) is out for public comment. DEQ's operating permit program is designed to incorporate all applicable air quality regulations and is to be renewed every five years so that it remains current. The operating permit identifies all air quality rules and regulations applicable to a facility. For the COB landfill, the operating permit specifies rules applicable to methane emissions, and fugitive dust emissions.

Federal regulations require that new or expanded MSW landfills comply with the New Source Performance Standards (NSPS) of 40 Code of Federal Regulations (CFR) Part 60 Subpart WWW and Subpart XXX. The proposed expansion would make the COB landfill an affected facility for both 40 CFR Part 60 Subparts WWW and XXX because the existing landfill design capacity is already equal to or greater than the qualifying design thresholds for applicability of 2.5 million cubic meters and 2.5 million metric tons. NSPS Subparts WWW and XXX require the installation of a gas collection and control system (GCCS) if the non-methane organic compound (NMOC) emission rate is 50 metric tons per year or more and 34 metric tons per year or more. The operating permit will be required to be amended to reflect Subparts WWW and XXX apply after commencing construction of the proposed expansion.

Fires are infrequent events at landfills in Montana. If a fire were to occur at the proposed expansion, the fire would contribute to poor air quality near the proposed action. Since fires at landfills are infrequent and active measures are used to extinguish the fire it would be a short-term impact to air quality.

Landfill fires are typically attributable to the placement of a hot load in the working face. It is important to note that the different landfill dynamics, characteristics, and regulations, and the fires that occur in them, require different tactics to extinguish them. Efforts would vary depending upon the waste characteristics, a surface fire versus an underground fire, the depth of the fire if it's an underground fire, and the fire's ignition source. Incident Commanders at landfill fires must address a variety of logistical concerns to facilitate operations. Surface fires generally burn at relatively low temperatures and are characterized by the emission of dense white smoke and the products of incomplete combustion. To access waste below the landfill surface or move burning waste away from the landfill, it may be necessary to use heavy equipment such as bulldozers. COB already owns this equipment and has personnel trained in its use. In addition, depending on the characteristics of the materials burning, water may be a better fire suppressant than foam. If a fire affects the structural stability of a landfill, operating heavy equipment on the landfill surface would be dangerous. Finally, depending on the landfill's location and design, operating heavy equipment on the site could be quite difficult.

COB uses the Incident Command System to respond to emergencies at the landfill. Contingency plans are implemented once personnel have been evacuated as necessary and the affected area has been secured. The Operations and Maintenance Plan contains the plans and procedures for emergency response involving hot loads and fires.

Fires would be handled in a preventive as well as corrective manner. Operators would inspect for hot loads. Hot loads would be isolated and extinguished before they are placed in the landfill. If a fire occurs on the active fill, the operators would use their equipment to push the burning waste away from the active landfill, if they can do so safely. Once the waste is isolated, landfill operators and equipment would extinguish the fire. In the event of a larger or more persistent fire, the local fire department would be summoned. In the event of a larger fire, the landfill would notify the DEQ and the landfill engineering consultant.

In summary, fugitive dust from the landfill can be minimized through good operating practices and use of abatement techniques that include applying water and chemical dust suppressants to during construction, excavation and on roads, storage piles and the active landfill. Landfill gas emissions will be controlled using a GCCS system when NMOC emissions from the landfill exceed the NSPS Subpart WWW or XXX thresholds. Air quality impacts from the landfill expansion are not expected to change significantly from those produced by the current landfill operations. Therefore, DEQ expects minor air quality impacts to the analysis area should the Facility be built.

3.8 ODORS

3.8.1 ANALYSIS AREA AND METHODS

The analysis area for odor impacts is the proposed expansion site adjacent to the current COB Landfill. The analysis method considers the information provided by the applicant and DEQ's experience with other major Class II landfill facilities. All facilities are required to comply with applicable air quality rules.

3.8.2 AFFECTED ENVIRONMENT

The proposed expansion site is along the south-east border of the active COB landfill. The COB owns the property. Odor impacts from the current activity is minimal.

3.8.3 ENVIRONMENTAL CONSEQUENCES

3.8.3.1 No Action Alternative

Under this alternative, because the site would not be developed, the area for the expansion will have no change to its odor impact.

3.8.3.2 Proposed Action

MSW landfills produce gas, primarily hydrogen sulfide and ammonia, from the bacterial breakdown of waste material resulting in odors. The amount of gas produced depends on the type of waste present in the landfill, the age of the landfill, oxygen content, the amount of moisture, and temperature. Gas formation increases as the temperature and moisture content increase.

The location of the COB landfill expansion is in a region that receives low levels of precipitation, averaging less than 14 inches of moisture per year since 2000. The annual mean temperature in the Billings area is 47.4 degrees Fahrenheit and the maximum summer-time monthly average measured was 79.1 degrees Fahrenheit. The average wind speed in Billings is 10.8 mph with regular gusts greater than 25 mph. These winds predominantly blow from the southwest. Higher winds would create more mixing of the landfill gas and reduce the concentration of odorous gases. Odors would be most problematic during calm periods which occurs less than 7.2 percent of the time as shown on Figure 1 in Section 3.7.
Odors at the landfill would be controlled through daily operating practices. At the end of each day, new MSW would be required to be covered with 6 inches of cover material unless DEQ approves an alternative daily cover. The strong and consistent winds in Billings will alleviate odors by dispersion and dilution. Odors from the landfill expansion are not expected to significantly change from current odor levels occurring at the operating site. DEQ expects minor odor impacts to the analysis area should the Facility be built.

3.9 INDUSTRIAL, COMMERCIAL, AND AGRICULTURAL ACTIVITIES

3.9.1 ANALYSIS AREA AND METHODS

The analysis area for industrial, commercial, and agricultural activities is the site of the proposed COB Class II Landfill expansion site. The analysis methods for these activities included several site visits to determine current land use.

3.9.2 AFFECTED ENVIRONMENT

The property proposed for the COB Class II Landfill expansion site encompasses approximately 350 acres. The parcel is currently used intermittently for livestock grazing, which provides some nominal income to the COB. There are no other known commercial or industrial uses of the property.

3.9.3 ENVIRONMENTAL CONSEQUENCES

3.9.3.1 No Action Alternative

Under this alternative, the site would not be developed as a solid waste management facility, there would be no impacts to existing land use activities.

3.9.3.2 Proposed Alternative

Construction and operation of the proposed COB Class II Landfill expansion facility would cause an increase in the industrial activity of the area due to the need for contractors and associated materials, machinery, and machinery repairs. Once construction activities are complete, industrial activities in the area would be similar to those currently experienced at the currently licensed and active COB Class II Landfill. There were no other commercial activities identified at the site of the proposed COB Class II Landfill expansion. The current agricultural activity in the area occurs primarily along the Yellowstone River. The proposal would remove 350 acres of land from livestock grazing activities, there would be an impact to agricultural activities in footprint of the proposed action. However, upon closure, the proposed post-closure use is restricted. Livestock grazing activities could be resumed once the facility has been closed and the site has been revegetated. The final cover of the landfill units will be seeded with an NRCS-approved seed mix adapted to the local area climate and could provide a better quality and healthier stand of grasses due in part to the requirement for the placement of six inches of topsoil material.

3.10 TRAFFIC AND UTILITIES

3.10.1 ANALYSIS AREA AND METHODS

The analysis area for traffic and utilities includes the site of the proposed COB Class II Landfill expansion as well as the intersection of Blue Creek Road and Hillcrest Road, and Hillcrest Road as it approaches the entrance to the proposed facility. The analysis methods for these activities included a site reconnaissance to identify potential traffic impacts, issues with existing utilities, and necessary road and utility improvements, research conducted by the COB and their engineering consultants, and communications between the COB, their engineering consultants, and the Montana Department of Transportation (MDT).

3.10.2 AFFECTED ENVIRONMENT

The property proposed for the COB Class II Landfill expansion site encompasses an approximately 350-acre parcel owned by the applicant. The affected environment for traffic includes the junction of Blue Creek Road and Hillcrest Road as well as Hillcrest Road itself. South Billings Boulevard converts to Blue Creek Road as it crosses the Yellowstone River. This road accommodates vehicles accessing the landfill, as well as residential and agricultural properties located south of Interstate-90.

3.10.3 ENVIRONMENTAL CONSEQUENCES

3.10.3.1 No Action Alternative

Under this alternative, the site would not be developed as a solid waste management facility, there would be no impacts to existing traffic and utilities. The 350-acre parcel is currently used intermittently for livestock grazing. There are no other known commercial or industrial uses of the property. As a result, traffic accessing the facility varies depending upon the maintenance needs and the need to access livestock grazing on site.

3.10.3.2 Proposed Alternative

Currently, the landfill is accessed via Jellison Road from Blue Creek Road. Presently, vehicles travel south on Blue Creek Road, then turn west utilizing the dedicated right turn lane onto Jellison Road. The existing entrance to the current COB Class II Landfill is approximately 0.7 mile down Jellison Road to the south. Access to the expansion would be from Hillcrest Road. Hillcrest Road is not currently designed to handle the increase in traffic to the expansion area once the landfill is constructed and is operating. Therefore, changes in access to the COB Class II Landfill expansion area would require modifications to existing roads and utilities. During the construction phases, there may be a slight increase in traffic on the roads leading to the landfill because of approximately 15 construction workers and the mobilization/demobilization of equipment for facility construction activities. The mobilization and demobilization of equipment would take approximately five days total for both activities.

3.10.3.2.1 Traffic and Road Modifications

Hillcrest Road is located between the existing COB Class II Landfill and the proposed expansion area. Construction and operation of the proposed COB Class II Landfill expansion would require changes to the route to the landfill. The COB has proposed the use of Hillcrest Road to access the expansion area. During development of the proposed landfill expansion application, the COB considered three separate road improvement alternatives (Appendix E). These alternatives consisted of:

1. Reconstructing Hillcrest Road;
2. Rerouting Hillcrest Road to the perimeter of the expansion area; and,
3. Rerouting Hillcrest Road to Collier Road.

Field and topographical map reconnaissance surveys were conducted to determine potential alternate routes to accommodate expansion of the landfill south across Hillcrest Road while still providing acceptable levels of service. Hillcrest Road is a County collector road that serves residential and ranching properties to the south of Blue Creek Road. An electrical substation, overhead power, buried telephone lines, gas mains, and a commercial property are located along Hillcrest Road. Existing curve data and the roadway function were used to determine a design speed of 45 mph. This design speed is used for all roadway alternatives. For the purpose of the expansion application, the reconstruction of Hillcrest Road was presented as the COB's preferred alternative that meets the project goal of maintaining a cost-effective method of solid waste management and providing safe access to all site users.

The Montana Department of Transportation (MDT) maintains records of average annual daily traffic on state roadways; data for South Billings Boulevard (Blue Creek Road) 1.5 miles south of the Yellowstone River Bridge located approximately one mile west-northwest of the proposed Facility's approach. According to the MDT data, the annual average daily traffic (AADT) observed in 2011 along Blue Creek Road was 4,850 vehicles.

The COB's consulting engineers conducted a peak hour traffic analysis at the intersection of Blue Creek Road and Jellison Road. Vehicles were counted on Wednesday morning, October 17, 2012, from 7:30 am to 9:30 am. The counting time was selected on previous traffic counts and intended to capture the time when the intersection saw the highest traffic impact. The analysis found that the eastbound movement operates at Level of Service (LOS) B, while the other intersection movements operate at a LOS A. LOS A means that the delay per vehicle is less than or equal to 10 seconds and there is little or no delay to street traffic; LOS B means that the delay per vehicle is between 10 and 15 seconds and traffic experiences short delays. Based on the recent LOS analysis, the COB and their consulting engineers determined that routing to the proposed expansion area via Hillcrest Road would not adversely impact these intersections. The level of traffic on a newly reconstructed Hillcrest Road would increase as a result of the expansion, but the goal of the road reconstruction efforts is to accommodate the increased traffic. The redesign of Hillcrest Road and modifications to Blue Creek Road would be subject to review and approval by MDT and Yellowstone County. Blue Creek Road is an On-system Urban Route. As a result, any work done on the roadway is under the jurisdiction of the Montana Transportation Commission. COB would obtain all necessary permits prior to commencing any modifications to either road.

The COB's preferred alternative would maintain the existing horizontal alignment, but would improve the typical section to include two foot shoulders as well as improving the cut/fill slopes to meet existing County Road standards. Approximately 1100 feet of Blue Creek Road would be reconstructed to meet minimum MDT requirements for the intersection sight distance and includes the construction of an approach landing along Hillcrest Road that would result in an approximate ten foot cut adjacent to the substation. This cut creates the need for a retaining wall separating the lowered Hillcrest Road from the electric substation to minimize impacts. Utility relocation would be required.

According to the COB's consulting engineers, the current right turn lane found at the intersection of Blue Creek and Jellison does not appear to be warranted based on traffic count data alone but is likely there due to accident data. During the COB's field reconnaissance efforts, a crash occurred as a result of a north turning vehicle on Jellison unable to see north on Blue Creek due to the presence of a large commercial vehicle. Therefore, the COB's consulting engineers recommended a dedicated right turn lane from Blue Creek Road to Hillcrest Road and a signalized intersection on Hillcrest Road at the access point to the expansion area.

Since modifications to Hillcrest Road are not expected to occur for 20-25 years, all plans for road reconstruction would first be approved by MDT and Yellowstone County as required prior to construction. As a result, any plan for future modifications to Blue Creek Road and Hillcrest Road would likely require a new traffic analysis based upon conditions at the time of landfill development.

3.10.3.2.2 Utility Modifications

Existing utilities located in the landfill expansion area must be relocated and would affect the overall cost of the landfill expansion project. An overhead power line owned by North Western Energy and an underground gas line owned by Montana-Dakota Utilities Company would need to be realigned. These lines would be redirected south from Hillcrest Road to run along the southern, then eastern boundary of the proposed project area. An underground telephone line that runs adjacent to Hillcrest Road may also need to be relocated. Figures 3.3 and 3.4 provide the proposed locations of the utility realignments. Construction efforts necessary to relocate utility lines would be conducted prior to shutting the lines off for reconnection. The relocation of these lines may affect surrounding residents for a short time period while the utility companies connect the new utility lines where they are realigned to the existing lines.

3.11 VISUALS

3.11.1 ANALYSIS AREA AND METHODS

The analysis area for visuals is the site of the proposed COB Class II Landfill expansion and Hillcrest Road as it approaches the entrance to the proposed facility. The analysis methods for these activities included a site reconnaissance to identify potential visual impacts.

3.11.2 AFFECTED ENVIRONMENT

The property proposed for the COB Class II Landfill expansion site encompasses an approximately 350-acre parcel owned by the applicant. There are no local restrictions that prohibit the location of the facility at the site the applicant selected. The affected environment includes the site of the proposed expansion as well as Hillcrest Road.

3.11.3 ENVIRONMENTAL CONSEQUENCES

3.11.3.1 No Action Alternative

Under this alternative, the site would not be developed as a solid waste management facility, there would be no additional impacts to the visual landscape

3.11.3.2 Proposed Alternative

The proposed COB Class II Landfill facility expansion area is located within a 350-acre parcel owned and controlled by the applicant and is located immediately southeast of the existing COB Class II Landfill facility. The site location was selected by the applicant. The proposed expansion area site extends from just south of the intersection of Hillcrest Road and Montana State Highway 416 (Blue Creek Road) south approximately one-mile to the Section 29 boundary line. The facility would be visible from Hillcrest and Stratton Roads, but the visual impacts should be limited to passing traffic or cyclists passing the facility. The COB plans to begin planting trees and shrubs along the northern boundary of the proposed facility that parallels Hillcrest Road within the next few years. As these trees and shrubs grow, they could serve as a visual barrier to traffic along Hillcrest Road. Presently, the active COB Class II Landfill is visible along Hillcrest Road and from the Yellowstone River. Although landfill features and activities may be partially visible through the trees and shrubs, the expansion area would be less visible to traffic along Hillcrest Road because the expansion area is shielded by higher topography next to the road. The elevation of the landfill would rise very little relative to the surrounding natural grade. By filling the coulee, the peak 3,550-foot elevation of ultimate grade at closure is only about 150 feet above Hillcrest Road. Most of the operations would not be visible as the base and slopes of the coulee fill with waste. Upon closure, the final landfill cover would appear as low rounded hills that blend into the existing natural surrounding landscape.

The landscape affected by the current proposal is not locally or regionally unique but is typical of the overall landscape in the area. The proposed expansion area is adjacent to the existing COB Class II landfill and is currently used for livestock grazing that has impacted existing vegetation, especially in those areas that have been more heavily grazed. The dominant color of the land is tawny brown, except for the few months in late spring and early summer when there is enough moisture and plant growth to cover the land in varying shades of green.

Adequate litter control is required according to approved procedures in the landfill Operation and Maintenance (O&M) Plan. The active COB landfill submitted an updated plan for improved litter control that includes special provisions for windy periods. The updated plan was reviewed and approved by DEQ. In accordance with the approved plan, the City has purchased and is using additional wind screens to capture litter around the active working face (area where garbage is deposited). They have also reduced the size of the working face to minimize the potential for windblown litter. The City has indicated that most of the litter originates while garbage is being unloaded by residents and dumped by trucks. Keeping the working face contained to a smaller area would reduce the volume of loose, uncovered wastes during working hours. An irrigation system was installed, and trees and bushes were planted along the north side of Hillcrest Road between March and May 2017. This could provide a visual barrier but could also help prevent litter from migrating towards the south side of Hillcrest Road.

Construction and operation of the facility would change the immediate area from grazing land to a landfill. As areas of the expansion are closed, capped, and revegetated, the visual landscape would change to manmade hills as those operations are completed. This change would occur within the licensed boundary over the projected life of the facility. Therefore, the impact of the construction, operation, and closure of the proposed expansion area would be similar to how the existing facility would look upon closure.

3.12 NOISE

3.12.1 ANALYSIS AREA AND METHODS

The analysis area is the site of the proposed COB Class II Landfill expansion. The analysis methods included a site reconnaissance and inspections of the currently active COB Class II Landfill facility.

3.12.2 AFFECTED ENVIRONMENT

The property proposed for the COB Class II Landfill expansion site encompasses an approximately 350-acre parcel owned by the applicant. The affected environment includes the proposed landfill site as well as adjacent properties.

3.12.3 ENVIRONMENTAL CONSEQUENCES

3.12.3.1 No Action Alternative

Under this alternative, because the site would not be developed as a solid waste management facility, there would be no additional impacts to noise in the area.

3.12.3.2 Proposed Alternative

Landfill generated noise resulting from the equipment operation associated with disposal activities would not be expected to increase as a result of the continued operation of the landfill in the proposed expansion area. Daily landfilling operations in the proposed expansion area would not fully commence until the current COB Class II Landfill has reached capacity. Noise levels from activities in the expansion area once landfilling activities have moved from the closed area would be similar to noise from current activities. There may be an increase in noise generated from construction activities. However, that activity would be temporary. Therefore, the impact of the construction, operation, and closure of the proposed expansion area on noise in the area would be similar to the existing landfill.

3.13 DEMANDS FOR GOVERNMENT SERVICES

3.13.1 ANALYSIS AREA AND METHODS

The analysis area is the site of the proposed COB Class II Landfill expansion. The analysis methods included research regarding city infrastructure and state services.

3.13.2 AFFECTED ENVIRONMENT

The property proposed for the COB Class II Landfill expansion site encompasses an approximately 350-acre parcel owned by the applicant. The undeveloped site is not yet subject to inspections performed by DEQ's SWS. Current Class II Landfill personnel occasionally drive through the parcel to ensure fences and gates are in good working order.

3.13.3 ENVIRONMENTAL CONSEQUENCES

3.13.3.1 No Action Alternative

Under this alternative, because the site would not be developed as a solid waste management facility, there would be no additional impacts to the demands for government services.

3.13.3.2 Proposed Alternative

DEQ's SWS would perform inspections of the site both during and after construction, a typical routine activity for all proposed and licensed facilities. The Yellowstone County Environmental Health Department may also conduct inspections of the site during and after construction.

Ongoing city services and equipment operations and maintenance required for the proposed facility would be no different than what is currently required for the active COB landfill.

During the construction phases, there may be a slight increase in traffic on the roads leading to the landfill. This would result in a minor impact to roadway infrastructure and traffic enforcement. Road crews and contractors would be responsible for making the necessary modifications to both the state highway and Hillcrest Road once the applicant receives a permit from the Montana Department of Transportation and Yellowstone County to modify the facility approaches off of Montana State Highway 416 and Hillcrest Road. This is not expected to occur for 20-25 years. However, the additional traffic associated with highway reconstruction would be short-term relative to the operational life of the facility.

Once the facility is operational, DEQ's SWS would be responsible for performing inspections and providing compliance assistance. The County and State road department maintenance crews may be required to perform additional road maintenance after any necessary improvements have been made.

The Yellowstone County Sanitarian, the Montana Department of Transportation's (MDT) Motor Carrier Services Division, and DEQ's Solid Waste Section and Enforcement Division may be called upon to respond to complaints and spills on County roads and State highways. Spills of any size may be reported to the Yellowstone County Sanitarian. Spills that exceed 25 gallons must be reported to DEQ's Spill Hotline. The clean-up of spills that occur during transportation will be overseen by the Yellowstone County Sanitarian and/or DEQ's Enforcement Division and must be completed in accordance with the state and/or federal requirements. Individual haulers and hauling contractors are fully responsible for expenses and proper clean-up related to accidental spills caused from hauling materials to and from the facility.

3.14 CULTURAL UNIQUENESS AND DIVERSITY

3.14.1 ANALYSIS AREA AND METHODS

The analysis area is the site of the proposed COB Class II Landfill expansion. The analysis methods included research conducted by the State Historic Preservation Office (SHPO).

3.14.2 AFFECTED ENVIRONMENT

The property proposed for the COB Class II Landfill expansion site encompasses an approximately 350-acre parcel owned by the applicant. The undeveloped site is used currently for intermittent cattle grazing.

3.14.3 ENVIRONMENTAL CONSEQUENCES

3.14.3.1 No Action Alternative

Under this alternative, because the site would not be developed as a solid waste management facility, there would be no additional impacts to the cultural uniqueness and diversity within the project area.

3.14.3.2 Proposed Alternative

SHPO conducted a cultural resource file search for Section 29, Township 1 South, Range 26 East, which indicated there have been no previously recorded sites within the area. Based upon previous ground disturbances in Section 29 associated with the currently licensed active COB Class II Landfill, agricultural activities, and residential development in the area, SHPO determined that there is a low likelihood that cultural properties would be impacted.

Figure 3.3 – Gas Line Realignment Plan

*(Source: Great West Engineering, Billings Landfill Expansion Application, March 2015 (*not to scale))*

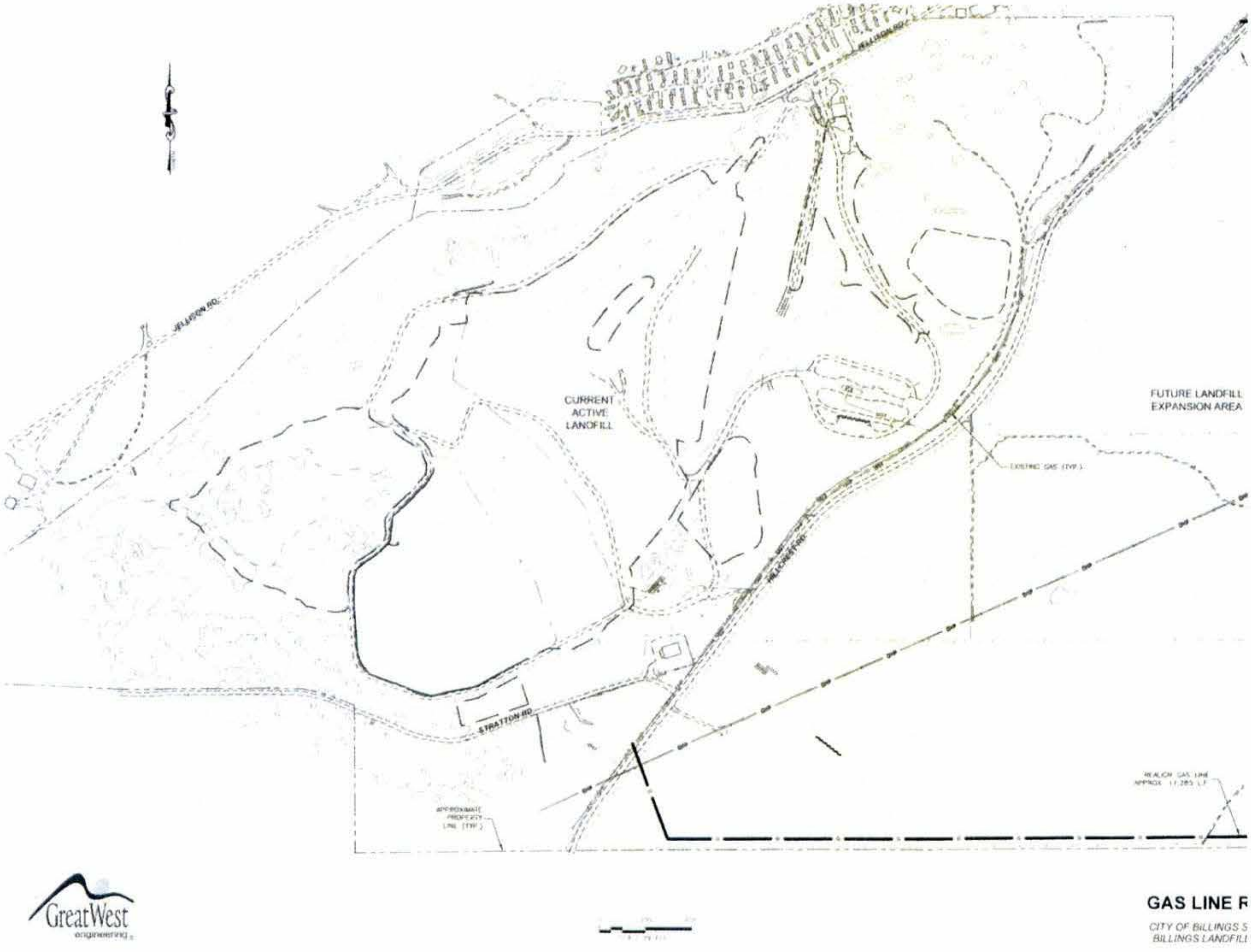
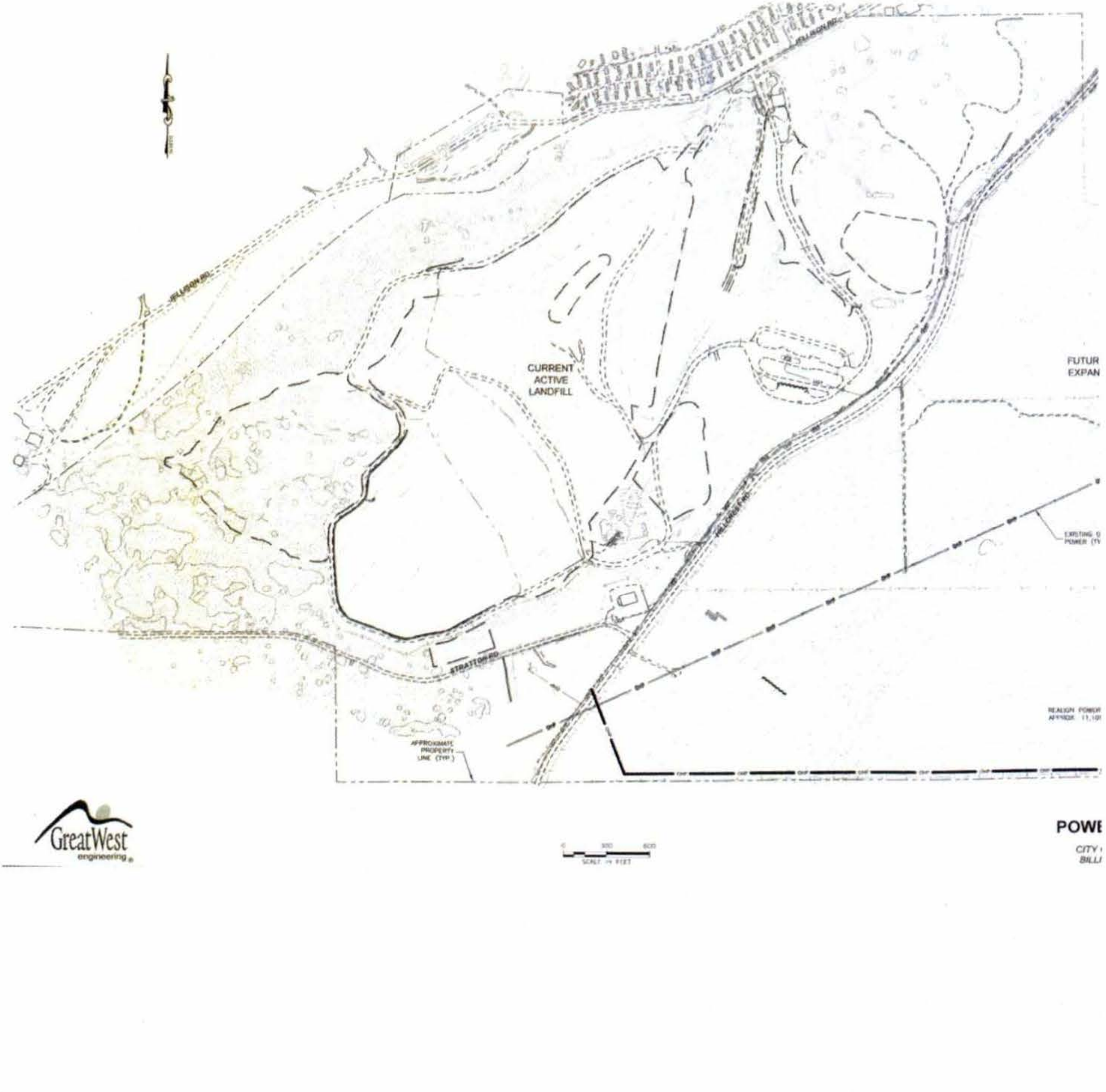


Figure 3.4 – Power Line Realignment Plan

*(Source: Great West Engineering, Billings Landfill Expansion Application, March 2015 (*not to scale))*



COB consultants conducted a cultural resource inventory of the expansion area to identify and provide preliminary National Register of Historic Places eligibility evaluations of sites located within the proposed expansion area. The cultural resource inventory identified one site and one isolated find. However, neither demonstrated the potential to be listed on the National Register of Historic Places.

3.15 PROPERTY VALUES

3.15.1 ANALYSIS AREA AND METHODS

The analysis area is the site of the proposed COB Class II Landfill expansion and residential and vacant lots within a two-mile radius of the site. The analysis method consisted of DEQ's research of peer-reviewed published papers on the effect of landfills on residential property values. In the past 30 years, various research has been done on the effects of landfills on property values. These studies have yielded inconsistent results. Typically, hedonic regression models have been used to try to isolate the effects of landfills on property values holding all other variables constant. Surveys have also been used in studies. Some studies show statistically significant adverse effects of landfills on property values and some do not. Generally, larger effects on property values are seen from larger landfills, less modern landfills, landfills that accept hazardous waste or pose health risks, areas with negative perceptions of landfills, landfills that are more visible, and higher end properties. However, even these effects are not robust across all studies and not all of these effects were studied in every study.

A study by Bouvier, R. A., et al. entitled "The Effect of Landfills on Rural Residential Property Values: Some Empirical Evidence." (2000, The Journal of Regional Analysis & Policy) does not provide grounds for broad generalization about the effect of rural landfills on property values. It finds that in five of the landfills studied (in rural to semi-rural areas), no statistically significant evidence of an effect from landfills was found. In the remaining case, evidence of an effect was found, indicating that houses in close proximity to this landfill suffered an average loss of about six percent in value. This significant case was a landfill that was unlined and uncapped and is on EPA's "potential health risk" list. Bouvier suggests that each landfill be studied on a case-by-case basis.

A study by Cartee, C. P. entitled "A Review of Sanitary Landfill Impacts on Property Values." (1989, Real Estate Appraiser and Analyst) found that while it generally is believed that landfills negatively impact property values, in some cases, the development of a sanitary landfill may enhance a property's value. It finds that the introduction of new roads, utilities, and drainage may stimulate development and lead to increases in land values.

A study by Nelson, A. C., et al. (1992, "Price Effects of Landfills on House Values." Land Economics 68: 359) indicates that the studied landfill adversely affected home values in the range of 12 percent at the landfill boundary and 6 percent at about one mile. Beyond about 2-2.5 miles adverse effects are negligible. Another study by Zeiss, C. and J. Atwater entitled "Waste Facility Impacts on Residential Property Values." (1989, Journal of Urban Planning and Development, 115: 64-80) finds no significant impacts from landfills.

A study by Reichert, A. K., et al. entitled "The Impact of Landfills on Residential Property Values." (1992, Journal of Real Estate Research: 297-314) shows negative impacts up to 7 percent on property values. This study looks to determine the impact of five municipal landfills on residential property value in a major metropolitan area (Cleveland, Ohio). The study concludes that landfills will likely have an adverse impact upon housing values when the landfill is located within several blocks of an expensive housing area. The negative impact is between 5.5%-7.3% of market value depending on the actual distance from the landfill. For less expensive, older areas the landfill effect is considerably less pronounced, ranging from 3% to 4% of market value, and the effect is essentially non-existent for predominantly rural areas. The study mentions that data limitations may make it impossible to model all possible factors.

Another study by Nelson A.C. et al. entitled "Price Effects of Landfills on Different House Value Strata." (1997, Journal of Urban Planning and Development 123: 59-67) uses a large number of homes near a landfill and finds negative home price effects associated with the proximity of a landfill. It also shows that such effects fall disproportionately on higher priced homes.

Finally, a meta-analysis conducted by Richard C. Ready entitled *"Do Landfills Always Depress Nearby Property Values?"* (May 2005, Rural Development Paper No. 27), concluded that landfills do not always depress nearby property values:

> The impact of Western Berks Landfill on nearby residential property values was essentially zero and was estimated with high precision. The meta-analysis of available landfill property value impact studies showed that 20%–26% of landfills that accept low volumes of waste do not have a negative impact on nearby property values. However, essentially all landfills that accept high volumes of waste do have negative impacts on nearby property values.
>
> These meta-analysis results are consistent with previous within-study comparisons of landfills operating at different scales. Lim and Missios (2003) compared two landfills in Toronto, Ontario, and found that the landfill that accepted a higher volume of waste had a larger property value impact than the landfill that accepted a lower volume. Similarly, in this study, the two landfills that accepted high volumes of waste had statistically significant

negative impacts on nearby property values, while the landfill that accepted less waste did not.

One would similarly expect that a landfill's prominence on the landscape would help determine whether and how much it impacts nearby property values. The results presented here for the three Berks County landfills were consistent with that conjecture. Anstine (2003) also found that the degree to which a facility impacted nearby property values depended on whether it was visible from the surrounding area. Similarly, Hite (1998) found that only when buyers were aware of the presence of a landfill were property values bid down. Unfortunately, prominence on the landscape could not be included as an explanatory variable in the meta-analysis, because it could not be objectively measured for all of the landfills in the meta-analysis. To do so would require site visits, and line of sight analyses to take into account visual buffering by terrain and trees. This is an important limitation because less-prominent landfills will tend to be smaller in footprint and accept lower volumes. It is difficult to disentangle the impacts of prominence and volume accepted. Volume of waste accepted, as measured in this analysis, should therefore be viewed as a proxy variable that captures both scale of operation and prominence on the landscape.

The meta-analysis presented here suffers from the usual limitation that it is confined to published studies. Studies may have been conducted that failed to show an impact on property values where the authors or journal editors chose to not publish the results (Wolf, 1986). To the extent that this "file drawer" bias exists, the results presented here would tend to overestimate the average impact of landfills on property values and underestimate the proportion of landfills with no impact.

With that caveat, the results of the meta-analysis can provide landfill permit applicants, permitting agencies and local citizens with useful information on the potential impact that a landfill could have on nearby property values. In particular, they emphasize that the property value impact will vary across landfills. Some of this variation can be predicted, depending on the scale of operation of the landfill. However, there will remain some uncertainty over the magnitude of the impact from a landfill. The meta-analysis presented here can be used to generate a distribution of the possible impacts. (Ready, pp. 17-18.)

3.15.2 AFFECTED ENVIRONMENT

The property proposed for the COB Class II Landfill expansion site encompasses approximately 350-acre parcel owned by the applicant. There are residential subdivisions located within a two-mile radius the current facility and proposed expansion area.

3.15.3 ENVIRONMENTAL CONSEQUENCES

3.15.3.1 No Action Alternative

Under this alternative, because the site would not be developed as a solid waste management facility, there would be no impacts.

3.15.3.2 Proposed Alternative

DEQ regulates over 145 solid waste management systems statewide. Many of the large Class II landfills are located near residential subdivisions and neighborhoods with more than 20 residences. The current COB Class II Landfill is nearing capacity of its existing licensed disposal area. COB submitted an application to construct and operate new landfill cells in an area adjacent to the existing footprint. This is not an endeavor to expand volume of waste received, but rather to simply create new air space to dispose of waste in the future. The proposed expansion area would receive approximately 800 tons per day, similar to what COB receives at the current landfill. While there are many homes within two miles of the proposed expansion area, there are no existing homes directly adjacent to the new landfill footprint. The new expansion would not generally be visible from homes as it would be sited at a higher elevation than surrounding neighborhoods and would include visual and wind blocks as well. The homes within two miles of the landfill are of mixed value (from high end to medium value to manufactured homes) and not particularly dense in their spacing. While not directly in Billings, the area is in the rural-urban interface and less than two miles from town.

In the Google Earth image below, we are looking north towards the city of Billings. The landfill expansion would be in the foreground. The affected homes are mostly on the northern side of the landfill in the upper half of the image.

The existing landfill in Billings has been accepting the same amounts of garbage for many years, having an effect all of that time on existing homes within two to three miles of that facility. Additional adverse effects from a similar landfill next to the existing one are hard to quantify and are likely less than they would be for a new landfill in an existing area. Also, this is a municipal solid waste landfill and not a hazardous waste facility, potentially lowering any effect on houses. Thus, it is hard to say what the impacts would be on homes. Clearly, mitigating factors such as distance from homes, visual breaks, location away from the denser Billings city limit and an existing landfill already incorporated into existing home price would lower any effect that occurs. Likewise, evidence of the lowering of a single home's value, in the absence of the type of study addressed herein, would not provide adequate proof of the effect of the COB landfill expansion on home values in the area surrounding the site.

3.16 SOCIOECONOMIC

3.16.1 ANALYSIS AREA AND METHODS

The analysis area for the proposed landfill is located south of the current COB Class II landfill across Hillcrest Road, directly south of the intersection of Hillcrest Road and Highway 416 (Blue Creek Road) in Yellowstone County, Montana. Data were collected from the COB's application, landfill staff, and engineering consultant.

3.16.2 AFFECTED ENVIRONMENT

The COB landfill manages wastes generated by residents in the City of Billings, Yellowstone County, Stillwater County, and Worland, Wyoming. The existing operations at the COB landfill provide employment for 15 people in Yellowstone County.

3.16.3 ENVIRONMENTAL CONSEQUENCES

3.16.3.1 No Action Alternative

Under this alternative, because the site would not be developed as a solid waste management facility, existing landfill staff and contractors could be forced to find similar employment elsewhere once the existing landfill is closed; this could likely result in the relocation of landfill staff to other communities for employment.

In addition, current landfill users would be forced to obtain waste disposal services elsewhere. The nearest licensed Class II landfill is located in Hardin, approximately 54 miles east of Billings. Transportation of solid wastes currently managed at the COB landfill would result in an increase in costs to site users, not only for transportation fees, but also landfill tipping fees since the City of Hardin landfill would need to add additional landfill staff to manage the increased incoming waste volumes. The remaining capacity of the Hardin landfill is approximately 336,000 tons. If the Hardin facility were to have to handle the additional waste coming from the COB landfill, the City of Hardin landfill could reach capacity in as little as one year. The City of Hardin could submit an application to expand their landfill for this increased volume of waste. Transportation would also result in an increase in vehicle emissions from users transporting their wastes to the Hardin landfill.

3.16.3.2 Proposed Alternative

During the construction phases of the landfill expansion, especially during the initial startup of the expansion area operations, there would be a minor increase in local employment due to the additional need for contractors, site operators, and associated support. Landfill construction activities would employ approximately 15 additional people as construction workers for about six months. However, because this would occur only during the construction of landfill features, the impact of these activities on employment are of short duration compared to the life of the landfill. Operations would move from the current landfill to the expansion area once the site features have been constructed; existing landfill staff would move at the same time. The long-term employment requirements will be similar to existing employment at the current COB Class II landfill.

3.17 CUMULATIVE EFFECTS

Cumulative impacts are the collective impacts on the human environment when considered in conjunction with other past, present, and future actions by location and generic type. Cumulative impact analysis under MEPA requires an agency to consider all past and present state and non-state action. Related future actions must also be considered when these actions are under concurrent consideration by any state agency through pre-impact statement studies, separate impact statement evaluation, or license process procedures. Cumulative impact analyses help to determine whether an action would result in significant impacts when added to other activities.

According to MDT, Blue Creek Road is an On-system Urban Route. As a result, any work done on the roadway is under the jurisdiction of the Montana Transportation Commission. There is a high likelihood that there could be pavement preservation projects along the roadway, including a chip seal or a mill and overlay. There could also be maintenance work on the bridge deck for the bridge over the Yellowstone River. One project, scheduled for 2026, is the addition of a right-turn lane at the intersection of Blue Creek Road and Hillcrest Road. However, the timing of the project could change if issues arise with right-of-way or funding.

The City of Billings-Yellowstone County Planning Department indicated that a new commercial development is proposed for property on the east side of Blue Creek Road, just northeast of the intersection of Jellison Road and Blue Creek Road. However, this project has not moved forward for full development review. Therefore, no additional details are available. However, once completed, this may increase traffic on Blue Creek Road.

By the time construction activities commence in the proposed expansion area, the existing COB landfill would be in the final stages of landfilling and preparing for final facility closure construction. The proposed COB Class II Landfill expansion area is adjacent to the existing COB Class II Landfill. Historic land uses of the area south of the Billings area include both commercial and non-commercial activities. Commercial uses include livestock grazing, hay, and wheat production, several types of businesses from trucking to energy recovery. Non-commercial uses include wildlife habitat, watershed, and residential sites. Landfilling activities would simply move from the currently licensed COB Class II Landfill to the proposed expansion area once the current landfill reaches capacity. As population grows, there may be an increase in demands on the landfill from the expanding population. However, the proposed expansion is designed to accommodate the additional anticipated demands.

3.18 UNAVOIDABLE ADVERSE EFFECTS

Residual impacts from the Proposed Action would include the loss of developed soil and vegetation from approximately 293 acres of the 350-acre site for use on roads, cover soils, and for the construction of berms and other landfill features. However, topsoil would be placed as part of the cap construction during final closure of the facility. The topsoil would be reseeded with native vegetation. Some sediment control structures would remain and the capped landfill units would appear as man-made features across the landscape. Post-closure land use would be restricted to animal grazing. No structures that require the placement of footings or foundations are allowed over the closed landfill units. Any disturbance of the closed landfill final cover for construction of any structure would have to be approved in advance by DEQ.

Plant communities dominated by native plants would be replaced by reclaimed plant communities on the property. Noxious weeds would increase from the soil disturbance, but weeds would be treated to ensure revegetation by native local grasses occurs as required by the county weed control program. The disturbed areas would be reclaimed, reseeded, revegetated, and a program implemented to inventory and treat noxious weeds would be implemented.

4 CONCLUSIONS AND FINDINGS

4.1 A listing and appropriate evaluation of mitigation, stipulations and other controls enforceable by the agency or another government agency:

The proposed licensure of the COB Class II Landfill expansion facility will meet the requirements of the Montana Solid Waste Management Act and administrative rules regulating solid waste disposal. Adherence to the Solid Waste, Water Quality, and Air Quality regulations and the approved facility Operation and Maintenance Plan will mitigate the potential for harmful releases and impacts to human health and the environment by the proposed facility.

4.2 Findings:

An EIS is not required under the Montana Environmental Policy Act because the project lacks significant adverse effects to the human and physical environment based on the following criteria in ARM 17.4.608(1)(a) through (g):

(a) the severity, duration, geographic extent, and frequency of occurrence of the impact;
(b) the probability that the impact will occur if the proposed action occurs; or conversely, reasonable assurance in keeping with the potential severity of an impact that the impact will not occur;
(c) growth-inducing or growth-inhibiting aspects of the impact, including the relationship or contribution of the impact to cumulative impacts;
(d) the quantity and quality of each environmental resource or value that would be affected, including the uniqueness and fragility of those resources or values;
(e) the importance to the state and to society of each environmental resource or value that would be affected;
(f) any precedent that would be set as a result of an impact of the proposed action that would commit the department to future actions with significant impacts or a decision in principle about such future actions; and
(g) potential conflict with local, state, or federal laws, requirements, or formal plans.

The project area is located south of the currently licensed and operating City of Billings Class II Landfill Facility (Facility). The Facility would consist of two separate Class II landfills and two separate Class IV landfills that will be developed in seven phases over the life of the facility.

The proposed expansion area encompasses 350 acres of city-owned property and would be accessed from Hillcrest Road. Of the 350 acres proposed for the expansion, the project will result in a disturbance total of 293 acres for landfill disposal units, storm water and leachate retention ponds, roads, and buildings during the entire life cycle of the facility. The landfill disposal units would disturb a total of 232 acres and the remaining 61 acres for the construction of the ponds, roads, buildings and ditches. The landfill disposal units will be partially closed when it reaches final grade and the maximum open area at any one point in time will be 119 acres. The total on-site waste tonnage at closure is estimated to be 13,392,580 tons. Based upon the municipal solid waste density, the waste acceptance rate, and the projected growth rate in the Billings area, the proposed COB expansion will extend the life of the COB Class II Landfill by approximately 48 years. When each disposal unit has reached capacity, the daily or intermediate covered waste will provide the base for the final cover system. This surface will be prepared smooth and firm. A 48-inch thick monolithic, evapotranspiration layer will be constructed in one or two continuous lifts compacted to a maximum of 85% standard proctor. The top layer will consist of six inches of loose topsoil and will be fertilized and seeded with select native vegetation adapted to the area climate. Thus, the disturbed area will be returned to native vegetation after the 48-plus year life of the expansion area.

The applicant proposed an alternative liner design for the Class II disposal units consists of a 60-mil flexible membrane liner made of high-density polyethylene (HDPE). The HDPE overlies an in-place, re-compacted native subgrade material.

This design matches the synthetic membrane standard and lower soil component. An alternative liner demonstration was previously approved by DEQ for compliance with the composite liner design requirements and the contaminant migration standards for the currently active, licensed Class II landfill. Incorporation of this previous demonstration report into the proposed expansion application documents is justified because (i) all site investigations confirm that the geologic conditions beneath the expansion area correspond with the reported data, and (ii) the proposed liner is identical to the liner in the demonstration.

HDPE is a very low permeability, flexible, synthetic membrane (geomembrane) that is widely used to contain or control liquid and gas migration in an engineered project, structure, or system. Also, HDPE pipe commonly conveys water or wastewater for many municipal systems. HDPE geomembrane liners are highly impermeable barriers which prevent the contamination of soil and groundwater from chemicals in liquids that may be derived from the solid waste. The lower, compacted, in-place native component of the proposed composite liner will function as a secondary liner to enhance the primary upper geomembrane providing further protection by retarding seepage and landfill gas diffusion as noted.

A geosynthetic liner is not required for the Class IV units. The Class IV units will be excavated to base grade in shallow bedrock and will provide for the disposal of 4,220,000 cubic yards of Group IV waste.

A leachate collection and removal system and leachate ponds will be installed for the east and west Class II landfill units. All leachate will be collected over the lined base of each Class II landfill unit within the granular leachate collection layer. All leachate will be directed to the leachate ponds via gravity flow through an external buried, double-walled HDPE leachate conveyance pipe. These double-walled HDPE leachate conveyance pipes will transport leachate by gravity along both sides of the central road and discharge into the east and west leachate ponds via dissipation manholes. Leachate will be managed largely by evaporation from the leachate pond, but may be applied over the lined active waste disposal areas (areas that are not under final or intermediate cover) for dust control, if needed. This management allows the pond to be emptied faster to assure that there is sufficient capacity available at all times.

The expansion area is located in the Big Sagebrush Steppe and Great Plains Mixedgrass Prairie ecosystem. The existing vegetation at this site is not unique or limited, consisting of Wyoming big sagebrush, western wheatgrass, thickspike wheatgrass, green needlegrass, blue grama, and needle and thread. In grazing areas, the predominant species include Kentucky bluegrass, smooth brome, and Japanese brome. Along Stream 1, there are areas identified as Great Plains Ponderosa Pine Woodland and Savanna, Great Plains Wooded Draw and Ravine, and Great Plains Riparian. Vegetation in these areas include ponderosa pine uphill from drainages, Rocky Mountain juniper in valleys and ravines, and both narrowleaf cottonwood and Plains cottonwood in the floodplains. There are no records of plant Species of Concern, Potential Species of Concern, or Special Status Species in the area surrounding the proposed COB Class II Landfill expansion site. During facility construction, vegetation would be removed from areas of the site for establishing the proposed landfill disposal units, roads, buildings, and storm water control features. Some soils removed during excavation of each landfill unit may be stockpiled in the area of the subsequent unit and would be used as-needed for daily, intermediate, or final soil cover. Ground disturbance activities could increase the potential for noxious weeds on the facility, but COB would be required to obtain and implement a County-approved noxious weed plan during all stages of the project.

There are no threatened or endangered terrestrial or avian species, nor Species of Concern or Special Status species. While the removal of areas of wildlife habitat as a result of construction and operation of the facility may alter the movement of local wildlife, populations of transient wildlife that may inhabit portions of the proposed expansion area site will move to other areas of similar habitat. Not all disposal areas within the proposed expansion area will be open at any one time; a maximum of 119 acres of landfill units would be open at any one time. This would leave undisturbed areas available for grazing and bedding. Once the current COB landfill reaches capacity, the disposal units would be closed, capped, and revegetated. Existing wildlife would likely migrate away from disturbances in the proposed expansion area and move into the closed landfill where interactions with humans, vehicles, and heavy equipment would be minimal. Therefore, the impacts from landfill construction and operation on wildlife habitat will be minor due to the abundance of surrounding similar habitats in the vicinity to accommodate any terrestrial or avian species that may be forced to relocate.

Construction of landfill units and associated features of the proposed expansion area will impact the existing wetlands identified on site. As a result, the construction of mitigated wetlands is required and must occur prior to construction. The wetlands and bodies of water that would be affected by the expansion have direct contact to Blue Creek, which flows into the Yellowstone River. The United States Army Corps of Engineers (USACE) has elected the Yellowstone River as Traditional Navigable Water, or TNW. Thus, all impacted wetlands and bodies of water are subject to jurisdiction under Section 404 of the Clean Water Act. COB must also obtain a 401 certification from DEQ's Water Quality Bureau prior to any construction activity. The USACE is accountable for Section 404 determinations. The COB must obtain a 404 permit from the USACE prior to any wetland disturbance.

A storm water control system will be constructed to accommodate runoff from a 25-year, 24-hour storm event at the site. Storm water sediment retention ponds will contain any expected storm water runoff generated by intense rainfall or storm melt, allowing sediments to settle out. If a discharge from the storm water retention ponds is necessary, the water discharged would not contain the sediment load that is currently found in uncontrolled runoff events at the undeveloped site.

Under ARM 17.50.1204(1), an owner may only construct a Class II landfill after gaining DEQ approval that the design either a) ensures that specified concentration values will not be exceeded at the relevant point of compliance; or b) uses a composite liner and a leachate collection and removal system that is designed and constructed to maintain less than a 30-cm depth of leachate over the liner. The overall conclusion from the site hydrogeologic investigation is that the property and surrounding upland areas do not present an identifiable connecting groundwater system that would allow for the placement of either background wells or downgradient wells. These conditions also exist to the immediate south and west of the expansion area and are apparent by the fact that homes built in this area do not have wells but have cisterns and potable water is hauled in due to the lack of available groundwater. COB successfully demonstrated there is no potential for the migration of contaminants to groundwater. In addition, COB will install high density polyethylene liners beneath the Class II disposal units. High density polyethylene liners are highly impermeable and is the same material used to contain or control liquid and gas migration in an engineered project, structure or system. Moreover, the Facility will construct the lower component with six inches of re-compacted native clay soil. Thus, while groundwater is a valuable environmental resource, there is reasonable assurance that any groundwater beneath the Facility will not be impacted.

DEQ has not identified any growth-inducing or growth-inhibiting aspects of the Facility. DEQ's approval of the Facility does not set any precedent and would not commit the DEQ to any future action with significant impacts, nor is it a decision in principle about any future actions that DEQ may act on. Finally, construction and operation of the Facility does not conflict with any local, state, or federal laws, requirements, or formal plans.

Based on consideration of all of the criteria set forth in Arm 17.4.608, DEQ has determined construction and operation of the Facility will not significantly affect the human environment. Therefore, an environmental assessment is the appropriate level of environmental review and preparation of an environmental impact statement is not required.

4.3 Other groups or agencies contacted or contributing to this EA:

Montana Natural Heritage Program
State of Montana Historic Preservation Office
Great West Engineering
HRD Engineering, Inc.
Ethnoscience, Inc.
Tetra Tech

U.S. Geological Survey
Montana Bureau of Mines and Geology
U.S. Department of Agriculture - Natural Resource Conservation Service
Montana Department of Transportation
City of Billings-Yellowstone County Planning Department

4.4 Authors:

Final EA prepared by:
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Montana DEQ, Solid Waste Section

Date: December 17, 2018

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APPENDIX A

City of Billings Solid Waste Alternative Analysis
(Prepared by Great West Engineering and HDR Engineering for the City of Billings)

City of Billings

Solid Waste Alternatives Analysis

Job No. W.O. 12-29

ENVIRONMENTAL ASSESSMENT TECHNICAL MEMORANDUM

February 2014

Prepared for:

City of Billings

Prepared by:

Great West Engineering

HDR Engineering, Inc.

Table of Contents:

Section 1.0 Description of Project

1.1 Introduction

The team of Great West Engineering and HDR Engineering has been hired by the City of Billings (City) to prepare a Solid Waste Alternatives Analysis. The scope of the project includes an evaluation of the existing facilities and master planning activities, which also includes examining the feasibility of expanding the landfill to City property adjacent the existing landfill. The City will be required to comply with Montana Department of Environmental Quality (DEQ) Rules if a landfill expansion is proposed. The *Solid Waste Alternatives Analysis Report* (City of Billings 2013), the Master Plan Design Report (Great West 2013c) and other supporting documentation were used to develop this technical memorandum. The purpose of this technical memorandum is to provide environmental documentation that is anticipated to be used by the DEQ for preparation of an environmental assessment in accordance with the Montana Administrative Rule ARM 17.4.601 and the DEQ's Procedural Rules for implementing Montana Environmental Policy Act (MEPA).

1.2 Background

The existing DEQ solid waste permit was issued to the City in 1978 and included 421 acres of City property. The City has since acquired additional property and now owns approximately 842 acres. The additional property includes the 350-acre proposed landfill expansion study area. The limits of the current landfill licensed area and the proposed landfill expansion study area are shown on Figure 1.1.

Of the total existing landfill property, 226 acres are currently permitted for disposal of Class II waste and 28 acres for the disposal of Class IV waste. The existing landfill is accessed by South Billings Boulevard, Jellison Road and a paved on-site access road. The terrain slopes primarily to the north, with the Yellowstone River located approximately 2,000 feet north of the existing landfill. Figure 1.2 details the existing site plan for the Billings Landfill. The 842 acres is located in Sections 29 and 30 of Township 1 South, Range 26 East.

Current estimates calculate the remaining life of the 421-acre existing licensed landfill area to be between 39 to 62 years depending on waste volumes accepted for disposal (Great West 2013a). In anticipation of reaching the existing landfill's capacity, the City is initiating the steps necessary to license and expand the landfill to the adjacent 350 acres of City property.

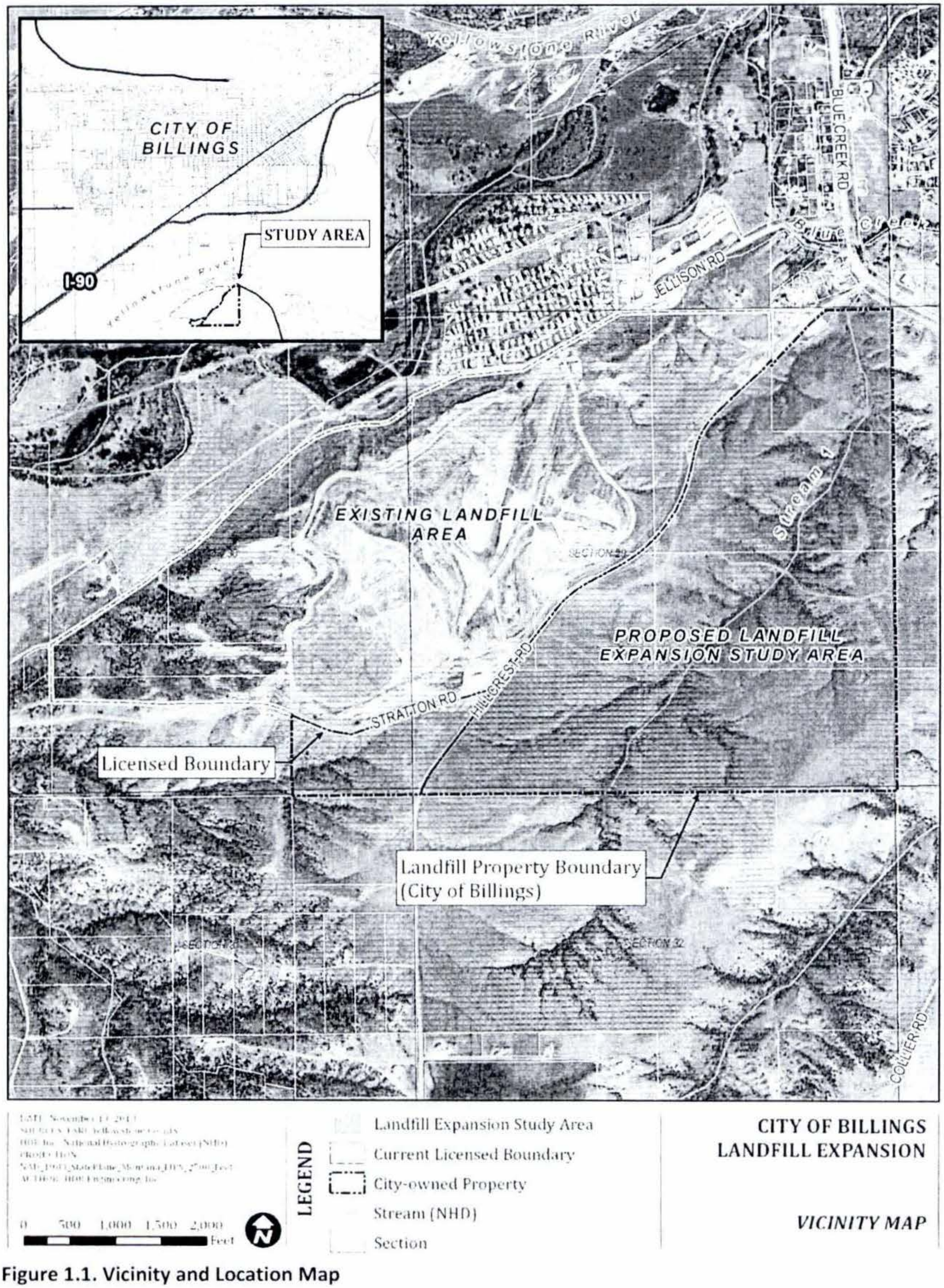

Figure 1.1. Vicinity and Location Map

Figure 1.2. Existing Site Plan

1.3 Project Site Location

The City of Billings, Montana, proposes to expand their landfill operations into the southeast half of Section 29 of Township 1 South, Range 26 East. The project is located in Yellowstone County, Montana, just south of the City of Billings. In particular, the study area is located in Section 29, Township 1 South, Range 26 East, Montana Principal Meridian, and is centered at latitude 45° 43' 08" North and longitude 108° 32' 06" West. The proposed landfill expansion study area is located on approximately 350 acres of City-owned land immediately southeast of the existing Billings Landfill. The project site extends from just south of the intersection of Hillcrest Road and Montana State Highway 416 (Blue Creek Road) south approximately 1 mile to the Section 29 boundary line. Figure 1.3 details ownership of other parcels near the study area including the 350 acres of unlicensed property owned by the City.

Figure 1.3. Site Plan and Land Ownership

1.4 Proposed Action

A technical evaluation of landfill expansion alternatives was conducted and results are found in the *Solid Waste Alternatives Analysis Final Report* (City of Billings 2013). Of the four alternatives presented in the analysis, Alternatives 1, 2, and 4 were carried forward for more detailed analysis. Alternative 3 was screened out and removed from further consideration, as described in Section 2.0. Initially, Alternative 1 was selected as the preferred alternative; however, following initial geotechnical investigations, it was later determined that construction of the large perimeter storm water ditches needed to control storm water run-on[1] under Alternatives 1 and 2 were economically infeasible. Alternative 4 was subsequently developed and chosen by the City as the preferred alternative. All alternatives are described in greater detail below.

Description of the Proposed Action (Alternative 4)

Alternative 4 develops the landfill into two separate units on either side of the primary drainage (Stream 1, Figure 1.1) which runs south to north through the property. By developing two separate units, the Proposed Action eliminates the need for a large perimeter run-on control ditch (as required under Alternatives 1 and 2, described below). The planned excavations for Alternative 4 cells will be significantly shallower than those originally anticipated for Alternatives 1 and 2. In order for this alternative to provide adequate cover soil, it will be essential for the City to dramatically reduce its daily cover soil usage. See Figure 1.4 for the Alternative 4 Site Plan.

Alternative 4 includes utilizing Hillcrest Road as access to the site, but includes improvements to widen the roadway and bring it up to County Road standards. Other roadway improvements under Alternative 4 include: reduction of steep grades on Hillcrest Road; improving sight distances at the Blue Creek Road/Hillcrest Road intersection to meet MDT requirements; and an addition of a dedicated right turn lane from Blue Creek Road to Hillcrest Road. Refer to the Transportation section for a more detailed description of roadway improvements under the Proposed Action.

[1] Storm water run-on is water that flows from adjacent properties onto the proposed landfill expansion study area.

Figure 1.4. Alternative 4 Site Plan

1.5 Benefits of the Proposed Action

The City ultimately selected Alternative 4 as the preferred alternative after detailed analysis of site conditions, capital costs, and capacity limits. Alternative 4 took the place of Alternative 1 as the preferred alternative following results of geotechnical investigations that showed an unanticipated presence of hard rock at relatively shallow depths. The primary differentiation between Alternative 4 and Alternatives 1 and 2 is constructability. Alternatives 1 and 2 were deemed economically infeasible due to the underlayment of the recently discovered hard rock that would dramatically increase excavation costs.

Alternative 4 has the highest unit capital costs at $6.65 per ton. This is due primarily to the reduced overall capacity of this alternative. This alternative has the highest capital cost per ton but the lowest overall capital cost (refer to the Master Plan Design Report [Great West 2013c]).

Alternative 4 retains the use of Hillcrest Road and plans for certain improvements to the road. The project team determined that removal of Hillcrest Road, as identified in Alternative 2, would be viewed negatively by the public. Removing Hillcrest Road under Alternative 2 would result in higher road costs with a potential need to acquire additional land for the other road alternatives. Therefore, it is likely that Alternative 4 would be viewed favorably by the surrounding property owners and general public due to the planned improvements to Hillcrest Road.

Alternative 4 has some minor regulatory advantages over Alternative 2. Alternative 4 could be licensed as either a brand new license or as a license expansion. Alternative 2 would need to be licensed as an expansion because of the eventual overlap of fill onto the existing licensed area. If Alternative 4 was licensed under a new license, the City would be able to start the 30-year post-closure care period on the existing landfill once the final closure work was complete. The primary financial advantage is that the City could stop the groundwater monitoring at the existing landfill once the post closure period is completed. However, there are some advantages to licensing the new area as an expansion of the license rather than a new landfill license. Licensing Alternative 4 as an expansion will likely be preferable from a public relations perspective and will also aid the process with DEQ because licensing as an expansion clearly indicates the connection to an existing landfill.

Section 2.0 Alternatives Considered

The alternatives analysis included 4 potential expansion alternatives, identified as Alternatives 1, 2, 3 and 4 (City of Billings 2013). The alternatives evaluation was based on the following considerations: soil balance, capacity, lifespan, and capital costs/costs per ton. Alternative 4 (the City-selected preferred alternative) is described above in Section 1.4. The other alternatives developed for evaluation are described in greater detail below.

2.1 Alternative 1

Alternative 1 is designed to stand alone from the existing landfill (Figure 2.1). The footprint is situated in a manner that maximizes space while allowing for setback from the property lines, and to direct the storm water run-on around the landfill to the northwest via a drainage ditch. This option would most likely utilize Hillcrest Road as access to the site, which would require improvements to reduce the steep grades to a more optimum grade for the haul trucks to maintain speed, and to meet the required sight distances for the speed limit of the road. This alternative may also use the option to reroute Hillcrest Road around the expansion area. Each alternative will be required to reroute a large overhead power transmission line. Due to the presence of large quantities of hard rock excavation, construction of the large perimeter storm water ditch was determined economically infeasible and impracticable.

2.2 Alternative 2

Alternative 2 is designed to overlap onto the existing landfill and remove Hillcrest Road (Figure 2.2). This alternative capitalizes on the airspace gained with overlap of the existing fill, which will allow more capacity in the early life of this alternative. The footprint is also situated in a manner that maximizes space while allowing for setback from the property lines, and to direct the storm water run-on around the landfill to the southeast via a large drainage ditch. This alternative would require the reroute of Hillcrest Road as access to the site around the expansion area either by utilizing and improving Collier Road or providing a new access off of Blue Creek Road. In addition, this alternative will also be required to reroute a large overhead power transmission main. Due to the presence of large quantities of hard rock excavation, construction of the large perimeter storm water ditch was determined economically infeasible and impracticable.

2.3 Alternative 3

Alternative 3 is a standalone facility, and, due to its configuration, would result in a reduced capacity and lifespan as compared to Alternatives 1 and 2, without providing any technical or financial advantages. Alternative 3 was therefore removed during the screening process.

2.4 No Action Alternative

Under the No Action Alternative, a final decision would not be required by DEQ because the City will have chosen to withdraw the application for licensure. Under a No Action Alternative, the City of Billings will continue utilizing the existing landfill facility and would not seek to license any additional property. The existing landfill facility was thoroughly evaluated during alternative analyses for capacity and life expectancy. Based on this evaluation, the existing landfill has between approximately 39 to 62 years remaining, at which point the City would need to identify additional area for landfill activities.

Figure 2.1. Alternative 1 Site Plan

Figure 2.2. Alternative 2 Site Plan

2.5 Comparison of the Reasonable Alternatives

Based on the screening criteria, Alternatives 1, 2, and 4 were the reasonable alternatives carried forward. This section provides a brief comparison of the reasonable alternatives; for more information, see the *Solid Waste Alternative Analysis Report* (City of Billings 2013). Alternative 4 is further developed in the *Landfill Master Plan* and *Master Plan Design Report* (Great West 2013c).

The life of each expansion alternative is determined using waste volume and waste tonnage calculated with the soil balance and total airspace as described above. For purposes of comparing alternatives, four different life estimate calculation methods are shown in Table 2.1. Of the methods used, Alternative 2 provides the greatest life estimate benefits and Alternative 4 provides the least.

Table 2.1. Expansion Life Estimates Comparison

ALTERNATIVE	Calculation Method	Air Space Capacity (CY)	Solid Waste Capacity (Tons)	Solid Waste Capacity (CY)	Daily Cover (CY)	Approximate Life (Years)
ALTERNATIVE 1	250,000 Tons/Year	62,587,000	31,293,000	43,621,000	18,966,000	123
	416,686 Tons/Year with 1.07% Inflation, Begin Year 2060	62,587,000	31,293,000	43,621,000	18,966,000	54
	351,561 Tons/Year with 1.07% Inflation and Planned Diversion Begin Year 2062	62,587,000	31,293,000	43,621,000	18,966,000	62
	Expanded Service Area 486,911 Tons/Year with 1.07% Inflation Begin Year 2051	62,587,000	31,293,000	43,621,000	18,966,000	47
ALTERNATIVE 2	250,000 Tons/Year	72,430,900	36,215,000	50,482,100	21,948,800	142
	416,686 Tons/Year with 1.07% Inflation, Begin Year 2060	72,430,900	36,215,000	50,482,100	21,948,800	59
	351,561 Tons/Year with 1.07% Inflation and Planned Diversion Begin Year 2062	72,430,900	36,215,000	50,482,100	21,948,800	69
	Expanded Service Area 486,911 Tons/Year with 1.07% Inflation Begin Year 2051	72,430,900	36,215,000	50,482,100	21,948,800	53
ALTERNATIVE 4	250,000 Tons/Year	23,544,400	12,068,200	18,566,400	3,713,300	49
	416,686 Tons/Year with 1.07% Inflation, Begin Year 2060	23,544,400	12,068,200	18,566,400	3,713,300	26
	351,561 Tons/Year with	23,544,400	12,068,200	18,566,400	3,713,300	31

ALTERNATIVE	Calculation Method	Air Space Capacity (CY)	Solid Waste Capacity (Tons)	Solid Waste Capacity (CY)	Daily Cover (CY)	Approximate Life (Years)
	1.07% Inflation and Planned Diversion Begin Year 2062					
	Expanded Service Area 486,911 Tons/Year with 1.07% Inflation Begin Year 2051	23,544,400	12,068,200	18,566,400	3,713,300	22

Source: City of Billings Solid Waste Alternatives Analysis, July 2013

Planning level cost estimates comparing the construction of expansion and closure of each alternative are shown in Table 2.2. These capital cost estimates focus on capital infrastructure improvements at the landfill and do not include estimates for replacement of equipment such as drop boxes, trucks, earthmoving machines, etc. Estimates also do not include operations and maintenance costs for the landfill, which represent the most significant costs associated with most solid waste facilities. The construction estimates assume the City will excavate each of the landfill expansion areas as part of its excavations needed for daily cover. The estimates also assume that the City will continue constructing its own on-site roads rather than contracting them out. Cost tables include estimates for cell construction, liners and leachate collection systems, closure projects, infrastructure improvements and miscellaneous engineering tasks. Alternative 4 has the highest capital cost per ton.

Table 2.2. Alternative Cost Estimate Comparison (2013 Dollars)

ALTERNATIVE	Expansion Cost	Closure Cost	Total Capital Cost	Total Tonnage	Capital Cost Per Ton
ALTERNATIVE 1	$126,909,000	$10,557,000	$137,466,000	31,293,000	$4.40
ALTERNATIVE 2	$140,575,000	$9,544,000	$150,119,000	36,215,000	$4.15
ALTERNATIVE 4	$72,512,740	$7,981,570	$80,494,310	12,068,200	$6.65

Source: City of Billings Solid Waste Alternatives Analysis, July 2013

Section 3.0 Analysis of Potential Impacts

This section evaluates the potential environmental effects that may occur on the physical and human environment if the proposed facility is approved and constructed. Tables 3.1 and 3.7 identify the physical and human elements that may be impacted by licensure of the proposed facility. Each table is followed by a discussion of the potential impacts to the resources that might be affected by the Alternative 4 as the proposed action.

3.1 Potential Impacts on the Physical Environment

This section evaluates the potential environmental effects that may occur on the physical environment due to implementation of the proposed action, Alternative 4. The resources listed in Table 3.1 are described in greater detail in the following sections. Generally, only those resources potentially affected by the proposed action are discussed in greater detail. If there is no effect on a resource or the resource is not present within the study area, it is noted in the respective section and not analyzed any further.

Table 3.1. POTENTIAL IMPACTS ON THE PHYSICAL ENVIRONMENT

PHYSICAL ENVIRONMENT	Major	Moderate	Minor	No	Unknown
SITE GEOLOGY & SOIL QUALITY - STABILITY & MOISTURE: Are there unusual geologic features?				X	
Will the surface features be changed?	X				
Are fragile, compactible or unstable soils present?				X	
Are there special reclamation considerations?			X		
WATER QUALITY, QUANTITY & DISTRIBUTION: Are important surface or ground water resources present?				X	
Is there potential for violation of ambient water quality standards, drinking water maximum contaminant levels, or degradation of water quality?				X	
AIR QUALITY: Will pollutants or particulate be produced?			X		
Is the project influenced by air quality regulations or zones (Class I air-shed)?				X	
DEMANDS ON ENVIRONMENTAL RESOURCES OR LAND, WATER, AIR OR ENERGY: Will the project use resources that are limited in the area?				X	
Are there other activities nearby that will affect the project?				X	
TERRESTRIAL, AVIAN, AND AQUATIC LIFE AND HABITATS: Is there substantial use of the area by important wildlife, birds or fish?			X		
VEGETATION COVER, QUANTITY & QUALITY: Will vegetative communities be permanently altered?		X			
Are any rare plants or cover types present?				X	
UNIQUE, ENDANGERED, FRAGILE OR LIMITED ENVIRONMENTAL RESOURCES: Are any federally listed threatened or endangered species or identified habitat present?				X	
Any wetlands?			X		
Any species of special concern?				X	
HISTORICAL AND ARCHAEOLOGICAL SITES: Are any historical, archaeological or paleontological resources present?				X	
HAZARDOUS WASTE AND SITES: Are there any hazardous materials within or adjacent the study area?				X	
AESTHETICS: Is the project on a prominent topographical feature?				X	
Will it be visible from populated or scenic areas?			X		
Will there be excessive noise, light or odors?				X	

Site Geology and Soil Quality

General Geology and Soil Characteristics

The project site is located in the Missouri Plateau, Unglaciated Section of the Great Plains Province of the Interior Plains (USDA NRCS 2013). It is an area of old plateaus and terraces that have been eroded. Slopes generally are gently rolling to steep and wide belts of steeply sloping badlands border a few of the larger river valleys. Nearly the entire project site is mapped as Lismas Clay (map unit "Ln"), 15 to 35 percent slopes (USDA NRCS 2012). These soils are characterized as shallow, well-drained, moderately steep calcerous clay soils on upland (Meshnick 1972). Figure 3.1 shows the various soil types located within the landfill expansion area and soil properties are described in Table 3.2. Topographically, the study area consists of an upland plain, dissected by a large, second-order drainage (Stream 1) that discharges to Blue Creek, a tributary of the Yellowstone River. Numerous first-order drainages are located throughout the study area and all drain to Stream 1 (see Figure 1.1). Surface elevation in the study area ranges from 3200 feet to 3500 feet above mean sea level.

Soil types within the study area do not represent any rare or unusual properties and similar soils types can be abundantly found surrounding the study area. Construction and operation of the proposed project would result in major earth moving activities and would affect the existing topography of the site. Following closure of the landfill, topsoil will be replaced and revegetated according to the reclamation plan. Due to the plastic nature of on-site soils and limited topsoil available, reclamation of disturbed areas will require augmentation of surface soils with compost or mulch.

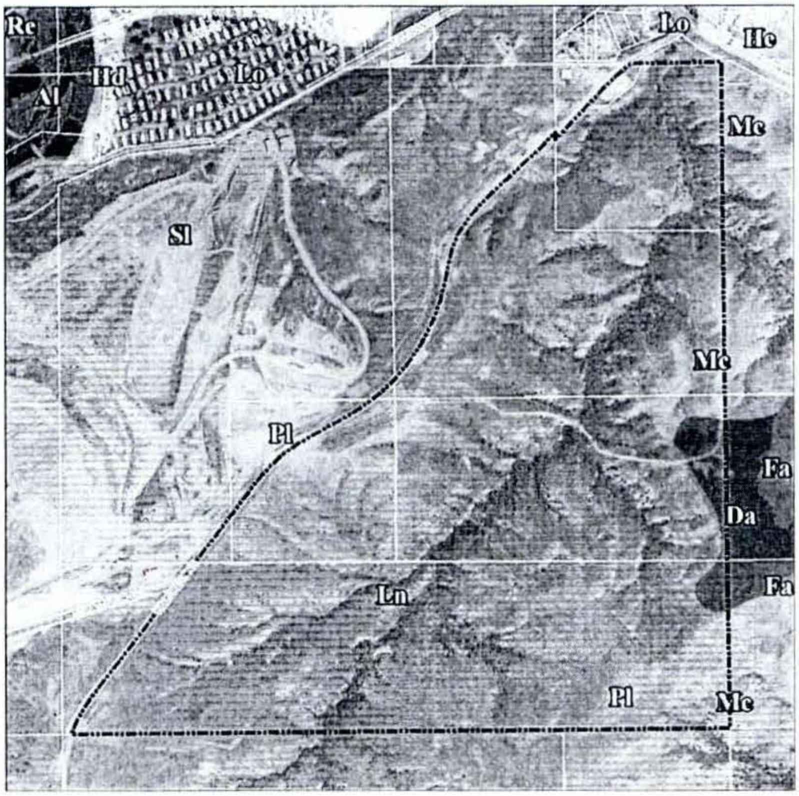

Figure 3.1. Soil Types within the Study Area

Table 3.2. Summary of Soil Properties within the Study Area

SOIL TYPE	MAP UNIT SYMBOL	ACRES IN STUDY AREA	DRAINAGE	PERMEA-BILITY	AVAILABLE WATER CAPACITY	DEPTH TO WATER TABLE
Lismas clay, 15 to 35 percent slopes	Ln	278	Well drained	Very low to moderately high	Very low	More than 80 in.
Pierre-Lismas clays, 7 to 15 percent slopes	Pl	57	Well drained	Very low to moderately low	Low	More than 80 in
Maginnis channery clay loam, 15 to 35 percent slopes	Mc	28	Well drained	Very low to moderately high	Very low	More than 80 in
Danvers silty clay loam, 2 to 4 percent slopes	Da	7	Well drained	Moderately low to moderately high	High	More than 80 in

Source: USDA NRCS 2013

Study Area Geology

Geologists conducted initial geotechnical investigations of the proposed expansion area to determine feasibility of expansion alternatives. A full description of geotechnical methodologies and results can be found in the *Report of Geotechnical Investigation* Technical Report (Tetra Tech 2013) and the *Billings*

Regional Landfill Facility Expansion Feasibility Study (Great West 2013b). Pertinent information is summarized below to provide a more detailed description of the expansion area.

Two geological units are exposed within the proposed landfill expansion property: The Belle Fourche unit and the Quaternary-aged (Pleistocene) deposit. The Belle Fourche shale underlies the entire site, either at the surface or near the surface. The unit is a fine-grained sedimentary rock of upper Cretaceous age. The unit is thinly-laminated, dark bluish-gray, and consists almost entirely of silt- and clay-sized particles. The Quaternary-aged (Pleistocene) deposit consists of silt, sand and gravel that underlie the center of the easternmost part of the property; it is expressed as a flat, non-eroded prairie and is obvious on the land east of the City property.

Geologists identified several faults within the landfill expansion property. One fault lies within a few hundred feet of the southeastern extreme of the property; about one-quarter mile further to the southeast is another normal fault. The far northern extreme of the proposed landfill site is transected by a northwest-trending normal fault. None of the faults in the area are active and the proposed facility does not lie within any seismic impact zones.

Field exploration and test borings were completed in March and April 2013. Eight test borings were completed ranging from 17 to 300 feet using a tracked drilling rig with auger and core capabilities. In addition, 17 shallower test excavations using a backhoe were completed. All four of the deeper holes reflected a change in the character of the rock at 35 to 45 feet. Above that level slightly degraded structure, iron stains, and secondary mineral fracture fillings provide evidence that water has penetrated the shale; below that level the rock is intact, resistant, and shows no evidence of water infiltration.

Water Quality, Quantity, and Distribution

All landfills are required to obtain coverage under the Montana Pollution Discharge Elimination System Permit (MPDES). The State of Montana gained delegation of the MPDES Permit Program from EPA by demonstrating that the state would maintain a permit program that is at least as stringent as the Federal requirements. The existing landfill has coverage under the MPDES General Permit for Industrial Activity No. MTR 000380. Since the new landfill area will have a separate discharge location, it will require its own Industrial Storm Water Permit.

The new landfill design incorporates perimeter ditches and berms to divert any run-on from entering any waste area. There is also a run-on ditch located in the existing drainage (Stream 1) between the two halves of the landfill development. These perimeter ditches provide effective run-on and run-off control for the active area. All run-off collected from the landfill area is directed to one of two water detention ponds. The detention ponds are designed to detain the total volume of water from the 25-year, 24-hour storm event in accordance with State and Federal requirements. The City staff will be responsible for maintenance of all on-site drainage structures and ditches. Maintenance will include the implementation of Best Management Practices (BMPs) to control erosion and sediment transport. The new landfill will operate and maintain the detention ponds and ditches in accordance with the Surface Water Pollution Prevention Plan (SWPPP) and General Industrial MPDES Permit.

Surface Water

Surface water and hydrographical features within the landfill expansion area are described in greater detail within the Wetlands and Water Bodies section.

Groundwater

Groundwater occurred in at least two of the four deeper borings and monitoring wells were established at these two sites. In general, the lower depths of the weathered Belle Fourche, perhaps as deep as 45 feet below ground surface, appear capable of transmitting small quantities of groundwater. Groundwater also migrates on top of thicker bentonite beds. Based on the lack of consistency in the occurrence of groundwater, the generally shallow depths at which it was conclusively detected and apparently low yields of the water-bearing formations, the hydrogeological regime consists of locally-recharged perched aquifers. Conditions documented during the geotechnical analyses lend support to the assertion that groundwater is not contiguous, is locally recharged, and occurs as isolated, perched water-bearing zones. Again, those conditions dominate the existing landfill, which is immediately adjacent to the proposed expansion area.

Nearby Groundwater Supply Wells

Based on a review of the Montana Bureau of Mines and Geology (MBMG) database of existing water supply wells, there are 13 monitoring wells located on the City property (MBMG 2013). Two wells are located on the landfill expansion area and 11 are located on adjacent City-owned land. Of the two wells located within the landfill expansion area, well depths range from 45 to 53 feet. The static water levels ranges between 42.3 to 45.85 feet. There are numerous other wells located nearby. Including the wells located on adjacent City property, there are a total of 73 wells located within a one-mile search radius from the landfill expansion area. According to the MBMG database, these wells are completed at depths from 0 to 110 feet below ground surface and have static water levels between 0 and 45.85 feet. The majority of those wells encountered groundwater in the alluvial deposits associated with the Yellowstone River. A full accounting of the groundwater conditions is presented in the *Billings Regional Landfill Expansion Feasibility Study*, which was conducted as part of the environmental evaluation of the proposed landfill site.

Air Quality

In general, landfills contribute to air quality degradation due to increased levels of dust from landfill traffic, site construction, and ongoing maintenance activities. Short-term temporary increases in airborne dust and particulate matter may be experienced as additional traffic along Hillcrest Road is required to construct the landfill. Air quality impacts due to general operations are anticipated to be no more significant than what is currently experienced with the existing landfill. During construction and periods of dry conditions, dust suppression methods such as watering the haul roads will effectively reduce air quality impacts. Because the construction of the proposed facility would be temporary and short-term, the overall effects to air quality are anticipated to be minor.

Per requirements of the Montana Solid Waste Management Act and the Montana Administrative Rule ARM 17.50.1107, the proposed facility would be required to comply with all applicable air quality criteria developed under a State Implementation Plan (SIP) promulgated by the EPA Regional Administrator pursuant to section 110 of the Clean Air Act, as amended, or any other applicable air quality requirements.

Billings Air Quality Monitoring Sites

According to the DEQ, the City of Billings has two air quality monitoring sites: one located along Coburn Road, called Billings-Coburn, and one downtown at the corner of 2nd Avenue North and North 32nd Street, called Billings-St Luke's (DEQ 2013a). The Billings-Coburn Road site is a neighborhood scale historical SO2 monitoring site located at higher elevations south of the Conoco and Exxon refineries, approximately 5.5 miles away from the landfill expansion study area. It has been operational for the last three decades and exists to monitor compliance with the federal and state SO2 ambient air standards. The Billings-St Luke's site monitors carbon monoxide (CO) on a microscale basis and is located approximately 4.0 miles away from the study area. The site was installed to demonstrate compliance with the CO NAAQS in the Billings non-attainment area. In 2008, the City began continuous PM2.5 monitoring to support daily informational website publication as well for public health protection plans during periods of poor air quality.

Billings Air Quality Background

The EPA requires each state to establish a network of monitors to measure concentrations of the air quality criteria pollutants[2] based upon population, regional air quality, and regulatory concerns (DEQ 2012a). The City of Billings is one of three Metropolitan Statistical Areas (MSAs) in Montana[3] for which certain monitoring requirements are mandated by the EPA. Of the six criteria pollutants regulated, Billings has only historically (pre-1990) exceeded air quality standards for CO.

The Montana Community Designation Status (refer to 40 CFR 81.327) was reviewed to determine the air quality nonattainment status for the City of Billings. According to the attainment status designation table, the study area falls within an attainment area as designated on April 22, 2002 (DEQ 2013b).

In 2002, the EPA approved a change in the legal designation of the Billings area from "not classified" nonattainment for CO to a limited maintenance plan attainment area, and approved the maintenance plan that was designed to keep the area in attainment for CO for the next 10 years (City of Billings 2009). In 2010, the City submitted a revised maintenance plan that provides for maintenance of the CO standards for an additional 10 years. Provided Billings does not exceed the 8-hour standard of 9.0 ppm more than once per calendar year during the next 20 years, it can then request full attainment status.

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[2] The six criteria pollutants are: carbon monoxide (CO), sulfur dioxide (SO2), lead (Pb), nitrogen dioxide (NO2), ozone (O3), and particulate matter (PM). PM includes two sizes of particles, those with an aerodynamic diameter of 10 microns and less (PM10), and particles with an aerodynamic diameter of 2.5 microns and less (PM2.5).

[3] A MSA must contain an urbanized area of 50,000 or more population. Missoula and Great Falls are the other two MSAs in Montana.

DEQ and the local City-County Health Department continue to monitor and analyze CO levels in Billings to help demonstrate ongoing compliance with the CO standards.

Demands on Environmental Resources or Land, Water, Air, or Energy

The primary energy demand required for the proposed landfill expansion would be the ongoing landfill operations of transporting waste to the facility. To a lesser extent, energy demands would be required for operations relating to excavation and construction of new cells, and the compaction, covering, and other routine landfill activities. During construction of the new facility, there would be a higher than normal energy demand; however, this would be a short-term temporary expenditure lasting no more than a couple construction seasons. The continuation of landfill operations on the expansion area would result in similar activities and energy demands to what currently occurs at the existing landfill. For this reason, it is anticipated that no additional impacts would occur.

Terrestrial, Avian, and Aquatic Life and Habitats

The landfill expansion study area consists of an upland plain dissected by a large secondary drainage (Stream 1) that discharges to Blue Creek, a tributary of the Yellowstone River. The study area is currently used for cattle grazing and horse pasture and is sparsely vegetated with grasses, cactus, and sage. In the vicinity of the study area, there are similar large tracts of open space adjacent the City property and sparse rural development. Due to the abundance of adjacent open space, there is adequate acreage of suitable habitat available for populations of grazing large game, terrestrial predators, avian species, and burrowing small animals that may be displaced by the proposed landfill expansion

Wetlands and Water Bodies

A wetland and stream delineation of the landfill expansion area was conducted in October 2012. The field investigation identified 14 wetlands with a cumulative area of 2.41 acres in the study area. Wetlands were distinguished from adjoining uplands by the presence of indicators for wetland hydrology, hydric soils, and hydrophytic vegetation. Figure 3.2 shows an overview of the wetlands and water bodies in the study area. For more information on the methodology and results, refer to the *Wetland and Stream Delineation Technical Report* (HDR 2013). With the exception of Wetlands 5 and 6, all wetlands identified in the study area adjoin Stream 1, the large second-order drainage that discharges to Blue Creek. Table 3.3 summarizes the size, hydrogeomorphic (HGM) and Cowardin classification of the wetlands found within the study area.

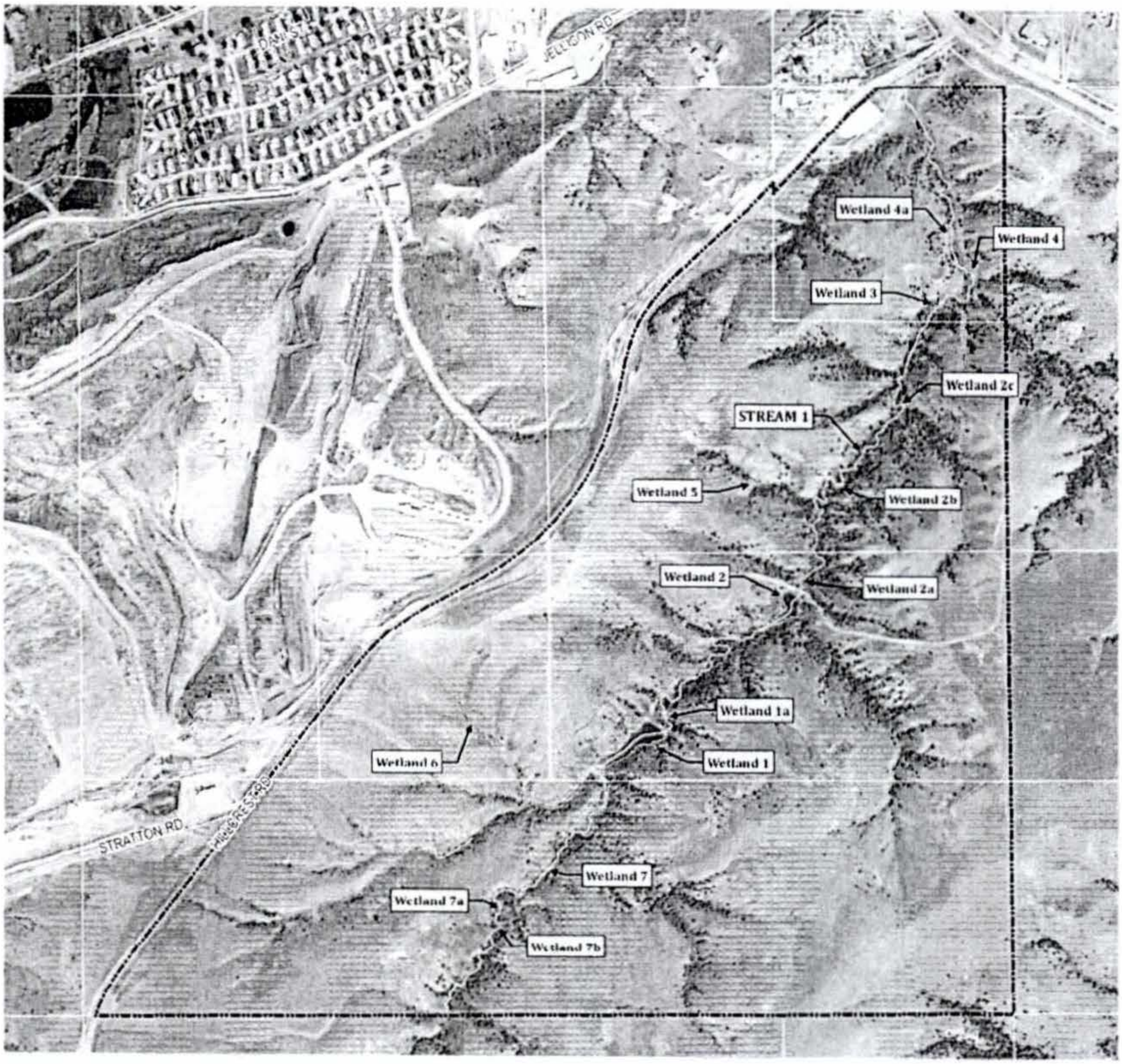

Figure 3.2. Wetlands Overview Map

Table 3.3. Summary of Wetlands in the Landfill Expansion Area

Wetland Name	Wetland area on Project Site	Hydrogeomorphic (HGM) Classification[a]	Cowardin Classification[b]
1	1.32 ac	Riverine	PEM1/PAB1
1a	0.02 ac	Riverine	PEM1
2	0.40 ac	Riverine	PEM1/PAB1
2a	0.03 ac	Riverine	PEM1
2b	0.02 ac	Riverine	PEM1
2c	0.02 ac	Riverine	PEM1
3	0.10 ac	Riverine	PEM1
4	0.05 ac	Riverine	PEM1
4a	0.03 ac	Riverine	PEM1
5	0.01 ac	Depressional	PEM1
6	0.30 ac	Slope	PEM1
7	0.09 ac	Riverine	PEM1
7a	0.01 ac	Riverine	PEM1
7b	0.01 ac	Riverine	PEM1
TOTAL AREA	**2.41 ac**		

The study area is located in the Blue Creek Watershed, located in the Upper Yellowstone-Lake Basin Watershed (USGS HUC 17010204) (USEPA 2012). Hydrographical features in the study area include a large second-order stream (Stream 1), which dissects the property, originating south of the study area boundary and flowing 1.5 miles north/northeast through the study area, finally discharging to Blue Creek through culverts under Blue Creek Road. The study area also contains 22 first-order seasonal drainages that discharge into Stream 1. None of the streams and drainages contained surface water flow in any part of the channel during the October 2012 field investigation. It is likely that, during springtime flows, aquatic habitat consists primarily of low-gradient riffles, with large, deep pools at the two impoundments associated with Wetlands 1 and 2. None of the streams and drainages are considered to support fish species (MFWP 2012).

Implementation of Alternative 4 would result in unavoidable impacts to wetlands. The wetlands and water bodies associated with the landfill expansion area are all located adjacent to Blue Creek and have a direct surface water connection to the creek, which discharges into the Yellowstone River. The US Army Corps of Engineers (USACE) has designated the Yellowstone River as a Traditional Navigable Water, or TNW. Therefore, all wetlands and water bodies within the landfill expansion study area are likely subject to jurisdiction under Section 404 of the Clean Water Act. The USACE is ultimately responsible for all jurisdictional determinations.

In accordance with ARM 17.50.1005, a new landfill unit, or a lateral expansion of an existing landfill unit, may not be located in wetlands, unless the owner/applicant can clearly demonstrate to DEQ that a practicable alternative to the proposed action that does not involve wetlands is unavailable. If no practicable alternative exists to the proposed action, then pursuant to 33 USC 1344 (Section 404 of the Federal Clean Water Act, as amended) or applicable Montana wetlands laws, the owner/applicant must offset remaining unavoidable wetland impacts through compensatory mitigation.

In 2008, EPA 40 CFR 230 and USACE 33 CFR 332 published a final rule that addresses compensatory mitigation for unavoidable losses of aquatic resources. As a result, compensatory mitigation is expected to be required for most projects involving wetland impacts. Permitting conditions and final mitigation ratios, if applicable, would be negotiated with the USACE during the Section 404 permitting process.

Considerations for Permitting and Compensatory Mitigation

The proposed landfill expansion would impact 2.41 acres of wetland. The minimum wetland mitigation requirement would be a 1:1 ratio to achieve 2.41 acres of wetland, or 2.41 mitigation credits. However, mitigation could require at least a 2:1 ratio, depending on project timing and whether or not mitigation wetlands are likely to provide the same or better quality of habitat. Actual mitigation requirements will be determined prior to 404 permitting in a Wetland Mitigation Plan. The wetland delineation report identified other potentially jurisdictional waterbodies, including Stream 1, a seasonal tributary to Blue Creek, and several ephemeral tributaries to Stream 1. While similar projects in the past have not required stream mitigation, the possibility of stream mitigation requirements should be kept in mind due to new regulatory requirements. The construction for the expansion will be considered one project, so all impacted wetlands and jurisdictional water bodies would require mitigation even if construction is completed in phases and only disturbs a portion of the waterbodies at any given time. Additional mitigation credits will be required if mitigation is not completed before construction. Any additional investigations or data collection will be defined in the future during the permitting process.

A number of options currently exist for compensatory wetland and stream mitigation. While the options and agency preferences may change in the coming years, the following list encompasses the primary options available:

- Buy into existing wetland mitigation bank;
- Pay into in-lieu fee program prior to anticipated impacts;
- Pay into in-lieu fee program at time of permitting and anticipated impacts;
- Create mitigation bank for City of Billings prior to anticipated impacts on existing City property or purchased property to have mitigation wetlands in place before permitting and anticipated impacts to minimize required credits;
- Create mitigation bank for City of Billings at time of permitting and create additional wetland to fulfill additional required credits because mitigation follows impact;
- Contract off-site wetland creation and/or restoration before anticipated impact or additional acreage after impact;

- Create wetland on-site at downstream end of intermittent stream/run-on ditch in lower-lying areas for partial mitigation, combined with one of the above strategies to fulfill any remaining mitigation credit requirements; or
- Create wetland on-site at downstream end of intermittent stream/run-on ditch, excavating a greater volume of soil as needed to create wetland acreage sufficient to create all required mitigation credits; some stream mitigation off-site could still be required.

Vegetation Cover, Quantity, and Quality

According to the Montana Natural Heritage Program (MNHP) land cover atlas maps the upland plains in the study area are identified as Big Sagebrush Steppe and Great Plains Mixedgrass Prairie (MNHP 2013). Predominant species in these areas include Wyoming and basin big sagebrush (*Artemisia tridentata* ssp. *wyomingensis*, *Artemisia tridentata* ssp. *tridentata*). Grazed areas are dominated by exotics such as Kentucky bluegrass (*Poa pratensis*), smooth brome (*Bromus inermis*), and Japanese brome (*Bromus japonicus*), as well as western wheatgrass (*Pascopyrum smithii*) and crested wheatgrass (*Agropyron cristatum*). Portions of Stream 1 and the tertiary drainages are mapped as Great Plains Ponderosa Pine Woodland and Savanna, and Great Plains Wooded Draw and Ravine, and Great Plains Riparian site types. Dominant species in these land cover types include narrowleaf cottonwood (*Populus angustifolia*) and Plains cottonwood (*Populus deltoides*) in floodplains, Rocky Mountain juniper (*Juniperus scopulorum*) in the draws and ravines, and ponderosa pine (*Pinus ponderosa*) near the uphill extent of the drainages.

In accordance with ARM 17.50.530, the landfill closure requirements and design criteria, the final cover system for the proposed facility will include a water-balance cover similar to those approved at the existing facility. That design includes a thickness of naturally-occurring soils with a compost-soil surface layer. The system is designed to store a volume of water equivalent to the highest single precipitation total on record, allowing that moisture to be released to the atmosphere via evapotranspiration processes facilitated by the reestablishment of a native plant community atop the engineered cover. That cover would be subject to the alternative cover demonstration process delineated by the Montana Department of Environmental Quality. The closure plans would require the final cover to be revegetated with native species within one year of placement of the final cover. The DEQ may also approve alternative revegetation plans and sequencing. Post closure of the proposed landfill, revegetation and plant succession will make the area suitable once again for wildlife habitat and livestock grazing.

Unique, Endangered, Fragile or Limited Environmental Resources

The MNHP was accessed on March 6, 2013 to determine what threatened and endangered (T&E) species and species of concern for the State of Montana exist in Section 29, T1S, R26E, in Yellowstone County. According to the MNHP, three species of concern have been documented within Section 29. Table 3.4 provides a list of the species of concern that may occur in the vicinity of the landfill expansion study area.

Table 3.4 Montana Natural Heritage Program's Species of Concern Potentially Occurring within Section 29

COMMON NAME	SCIENTIFIC NAME
Milksnake	*Lampropeltis triangulum*
Western Hog-nosed Snake	*Heterodon nasicus*
Spotted Bat	*Euderma maculatum*

Source: MT Natural Heritage Program, 2013

According to data received from MNHP, no plant species of concern were documented within Section 29, T1S, R26E, in Yellowstone County.

The U.S. Fish and Wildlife Service (USFWS) Threatened and Endangered Species Program website was searched on April 18, 2013 to determine if any threatened and endangered species (T&E) and/or critical habitat are located within or near the study area. Table 3.5 lists the USFWS results for T&E species occurring within Yellowstone County, Montana. Of the species identified, the Whooping Crane and Black-footed ferret are considered "endangered," the Greater sage grouse and Sprague's pipit are considered "candidate" species, and the Gray wolf has the status of "recovery." Note that the USFWS T&E database search provides results at the county level; actual frequency of each species' presence within the study area is unknown.

Table 3.5. Threatened and Endangered Species Occurring in Yellowstone County, MT

GROUP	COMMON NAME	SCIENTIFIC NAME	STATUS
Bird	Whooping Crane	*Grus americana*	Endangered
	Greater sage grouse	*Centrocercus urophasianus*	Candidate
	Sprague's pipit	*Anthus spragueii*	Candidate
Mammal	Black-footed ferret	*Mustela nigripes*	Endangered
	Gray wolf	*Canis lupus*	Recovery

Source: USFWS, 2013

The landfill expansion area does not have any documented occurrences of critical habitat. The existing vegetation types are neither unique nor limited in quantity, especially considering the abundance of similar land cover adjacent the study area.

No effect on any threatened, endangered, proposed, candidate or sensitive species area is anticipated to occur due to the proposed project. Considering the abundance of available habitat within proximity to the study area, the impact resulting from construction of the project would have a negligible effect to wildlife.

Historical and Archaeological Sites

A Class III cultural resources inventory of the landfill expansion area was conducted by Ethnoscience, Inc. to investigate and document the presence of any significant cultural resources and provide preliminary National Register of Historic Places (NRHP) eligibility evaluations of sites located with the study area. A pedestrian survey (field investigation) was conducted of the entire study area on October 8, 2012. Additionally, the State Historic Preservation Office (SHPO) was contacted to obtain all relevant files, survey reports, and site records. From the records search, no existing historical or archaeological sites were identified within the study area. Due to the proximity to the existing landfill, other miscellaneous pieces of cans, glass, and debris of undetermined age were visible but were not recorded.

The field investigation resulted in identification of one site and one isolate, which were documented on the appropriate state forms (Ethnoscience 2012). Site 24YL1868 is a historic cultural material scatter located on the spine and slope of a ridge that overlooks a secondary drainage, approximately in the center of the study area (see Figure 3.3). The site consists of glass shards of various colors, a ceramic bowl shard, two pull tabs, a bird cage, numerous asphalt and wood boards associated with a roof, and the engine hood of a circa 1940s Ford vehicle. It was determined that this site was likely a local secondary trash dump. All materials appear on the surface and it is unlikely that a significant buried component exists at the site. The isolate (see HDRIF-1 on Figure 3.3) consists of the remains of a 1940s era vehicle and a pull-tab beer can located at the bottom of a very steep drainage near the road to the current landfill. Neither the one site nor the one isolate find are recommended NRHP eligible as they lack sufficient qualities to be considered significant. The proposed project was determined as having no adverse effect upon significant cultural resources.

Figure 3.3. Cultural Resource Survey Results

Hazardous Waste and Sites

The DEQ Remediation Division, Permitting and Compliance Division (Waste and Underground Tank Management Bureau), Petroleum Tank Release Compensation Board (PTRCB) and the Montana State Library, Natural Resource Information System (NRIS) cooperatively provide database information regarding the following:

- Active and Inactive Regulated Underground Storage Tank sites;
- Abandoned/Inactive Mine sites;
- Active and Inactive Leaking Underground Storage Tank sites;
- State and Federal Superfund sites (including CERCLA, CECRA, WQA, ACGP, CALA, VCRA, and Brownfields), and;
- Petroleum Tank Release Compensation Board sites.

The online database was searched on April 18th, 2013 to investigate the presence of any hazardous materials within or near the study area. Database results were provided initially for the entire Yellowstone County. The sites were then narrowed down to include only sites within an approximate one-mile search radius from the landfill expansion study area. Results for sites located near the study area are listed in Table 3.6.

Table 3.6. Hazardous Waste Sites Located Near the Study Area

SITE NAME	ADDRESS	FACILITY ID	ACTIVE	PRIORITY RANKING	LOCATED IN T1S R26E SECTION 29?
BLUE BASKET FOOD MARKET 1 #946	2007 BLUE CREEK RD	5606595	YES	5.0 - Pending Closure	NO
CASEYS CORNER #7 #4924	2007 BLUE CREEK RD	5606595	YES	1.4 - High Priority Characterization	NO
CITY LANDFILL #3372	5240 JELLISON RD	5609744	YES	5.0 - Pending Closure	NO

Source: MT Department of Environmental Quality, 2013

A review of NRIS databases for LUSTs, Petroleum Tank Release Compensation Sites, and Remediation Response Sites found no record of hazardous materials or contamination within the study area (DEQ 2013c). The EPA CERCLIS Public Access Database site was also searched and found no listed sites within or near our study area.

Aesthetics

The proposed landfill expansion will likely have only minor impacts on aesthetics. The landfill expansion site is immediately adjacent the existing landfill which is an existing feature on the landscape. The proposed landfill expansion area is currently used for livestock grazing, which has impacted vegetation and eroded soils in the more heavily grazed areas. Portions of the proposed landfill expansion would be visible from Hillcrest Road and Stratton Road. The visual impacts would likely be limited to vehicular traffic or occasional cyclists traveling immediately next to the facility. The landfill expansion area would be less visible from the more heavily traveled Blue Creek Road because the expansion area is shielded by taller topography next to the road. The landscape affected by the proposed landfill expansion is not regionally or locally unique as large expanses of similar land cover exist in the immediate vicinity. In general, visual impacts resulting from the landfill expansion will not be permanent and will occur for only as long as the facility or each particular phase is in operation. As areas are capped, closed, and re-vegetated at the landfill, the aesthetics will gradually improve in those locations as operations are completed.

3.2 Potential Impacts on the Human Environment

This section analyzes the potential effects that may occur on the human environment due to implementation of the proposed action, Alternative 4. The resources listed in Table 3.7 are described in greater detail in the following sections. Generally, only those resources potentially affected by the proposed action are discussed in greater detail. If there is no effect on a resource or the resource is not present within the study area, it is noted in the respective section and not analyzed any further.

ACTS ON THE HUMAN ENVIRONMENT

UMAN ENVIRONMENT	Major	Moderate	Minor	No	Unknown
ES: Is some disruption of native or traditional lifestyles or				X	
/ERSITY: Will the action cause a shift in some unique				X	
POPULATION & HOUSING: Will the project add to the housing?				X	
'ill this project add to health and safety risks in the area?				X	
:OME: Will the facility generate or degrade income?				X	
EMPLOYMENT: Will the project create, move or eliminate			X		
				NA*	
VENUES: Will the project create or eliminate tax revenue?			X		
SERVICES: Will substantial traffic be added to existing			X		
tion, police, schools, etc.) be needed?				X	
AGRICULTURAL ACTIVITIES & PRODUCTION: Will the ties?			X		
CREATIONAL & WILDERNESS ACTIVITIES: Are ocated nearby or accessed through this tract?				X	
within the tract?				X	
MENTAL PLANS & GOALS: Are there state, county, city, management plans in effect?				X	
oject affect local transportation networks and traffic flows?			X		

porary construction jobs during construction of the project

Social Structures and Mores

The proposed project will have no impact to native or traditional lifestyles or communities because these communities do not exist in the proposed landfill expansion study area.

Cultural Uniqueness and Diversity

The proposed project will have no impact to or affect any unique quality or culturally unique or diverse area within the vicinity of the project. Refer to the Historical and Archeological Sites section for more information on cultural resources within the study area.

Density and Distribution of Population and Housing

The proposed landfill expansion project would not result in an increase of population or require the need for additional housing.

Human Health and Safety

Impacts to human health and safety under the proposed alternative would not increase from existing conditions. Potential impacts resulting from the proposed project may include dust and debris transport from operations, the potential for disease transmission from animal and/or insect vectors, or potential for water contamination from storm water runoff. There are no close residents downwind or adjacent the proposed facility. The proposed landfill expansion would be designed and operated in accordance with the Montana Solid Waste Management Act and the Montana Administrative Rule ARM Title 17, Chapter 50 which provides the requirements for siting, construction, operation, and monitoring of solid waste facilities. There are no impacts to human health and safety anticipated by the proposed landfill expansion project.

Community and Personal Income

The proposed landfill expansion project would have no effect on community or personal income levels. Development of the landfill expansion site would have no impact on waste disposal costs.

Quantity and Distribution of Employment

The proposed project would have no long-term effect on the quantity and distribution of employment in the region. There would likely be a short-term increase on local employment during the construction phase of the project due to the need for contractors. The long-term requirement for operations and maintenance are expected to similar to existing conditions.

Local and State Tax Base Revenues

The short-term influx in local employment during the construction phase of the project would result in a minor beneficial impact to the local tax base. No long-term impacts, either positive or negative, are anticipated.

Demand for Government Services

The potential impact that the proposed landfill expansion facility licensure will have on the demand for government services will be minor. State personnel within the Montana Department of Environmental Quality (DEQ) will be required to review the proposal and licensing of the landfill, as well as periodic site visits during implementation. Ongoing city services and equipment operations and maintenance required for the proposed facility will be no different than what is currently required for the existing landfill. During the construction phase, there would be a temporary increase in traffic on the roads leading to the facility; however, the impact is expected to be minor to roadway infrastructure or traffic enforcement. There will be a significant shift of traffic volume from Jellison Road to Hillcrest Road with the permitting of the new landfill. Improvements proposed to mitigate these impacts are discussed in more detail within the Transportation section below.

Industrial, Commercial, and Agricultural Activities and Production

Construction of the proposed facility will result in a minor increase in industrial activity due to the need for construction contractors, additional machinery, and associated materials. The area surrounding the proposed landfill expansion area is sparsely populated and the housing that is nearest the existing facility has long been accustomed to the noise associated with landfill operations. No noise sensitive receptors are located near the study area and therefore noise impacts from construction activities are expected to be minor.

Part of the study area is zoned Agricultural Open (see Land Use and Zoning below). Current agricultural activities within the study area are limited to cattle grazing, which produces nominal income for the City. The loss of the study area for this use is not expected to affect the City negatively. Additionally, ample open space exists near the study area for future cattle grazing opportunities.

Access to and Quality of Recreational and Wilderness Activities

The proposed landfill expansion will not affect access to or quality of any wilderness or recreational areas. The City of Billings has a diverse array of trails and recreational areas; however, these recreational resources are concentrated within city limits and north of the Yellowstone River, and are not in proximity to the study area.

Locally Adopted Environmental Plans and Goals

The proposed project has not been identified as conflicting or inconsistent with any locally adopted environmental plans or goals. No impacts are anticipated.

Land Use and Zoning

The proposed landfill expansion area is located on approximately 350 acres of land owned by the City of Billings. The existing landfill and expansion area is located outside of the Billings city limits. The majority of the expansion area is zoned Agricultural Open, or A1. A portion of the expansion area that is nearest Hillcrest Road, including the existing landfill, is zoned Public, or P (Yellowstone County 2013). The area is currently used for livestock grazing and horse pasture and is primarily vacant open space. Located in the very northern portion of the study area, near the Hillcrest Road/Blue Creek Road intersection, are a corral, watering tanks, and a stockpile of pipes. There is also a power substation located along Hillcrest Road. Within the landfill expansion area, the City has two separate parcels that allow grazing activities, each of which generates $300/year in revenue. The City would lose this revenue for several decades if the land use was converted to a landfill.

Transportation

Existing Transportation

Access to the existing landfill is provided by Jellison Road from South Billings Boulevard /Blue Creek Road. South Billings Boulevard, which turns into Blue Creek Road, has an interchange on Interstate 90 and provides good access to the landfill entrance. The existing primary route for vehicles arriving at the landfill is to travel south on Blue Creek Road then turn west onto Jellison Road. The right turn movement at this intersection utilizes a dedicated right turn lane. The landfill entrance is located approximately 0.7 miles along Jellison Road to the south. South Billings Boulevard has an interchange on Interstate 90 which provides good access to the landfill entrance. Hillcrest Road is located between the existing landfill and the expansion area.

Peak hour traffic analysis was conducted at the intersection of Blue Creek Road and Jellison Road from 7:30 am to 9:30 am. The analysis found that the eastbound movement operates at Level of Service (LOS) B, while the other intersection movements operate at a LOS A. Based on the LOS analysis, it was determined that directing traffic from Jellison Road to Hillcrest Road as required under Alternative 4 is not anticipated to significantly impact these intersections.

Roadway Improvements under Alternative 4

Field and topographical map reconnaissance surveys were conducted to determine potential alternate routes to accommodate expansion of the landfill south across Hillcrest Road while still providing acceptable levels of service. Hillcrest Road is a County collector road that serves residential and ranching properties to the south of Blue Creek Road. An electrical substation, overhead power, buried telephone lines, gas mains, and a commercial property are located along Hillcrest Road. Existing curve data and the roadway function were used to determine a design speed of 45 mph. This design speed is used for all roadway alternatives.

During development of the landfill expansion alternatives, three separate road improvement alternatives have been considered:

- Roadway Alternative 1: Reconstruction of Hillcrest Road
- Roadway Alternative 2: Reroute of Hillcrest Road to perimeter of expansion area
- Roadway Alternative 3: Reroute of Hillcrest Road to Collier Road

A detailed description of these 3 roadway alternatives can be found in Chapter 11 of the *Solid Waste Alternatives Analysis Final Report* (City of Billings 2013). Of the 3 scenarios developed, Roadway Alternative 1 was selected as part of Alternative 4. Roadway Alternative 1 is described below.

Roadway Scenario 1: Reconstruction of Hillcrest Road

This alternative will maintain the existing horizontal alignment, but will improve the typical section to include two foot shoulders as well as improving the cut/fill slopes to meet existing County Road standards. The intersection of Hillcrest Road and Blue Creek Road does not provide adequate grades or sight distances. This alternative includes the construction of an approach landing along Hillcrest Road to meet MDT standards resulting in an approximate ten foot cut adjacent to the substation. This cut creates the need for a retaining wall separating the lowered Hillcrest Road from the substation to minimize impacts. Utility relocation will be required.

The alternative includes reconstruction of approximately 1100 feet of Blue Creek Road to improve the intersection sight distance to meet minimum MDT requirements.

The right turn lane found at the intersection of Blue Creek and Jellison does not appear to be warranted based on traffic count data alone, but is likely there due to accident data. During the field reconnaissance, a crash occurred that was caused by a north turning vehicle on Jellison unable to see north on Blue Creek due to the presence of a large commercial vehicle. An addition of a dedicated right turn lane from Blue Creek Road to Hillcrest Road is recommended due to type of vehicles utilizing the landfill.

Alternative 4 includes an on-grade crossing of landfill traffic at Hillcrest Road. A signalized intersection is recommended at this location. The estimated cost of this roadway alternative is $5.3 million in 2012 dollars. Property acquisition will be required on the eastern end of Hillcrest Road on the north side of the road.

Figures 3.4, 3.5, and 3.6 illustrate the three roadway alternatives and provide additional information for the reconstruction of Hillcrest Rd.

Utilities

There are existing utilities located in the landfill expansion area which will affect the overall cost of the landfill expansion project. There is an overhead power line and underground telephone line running along Hillcrest Road. Also located along Hillcrest Road is an unknown diameter underground gas line owned by Montana-Dakota Utilities Company. Portions of these utilities will be required to be relocated for Alternative 4. Additionally, a large overhead power transmission line runs through the expansion area owned by Northwestern Energy.

Figure 3.4

Figure 3.5

Figure 3.6

Section 4.0 References

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APPENDIX B

ARM 17.50.1204, Table 1
Groundwater Protection Standards

ARM 17.50.1204 - Table 1
Groundwater Protection Standards

Chemical	MCL (mg/l)	Chemical	MCL (mg/l)
Arsenic	0,05	Lindane	0.004
Barium	1.0	Lead	0.05
Benzene	0.005	Mercury	0.002
Cadmium	0.01	Methoxychlor	0.1
Carbon tetrachloride	0.005	Nitrate	10
Chromium (hexavalent)	0.05	Selenium	0.01
2,4-Dichlorophenoxy acetic acid	0.1	Silver	0.05
1,4-Dichlorobenzene	0.075	Toxaphene	0.005
1,2-Dichloroethane	0.005	1,1,1-Trichloromethane	0.2
1,1-Dichloroethylene	0.007	Trichloroethylene	0.005
Endrin	0.0002	2,4,5-Trichlorophenoxy acetic acid	0.01
Fluoride	4	Vinyl Chloride	0.002

APPENDIX C

Alternative Liner Demonstration
Phase 5 Billings Regional Landfill

(Prepared by Great West Engineering for the City of Billings)

ORIGINAL

ALTERNATIVE LINER DEMONSTRATION

Phase 5 Billings Regional Landfill

Prepared for:
City of Billings

Prepared by:
Great West engineering

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Introduction

Purpose and Scope

This document is intended to demonstrate that a proposed Phase 5 liner design for the Billings Regional Landfill, municipal solid waste license #113, meets the Design Criteria defined in Montana ARM 17.50.1204.

This investigation includes a review of hydrogeological and engineered site conditions, an evaluation of landfill leachate volume and chemistry, and an evaluation of the potential for leachate and landfill gas migration to affect the uppermost aquifer at the site. Previous studies of the facility include hydrogeological investigations, alternative liner demonstrations, alternative cover demonstrations, quality control/assurance documentation for both liners and covers, and semi-annual groundwater monitoring reports. This investigation includes information obtained from exploratory work conducted in February, 2012. That work included the drilling of three test borings and physical property analyses of 9 samples obtained via split-spoon sampler. The geotechnical report is included as Appendix A of this document.

Facility History

The Billings Regional Landfill is located at 5240 Jellison Road in the east ½ Section 29 and west ½ Section 30, Township 1 South, Range 26 East (Figure 1). It began accepting waste in about 1969, with an estimated annual waste acceptance of less than 45,000 tons. Steady population growth in the Billings area, along with the inclusion of additional towns and counties in the area, has resulted in an increase of waste disposal to the 227,700 tons accepted in 2011. With the advent of the revised solid waste regulations in 1994, more-highly engineered waste units have been designed and constructed at the facility. This also continued with the historical unlined waste areas (Phases 1 and 2) as they reached capacity. In 2007, the City began diverting Class IV waste from the main waste stream to a permitted area, and in 2008 they constructed a new lined cell in the Phase 3 area. Another new lined waste unit, Phase 4, was built in 2009. The facility operators previously received approval for an alternative liner for the Phases 3 and 4 expansions.

Site Characteristics

Climate

A summary of climatic data collected at the Billings airport is listed in Table 1. The complete daily records are available from the Desert Research Institute in Reno, Nevada. The annual average precipitation is 14.29 inches with a total average snowfall of 57 inches. The mean average daily high is 58.7 degrees Fahrenheit (F) and the mean daily low is 35.7 F.

Geology and Soils

The geology and soils are described in detail in Damschen & Associates (1991), EMCON (1996), and Tetra Tech (2007). The City of Billings landfill is located in dissected shale and bentonite deposits on the south side of the Yellowstone River, about five miles south of Billings, Montana. According to EMCON (1996), "The landfill is in a north-sloping drainage basin formerly occupied by ephemeral streams." These draws have been filled with municipal waste since the 1960s, and much of the existing waste lies atop unlined soil. Outcropping bedrock consists of Cretaceous-aged sedimentary rocks. EMCON (1996) reports that the facility and the area to the south are part of the Belle Fourche shale and the Greenhorn formation, which are dated to the upper Cretaceous. The Belle Fourche is described as dark grey, fissile, non-calcareous shale with interbedded bentonite beds that range from a few inches to several feet in thickness. This description fits the on-site exposures and well logs, although some reports describe the shale as claystone. The Tetra Tech (2007) report uses the term "claystone" throughout. Appendix A of this document has additional geological and soils information pertinent to the proposed waste unit.

Some localized landslide deposits and thin layers of colluvial soils are also present at the site (EMCON, 1996). These deposits have generally been excavated or covered during the deposition of municipal waste. Some of those younger deposits are still visible on the edges of the landfill.

A number of tests have been conducted by prior investigators, including laboratory-based evaluations of hydraulic conductivity and field tests of wells and piezometers. A summary of the laboratory assessments of hydraulic conductivity are included in Table 2, however the EMCON (1996) document from which some of the data are obtained does not include any analytical reports. The source of their summary values is not clear, but the data probably represent the results of all of the laboratory analyses and field investigations. It appears that only one sample of the bentonite was tested for hydraulic conductivity. Great West Engineering submitted an additional sample of the bentonite for analysis. EMCON/OWT, Inc. (2002) contains the hydraulic conductivity values of the colluvium (also referred to as "cover soil" and "CAH" in other publications) that was used as final cover for a portion of the Billings landfill. These soils were recompacted to 90 percent of standard Proctor moisture analysis and were analyzed by EMCON/OWT for permeability.

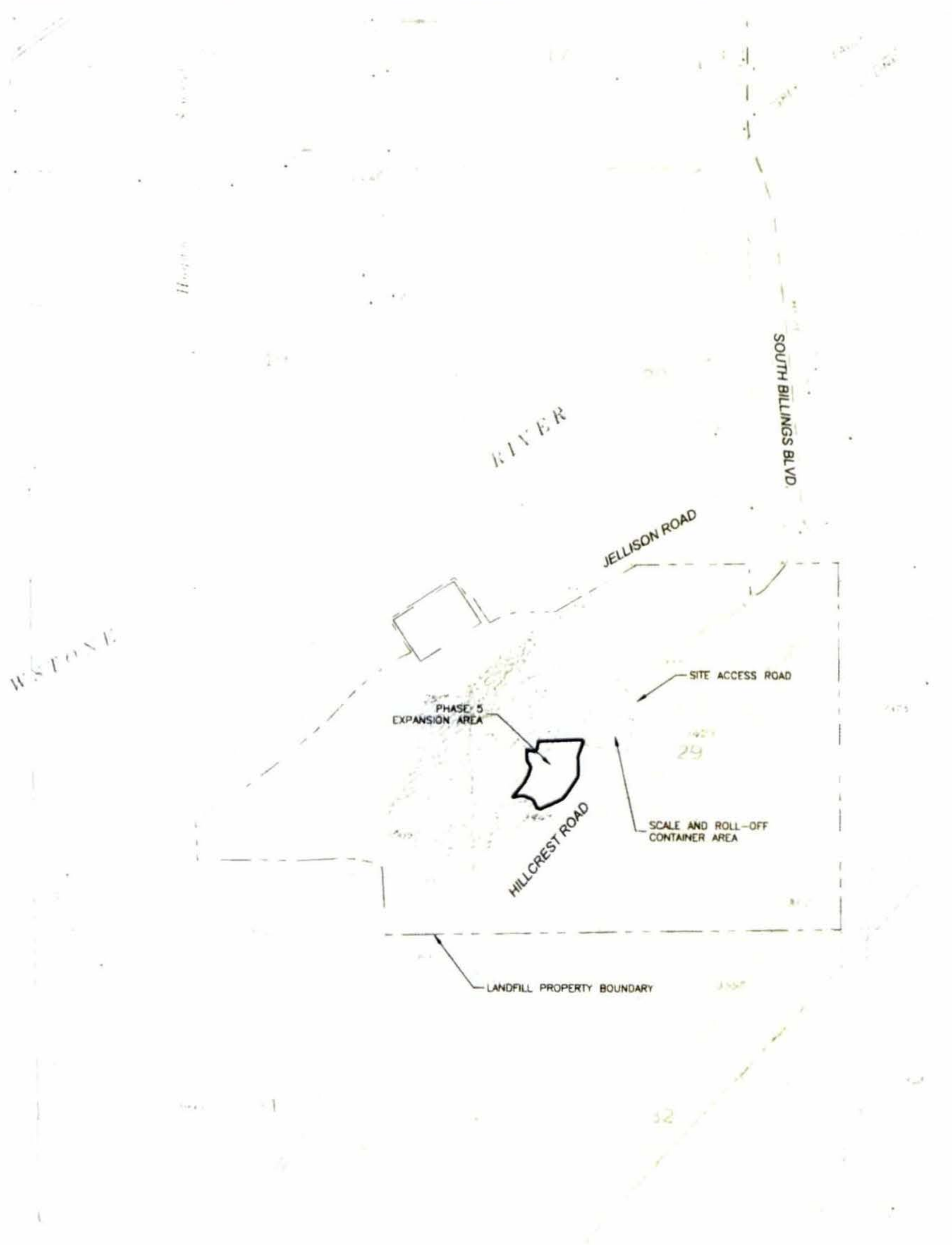

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Figure 1
Location Map

CITY OF BILLINGS SOLID WASTE DIVISION
ALTERNATIVE LINER DEMONSTRATION

Table 1 - Summary of climatic data from the Billings, Montana Airport

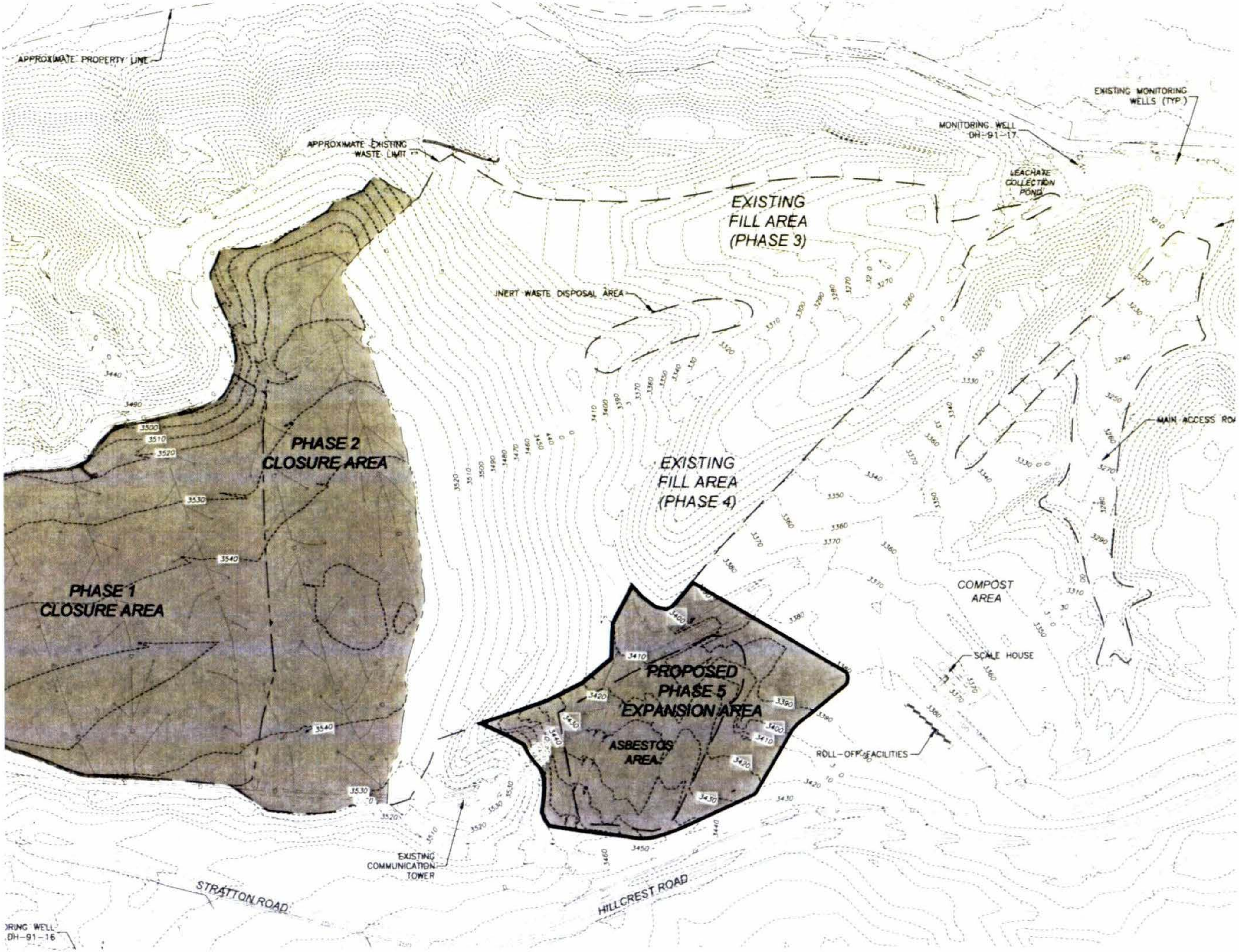
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Average Max. Temperature (F)	32.7	39	46	56.8	67.1	76.8	86.5	85.1	72.6	60.3	44.9	36	58.7
Average Min. Temperature (F)	14.2	19.5	25	34	43.4	51.7	58.3	56.8	47	37.3	26	18.2	35.9
Average Total Precipitation (in.)	0.74	0.61	1.07	1.8	2.26	2.08	1.1	0.85	1.28	1.14	0.72	0.64	14.29
Average Total SnowFall (in.)	9.8	7	9.8	8.9	1.7	0	0	0	1	4	6.5	8.3	57

Hydrogeology

Damschen & Associates (1991) and EMCON (1996) report the presence of three distinct hydrostratigraphic units at the Billings landfill. These are a shale bedrock unit, a colluvial unit, and an alluvial/landslide unit. The latter two are unconsolidated. Moisture migration in the shale bedrock unit is apparently controlled by fractures and bedding planes. The groundwater monitoring wells are located in shale, which probably belongs to the Cretaceous-aged Belle Fourche formation. The Greenhorn formation also occurs at the landfill, but overlies the Belle Fourche and its thickness at the facility has not been delineated. The colluvial and alluvial/landslide units host small quantities of locally-infiltrating water. The groundwater in these units tend to move laterally atop the shale bedrock unit, and, in places, infiltrates into that unit.

In general, recharge is thought to be local, with the shale bedrock unit being recharged in the low ridge on the south end of the landfill. Previous investigators have suggested that groundwater eventually discharges to the alluvial and fluvial deposits related to the Yellowstone River some 2,000 feet north of the facility. The groundwater flow in this unit appears to be toward the northeast with an estimated seepage velocity of 0.002 to 0.1 feet per day (ft/day), as reported by EMCON (1996). The horizontal flux through the unit was estimated presuming an average hydraulic conductivity of 0.1 ft/day, an average hydraulic gradient of 0.07. These calculations were based upon on-site slug tests, measured hydraulic gradients, literature values for porosity, and information provided in Reiten (1992). The EMCON report does not specifically reference the data used for these calculations, but appears to use low and high values to establish the ranges presented. Those previous investigators also suggest that the groundwater flow south of the Phase 1 and 2 areas is toward the south.

The most-recent investigation (Appendix A; Figure 2) did not reveal the presence of groundwater within 50 feet below the existing surface, to an elevation of approximately 3,320 feet MSL in the boring dubbed DH-1. Groundwater flow maps imply that groundwater should occur at an elevation of about 3,330 feet MSL. Likewise, boring DH-3 was completed to a depth to about 3,368 feet MSL, with groundwater being mapped at elevations between 3,400 and 3,450 feet MSL. Groundwater is mapped at an elevation of about 3,300 feet elevation near boring DH-2, which was drilled to a depth


APPROXIMATE PROPERTY LINE
APPROXIMATE EXISTING WASTE LIMIT
EXISTING MONITORING WELLS (TYP.)
MONITORING WELL DH-91-17
LEACHATE COLLECTION POND
EXISTING FILL AREA (PHASE 3)
INERT WASTE DISPOSAL AREA
MAIN ACCESS ROA
PHASE 2 CLOSURE AREA
EXISTING FILL AREA (PHASE 4)
PHASE 1 CLOSURE AREA
COMPOST AREA
SCALE HOUSE
PROPOSED PHASE 5 EXPANSION AREA
ASBESTOS AREA
ROLL-OFF FACILITIES
EXISTING COMMUNICATION TOWER
STRATTON ROAD
HILLCREST ROAD
ORING WELL DH-91-16

of about 3,310 feet MSL. It is possible that boring DH-2 did not achieve sufficient depth to encounter groundwater. However, borings DH-1 and -3 would have encountered groundwater if it occurred as the existing maps indicate. The nearest groundwater monitoring well (DH-91-16) is over 2,500 west-southwest of boring DH-3. The water level in that well is reported to be about 3,464 feet MSL.

If groundwater was contiguous across the site, some evidence of it should have been discovered in the 2012 site investigation. The subsurface consists of exclusively fine-grained material, most of which does not transmit water efficiently. Water could possibly move through fractures or bedding planes, but the recent drilling indicates that those structures are commonly filled with bentonite. It is highly unlikely that groundwater underlies the entire facility in anything resembling a contiguous aquifer. More likely, groundwater seeps through preferred pathways that are difficult to predict.

The existing information suggests that groundwater is contained within either locally-derived, unconsolidated deposits or the Belle Fourche shale. Even though the groundwater is presumed to have a local recharge source, the quality is very poor, owing to the nature of the water-bearing units. The results from groundwater monitoring at the facility include chloride values from 100 to nearly 1,000 milligrams per liter (mg/L), sulfate concentrations in excess of 13,000 mg/L, and specific conductance values approaching 20,000 micromhos per centimeter. If the value of the groundwater to humans is to be taken into consideration, then the potential for any application is very low.

Perhaps the most telling evidence for the argument against the presence of any viable groundwater resources is the paucity of wells in the Belle Fourche shale. There are dozens of residences off of Hillcrest Road, within two miles of the landfill, and none of them have wells. The only wells noted in the GWIC database are shallow ranch wells located in the bottom of a coulee. We consider the Belle Fourche shale to be an aquitard.

Phase 5 Soil Properties

Three test borings drilled within and proximal to the Phase 5 waste unit revealed the presence of mostly shale belonging to the Belle Fourche formation. Bentonite occurred in scattered locations as fracture fillings and thin seams. Two thin beds (two feet or less) of bentonite occurred in the hole designated as DH-3. That test boring was completed to a depth of 90 feet and was situated at the south end of the facility, just outside of the lined waste cell limit. Those beds, if they continue northward, will be excavated over most of the Phase 3 unit.

The moisture content of the samples ranged from 6.5 to 10.6 percent by weight, with one exception (Table 3). The interval at 15-20 feet in DH-1, which was drilled in the northern part of the cell base, had a moisture content approaching 20 percent. That Table 2 - Summary of Hydraulic Conductivity values of subsurface and surface soils at the City of Billings, Montana landfill.

Table 2 - Summary of Hydraulic Conductivity

Location	Depth (feet)	Material	Condition*	Hydraulic Conductivity (cm/sec)
DH-1 (Phase III cell)	26 - 29	Claystone	Remolded	3.80E-09
DH-2 (Phase III cell)	16 - 19	Claystone	Remolded	1.90E-09
DH-3 (Phase III cell)	15 - 18	Claystone	Remolded	1.90E-09
DH-7 (Phase III cell)	22 - 25	Claystone	Remolded	3.10E-09
Average of 35 Samples, Undisturbed From Final Cover	Surface	Colluvium (CAH)	On-Site Recompacted	6.50E-08
DH-2	2.2 - 12.2	Clay	Remolded	2.00E-04
DH-6	2.4 - 12.4	Clay	Remolded	6.00E-07
DH-6	8.0 - 8.5	Clay	Undisturbed	1.00E-06
DH-1	22.6 - 32.1	Shale	Remolded	5.00E-07
DH-5	22.5 - 24.0	Shale	Undisturbed	2.00E-05
DH-5	33.3 - 40.3	Shale	In-situ	3.00E-06
DH-90-3	43.5 - 44.0	Bentonite	Undisturbed	4.00E-09
DH-90-4	30.0 - 40.0	Sandy Mudstone	In-situ	8.00E-07
DH-90-5	40.0 - 50.0	Shale	In-situ	4.00E-07
Cell Exposure	Surface	Bentonite	Remolded	5.44E-10
32 Unknown Locations	0.5 - 1.67	Various	In-situ	1.97E-06 - 6.38E-03
Unknown	unknown	Shale	Various	4.00E-07 - 3.00E-06
Unknown (same as DH-90-3?)	unknown	Bentonite	Various	4.00E-09

*Indicated samples remolded to 90 percent of optimum moisture/density;

In-situ data from slug tests or Guelph permeameter tests performed in indicated well.

Table 3 - Summary of soil properties from the 2012 geotechnical investigation of the proposed Phase 5 unit, Billings Regional Landfill

Test Boring/ Depth	Percent Sand	Percent Fines (passing #200)	Percent Silt	Percent Clay	Liquid Limit	Plastic Limit	Plasticity Index	Maximum Dry Density (lb/ft^3)	Optimum Moisture (percent weight)	Percent Moisture (percent weight)	Saturated Hydraulic Conductivity (recompacted to 95 % of standard Proctor; cm/sec)	Saturated Hydraulic Conductivity (core sample; cm/sec)	Porosity
DH-1 (15-15.9')	3	97	63.8	32.9	43	19	24						
DH-1 (15-20')								102.9	19.6	19.7	4.64E-07		0.410
DH-1 (25-25.7')	2	98	62.3	35.4	44	18	26						
DH-1 (25-30.7')										9	5.94E-09		0.258
DH-1 (35-35.5')	1	99	52.2	47	59	19	40						
DH-1 (35-40')										10	7.12E-09		0.270
DH-1 (45-45.4')	9	94	37.7	55.3	67	20	47			10.6	2.56E-09		0.279
DH-2 (20-20.4')	3	97	60.3	36.7	43	19	24						
DH-2 (20-25.4')										9.9	7.87E-09		0.288
DH-2 (35-35.4')	7	93	47.8	45.3	45	18	27			7.3	5.89E-09		0.259
DH-3 (55-60')	5	95	57.3	38	42	19	23			6.5		3.83E-11	0.142
DH-3 (70-75')	2	98	59.2	39.2	48	20	28			7.3		7.16E-11	0.186
DH-3 (85-90')	1	99	68.2	31	55	22	33			7.6		2.19E-11	0.190
mean values	3.7	96.7	56.5	40.1	49.6	19.3	30.2			9.8	1.15E-08	4.39E-11	0.254

area had been used as a borrow source for daily cover, is relatively flat, and receives moisture from a large portion of the proposed waste cell area. The higher moisture content is presumably due to surface infiltration in disturbed soil.

The shale consists of 94 to 99 percent fines (passing the -200 sieve). One sample, from DH-1, underwent moisture-density relationship testing and was found to have a maximum dry density of 102.9 pounds per cubic foot and an optimum compaction moisture content of 19.7 percent.

Four soils samples from test boring DH-1 and two samples from boring DH-2 were recompacted to 95 percent of standard Proctor and tested for saturated hydraulic conductivity. The results ranged from 2.56 x 10-9 to 4.64 x 10-7 centimeters per second (cm/sec). However, the fastest value was produced by a sample from 15-20 feet below the surface in DH-1. All of the other recompacted samples exhibited hydraulic conductivities in the 10-9 cm/sec range. Three core samples from boring DH-3 also underwent testing for hydraulic conductivity. Those undisturbed samples returned values in the 10-11 cm/sec range. Please note that the "core" samples were drilled cores, not driven split-spoon samples. We feel that the cored samples are perhaps the best reflection of the physical properties of the shale because they were not subjected to any additional compaction or other physical manipulation during the collection process.

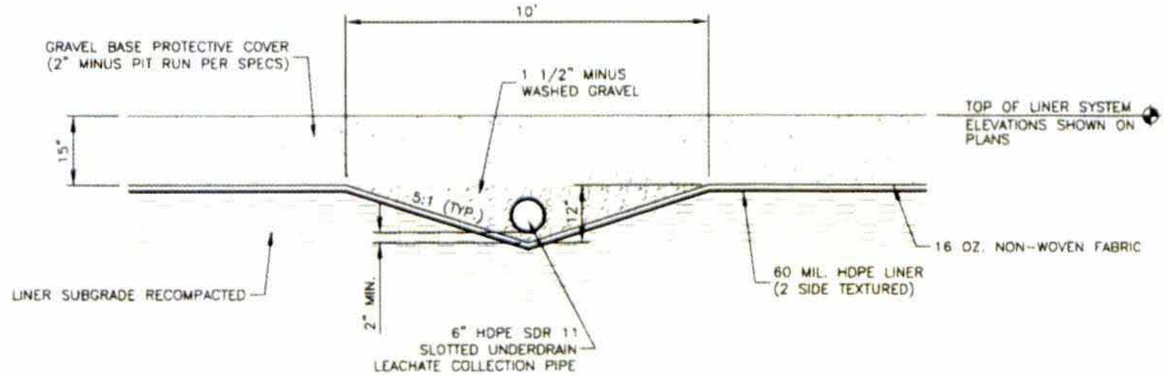
The Phase 5 footprint area is the source of borrow material used for the construction of the Phase 2 closure. The material was tested extensively during that process, with the analyses including nearly 60 sieve samples, seven hydrometer grain-size tests, and over 100 in-place density tests. The in-place density tests, however, are not representative of in-situ material because the subject soils were not highly recompacted. Analyses conducted on the material prior to placement was completed on samples recompacted to 85 percent of standard Proctor values, and resulted in bulk densities on the order of 87 pounds per cubic foot (pcf) or 1.40 grams per cubic centimeter (g/cm3). The hydraulic conductivities of two samples recompacted to 85 percent of standard Proctor values were 3.4 x 10-5 and 8.0 x 10-6 cm/sec. The average of five laboratory-tested composite samples of the cover material recompacted to 85 percent of standard Proctor value was 1.38 g/cm3, or 87.4 pcf. The recompacted saturated hydraulic conductivity of those same samples ranged from 5.4 x 10-6 to 2.5 x 10-4 cm/sec.

Again, the sample analyses from the Phase 2 closure construction testing either do not represent in-situ, undisturbed soil, or they represent tests conducted at a considerably lower recompaction rate. The average dry bulk density value of the 2012 testing of 1.65 g/cm3, when compared to the 1.38 to 1.40 g/cm3 value of the construction soils, appears reasonable. Also, the saturated hydraulic conductivity of the Phase 5 testing shows results consistently lower than those produced by the construction soils.

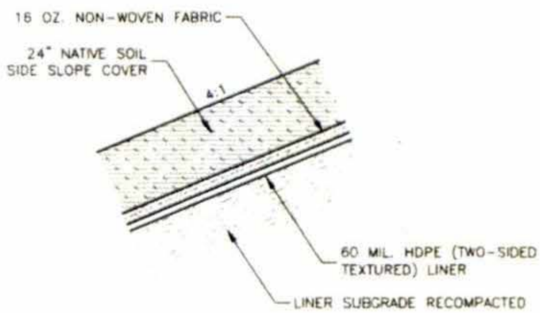
Liner Design

The unit covers about 15 acres, with about 20 percent of the cell comprising side slopes. The proposed liner (Figure 3) on the sideslopes consists of, from top to bottom, 24 inches of native soil cover, a 16-ounce non-woven fabric, 60 mil HDPE liner with two-sided texture, and native soil. The base will have 16 inches of gravel as protection for the liner. Native soil that is not suitable for compaction will be excavated to a depth of six inches and replaced with appropriately-compacted soil. The sides of the waste unit will generally be a 4:1 slope and the slope of the base range from 6 to 10 percent. The dimensions of the Phase 5 waste unit are shown on Figure 4. The cell will be filled with five- to ten-foot lifts of waste to a full thickness of 125 feet.

Phase 5 will essentially serve as the side of an adjoining cell that will be designed in the future. The Phase 5 unit will ultimately have about 125 feet of waste, daily cover, and intermediate cover.



TYPICAL BASE LINER/LEACHATE COLLECTION LATERAL



TYPICAL SIDE SLOPE LINER DETAIL

NOT TO SCALE

GreatWest engineering®

Figure 3
Typical Base Liner/Leachate Collection Lateral Cross Sections

CITY OF BILLINGS SOLID WASTE DIVISION
ALTERNATIVE LINER DEMONSTRATION

Design Criteria Evaluation

Introduction

The Administrative Rules of Montana 17.50.1204 (1) states that "An owner of operator of a new Class II or Class IV landfill unit or a lateral expansion of of an existing Class II or Class IV landfill unit may construct it only if the owner or operator has obtained department approval of a design that either: (a) ensures that the concentration values listed in Table 1 of this rule will not be exceeded at the relevant point of compliance, or, (b) utilizes a composite liner and a leachate collection and removal system that is designed and constructed to maintain less than a 30-cm depth of leachate over the liner." The proposed liner system at the Billings facility will have a leachate collection and removal system, but the liner design does not meet the definition of "composite liner" outlined in ARM 17.50.1202 (5). That definition states that a "Composite liner" means a system of two components, including a flexible membrane underlain by at least two feet of clay recompacted to a hydraulic conductivity of no less than 1×10^{-7} cm/sec. The base proposed to underlie the 60-mil HDPE liner at the facility is designed to be either appropriately-compacted native soil or six inches of recompacted native soil, therefore, the owner or operator must ensure that the conditions of 17.50.1204 (1) (a) are met. The conditions of rules differ from the previous regulations, in that the old rules prescribed a specific set of design criteria that would be equivalent to those prescribed in the federal Sub-Title D rule. With that language absent, it is the responsibility of the owner or operator to insure that the constituents in Table 1 will not be exceeded in groundwater at the relevant point of compliance.

The objective of this evaluation is to demonstrate that the constituents listed in Table 1 will not be exceeded at the relevant point(s) of compliance at the Billings Regional Landfill. The points of compliance, for the purpose of this investigation, are assumed to be the down-gradient edge of the licensed facility. The limit of Table 1 concentrations in groundwater are defined by the limits set in the Montana Department of Environmental Quality Circular 7 for groundwater.

The geology of the site is such that leachate would be unlikely to migrate very far or very fast. Well-compacted shale with a 30 to 55 percent clay fraction cannot be considered as a potentially robust aquifer. We feel, consequently, that gaseous diffusion would appear to be the most probable process by which contaminants could reach groundwater. Previous analyses for Phases 3 and 4 have demonstrated that fluid migration through the shale bedrock is not a viable pathway for contaminants for exceptionally long periods of time.

Background and Assumptions

An investigation of chemical migration through saturated and unsaturated media needs to take into account a rather large number of real and potential conditions. Among those elements are: volume and chemical character of leachate; potential head of the leachate over the liner; structural competency of the flexible membrane; permeability and attenuation characteristics of the liner system, and; permeability and attenuation characteristics of the soil between the liner system and the uppermost aquifer. Some of these elements are impossible to measure in a system that has not been constructed, therefore, one must rely on information available in published literature.

In the case of the Billings Regional Landfill landfill, extensive studies of the soils and groundwater have already been conducted. The subsurface conditions can be reasonably well characterized and, in many instances, quantified. The geotechnical study completed for this demonstration (Appendix A) provides important physical characteristics of the soil and groundwater within and proximal to the Phase 5 unit.

Characteristics of Liner System Components

The liner system at the Billings Regional Landfill, as outlined above, includes a flexible membrane liner, an underlying native or recompacted clay layer, and a leachate collection and removal system. In addition to the engineered system, some investigators (Rowe and Brachman, 2004; Lake and Rowe, 2005; Rowe, 2005) suggest that the protective value of natural or engineered soil between the liner and the top of the uppermost aquifer is an integral part of the system. In the case of this investigation, that attenuation layer consists of the naturally-occurring sediments in the Oligocene-aged deposits underlying the facility.

HDPE Flexible Membrane

For the purposes of this investigation, the 60-mil HDPE flexible membrane is assumed to be well-placed, with an average of one hole having a radius of 0.00564 meters (or an area of 98.5 square millimeters; 0.153 square inches) per acre, which, according to Rowe and Brachman (2004), is a reasonable assumption. The permeability characteristics of the HDPE membrane are assumed to be similar to those described by Rowe and Brachman (2004), Rowe (2005) and Lake and Rowe (2005).

Undisturbed or Recompacted Native Soil

The native soil proposed for the barrier layer beneath the flexible membrane liner (FML) is assumed to have a hydraulic conductivity no greater than 1 x 10-7 cm/sec, which is the regulatory standard for a recompacted soil liner. One of the four soil samples taken for this study did not meet that standard when recompacted to 95 percent of Standard Proctor compaction. However, the other three samples returned values of 2.56 to 7.12 x 10-9 cm/sec. The geometric mean of those four values is 1.49 x 10-8 cm/sec.

The data from both Table 2 and 3 supports the use of 1 x 10-7 cm/sec as a conservative value. Four samples of recompacted claystone from the base of Phase 3 averaged 2.68×10^{-9} cm/sec and an average of 35 samples obtained from the final cover used for a large portion of the landfill yielded an average recompacted hydraulic conductivity of 6.5×10^{-8} cm/sec.

Attenuation Layer

The attenuation layer for modeling purposes is accepted to be the native soil lying between the base of the engineered liner and the top of the uppermost aquifer. In this case, that thickness is problematic, because no groundwater was detected at the elevations where it is mapped. The absence of groundwater in the Phase 5 area is discussed in a previous section.

We also note that a test boring drilled in the lower end of the Phase 3 cell in 2007 (DH-8; TetraTech, Inc., 2007) was terminated at depth of 60 feet, at an elevation of 3,171 feet MSL. No groundwater was encountered in that test boring. A groundwater monitoring well about 900 feet northeast of that location (well DH-91-17) is reported to have a static water level of about 3,190 feet MSL. That well is completed in "dark gray shale" noted as the Frontier formation. More-recent geological mapping has confirmed that the rock is considered to be the Belle Fourche formation. Groundwater maps indicate that groundwater should have been detected in test boring DH-8 at an elevation of about 3,225 feet MSL.

The nearest water well registered with the Montana Ground Water Information Center for domestic use lies about three-quarters of a mile to the west-southwest of the landfill, in Section 31 (the "Stratton" well, GWIC #94193). That well is over 1,200 feet deep and appears to traverse the Belle Fourche formation, the Mowry shale and the Thermopolis shale into either the Fall River sandstone or the Kootenai formation. It is reported to be a flowing well.

Clearly, groundwater does not underlie the entire facility in a single discrete aquifer within 1,000 feet of the ground surface. The "Stratton" well west of the landfill taps a water-bearing zone that can be considered as a regional aquifer. As noted in the previous section discussing the site hydrogeology, recharge in the colluvium, landslide deposits and the shale is considered to be local. Phase 5 lies near the top of a low ridge and is underlain by the Belle Fourche shale. The fact that groundwater is not found everywhere across the unit or the site is not unusual. Precipitation is relatively low, the permeability of the substrate is exceptionally low, interstices and fractures in the substrate are commonly filled with bentonite, and weathered bedrock tends to form a clay-rich regolith that is not able to transmit large volumes of moisture.

Given these conditions, the thickness of the attenuation layer can be viewed in a number of ways. With respect to gaseous diffusion, the nearest groundwater that could impact human health and safety lies over 1,000 feet below the surface. From the perspective of the groundwater monitoring system, however, groundwater beneath the waste unit that might migrate to a point of compliance needs to be considered. But, there is no shallow groundwater underlying the Phase 5 site at the depths indicated by the monitoring reports submitted to the Department. Therefore, an alternative approach is required. Lacking a clear presence of shallow groundwater, then, we assume that the attenuation layer would comprise the material between the base of the liner system to a depth equal to that of the highest groundwater elevation found at the down-gradient point of compliance. The highest elevation of groundwater at the down-gradient side of the facility is about 3,194.5 feet MSL. The lowest point of the base of the Phase 5 unit will be at an elevation of approximately 3,375 ft MSL. Therefore, the attenuation layer for the model is assumed to be 180 feet.

Aquifer Characteristics

Groundwater occurs in relatively thin zones within three different geological materials. For the purposes of this investigation, only the groundwater in the Belle Fourche shale will be considered, since the other two potential water-bearing formations overlie the shale.

As noted by previous investigators (Damschen & Associates, 1991; EMCON, 1996), groundwater in the shale does not occur in a discrete formation beneath the entire facility. The existing groundwater monitoring network appears to tap at least one water-bearing zone related to the Belle Fourche shale. Water migrates through fractures and/or bedding planes over a zone less than three feet thick.

Landfill Leachate Characteristics

Landfill leachate chemistry is dependent upon the nature of the waste, climatic influences, and the age of the waste (Klinck and Stuart, 1999; Bonaparte and others, 2002). Nationally, municipal solid waste landfill leachate from landfills constructed after 1990 is slightly acid, with very high specific conductance (>3,700 umhos/cm) and high total dissolved solids (>2,700 milligrams per liter; mg/L; Bonaparte and others, 2002).

Inorganic Constituents

The predominate dissolved solids are typically chloride, sulfate, calcium, magnesium and sodium (Klinck and Stuart, 1999; Bonaparte and others, 2002),. Heavy metals occur in post-1990 landfills typically in excess of maximum contaminant levels (MCLs) established by the U.S. EPA and state agencies. For example, the average concentration of arsenic in post-1990 landfill leachate for 22 U.S. landfills was 23 micrograms per liter (ug/L; Bonaparte and others, 2002). The Montana Human Health Standard for arsenic in drinking water is 10 ug/L. The average lead concentration in leachate is on the order of 15 ug/L (Bonaparte and others, 2002), which equals the Montana Human Health Standard in groundwater. Samples of leachate collected from a landfill in north-central Montana in 1995 and 1997, within three years of the first acceptance of waste, contained sulfate (130 and 210 milligrams per liter; mg/L), chloride (7 and 19 mg/L), nitrate (1.39 and 1.18 mg/L) and iron (0.03 and 0.07 mg/L). We consider these analyses to be somewhat atypical because they most likely reflect a fair amount of dilution resulting from the relatively thin waste cover. The sample from 1995 represents water that collected while there was no waste on a large portion of the cell. The later sample was collected after a large precipitation event when there was less than four feet of total waste cover on the cell. Very little leachate was produced in the year between the collection dates of the two samples.

Certain organic compounds can capture inorganic ions and move them in solution through soil, but most dissolved polar ions are susceptible to at least some level attenuation in the vadose zone. The Billings facility is underlain by soils dominated by fine-grained material, of which clay constitutes an average of over 25 percent by mass (Table 1) and for which the mean plasticity index is over 55. While the estimated porosity is fairly high (Table 1), the high percentage of fines and generally poor sorting of the sediments will lead to a fairly high tortuosity (Fetter, 1988), increasing the attenuation factor.

Volatile Organic Compounds

Bonaparte and others (2002) report average concentrations of volatile organic compounds (VOCs) to be wide-ranging, with most not detected at over 50 percent of landfills investigated. Klett and others (2005) report a wide variety of concentrations of VOCs in samples of leachate from facilities in Wisconsin, ranging from nearly 90 percent of 49 landfills reporting the presence of toluene to two percent reporting the presence of bromomethane and trans-1,2-dichloroethene. It is important to note that the values reported by Klett and others (2005) represent lined facilities dating back to 1985, so there is a possibility that some mixed waste landfilling occurred at some sites.

Rowe (2005) has noted that ions and compounds with larger molecular diameters are generally actively attenuated from landfill leachate by clay barriers and/or attenuation layers. Polar ions are adsorbed onto substrate particles or simply prevented from migrating due to the tortuosity and small pore matrix of clay barriers and soils. In cases where leachate successfully migrates through a barrier system, the larger-diameter ions and compounds are adsorbed by the substrate particles or otherwise attenuated. In addition, leaks in a reasonably well-constructed geomembrane will tend to spread over a relatively large area rather than penetrate the clay barrier at specific leak points that would result in stochastic flow. That process essentially reduces the potential head and increases the surface area of the infiltration. In short, unless a barrier system suffers from a serious failure at a point of high leachate head, the potential for significant quantities of leachate to breach the liner and migrate to a water-bearing stratum is relatively low. Conversely, poorly-constructed membranes that have numerous hole and wrinkles are susceptible to considerable leakage, particularly if clogging of the drainage layer occurs because of insufficient thickness and/or permeability.

Leachate Volume

The Billings facility has a leachate collection system that drains 18 acres in Phases 3 and 4. The facility recirculated approximately 50,000 gallons of leachate from their collection pond in 2011. That leachate was applied back onto Phases 3 and 4, where the bulk of the gas extraction is occurring. However, moisture from the gas-extraction plant is being applied to the Phase 3 unit via a horizontal injection well. The gas-extraction plant operator estimates that the process injected some 120,200 gallons of moisture from the concentrator into Phase 3. Given that the leachate collection pond has received only 50,000 gallons of leachate, along with the potential for summertime evaporation from the pond, the leachate production appears to be a net loss. A temporal aspect of this process may come into play, however. The condensate may be distributed throughout what was relatively dry waste. The Landfill Gas Condensate and Leachate Recirculation Plan (Wenck Associates, Inc., 2010, unpublished) contains information regarding the waste moisture content in Phases 1 and 2. The authors of the plan assume a default moisture content value for municipal solid waste of 15 percent by weight. The test data show that the actual moisture content varies considerably throughout the vertical profile of the Phase 1 and 2 areas, with some samples returning moisture contents below six percent. Much of the condensate is apparently being absorbed by waste, but the cells are still producing considerably more leachate than they did prior to the injection of the condensate. The operators of the facility report that Phases 3 and 4 produced less than 10,000 gallons of leachate annually prior to the construction of the gas extraction plant (pers. comm., Barbara Butler, City of Billings Environmental Coordinator). As of yet, the moisture being recirculated in Phases 3 and 4 have not yet reached a point of equilibrium.

Landfill Gas Characteristics

The Billings Regional Landfill has complied with the EPA and Montana requirements regarding the estimation of the production of gaseous non-methane organic chemicals (NMOC). The last NMOC testing was undertaken in 2007, and the data were applied to the EPA LandGEM model. The model uses average analytical values generated from multiple sampling points across the facility. That model assumes that NMOC concentrations constitute 0.178 percent by mass of total landfill gas produced. The results of the 2007 model predicted the total mass of landfill gas produced in 2011 to be 23,620 tons (1.719 x 107 cubic meters). The model also predicted an NMOC mass of 42.1 tons (10,680 cubic meters).

We feel it important to point out that the values produced by the LandGEM model may be gross over-estimates of gas production. The US Environmental Protection Agency, which produced the LandGEM model, also requires that landfills of a certain minimum size report the potential production of greenhouse gases, including methane, on an annual basis. The spreadsheet calculators provided for the agency provide a standard process by which facility operators may calculate methane production. Those spreadsheet results are, in this case, based on exactly the same waste-in-place masses as the LandGEM model. However, they produce very different results. The LandGEM model predicts that the Billings Regional Landfill is producing over 21,000 metric tons of methane annually. The Greenhouse Gas Reporting (GHG) process estimates that value to be about 4,000 metric tons. We have chosen to use the LandGEM values in an attempt to be conservative in our modeling inputs. If the GHG values are correct, we have over-estimated the production of landfill gas and its related NMOC constituents by an order of magnitude.

Additional details of the landfill gas characteristics are discussed further in a subsequent section of this document.

Modeling

General Background and Assumptions

The 2010 changes in Montana regulations have demanded a somewhat different approach to the evaluation of alternative liners. ARM 17.50.1202 (5) provides for a "prescriptive" liner design and conditions for the implementation of a leachate collection system. In the case of the Billings Regional Landfill, the proposed liner design differs with the prescribed liner primarily in that the recompacted soil base is replaced either by native soil or six inches of recompacted soil. While the design includes an HDPE liner of the appropriate thickness and a leachate collection system that will minimize standing head on the liner to 30 centimeters (cm; one foot), the barrier layer below the geomembrane does not meet the two-foot thickness requirement. Therefore, the conditions of ARM 17.50.1204 (1)(a) must be met. Those conditions require that the owner/operator ensure that the concentration values listed in Table 1 will not be exceeded at the relevant point of compliance in the uppermost aquifer. In order to demonstrate that the proposed liner will meet those conditions, the DEQ guidance proposes a three-step approach to the investigation and regulatory approval of an alternative liner. If the proposed liner system is a composite system that includes an approved geomembrane (flexible membrane liner) and leachate collection system, then the liner system must be shown to be as effective as the prescribed system at its base with regard to transmission of the ARM 17.50.1200 Table 1 constituents. If that cannot be demonstrated successfully, then further investigations must be undertaken to demonstrate that the Table 1 constituents will not exceed regulatory standards at the relevant point of compliance within a period of time of at least the life of the landfill plus its minimum post-closure period of 30 years.

The geology of the attenuation layer involves shale having an average porosity of 0.254 and a moisture content of 9.8 percent (Table 3). The geometric mean of all the hydraulic conductivity tests is 1.73 x 10-9 cm/sec. Using those assumptions, the seepage velocity (based on a hydraulic gradient of unity) would be 6.81 x 10-9 cm/sec, or 1.931 x 10-5 feet per day (ft/day). A very simple time-of-travel calculation through the 180-foot thick attenuation zone, then, yields a value of over 25,500 years. However, since moisture appears to travel along preferential flow paths, that value is not realistic. It still offers a sense of the hydraulic conditions in the attenuation layer. With a porosity of 0.254 and a moisture content of about 10 percent, even relatively small volumes of water traveling along bedding planes would require considerable periods of time to saturate any part of the attenuation layer. This concept is supported by the demonstrated absence of water-bearing zones over most of the facility.

We are of the opinion that a much greater risk to groundwater is the diffusion of VOCs from landfill leachate and, even more critically, landfill gas. Fluid can only move via advection through defects in the liner or degradation of the geomembrane over time and, in either event, it still has to migrate through many tens of feet of clay-rich soil. Gases, however, can diffuse through intact geomembranes, recompacted clay liners, and naturally-occurring soil (Carpenter and others, 1993; Hoffman and Chiarappa, 1998; Rowe and Brachman, 2004; Lake and Rowe, 2005; Stark and Choi, 2005; Rimal and Rowe, 2009).

Based on all of the above criteria and observations, we selected the POLLUTE (T) V. 7 software to model the potential migration of contaminants. The model has a 15-year history, and functions on the integration of data to develop rates of flow and contaminant concentrations based on diffusion.

Model Input Values

The following section describes and qualifies the POLLUTE v.7 inputs. We developed two models, one for the composite liner as described in ARM 17.50.1402 and one for the proposed design. Many aspects of both models are the same, such as initial VOC concentrations, attenuation layer characteristics, etc. Differences between the two models are called out in the descriptions for each input. However, prior to describing the inputs, a consideration of some bases and rationale for certain input values is warranted.

Perhaps the most critical element of a diffusion model involves the chemical of concern (COC). The source concentration is an important aspect of the model, but the diffusivity of the selected COC across a given barrier is also critical. The following discussion presents the reasoning for the selection of certain model inputs specifically regarding the COC.

Table 1 of ARM 17.51.1204 presents a group of VOCs that constitute COCs for which maximum contaminant limits (MCLs) cannot be exceeded. Perhaps the most logical target in that list for estimation of concentrations at the relevant point of compliance (RPOC) is vinyl chloride (VC). Vinyl chloride has a low maximum contaminant level (2 ug/L), a low minimum reporting level (0.5 ug/L) and considered to be a carcinogen of significant risk. However, vinyl chloride is rarely, if ever, introduced to MSW as a compound because it is highly volatile, difficult to contain and very flammable. More commonly, vinyl chloride is a biodegradation product of other VOCs. Tetrachloroethene (PCE) and trichloroethane (TCA) are well-known sources for VC, as they can be the parent chemicals that degrade to 1,1,1-trichloroethene (TCE), cis- and trans-1,2-dichloroethene (c-1,2-DCE, t-1,2-DCE), 1,1-dichloroethene (1,1-DCE), to VC. Soltani-Ahmadi (2000) lists EPA-derived averages of various VOCs measured in landfill gas samples in the US, noting concentrations of PCE (1.19 ppmv = 10.4 ug/L, at 48 sites), TCE (0.381 ppmv = 13.1 ug/L, at 48 sites), t-1,2-DCE (0.051 ppmv = 7.7 ug/L, at one site), DCE (0.092 ppmv = 3.7 ug/L, at 45 sites), and vinyl chloride (1.08 ppmv = 2.8 ug/L, at 46 sites).

The authors cited above also note that the concentrations of VOCs in NMOC gas are variable over time and, over the very long term, VOC generation will become a very small part of the landfill gas. The implication is that the volatile nature of the COCs is such that they tend to find migration routes out of the waste pile, most probably via diffusion. The degradation of certain synthetic material, particularly since there is a fixed mass of waste at the point of facility closure, the VOC fraction of the waste will eventually decline.

Hoffman and Chiarappa (1998) and Hoffman and others (1999) conducted studies of VOC migration relative to the tortuosity of various unconsolidated sediments, which impact diffusion rates through soil. Those studies yielded a range of a retardation factors that reduced diffusion time through soils by 0.2 to 0.8. Tortuosity is not directly considered in the POLLUTE model.

An additional factor of sorption plays into the diffusion process, with clay particles and organic content acting to remove some organic constituents from water and gas. The POLLUTE model can apply a distribution coefficient to accommodate that aspect of the diffusion process.

Scheutz (2002) notes that methanotrophic bacteria in landfill soil covers are able to co-oxidize large quantities of VOCs, in some cases to the point of non-detection. Oxidation processes will dechlorinate the dichloroethene isomers and vinyl chloride, but reducing environments are more effective in the dechlorination of larger halogenated carbon compounds.

Since the effective diffusion value differs for various VOCs, and since the physical characteristics of the soil affect the diffusivity of the gas, the POLLUTE model attempts to develop a flux by using the effective porosity and bulk density of the model soil.

The POLLUTE model does not account for any chemical processes that might occur in either vapor or solute phase in the linear calculations. That is, the dechlorination of PCE to VC cannot be accommodated unless the non-linear sorption or passive sink options are engaged.

General Background and Assumptions

Both the site-specific model and the prescribed design model consist of a geomembrane (GM) underlain by a clay soil layer. Both assume there is an aquifer with an overlying aquitard.

Source

The source concentrations of VOCs in landfill leachate and landfill gas are an important point of discussion. The POLLUTE model allows several options based primarily on VOC concentration and landfill size. The model can be run using either a constant source concentration or a finite mass of VOC in the waste. If the finite mass is used, additional input data or assumptions are required from the user.

Concentration

The Billings Regional Landfill conducted a Tier II NMOC evaluation in 2007. The objective of the evaluation is to determine if the facility will reach a threshold of non-methane gas generation that would trigger the installation of a gas-capture system that would eliminate fugitive emissions. The evaluation consisted of sampling 51 locations within the waste, analyzing the gas samples, correcting the nitrogen and oxygen contents of the samples, determining the non-methane concentration of the gas, and applying the resultant data to the LandGEM model as a means of estimating future production of NMOC gases. The Billings landfill has a design capacity that exceeds the number of years allowed in the LandGEM model. The model, by default, allows the evaluation to continue for 80 years, two years short of the anticipated lifespan of the Billings facility. Predictions, therefore, are only available up to the year 2048. We feel that, for the purposes of this investigation, that is a sufficiently long model period.

The LandGEM model includes an option to predict specific VOCs. That option is based on EPA estimates of VOC concentrations in landfill gas derived from their own studies and literature-based data. In the case of the Billings facility, LandGEM predicts the vinyl chloride production at the facility in 2048 to be 1.036 tons (0.9422 megagrams; Mg) or 326 cubic meters (m3: Appendix B).

The POLLUTE model requires an input in terms of mass per unit volume. For the year 2048 the LandGEM model predicts a total of 4.965 x 107 m3 and a vinyl chloride mass of 1.036 Mg. The concentration of vinyl chloride, then is 9.433×10^{11} micrograms (ug) divided by 4.965×10^{10} liters (L), or 19 ug/L.

Landfill Length

This parameter involves the length of the landfill parallel to the direction of flow of the leachate collection system, which, in this case, is 950 feet.

Source Type

Two different inputs are allowed: a constant concentration, or; a finite mass. The constant concentration option assumes that the concentration of the COC remains constant over the span of the model run. The finite mass option requires inputs for waste thickness, which, according the facility master plan, is 125 feet.

Infiltration

The POLLUTE model also requires a moisture-infiltration rate. In this instance, that figure is not readily calculated for a number of reasons. For example, one section of the landfill (Phase 2) is closed with an evapotranspiration cover, so should receive little, if any, infiltration. Conversely, Phase 4 is receiving both recirculated leachate as a surface application and gas-extraction condensate via a horizontal well. The gas extraction process has provided over 120,000 gallons of moisture to Phase 3, and approximately 25,000 gallons of leachate from the pond has been sprayed on Phase 3. That cell is approximately 9 acres, so the additional moisture amounts to only 0.59 inches. The annual average precipitation is 14.3 inches, so assuming that moisture will be recirculated on and/or within Phase 5, the use of 15 inches of infiltration is conservative. The model unit requirements require recalculation of that value to 0.0034 feet per day (1.25 feet/365.25 days).

Waste Density

The other required inputs to the model are waste density, which is assumed at 1,200 pounds per cubic yard (about 711 kilograms per cubic meter.

Percent of Mass

The POLLUTE model requires a mass of leachable contaminant per unit mass of the waste. The percentage of leachable COC, in this case, vinyl chloride, of a given mass of waste could be quite variable. The LandGEM model predicts the generation of 57 Mg vinyl chloride over the entire lifespan plus 60 years post-closure at the Billings Regional landfill. If the predicted 1.6-percent increase in the waste acceptance rate reasonable, the total mass waste in 2048 (80 years after opening) would be just over 17,000,000 Mg. The predicted vinyl chloride production in the last year of the model amounts to 0.09 Mg, in contrast to the peak production of 0.9 Mg in 2049. The production curve (Figure 4) generated by the model implies that vinyl chloride would be produced at a declining rate for some time after the year 2109. Using the total mass and vinyl chloride production within the LandGEM model limits, the mass of leachable gas would be 0.00034 percent. To be conservative, and to account for the long-term production, we use a percent of mass of 0.001 percent in the model.

Hydraulic Heads

Two inputs are required by the model.

Leachate Head on Primary Liner

The leachate head is assumed to be the one-foot (30 cm) maximum allowed by ARM 17.50.1200.

Groundwater Level Relative to Top of Aquifer

The groundwater at the Billings facility does not appear to maintain any artesian head. The groundwater level relative to the top of the aquifer is assumed to be zero.

Geomembranes

The geomembrane input considers thickness, diffusion coefficient, and the method of calculating leakage.

Thickness

The proposed alternative liner is designed to have a 60-mil (1.523 mm) HDPE membrane as the upper part of the barrier system.

Diffusion Coefficient

The POLLUTE model input requires a diffusivity value for geomembrane, clay liner and attenuation layer. A review of available literature (Rowe and others, 1995; Rowe ,1997; Rowe and Brachman, 2004, and; Lake and Rowe, 2005) reveals that diffusivity coefficients for either synthetic or naturally-occurring materials are not commonly developed, probably due to the hazardous nature of the compound. However, methylene chloride has been used by researches to develop coefficients for those materials. While methylene chloride and vinyl chloride exhibit a number of physical differences, we feel that the similarities in molecular weight, density and diffusivity make for a reasonable substitution. The diffusivity inputs for this model, therefore, are based on literature values for methylene chloride and assigned as 2.0×10^{-8} cm^2/sec.

Leakage Method

The software author's default methodology is the preferred process.

Leakage

The Leakage inputs control leachate migration through the barrier system. The geomembrane is considered to be impervious to water when intact.

Hole Frequency

The default hole frequency is one hole per acre (2.5 holes per hectare).

Hole Radius

The default hole radius of 0.00564 m (0.22 inches; area of 0.152 inches), which is the default for the program.

Wrinkle Radius

Rowe (2005) has determined, through laboratory aging of a number of liner materials and field-based data, that wrinkles in geomembranes can constitute a significant source of leakage over time. The Wrinkle Radius used for the model is the default value of 0.155 inches

CFLAG

The CFLAG value is either 1 or 0 depending upon the boundary. CFLAG is 1 when head in the underlying aquifer is greater than zero, and is 0 when the head is greater than the thickness of the soil layer above the first aquifer. In this case, the aquifer head is greater than zero but less than the attenuation layer thickness.

Transmissivity (THETA)

The transmissivity referred to in this instance pertains to the contact between the GM and the CCL. The value used for this model is 1.0×10^{-10} m^2/sec, which is the suggested default value for a liner that has good overall contact with the soil. The model offers values for "perfect" contact, which is probably unrealistic in most instances.

Conductivity

In this case, the conductivity refers to the hydraulic conductivity of the material directly overlying the GM. This is used in the model to determine flow through holes and wrinkles. Since uncompacted native material will be used, we assigned the lowest of the values reported for the Phase 2 closure construction materials, 2.5×10^{-4} cm/sec, as the conductivity of the protective layer.

Clay Liner

The inputs for the CCL are similar to those for the Geomembrane, but require some additional definitions.

Thickness

The thickness for the prescribed composite liner model is two feet. The actual proposed thickness for the recompacted soil layer of the alternative liner is one foot or zero for areas where the native soil meets the moisture-density, compaction and hydraulic conductivity specifications. The hydraulic conductivity of the shale underlying Phase 5 ranges from 2.19×10^{-11} to 4.64×10^{-7} cm/sec, and the geometric mean of all of the samples (both recompacted and cores) is 1.73×10^{-9} cm/sec. We assume that some disturbance of the soil will occur over the entire site, which could reduce that average hydraulic conductivity by as much as an order of magnitude. Therefore, we assume that there will be a zone of at least 0.5 feet that will have a hydraulic conductivity of 1×10^{-7} cm/sec.

Density

A number of tests have been conducted on the substrate within the Phase 5 unit. The calculated bulk dry density of a sample taken at a depth of 15 feet from test boring DH-1 was 102.9 pounds per cubic foot (pcf) or 1.65 grams per cubic centimeter (gm/cm^3).

Conductivity

The hydraulic conductivity of the CCL in both model scenarios has been assigned 1×10^{-7} cm/sec, which is the regulatory minimum.

Diffusion Coefficient

As with the geomembrane model inputs, a diffusion coefficient specific to the CCL for a specific COC is required. In this case, Lake and Rowe (2004) conducted tests on a limited number of VOCs, and present a value of 6×10^{-10} m^2/sec (6×10^{-6} cm^2/sec) for DCM through a CCL.

Distribution Coefficient

The distribution coefficient is a measure of the potential attenuation of a VOC in a particular soil, primarily based on the COC's affinity to adsorption onto organic or soil particles. The carbon content has not been measured at the site, but is assumed to be normal for a marine shale. Soil adsorption coefficients (K_{oc}) for VC are variously reported as 14 to 131. However, since the adsorption potential cannot be verified from on-site samples, the distribution coefficient is assigned as zero.

Porosity

The porosity of nine samples taken within and proximal to the Phase 5 cell averages to 0.254 (Table 3). That average includes a recompacted sample from a depth of 15 to 20 feet below the existing surface that yielded a porosity of 0.41. Samples taken from deeper in that same boring had porosities of 0.258 to 0.279. Samples of the shale taken from greater depths, including three cores from DH-2, had much lower porosities, in the range of 0.14 to 0.19. We feel that the average value of 0.254 is reasonable because it represents a mean that is slightly lower than what was found beneath the proposed waste unit. That is a conservative value because the smaller void volume increases the diffusion of gases in the model. The model does not account for tortuosity.

Attenuation Layer (Aquitard)

As with the geomembrane and the CCL, the aquitard requires a delineation of physical attributes. The model considers the aquitard to represent an attenuation layer capable of transmitting and removing a certain percentage of pollutants.

Thickness

The thickness of the attenuation layer is described above. The assumed thickness of the attenuation layer is 180 feet.

Density

Table 3 shows the attributes of the substrate beneath and proximal to the proposed waste unit. The bulk dry density of the material underlying Phase 5 is calculated to be 1.65 g/cm^3, or 102.9 pcf.

Conductivity

The geometric mean of hydraulic conductivities returned from the analysis of soils underlying and proximal to the proposed Phase 5 unit is 1.73×10^{-9} cm/sec. The geometric mean of the hydraulic conductivity values reported for samples from test boring DH-1, directly underlying the proposed cell, is 2.697×10^{-8} cm/sec. That mean value includes three samples, two of which were in the 10^{-9} cm/sec range. The hydraulic conductivity of three core samples taken from test boring DH-3, located just outside of the proposed cell on its southern boundary, ranged in the 10^{-11} cm/sec range. Given this of information, we feel that the use of the geometric mean value of 2.7×10^{-8} cm/sec from test boring DH-1 is reasonable and conservative.

Diffusion Coefficient

As with the other layers of the model, a diffusion coefficient for the attenuation layer is required for the attenuation layer. Values reported by Carpenter and others (1993), Lake and Rowe (2004), Rowe (2005) and Rimal and Rowe (2009) indicate that the diffusion coefficient of naturally-occurring clay and mechanically-mixed fine-grained soils for the COC ranges from 2 to 6 x 10^{-6} cm^2/sec (2-6 x 10^{-10} m^2/sec). Based on that, along with the diffusion coefficient reported by Lake and Rowe (2004) for compacted clay liners, a value of 6 x 10^{-6} cm^2/sec is used for the model.

Distribution Coefficient

Based on the same arguments presented for the CCL, above, the distribution coefficient for the attenuation layer is assigned as zero.

Porosity

Based on previous work (Table 1) as described for the Clay Layer, above, a porosity of 0.25 is assigned to the attenuation layer.

Aquifer

The lowermost layer of the model represents the aquifer.

Thickness

The thickness of water-bearing units is problematic. Drilling logs indicate that such units range from a foot to a few feet in thickness, and are not within easily-delineated or discrete geological units. A thinner water-bearing zone would be more likely to concentrate contaminants that diffused or flowed through overlying strata. Therefore, we have assigned a one-foot thickness to the modeled aquifer thickness.

Porosity

The porosity of any water-bearing zones is unknown. For the purposes of the model, we have assigned the porosity as 0.3, which is slightly higher than that of the attenuation layer, in spite of the fact that the water-bearing zones comprise the same geological material.

Run Parameters

The run parameters control the type and timing of the model outputs. The model is set up to produce concentrations at specific times. Currently, the Billings Regional Landfill is not slated to close until 2050, so we set the model up to run for the lifetime of the Phase 5 unit (2012-2050) plus 60 years.

Model Results

Appendix B contains the results of the models described above, as well as additional outputs for maximum concentrations and sensitivity analyses. Please note that the output text lists the landfill length as 289.56 meters. The landfill length is 980 feet, but an apparent bug in the software lists the length in meters. Note also that the POLLUTE software interprets the length and height of the waste mass for the fixed mass option as one unit wide, thereby producing an output that accounts for time and concentration with depth.

Prescribed Liner

Given the inputs described above, a model gas having the general behavior of methylene chloride using a concentration of vinyl chloride predicted by NMOC testing would fall below the detection limit used by the DEQ for volatile organic compounds in soils (+/- 10^{-3} ug/L) at a depth of less than 25 feet below the base after 98 years.

Proposed Alternative Liner

Using the inputs described above, but replacing the clay sub-base with six inches of disturbed soil, the model predicted that the COC concentrations after 98 years would fall below the DEQ detection limit at a depth of less than 20 feet.

Maximum Potential Concentrations

Both baseline models predicted that the maximum concentration of the liner and attenuation layer would be attained after 9,900 years. The model predicted that the maximum concentration at 187 feet would be 0.01 ug/L of the COC.

Sensitivity Analysis

Sensitivity analyses can be conducted in any number of ways. The POLLUTE model offers a range of sensitivity analysis options including the initial source concentrations, Darcy velocity, layer thickness, diffusion coefficient and distribution coefficient. Previous experience with the POLLUTE model, along with the knowledge that the Belle Fourche formation underlying the Phase 5 unit is relatively homogeneous, allowed the investigators to eliminate hydraulic conductivity (Darcy velocity), layer thickness, and porosity from consideration for a sensitivity analysis. In the case of the Phase 5 waste cell, the shale is relatively uniform in its properties, with the exception that some pores, fractures and bedding planes within the strata are filled with bentonite. That condition would affect the diffusion coefficient, at least to some degree. A run of the model with a diffusion coefficient two orders of magnitude greater than the initial model shows a potential for deeper infiltration of gas. The 100-year run predicted concentrations of the COC at a depth of 185 feet below the waste unit to be an order of magnitude above the DEQ detection limit for gas sampling. Another run using a diffusion coefficient one order of magnitude greater than the initial runs predicted that, after 100 years, the COC would be undetectable 80 feet below the base of the cell.

Interpretation of Results

Predicted Values

The POLLUTE model predicted that the model COC could attain detectable concentrations at depths of 20 to 25 feet. While it may seem counter-intuitive, the proposed liner system appeared to perform better than the prescribed liner system. The reason for that is the difference in physical characteristics between a two-foot clay liner and the native shale. The shale is, in reality, less permeable and less porous than a recompacted clay liner. For the purposes of this investigation, the model shows that the existing ground is at least as protective of groundwater as a two-foot recompacted clay layer.

Attenuation

The longer-term, maximum concentration runs predicted deeper penetrations of landfill gas over time. That, however, is not necessarily a realistic scenario. Any number of aspects of the POLLUTE model for the Billings facility can be points of contention. We have constructed the model on what we consider to be an extremely conservative basis using the best data available. The model does not account for any attenuation, which is conservative but unrealistic. As anaerobic conditions develop in the waste mass, some percentage of the parent compounds of VC, such as PCE and TCE will be dechlorinated. The resulting DCE isomers and VC can be attenuated by methanotrophic bacteria living in the oxygenated soil surrounding the cover and portions of the liner (Scheutz, 2002). Other VOCs can be attenuated by complexing with organic and inorganic compounds that develop in the leachate, which will presumably be removed via the leachate collection system for at least the life of the facility. Assuming the final cover is either vented or consists of an evapotranspiration cover, considerable masses of VOCs will simply escape to the atmosphere. A fraction of the landfill gas can also escape through the leachate collection system. A small fraction of some VOCs will simply be contained for a period as they adsorb onto the carbonaceous material within the waste mass. The model does not account for preferential pathways, which would allow landfill gas to migrate laterally through strata that have higher porosity or lower tortuosity, and which are better-connected to atmospheric venting conditions. Given all of the potential for attenuation, a model that assumes none can be considered conservative.

Another potential attenuation factor not integrated into the model involves the adsorption potential of the Belle Fourche shale. Gautier (1985) and Ho and Meyers (1987) report organic carbon contents ranging from 0.2 to 4.3 percent organic carbon in the formation in Phillips County, Montana and Johnson County, Wyoming. VOCs will adsorb onto organic carbon, and there no reason to believe that such a process will not occur in the substrate beneath the proposed Phase 5 waste-fill area.

Also note that the width and depth dimensions used in the model represent 125 feet of waste over the entire 950 feet of cell length. Those dimensions cannot be applied over the entire waste unit because the sides are sloped, so when the input dimensions are applied to the entire cell, the waste mass is over-estimated by as much as 20 percent.

Mitigating Conditions

An important mitigating factor pertaining to landfill gas involves the gas-to-energy system at the Billings facility. The system is currently in place and will be expanded into Phase 5 as it is being filled. Records obtained from Montana-Dakota Utilities indicates that as much as 490 metric tons of methane are being recovered annually from the extraction system. That fact is very important in considering the modeling effort as well as *in-situ* conditions.

We feel it highly unlikely that only 490 metric tons of methane is being captured if the total methane production is on the order of 21,000 tons as predicted by the LandGEM model. Those values imply that the collection network is collecting only 2.3 percent of the methane being produced. The system currently in place at the Billings facility only covers over half of the the entire mass of waste, but it is still reasonably efficient. Using the GHG-calculated values for methane generation, the recovery rate for 2011 would be over 12 percent, which is a more reasonable rate of capture. At that, the existing waste pile was not producing enough methane for capture, and additional intake lines had to be installed. We find it unlikely that the methane generation is as high as predicted by the LandGEM model and, therefore, the concentration of VOCs and NMOCs is probably not as high as implied in the model.

The fact that a large percentage of the landfill gas is being removed means that there is a lower mass of VOCs and NMOCs in the landfill gas. While the percentage of those constituents may remain the same, the presumption of the mass-based gas production used in the POLLUTE model also represents an over-estimation.

The mechanical removal of the landfill gas has certain physical effects on gas migration. As the gas is removed from the waste pile, a number of phenomena occur. The internal pressure of the gas is at least reduced, if not entirely eliminated. That is, if gas extraction rates exceed gas production (which appears to be the case in at least part of the collection system), the voids must be filled with another gas, presumably of atmospheric origin. That implies that some portions of the waste mass will experience a dilution effect of the landfill gas. At the very least, the internal gas pressure of the capped waste mass will be reduced, thereby reducing the effect of one of the mechanisms that can lead to gas leakage through the liner system.

Conclusion and Summary

The subsurface underlying the proposed waste cell comprises carbonaceous shale of the Cretaceous-aged Belle Fourche formation, and consists of at least 94 percent fines (passing #200 sieve) and, in places, contains as much as 55 percent clay. Measured hydraulic conductivities range from the 10^{-11} to the 10^{-7} cm/sec range, with the geometric mean of values produced from samples underlying and proximal to the proposed cell being 1.73×10^{-9} cm/sec. The average porosity is calculated to be 0.254 and the bulk dry density is assumed to be 102.9 pcf, the latter being based on a single analysis from the cell base.

The liner design consists of, from top to bottom, 16 inches of gravel cover, a 16-ounce non-woven fabric, 60 mil HDPE liner with two-sided texture, and native soil. Native soil that does not meet the compaction requirements will be excavated to a depth of six inches and replaced with appropriately-compacted soil.

Using data from the physical properties of the soil, along with literature-based diffusion estimates, the POLLUTE model predicts that the proposed liner design for the Phase 5 waste unit at the Billings Regional Landfill is at least as protective of the environment as the prescriptive cover design developed by the Montana DEQ. The model inputs included gas production rates and content based on the LandGEM model and data collected from the facility for a 2007 NMOC Tier II gas evaluation. The model may be considered conservative because no additional attenuation factors were introduced and there is a good probability that the LandGEM estimates for gas production are an order of magnitude high. The model predicted the model COC to be at undetectable levels less than 25 feet below the Phase 5 cell 98 years after the cell closure. That time period includes the entire lifespan of the facility plus 60 years of post-closure time. A 10,000-year model run predicts COC concentrations at a depth of 185 feet to be about 1×10^{-2} ug/L, one order of magnitude higher than the DEQ-established detection limit for gas sampling at hazardous waste facilities of 0.001 ug/L.

Additional mitigating factors include the relatively high organic carbon component of the Belle Fourche shale and the landfill gas-to-energy system that will actively remove methane and the VOCs associated with landfill gas from the proposed Phase 5 unit.

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Appendix A

Geotechnical Investigation, Billings Landfill Phase V Expansion

TETRA TECH

Report of

Geotechnical Investigation
Billings Landfill Phase V Expansion

Billings, Montana

April 2012

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CLEAR SOLUTIONS™

Report of Geotechnical Investigation

Billings Landfill Phase V Expansion
Billings, Montana

Prepared for:

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Tetra Tech Project No. 114-550852

April 2, 2012

TETRA TECH

April 2, 2012

Mr. Bruce Siegmund
Great West Engineering
PO Box 4817
Helena, Montana 59604

SUBJECT: Geotechnical Investigation
Billings Landfill Phase V Expansion
Billings, Montana
Tetra Tech Project No. 114-550852

Dear Mr. Siegmund:

At your request, we have performed a limited geotechnical investigation at the site of the proposed Billings Landfill Phase V Expansion located in Billings, Montana. The report that follows describes in detail our investigation, summarizes our findings, and presents our opinions regarding the similarity of engineering properties of the soil and bedrock between the Phase V expansion and the expansions previously explored.

It is important that we provide consultation during design, and field services during construction, to review and monitor implementation of the geotechnical recommendations.

If you have any questions regarding this report, please contact us. We appreciate the opportunity to provide geotechnical engineering services to you on this project.

Respectfully submitted,

Tetra Tech

Travis Goracke, P.E.
Geotechnical Engineer

TG/ba

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(in four copies)

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EXECUTIVE SUMMARY

The project consists of the expansion of a section of the Billings Landfill to determine if subsurface soil and bedrock conditions are favorable for the construction of an additional cell for disposal of waste. The proposed cell location is directly southwest of the scale house and is approximately 24 acres in size.

On February 20 and 21, 2012, three exploration borings were drilled to identify subsurface soil, bedrock, and groundwater conditions. The subsurface profile in boring DH-1 generally consisted of six feet of lean clay fill overlying shale bedrock, which extends beyond the maximum depth explored, 50.4 feet. The subsurface profile in boring DH-2 generally consisted of shale bedrock extending from the ground surface to beyond the maximum depth explored, 40.5 feet. The subsurface profile in boring DH-3 generally consisted of 15 feet of lean clay fill underlain by shale bedrock which extends beyond the maximum depth explored, 90 feet. Groundwater was not encountered in the borings at the time of the field exploration. Numerous factors contribute to groundwater fluctuations, and evaluation of such factors is beyond the scope of this report.

As requested, the geotechnical investigation was performed to determine if the subsurface soil and bedrock encountered below the proposed Phase V cell expansion has similar engineering properties and the lithology was generally similar to that identified for the exploration borings previously performed for the Phase III and IV expansions. Our findings and conclusions can be found later in this report.

We have prepared this executive summary solely to provide a general overview. This executive summary should not be relied on for any purpose except for that for which it was prepared. Only the full report should be relied on for information about findings, recommendations and other concerns.

PURPOSE AND SCOPE OF STUDY

The purpose of this study is to determine the subsurface lithology of the proposed Phase V cell area and determine if it is consistent with previous expansions explored at the landfill. We understand that if the subsurface soil and bedrock have similar engineering properties, and are encountered at similar depths, the field exploration will provide sufficient design information to provide approval of an alternative liner for Phase V. As requested, historical data from previous investigations, including laboratory testing, has been reviewed and is included in this report.

Tetra Tech, Inc. conducted a field exploration program consisting of drilling three exploration borings in the area of the proposed Phase V expansion to obtain information on site and subsurface conditions. Samples obtained during the field investigation were tested in Tetra Tech's laboratory to determine the physical and engineering characteristics of the on-site soils and bedrock. Results of the field investigation and laboratory tests were analyzed to characterize the site material properties. This report summarizes the field data and presents conclusions based on the proposed construction and subsurface conditions encountered. The investigation was performed in accordance with Tetra Tech's contract with Great West Engineering dated February 9, 2012.

This study does not address a slope stability analysis or provide liner recommendations for the Phase V expansion.

PROJECT DESCRIPTION

The proposed project consists of the expansion of the Billings Landfill within its current property limits to add an additional cell for disposal of waste. The cell is located directly southwest of the existing scale house. The proposed new cell is approximately 24 acres in size and is located between an existing access road to the south, the scale house on the north, existing cells to the east and an existing communications tower to the west. Excavation depth to the base of the cell will vary based on the construction of a new leachate collection system. The project site and proposed cell location are shown on Drawing No. 550852-1.

Looking northeast toward Boring DH-3.

FIELD EXPLORATION

The field exploration was conducted on February 20 and 21, 2012. Three borings were drilled at the locations shown on Drawing No. 550852-1 to explore subsurface soil, bedrock, and groundwater conditions. Borings were advanced through the overburden soils and bedrock with a truck-mounted drill rig equipped with 8-¼-inch diameter hollow-stem augers. The borings were logged by a Tetra Tech representative.

Samples of the upper subsurface materials were taken with 2-inch outside-diameter split-spoon samplers driven into the various strata using a 140-pound hammer falling 30 inches. The number of blows required to advance the sampler each successive 6-inch increment was recorded; the total number of blows required to advance the sampler the second and third 6-inch increments is the penetration resistance (N value). This is the standard penetration test described by American Society for Testing and Materials (ASTM) Method D1586. Penetration resistance values indicate the relative density or consistency of the soils. Bulk samples and split spoon samples of soil were obtained from the hollow-stem augers at locations chosen by the field engineer. Sample depths were recorded on the field log and are shown on the logs of exploration borings.

LABORATORY TESTING

Samples obtained during the field exploration were taken to Tetra Tech's laboratory, where they were observed and visually classified in accordance with ASTM D2487, which is based on the Unified Soil Classification System. Representative samples were selected for testing to determine the engineering and physical properties of the soils in general accordance with ASTM or other approved procedures.

Tests Conducted:	To Determine:
Grain-size Distribution	Size and distribution of soil particles (i.e., clay, silt, sand, and gravel).
Natural Moisture Content	Moisture content representative of field conditions at the time samples were taken.
Atterberg Limits	The effect of varying water content on the consistency of fine-grained soils.
Moisture-Density Relationship	The optimum moisture content for compacting soil and the maximum dry unit weight (density) for a given compactive effort.
Hydraulic Conductivity	The rate with which water will flow through soil.

Field and laboratory test results are summarized on Figures 4 through 22 in the Appendix. These data and the field information were used to prepare the exploration boring logs on Figures 1 through 3.

LOCAL GEOLOGY

The landfill is located in the western half of Section 29 and the eastern half of Section 30, Township 1S, Range 26E and is about 4.5 miles southwest of Billings, Montana. This area marks the southern valley wall to the ancestral floodplain for the Yellowstone River. Maximum relief between the ridge tops and floodplain ranges from about 250 feet to 330 feet. Many of the north-facing slopes along the valley wall are oversteepened as a result of erosion at the toe by past meandering of the Yellowstone River. Topography above the floodplain is dissected by secondary, intermittent drainages forming parallel trending ridgelines and steep V shaped drainages profiles. Inclination of side slopes in secondary drainages range from approximately 33 to 35 degrees near the crestline steepening to between 42 to 57 degrees on the sidewalls.

Hills in the area are comprised of redeposited alluvial clay soils overlying claystone-shale from the Mowery formation. The shale is lower Cretaceous in age. When viewed in cross-section, the slope inclination increases at the transition from clay soil to claystone-shale. This contact is readily identifiable within the landfill site.

At most exposed claystone-shale outcrop locations, clay soil is encountered at the top of the bedrock. Upon inspection of the clay soil texture, thin parallel platelets of shale and claystone are observed. This information indicates an old erosional surface existed at the top of the claystone-shale which was subsequently buried by more recent clay soil deposits. The old bedrock topography can be characterized as moderate rolling hills and U shaped drainages.

The Cretaceous claystone-shale is encountered extensively throughout the landfill. It is typically dark gray in color, fissile, thinly laminated and jointed. When exposed, the shale slakes and weathers near the surface but becomes hard and competent with increasing depth of penetration. Occasional highly plastic beds varying from about one foot to several feet thick are interbedded throughout the shale.

SUBSURFACE CONDITIONS

The subsurface profile in boring DH-1 generally consisted of six feet of lean clay fill overlying shale bedrock, which extends beyond the maximum depth explored, 50.4 feet. The subsurface profile in boring DH-2 generally consisted of shale bedrock extending from the ground surface to beyond the maximum depth explored, 40.5 feet. The subsurface profile in boring DH-3 generally consisted of 15 feet of lean clay fill underlain by shale bedrock which extends beyond the maximum depth explored, 90 feet. Groundwater was not encountered in the borings at the time of the field exploration.

The boring logs should be referenced for complete descriptions of the soil and rock types and their estimated depths. A characterization of the subsurface profile normally includes grouping soils with similar physical and engineering properties into a number of distinct layers. The representative subsurface layers at the site are presented below, starting at the ground surface.

FILL

Fill was encountered at the surface in Boring DH-3. The fill visually classifies as lean clay according to ASTM D2487. The fill contained scattered fine grained sand lenses and fine to coarse subrounded gravel. Penetration resistance values ranged from 14 to 16 blows per foot. The natural moisture content varies from 10 to 29 percent.

Lean CLAY (CL)

Lean clay was encountered at the surface in Boring DH-1. The clay visually classifies as lean clay according to ASTM D2487. Penetration values in the clay are on the order of 10 blows per foot which is indicative of a stiff soil stratum. The natural moisture content ranged from 15 to 19 percent.

SHALE

Shale was encountered below the clay in Boring DH-1, at the surface in Boring DH-2, and below the fill in Boring DH-3. The shale is medium hard to hard with medium to high plasticity characteristics. Penetration values in the shale bedrock exceeded 50 blows per foot. Specific gravities performed on the shale bedrock ranged from 2.66 to 2.73. The natural moisture content varies from 7 to 17 percent. Liquid and plastic limit tests indicate the shale has a liquid limit varying from 42 to 67 percent and a plasticity index varying from 23 to 46 percent (Figures 4 through 12). A moisture density relationship test performed on the shale indicates a maximum dry density on the order of 102.9 pounds per cubic foot at optimum moisture content of 19.6 percent (Figure 13). A hydraulic conductivity test performed on a sample of shale bedrock remolded to 95 percent of the maximum dry density, as determined by ASTM D698, indicates a rate of 4.64×10^{-7} centimeters per second (Figure 14). Hydraulic conductivity tests performed on samples of shale bedrock remolded to near in-place density measured indicate a rate varying from 2.56×10^{-9} to 7.87×10^{-9} centimeters per second (Figures 15 through 19). Hydraulic conductivity tests performed on undisturbed core samples of shale bedrock indicate a rate varying from 2.19×10^{-11} to 7.16×10^{-11} centimeters per second (Figures 20 through 22).

GROUNDWATER

Groundwater was not encountered in the borings at the time of the field exploration. Numerous factors contribute to groundwater fluctuations, and evaluation of such factors is beyond the scope of this report.

CONCLUSIONS

The requested scope of work for this project was to determine if the subsurface lithology of the proposed Phase V expansion area was generally similar to that encountered in the exploration borings performed for the Phase III and IV expansions located to the north. The requested scope was also to determine if the subsurface soil and bedrock have similar engineering properties, and are encountered at similar depths as the previous expansions.

When comparing our findings from the field investigation performed for this study to the previous investigations performed in February of 2009 and in March and April of 2007, minor variations in the subsurface profile such as the thickness of the fill, clay and claystone were observed. This can be attributed to an irregular bedrock contact variations in the existing topography and disturbance from previous landfill operations and excavations. The hydraulic conductivity rates from samples obtained in the Phase III expansion ranged from 1.9×10^{-9} to 3.8×10^{-9} centimeters per second. Samples from the Phase IV expansion ranged from 1.09×10^{-8} to 3.36×10^{-9} centimeters per second. In general, it is our opinion that the subsurface profile and engineering properties of the bedrock and soil stratum encountered at the Phase V expansion are similar to those encountered in the Phase III and IV expansions.

It should be noted that slope stability and liner recommendations were not requested or addressed by this study. Due to the limited number of borings drilled at the site, it is possible that soil and rock conditions may differ from those included in this report. Tetra Tech should observe the excavation prior to the placement of the plastic liner to verify soil and bedrock conditions are similar to those encountered during the field exploration. If needed, further investigation and additional recommendations can be provided at your request.

CONTINUING SERVICES

Two additional elements of geotechnical engineering service are important to the successful completion of this project.

1. **Consultation with Tetra Tech, Inc. during the design phase.** This is essential to ensure that the intent of our recommendations is incorporated in design decisions related to the project and that changes in the design concept consider geotechnical aspects.

2. **Observation and monitoring during construction.** Tetra Tech should be retained to observe the earthwork phases of the project, to determine that the subsurface conditions are compatible with those used in our analysis and design. Placement of fill should be observed on a full time basis and tested to confirm that the required density has been achieved. In addition, if environmental contaminants or other concerns are discovered in the subsurface, Tetra Tech professionals are available for consultation.

LIMITATIONS

This study has been conducted in accordance with generally accepted geotechnical engineering practices in the region where the work was conducted. The conclusions and recommendations submitted in this report are based upon project information provided to Tetra Tech and data obtained from the exploratory borings drilled at the locations indicated. The nature and extent of subsurface variations across the site may not become evident until construction. Tetra Tech should be on site during construction, to verify that actual subsurface conditions are consistent with those described herein.

This report has been prepared exclusively for our client. This report and the data included herein shall not be used by any third party without the express written consent of both the client and Tetra Tech. Tetra Tech is not responsible for technical interpretations by others. As the project evolves, we should provide continued consultation and field services during construction to review and monitor the implementation of our recommendations, and verify that our recommendations have been appropriately interpreted. Significant design changes may require additional analysis or modifications of the recommendations presented herein. We recommend on-site observation of excavations and foundation bearing strata and testing of fill by a representative of the geotechnical engineer.

Prepared by: Travis Goracke, P.E. Reviewed by: Jared Jung, P.E.

Appendices

IMPORTANT INFORMATION
ABOUT YOUR
GEOTECHNICAL ENGINEERING REPORT

More construction problems are caused by site subsurface conditions than any other factor. As troublesome as subsurface problems can be, their frequency and extent have been lessened considerably in recent years, due in large measure to programs and publications of ASFE/The Association of Engineering Firms Practicing in the Geosciences.

The following suggestions and observations are offered to help you reduce the Geotechnical-related delays, cost-overruns and other costly headaches that can occur during a construction project.

A GEOTECHNICAL ENGINEERING REPORT IS BASED ON A UNIQUE SET OF PROJECT-SPECIFIC FACTORS

A Geotechnical engineering report is based on a subsurface exploration plan designed to incorporate a unique set of project-specific factors. These typically include: the general nature of the structure involved, its size and configuration; the location of the structure on the site and its orientation; physical concomitants such as access roads, parking lots, and underground utilities, and the level of additional risk which the client assumed by virtue of limitations imposed upon the exploratory program. To help avoid costly problems, consult the geotechnical engineer to determine how any factors which change subsequent to the date of the report may affect its recommendations.

Unless your consulting Geotechnical engineer indicates otherwise, *your Geotechnical engineer report should not be used:*

- When the nature of the proposed structure is changed, for example, if an office building will be erected instead of a parking garage, or if a refrigerated warehouse will be built instead of an unrefrigerated one;
- when the size or configuration of the proposed structure is altered;
- when the location or orientation of the proposed structure is modified:
- when there is a change of ownership, or
- for application to an adjacent site.

Geotechnical engineers cannot accept responsibility for problems which may develop if they are not consulted after factors considered in their reports' development have changed.

MOST GEOTECHNICAL "FINDINGS" ARE PROFESSIONAL ESTIMATES

Site exploration identifies actual subsurface conditions only at those points where samples are taken, when they are taken. Data derived through sampling and subsequent laboratory testing are extrapolated by geotechnical engineers who then render an opinion about overall subsurface conditions, their likely reaction to proposed conditions, their likely reaction to proposed construction activity, and appropriate foundation design. Even under optimal circumstances actual conditions may differ from those inferred to exist, because no Geotechnical engineer, no matter how qualified, and no subsurface exploration program, no matter how comprehensive, can reveal what is hidden by earth, rock and time. The actual interface between materials may be far more gradual or abrupt than a report indicates. Actual conditions in areas not sampled may differ from predictions. *Nothing can be done to prevent the unanticipated, but steps can be taken to help minimize their impact.* For this reason, *most experienced owners retain their Geotechnical consultants through the construction stage*, to identify variances, conduct additional tests which may be needed, and to recommend solutions to problems encountered on site.

SUBSURFACE CONDITIONS CAN CHANGE

Subsurface conditions may be modified by constantly-changing natural forces. Because a Geotechnical engineering report is based on conditions which existed at the time of subsurface exploration, *construction decisions should not be based on a Geotechnical engineering report whose adequacy may have been affected by time.* Speak with the Geotechnical consultant to learn if additional tests are advisable before construction starts.

Construction operations at or adjacent to the site and natural events such as flood, earthquakes or groundwater fluctuations may also affect subsurface conditions and, thus, the continuing adequacy of a geotechnical report. The geotechnical engineer should be kept apprised of any such events, and should be consulted to determine if additional tests are necessary.

GEOTECHNICAL SERVICES ARE PREFORMED FOR SPECIFIC PURPOSES AND PERSONS

Geotechnical engineers' reports are prepared to meet the specific needs of specific individuals. A report prepared for a consulting civil engineer may not be adequate for a construction contractor, or even some other consulting civil engineer. Unless indicated otherwise, this report was prepared expressly for the client involved and expressly for purposes indicated by the client. Use by any other persons for any purpose, or by the client for a different purpose, may result in problems. *No individual other than the client should apply this report for its intended purpose without first conferring with the geotechnical engineer. No person should apply this report for any purpose other than that originally contemplated without first conferring with the geotechnical engineer.*

A GEOTECHNICAL ENGINEERING REPORT IS SUBJECT TO MISINTERPRETATION

Costly problems can occur when other design professionals develop their plants based on misinterpretations of a geotechnical engineering report. To help avoid these problems, the geotechnical engineer should be retained to work with other appropriate design professionals to explain relevant geotechnical findings and to review the adequacy of their plans and specifications relative to geotechnical issues.

BORING LOGS SHOULD NOT BE SEPARATED FROM THE ENGINEERING REPORT

Final boring logs are developed by geotechnical engineers based upon their interpretation of field logs (assembled by site personnel) and laboratory evaluation of field samples. Only final boring logs customarily are included in geotechnical engineering reports. *These logs should not under any circumstances be redrawn* for inclusion in architectural or other design drawings, because drafters may commit errors or omissions in the transfer process. Although photographic reproduction eliminates this problem, it does nothing to minimize the possibility of contractors misinterpreting the logs during bid preparation. When this occurs, delays, disputes and unanticipated costs are the all-too-frequent result.

To minimize the likelihood of boring log misinterpretation, *give contractors ready access to the complete geotechnical engineering report* prepared or authorized for their use. Those who do not provide such access may proceed under the *mistaken* impression that simply disclaiming responsibility for the accuracy of subsurface information always insulates them from attendant liability. Providing the best available information to contractors helps prevent costly construction problems and the adversarial attitudes which aggravate them to disproportionate scale.

READ RESPONSIBILITY CLAUSES CLOSELY

Because geotechnical engineering is based extensively on judgment and opinion, it is far less exact than other design disciplines. This situation has resulted in wholly unwarranted claims being lodged against geotechnical consultants. To help prevent this problem, geotechnical engineers have developed model clauses for use in written transmittals. These are *not* exculpatory clauses designed to foist geotechnical engineers' liabilities onto someone else. Rather, they are definitive clauses which identify where geotechnical engineers' responsibilities begin and end. Their use helps all parties involved recognize their individual responsibilities and take appropriate action. Some of these definitive clauses are likely to appear in your geotechnical engineering report, and you are encouraged to read them closely. Your geotechnical engineer will be pleased to give full and frank answers to your questions.

OTHER STEPS YOU CAN TAKE TO REDUCE RISK

Your consulting geotechnical engineer will be pleased to discuss other techniques which can be employed to mitigate risk. In addition, ASFE as developed a variety of materials which may be beneficial. Contact ASFE for a complimentary copy of its publications directory.

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TETRA TECH

LOGS OF EXPLORATIONS
EXPLANATION OF ABBREVIATIONS AND DESCRIPTIVE TERMS

SSS (SPT) - Standard penetration resistance test – results recorded as the number of blows of a 140-pound hammer falling 30 inches required to drive a 2-inch O.D. split sample spoon the second and third 6-inch increments of an 18-inch distance.

LSS - Modified penetration test – results recorded as the number of blows of a 140-pound hammer falling 30 inches required to drive a 2.5-inch O.D. split spoon the second and third 6-inch increments of an 18-inch distance.

SRS - Split barrel ring sampler 2-inches I.D. for taking undisturbed samples.

LRS - Split barrel ring sampler 2.5 inches I.D. for taking undisturbed samples.

STS - Shelby tube sampler for taking undisturbed samples (2" to 3-5/16" I.D.).

Sack (SK) or Bag - Sample of disturbed soil placed in canvas sack or plastic bag.

GWL - Groundwater level on the date shown on the logs.

RQD - Rock quality designation (RQD) for the bedrock samples are determined for each core run by summing the length of all sound, hard pieces of core over four inches in length, and dividing this number by the total length of the core run. This value, along with the core recovery percentage, is recorded on the drill logs.

GRAIN SIZES

	U.S. Standard Series Sieve					Clear Square Sieve Openings
	200	40	10	4	¾"	3" 12"
Silts & Clays Distinguished on Basis of Plasticity	SAND			GRAVEL		Cobbles Boulders
	Fine	Medium	Coarse	Fine	Coarse	

CONSISTENCY		RELATIVE DENSITY	
Clays & Silts	SPT* Blows/foot	Sands & Gravels	SPT* Blows/foot
Very Soft	0 – 2	Very Loose	0 – 4
Soft	3 – 4	Loose	5 – 10
Firm	5 – 8	Medium Dense	11 – 30
Stiff	9 – 15	Dense	31 – 50
Very Stiff	15 – 30	Very dense	Over 50
Hard	Over 30		

*Standard Penetration Test; PL = Plastic Limit; LL = Liquid Limit

CLASSIFICATION OF SOILS FOR ENGINEERING PURPOSES

ASTM Designation: D 2487 - 83

(Based on Unified Soil Classification System)

Criteria for Assigning Group Symbols and Group Names Using Laboratory Tests[A]				Soil Classification: Group Symbol	Soil Classification: Name[B]
Coarse-Grained Soils More than 50% retained on No. 200 sieve	Gravels More than 50% coarse fraction retained on No. 4 sieve	Clean Gravels Less than 5% fines[C]	Cu≥4 and 1≤Cc≤3[E]	GW	Well graded gravel[F]
			Cu<4 and/or 1>Cc>3[E]	GP	Poorly graded gravel[F]
		Gravels with Fines More than 12% fines[C]	Fines classify as ML or MH	GM	Silty gravel[F,G,H]
			Fines classify as CL or CH	GC	Clayey gravel[F,G,H]
	Sands 50% or more of coarse fraction passes No. 4 sieve	Clean Sands Less than 5% fines[D]	Cu≥6 and 1≤Cc≤3[E]	SW	Well-graded sand[I]
			Cu<6 and/or 1>Cc>3[E]	SP	Poorly graded sand[I]
		Sands with Fines More than 12% fines[D]	Fines classify as ML or MH	SM	Silty sand[G,H,I]
			Fines classify as CL or CH	SC	Clayey sand[G,H,I]
Fine-Grained Soils 50% or more passes the No. 200 sieve	Silts and Clays Liquid limit less than 50	inorganic	PI>7 and plots on or above "A" line[J]	CL	Lean clay[K,L,M]
			PI<4 or plots below "A" line[J]	ML	Silt[K,L,M]
		organic	$\frac{\text{Liquid limit - oven dried}}{\text{Liquid limit - not dried}} < 0.75$	OL	Organic clay[K,L,M,N] Organic silt[K,L,M,O]
	Silts and Clays Liquid limit 50 or more	inorganic	PI plots on or above "A" line	CH	Fat clay[K,L,M]
			PI plots below "A" line	MH	Elastic silt[K,L,M]
		organic	$\frac{\text{Liquid limit - oven dried}}{\text{Liquid limit - not dried}} < 0.75$	OH	Organic clay[K,L,M,P]
					Organic silt[K,L,M,Q]
Highly organic soils	Primarily organic matter, dark in color, and organic odor			PT	Peat

[A] Based on the material passing the 3-in. (75-mm) sieve

[B] If field sample contained cobbles or boulders, or both, add "with cobbles or boulders, or both" to group name

[C] Gravels with 5 to 12% fines require dual symbols
- GW-GM well-graded gravel with silt
- GW-GC well-graded gravel with clay
- GP-GM poorly graded gravel with silt
- GP-GC poorly graded gravel with clay

[D] Sands with 5 to 12% fines require dual symbols
- SW-SM well-graded sand with silt
- SW-SC well-graded sand with clay
- SP-SM poorly graded sand with silt
- SP-SC poorly graded sand with clay

[E] $Cu = D_{60}/D_{10}$ $Cc = \frac{(D_{30})^2}{D_{10} \times D_{60}}$

[F] If soil contains ≥15% sand, add "with sand" to group name

[G] If fines classify as CL-ML, use dual symbol GC-GM, or SC-SM

[H] If fines are organic, add "with organic fines" to group name

[I] If soil contains ≥15% gravel, add "with gravel" to group name

[J] If Atterberg limits plot in hatched area, soil is a CL-ML, silty clay

[K] If soil contains 15 to 29% plus No. 200, add "with sand" or "with gravel", whichever is predominant

[L] If soil contains ≥30% plus No. 200, predominantly sand, add "sandy" to group name

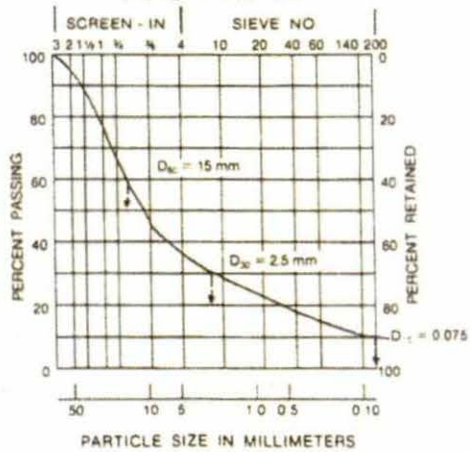
[M] If soil contains ≥30% plus No. 200, predominantly gravel add "gravelly" to group name

[N] PI≥4 and plots on or above "A" line

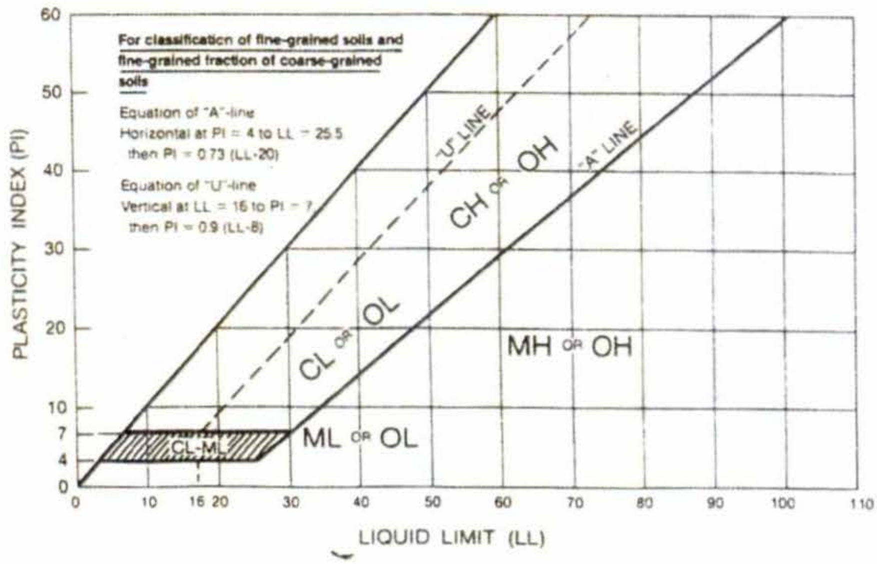
[O] PI<4 or plots below "A" line

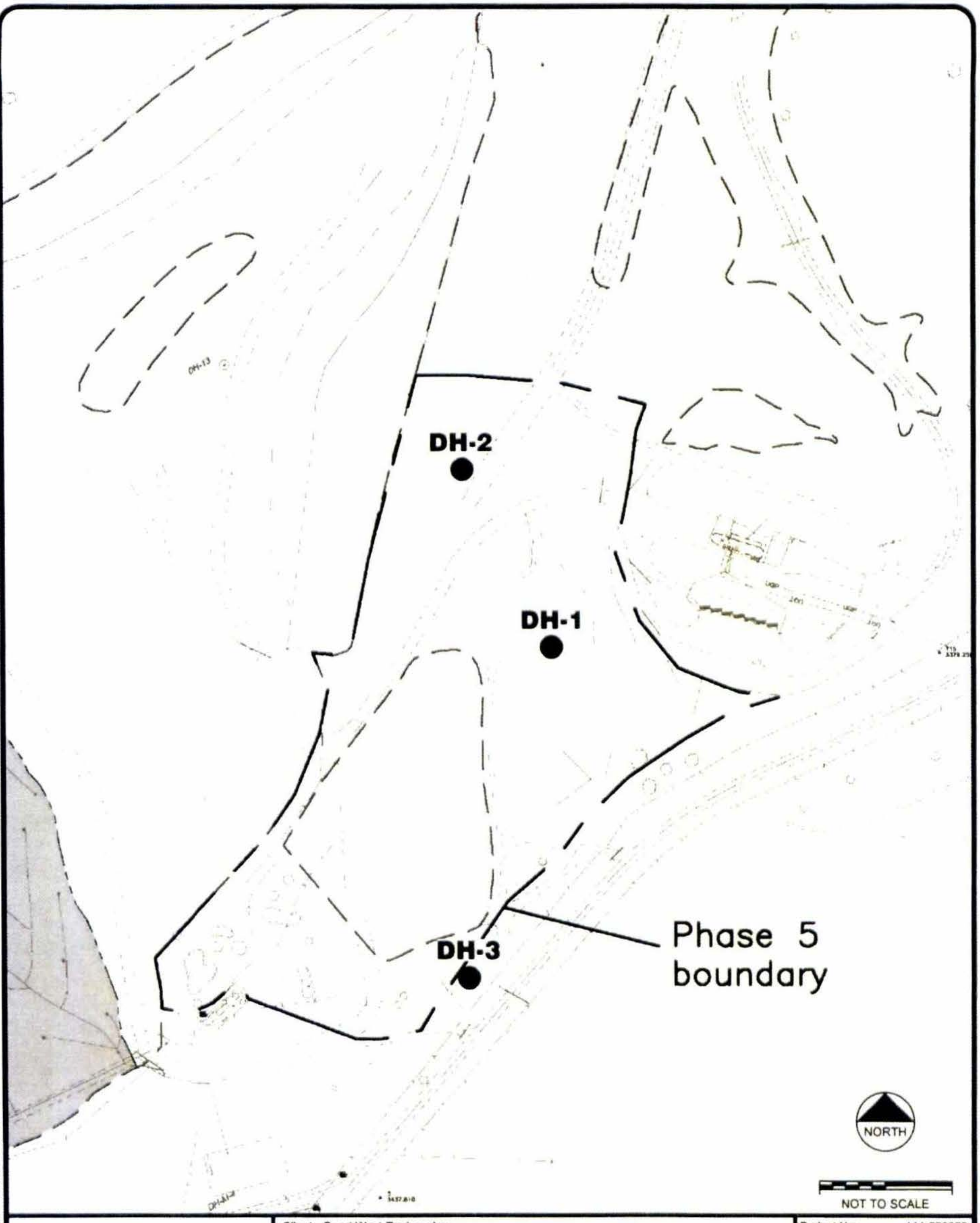
[P] PI plots on or above "A" line

[Q] PI plots below "A" line



$C_u = \frac{D_{60}}{D_{10}} = \frac{15}{0.075} = 200$ $C_c = \frac{(D_{30})^2}{D_{10} \times D_{60}} = \frac{(2.5)^2}{0.075 \times 15} = 5.6$





3/28/2012 10:15:01 AM - N:\GEO\MONTANA JOBS\2012 MT JOBS\114-550852 - BILLINGS LANDFILL PHASE V EXPAN\DRAFTING\550852-1.DWG - TAYLOR, MARIE

TETRA TECH www.tetratech.com 618 South 25th Street Billings, MT 59101-4549 PHONE: 406-248-9161 FAX: 406-248-9282	Client: Great West Engineering Billings Landfill Phase V Expansion Billings, Montana LOCATION OF EXPLORATORY BORINGS	Project No.: 114-550852 Date: March 2012 Drawn By: MAT DRAWING 550852-1

Project Name: Billings Landfill Phase V Expansion

Borehole Location: See Drawing 550852-1

Borehole Number: DH-1		Driller: Haztech	Logger: Travis Goracke
Drilling Equipment: BK-81	Borehole Diameter (in.): 8.25	Date Started: 2-20-12	Date Finished: 2-20-12

Elevation and Datum: Ground: 3383

Notes: Center Boring. Elevation provided by Great West Engineering.

DEPTH (ft)	STANDARD PENETRATION TEST SPT	MOISTURE CONTENT (%)	DRY DENSITY (pcf)	LIQUID LIMIT LL	PLASTICITY INDEX PI	-200 (%)	MATERIAL DESCRIPTION	DEPTH (ft)
0	2-2-8	19.5					**Lean CLAY** - brown, moist.	
		15.0						6
	15-22-26						**SHALE** - gray, moderately hard rock, moist, weathered in the upper 2 feet, blocky structure in the upper 8 feet, thinly laminated from 8.5 to 50.4 feet.	
10	15-29-41	13.7						
	36-50/0.4	9.1	118.3	43	24	97		
20	44-50/0.2	8.3						
	42-50/0.2	9.0	136.1	44	26	98		
30	47-50/0.2	8.6						
	50/0.5	10.1	121	59	40	99		
40	44-50/0.2	9.9						
	50/0.4	10.6	123.1	67	46	93		
50	50/0.4							50.4

End of Boring.

Sampler Types: Split Spoon; Shelby; Bulk Sample; Grab Sample; Penetrometer; Vane Shear; California; Test Pit

Operation Types: Hand Auger; Auger; Air Rotary; Core Barrel; Excavated Pit

WATER LEVEL OBSERVATIONS

While Drilling ∇ Dry ft Upon Completion of Drilling ▼ Dry ft

Time After Drilling

Depth To Water (ft)

Remarks:

114-550852 | TETRA TECH | **LOG OF EXPLORATORY BORING DH-1** | Fig. 1

Project Name: Billings Landfill Phase V Expansion

Borehole Location: See Drawing 550852-1 | Sheet 1 of 1

Borehole Number: DH-2 | Driller: Haztech | Logger: Travis Goracke

Drilling Equipment: BK-81 | Borehole Diameter (in.): 8.25 | Date Started: 2-20-12 | Date Finished: 2-20-12

Elevation and Datum: Ground: 3350

Notes: North Boring. Elevation provided by Great West Engineering.

DEPTH (ft)	STANDARD PENETRATION TEST SPT	MOISTURE CONTENT (%)	DRY DENSITY (pcf)	LIQUID LIMIT LL	PLASTICITY INDEX PI	-200 (%)	MATERIAL DESCRIPTION	DEPTH (ft)
0	4-13-24	15.2					**SHALE** - gray, moderately hard rock, moist, upper 2 feet is weathered, blocky structure in the upper 5 feet, thinly laminated from 5 to 40.5, bentonite noted in 40 foot splitspoon.	
5	18-33-50/0.3	12.7						
10	34-50/0.4	8.5						
15	50/0.5	6.7						
20	50/0.4	7.9	122.6	43	24	97		
25	50/0.4	7.8						
30	50/0.4	8.5						
35	50/0.4	7.3	126.1	45	27	93		
40	50/0.5	17.4					End of Boring.	40.5

Sampler Types: Split Spoon; Shelby; Bulk Sample; Grab Sample; Penetrometer; Vane Shear; California; Test Pit

Operation Types: Hand Auger; Auger; Air Rotary; Core Barrel; Excavated Pit

WATER LEVEL OBSERVATIONS

While Drilling: Dry ft | Upon Completion of Drilling: Dry ft

Time After Drilling:

Depth To Water (ft):

Remarks:

114-550852 | TETRA TECH | LOG OF EXPLORATORY BORING DH-2 | Fig. 2

Project Name: Billings Landfill Phase V Expansion			
Borehole Location: See Drawing 550852-1			Sheet 1 of 2
Borehole Number: DH-3		Driller: Haztech	Logger: Travis Goracke
Drilling Equipment: BK-81	Borehole Diameter (in.): 8.25	Date Started: 2-21-12	Date Finished: 2-21-12
Elevation and Datum: Ground: 3458	Notes: South Boring. Elevation provided by Great West Engineering.		

DEPTH (ft)	DRILL OPERATION	SAMPLE	STANDARD PENETRATION TEST SPT	MOISTURE CONTENT (%)	DRY DENSITY (pcf)	LIQUID LIMIT LL	PLASTICITY INDEX PI	-200 (%)	GRAPHIC LOG	MATERIAL DESCRIPTION	DEPTH (ft)
	Auger	Bulk	8-8-7	10.5						**FILL - Lean Clay** - brown, stiff to very stiff, moist, scattered fine grained sand lenses and fine to coarse subrounded gravel.	
	Auger	Split Spoon	5-6-10	28.8							
10	Auger	Split Spoon	4-5-9	16.8							
	Auger	Bulk	5-9-11	39.1						**BENTONITE** - yellow to gray, very soft rock, moist, blocky structure, high plasticity.	15
20	Auger	Split Spoon	13-24-26	13.8						**SHALE** - gray, moderately hard rock, weathered from 18 to 33 feet, blocky structure from 18 to 33 feet, thinly laminated from 33 to 76.8	18
	Auger	Split Spoon	14-16-17	12.9							
30	Auger	Split Spoon	11-17-21	13.0							
	Core Barrel									Highly fractured zone noted from 35 to 37 feet.	
40	Core Barrel									Iron staining noted in joint at 36.8 feet. Broken zone with thin bentonite lenses noted from 37 to 37.2 feet, maintained circulation.	
	Core Barrel									Iron staining noted in joint at 41.5 feet.	
50	Core Barrel										

Sampler Types: Split Spoon; Shelby; Bulk Sample; Grab Sample; Penetrometer; Vane Shear; California; Test Pit

Operation Types: Hand Auger; Auger; Air Rotary; Core Barrel; Excavated Pit

WATER LEVEL OBSERVATIONS

While Drilling ▽ Dry ft Upon Completion of Drilling ▼ Dry ft

Time After Drilling

Depth To Water (ft)

Remarks:

114-550852	TETRA TECH	LOG OF EXPLORATORY BORING DH-3	Fig. 3

Project Name: Billings Landfill Phase V Expansion			
Borehole Location: See Drawing 550852-1			Sheet 2 of 2
Borehole Number: DH-3		Driller: Haztech	Logger: Travis Goracke
Drilling Equipment: BK-81	Borehole Diameter (in.): 8.25	Date Started: 2-21-12	Date Finished: 2-21-12
Elevation and Datum: Ground: 3458	Notes: South Boring. Elevation provided by Great West Engineering.		

DEPTH (ft)	DRILL OPERATION	SAMPLE	STANDARD PENETRATION TEST SPT	MOISTURE CONTENT (%)	DRY DENSITY (pcf)	LIQUID LIMIT LL	PLASTICITY INDEX PI	-200 (%)	GRAPHIC LOG	MATERIAL DESCRIPTION	DEPTH (ft)
										SHALE - gray, moderately hard rock, weathered from 18 to 33 feet, blocky structure from 18 to 33 feet, thinly laminated from 33 to 76.8	
				6.5	146.3	42	23	95			
60											
										6 inch weathered zone noted at 65 feet, highly fractured from 65 to 68 feet, maintained circulation.	
										Bentonite infilling noted in joints at 68 feet.	
70										6-inch weathered zone noted at 69.5 feet.	
				7.3	138.7	48	28	98			
											76.8
										BENTONITE - yellow to gray, very soft rock, blocky structure, high plasticity.	77.7
										SHALE - gray, moderately hard rock, thinly laminated.	
80											
										Bentonite infilling noted in joint at 81.8 feet.	
				7.6	137.5	55	32	99			
										Thin interbedded bentonite seams noted from 88.2 to 88.6 feet.	
90										6-inch bentonite zone noted from 89.5 to 90 feet.	90
										End of Boring.	

Sampler Types: Split Spoon; Penetrometer; Shelby; Vane Shear; Bulk Sample; California; Grab Sample; Test Pit

Operation Types: Auger; Hand Auger; Air Rotary; Core Barrel; Excavated Pit

WATER LEVEL OBSERVATIONS

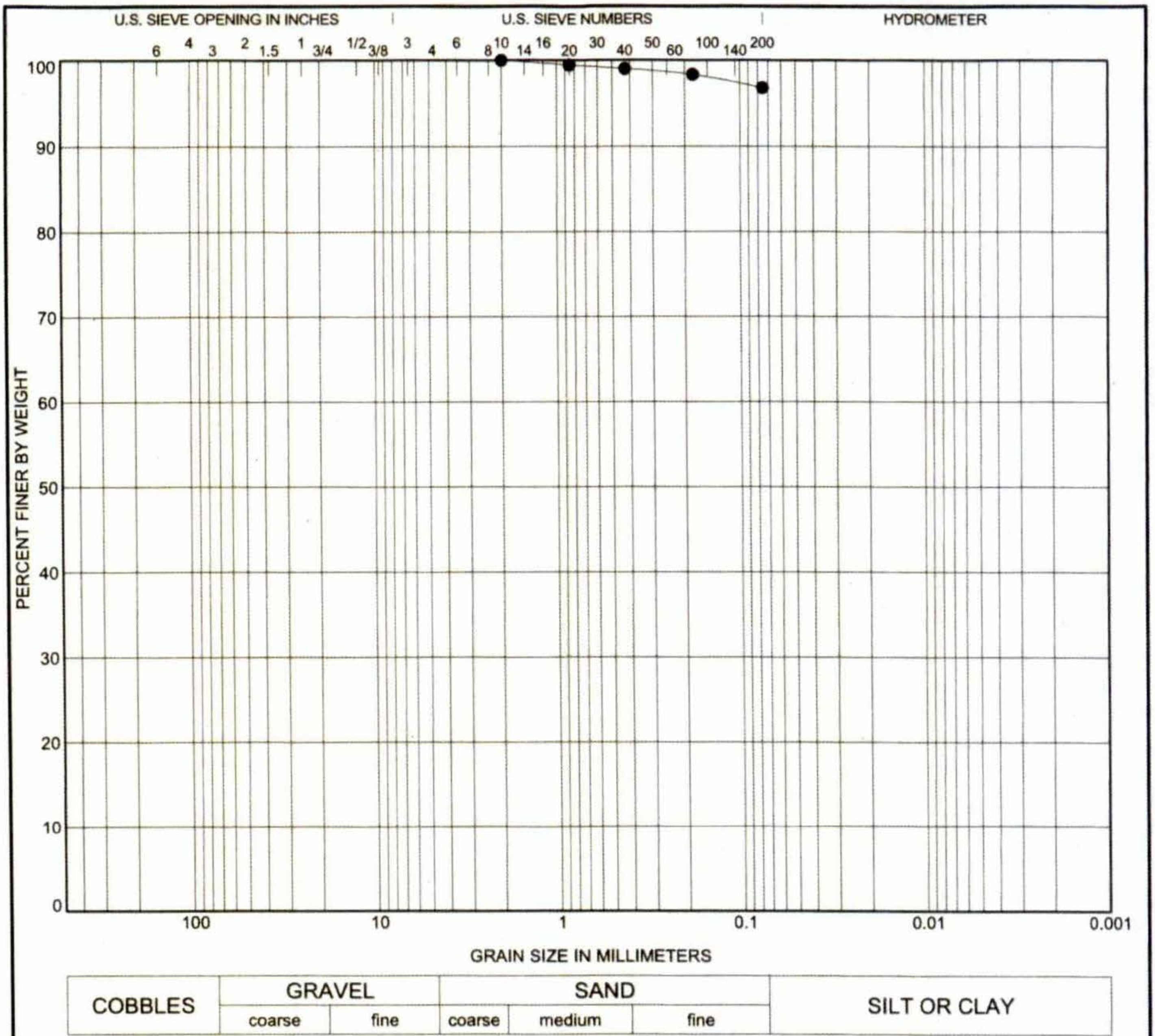
While Drilling ∇ Dry ft   Upon Completion of Drilling ▼ Dry ft

Time After Drilling

Depth To Water (ft)

Remarks:

114-550852	TETRA TECH	LOG OF EXPLORATORY BORING DH-3	Fig. 3



Specimen Identification	Classification	LL	PL	PI	Cc	Cu
DH-1 - (15 - 15.9 ft)	**LEAN CLAY(CL)**	**43**	**19**	**24**		

Specimen Identification	D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
DH-1 - (15 - 15.9 ft)	**2**				**0**	**3**	**97**	

TETRA TECH

GRAIN SIZE DISTRIBUTION

Project: Billings Landfill Phase V Expansion

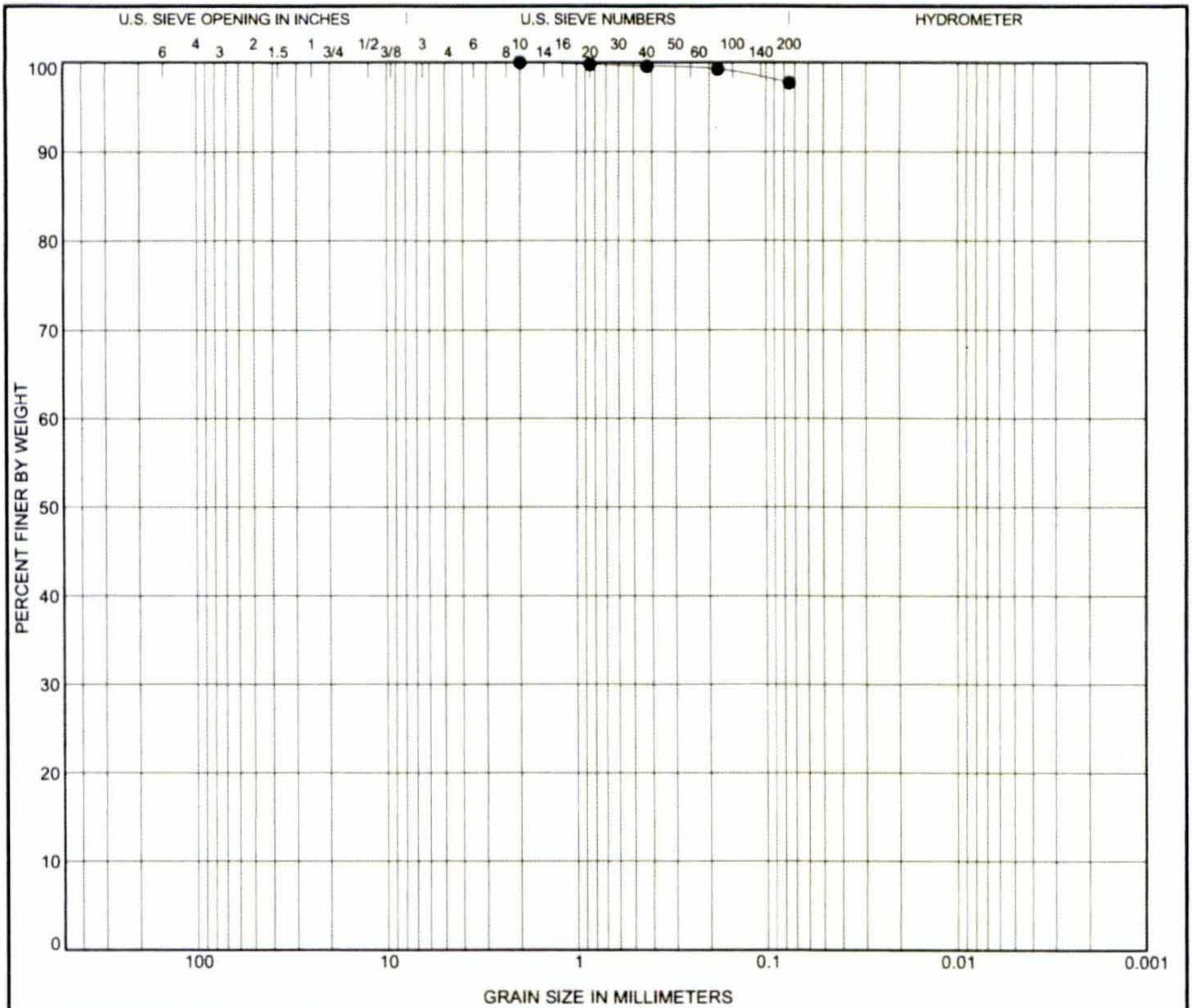
Location: See Drawing 550852-1

Number: 114-550852

Figure No. 4

BILLINGS LANDFILL LOGS.GPJ 3-29-12 TT_US GRAIN SIZE

Revised 1-23-08 (MAT)



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

Specimen Identification	Classification	LL	PL	PI	Cc	Cu
DH-1 - (25 - 25.7 ft)	**LEAN CLAY(CL)**	**44**	**18**	**26**		

Specimen Identification	D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
DH-1 - (25 - 25.7 ft)	**2**				**0**	**2**	**98**	

TETRA TECH

GRAIN SIZE DISTRIBUTION

Project: Billings Landfill Phase V Expansion

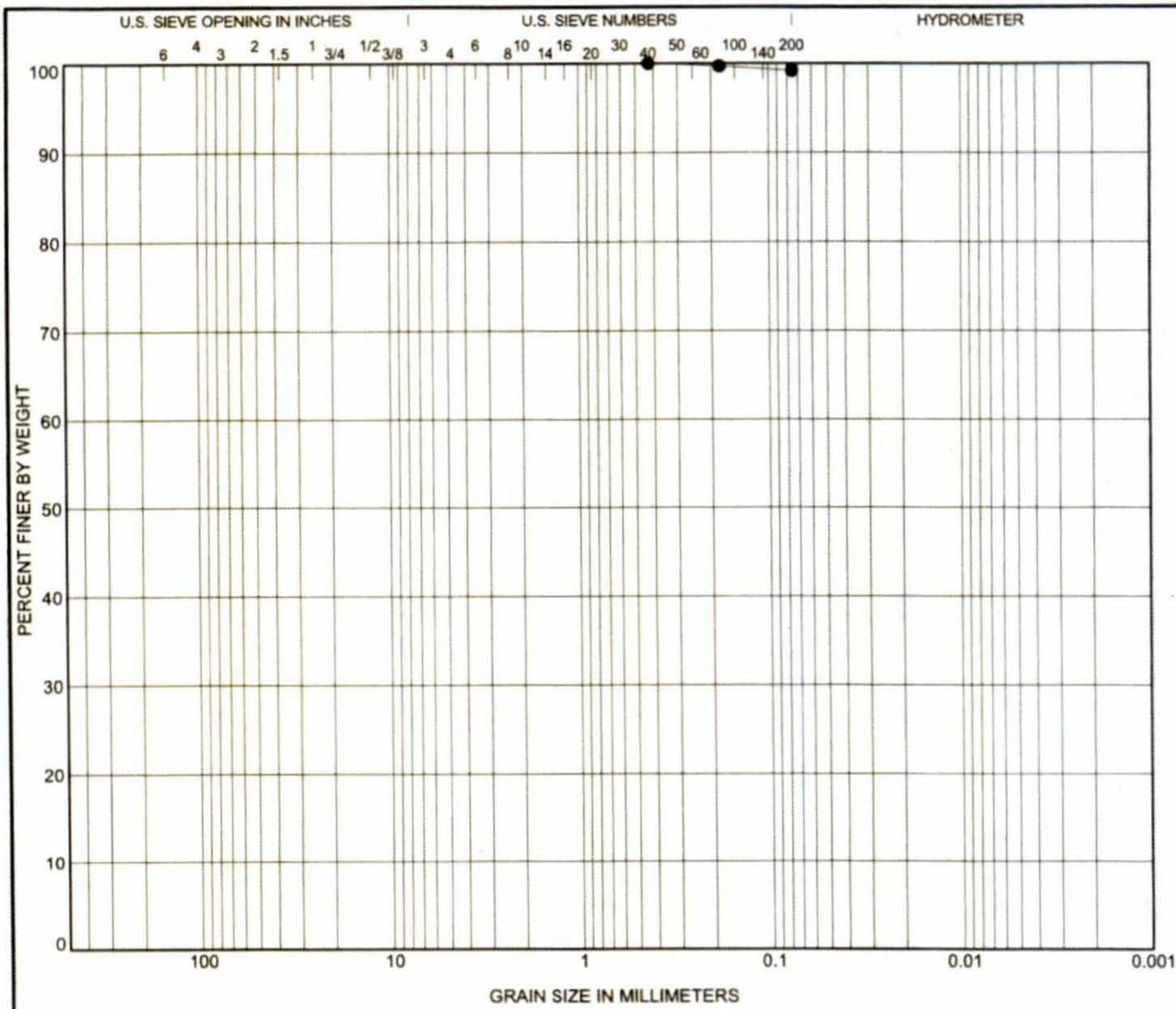
Location: See Drawing 550852-1

Number: 114-550852

Figure No. 5

BILLINGS LANDFILL LOGS.GPJ 3-29-12 TT_US GRAIN SIZE

Revised 1-23-08 (MAT)



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

Specimen Identification	Classification	LL	PL	PI	Cc	Cu
DH-1 - (35 - 35.5 ft)	FAT CLAY(CH)	59	19	40		

Specimen Identification	D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
DH-1 - (35 - 35.5 ft)	0.425				0	1	99	

TETRA TECH

GRAIN SIZE DISTRIBUTION

Project: Billings Landfill Phase V Expansion

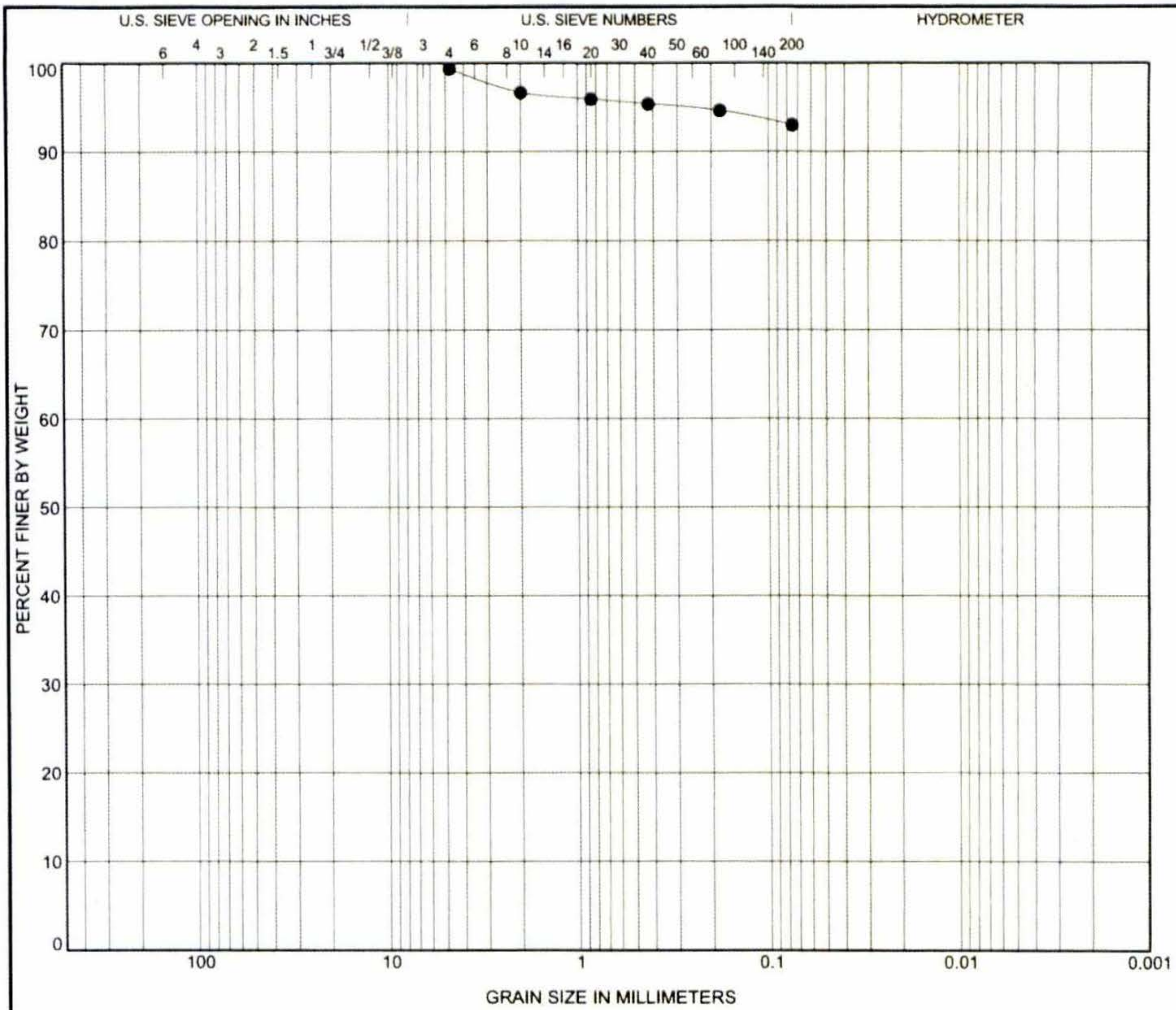
Location: See Drawing 550852-1

Number: 114-550852

Figure No. 6

BILLINGS LANDFILL LOGS.GPJ 3-29-12 TT_US GRAIN SIZE

Revised 1-23-08 (MAT)



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

Specimen Identification	Classification	LL	PL	PI	Cc	Cu
DH-1 - (45 - 45.4 ft)	**FAT CLAY(CH)**	**67**	**20**	**47**		

Specimen Identification	D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
DH-1 - (45 - 45.4 ft)	**4.75**				**0**	**6**	**93**	

TETRA TECH

GRAIN SIZE DISTRIBUTION

Project: Billings Landfill Phase V Expansion

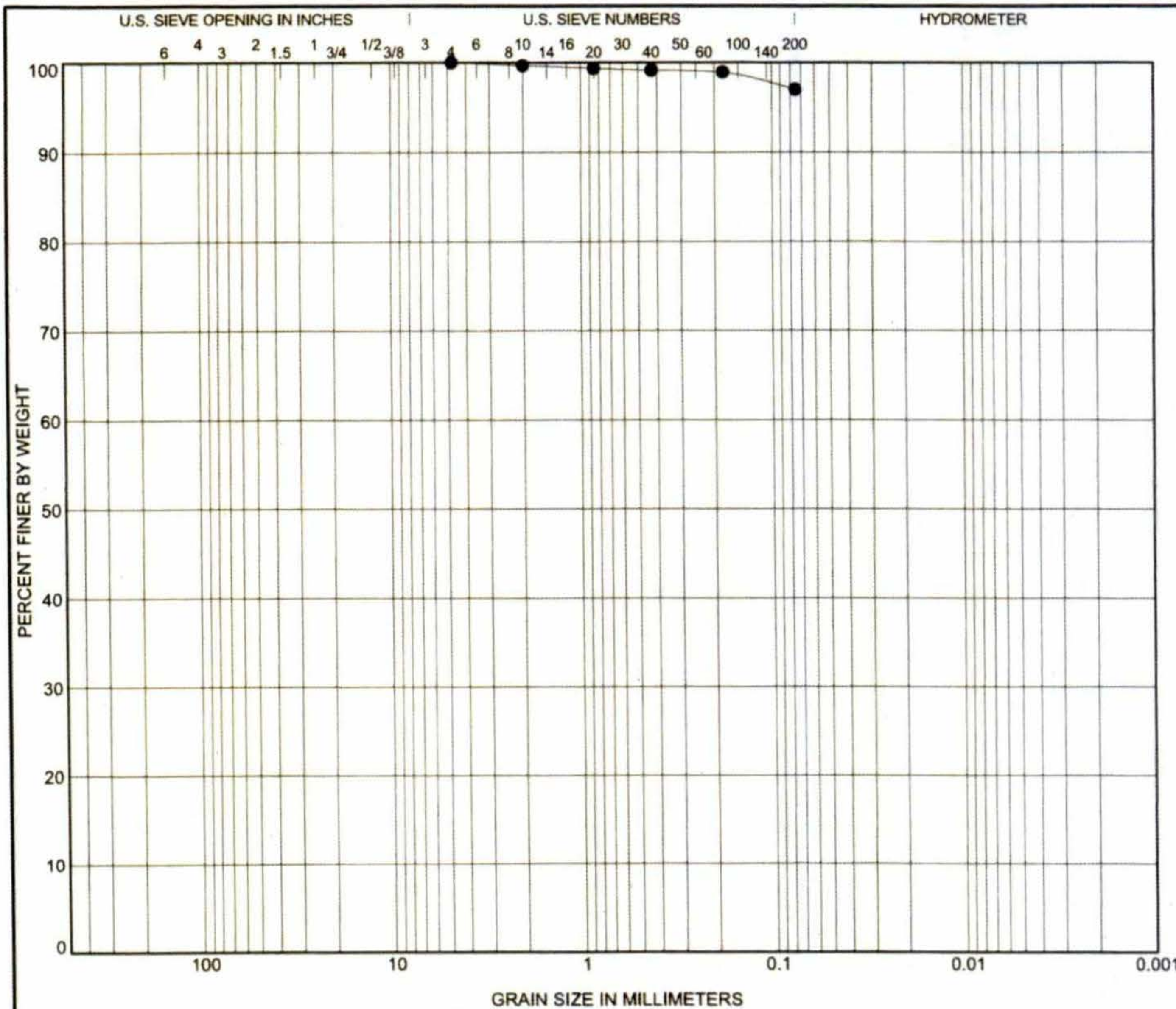
Location: See Drawing 550852-1.

Number: 114-550852

Figure No. 7

BILLINGS LANDFILL LOGS.GPJ 3-29-12 TT_US GRAIN SIZE

Revised 1-23-08 (MAT)



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

Specimen Identification	Classification	LL	PL	PI	Cc	Cu
DH-2 - (20 - 20.4 ft)	**LEAN CLAY(CL)**	**43**	**19**	**24**		

Specimen Identification	D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
DH-2 - (20 - 20.4 ft)	**4.75**				**0**	**3**	**97**	

TETRA TECH

GRAIN SIZE DISTRIBUTION

Project: Billings Landfill Phase V Expansion

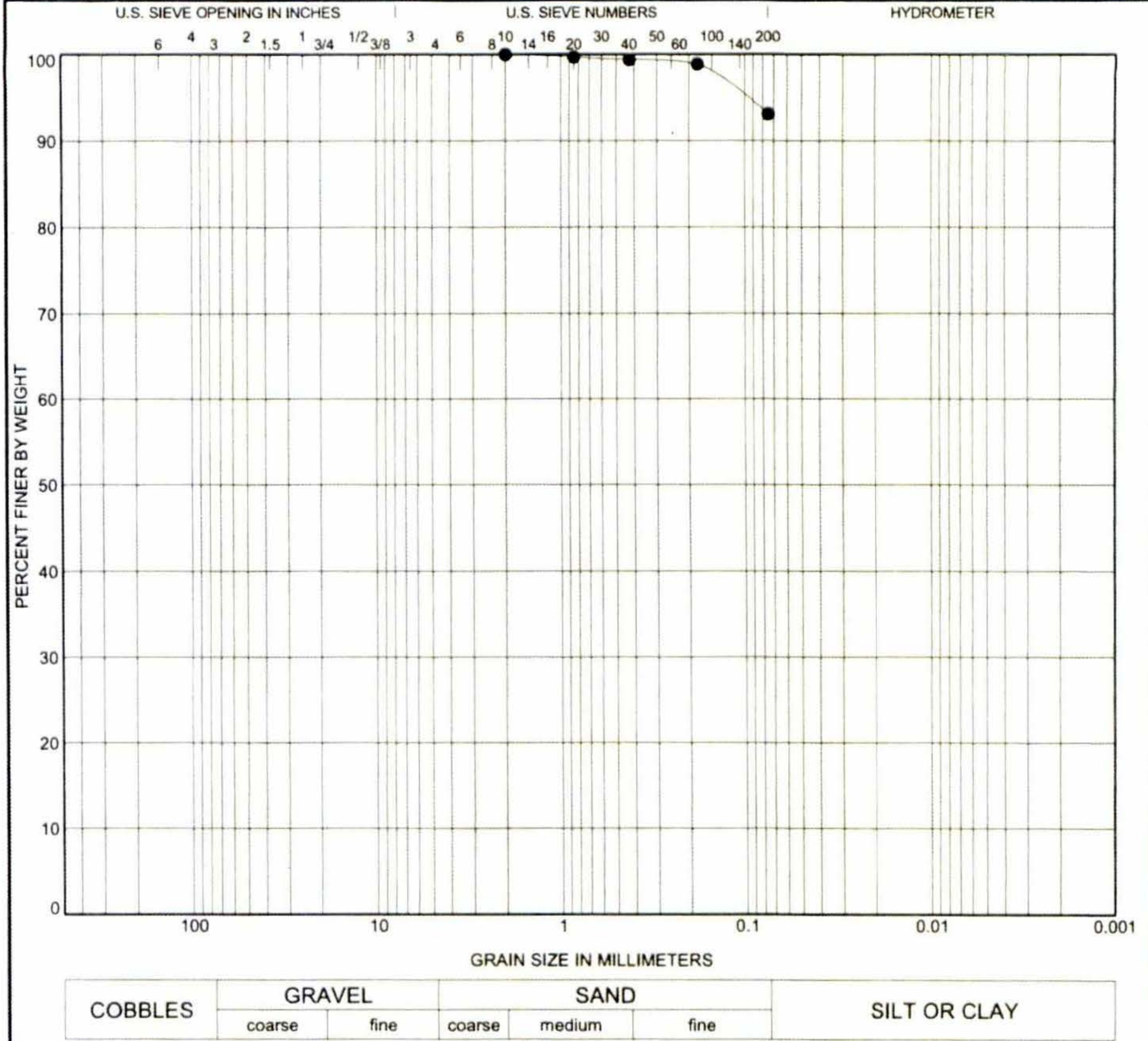
Location: See Drawing 550852-1

Number: 114-550852

Figure No. 8

BILLINGS LANDFILL LOGS.GPJ 3-29-12 TT_US GRAIN SIZE

Revised 1-23-08 (MAT)



Specimen Identification	Classification	LL	PL	PI	Cc	Cu
DH-2 - (35 - 35.4 ft)	**LEAN CLAY(CL)**	**45**	**18**	**27**		

Specimen Identification	D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
DH-2 - (35 - 35.4 ft)	**2**				**0**	**7**	**93**	

BILLINGS LANDFILL LOGS.GPJ 3-29-12 TT_US GRAIN SIZE

TETRA TECH

GRAIN SIZE DISTRIBUTION

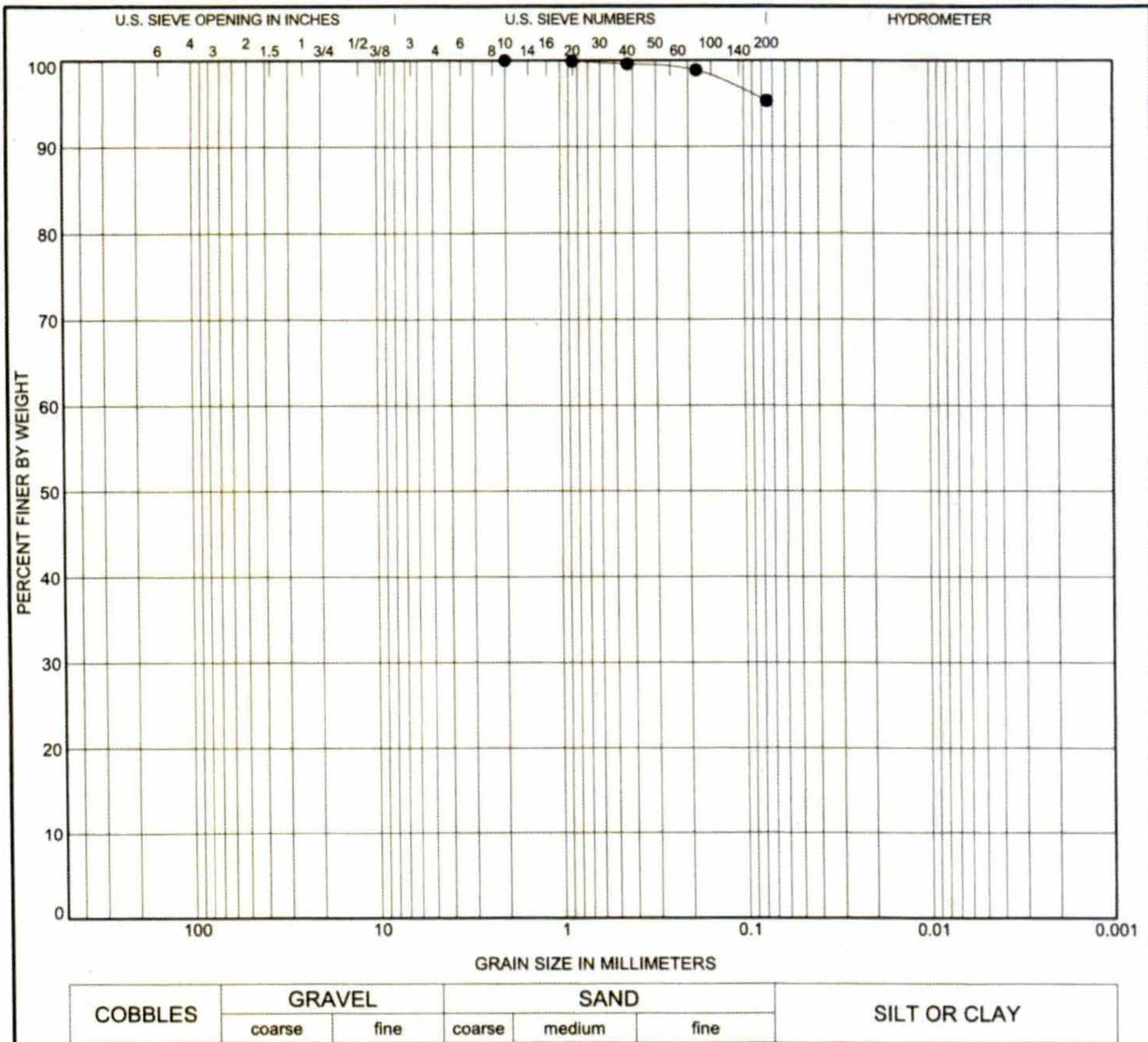
Project: Billings Landfill Phase V Expansion

Location: See Drawing 550852-1

Number: 114-550852

Figure No. 9

Revised 1-23-08 (MAT)



Specimen Identification	Classification	LL	PL	PI	Cc	Cu
DH-3 - (55 - 60 ft)	**LEAN CLAY(CL)**	**42**	**19**	**23**		

Specimen Identification	D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
DH-3 - (55 - 60 ft)	**2**				**0**	**5**	**95**	

TETRA TECH

GRAIN SIZE DISTRIBUTION

Project: Billings Landfill Phase V Expansion

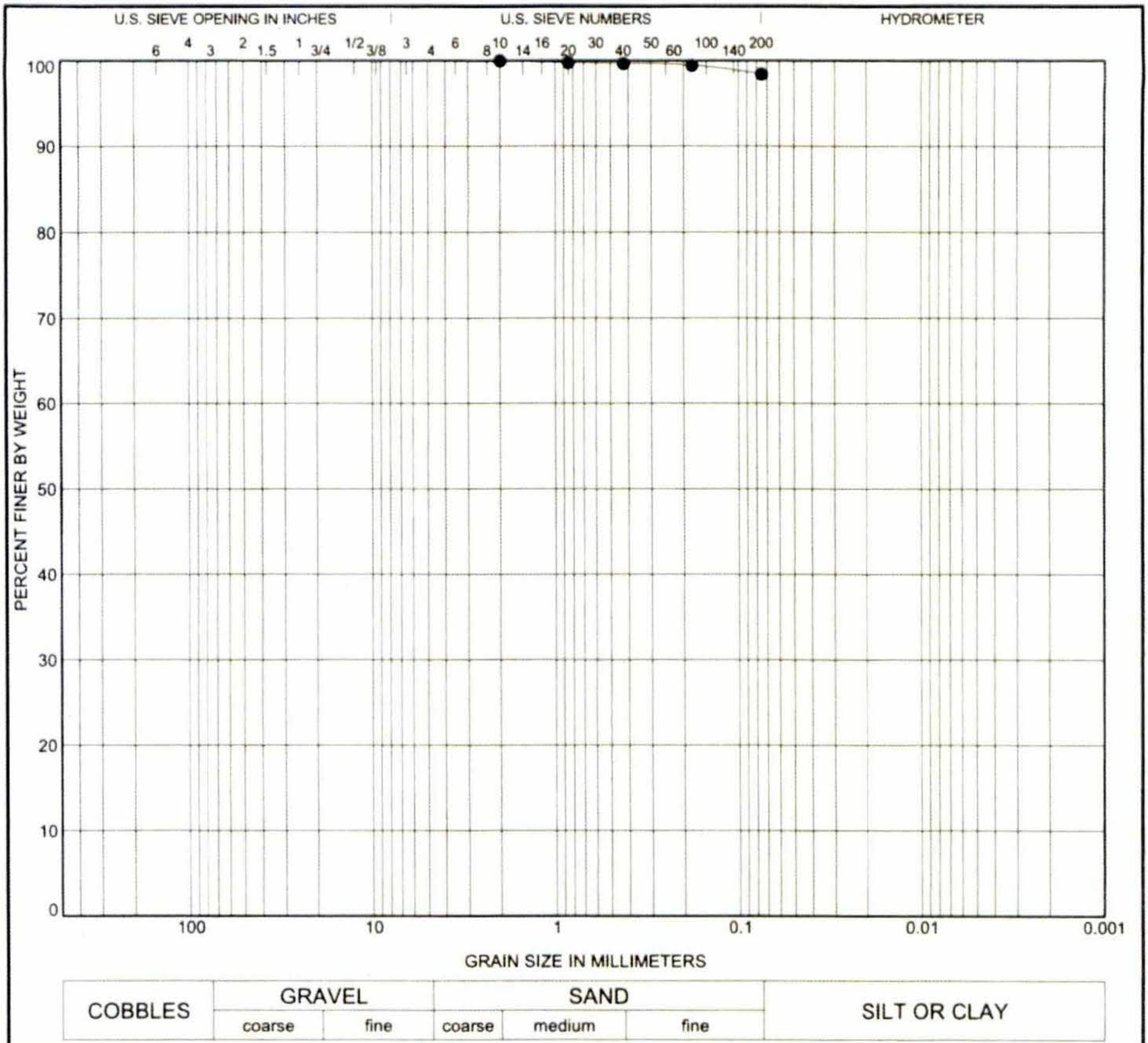
Location: See Drawing 550852-1

Number: 114-550852

Figure No. 10

BILLINGS LANDFILL LOGS.GPJ 3-29-12 TT_US GRAIN SIZE

Revised 1-23-08 (MAT)



Specimen Identification	Classification	LL	PL	PI	Cc	Cu
DH-3 - (70 - 75 ft)	**LEAN CLAY(CL)**	**48**	**20**	**28**		

Specimen Identification	D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
DH-3 - (70 - 75 ft)	**2**				**0**	**2**	**98**	

TETRA TECH

GRAIN SIZE DISTRIBUTION

Project: Billings Landfill Phase V Expansion

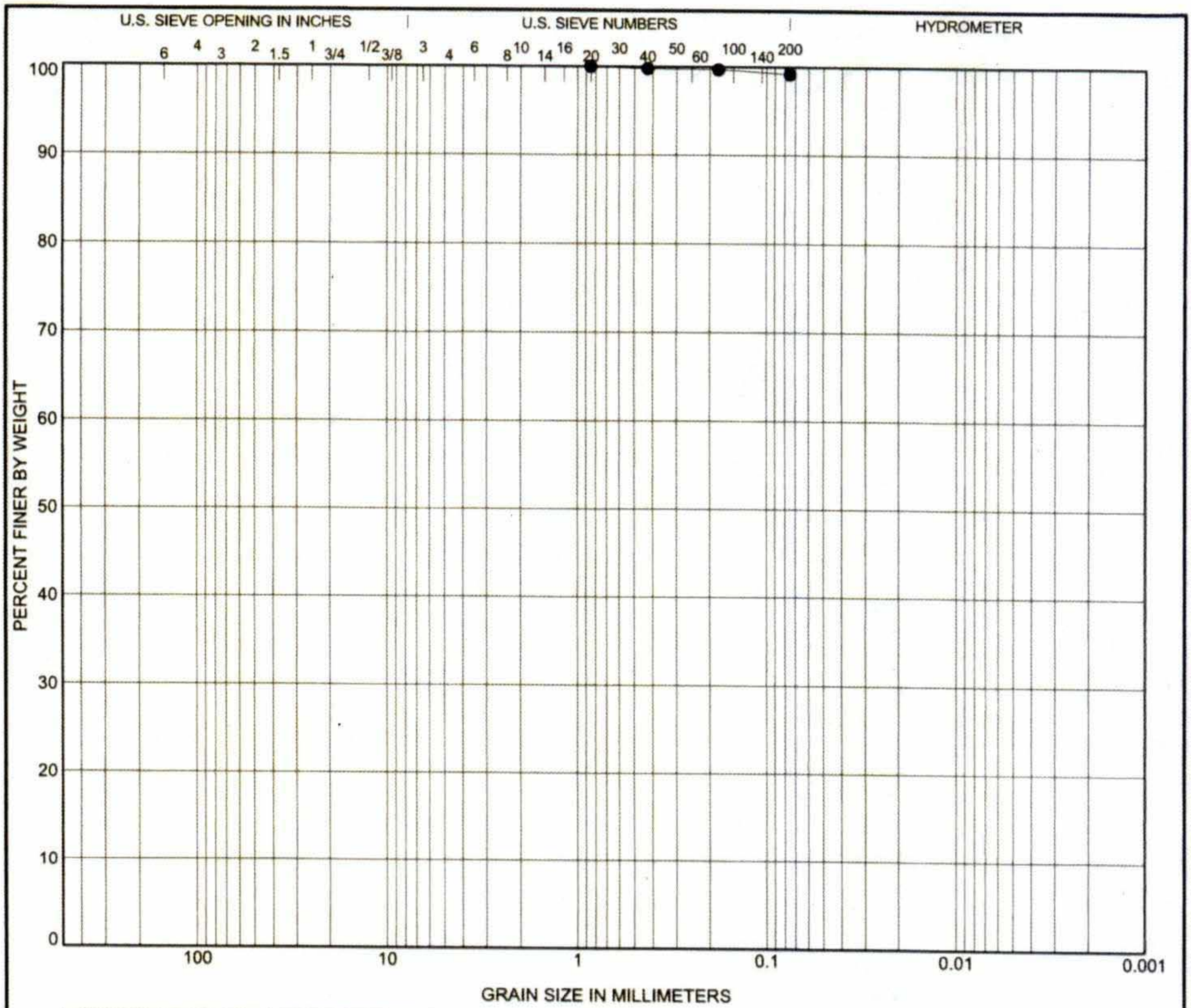
Location: See Drawing 550852-1

Number: 114-550852

Figure No. 11

BILLINGS LANDFILL LOGS.GPJ 3-29-12 TT_US GRAIN SIZE

Revised 1-23-08 (MAT)



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

Specimen Identification	Classification	LL	PL	PI	Cc	Cu
DH-3 - (85 - 90 ft)	**FAT CLAY(CH)**	**55**	**22**	**33**		

Specimen Identification	D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
DH-3 - (85 - 90 ft)	**0.85**				**0**	**1**	**99**	

TETRA TECH

GRAIN SIZE DISTRIBUTION

Project: Billings Landfill Phase V Expansion

Location: See Drawing 550852-1

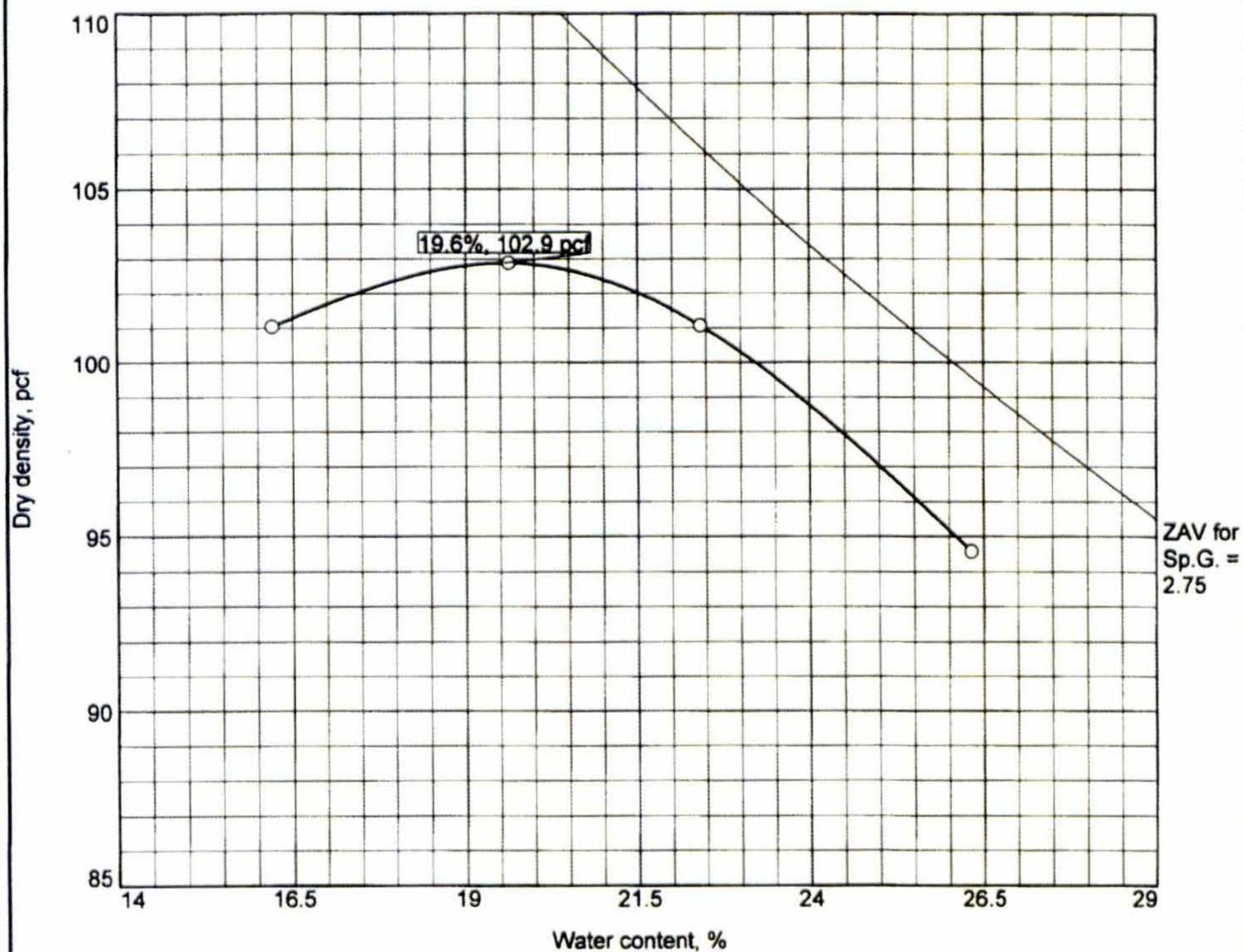
Number: 114-550852

Figure No. 12

BILLINGS LANDFILL LOGS.GPJ 3-29-12 TT_US GRAIN SIZE

Revised 1-23-08 (MAT)

Moisture Density Relationship



Test specification: ASTM D 698-07 Method A Standard

Elev/ Depth	Classification		Nat. Moist.	Sp.G.	LL	PI	% > #4	% < No.200
	USCS	AASHTO						
15.0'-20.0'								

TEST RESULTS	MATERIAL DESCRIPTION
Maximum dry density = 102.9 pcf Optimum moisture = 19.6 %	Lean CLAY

Project No. 114-550852 **Client:** Great West Engineering
Project: Billings Landfill Phase V Expansion

○ **Source of Sample:** DH-1 **Depth:** 15.0'-20.0'

Tetra Tech, Inc.

Billings, MT

Remarks:

Figure 13

PERMEABILITY TEST REPORT

TEST DATA:

Specimen Height (cm): 5.08
Specimen Diameter (cm): 7.11
Dry Unit Weight (pcf): 97.9
Moisture Before Test (%): 19.7
Moisture After Test (%): 0.0
Run Number: 1 ● 2 ▲
Cell Pressure (psi): 65.0
Test Pressure(psi): 60.0
Back Pressure(psi): 57.9
Diff. Head (psi): 2.1
Flow Rate (cc/sec): 5.35 x 10^-4
Perm. (cm/sec): 4.64 x 10^-7

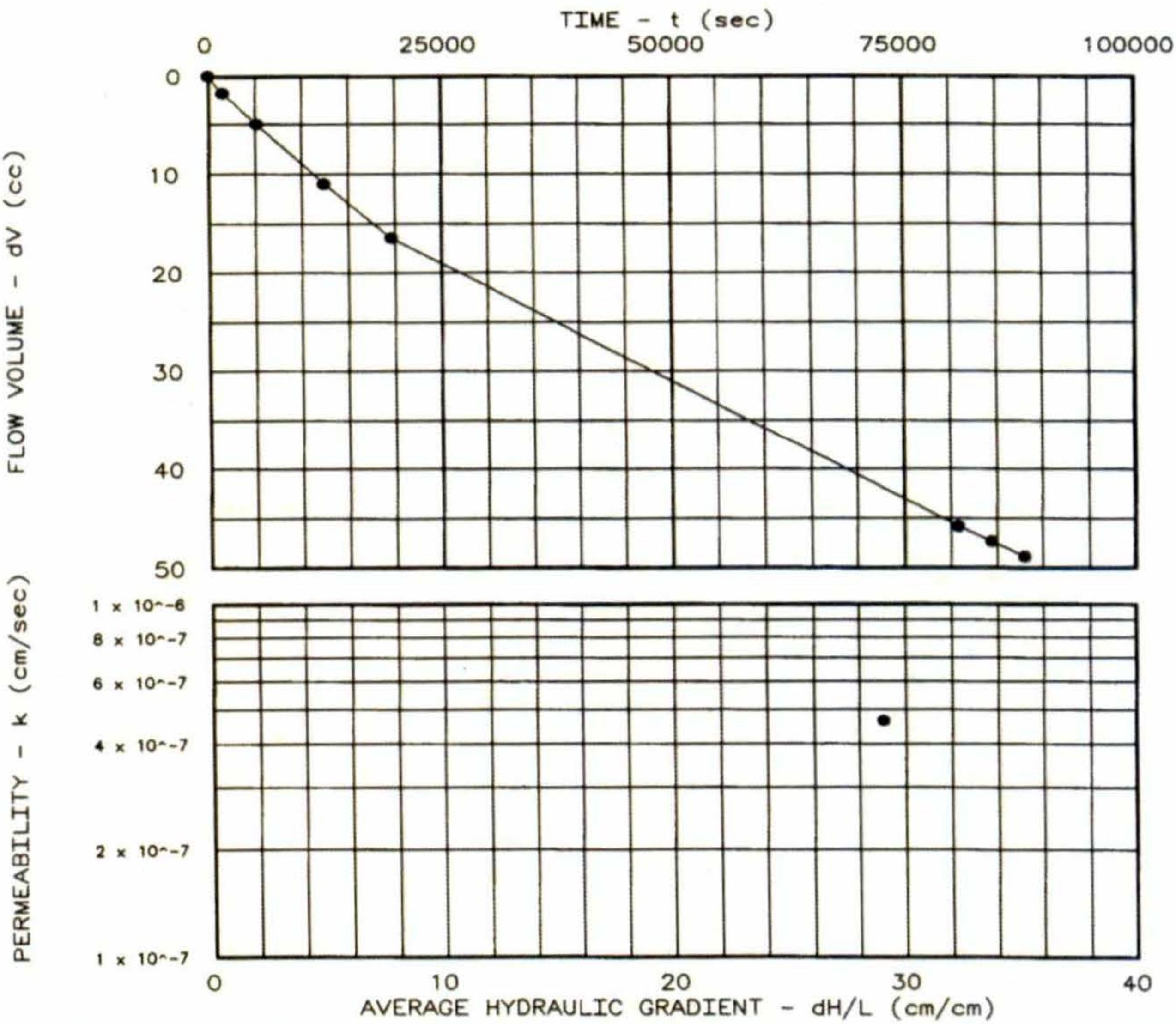
SAMPLE DATA:

Sample Identification: DH-1 15.0'-20.0'

Visual Description:

Remarks: Sp Gr 2.66 Por 0.4104

Maximum Dry Density (pcf): 102.9
Optimum Moisture Content (%): 19.6
ASTM(D698)
Percent Compaction: 95.1%
Permeameter type: Flexwall
Sample type: Remolded



Project: Billings Landfill Phase V Expansion	Project No.: 114-550852
Location:	File No.: 229
Date: 3/26/2012	Lab No.:
PERMEABILITY TEST REPORT	Tested by:
	Checked by:
TETRA TECH	Test: CH - Constant head

PERMEABILITY TEST REPORT

TEST DATA:

Specimen Height (cm): 1.78
Specimen Diameter (cm): 3.56
Dry Unit Weight (pcf): 125.0
Moisture Before Test (%): 9.0
Moisture After Test (%): 0.0
Run Number: 1 ● 2 ▲
Cell Pressure (psi): 65.0
Test Pressure(psi): 62.0
Back Pressure(psi): 57.7
Diff. Head (psi): 4.3
Flow Rate (cc/sec): 1.01 x 10^-5
Perm. (cm/sec): 5.94 x 10^-9

SAMPLE DATA:

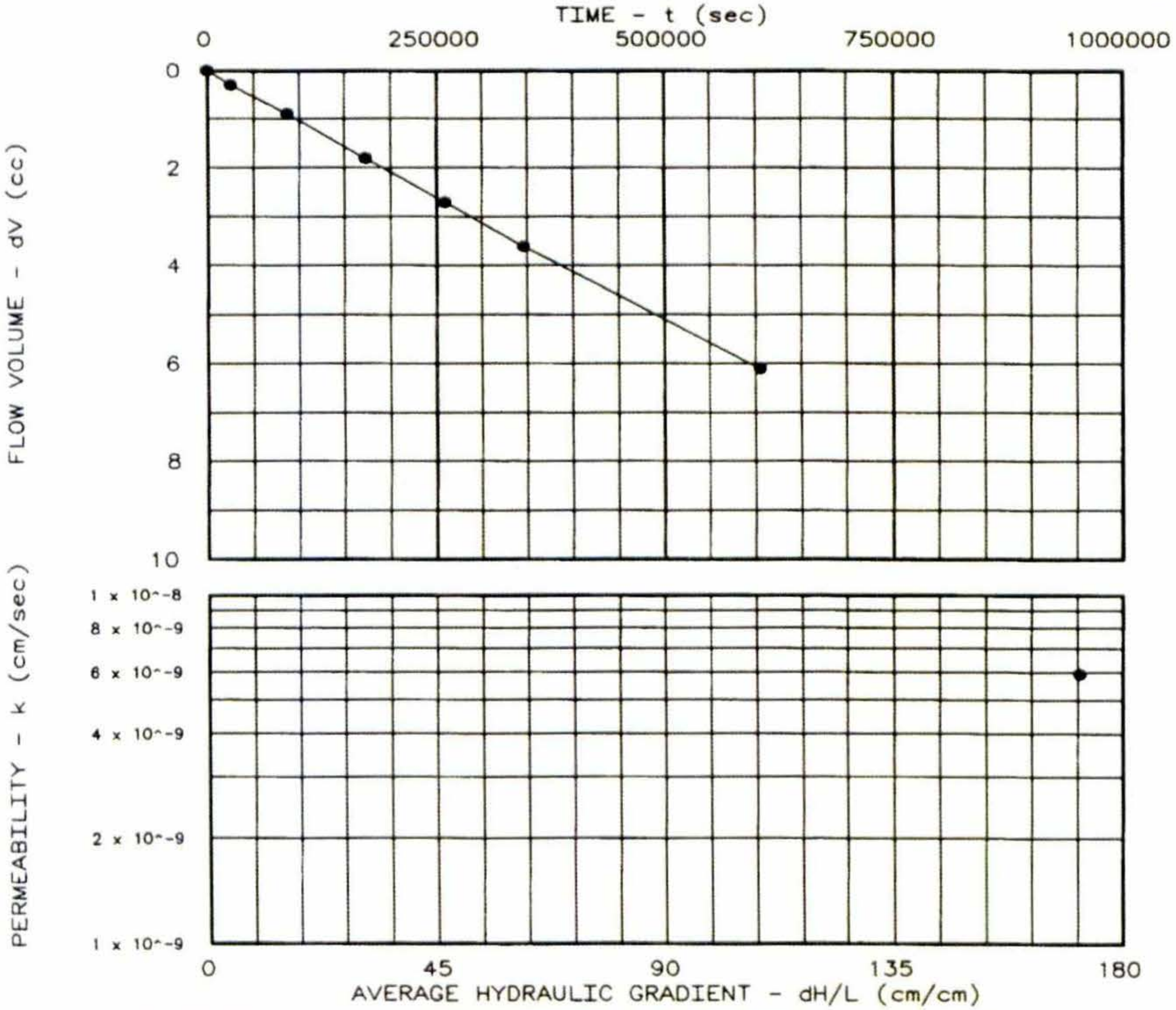
Sample Identification: DH-1 25.0'-30.7'

Visual Description:

Remarks: Sp Gr 2.70 Por 0.2583

Maximum Dry Density (pcf):
Optimum Moisture Content (%):

Percent Compaction:
Permeameter type: Flexwall
Sample type: Remolded



Project: Billings Landfill Phase V Expansion	Project No.: 114-550852
Location:	File No.: 225
Date: 3/19/12	Lab No.:
PERMEABILITY TEST REPORT	Tested by:
TETRA TECH	Checked by:
	Test: CH - Constant head

PERMEABILITY TEST REPORT

TEST DATA:

Specimen Height (cm): 1.78
Specimen Diameter (cm): 3.56
Dry Unit Weight (pcf): 123.3
Moisture Before Test (%): 10.0
Moisture After Test (%): 0.0
Run Number: 1 ● 2 ▲
Cell Pressure (psi): 65.0
Test Pressure(psi): 60.0
Back Pressure(psi): 57.6
Diff. Head (psi): 2.4
Flow Rate (cc/sec): 6.59 x 10^-6
Perm. (cm/sec): 7.12 x 10^-9

SAMPLE DATA:

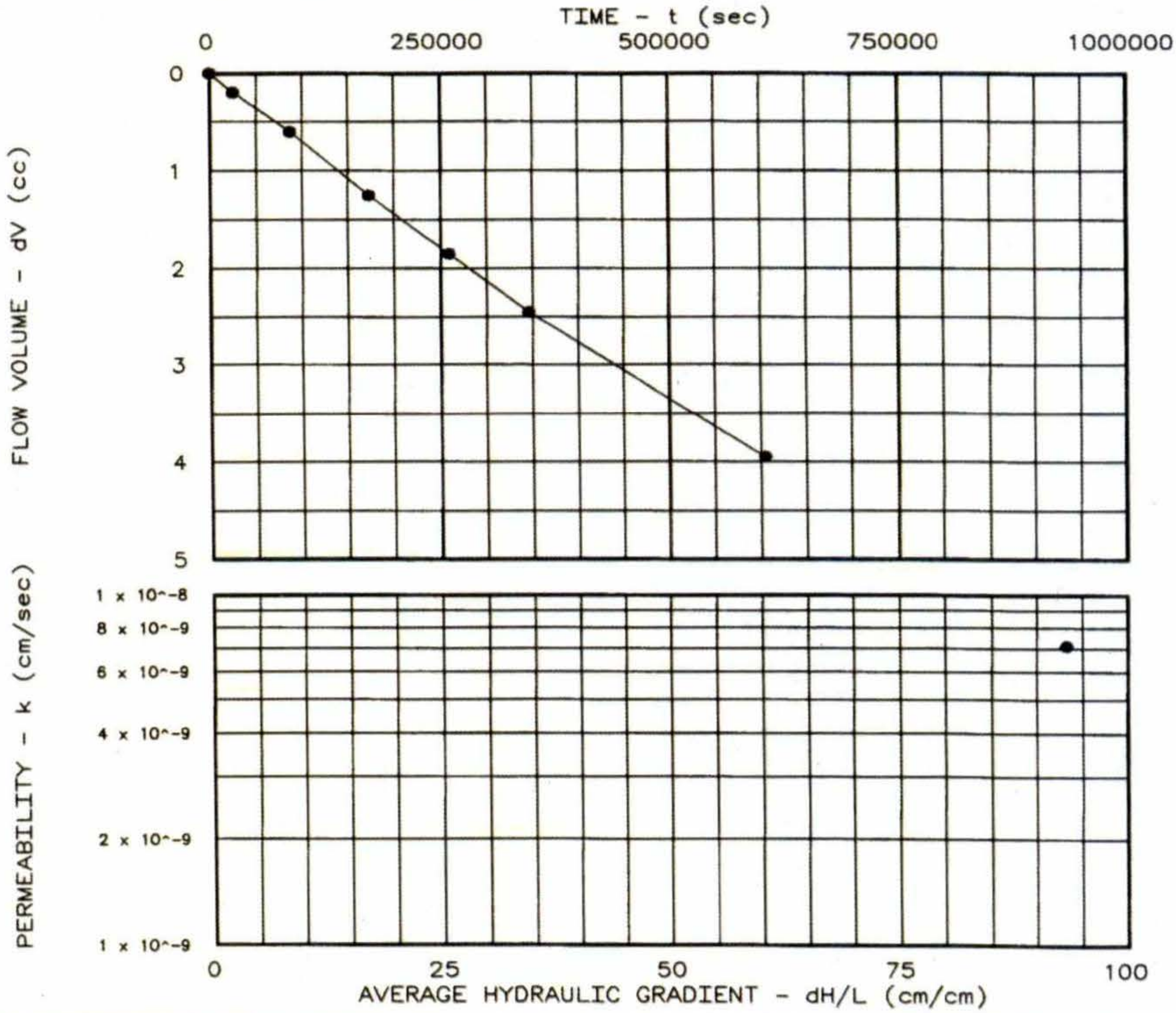
Sample Identification: DH-1 35.0'-40.7'

Visual Description:

Remarks: Sp Gr 2.72 Por 0.2736

Maximum Dry Density (pcf):
Optimum Moisture Content (%):

Percent Compaction:
Permeameter type: Flexwall
Sample type: Remolded



Project: Billings Landfill Phase V Expansion	Project No.: 114-550852
Location:	File No.: 226
Date: 3/19/2012	Lab No.:
PERMEABILITY TEST REPORT	Tested by:
	Checked by:
TETRA TECH	Test: CH - Constant head

PERMEABILITY TEST REPORT

TEST DATA:

Specimen Height (cm): 1.78
Specimen Diameter (cm): 3.56
Dry Unit Weight (pcf): 122.9
Moisture Before Test (%): 10.6
Moisture After Test (%): 0.0
Run Number: 1 ● 2 ▲
Cell Pressure (psi): 65.0
Test Pressure(psi): 60.0
Back Pressure(psi): 57.6
Diff. Head (psi): 2.4
Flow Rate (cc/sec): 2.40 x 10^-6
Perm. (cm/sec): 2.56 x 10^-9

SAMPLE DATA:

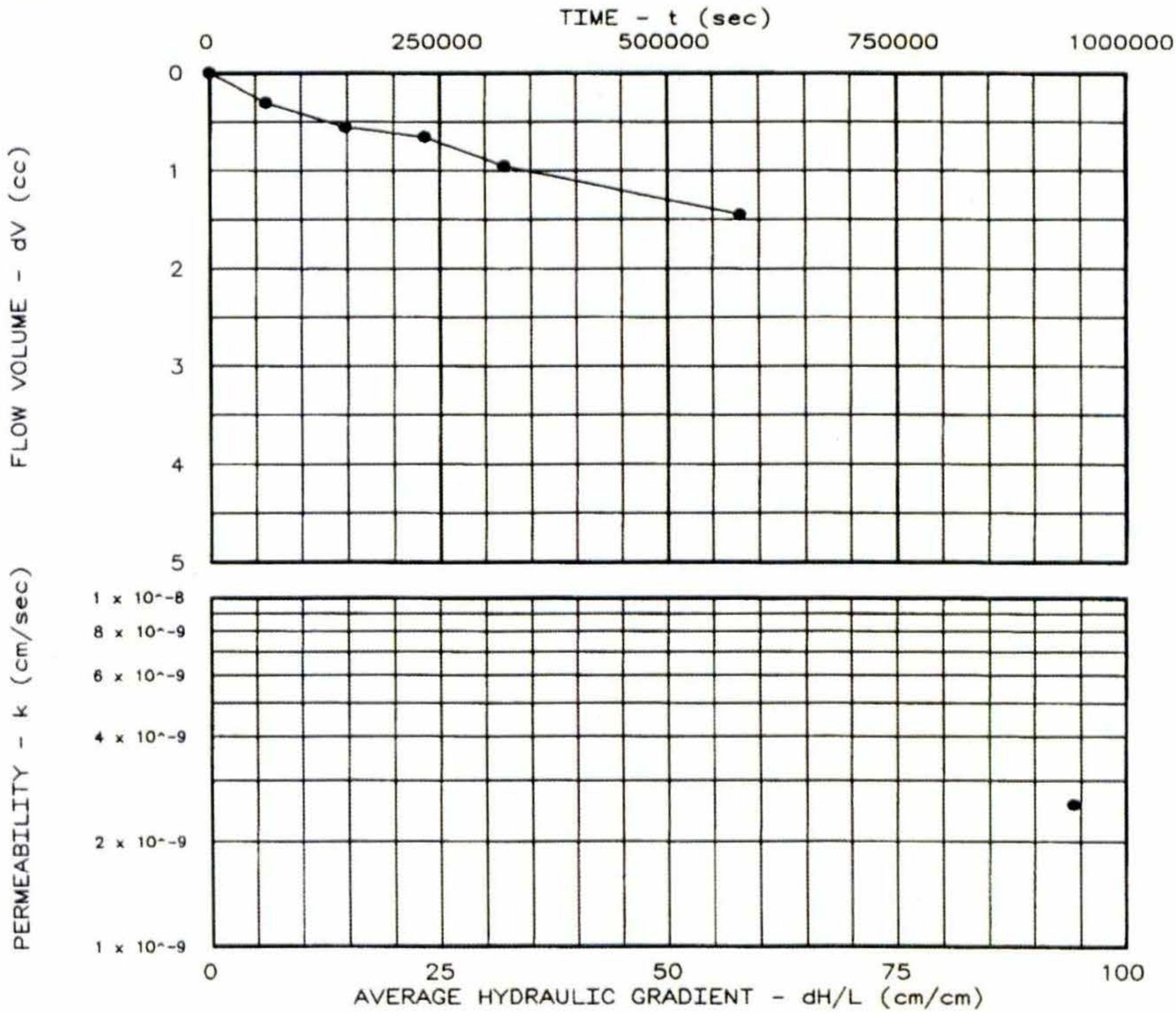
Sample Identification: DH-1 45.0'-45.6'

Visual Description:

Remarks: Sp Gr 2.73 Por 0.2791

Maximum Dry Density (pcf):
Optimum Moisture Content (%):

Percent Compaction:
Permeameter type: Flexwall
Sample type: Remolded



Project: Billings Landfill Phase V Expansion	Project No.: 114-550852
Location:	File No.: 224
Date: 3/19/2012	Lab No.:
PERMEABILITY TEST REPORT	Tested by:
	Checked by:
TETRA TECH	Test: CH - Constant head

PERMEABILITY TEST REPORT

TEST DATA:

Specimen Height (cm): 1.78
Specimen Diameter (cm): 3.56
Dry Unit Weight (pcf): 120.1
Moisture Before Test (%): 9.9
Moisture After Test (%): 0.0

Run Number:	1 ●	2 ▲
Cell Pressure (psi):	65.0	
Test Pressure(psi):	60.0	
Back Pressure(psi):	57.3	
Diff. Head (psi):	2.7	
Flow Rate (cc/sec):	8.28 x 10^-6	
Perm. (cm/sec):	7.87 x 10^-9	

SAMPLE DATA:

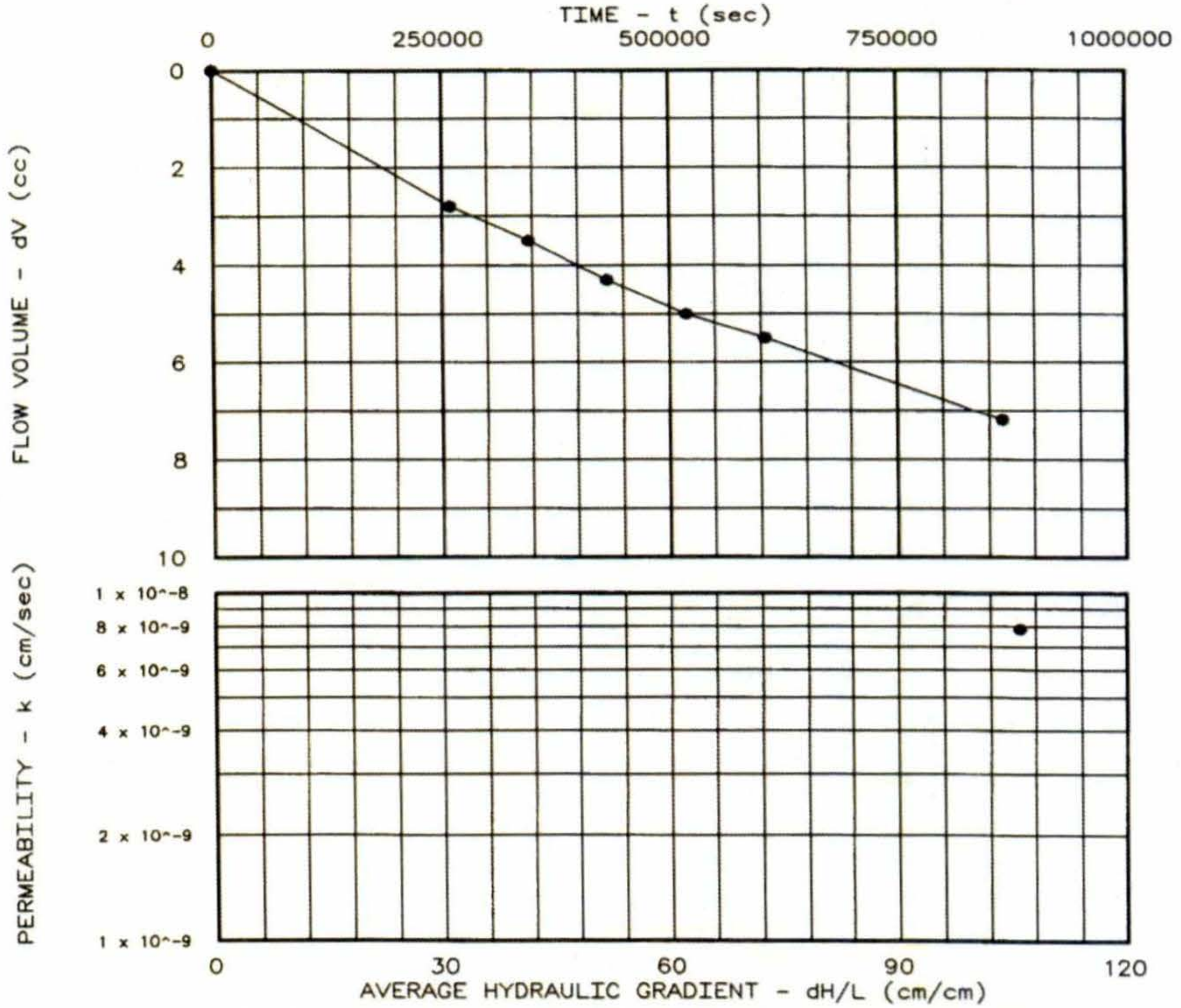
Sample Identification: DH-2 20.0'-25.4'

Visual Description:

Remarks: Sp Gr 2.70 Por 0.2875

Maximum Dry Density (pcf):
Optimum Moisture Content (%):

Percent Compaction:
Permeameter type: Flexwall
Sample type: Remolded



Project: Billings Landfill Phase V Expansion	Project No.: 114-550852
Location:	File No.: 228
Date: 3/26/2012	Lab No.:
PERMEABILITY TEST REPORT	Tested by:
TETRA TECH	Checked by:
	Test: CH - Constant head

PERMEABILITY TEST REPORT

TEST DATA:

Specimen Height (cm): 1.78
Specimen Diameter (cm): 3.56
Dry Unit Weight (pcf): 125.8
Moisture Before Test (%): 7.3
Moisture After Test (%): 0.0
Run Number: 1 ● 2 ▲
Cell Pressure (psi): 65.0
Test Pressure(psi): 60.0
Back Pressure(psi): 57.3
Diff. Head (psi): 2.7
Flow Rate (cc/sec): 6.28 x 10^-6
Perm. (cm/sec): 5.89 x 10^-9

SAMPLE DATA:

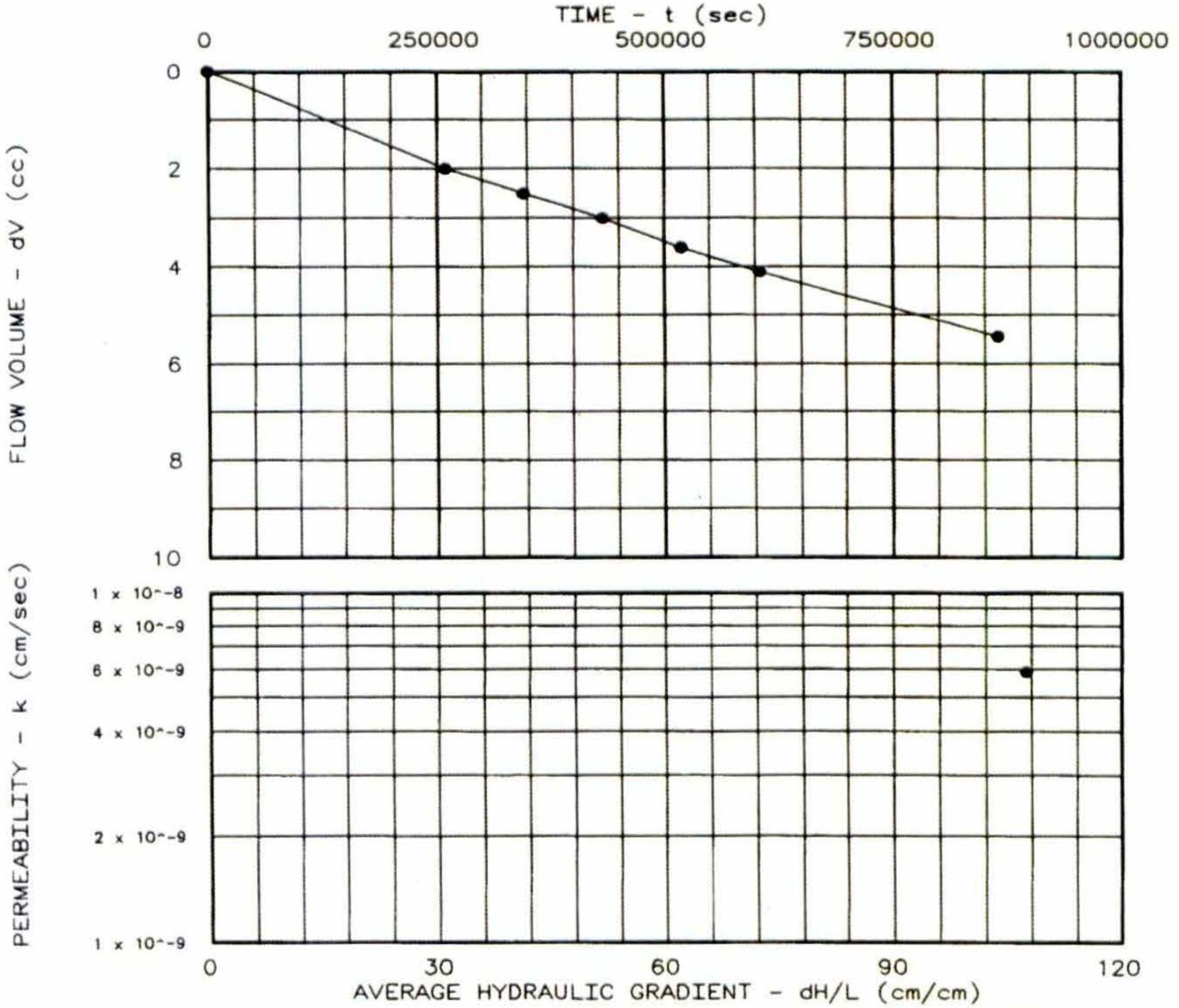
Sample Identification: DH-2 35.0'-35.4'

Visual Description:

Remarks: Sp Gr 2.72 Por 0.2594

Maximum Dry Density (pcf):
Optimum Moisture Content (%):

Percent Compaction:
Permeameter type: Flexwall
Sample type: Remolded



Project: Billings Landfill Phase V Expansion	Project No.: 114-550852
Location:	File No.: 227
Date: 3/26/2012	Lab No.:
PERMEABILITY TEST REPORT	Tested by:
	Checked by:
TETRA TECH	Test: CH - Constant head

PERMEABILITY TEST REPORT

TEST DATA:

Specimen Height (cm): 2.16
Specimen Diameter (cm): 6.07
Dry Unit Weight (pcf): 146.3
Moisture Before Test (%): 6.5
Moisture After Test (%): 0.0
Run Number: 1 ● 2 ▲
Cell Pressure (psi): 65.0
Test Pressure(psi): 60.0
Back Pressure(psi): 57.4
Diff. Head (psi): 2.6
Flow Rate (cc/sec): 9.27 x 10^-8
Perm. (cm/sec): 3.83 x 10^-11

SAMPLE DATA:

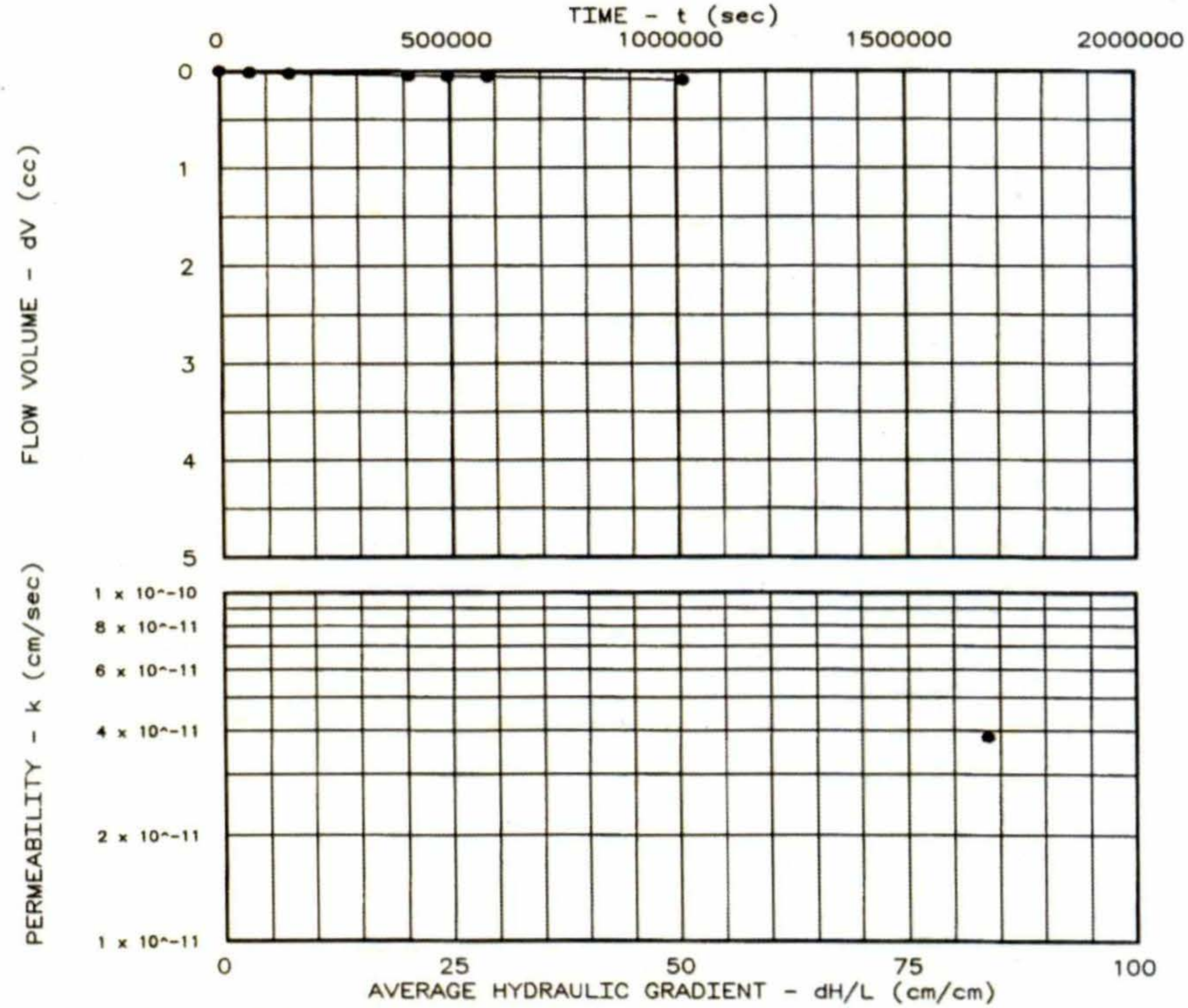
Sample Identification: DH-3 55'-60'

Visual Description:

Remarks: Sp Gr 2.73 Por 0.1417

Maximum Dry Density (pcf):
Optimum Moisture Content (%):

Percent Compaction:
Permeameter type: Flexwall
Sample type: Core



Project: Billings Landfill Phase V Expansion
Location:
Date: 3/12/12

Project No.: 114-550852
File No.: 222
Lab No.:
Tested by:
Checked by:
Test: CH - Constant head

PERMEABILITY TEST REPORT

TETRA TECH

PERMEABILITY TEST REPORT

TEST DATA:

Specimen Height (cm): 2.20
Specimen Diameter (cm): 6.10
Dry Unit Weight (pcf): 138.7
Moisture Before Test (%): 7.3
Moisture After Test (%): 0.0

Run Number:	1 ●	2 ▲
Cell Pressure (psi):	65.0	
Test Pressure(psi):	60.0	
Back Pressure(psi):	57.6	
Diff. Head (psi):	2.4	
Flow Rate (cc/sec):	1.61 x 10^-7	
Perm. (cm/sec):	7.16 x 10^-11	

SAMPLE DATA:

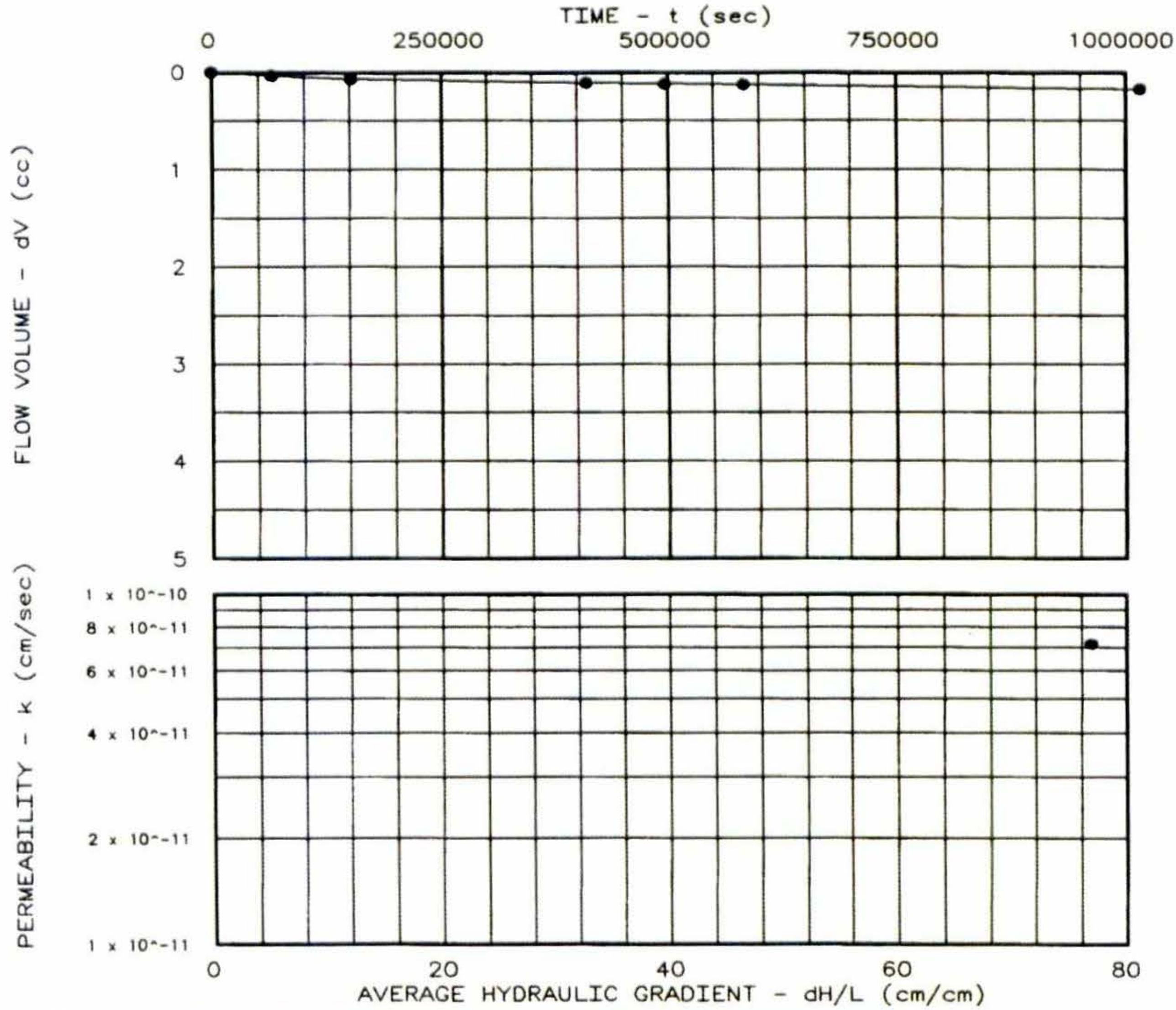
Sample Identification: DH-3 70'-75'

Visual Description:

Remarks: Sp Gr 2.73 Por 0.1860

Maximum Dry Density (pcf):
Optimum Moisture Content (%):

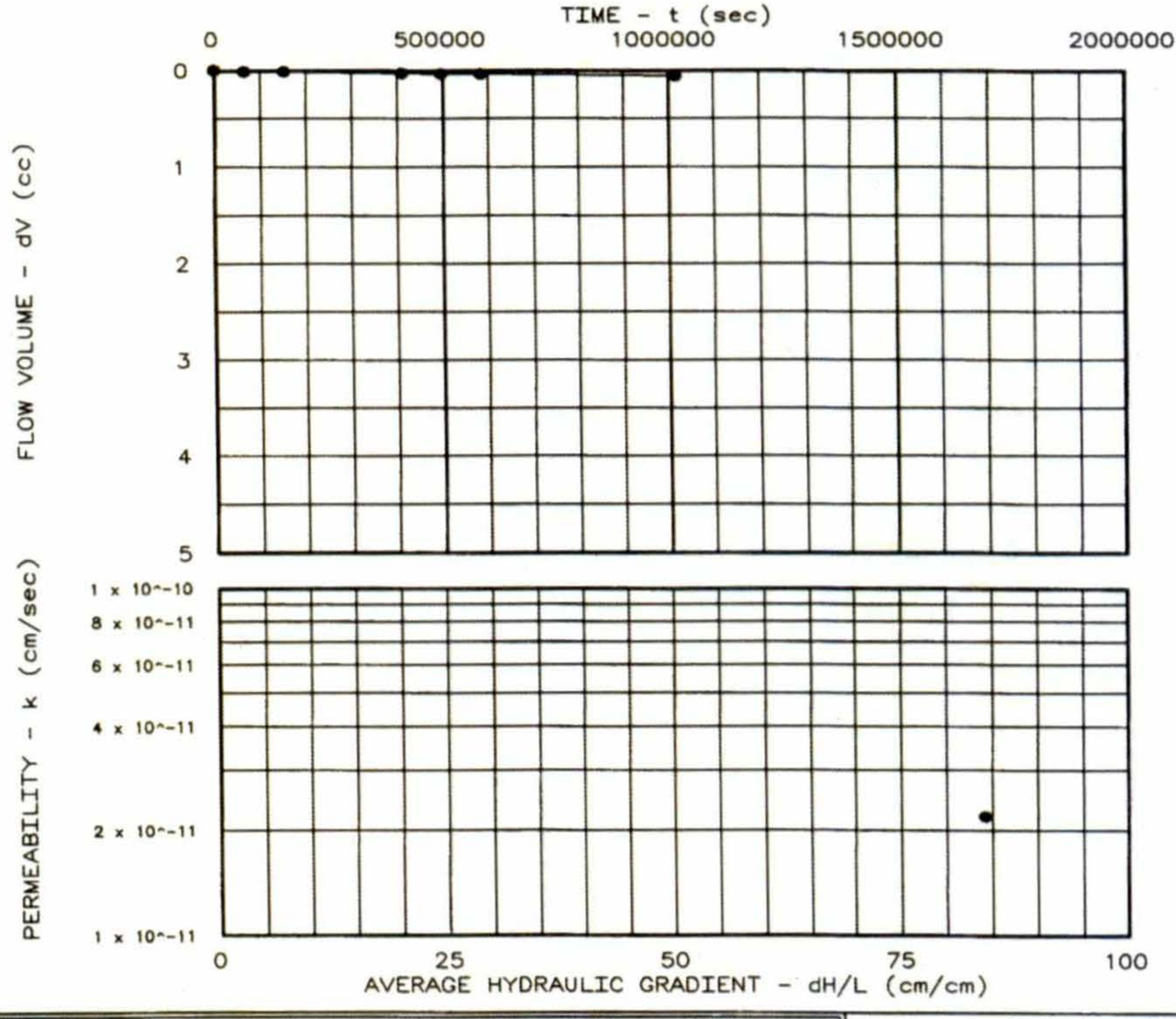
Percent Compaction:
Permeameter type:
Sample type: Core



Project: Billings Landfill Phase V Expansion	Project No.: 114-550852
Location:	File No.: 221
Date:	Lab No.:
PERMEABILITY TEST REPORT	Tested by:
	Checked by:
TETRA TECH	Test: CH - Constant head

PERMEABILITY TEST REPORT

TEST DATA:			SAMPLE DATA:
Specimen Height (cm):	2.22		Sample Identification: DH-3 85'-90'
Specimen Diameter (cm):	6.10		
Dry Unit Weight (pcf):	137.5		Visual Description:
Moisture Before Test (%):	7.6		
Moisture After Test (%):	0.0		Remarks: Sp Gr 2.73 Por 0.1933
Run Number:	1 ●	2 ▲	
Cell Pressure (psi):	65.0		Maximum Dry Density (pcf):
Test Pressure(psi):	60.0		Optimum Moisture Content (%):
Back Pressure(psi):	57.3		
Diff. Head (psi):	2.7		Percent Compaction:
Flow Rate (cc/sec):	5.39 x 10^-8		Permeameter type: Flexwall
Perm. (cm/sec):	2.19 x 10^-11		Sample type: Core



Project: Billings Landfill Phase V Expansion
Location:
Date: 3/12/12

Project No.: 114-550852
File No.: 223
Lab No.:
Tested by:
Checked by:
Test: CH - Constant head

PERMEABILITY TEST REPORT

TETRA TECH

PERMEABILITY TEST REPORT

TEST DATA:

Specimen Height (cm): 1.78
Specimen Diameter (cm): 3.56
Dry Unit Weight (pcf): 122.9
Moisture Before Test (%): 10.6
Moisture After Test (%): 0.0
Run Number: 1 ● 2 ▲
Cell Pressure (psi): 65.0
Test Pressure(psi): 60.0
Back Pressure(psi): 57.6
Diff. Head (psi): 2.4
Flow Rate (cc/sec): 2.40 x 10^-6
Perm. (cm/sec): 2.56 x 10^-9

SAMPLE DATA:

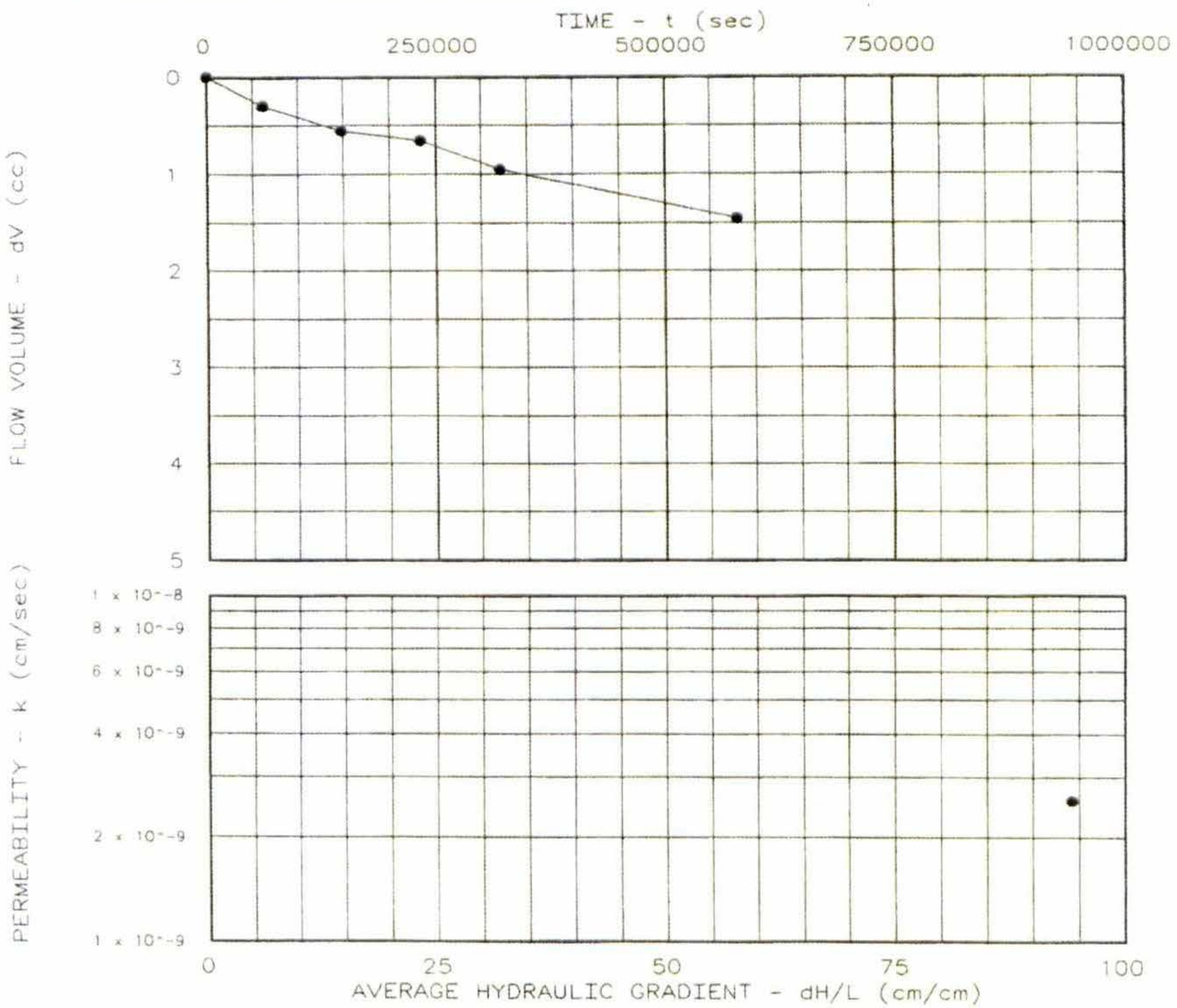
Sample Identification: DH-1 45.0'-45.6'

Visual Description:

Remarks:

Maximum Dry Density (pcf):
Optimum Moisture Content (%):

Percent Compaction:
Permeameter type: Flexwall
Sample type: Remolded



Project: BILLINGS LANDFILL EXPANSION	Project No.: 114-550852
Location:	File No.: 224
Date: 3/19/2012	Lab No.:
PERMEABILITY TEST REPORT	Tested by:
TETRA TECH	Checked by:
	Test: CH - Constant head

PERMEABILITY TEST REPORT

TEST DATA:

Specimen Height (cm): 1.78
Specimen Diameter (cm): 3.56
Dry Unit Weight (pcf): 123.3
Moisture Before Test (%): 10.0
Moisture After Test (%): 0.0
Run Number: 1 ● 2 ▲
Cell Pressure (psi): 65.0
Test Pressure(psi): 60.0
Back Pressure(psi): 57.6
Diff. Head (psi): 2.4
Flow Rate (cc/sec): 6.59 x 10^-6
Perm. (cm/sec): 7.12 x 10^-9

SAMPLE DATA:

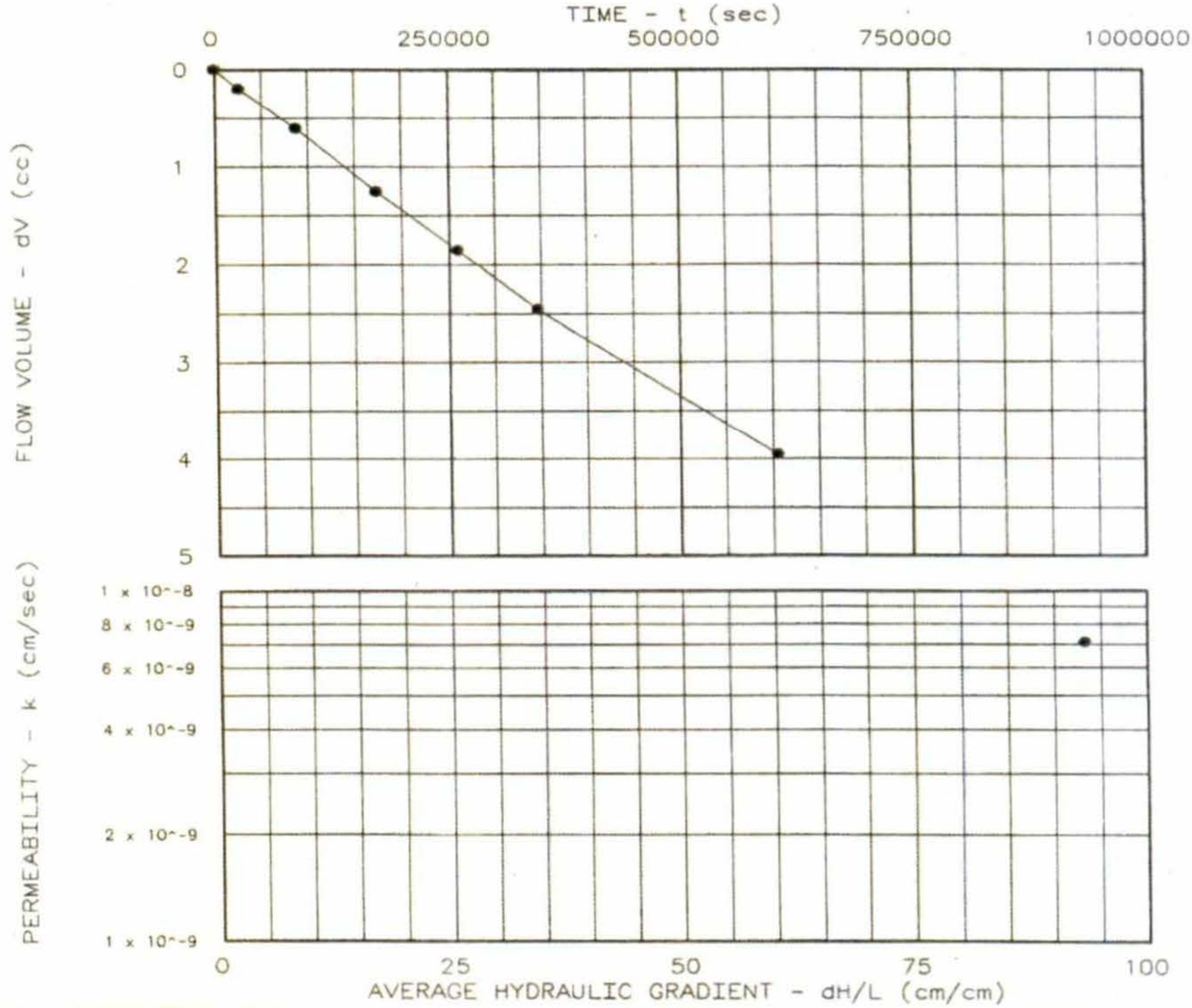
Sample Identification: DH-1 35.0'-40.7'

Visual Description:

Remarks:

Maximum Dry Density (pcf):
Optimum Moisture Content (%):

Percent Compaction:
Permeameter type: Flexwall
Sample type: Remolded



Project: BILLINGS LANDFILL EXPANSION
Location:
Date: 3/19/2012

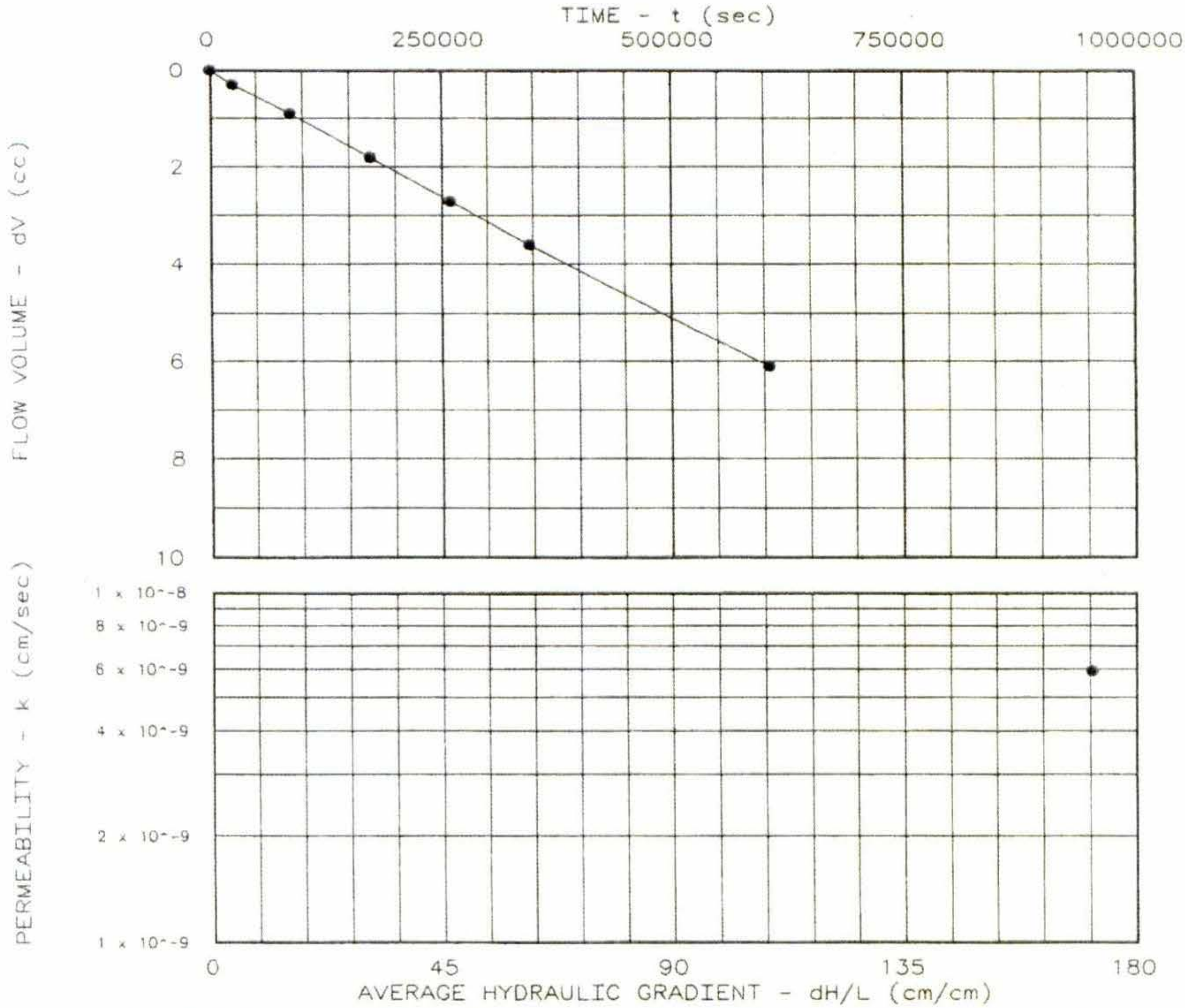
PERMEABILITY TEST REPORT

TETRA TECH

Project No.: 114-550852
File No.: 226
Lab No.:
Tested by:
Checked by:
Test: CH - Constant head

PERMEABILITY TEST REPORT

TEST DATA:			SAMPLE DATA:
Specimen Height (cm): 1.78			Sample Identification: DH-1 25.0'-30.7'
Specimen Diameter (cm): 3.56			
Dry Unit Weight (pcf): 125.0			Visual Description:
Moisture Before Test (%): 9.0			
Moisture After Test (%): 0.0			Remarks:
Run Number:	1 ●	2 ▲	
Cell Pressure (psi):	65.0		Maximum Dry Density (pcf):
Test Pressure(psi):	62.0		Optimum Moisture Content (%):
Back Pressure(psi):	57.7		
Diff. Head (psi):	4.3		Percent Compaction:
Flow Rate (cc/sec):	1.01 x 10^-5		Permeameter type: Flexwall
Perm. (cm/sec):	5.94 x 10^-9		Sample type: Remolded



Project: BILLINGS LANDFILL EXPANSION	Project No.: 114-550852
Location:	File No.: 225
Date: 3/19/12	Lab No.:
PERMEABILITY TEST REPORT	Tested by:
TETRA TECH	Checked by:
	Test: CH - Constant head

TETRA TECH

April 13, 2012

Mr. Bruce Siegmund
Great West Engineering
PO Box 4817
Helena, Montana 59604

Delivered via email

SUBJECT: Additional Test Results and Historical Data
Billings Landfill Phase V Expansion
Billings, Montana
Tetra Tech Project No. 114-550852

Dear Mr. Siegmund:

At your request, we have performed hydrometer testing and researched previous geotechnical investigations performed for the Billings Landfill for your use in preparing models for the City of Billings. Attached are the results for hydrometer testing, "Preliminary Subsurface Soils Investigation – Billings Sanitary Landfill" dated August 17, 1977, and "Billings Landfill Field Exploration Services" dated August 14, 1990.

If you have any questions regarding this information, please contact us. We appreciate the opportunity to provide geotechnical engineering services to you on this project.

Respectfully submitted,

Tetra Tech

Travis Goracke, P.E.
Geotechnical Engineer

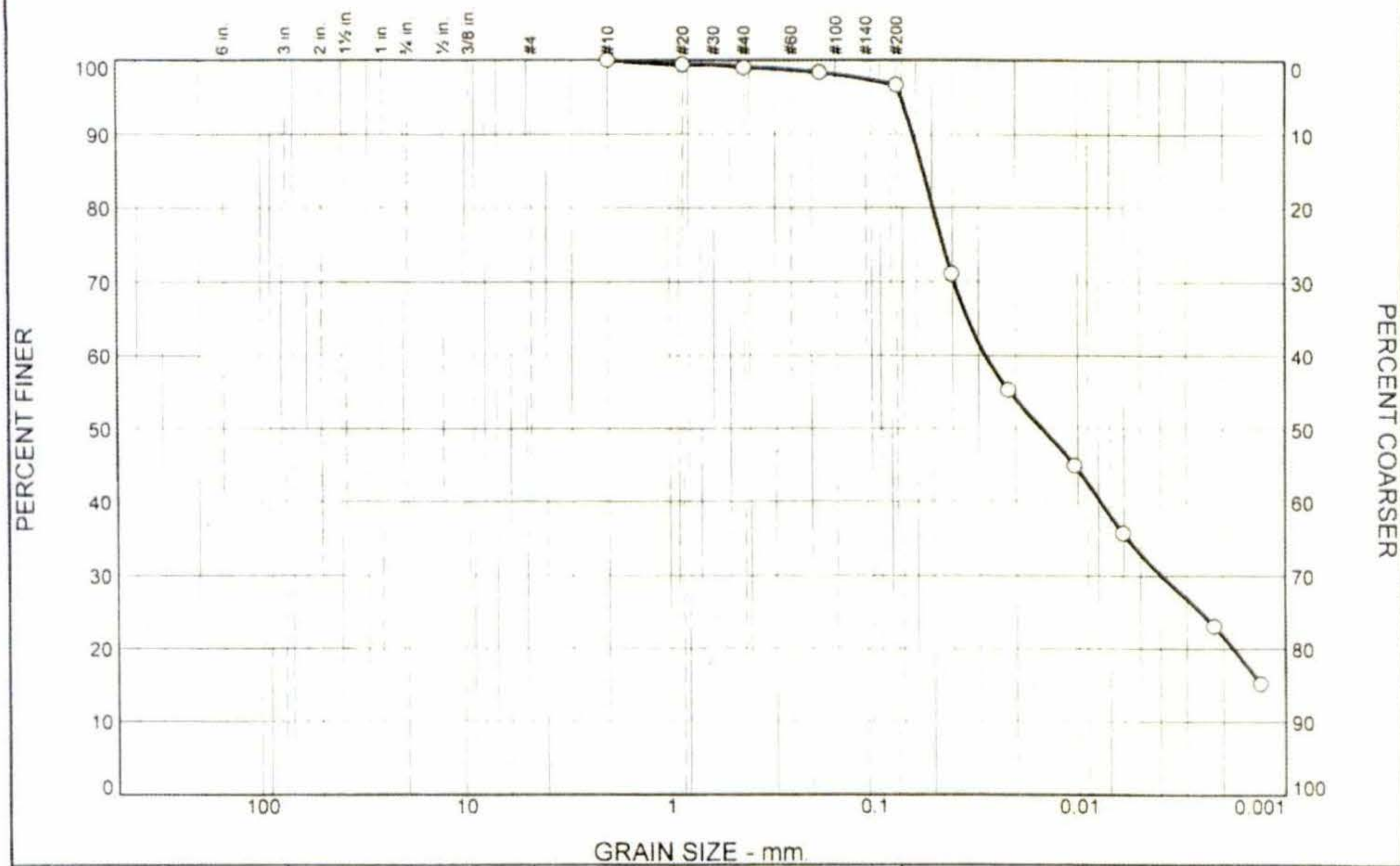
TG/ba

N:\TYPING\GEOTECH\550852\Additional Info\Phase V Additional Info Letter.docx

Enclosures

Tetra Tech
P.O. Box 30615, Billings, MT 59107
618 South 25th Street, Billings, MT 59101
Tel 406 248 9161 **Fax** 406 248 9282 www.tetratech.com

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	0.0	0.0	1.0	2.3	63.8	32.9

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#10	100.0		
#20	99.4		
#40	99.0		
#80	98.3		
#200	96.7		

* (no specification provided)

Material Description

Lean Clay

Atterberg Limits

PL= 19 LL= 43 PI= 24

Coefficients

D_{90}= 0.0620 D_{85}= 0.0553 D_{60}= 0.0279
D_{50}= 0.0148 D_{30}= 0.0039 D_{15}=
D_{10}= C_u= C_c=

Classification

USCS= CL AASHTO= A-7-6(25)

Remarks

Source of Sample: DH-1 **Depth:** 15.0'-15.9'

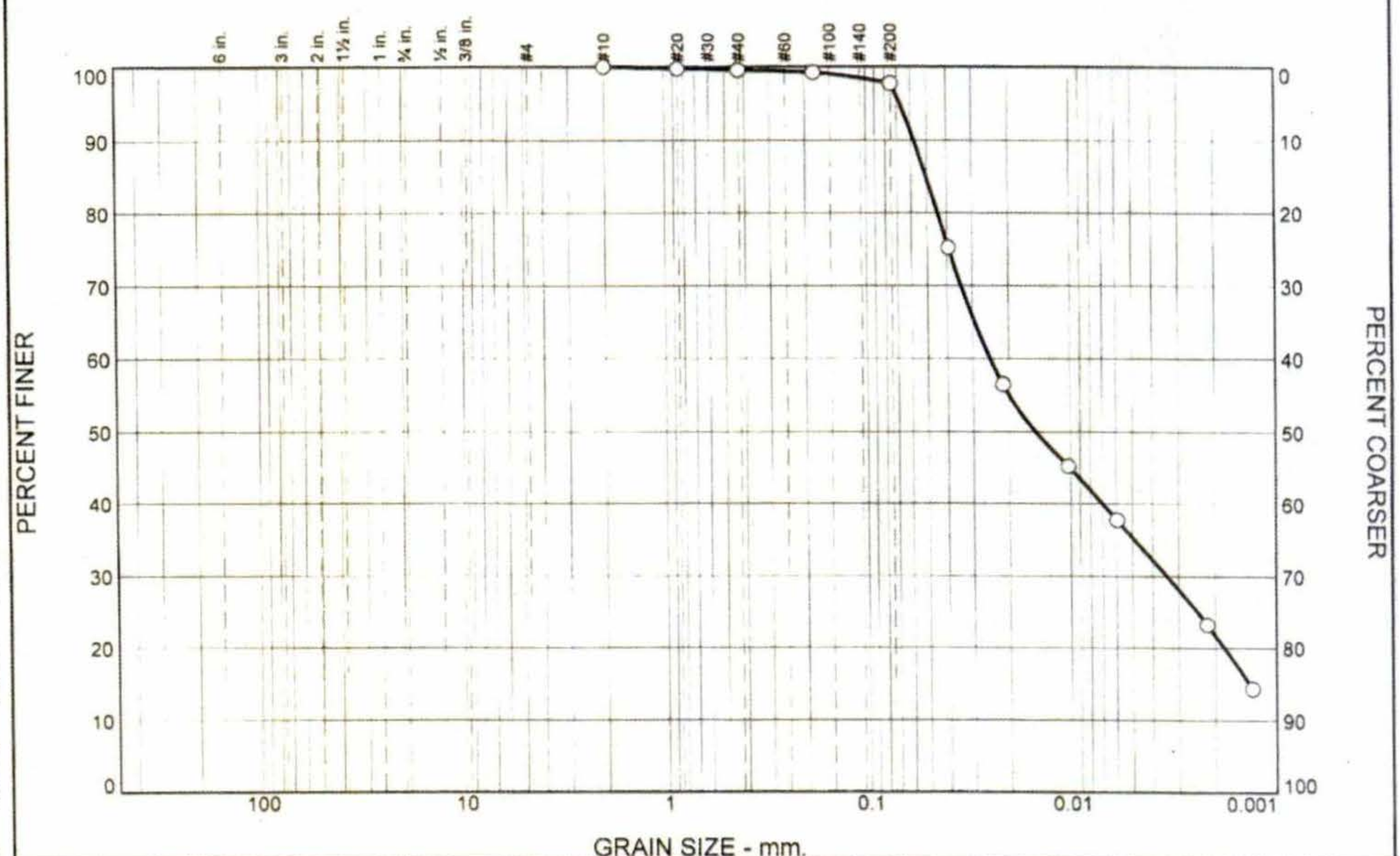
Date:

Tetra Tech, Inc.

Billings, MT

Client: Great West Engineering
Project: Billings Landfill Phase V Expansion
Project No: 114-550852 **Figure**

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	0.0	0.0	0.4	1.9	62.3	35.4

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#10	100.0		
#20	99.8		
#40	99.6		
#80	99.2		
#200	97.7		

* (no specification provided)

Material Description

Silt

Atterberg Limits

PL= 28 LL= 44 PI= 16

Coefficients

D_{90}= 0.0576 D_{85}= 0.0504 D_{60}= 0.0247
D_{50}= 0.0148 D_{30}= 0.0034 D_{15}= 0.0014
D_{10}= C_u= C_c=

Classification

USCS= ML AASHTO= A-7-6(19)

Remarks

Source of Sample: DH-1 **Depth:** 25.0'-25.7'

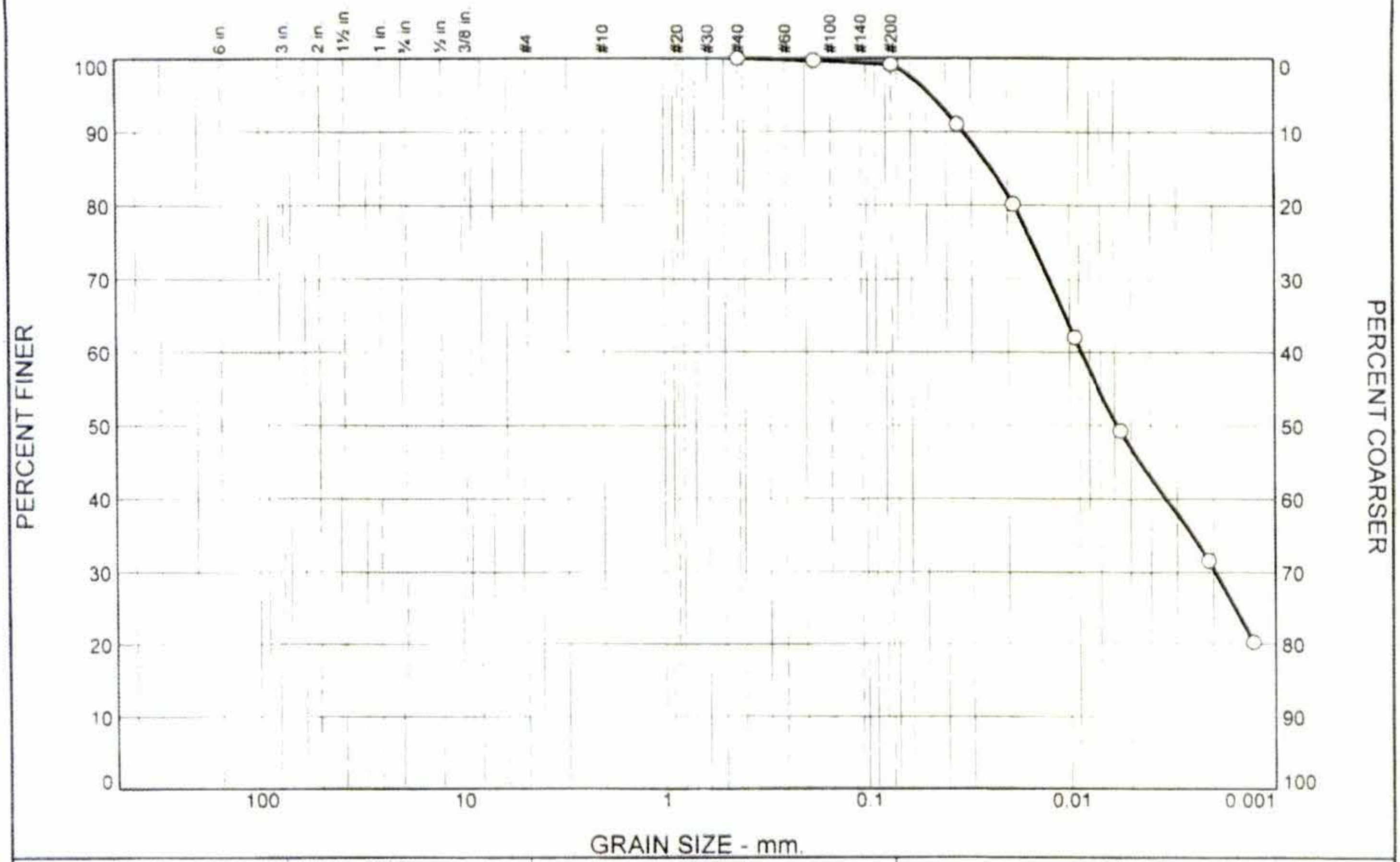
Date:

Tetra Tech, Inc.

Billings, MT

Client: Great West Engineering
Project: Billings Landfill Phase V Expansion
Project No: 114-550852 **Figure**

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	0.0	0.0	0.0	0.8	52.2	47.0

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#40	100.0		
#80	99.7		
#200	99.2		

* (no specification provided)

Material Description

Fat Clay

Atterberg Limits

PL= 19 LL= 59 PI= 40

Coefficients

D_{90}= 0.0326 D_{85}= 0.0239 D_{60}= 0.0088
D_{50}= 0.0058 D_{30}= 0.0019 D_{15}=
D_{10}= C_u= C_c=

Classification

USCS= CH AASHTO= A-7-6(44)

Remarks

Source of Sample: DH-1 **Depth:** 35.0'-35.5'

Date:

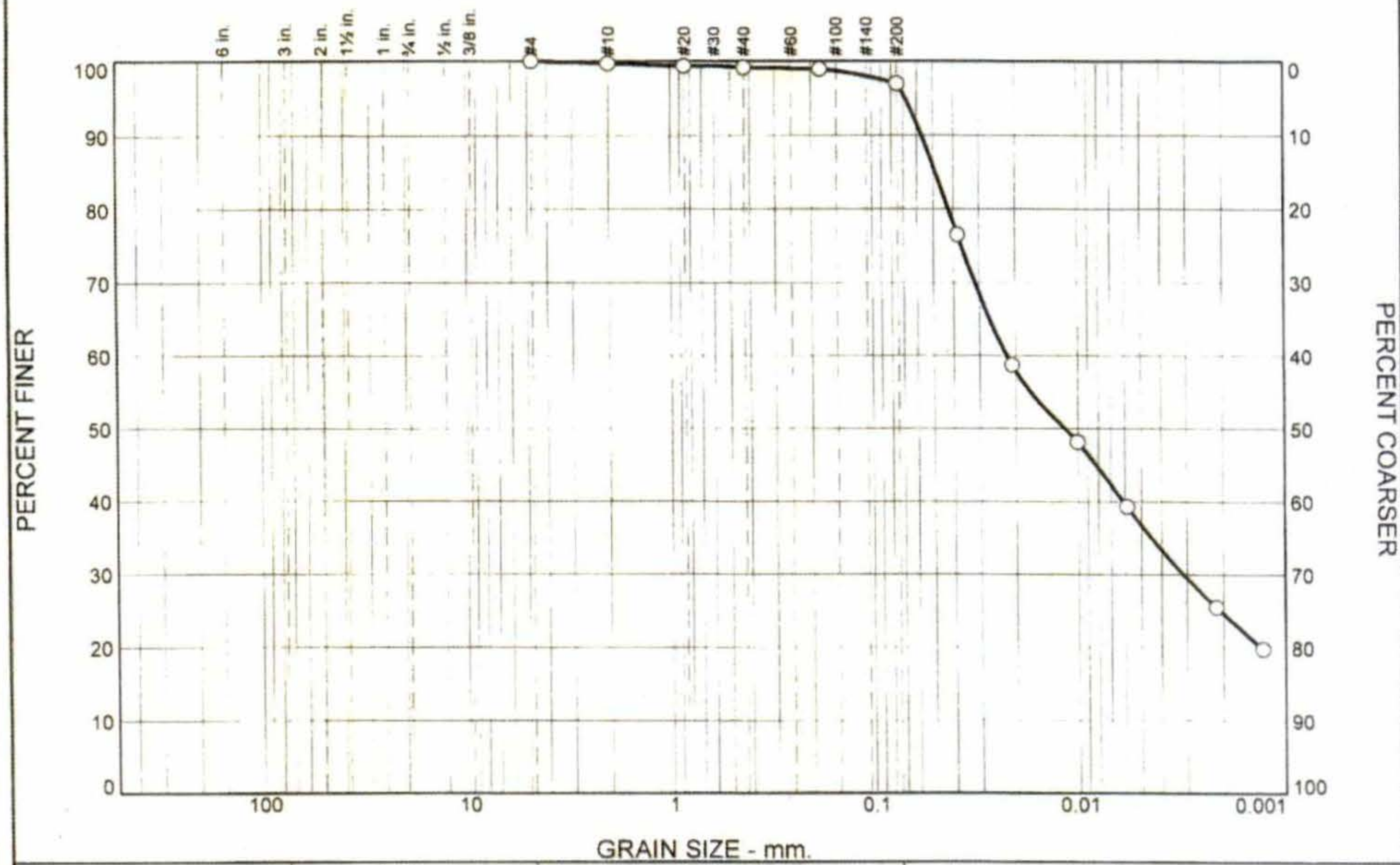
Tetra Tech, Inc.

Billings, MT

Client: Great West Engineering
Project: Billings Landfill Phase V Expansion

Project No: 114-550852 **Figure**

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	0.0	0.3	0.6	2.1	60.3	36.7

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#4	100.0		
#10	99.7		
#20	99.4		
#40	99.1		
#80	98.9		
#200	97.0		

* (no specification provided)

Material Description

Lean Clay

Atterberg Limits

PL= 19 LL= 43 PI= 24

Coefficients

D_{90}= 0.0567 D_{85}= 0.0486 D_{60}= 0.0221
D_{50}= 0.0116 D_{30}= 0.0031 D_{15}=
D_{10}= C_u= C_c=

Classification

USCS= CL AASHTO= A-7-6(25)

Remarks

Source of Sample: DH-2 **Depth:** 20.0'-20.4'

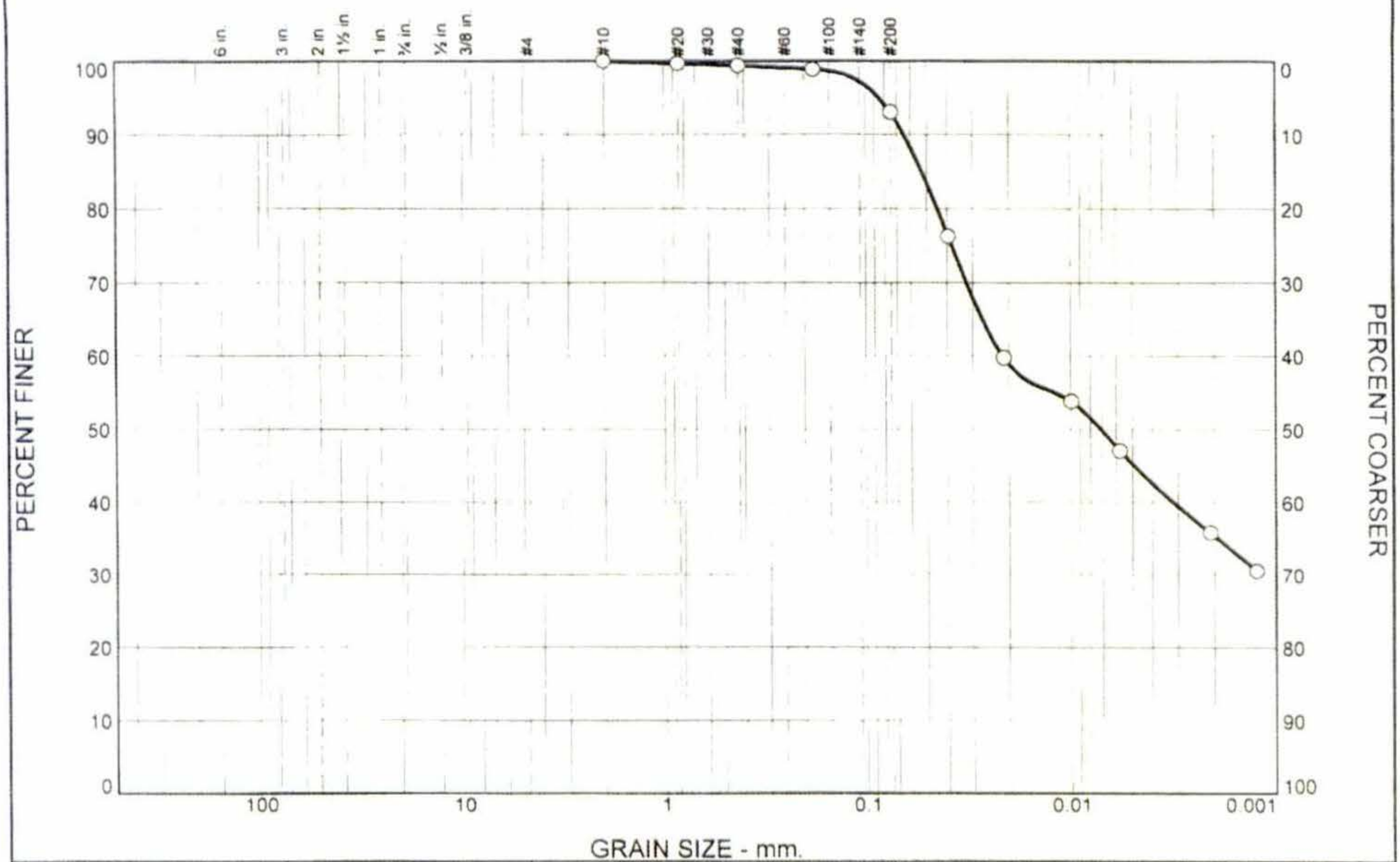
Date:

Tetra Tech, Inc.

Billings, MT

Client: Great West Engineering
Project: Billings Landfill Phase V Expansion
Project No: 114-550852 **Figure**

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	0.0	0.0	0.6	6.3	47.8	45.3

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#10	100.0		
#20	99.7		
#40	99.4		
#80	98.9		
#200	93.1		

* (no specification provided)

Material Description

Lean Clay

Atterberg Limits

PL= 18 LL= 45 PI= 27

Coefficients

D_{90}= 0.0643 D_{85}= 0.0528 D_{60}= 0.0215
D_{50}= 0.0071 D_{30}= D_{15}=
D_{10}= C_u= C_c=

Classification

USCS= CL AASHTO= A-7-6(26)

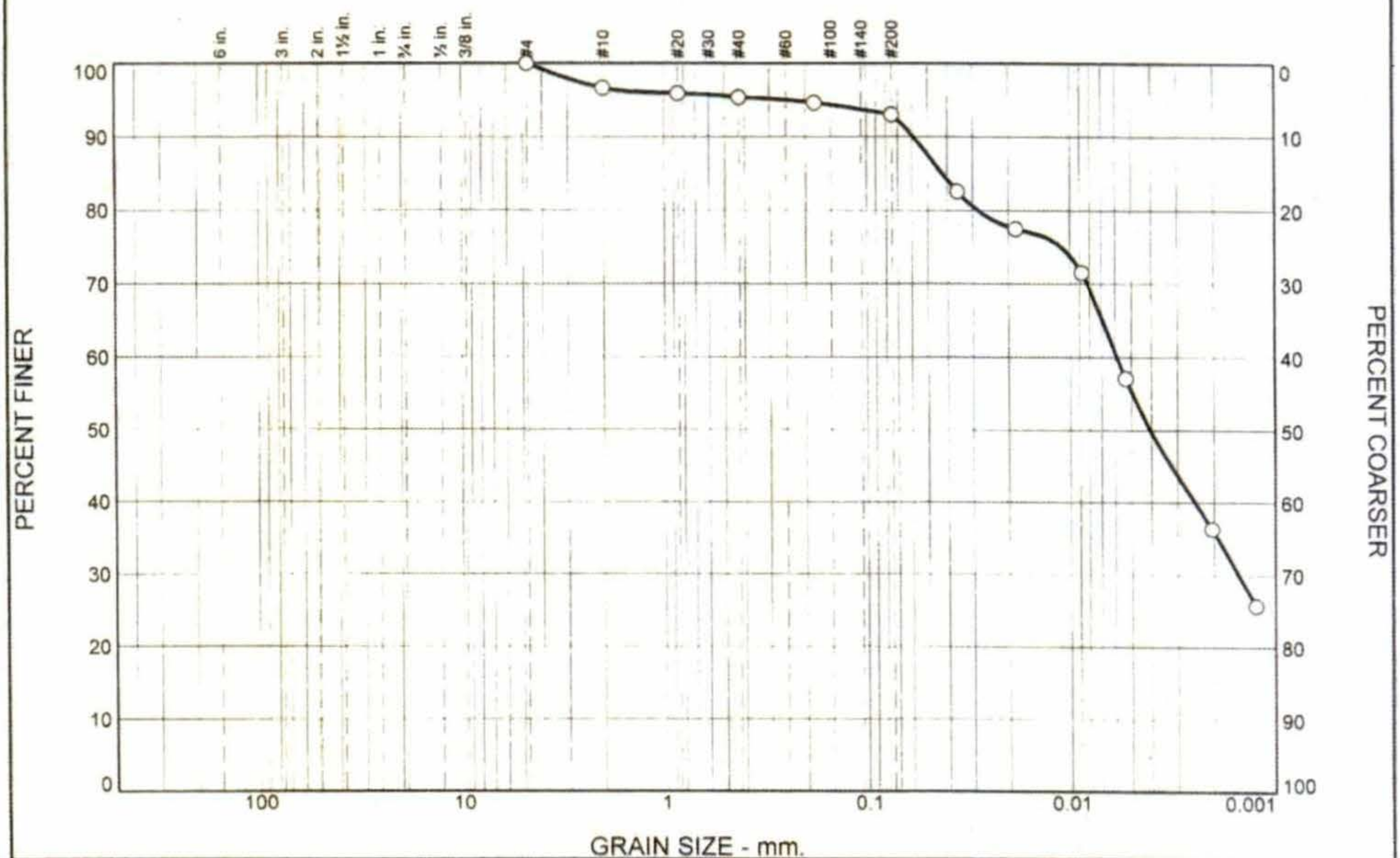
Remarks

Source of Sample: DH-2 **Depth:** 35.0'-35.4'

Date:

Tetra Tech, Inc.	**Client:** Great West Engineering
	Project: Billings Landfill Phase V Expansion
Billings, MT	**Project No:** 114-550852 **Figure**

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	0.0	3.4	1.3	2.3	37.7	55.3

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#4	100.0		
#10	96.6		
#20	95.9		
#40	95.3		
#80	94.6		
#200	93.0		

* (no specification provided)

Material Description

Fat Clay

Atterberg Limits

PL= 20 LL= 67 PI= 47

Coefficients

D_{90}= 0.0587 D_{85}= 0.0424 D_{60}= 0.0059
D_{50}= 0.0040 D_{30}= 0.0015 D_{15}=
D_{10}= C_u= C_c=

Classification

USCS= CH AASHTO= A-7-6(48)

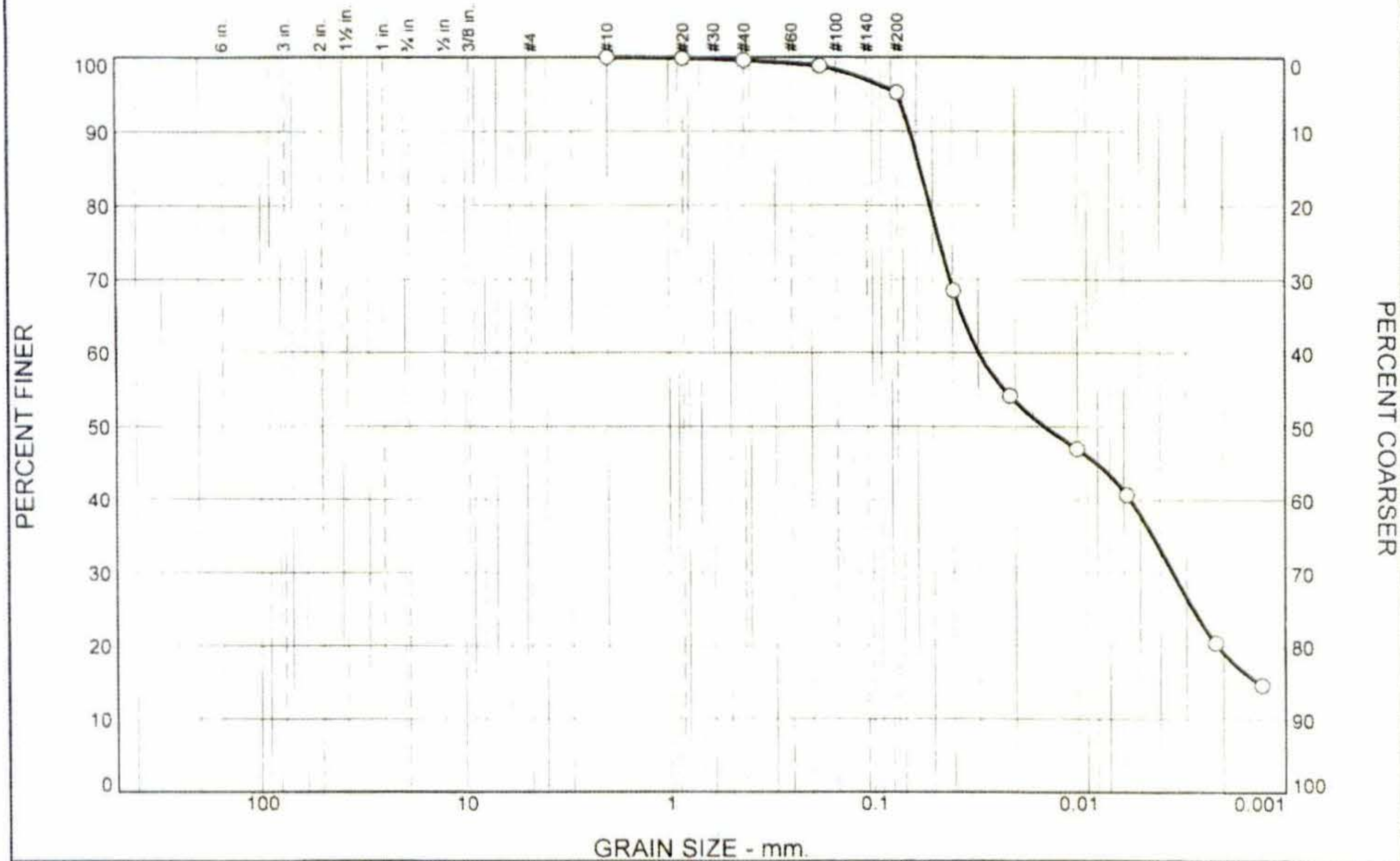
Remarks

Source of Sample: DH-1 **Depth:** 45.0'-45.4'

Date:

Tetra Tech, Inc.	**Client:** Great West Engineering
	Project: Billings Landfill Phase V Expansion
Billings, MT	**Project No:** 114-550852 **Figure**

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	0.0	0.0	0.4	4.3	57.3	38.0

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#10	100.0		
#20	99.9		
#40	99.6		
#80	98.9		
#200	95.3		

* (no specification provided)

Material Description

Lean Clay

Atterberg Limits

PL= 19 LL= 42 PI= 23

Coefficients

D_{90}= 0.0645 D_{85}= 0.0574 D_{60}= 0.0298
D_{50}= 0.0143 D_{30}= 0.0035 D_{15}= 0.0013
D_{10}= C_u= C_c=

Classification

USCS= CL AASHTO= A-7-6(23)

Remarks

Source of Sample: DH-3 **Depth:** 55.0'-60.0'

Date:

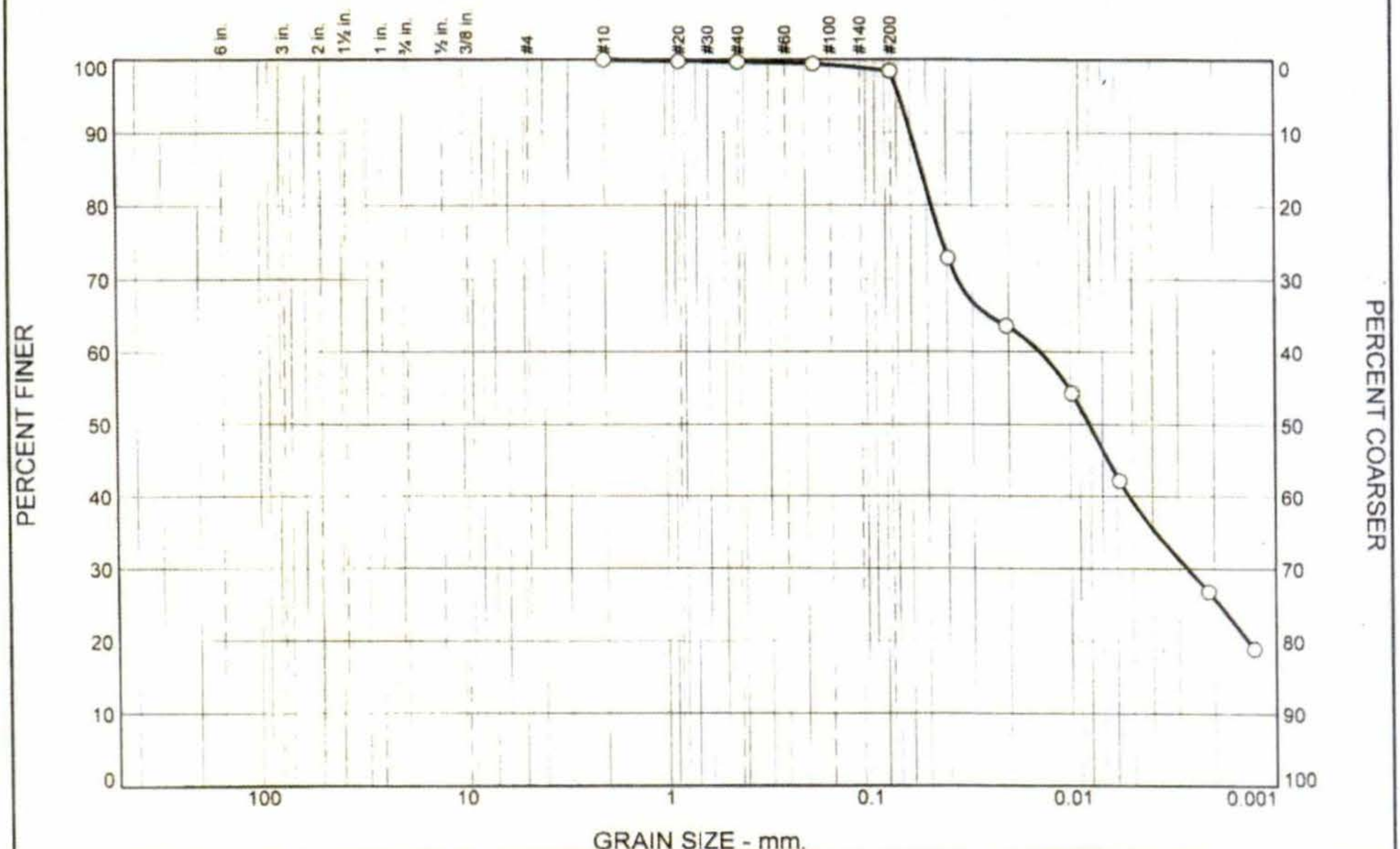
Tetra Tech, Inc.

Billings, MT

Client: Great West Engineering
Project: Billings Landfill Phase V Expansion

Project No: 114-550852 **Figure**

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	0.0	0.0	0.3	1.3	59.2	39.2

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#10	100.0		
#20	99.8		
#40	99.7		
#80	99.4		
#200	98.4		

* (no specification provided)

Material Description

Lean Clay

Atterberg Limits

PL= 20 LL= 48 PI= 28

Coefficients

D_{90}= 0.0594 D_{85}= 0.0530 D_{60}= 0.0140
D_{50}= 0.0081 D_{30}= 0.0027 D_{15}=
D_{10}= C_u= C_c=

Classification

USCS= CL AASHTO= A-7-6(30)

Remarks

Source of Sample: DH-3 **Depth:** 70.0'-75.0'

Date:

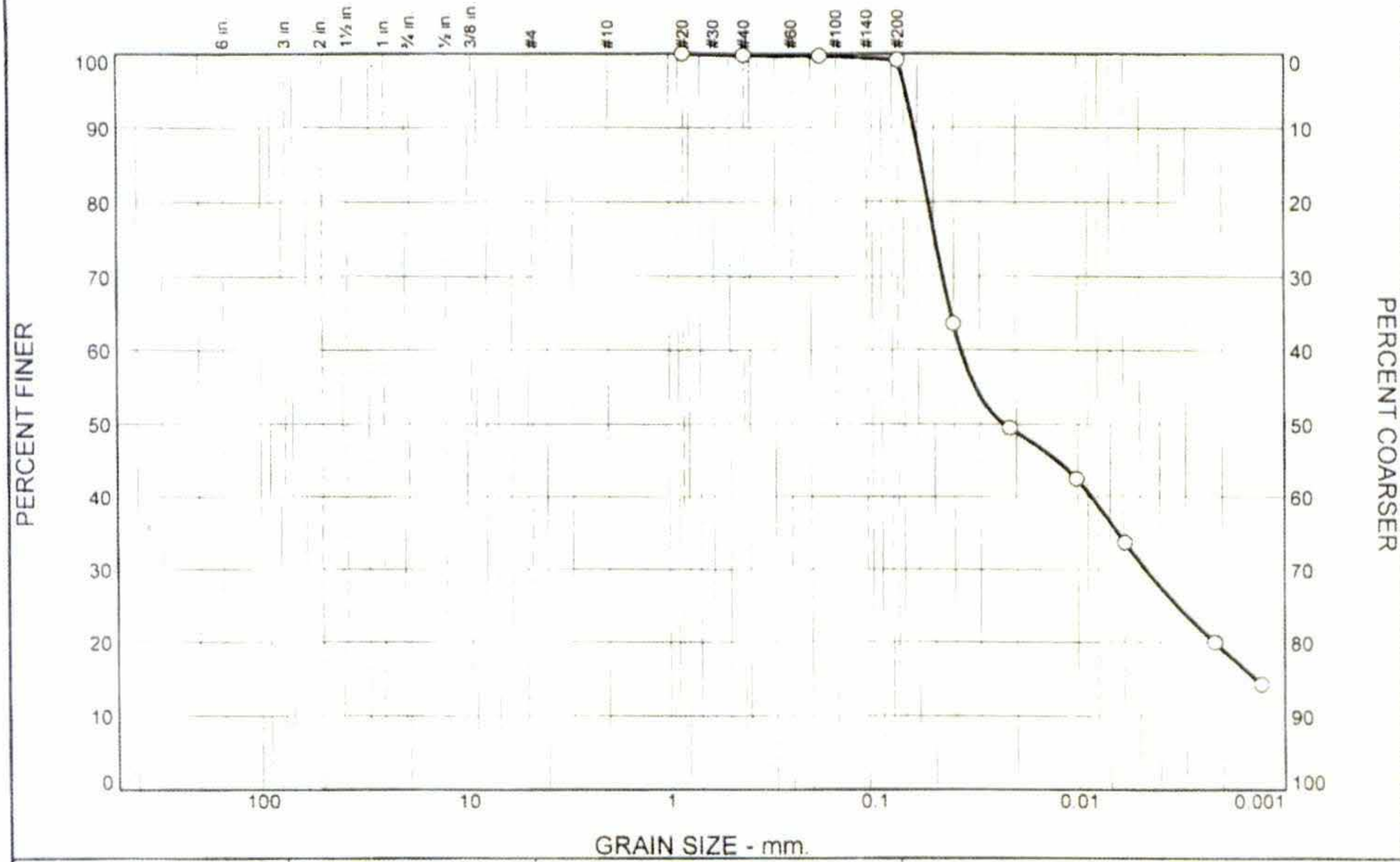
Tetra Tech, Inc.

Billings, MT

Client: Great West Engineering
Project: Billings Landfill Phase V Expansion

Project No: 114-550852 **Figure**

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	0.0	0.0	0.2	0.6	68.2	31.0

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#20	100.0		
#40	99.8		
#80	99.7		
#200	99.2		

* (no specification provided)

Material Description

Fat Clay

Atterberg Limits

PL= 22 LL= 55 PI= 33

Coefficients

D_{90}= 0.0624 D_{85}= 0.0575 D_{60}= 0.0371
D_{50}= 0.0227 D_{30}= 0.0047 D_{15}= 0.0014
D_{10}= C_u= C_c=

Classification

USCS= CH AASHTO= A-7-6(37)

Remarks

Source of Sample: DH-3 **Depth:** 85.0'-90.0'

Date:

Tetra Tech, Inc.	**Client:** Great West Engineering
	Project: Billings Landfill Phase V Expansion
Billings, MT	**Project No:** 114-550852 **Figure**

REPORT
OF
PRELIMINARY SUBSURFACE SOILS INVESTIGATION

SANITARY LANDFILL
Billings, Montana

TO
HENNINGSON, DURHAM & RICHARDSON
CONSULTING ENGINEERS
Helena, Montana

PREPARED
BY
NORTHERN TESTING LABORATORIES, INC.
CONSULTING GEOTECHNICAL ENGINEERS
Billings, Montana

AUGUST, 1977

Ge echnical Engineering

Field and Laboratory Investigations
Engineering Analysis and Recommendations
Consultation

Great Falls Billings Montana — Boise Idaho — Gillette Wyoming

P.O. Box 30615
600 South Twenty-fifth Street
Billings, Montana 59103
(406) 248-9161

August 17, 1977

Henningson, Durham & Richardson
Consulting Engineers
2225 Eleventh Avenue
Helena, Montana 59601

ATTENTION: Mr. Barry E. Damschen

Subject: Preliminary Subsurface Soils Investigation
Billings Sanitary Landfill

Gentlemen:

In accordance with our agreement dated May 11, 1977, we have made a preliminary subsurface soils investigation at the site of the proposed Billings sanitary landfill expansion. The purpose of this investigation was to provide subsurface information for use in planning.

A preliminary scope of work was developed in the field after conversation with your personnel, which included the following:

1) Recommendations for maximum excavation and fill slopes, based on past experience with similar soil types.

2) Determine if rock excavation will be required.

3) In-place and remolded permeability tests for materials used as cover over the landfill and at the base.

Our findings are briefly summarized below and a complete summary of the field and laboratory test results and test boring logs are enclosed.

FIELD INVESTIGATIONS

Six test borings were drilled to depths varying from 17.6 to 48.9 feet. The locations and elevations of the borings were determined by your personnel.

Continuous logs of the soil conditions were recorded, standard penetration resistance and field permeability tests made, and disturbed, undisturbed and NQ core samples obtained, during the field drilling program. The core samples were taken in the bedrock near the estimated base elevation. They were classified and a rock quality designation (RQD) analysis was calculated in the field. The RQD factor, shown on the drill logs, is determined by summing the length of all pieces of sound core, 4 inches or greater in length, and dividing this length by the total length of the core run. These values provide information helpful in evaluating the subsoil permeability and in determining the depth to which the material can be excavated.

A 30-foot-length of 4-inch-diameter perforated PVC pipe was installed in Drill Hole 4 for water sampling and monitoring groundwater levels.

LABORATORY INVESTIGATIONS

Samples obtained during the field exploration were taken to the laboratory where they were carefully inspected and visually classified in accordance with the Unified Soils Classification System. Representative samples were selected for tests to determine the engineering and physical properties of the soils.

These included:	To determine:
Grain-size distribution.............	size and distribution of soil particles, i.e., clay, silt, sand, gravel.
Atterberg limits....................	the consistency and "stickiness," as well as the range of moisture content within which the material is "workable."
Natural moisture....................	moisture content representative of field conditions at time sample was taken.
Natural density.....................	dry unit weight of sample representative of in-place undisturbed condition.

LABORATORY INVESTIGATIONS, continued

Direct shear........................soil shearing strength under varying load and/or moisture conditions. For use in foundation design and slope stability evaluation.

Permeability........................the rate at which fluid (water) will flow through soil or rock.

Moisture-density relationship.......the optimum (best) moisture content for compacting soil and the maximum dry unit weight (density) for a given compactive effort.

The results of all field and laboratory tests are summarized on the enclosed Table and Plates. This information, along with the field observations, was used to prepare the final test boring logs shown in the Appendix. Sampling and testing procedures are further described in the Appendix.

SUBSURFACE CONDITIONS

The natural soil profile consists generally of clay underlain by claystone shale. The silty clay is very stiff and has moderate shear strength. The claystone shale bedrock is slightly weathered and fractured near the contact zone, then becomes competent with depth. It contains interbedded seams of bentonite and sandy and siltstone shales. An exception to the above profile was encountered in Drill Hole 6, where bedrock was not reached.

FINDINGS

We understand the landfill operation will consist of excavating the natural materials to a specified level, placing the refuse, and eventually providing a soil cover to limit the infiltration of water into the refuse.

Excavations will be in clay and shale. These materials are generally stable at moderate slopes, and can be excavated by conventional means. A ripper may be required in the more competent shale. Permeability tests on both in-place and remolded samples indicate the in-place shale has a very low permeability and will be an excellent material for the base of the landfill. If the landfill base is in the clay stratum, it will require overexcavation and recompaction so sandy seams can be intermixed with the clay. As indicated by the test results shown below, the clay has low to very low permeability characteristics when compacted, and the shale is practically impermeable:

Henningson, Durham & Richardson
Helena, Montana

FINDINGS, continued

Material	Location and Depth in Feet	Condition	Permeability, cm/sec.
Clay	DH 2, 2.2 - 12.2	Remolded*	2×10^{-4}
Clay	DH 6, 2.4 - 12.4	Remolded*	6×10^{-7}
Clay	DH 6, 8.0 - 8.5	Undisturbed (lab)	1×10^{-6}
Shale	DH 1, 22.6 - 32.1	Remolded*	5×10^{-7}
Shale	DH 5, 22.5 - 24.0	Undisturbed (lab)	2×10^{-6}
Shale	DH 5, 33.3 - 40.3	In-place (field)	3×10^{-6}

*Samples were remolded at optimum moisture content to 90 percent of maximum dry density as determined by ASTM D698.

Permeability values (K) can be evaluated using the following criteria:

K in cm/sec.	
Greater than 10^{-3}	Permeable
10^{-3} to 10^{-5}	Low
10^{-5} to 10^{-7}	Very Low
10^{-7}	Practically Impermeable

Both the clay and shale, when compacted, are suitable for cover material.

CONCLUSIONS

Based on a minimum number of tests and past experience with soils having similar physical properties, general guidelines for planning are as follows:

1. Permanent cutslopes in either the silty clay or the claystone shale should not be steeper than 2:1 (horizontal to vertical).

CONCLUSIONS, continued

2. Fill slopes will vary, depending on the soil density and the refuse content. If uncontaminated (no refuse) materials are placed in 8-inch lifts and compacted at optimum moisture content to at least 90 percent of the maximum dry density determined by ASTM D698, slopes should not be steeper than 2-1/2:1.

3. The in-place materials can be excavated to the depths of our test borings using conventional excavation equipment.

4. Both the shale or clay, compacted to 90 percent of its maximum dry density, can be used for cover material.

5. If clay is encountered at the base elevation, it should be excavated an additional 24 inches, replaced in 8-inch lifts, and compacted to 95 percent of the maximum dry density as determined by ASTM D698.

If you have any questions concerning this report, please contact us at your convenience.

Respectfully submitted,

Larry G. O'Dell, P. E.

LGO/mb
Enclosures
In triplicate

90-544

REPORT
OF
GEOTECHNICAL INVESTIGATION

DAMSCHEN AND ASSOCIATES
P O BOX 4817
HELENA, MT 59604

BILLINGS LANDFILL
FIELD EXPLORATION SERVICES
CHEN-NORTHERN PROJECT NO. 90-544

PREPARED
BY
CHEN-NORTHERN, INC.
CONSULTING GEOTECHNICAL ENGINEERS
BILLINGS, MONTANA

AUGUST, 1990

August 14, 1990

Damschen and Associates
P O Box 4817
Helena, MT 59604

SUBJECT: Billings Landfill
Field Exploration Services

ATTENTION: Mr. Barry Damschen

Gentlemen:

At your request and in accordance with our agreement dated May 16, 1990 we have completed Tasks II and III of the proposed scope of services for the subject project. We have discussed our findings and recommendations with you as the work progressed.

The field exploration was conducted on May 9 and 10, 1990. Three borings were drilled and ten test pits excavated during the field exploration to observe subsoil and groundwater conditions near the central portion of the landfill site. The three exploration borings and two of the ten test pits were completed as temporary geotechnical observation holes for monitoring seepage levels in the claystone. Locations of the exploratory borings and test pits were approximated by you, referenced to recent aerial photography of the site; elevations were also provided by you. The approximate boring and test pit locations are shown on the enclosed site plan.

Subsoils at the site consist primarily of lean clay underlain by claystone and bentonite. The clay soil is typically firm to stiff and has low to medium plasticity. The claystone and bentonite are moderately hard to hard rock with high plasticity. Joint discontinuities are prevalent in the claystone and appear to be a primary seepage path in the area. During the field investigation numerous seeps were encountered in the test pits originating from joint surfaces exposed in the pit walls.

Enclosed are drill logs for each test pit and exploration boring. Test results from laboratory analysis of soil samples, joint orientations and groundwater levels are presented on the logs. Results of water quality tests were previously submitted in our technical report dated June 28, 1990. The invoice for field investigation and laboratory services is attached.

If you have any questions or if we can be of further service, please contact us.

Respectfully submitted

CHEN-NORTHERN, INC

David M. Hummel, Jr., P.E.

Richard P. Dombrouski

DMH(RPD)rl
Enclosures

Chen Northern, Inc.

A member of the HIH group of companies

LOG OF EXPLORATION BORING

PROJECT: BILLINGS LANDFILL
JOB NO.: 90-544
DRILL TYPE: SOIL MOBIL B 53, HOLLOWSTEM AUGERS
ROCK
DRILLED BY: BEN KRUEGER
LOGGED BY: R. DOMBROUSKI
REMARKS:

HOLE NO. DH-90-1
SHEET 1 OF 1
LOCATION: Refer to Site Plan
ELEVATION: TOP OF HOLE 3425.1
GROUNDWATER
DATE: HOLE STARTED 5/9/90
COMPLETED 5/9/90

DEPTH (Feet)	CLASSIFICATION AND DESCRIPTION	SAMPLE SYMBOL	S.P.T. (N) (BLOWS/FT.)	MOISTURE CONTENT (%)	IN-PLACE DRY DENSITY (pcf)	L.L. %	P.I. %	GRAVEL %	SAND %	SILT %	CLAY %
0.0	CLAYSTONE; gray, moderately hard rock, laminated, weathered, salts, jointed	LSS	50/0.4	16							
		LSS	50/0.4	17							
10											
13.5	BENTONITE; white-gray, soft to moderately hard rock, high plasticity, moist	LSS	50/0.3	26							
		LSS	50/0.0	-							
20.0	CLAYSTONE and SHALE; gray, hard rock, fissle, slightly weathered	LSS	50/0.0	-							
		LSS	50/0.0	-							
28.5	BOTTOM OF HOLE										

Chen Northern, Inc.

A member of the HIH group of companies

LOG OF EXPLORATION BORING

PROJECT: BILLINGS LANDFILL
JOB NO.: 90-544
DRILL TYPE: SOIL MOBIL B 53, HOLLOWSTEM AUGERS
ROCK
DRILLED BY: BEN KRUEGER
LOGGED BY: R. DOMBROUSKI
REMARKS:

HOLE NO. DH-90-2
SHEET 1 OF 2
LOCATION: Refer to Site Plan

ELEVATION: TOP OF HOLE 3454.6
GROUNDWATER
DATE: HOLE STARTED 5/9/90
COMPLETED 5/9/90

DEPTH (Feet)	CLASSIFICATION AND DESCRIPTION
0.0 – 4.0	Lean CLAY; stiff, moist, low plasticity, scattered claystone gravels, brown
4.0 – 38.5	CLAYSTONE; dark gray, soft to moderately hard rock, laminated, salts, jointed, becoming sandy below 8.5 feet, color change to brown at 8.0 feet, methane pocket from 33.5 to 38.5 feet
38.5 – 40	BENTONITE; white-gray, soft to moderately hard rock, high plasticity, moist

SAMPLE SYMBOL	S.P.T. (N) (BLOWS/FT.)	MOISTURE CONTENT (%)	IN-PLACE DRY DENSITY (pcf)	L.L. %	P.I. %	GRAVEL %	SAND %	SILT %	CLAY %
LSS	49	14							
LSS	50/0.4	12							
LSS	87/0.9	11							
LSS	50/0.5	10							
LSS	50/0.3	16							
LSS	50/0.4	14							
LSS	50/0.2	13							
LSS	50/0.2	24							

continued . . .

LOG OF EXPLORATION BORING

JOB NO. 90-544 HOLE NO. DH-90-2 SHEET 2 OF 2

DEPTH (Feet)	LEGEND	CLASSIFICATION AND DESCRIPTION	SAMPLE SYMBOL	S P T (N) (BLOWS FT.)	MOISTURE CONTENT (%)	IN-PLACE DRY DENSITY (pcf)	L L %	P I %	GRAVEL %	SAND %	SILT %	CLAY %
40		continued . . .										
40.7		BENTONITE; white-gray, soft to moderately hard rock, high plasticity, moist										
		CLAYSTONE	LSS	25/0.0	-							
43.5		BOTTOM OF HOLE										

NET 122C

Chen-Northern, Inc.

A member of the HIH group of companies

LOG OF EXPLORATION BORING

PROJECT: BILLINGS LANDFILL

JOB NO.: 90-544

DRILL TYPE SOIL: MOBIL B 53, HOLLOWSTEIN AUGERS

ROCK

DRILLED BY: BEN KRUEGER

LOGGED BY: R. DOMBROUSKI

REMARKS:

HOLE NO. DH-90-3

SHEET 1 OF 2

LOCATION: Refer to Site Plan

ELEVATION: TOP OF HOLE 3462.4

GROUNDWATER

DATE: HOLE STARTED 5/10/90

COMPLETED 5/10/90

DEPTH (Feet)	LEGEND	CLASSIFICATION AND DESCRIPTION	SAMPLE SYMBOL	S.P.T. (N) (BLOWS/FT.)	MOISTURE CONTENT (%)	IN-PLACE DRY DENSITY (pcf)	L.L. %	P.I. %	GRAVEL %	SAND %	SILT %	CLAY %
0.0												
			LSS	87	11							
10			LSS	82	10							
			LSS	50/0.3	5							
		CLAYSTONE; dark gray, moderately hard rock, laminated, high salt content, jointed, becoming hard below 15 feet	LSS	50/0.3	6							
20												
			LSS	50/0.4	5							
			LSS	50/0.4	13							
30												
			LSS	50/0.4	-							
40			LSS	50/0.2	-							

continued . . .

LOG OF EXPLORATION BORING

JOB NO. 90-544 HOLE NO. DH-90-3 SHEET 2 OF 2

DEPTH (Feet)	LEGEND	CLASSIFICATION AND DESCRIPTION	SAMPLE SYMBOL	S P T (N) (BLOWS FT.)	MOISTURE CONTENT (%)	IN-PLACE DRY DENSITY (pcf)	L L %	P I %	GRAVEL %	SAND %	SILT %	CLAY %
40		CLAYSTONE; dark gray, moderately hard rock, laminated, high salt content, jointed, becoming hard below 15 feet										
42.6		BENTONITE light gray, very soft rock, high plasticity, moist										
44.6		BOTTOM OF HOLE	STS / LSS	25/0.0	-	84	167	126	0	4	-96-	
						Coefficient of Permeability: k = 4 × 10-9 cm/sec						

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LOG OF EXPLORATION BORING

PROJECT: BILLINGS LANDFILL

JOB NO.: 90-544

DRILL TYPE: SOIL BACKHOE, JD610

ROCK

DRILLED BY: CITY OF BILLINGS

LOGGED BY: R. DOMBROUSKI

REMARKS:

HOLE NO. TP-1

SHEET 1 OF 1

LOCATION: Refer to Site Plan

ELEVATION: TOP OF HOLE 3433.5

GROUNDWATER

DATE: HOLE STARTED 5/9/90

COMPLETED 5/9/90

DEPTH (Feet)	LEGEND	CLASSIFICATION AND DESCRIPTION	SAMPLE SYMBOL	S.P.T. (N) (BLOWS/FT.)	MOISTURE CONTENT (%)	IN-PLACE DRY DENSITY (pcf)	L.L. %	P.I. %	GRAVEL %	SAND %	SILT %	CLAY %
0.0 0.5 5 6.0 6.3 6.4		CLAYSTONE; dark gray to brown, soft to moderately hard rock, very weathered, weakly cemented, thinly bedded, jointed, thin bentonite seam from 6.0 to 6.3 feet, low to moderate water inflow from joints	SACK	-	41		90	57	0	5	-95-	
		BOTTOM OF HOLE Joint Orientations 1. N 64° W, 81° NE 2. N 69° W, 81° NE 3. N 16° W, 79° SE										

(Rev. 1/89) CNI-1228

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LOG OF EXPLORATION BORING

PROJECT	BILLINGS LANDFILL	HOLE NO	TP-2
		SHEET	1 OF 1
JOB NO	90-544	LOCATION	Refer to Site Plan
DRILL TYPE SOIL	BACKHOE, JD610		
ROCK		ELEVATION TOP OF HOLE	3473.0
DRILLED BY	CITY OF BILLINGS	GROUNDWATER	
LOGGED BY	R. DOMBROUSKI	DATE HOLE STARTED	5/9/90
REMARKS		COMPLETED	5/9/90

DEPTH (Feet)	LEGEND	CLASSIFICATION AND DESCRIPTION	SAMPLE SYMBOL	S.P.T. (N) (BLOWS/FT.)	MOISTURE CONTENT (%)	IN-PLACE DRY DENSITY (pcf)	L.L. %	P.I. %	GRAVEL %	SAND %	SILT %	CLAY %
0.0–0.5		TOPSOIL with organic material										
0.5–4.0		Poorly Graded GRAVEL with Sand; very dense, slightly moist, nonplastic, scattered cobbles, estimate 8" maximum size, subrouded to rounded										
4.0–5.0		Lean CLAY; stiff, moist, low to medium plasticity, dark brown										
5.0–12.0		CLAYSTONE; dark gray, soft to moderately hard rock, slightly weathered, jointed, salts	L.SACK		12							
			L.SACK		11							
12.0		BOTTOM OF HOLE										

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LOG OF EXPLORATION BORING

PROJECT: BILLINGS LANDFILL

JOB NO: 90-544

DRILL TYPE: SOIL BACKHOE, JD610

ROCK

DRILLED BY: CITY OF BILLINGS

LOGGED BY: R. DOMBROUSKI

REMARKS:

HOLE NO. TP-3

SHEET 1 OF 1

LOCATION: Refer to Site Plan

ELEVATION: TOP OF HOLE 3452.3

GROUNDWATER

DATE HOLE STARTED 5/9/90

COMPLETED 5/9/90

DEPTH (Feet)	LEGEND	CLASSIFICATION AND DESCRIPTION	SAMPLE SYMBOL	S.P.T. (N) (BLOWS/FT.)	MOISTURE CONTENT (%)	IN-PLACE DRY DENSITY (pcf)	L.L. %	P.I. %	GRAVEL %	SAND %	SILT %	CLAY %
0.0		TOPSOIL with organic material										
0.2		Lean CLAY with Sand; firm to stiff, very moist, medium plasticity, claystone fragments, brown										
2.9		CLAYSTONE; dark gray, moderately hard rock, weakly cemented, thinly laminated, jointed, water inflow fromjoint at 8.6 feet Joint Orientation N 25° E, 90°	L. SACK	-	11							
9.7		BOTTOM OF HOLE										

(Rev 1/89) CNI 122B

Chen-Northern, Inc.

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LOG OF EXPLORATION BORING

PROJECT: BILLINGS LANDFILL
JOB NO.: 90-544
DRILL TYPE SOIL: BACKHOE, JD610
ROCK:
DRILLED BY: CITY OF BILLINGS
LOGGED BY: R. DOMBROUSKI
REMARKS:

HOLE NO.: TP-4
SHEET: 1 OF 1
LOCATION: Refer to Site Plan
ELEVATION: TOP OF HOLE 3404.8
GROUNDWATER:
DATE HOLE STARTED: 5/9/90
COMPLETED: 5/9/90

DEPTH (Feet)	LEGEND	CLASSIFICATION AND DESCRIPTION	SAMPLE SYMBOL	S.P.T. (N) (BLOWS/FT.)	MOISTURE CONTENT (%)	IN-PLACE DRY DENSITY (pcf)	L.L. %	P.I. %	GRAVEL %	SAND %	SILT %	CLAY %
0.0 – 3.0		Lean CLAY; firm to stiff, medium, moist, brown										
3.0 – 12.0		CLAYSTONE; dark gray, soft rock, weathered, moist, laminated, jointed										
12.0		BOTTOM OF HOLE										

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LOG OF EXPLORATION BORING

PROJECT: BILLINGS LANDFILL

JOB NO.: 90-544

DRILL TYPE: SOIL BACKHOE, JD610

ROCK

DRILLED BY: CITY OF BILLINGS

LOGGED BY: R. DOMBROUSKI

REMARKS:

HOLE NO. TP-5

SHEET 1 OF 1

LOCATION: Refer to Site Plan

ELEVATION: TOP OF HOLE 3398.2

GROUNDWATER

DATE: HOLE STARTED 5/9/90

COMPLETED 5/9/90

DEPTH (Feet)	LEGEND	CLASSIFICATION AND DESCRIPTION	SAMPLE SYMBOL	S.P.T. (N) (BLOWS/FT.)	MOISTURE CONTENT (%)	IN-PLACE DRY DENSITY (pcf)	LL %	P.I. %	GRAVEL %	SAND %	SILT %	CLAY %
0.0 – 2.5		Fat CLAY; stiff, very moist, high plasticity, salts, brown	SACK		38							
2.5 – 13.0		CLAYSTONE; dark gray, soft to moderately hard rock, moist, laminated, weakly cemented, jointed Joint Orientation N 22° E, 77° NW	SACK		14							
13.0		BOTTOM OF HOLE										

Depth scale: 0.0, 2.5, 5, 10, 13.0

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LOG OF EXPLORATION BORING

PROJECT: BILLINGS LANDFILL
JOB NO.: 90-544
DRILL TYPE: SOIL: BACKHOE, JD610
ROCK:
DRILLED BY: CITY OF BILLINGS
LOGGED BY: R. DOMBROUSKI
REMARKS:

HOLE NO. TP-6
SHEET 1 OF 1
LOCATION: Refer to Site Plan

ELEVATION: TOP OF HOLE 3386.4
GROUNDWATER
DATE: HOLE STARTED 5/9/90
COMPLETED 5/9/90

DEPTH (Feet)	LEGEND	CLASSIFICATION AND DESCRIPTION	SAMPLE SYMBOL	S.P.T. (N) (BLOWS/FT.)	MOISTURE CONTENT (%)	IN-PLACE DRY DENSITY (pcf)	L.L. %	P.I. %	GRAVEL %	SAND %	SILT %	CLAY %
0.0–0.3		TOPSOIL with organic material										
0.3–4.5		FILL; Lean Clay; firm, moist, medium plasticity, wood debris, garbage and refuse										
4.5–9.8		CLAYSTONE; gray to cream, soft rock, laminated, slightly moist, bentonite seam from 6.5 to 7.3 feet	L. SACK (5–7.3)		12							
			L. SACK (9.8)		11							
9.8		BOTTOM OF HOLE										

(Rev. 1/89) CNI-122B

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LOG OF EXPLORATION BORING

PROJECT: BILLINGS LANDFILL

JOB NO.: 90-544

DRILL TYPE: SOIL MOBIL B 53, HOLLOWSTEIN AUGERS

ROCK

DRILLED BY: BEN KRUEGER

LOGGED BY: R. DOMBROUSKI

REMARKS:

HOLE NO. TP-7

SHEET 1 OF 1

LOCATION: Refer to Site Plan

ELEVATION: TOP OF HOLE 3384.7

GROUNDWATER

DATE: HOLE STARTED 5/9/90

COMPLETED 5/9/90

DEPTH (Feet)	LEGEND	CLASSIFICATION AND DESCRIPTION	SAMPLE SYMBOL	S.P.T. (N) (BLOWS/FT.)	MOISTURE CONTENT (%)	IN-PLACE DRY DENSITY (pcf)	L.L. %	P.I. %	GRAVEL %	SAND %	SILT %	CLAY %
0.0		FILL; Lean Clay, very moist, firm to stiff, medium plasticity, light brown										
5.4		FILL; Garbage and Debris										
8.0		BOTTOM OF HOLE										

(Rev. 1/89) CNI-122B

LOG OF EXPLORATION BORING

PROJECT: BILLINGS LANDFILL
JOB NO.: 90-544
DRILL TYPE: SOIL BACKHOE, JD610
ROCK
DRILLED BY: CITY OF BILLINGS
LOGGED BY: R. DOMBROUSKI
REMARKS:

HOLE NO. TP-8
SHEET 1 OF 1
LOCATION: Refer to Site Plan
ELEVATION: TOP OF HOLE 3408.5
GROUNDWATER
DATE: HOLE STARTED 5/9/90
COMPLETED 5/9/90

DEPTH (Feet)	LEGEND	CLASSIFICATION AND DESCRIPTION	SAMPLE SYMBOL	S.P.T. (N) (BLOWS/FT.)	MOISTURE CONTENT (%)	IN-PLACE DRY DENSITY (pcf)	L.L. %	P.I. %	GRAVEL %	SAND %	SILT %	CLAY %
0.0		TOPSOIL with organic material										
0.1		CLAYSTONE; dark gray, soft to moderately hard rock, weakly cemented, thinly laminated, jointed, low water inflow from joint at 2.2 feet Joint Orientation 1. N 23° W, 87° SE 2. N 82° E, 90° 3. N 1° W, 83° NE 4. N 70° W, 85° NE 5. N 88° W, 84° NE										
7.0		BENTONITE; gray to white, soft rock, moist, high plasticity Probable Claystone-Shale contact, Practical Bucket Refusal at 12.0 feet	SACK; L. SACK		40							
12.0		BOTTOM OF HOLE										

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LOG OF EXPLORATION BORING

PROJECT: BILLINGS LANDFILL

JOB NO.: 90-544

DRILL TYPE: SOIL BACKHOE, JD610

ROCK

DRILLED BY: CITY OF BILLINGS

LOGGED BY: R. DOMBROUSKI

REMARKS:

HOLE NO. TP-9

SHEET 1 OF 1

LOCATION: Refer to Site Plan

ELEVATION: TOP OF HOLE 3400.6

GROUNDWATER NONE ENCOUNTERED

DATE: HOLE STARTED 5/9/90

COMPLETED 5/9/90

DEPTH (Feet)	LEGEND	CLASSIFICATION AND DESCRIPTION	SAMPLE SYMBOL	S.P.T. (N) (BLOWS/FT.)	MOISTURE CONTENT (%)	IN-PLACE DRY DENSITY (pcf)	L.L. %	P.I. %	GRAVEL %	SAND %	SILT %	CLAY %
0.0		TOPSOIL with organic material										
0.1		Lean CLAY; firm, moist, medium plasticity, brown										
2.0		CLAYSTONE; gray, slightly moist to dry, weakly cemented, thinly laminated										
4.1		BENTONITE; gray to white, soft rock, very moist, high plasticity										
		Probable Claystone-Shale contact, Practical Bucket Refusal at 8.8 feet	L SACK									
8.8		BOTTOM OF HOLE										

(Rev. 1/89) CNI-122B

Chen Northern, Inc.

A member of the HIH group of companies

LOG OF EXPLORATION BORING

PROJECT: BILLINGS LANDFILL

JOB NO.: 90-544

DRILL TYPE: SOIL

ROCK

DRILLED BY: CITY OF BILLINGS

LOGGED BY: R. DOMBROUSKI

REMARKS:

HOLE NO. TRENCH CUT TP-10

SHEET 1 OF 1

LOCATION: Refer to Site Plan

ELEVATION: TOP OF HOLE 3407.5

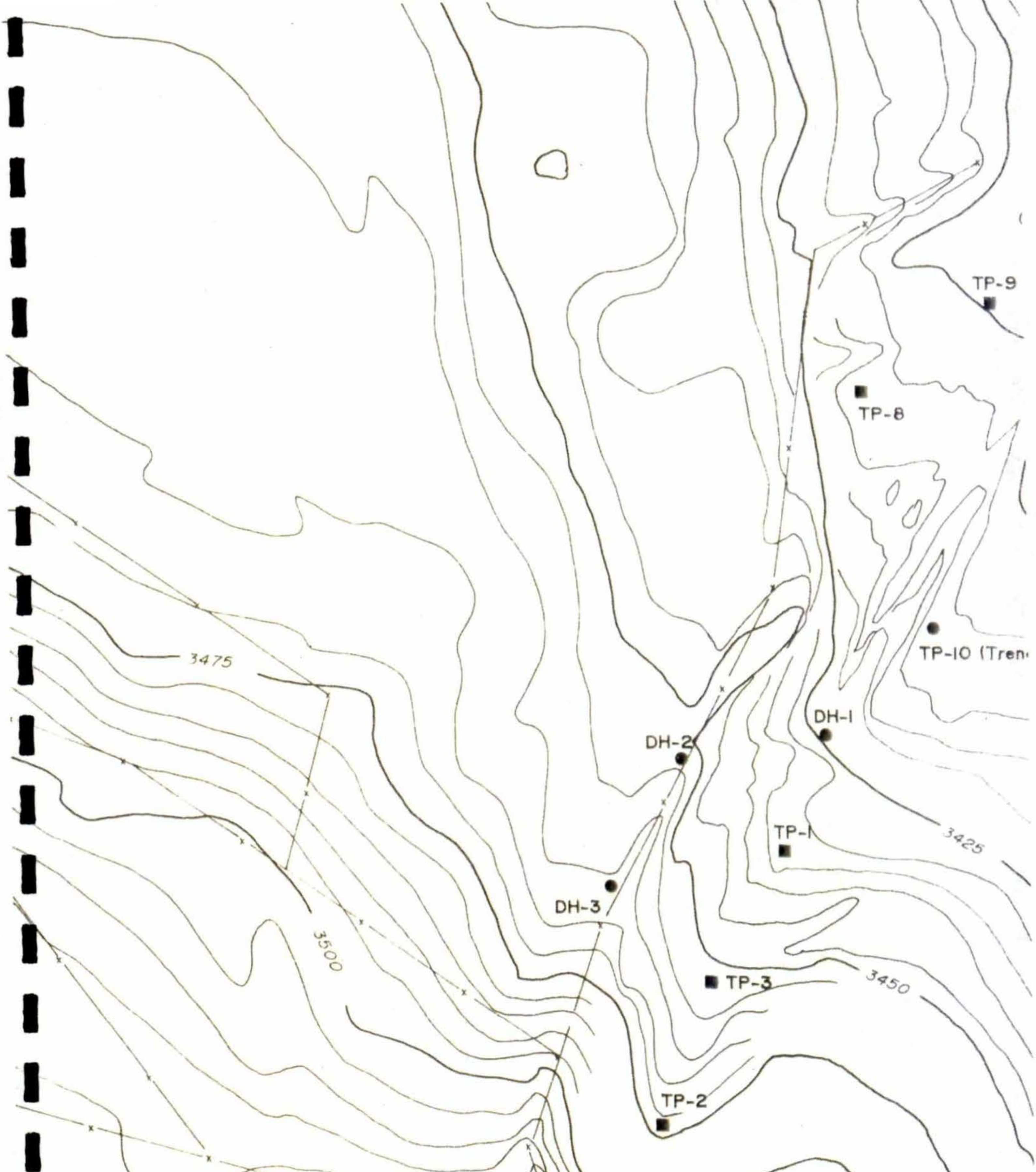
GROUNDWATER

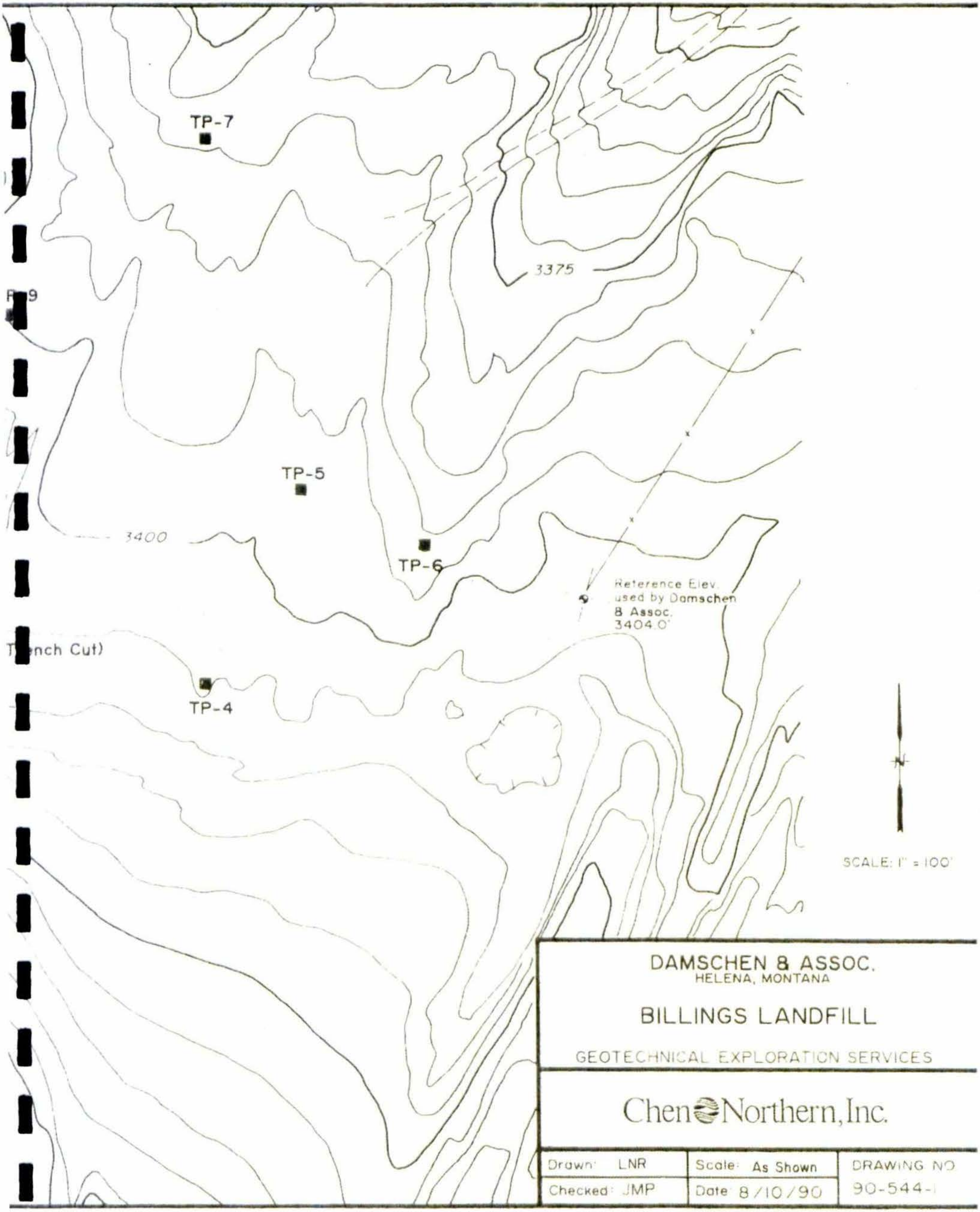
DATE: HOLE STARTED 5/9/90

COMPLETED 5/9/90

DEPTH (Feet)	LEGEND	CLASSIFICATION AND DESCRIPTION	SAMPLE SYMBOL	S.P.T. (N) (BLOWS/FT.)	MOISTURE CONTENT (%)	IN-PLACE DRY DENSITY (pcf)	L.L. %	P.I. %	GRAVEL %	SAND %	SILT %	CLAY %
0.0 – 12.5		CLAYSTONE; dark gray, soft rock, thinly laminated, weakly cemented, jointed, salts, parting at 4.0 feet and 8.0 feet, moderate water inflow at 12.5 feet from joints Joint Orientation 1. N 1° E, 77° NW 2. N 74° W, 89° NE 3. N 70° W, 88° NE 4. N 70° W, 88° NE 5. N 72° W, 89° NE 6. N 16° E, 90°										
12.0		GWL (5/9/90)										
12.5		BOTTOM OF HOLE										

(Rev. 1/89) CNI-122B


TP-9
TP-8
TP-10 (Tren
DH-1
DH-2
3475
TP-1
3425
DH-3
3500
TP-3
3450
TP-2



DAMSCHEN 8 ASSOC.
HELENA, MONTANA

BILLINGS LANDFILL

GEOTECHNICAL EXPLORATION SERVICES

Chen Northern, Inc.

Drawn: LNR	Scale: As Shown	DRAWING NO.
Checked: JMP	Date 8/10/90	90-544-1

Appendix B
LandGEM Results for 2007 NMOC Evaluation

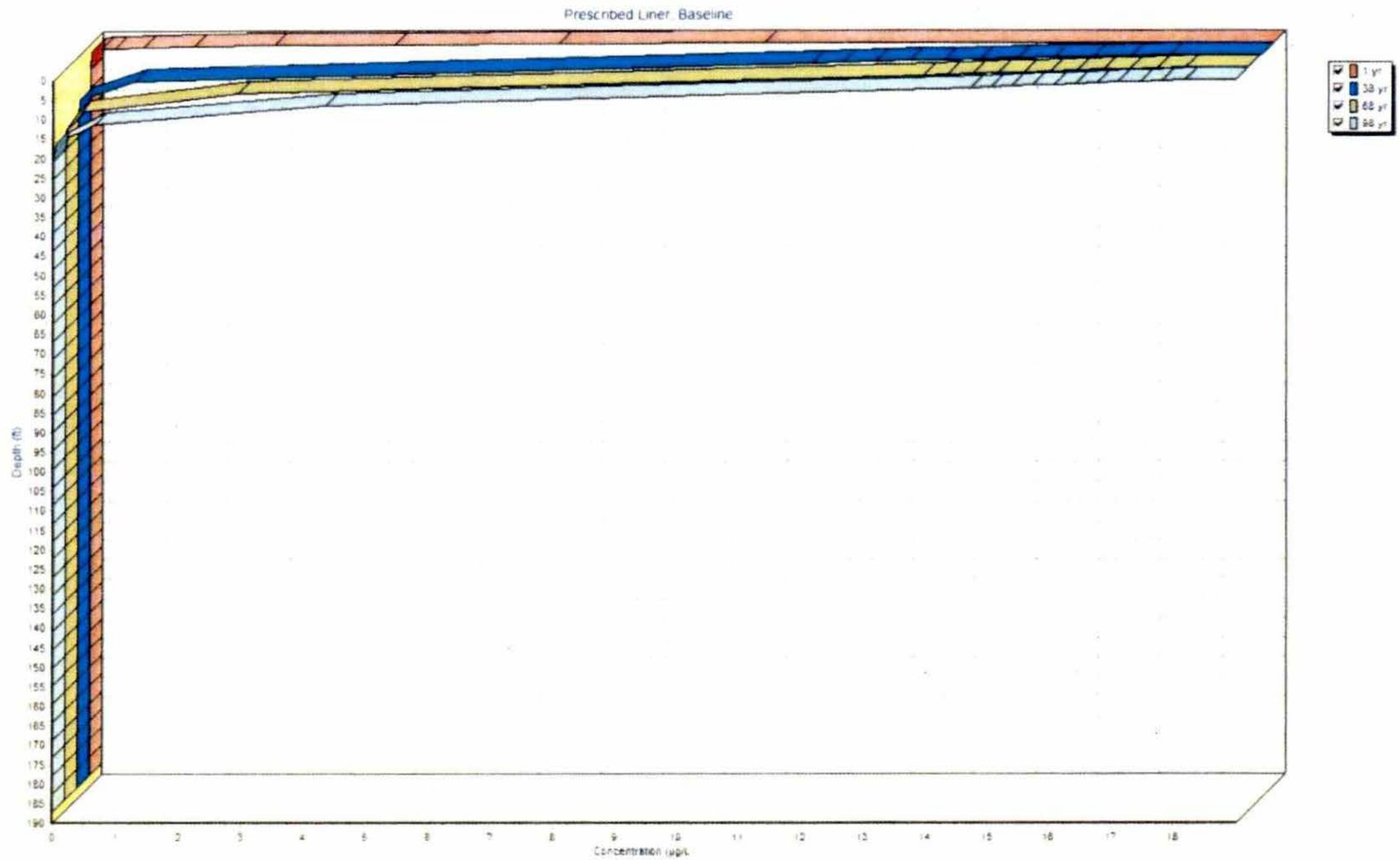
INVENTORY

Landfill Name or Identifier: Billings Regional Landfill

Enter year of emissions inventory: 2048

Gas / Pollutant	Emission Rate				
	(Mg/year)	*(m^3/year)*	*(av ft^3/min)*	*(ft^3/year)*	*(short tons/year)*
Total landfill gas	5.019E+04	4.019E+07	2.700E+03	1.419E+09	5.521E+04
Methane	1.341E+04	2.010E+07	1.350E+03	7.097E+08	1.475E+04
Carbon dioxide	3.679E+04	2.010E+07	1.350E+03	7.097E+08	4.046E+04
NMOC	8.946E+01	2.496E+04	1.677E+00	8.814E+05	9.841E+01
1,1,1-Trichloroethane (methyl chloroform) - HAP	1.070E-01	1.929E+01	1.296E-03	6.813E+02	1.178E-01
1,1,2,2-Tetrachloroethane - HAP/VOC	3.087E-01	4.421E+01	2.971E-03	1.561E+03	3.395E-01
1,1-Dichloroethane (ethylidene dichloride) - HAP/VOC	3.971E-01	9.646E+01	6.481E-03	3.406E+03	4.368E-01
1,1-Dichloroethene (vinylidene chloride) - HAP/VOC	3.241E-02	8.038E+00	5.401E-04	2.839E+02	3.565E-02
1,2-Dichloroethane (ethylene dichloride) - HAP/VOC	6.783E-02	1.648E+01	1.107E-03	5.819E+02	7.461E-02

Appendix C
POLLUTE Model Results



Prescribed liner, 98-year run.

POLLUTEv7

Version 7.11

Prescribed Liner, Baseline

THE DARCY VELOCITY (Flux) THROUGH THE LAYERS Va = 2.182E-6 ft/a

Layer Properties

Layer	Thickness	Number of Sublayers	Coefficient of Hydrodynamic Dispersion	Matrix Porosity	Distributon Coefficient	Dry Density
Geomembrane	60 mil	1	2E-8 cm2/s	1	0 m3/kg	950 kg/m3
Clay Base	2 ft	10	6E-6 cm2/s	0.3	0 mL/g	102.9 lb/ft3
Aquitard	185 ft	10	4E-6 cm2/s	0.254	0 mL/g	102.9 lb/ft3

Boundary Conditions

Finite Mass Top Boundary

Initial Concentration = 19 μg/L
Volume of Leachate Collected = 0.0339999940219178 ft/day
Thickness of Waste = 125 ft
Waste Density = 1200 lb/ft3
Proportion of Mass = 0.001
Reference Height of Leachate = 0 m

Fixed Outflow Bottom Boundary

Landfill Length = 289.56 m
Landfill Width = 1 m
Base Thickness = 1 ft
Base Porosity = 0.3
Base Outflow Velocity = 0.002073 ft/a

Laplace Transform Parameters

TAU = 7   N = 20   SIG = 0   RNU = 2

Calculated Concentrations at Selected Times and Depths

Time yr	Depth ft	Concentration µg/L
1	0.000E+00	1.900E+01
	5.000E-03	1.084E+01
	2.050E-01	7.518E+00
	4.050E-01	4.871E+00
	6.050E-01	2.936E+00
	8.050E-01	1.640E+00
	1.005E+00	8.464E-01
	1.205E+00	4.026E-01
	1.405E+00	1.761E-01
	1.605E+00	7.084E-02
	1.805E+00	2.651E-02
	2.005E+00	1.036E-02
	6.630E+00	1.239E-17
	1.126E+01	1.686E-32
	1.588E+01	4.115E-47
	2.051E+01	0.000E+00
	2.513E+01	0.000E+00
	2.976E+01	0.000E+00
	3.438E+01	0.000E+00
	3.901E+01	0.000E+00
	4.363E+01	0.000E+00
	4.826E+01	0.000E+00
	5.288E+01	0.000E+00
	5.751E+01	0.000E+00
	6.213E+01	0.000E+00
	6.676E+01	0.000E+00
	7.138E+01	0.000E+00
	7.601E+01	0.000E+00
	8.063E+01	0.000E+00
	8.526E+01	0.000E+00
	8.988E+01	0.000E+00
	9.451E+01	0.000E+00
	9.913E+01	0.000E+00
	1.038E+02	0.000E+00
	1.084E+02	0.000E+00
	1.130E+02	0.000E+00
	1.176E+02	0.000E+00

	1.223E+02	0.000E+00
	1.269E+02	0.000E+00
	1.315E+02	0.000E+00
	1.361E+02	0.000E+00
	1.408E+02	0.000E+00
	1.454E+02	0.000E+00
	1.500E+02	0.000E+00
	1.546E+02	0.000E+00
	1.593E+02	0.000E+00
	1.639E+02	0.000E+00
	1.685E+02	0.000E+00
	1.731E+02	0.000E+00
	1.778E+02	0.000E+00
	1.824E+02	0.000E+00
	1.870E+02	0.000E+00
10	0.000E+00	1.900E+01
	5.000E-03	1.584E+01
	2.050E-01	1.446E+01
	4.050E-01	1.312E+01
	6.050E-01	1.184E+01
	8.050E-01	1.063E+01
	1.005E+00	9.502E+00
	1.205E+00	8.462E+00
	1.405E+00	7.517E+00
	1.605E+00	6.669E+00
	1.805E+00	5.922E+00
	2.005E+00	5.276E+00
	6.630E+00	1.690E-03
	1.126E+01	3.551E-10
	1.588E+01	2.779E-14
	2.051E+01	1.277E-17
	2.513E+01	5.545E-22
	2.976E+01	1.592E-27
	3.438E+01	6.862E-32
	3.901E+01	8.490E-36
	4.363E+01	2.313E-40
	4.826E+01	1.487E-45
	5.288E+01	7.097E-50
	5.751E+01	0.000E+00
	6.213E+01	0.000E+00
	6.676E+01	0.000E+00
	7.138E+01	0.000E+00
	7.601E+01	0.000E+00
	8.063E+01	0.000E+00
	8.526E+01	0.000E+00
	8.988E+01	0.000E+00
	9.451E+01	0.000E+00

	9.913E+01	0.000E+00
	1.038E+02	0.000E+00
	1.084E+02	0.000E+00
	1.130E+02	0.000E+00
	1.176E+02	0.000E+00
	1.223E+02	0.000E+00
	1.269E+02	0.000E+00
	1.315E+02	0.000E+00
	1.361E+02	0.000E+00
	1.408E+02	0.000E+00
	1.454E+02	0.000E+00
	1.500E+02	0.000E+00
	1.546E+02	0.000E+00
	1.593E+02	0.000E+00
	1.639E+02	0.000E+00
	1.685E+02	0.000E+00
	1.731E+02	0.000E+00
	1.778E+02	0.000E+00
	1.824E+02	0.000E+00
	1.870E+02	0.000E+00
20	0.000E+00	1.900E+01
	5.000E-03	1.687E+01
	2.050E-01	1.593E+01
	4.050E-01	1.501E+01
	6.050E-01	1.412E+01
	8.050E-01	1.325E+01
	1.005E+00	1.241E+01
	1.205E+00	1.162E+01
	1.405E+00	1.086E+01
	1.605E+00	1.015E+01
	1.805E+00	9.481E+00
	2.005E+00	8.862E+00
	6.630E+00	1.092E-01
	1.126E+01	3.775E-05
	1.588E+01	3.106E-10
	2.051E+01	1.761E-13
	2.513E+01	1.474E-15
	2.976E+01	4.197E-18
	3.438E+01	3.581E-21
	3.901E+01	7.833E-25
	4.363E+01	6.090E-29
	4.826E+01	1.018E-31
	5.288E+01	2.124E-34
	5.751E+01	2.144E-37
	6.213E+01	9.806E-41
	6.676E+01	2.073E-44
	7.138E+01	7.757E-48

	7.601E+01 8.063E+01 8.526E+01 8.988E+01 9.451E+01 9.913E+01 1.038E+02 1.084E+02 1.130E+02 1.176E+02 1.223E+02 1.269E+02 1.315E+02 1.361E+02 1.408E+02 1.454E+02 1.500E+02 1.546E+02 1.593E+02 1.639E+02 1.685E+02 1.731E+02 1.778E+02 1.824E+02 1.870E+02	1.171E-50 0.000E+00
30	0.000E+00 5.000E-03 2.050E-01 4.050E-01 6.050E-01 8.050E-01 1.005E+00 1.205E+00 1.405E+00 1.605E+00 1.805E+00 2.005E+00 6.630E+00 1.126E+01 1.588E+01 2.051E+01 2.513E+01 2.976E+01 3.438E+01 3.901E+01 4.363E+01 4.826E+01	1.899E+01 1.734E+01 1.661E+01 1.589E+01 1.518E+01 1.449E+01 1.382E+01 1.316E+01 1.253E+01 1.192E+01 1.134E+01 1.079E+01 4.742E-01 2.008E-03 7.136E-07 2.414E-11 1.708E-13 3.693E-15 3.938E-17 1.942E-19 4.094E-22 3.380E-25

	5.288E+01	1.370E-28
	5.751E+01	5.059E-31
	6.213E+01	3.970E-33
	6.676E+01	1.984E-35
	7.138E+01	6.010E-38
	7.601E+01	1.066E-40
	8.063E+01	1.111E-43
	8.526E+01	1.163E-46
	8.988E+01	4.435E-49
	9.451E+01	0.000E+00
	9.913E+01	0.000E+00
	1.038E+02	0.000E+00
	1.084E+02	0.000E+00
	1.130E+02	0.000E+00
	1.176E+02	0.000E+00
	1.223E+02	0.000E+00
	1.269E+02	0.000E+00
	1.315E+02	0.000E+00
	1.361E+02	0.000E+00
	1.408E+02	0.000E+00
	1.454E+02	0.000E+00
	1.500E+02	0.000E+00
	1.546E+02	0.000E+00
	1.593E+02	0.000E+00
	1.639E+02	0.000E+00
	1.685E+02	0.000E+00
	1.731E+02	0.000E+00
	1.778E+02	0.000E+00
	1.824E+02	0.000E+00
	1.870E+02	0.000E+00
40	0.000E+00	1.899E+01
	5.000E-03	1.761E+01
	2.050E-01	1.700E+01
	4.050E-01	1.640E+01
	6.050E-01	1.580E+01
	8.050E-01	1.522E+01
	1.005E+00	1.464E+01
	1.205E+00	1.408E+01
	1.405E+00	1.353E+01
	1.605E+00	1.300E+01
	1.805E+00	1.249E+01
	2.005E+00	1.199E+01
	6.630E+00	1.018E+00
	1.126E+01	1.529E-02
	1.588E+01	3.649E-05
	2.051E+01	1.318E-08
	2.513E+01	2.515E-12

	2.976E+01 3.438E+01 3.901E+01 4.363E+01 4.826E+01 5.288E+01 5.751E+01 6.213E+01 6.676E+01 7.138E+01 7.601E+01 8.063E+01 8.526E+01 8.988E+01 9.451E+01 9.913E+01 1.038E+02 1.084E+02 1.130E+02 1.176E+02 1.223E+02 1.269E+02 1.315E+02 1.361E+02 1.408E+02 1.454E+02 1.500E+02 1.546E+02 1.593E+02 1.639E+02 1.685E+02 1.731E+02 1.778E+02 1.824E+02 1.870E+02	1.035E-13 3.583E-15 7.296E-17 8.385E-19 5.178E-21 1.622E-23 2.470E-26 3.296E-29 3.650E-31 5.498E-33 5.904E-35 4.375E-37 2.188E-39 7.251E-42 1.688E-44 5.175E-47 4.489E-49 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
50	0.000E+00 5.000E-03 2.050E-01 4.050E-01 6.050E-01 8.050E-01 1.005E+00 1.205E+00 1.405E+00 1.605E+00 1.805E+00 2.005E+00	1.899E+01 1.779E+01 1.726E+01 1.673E+01 1.621E+01 1.570E+01 1.519E+01 1.469E+01 1.420E+01 1.373E+01 1.326E+01 1.281E+01

	6.630E+00	1.633E+00
	1.126E+01	5.287E-02
	1.588E+01	3.975E-04
	2.051E+01	6.654E-07
	2.513E+01	2.496E-10
	2.976E+01	7.758E-13
	3.438E+01	5.191E-14
	3.901E+01	2.378E-15
	4.363E+01	7.099E-17
	4.826E+01	1.340E-18
	5.288E+01	1.546E-20
	5.751E+01	1.046E-22
	6.213E+01	3.985E-25
	6.676E+01	9.143E-28
	7.138E+01	5.020E-30
	7.601E+01	1.221E-31
	8.063E+01	2.703E-33
	8.526E+01	4.522E-35
	8.988E+01	5.618E-37
	9.451E+01	5.098E-39
	9.913E+01	3.332E-41
	1.038E+02	1.589E-43
	1.084E+02	7.003E-46
	1.130E+02	6.381E-48
	1.176E+02	1.062E-49
	1.223E+02	0.000E+00
	1.269E+02	0.000E+00
	1.315E+02	0.000E+00
	1.361E+02	0.000E+00
	1.408E+02	0.000E+00
	1.454E+02	0.000E+00
	1.500E+02	0.000E+00
	1.546E+02	0.000E+00
	1.593E+02	0.000E+00
	1.639E+02	0.000E+00
	1.685E+02	0.000E+00
	1.731E+02	0.000E+00
	1.778E+02	0.000E+00
	1.824E+02	0.000E+00
	1.870E+02	0.000E+00
60	0.000E+00	1.899E+01
	5.000E-03	1.792E+01
	2.050E-01	1.744E+01
	4.050E-01	1.697E+01
	6.050E-01	1.650E+01
	8.050E-01	1.604E+01
	1.005E+00	1.558E+01

	1.205E+00	1.513E+01
	1.405E+00	1.468E+01
	1.605E+00	1.425E+01
	1.805E+00	1.382E+01
	2.005E+00	1.341E+01
	6.630E+00	2.256E+00
	1.126E+01	1.224E-01
	1.588E+01	1.986E-03
	2.051E+01	9.269E-06
	2.513E+01	1.222E-08
	2.976E+01	7.320E-12
	3.438E+01	3.062E-13
	3.901E+01	2.369E-14
	4.363E+01	1.305E-15
	4.826E+01	5.006E-17
	5.288E+01	1.308E-18
	5.751E+01	2.265E-20
	6.213E+01	2.522E-22
	6.676E+01	1.748E-24
	7.138E+01	7.549E-27
	7.601E+01	3.501E-29
	8.063E+01	8.063E-31
	8.526E+01	2.787E-32
	8.988E+01	7.882E-34
	9.451E+01	1.755E-35
	9.913E+01	3.040E-37
	1.038E+02	4.046E-39
	1.084E+02	4.094E-41
	1.130E+02	3.173E-43
	1.176E+02	2.171E-45
	1.223E+02	2.360E-47
	1.269E+02	5.140E-49
	1.315E+02	1.227E-50
	1.361E+02	0.000E+00
	1.408E+02	0.000E+00
	1.454E+02	0.000E+00
	1.500E+02	0.000E+00
	1.546E+02	0.000E+00
	1.593E+02	0.000E+00
	1.639E+02	0.000E+00
	1.685E+02	0.000E+00
	1.731E+02	0.000E+00
	1.778E+02	0.000E+00
	1.824E+02	0.000E+00
	1.870E+02	0.000E+00
70	0.000E+00	1.899E+01
	5.000E-03	1.801E+01

	2.050E-01	1.758E+01
	4.050E-01	1.715E+01
	6.050E-01	1.672E+01
	8.050E-01	1.629E+01
	1.005E+00	1.587E+01
	1.205E+00	1.546E+01
	1.405E+00	1.505E+01
	1.605E+00	1.465E+01
	1.805E+00	1.425E+01
	2.005E+00	1.386E+01
	6.630E+00	2.856E+00
	1.126E+01	2.249E-01
	1.588E+01	6.331E-03
	2.051E+01	6.160E-05
	2.513E+01	2.033E-07
	2.976E+01	2.322E-10
	3.438E+01	1.166E-12
	3.901E+01	1.213E-13
	4.363E+01	1.023E-14
	4.826E+01	6.409E-16
	5.288E+01	2.933E-17
	5.751E+01	9.623E-19
	6.213E+01	2.215E-20
	6.676E+01	3.490E-22
	7.138E+01	3.670E-24
	7.601E+01	2.548E-26
	8.063E+01	1.486E-28
	8.526E+01	2.788E-30
	8.988E+01	1.246E-31
	9.451E+01	5.071E-33
	9.913E+01	1.694E-34
	1.038E+02	4.593E-36
	1.084E+02	1.000E-37
	1.130E+02	1.733E-39
	1.176E+02	2.371E-41
	1.223E+02	2.589E-43
	1.269E+02	2.554E-45
	1.315E+02	3.677E-47
	1.361E+02	1.008E-48
	1.408E+02	3.223E-50
	1.454E+02	0.000E+00
	1.500E+02	0.000E+00
	1.546E+02	0.000E+00
	1.593E+02	0.000E+00
	1.639E+02	0.000E+00
	1.685E+02	0.000E+00
	1.731E+02	0.000E+00
	1.778E+02	0.000E+00

	1.824E+02 1.870E+02	0.000E+00 0.000E+00
80	0.000E+00 5.000E-03 2.050E-01 4.050E-01 6.050E-01 8.050E-01 1.005E+00 1.205E+00 1.405E+00 1.605E+00 1.805E+00 2.005E+00 6.630E+00 1.126E+01 1.588E+01 2.051E+01 2.513E+01 2.976E+01 3.438E+01 3.901E+01 4.363E+01 4.826E+01 5.288E+01 5.751E+01 6.213E+01 6.676E+01 7.138E+01 7.601E+01 8.063E+01 8.526E+01 8.988E+01 9.451E+01 9.913E+01 1.038E+02 1.084E+02 1.130E+02 1.176E+02 1.223E+02 1.269E+02 1.315E+02 1.361E+02 1.408E+02 1.454E+02 1.500E+02 1.546E+02	1.899E+01 1.808E+01 1.768E+01 1.728E+01 1.689E+01 1.649E+01 1.610E+01 1.572E+01 1.534E+01 1.496E+01 1.459E+01 1.423E+01 3.420E+00 3.568E-01 1.521E-02 2.571E-04 1.693E-06 4.308E-09 6.963E-12 4.130E-13 4.753E-14 4.264E-15 2.935E-16 1.529E-17 5.930E-19 1.682E-20 3.419E-22 4.877E-24 4.828E-26 3.799E-28 6.537E-30 3.332E-31 1.765E-32 7.948E-34 2.991E-35 9.336E-37 2.397E-38 5.023E-40 8.557E-42 1.207E-43 1.621E-45 3.200E-47 1.112E-48 4.455E-50 0.000E+00

	1.593E+02 1.639E+02 1.685E+02 1.731E+02 1.778E+02 1.824E+02 1.870E+02	0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00

NOTICE

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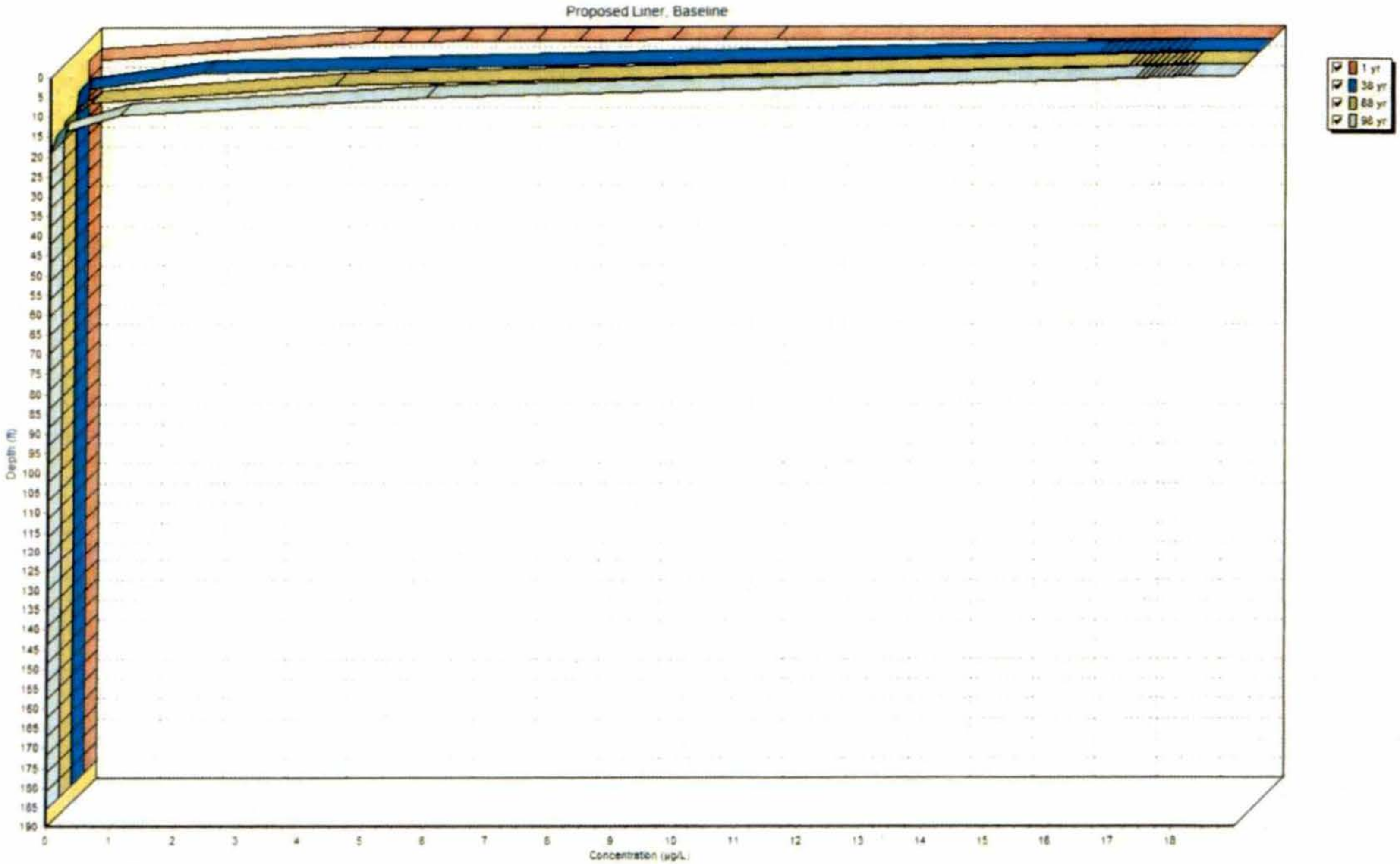


Proposed liner, 98-year run

POLLUTEv7

Version 7.11

Proposed Liner, Baseline

THE DARCY VELOCITY (Flux) THROUGH THE LAYERS Va = 1.092E-6 ft/a

Layer Properties

Layer	Thickness	Number of Sublayers	Coefficient of Hydrodynamic Dispersion	Matrix Porosity	Distributon Coefficient	Dry Density
Geomembrane	60 mil	1	2E-8 cm2/s	1	0 m3/kg	950 kg/m3
Clay Base	0.5 ft	10	6E-6 cm2/s	0.3	0 mL/g	102.9 lb/ft3
Aquitard	185 ft	10	4E-6 cm2/s	0.254	0 mL/g	102.9 lb/ft3

Boundary Conditions

Finite Mass Top Boundary

Initial Concentration = 19 µg/L
Volume of Leachate Collected = 0.0339999970082192 ft/day
Thickness of Waste = 125 ft
Waste Density = 1200 lb/ft3
Proportion of Mass = 0.001
Reference Height of Leachate = 0 m

Fixed Outflow Bottom Boundary

Landfill Length = 289.56 m
Landfill Width = 1 m
Base Thickness = 1 ft
Base Porosity = 0.3
Base Outflow Velocity = 0.002073 ft/a

Laplace Transform Parameters

TAU = 7 N = 20 SIG = 0 RNU = 2

Calculated Concentrations at Selected Times and Depths

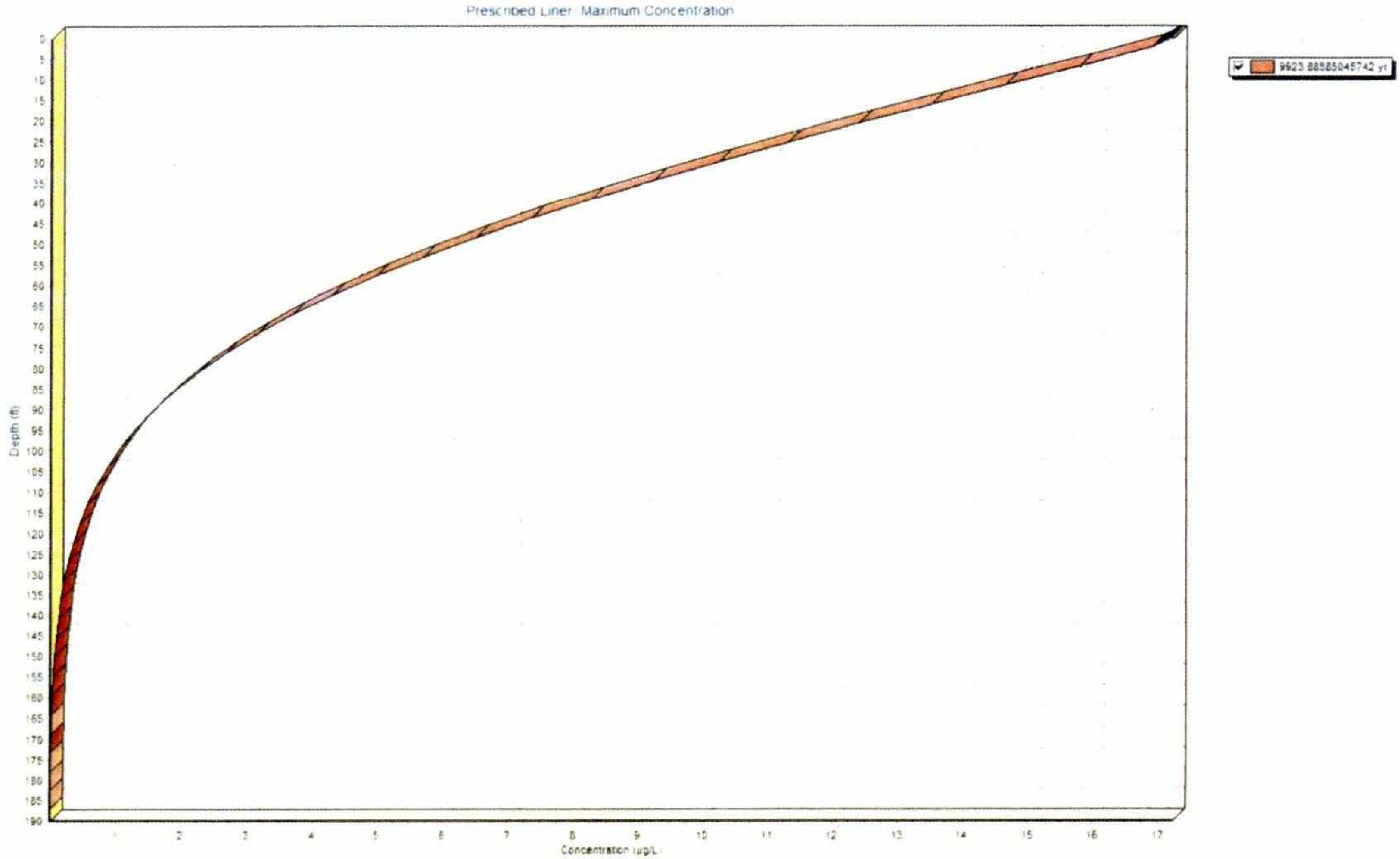
Time yr	Depth ft	Concentration µg/L
1	0.000E+00	1.900E+01
	5.000E-03	1.103E+01
	5.500E-02	1.017E+01
	1.050E-01	9.348E+00
	1.550E-01	8.570E+00
	2.050E-01	7.839E+00
	2.550E-01	7.157E+00
	3.050E-01	6.525E+00
	3.550E-01	5.946E+00
	4.050E-01	5.418E+00
	4.550E-01	4.944E+00
	5.050E-01	4.522E+00
	5.130E+00	8.444E-15
	9.755E+00	2.709E-29
	1.438E+01	8.482E-43
	1.901E+01	0.000E+00
	2.363E+01	0.000E+00
	2.826E+01	0.000E+00
	3.288E+01	0.000E+00
	3.751E+01	0.000E+00
	4.213E+01	0.000E+00
	4.676E+01	0.000E+00
	5.138E+01	0.000E+00
	5.601E+01	0.000E+00
	6.063E+01	0.000E+00
	6.526E+01	0.000E+00
	6.988E+01	0.000E+00
	7.451E+01	0.000E+00
	7.913E+01	0.000E+00
	8.376E+01	0.000E+00
	8.838E+01	0.000E+00
	9.301E+01	0.000E+00
	9.763E+01	0.000E+00
	1.023E+02	0.000E+00
	1.069E+02	0.000E+00
	1.115E+02	0.000E+00
	1.161E+02	0.000E+00
	1.208E+02	0.000E+00

	1.254E+02 1.300E+02 1.346E+02 1.393E+02 1.439E+02 1.485E+02 1.531E+02 1.578E+02 1.624E+02 1.670E+02 1.716E+02 1.763E+02 1.809E+02 1.855E+02	0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
38	0.000E+00 5.000E-03 5.500E-02 1.050E-01 1.550E-01 2.050E-01 2.550E-01 3.050E-01 3.550E-01 4.050E-01 4.550E-01 5.050E-01 5.130E+00 9.755E+00 1.438E+01 1.901E+01 2.363E+01 2.826E+01 3.288E+01 3.751E+01 4.213E+01 4.676E+01 5.138E+01 5.601E+01 6.063E+01 6.526E+01 6.988E+01 7.451E+01 7.913E+01 8.376E+01 8.838E+01 9.301E+01 9.763E+01	1.899E+01 1.777E+01 1.764E+01 1.750E+01 1.737E+01 1.723E+01 1.710E+01 1.697E+01 1.683E+01 1.670E+01 1.657E+01 1.643E+01 2.004E+00 4.149E-02 1.251E-04 5.169E-08 5.255E-12 1.361E-13 4.560E-15 8.767E-17 9.254E-19 5.086E-21 1.368E-23 1.722E-26 2.097E-29 2.310E-31 3.021E-33 2.747E-35 1.684E-37 6.793E-40 1.777E-42 3.418E-45 1.200E-47

	1.023E+02	1.058E-49
	1.069E+02	0.000E+00
	1.115E+02	0.000E+00
	1.161E+02	0.000E+00
	1.208E+02	0.000E+00
	1.254E+02	0.000E+00
	1.300E+02	0.000E+00
	1.346E+02	0.000E+00
	1.393E+02	0.000E+00
	1.439E+02	0.000E+00
	1.485E+02	0.000E+00
	1.531E+02	0.000E+00
	1.578E+02	0.000E+00
	1.624E+02	0.000E+00
	1.670E+02	0.000E+00
	1.716E+02	0.000E+00
	1.763E+02	0.000E+00
	1.809E+02	0.000E+00
	1.855E+02	0.000E+00
68	0.000E+00	1.899E+01
	5.000E-03	1.808E+01
	5.500E-02	1.798E+01
	1.050E-01	1.788E+01
	1.550E-01	1.778E+01
	2.050E-01	1.768E+01
	2.550E-01	1.758E+01
	3.050E-01	1.748E+01
	3.550E-01	1.738E+01
	4.050E-01	1.728E+01
	4.550E-01	1.718E+01
	5.050E-01	1.709E+01
	5.130E+00	4.322E+00
	9.755E+00	4.223E-01
	1.438E+01	1.453E-02
	1.901E+01	1.683E-04
	2.363E+01	6.409E-07
	2.826E+01	8.012E-10
	3.288E+01	1.729E-12
	3.751E+01	1.604E-13
	4.213E+01	1.362E-14
	4.676E+01	8.537E-16
	5.138E+01	3.884E-17
	5.601E+01	1.258E-18
	6.063E+01	2.834E-20
	6.526E+01	4.333E-22
	6.988E+01	4.374E-24
	7.451E+01	2.877E-26

	7.913E+01	1.545E-28
	8.376E+01	2.653E-30
	8.838E+01	1.132E-31
	9.301E+01	4.385E-33
	9.763E+01	1.387E-34
	1.023E+02	3.535E-36
	1.069E+02	7.190E-38
	1.115E+02	1.155E-39
	1.161E+02	1.454E-41
	1.208E+02	1.458E-43
	1.254E+02	1.360E-45
	1.300E+02	2.015E-47
	1.346E+02	5.533E-49
	1.393E+02	1.668E-50
	1.439E+02	0.000E+00
	1.485E+02	0.000E+00
	1.531E+02	0.000E+00
	1.578E+02	0.000E+00
	1.624E+02	0.000E+00
	1.670E+02	0.000E+00
	1.716E+02	0.000E+00
	1.763E+02	0.000E+00
	1.809E+02	0.000E+00
	1.855E+02	0.000E+00
98	0.000E+00	1.898E+01
	5.000E-03	1.823E+01
	5.500E-02	1.815E+01
	1.050E-01	1.807E+01
	1.550E-01	1.798E+01
	2.050E-01	1.790E+01
	2.550E-01	1.782E+01
	3.050E-01	1.773E+01
	3.550E-01	1.765E+01
	4.050E-01	1.757E+01
	4.550E-01	1.748E+01
	5.050E-01	1.740E+01
	5.130E+00	5.991E+00
	9.755E+00	1.084E+00
	1.438E+01	9.675E-02
	1.901E+01	4.110E-03
	2.363E+01	8.147E-05
	2.826E+01	7.449E-07
	3.288E+01	3.130E-09
	3.751E+01	8.819E-12
	4.213E+01	5.253E-13
	4.676E+01	7.735E-14
	5.138E+01	9.384E-15

	5.601E+01	9.209E-16
	6.063E+01	7.237E-17
	6.526E+01	4.505E-18
	6.988E+01	2.194E-19
	7.451E+01	8.240E-21
	7.913E+01	2.351E-22
	8.376E+01	5.017E-24
	8.838E+01	7.936E-26
	9.301E+01	9.963E-28
	9.763E+01	1.814E-29
	1.023E+02	1.001E-30
	1.069E+02	7.333E-32
	1.115E+02	4.852E-33
	1.161E+02	2.788E-34
	1.208E+02	1.381E-35
	1.254E+02	5.865E-37
	1.300E+02	2.122E-38
	1.346E+02	6.506E-40
	1.393E+02	1.684E-41
	1.439E+02	3.709E-43
	1.485E+02	7.425E-45
	1.531E+02	1.733E-46
	1.578E+02	6.596E-48
	1.624E+02	3.488E-49
	1.670E+02	1.884E-50
	1.716E+02	0.000E+00
	1.763E+02	0.000E+00
	1.809E+02	0.000E+00
	1.855E+02	0.000E+00



Prescribed liner, maximum concentration, 10,000-year run.

POLLUTEv7

Version 7.11

Prescribed Liner, Maximum Concentration

THE DARCY VELOCITY (Flux) THROUGH THE LAYERS Va = 2.182E-6 ft/a

Layer Properties

Layer	Thickness	Number of Sublayers	Coefficient of Hydrodynamic Dispersion	Matrix Porosity	Distributon Coefficient	Dry Density
Geomembrane	60 mil	1	2E-8 cm2/s	1	0 m3/kg	950 kg/m3
Clay Base	2 ft	10	6E-6 cm2/s	0.3	0 mL/g	102.9 lb/ft3
Aquitard	185 ft	10	4E-6 cm2/s	0.254	0 mL/g	102.9 lb/ft3

Boundary Conditions

Finite Mass Top Boundary

Initial Concentration = 19 μg/L
Volume of Leachate Collected = 0.0339999940219178 ft/day
Thickness of Waste = 125 ft
Waste Density = 1200 lb/ft3
Proportion of Mass = 0.001
Reference Height of Leachate = 0 m

Fixed Outflow Bottom Boundary

Landfill Length = 289.56 m
Landfill Width = 1 m
Base Thickness = 1 ft
Base Porosity = 0.3
Base Outflow Velocity = 0.002073 ft/a

Laplace Transform Parameters

TAU = 7 **N** = 20 **SIG** = 0 **RNU** = 2

Maximum Base Concentration Parameters

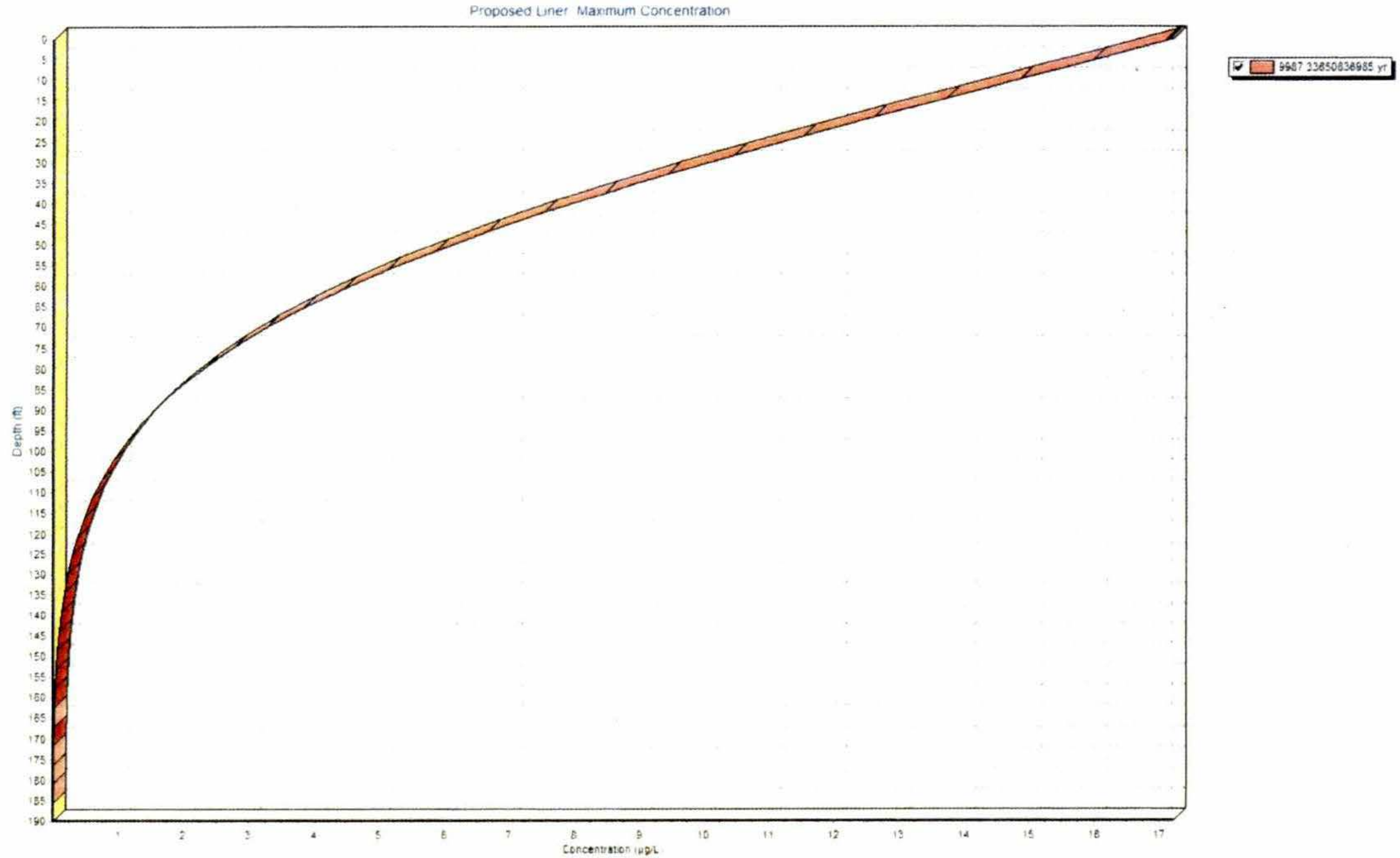
Depth to Search = 85 ft
Lower Time Limit = 1 year
Upper Time Limit = 10000 year
Base Concentration Accuracy = 0.25
Maximum Search Attempts = 25

Maximum Base Concentration and Time of Occurrence

Time yr	Depth ft	Concentration µg/L	Preceeding Time	Preceeding Concentration	Exceeding Time	Exceeding Concentration
9.9239E+03	0.0000E+00	1.7237E+01				
	5.0000E-03	1.7177E+01				
	2.0500E-01	1.7150E+01				
	4.0500E-01	1.7123E+01				
	6.0500E-01	1.7096E+01				
	8.0500E-01	1.7069E+01				
	1.0050E+00	1.7042E+01				
	1.2050E+00	1.7015E+01				
	1.4050E+00	1.6988E+01				
	1.6050E+00	1.6961E+01				
	1.8050E+00	1.6934E+01				
	2.0050E+00	1.6907E+01				
	6.6300E+00	1.5788E+01				
	1.1255E+01	1.4658E+01				
	1.5880E+01	1.3529E+01				
	2.0505E+01	1.2413E+01				
	2.5130E+01	1.1320E+01				
	2.9755E+01	1.0260E+01				
	3.4380E+01	9.2417E+00				
	3.9005E+01	8.2720E+00				
	4.3630E+01	7.3570E+00				
	4.8255E+01	6.5011E+00				
	5.2880E+01	5.7075E+00				
	5.7505E+01	4.9778E+00				
	6.2130E+01	4.3127E+00				
	6.6755E+01	3.7115E+00				
	7.1380E+01	3.1726E+00				
	7.6005E+01	2.6935E+00				

	8.0630E+01	2.2711E+00				
	8.5255E+01	1.9018E+00				
	8.9880E+01	1.5814E+00				
	9.4505E+01	1.3059E+00				
	9.9130E+01	1.0708E+00				
	1.0376E+02	8.7186E-01				
	1.0838E+02	7.0484E-01				
	1.1301E+02	5.6575E-01				
	1.1763E+02	4.5087E-01				
	1.2226E+02	3.5673E-01				
	1.2688E+02	2.8023E-01				
	1.3151E+02	2.1854E-01				
	1.3613E+02	1.6922E-01				
	1.4076E+02	1.3010E-01				
	1.4538E+02	9.9330E-02				
	1.5001E+02	7.5347E-02				
	1.5463E+02	5.6828E-02				
	1.5926E+02	4.2686E-02				
	1.6388E+02	3.2032E-02				
	1.6851E+02	2.4159E-02				
	1.7313E+02	1.8514E-02				
	1.7776E+02	1.4685E-02				
	1.8238E+02	1.2380E-02				
	1.8701E+02	1.1420E-02	9.9163E+03	1.8994E+00	9.9315E+03	1.9041E+00

Number of Search Attempts = 9



Proposed liner, maximum concentrations, 10,000-year run.

POLLUTEv7

Version 7.11

Proposed Liner, Maximum Concentration

THE DARCY VELOCITY (Flux) THROUGH THE LAYERS Va = 1.092E-6 ft/a

Layer Properties

Layer	Thickness	Number of Sublayers	Coefficient of Hydrodynamic Dispersion	Matrix Porosity	Distributon Coefficient	Dry Density
Geomembrane	60 mil	1	2E-8 cm2/s	1	0 m3/kg	950 kg/m3
Clay Base	0.5 ft	10	6E-6 cm2/s	0.3	0 mL/g	102.9 lb/ft3
Aquitard	185 ft	10	4E-6 cm2/s	0.254	0 mL/g	102.9 lb/ft3

Boundary Conditions

Finite Mass Top Boundary

Initial Concentration = 19 µg/L
Volume of Leachate Collected = 0.0339999970082192 ft/day
Thickness of Waste = 125 ft
Waste Density = 1200 lb/ft3
Proportion of Mass = 0.001
Reference Height of Leachate = 0 m

Fixed Outflow Bottom Boundary

Landfill Length = 289.56 m
Landfill Width = 1 m
Base Thickness = 1 ft
Base Porosity = 0.3
Base Outflow Velocity = 0.002073 ft/a

Laplace Transform Parameters

TAU = 7 **N** = 20 **SIG** = 0 **RNU** = 2

Maximum Base Concentration Parameters

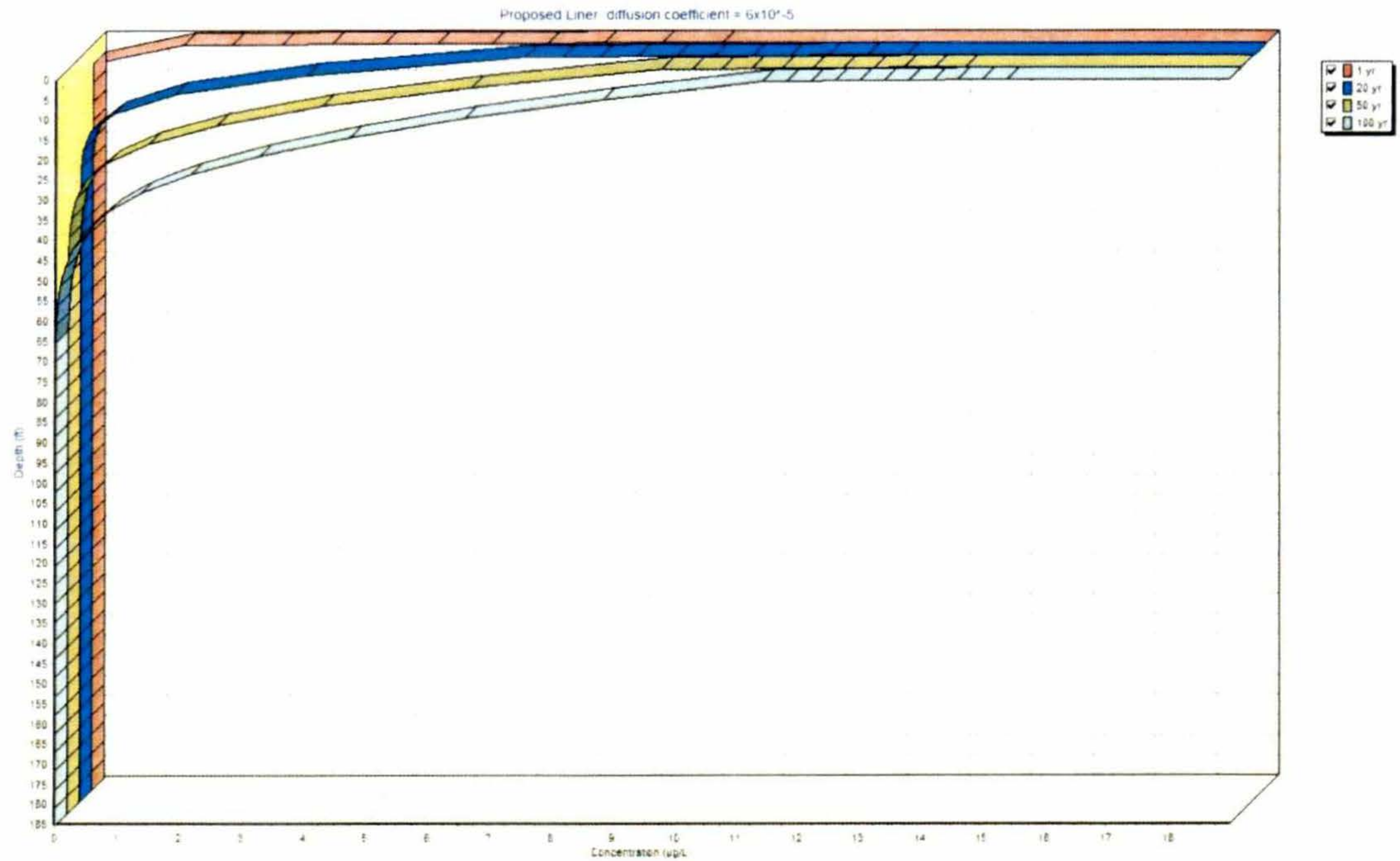
Depth to Search = 190 ft
Lower Time Limit = 1 year
Upper Time Limit = 10000 year
Base Concentration Accuracy = 0.25
Maximum Search Attempts = 25

Maximum Base Concentration and Time of Occurrence

Time yr	Depth ft	Concentration µg/L	Preceeding Time	Preceeding Concentration	Exceeding Time	Exceeding Concentration
9.9873E+03	0.0000E+00	1.7226E+01				
	5.0000E-03	1.7166E+01				
	5.5000E-02	1.7159E+01				
	1.0500E-01	1.7152E+01				
	1.5500E-01	1.7146E+01				
	2.0500E-01	1.7139E+01				
	2.5500E-01	1.7132E+01				
	3.0500E-01	1.7126E+01				
	3.5500E-01	1.7119E+01				
	4.0500E-01	1.7112E+01				
	4.5500E-01	1.7105E+01				
	5.0500E-01	1.7099E+01				
	5.1300E+00	1.5987E+01				
	9.7550E+00	1.4863E+01				
	1.4380E+01	1.3737E+01				
	1.9005E+01	1.2622E+01				
	2.3630E+01	1.1528E+01				
	2.8255E+01	1.0465E+01				
	3.2880E+01	9.4410E+00				
	3.7505E+01	8.4645E+00				
	4.2130E+01	7.5412E+00				
	4.6755E+01	6.6758E+00				
	5.1380E+01	5.8716E+00				
	5.6005E+01	5.1307E+00				
	6.0630E+01	4.4539E+00				
	6.5255E+01	3.8407E+00				
	6.9880E+01	3.2898E+00				
	7.4505E+01	2.7990E+00				

	7.9130E+01	2.3652E+00				
	8.3755E+01	1.9851E+00				
	8.8380E+01	1.6545E+00				
	9.3005E+01	1.3695E+00				
	9.7630E+01	1.1257E+00				
	1.0226E+02	9.1881E-01				
	1.0688E+02	7.4468E-01				
	1.1151E+02	5.9929E-01				
	1.1613E+02	4.7887E-01				
	1.2076E+02	3.7992E-01				
	1.2538E+02	2.9927E-01				
	1.3001E+02	2.3406E-01				
	1.3463E+02	1.8175E-01				
	1.3926E+02	1.4015E-01				
	1.4388E+02	1.0733E-01				
	1.4851E+02	8.1675E-02				
	1.5313E+02	6.1802E-02				
	1.5776E+02	4.6581E-02				
	1.6238E+02	3.5082E-02				
	1.6701E+02	2.6561E-02				
	1.7163E+02	2.0437E-02				
	1.7626E+02	1.6275E-02				
	1.8088E+02	1.3765E-02				
	1.8551E+02	1.2717E-02	9.9861E+03	1.2706E-02	9.9886E+03	1.2728E-02

Number of Search Attempts = 12



Proposed liner, diffusion coefficient increased by an order of magnitude, 100-year run.

POLLUTEv7

Version 7.11

Proposed Liner, diffusion coefficient = 6x10^-5

THE DARCY VELOCITY (Flux) THROUGH THE LAYERS Va = 1.092E-6 ft/a

Layer Properties

Layer	Thickness	Number of Sublayers	Coefficient of Hydrodynamic Dispersion	Matrix Porosity	Distributon Coefficient	Dry Density
Geomembrane	60 mil	1	2E-8 cm2/s	1	0 m3/kg	950 kg/m3
Clay Base	0.5 ft	10	6E-6 cm2/s	0.3	0 mL/g	102.9 lb/ft3
Aquitard	185 ft	10	6E-9 m2/s	0.4	0 mL/g	102.9 lb/ft3

Boundary Conditions

Finite Mass Top Boundary

Initial Concentration = 19 µg/L
Volume of Leachate Collected = 0.0339999970082192 ft/day
Thickness of Waste = 125 ft
Waste Density = 1200 lb/ft3
Proportion of Mass = 0.001
Reference Height of Leachate = 0 m

Fixed Outflow Bottom Boundary

Landfill Length = 289.56 m
Landfill Width = 1 m
Base Thickness = 1 ft
Base Porosity = 0.3
Base Outflow Velocity = 0.002073 ft/a

Laplace Transform Parameters

TAU = 7   N = 20   SIG = 0   RNU = 2

Calculated Concentrations at Selected Times and Depths

Time yr	Depth ft	Concentration µg/L
1	0.000E+00	1.900E+01
	5.000E-03	1.019E+01
	5.500E-02	9.219E+00
	1.050E-01	8.270E+00
	1.550E-01	7.343E+00
	2.050E-01	6.437E+00
	2.550E-01	5.554E+00
	3.050E-01	4.693E+00
	3.550E-01	3.853E+00
	4.050E-01	3.035E+00
	4.550E-01	2.235E+00
	5.050E-01	1.454E+00
	5.130E+00	4.145E-03
	9.755E+00	1.024E-07
	1.438E+01	2.417E-13
	1.901E+01	1.319E-15
	2.363E+01	1.933E-18
	2.826E+01	5.886E-22
	3.288E+01	2.945E-26
	3.751E+01	1.046E-30
	4.213E+01	1.097E-33
	4.676E+01	5.476E-37
	5.138E+01	9.840E-41
	5.601E+01	6.213E-45
	6.063E+01	7.640E-49
	6.526E+01	0.000E+00
	6.988E+01	0.000E+00
	7.451E+01	0.000E+00
	7.913E+01	0.000E+00
	8.376E+01	0.000E+00
	8.838E+01	0.000E+00
	9.301E+01	0.000E+00
	9.763E+01	0.000E+00
	1.023E+02	0.000E+00
	1.069E+02	0.000E+00
	1.115E+02	0.000E+00
	1.161E+02	0.000E+00
	1.208E+02	0.000E+00

	1.254E+02	0.000E+00
	1.300E+02	0.000E+00
	1.346E+02	0.000E+00
	1.393E+02	0.000E+00
	1.439E+02	0.000E+00
	1.485E+02	0.000E+00
	1.531E+02	0.000E+00
	1.578E+02	0.000E+00
	1.624E+02	0.000E+00
	1.670E+02	0.000E+00
	1.716E+02	0.000E+00
	1.763E+02	0.000E+00
	1.809E+02	0.000E+00
	1.855E+02	0.000E+00
20	0.000E+00	1.900E+01
	5.000E-03	1.337E+01
	5.500E-02	1.275E+01
	1.050E-01	1.212E+01
	1.550E-01	1.150E+01
	2.050E-01	1.088E+01
	2.550E-01	1.026E+01
	3.050E-01	9.637E+00
	3.550E-01	9.019E+00
	4.050E-01	8.402E+00
	4.550E-01	7.786E+00
	5.050E-01	7.172E+00
	5.130E+00	3.633E+00
	9.755E+00	1.526E+00
	1.438E+01	5.232E-01
	1.901E+01	1.445E-01
	2.363E+01	3.180E-02
	2.826E+01	5.542E-03
	3.288E+01	7.601E-04
	3.751E+01	8.170E-05
	4.213E+01	6.858E-06
	4.676E+01	4.484E-07
	5.138E+01	2.280E-08
	5.601E+01	9.046E-10
	6.063E+01	2.979E-11
	6.526E+01	1.555E-12
	6.988E+01	3.469E-13
	7.451E+01	1.169E-13
	7.913E+01	3.815E-14
	8.376E+01	1.169E-14
	8.838E+01	3.350E-15
	9.301E+01	8.969E-16
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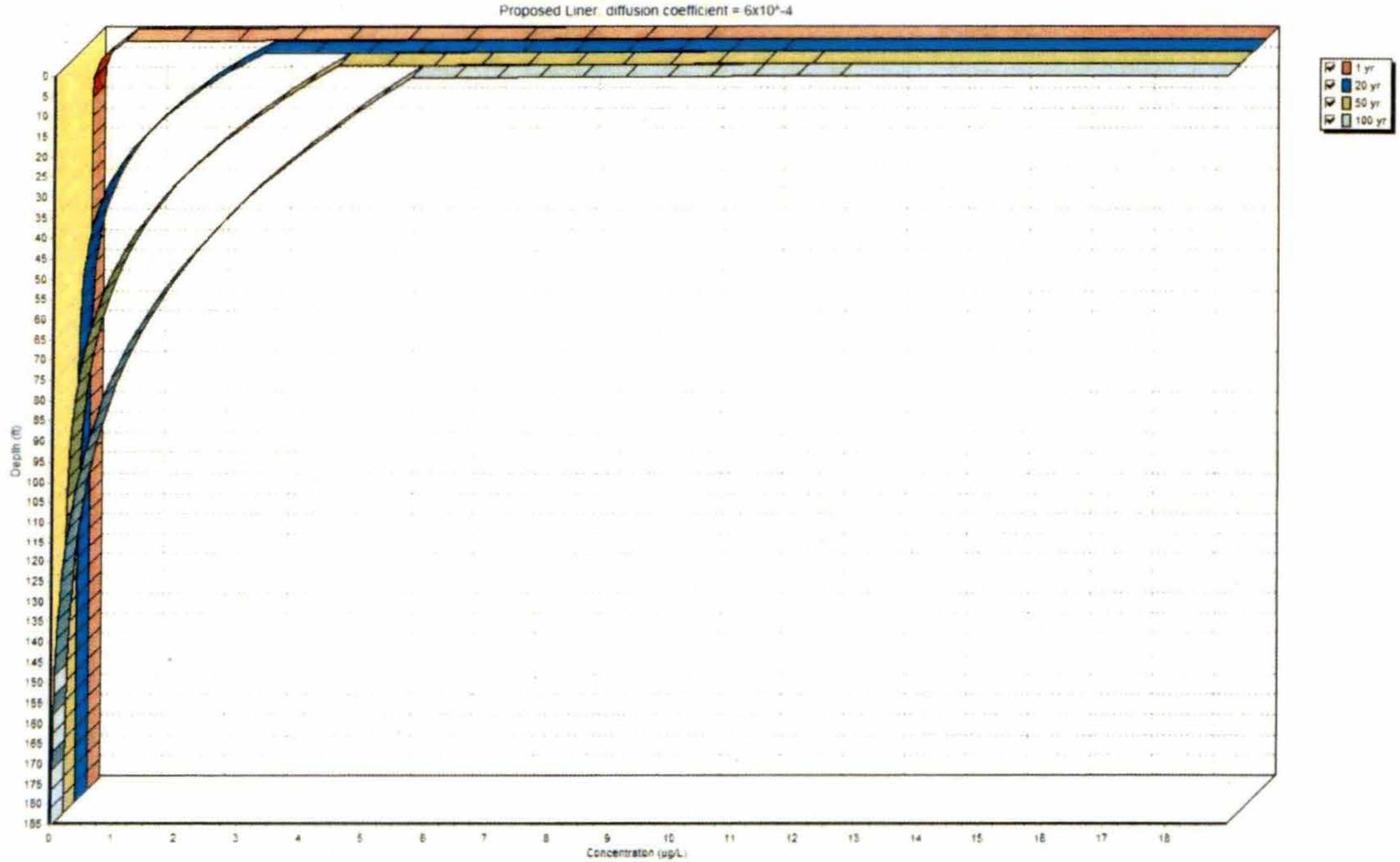
	1.161E+02	4.130E-19
	1.208E+02	7.027E-20
	1.254E+02	1.099E-20
	1.300E+02	1.576E-21
	1.346E+02	2.066E-22
	1.393E+02	2.469E-23
	1.439E+02	2.680E-24
	1.485E+02	2.640E-25
	1.531E+02	2.365E-26
	1.578E+02	1.960E-27
	1.624E+02	1.613E-28
	1.670E+02	1.607E-29
	1.716E+02	2.415E-30
	1.763E+02	4.964E-31
	1.809E+02	1.143E-31
	1.855E+02	3.952E-32
50	0.000E+00	1.899E+01
	5.000E-03	1.453E+01
	5.500E-02	1.403E+01
	1.050E-01	1.354E+01
	1.550E-01	1.304E+01
	2.050E-01	1.255E+01
	2.550E-01	1.205E+01
	3.050E-01	1.156E+01
	3.550E-01	1.107E+01
	4.050E-01	1.057E+01
	4.550E-01	1.008E+01
	5.050E-01	9.591E+00
	5.130E+00	6.496E+00
	9.755E+00	4.092E+00
	1.438E+01	2.386E+00
	1.901E+01	1.283E+00
	2.363E+01	6.337E-01
	2.826E+01	2.869E-01
	3.288E+01	1.187E-01
	3.751E+01	4.483E-02
	4.213E+01	1.541E-02
	4.676E+01	4.820E-03
	5.138E+01	1.369E-03
	5.601E+01	3.529E-04
	6.063E+01	8.248E-05
	6.526E+01	1.746E-05
	6.988E+01	3.347E-06
	7.451E+01	5.804E-07

	7.913E+01	9.104E-08
	8.376E+01	1.292E-08
	8.838E+01	1.661E-09
	9.301E+01	1.957E-10
	9.763E+01	2.249E-11
	1.023E+02	3.275E-12
	1.069E+02	9.138E-13
	1.115E+02	4.111E-13
	1.161E+02	2.068E-13
	1.208E+02	1.037E-13
	1.254E+02	5.089E-14
	1.300E+02	2.433E-14
	1.346E+02	1.133E-14
	1.393E+02	5.138E-15
	1.439E+02	2.266E-15
	1.485E+02	9.725E-16
	1.531E+02	4.057E-16
	1.578E+02	1.645E-16
	1.624E+02	6.474E-17
	1.670E+02	2.474E-17
	1.716E+02	9.182E-18
	1.763E+02	3.325E-18
	1.809E+02	1.236E-18
	1.855E+02	6.571E-19
100	0.000E+00	1.898E+01
	5.000E-03	1.540E+01
	5.500E-02	1.500E+01
	1.050E-01	1.460E+01
	1.550E-01	1.421E+01
	2.050E-01	1.381E+01
	2.550E-01	1.341E+01
	3.050E-01	1.301E+01
	3.550E-01	1.262E+01
	4.050E-01	1.222E+01
	4.550E-01	1.182E+01
	5.050E-01	1.143E+01
	5.130E+00	8.834E+00
	9.755E+00	6.587E+00
	1.438E+01	4.730E+00
	1.901E+01	3.266E+00
	2.363E+01	2.165E+00
	2.826E+01	1.377E+00
	3.288E+01	8.384E-01
	3.751E+01	4.887E-01
	4.213E+01	2.724E-01
	4.676E+01	1.451E-01
	5.138E+01	7.379E-02

	5.601E+01	3.582E-02
	6.063E+01	1.658E-02
	6.526E+01	7.321E-03
	6.988E+01	3.080E-03
	7.451E+01	1.235E-03
	7.913E+01	4.713E-04
	8.376E+01	1.713E-04
	8.838E+01	5.927E-05
	9.301E+01	1.952E-05
	9.763E+01	6.114E-06
	1.023E+02	1.822E-06
	1.069E+02	5.165E-07
	1.115E+02	1.392E-07
	1.161E+02	3.569E-08
	1.208E+02	8.704E-09
	1.254E+02	2.022E-09
	1.300E+02	4.491E-10
	1.346E+02	9.677E-11
	1.393E+02	2.116E-11
	1.439E+02	5.288E-12
	1.485E+02	1.806E-12
	1.531E+02	8.690E-13
	1.578E+02	5.038E-13
	1.624E+02	3.098E-13
	1.670E+02	1.928E-13
	1.716E+02	1.208E-13
	1.763E+02	7.775E-14
	1.809E+02	5.452E-14
	1.855E+02	4.600E-14



Proposed liner, diffusion coefficient increased by two orders of magnitude, 100-year run.

POLLUTEv7

Version 7.11

Proposed Liner, diffusion coefficient = 6x10^-4

THE DARCY VELOCITY (Flux) THROUGH THE LAYERS Va = 1.092E-6 ft/a

Layer Properties

Layer	Thickness	Number of Sublayers	Coefficient of Hydrodynamic Dispersion	Matrix Porosity	Distributon Coefficient	Dry Density
Geomembrane	60 mil	1	2E-8 cm2/s	1	0 m3/kg	950 kg/m3
Clay Base	0.5 ft	10	6E-6 cm2/s	0.3	0 mL/g	102.9 lb/ft3
Aquitard	185 ft	10	0.0006 cm2/s	0.4	0 mL/g	102.9 lb/ft3

Boundary Conditions

Finite Mass Top Boundary

Initial Concentration = 19 µg/L
Volume of Leachate Collected = 0.0339999970082192 ft/day
Thickness of Waste = 125 ft
Waste Density = 1200 lb/ft3
Proportion of Mass = 0.001
Reference Height of Leachate = 0 m

Fixed Outflow Bottom Boundary

Landfill Length = 289.56 m
Landfill Width = 1 m
Base Thickness = 1 ft
Base Porosity = 0.3
Base Outflow Velocity = 0.002073 ft/a

Laplace Transform Parameters

TAU = 7   N = 20   SIG = 0   RNU = 2

Calculated Concentrations at Selected Times and Depths

Time yr	Depth ft	Concentration µg/L
1	0.000E+00	1.900E+01
	5.000E-03	9.930E+00
	5.500E-02	8.930E+00
	1.050E-01	7.943E+00
	1.550E-01	6.971E+00
	2.050E-01	6.012E+00
	2.550E-01	5.068E+00
	3.050E-01	4.138E+00
	3.550E-01	3.220E+00
	4.050E-01	2.314E+00
	4.550E-01	1.417E+00
	5.050E-01	5.278E-01
	5.130E+00	1.340E-01
	9.755E+00	2.199E-02
	1.438E+01	2.278E-03
	1.901E+01	1.466E-04
	2.363E+01	5.788E-06
	2.826E+01	1.391E-07
	3.288E+01	2.026E-09
	3.751E+01	1.832E-11
	4.213E+01	2.543E-13
	4.676E+01	3.907E-14
	5.138E+01	8.231E-15
	5.601E+01	1.534E-15
	6.063E+01	2.496E-16
	6.526E+01	3.532E-17
	6.988E+01	4.322E-18
	7.451E+01	4.544E-19
	7.913E+01	4.080E-20
	8.376E+01	3.105E-21
	8.838E+01	1.988E-22
	9.301E+01	1.061E-23
	9.763E+01	4.690E-25
	1.023E+02	1.706E-26
	1.069E+02	5.204E-28
	1.115E+02	1.554E-29
	1.161E+02	7.873E-31
	1.208E+02	8.075E-32

	1.254E+02	9.756E-33
	1.300E+02	1.116E-33
	1.346E+02	1.168E-34
	1.393E+02	1.113E-35
	1.439E+02	9.623E-37
	1.485E+02	7.528E-38
	1.531E+02	5.311E-39
	1.578E+02	3.368E-40
	1.624E+02	1.915E-41
	1.670E+02	9.758E-43
	1.716E+02	4.482E-44
	1.763E+02	1.913E-45
	1.809E+02	8.422E-47
	1.855E+02	6.500E-48
20	0.000E+00	1.900E+01
	5.000E-03	1.138E+01
	5.500E-02	1.053E+01
	1.050E-01	9.683E+00
	1.550E-01	8.838E+00
	2.050E-01	7.993E+00
	2.550E-01	7.148E+00
	3.050E-01	6.305E+00
	3.550E-01	5.461E+00
	4.050E-01	4.619E+00
	4.550E-01	3.777E+00
	5.050E-01	2.936E+00
	5.130E+00	2.388E+00
	9.755E+00	1.910E+00
	1.438E+01	1.502E+00
	1.901E+01	1.160E+00
	2.363E+01	8.793E-01
	2.826E+01	6.540E-01
	3.288E+01	4.770E-01
	3.751E+01	3.409E-01
	4.213E+01	2.387E-01
	4.676E+01	1.637E-01
	5.138E+01	1.099E-01
	5.601E+01	7.214E-02
	6.063E+01	4.634E-02
	6.526E+01	2.910E-02
	6.988E+01	1.787E-02
	7.451E+01	1.072E-02
	7.913E+01	6.288E-03
	8.376E+01	3.601E-03
	8.838E+01	2.015E-03
	9.301E+01	1.101E-03
	9.763E+01	5.871E-04

	1.023E+02	3.057E-04
	1.069E+02	1.554E-04
	1.115E+02	7.706E-05
	1.161E+02	3.730E-05
	1.208E+02	1.761E-05
	1.254E+02	8.116E-06
	1.300E+02	3.648E-06
	1.346E+02	1.599E-06
	1.393E+02	6.839E-07
	1.439E+02	2.852E-07
	1.485E+02	1.160E-07
	1.531E+02	4.602E-08
	1.578E+02	1.780E-08
	1.624E+02	6.716E-09
	1.670E+02	2.472E-09
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	1.763E+02	3.143E-10
	1.809E+02	1.156E-10
	1.855E+02	6.160E-11
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	5.000E-03	1.205E+01
	5.500E-02	1.128E+01
	1.050E-01	1.051E+01
	1.550E-01	9.740E+00
	2.050E-01	8.970E+00
	2.550E-01	8.200E+00
	3.050E-01	7.430E+00
	3.550E-01	6.661E+00
	4.050E-01	5.892E+00
	4.550E-01	5.124E+00
	5.050E-01	4.356E+00
	5.130E+00	3.842E+00
	9.755E+00	3.367E+00
	1.438E+01	2.931E+00
	1.901E+01	2.534E+00
	2.363E+01	2.175E+00
	2.826E+01	1.854E+00
	3.288E+01	1.569E+00
	3.751E+01	1.317E+00
	4.213E+01	1.098E+00
	4.676E+01	9.079E-01
	5.138E+01	7.449E-01
	5.601E+01	6.063E-01
	6.063E+01	4.895E-01
	6.526E+01	3.919E-01
	6.988E+01	3.112E-01
	7.451E+01	2.450E-01

	7.913E+01	1.913E-01
	8.376E+01	1.481E-01
	8.838E+01	1.136E-01
	9.301E+01	8.641E-02
	9.763E+01	6.515E-02
	1.023E+02	4.868E-02
	1.069E+02	3.604E-02
	1.115E+02	2.645E-02
	1.161E+02	1.923E-02
	1.208E+02	1.386E-02
	1.254E+02	9.892E-03
	1.300E+02	6.996E-03
	1.346E+02	4.902E-03
	1.393E+02	3.403E-03
	1.439E+02	2.340E-03
	1.485E+02	1.595E-03
	1.531E+02	1.077E-03
	1.578E+02	7.208E-04
	1.624E+02	4.794E-04
	1.670E+02	3.181E-04
	1.716E+02	2.129E-04
	1.763E+02	1.474E-04
	1.809E+02	1.108E-04
	1.855E+02	9.716E-05
100	0.000E+00	1.898E+01
	5.000E-03	1.270E+01
	5.500E-02	1.200E+01
	1.050E-01	1.130E+01
	1.550E-01	1.060E+01
	2.050E-01	9.903E+00
	2.550E-01	9.205E+00
	3.050E-01	8.507E+00
	3.550E-01	7.810E+00
	4.050E-01	7.113E+00
	4.550E-01	6.416E+00
	5.050E-01	5.719E+00
	5.130E+00	5.248E+00
	9.755E+00	4.799E+00
	1.438E+01	4.374E+00
	1.901E+01	3.974E+00
	2.363E+01	3.597E+00
	2.826E+01	3.245E+00
	3.288E+01	2.917E+00
	3.751E+01	2.612E+00
	4.213E+01	2.331E+00
	4.676E+01	2.073E+00
	5.138E+01	1.836E+00

	5.601E+01	1.620E+00
	6.063E+01	1.424E+00
	6.526E+01	1.246E+00
	6.988E+01	1.087E+00
	7.451E+01	9.440E-01
	7.913E+01	8.166E-01
	8.376E+01	7.035E-01
	8.838E+01	6.037E-01
	9.301E+01	5.158E-01
	9.763E+01	4.389E-01
	1.023E+02	3.719E-01
	1.069E+02	3.138E-01
	1.115E+02	2.636E-01
	1.161E+02	2.206E-01
	1.208E+02	1.838E-01
	1.254E+02	1.525E-01
	1.300E+02	1.260E-01
	1.346E+02	1.037E-01
	1.393E+02	8.508E-02
	1.439E+02	6.959E-02
	1.485E+02	5.681E-02
	1.531E+02	4.636E-02
	1.578E+02	3.792E-02
	1.624E+02	3.120E-02
	1.670E+02	2.598E-02
	1.716E+02	2.208E-02
	1.763E+02	1.935E-02
	1.809E+02	1.769E-02
	1.855E+02	1.704E-02

APPENDIX D

Expansion Area Wetlands Delineation Report

(Prepared by HDR Engineering for the City of Billings)

City of Billings

Landfill Expansion

Wetlands and Stream Delineation Report

January 2014

Prepared for:

City of Billings

Prepared by:

HDR Engineering, Inc.

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Introduction

This report describes the methods and findings of wetlands and streams for the proposed City of Billings Landfill Expansion Project. The report was prepared by HDR Engineering, Inc. (HDR) biologists, and is intended to provide documentation of existing stream and wetland conditions in the project area to support applicable state and local agency permitting for the project.

1.1 Project Background and Setting

The team of Great West Engineering and HDR Engineering has been hired by the City of Billings to prepare a Solid Waste Management Plan. The scope of the project includes an evaluation of the existing facilities and master planning activities, which also includes examining the feasibility of expanding the landfill to City property adjacent the existing landfill. As part of the Solid Waste Management Plan, and to support future licensing requirements for landfill expansion, environmental documentation has been prepared that is anticipated to be used by the Montana Department of Environmental Quality (DEQ) for preparation of formal environmental assessment to comply with requirements per the Administrative rules of Montana (ARM) 17.4.601 and the agency's Procedural Rules for implementing Montana Environmental Policy Act (MEPA). This Wetland and Stream Delineation Report is one of several technical reports being prepared for this project.

The project is located in Yellowstone County, Montana, just south of the City of Billings (Figure 1). In particular, the project area is located in Section 29, Township 1 South, Range 26 East, Montana Principal Meridian, and is centered at latitude 45° 43' 08" North and longitude 108° 32' 06" West. The proposed landfill expansion site is located on approximately 370 acres of City-owned land immediately southeast of the existing Billings Landfill. The project site extends from just south of the intersection of Hillcrest Road and Montana State Highway 416 (Blue Creek Road) south approximately 1 mile to the Section 29 boundary line.

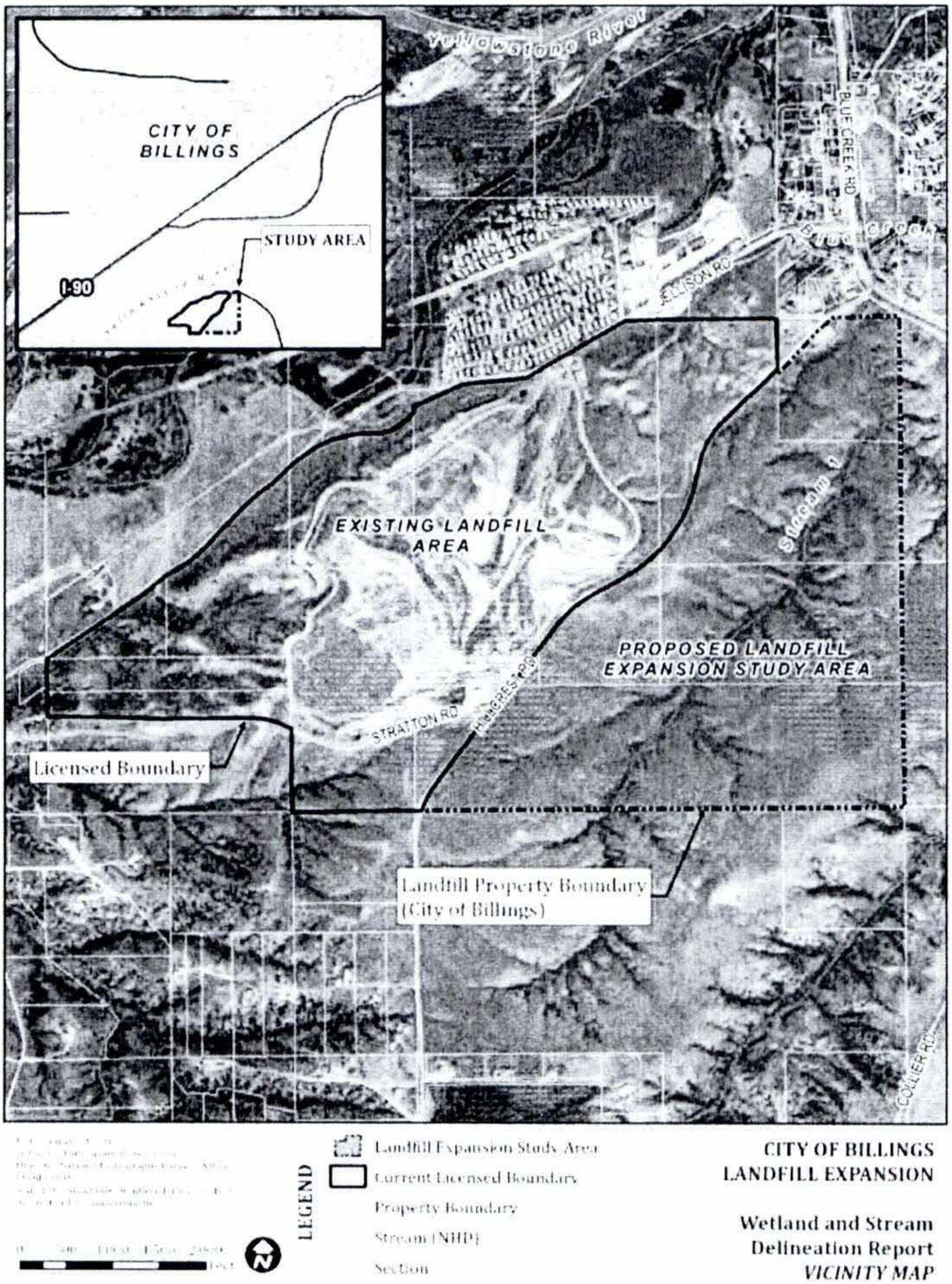

Figure 1. Project Vicinity Map

Methods

2.1 Study Area

The study area encompasses the project limits discussed in Section 1.1 and depicted on Figure 1. Wetlands and streams outside the study area were not formally delineated; these areas were assessed based on characteristics visible from public rights-of-way and on information obtained from existing documents and studies, maps, and aerial photographs.

Streams and potential wetlands in the study area were identified through a two-step process. HDR biologists first reviewed existing documents, including soil surveys, wetland and stream inventories, aerial photographs, and other reports that concern wetlands and streams in the project vicinity. After this review, HDR biologists completed a thorough field investigation of the study area that included wetland and stream identification, delineation, and classification.

2.2 Review of Existing Information

Existing documents reviewed for this wetland and stream study included the following:

- Soil Survey of Yellowstone County Area, Montana (USDA NRCS 2012)
- U.S. Fish and Wildlife Service (USFWS 2012) National Wetland Inventory Web site
- Federal Emergency Management Agency (FEMA 1981) Flood Insurance Rate Map for Unincorporated Yellowstone County
- Montana Fish Wildlife and Parks (2012) Montana Fisheries Information System (MFISH)
- Montana Natural Heritage Program Database (2012)

These documents provide background information on the soils, hydrology, land use, streams, and potential wetlands in the study area.

2.3 Field Investigation

Field investigation consisted of an initial field reconnaissance on October 7, 2012. The reconnaissance was followed by a more detailed investigation of streams and potential wetlands in the study area, which was conducted on October 8 and 9, 2012. In the week prior to the field investigation, Billings had received approximately 1.5 inches of rainfall (National Oceanic and Atmospheric Administration [NOAA] National Weather Service [NWS] 2012). Temperatures were generally within normal ranges for early October. Precipitation over the preceding two months was below the normal range for Billings, with only a trace of precipitation in the month of September (NOAA NWS 2012, USDA NRCS 2002).

Wetlands

HDR staff investigated the project site for wetlands using the three parameter methods described in the *Corps of Engineers Wetland Delineation Manual* (Environmental Laboratory 1987), as updated by the *Regional Supplement to the Corps of Engineers Wetland Delineation Manual: Great Plains Region* (U.S. Army Corps of Engineers [USACE] 2010). A detailed description of the field methods used in this study is provided in Appendix A. Due to field time constraints, paired sample plots were not gathered at some of the minor wetlands along Stream 1 and at Wetland 5. Mapping of these wetlands was based on the presence of hydrophytic vegetation communities comparable to those observed in other delineated wetlands.

Wetland boundary and data plot locations in the study area were marked in the field using a Trimble GeoXT 2005 GPS device, which is capable of sub meter accuracy. The resulting data were incorporated into project base maps as well as the previous survey data.

Streams

In order to determine the ordinary high water mark (OHWM) of streams in the study area, HDR utilized USACE (2005) guidance for OHWM identification. USACE (2005) defines "ordinary high water mark" as: "that line on the shore established by the fluctuations of water and indicated by physical characteristics such as a clear, natural line impressed on the bank, shelving, changes in the character of soil, destruction of terrestrial vegetation, the presence of litter and debris, or other appropriate means that consider the characteristics of the surrounding areas." HDR staff looked for physical indicators including, but not limited to, a natural line impressed on the bank, destruction of terrestrial vegetation, presence of litter and debris, vegetation matted down, bent or absent, scour, and bed and banks. Due to field time constraints, the OHWM of portions of Stream 1 and the first-order drainages to Stream 1 (1 East through 15 East and 1 West through 7 West) were not fully delineated. Rather, the centerline of Stream 1 was mapped through most of the project area, and the upstream limits of observable bed and bank were mapped for the first-order drainages.

Results

3.1 General Site Conditions

The project site is located just south of the city of Billings in unincorporated Yellowstone County (Figure 1). The project site is located in the Missouri Plateau, Unglaciated Section of the Great Plains Province of the Interior Plains (USDA NRCS 2013). It is an area of old plateaus and terraces that have been eroded. Slopes generally are gently rolling to steep and wide belts of steeply sloping badlands border a few of the larger river valleys. Nearly the entire project site is mapped as Lismas Clay, 15 to 35 percent slopes (USDA NRCS 2012). These soils are characterized as shallow, well-drained, moderately steep calcerous clay soils on upland (Meshnick 1972). Topographically, the project area consists of an upland plain, dissected by a large second-order drainage (Stream 1) that discharges to Blue Creek, a tributary of the Yellowstone River. Numerous first-order drainages are located throughout the project area and all drain to Stream 1. Surface elevation in the study area ranges from 3200 feet to 3500 feet above mean sea level.

Montana Natural Heritage Program (2013) land cover atlas maps the upland plains in the study area as Big Sagebrush Steppe and Great Plains Mixed Grass Prairie. Predominant species in these areas include Wyoming and basin big sagebrush (*Artemisia tridentata* ssp. *wyomingensis*, *Artemisia tridentata* ssp. *tridentata*); grazed areas are dominated by exotics such as Kentucky bluegrass (*Poa pratensis*), smooth brome (*Bromus inermis*), and Japanese brome (*Bromus japonicus*), as well as western wheatgrass (*Pascopyrum smithii*) and crested wheatgrass (*Agropyron cristatum*) (MNHP 2013). Portions of Stream 1 and the tertiary drainages are mapped as Great Plains Ponderosa Pine Woodland and Savanna, and Great Plains Wooded Draw and Ravine, and Great Plains Riparian. Predominant species in these land cover types include narrowleaf cottonwood (*Populus angustifolia*) and Plains cottonwood (*Populus deltoides*) in floodplains, Rocky Mountain juniper (*Juniperus scopulorum*) in the draws and ravines, and ponderosa pine (*Pinus ponderosa*) near the upward extent of the drainages. Uplands outside of the secondary and tertiary drainages are currently used as horse pastures. Current uses of the property include a corral and a watering tank for horses, a watering tank and several pipes, and a power station in the northwest corner of the project area. Linear man-made features include a power transmission/distribution line and several undeveloped roads and two-tracks.

3.2 Wetlands

HDR staff identified 14 wetlands in the study area that collectively cover an area of 2.41 ac. With the exception of Wetlands 5 and 6, all other wetlands identified in the study area adjoin Stream 1 landward of its top of bank. Wetlands were distinguished from adjoining uplands by the presence of indicators for wetland hydrology, hydric soils, and hydrophytic vegetation. Table 1 summarizes the size, hydrogeomorphic (HGM) and Cowardin classification of these wetlands found within the project area. Figure 2 shows an overview of the wetlands and waterbodies in the study area, and detailed maps of wetlands and streams delineated on the project site are shown in Appendix C. Wetland delineation data sheets for wetlands within the study area are provided in Appendix B, detailed wetland delineation maps are in Appendix C, and site photos are provided in Appendix D.

Table 1. Summary of Wetlands in the Study Area

Wetland Name	Wetland area on Project Site	Hydrogeomorphic (HGM) Classification[a]	Cowardin Classification[b]	Wetland Delineation Paired Sample Plots Completed in October 2012?
1	1.32 ac	Riverine	PEM1/PAB1	Yes
1a	0.02 ac	Riverine	PEM1	No
2	0.40 ac	Riverine	PEM1/PAB1	Yes
2a	0.03 ac	Riverine	PEM1	No
2b	0.02 ac	Riverine	PEM1	No
2c	0.02 ac	Riverine	PEM1	No
3	0.10 ac	Riverine	PEM1	Yes
4	0.05 ac	Riverine	PEM1	No
4a	0.03 ac	Riverine	PEM1	No
5	0.01 ac	Depressional	PEM1	No
6	0.30 ac	Slope	PEM1	Yes
7	0.09 ac	Riverine	PEM1	No
7a	0.01 ac	Riverine	PEM1	No
7b	0.01 ac	Riverine	PEM1	No

[a] Montana Department of Transportation (2008)

[b] Cowardin et al. (1979).

PEM1 = palustrine emergent, persistent; PAB1 = palustrine aquatic bed, algal

Wetland 1

Palustrine emergent persistent

1.32 acre total

Wetland 1 is an impounded riverine wetland located along Stream 1, located in the south portion of the site (Appendix C, Maps 9 and 11). Wetland 1 receives seasonal overbank flow from Stream 1 and surface flows from other seasonal drainages that discharge into the floodplain of Stream 1. Water in Wetland 1 is impounded by a road berm along the north wetland boundary of the wetland; one culvert is located in the road berm at an elevation at least 6 feet higher than the high water line observed in the wetland. The north portion of Wetland 1 corresponds to a PABFh wetland mapped in the NWI (USFWS 2012).

Figure 2. Study Area Overview Map

Wetland 1 is a palustrine, emergent wetland. In the north portion of the wetland, a narrow band of emergent vegetation dominated by twoscale saltbush (*Atriplex micrantha*) and rough cocklebur (*Xanthium strumarium*) surrounds an inundated and unvegetated depression where water ponds behind the road berm. Common spikerush (*Eleocharis palustris*) is predominant in the south-central portion of the wetland, and inland bluegrass (*Poa interior*) was predominant in the southwest arm of the wetland. Twoscale saltbush and rough cocklebur are introduced annuals that are not listed on the National Wetland Plant List (USACE 2013); however, hydrophytic vegetation is presumed to be present due to hydric soil and wetland hydrology indicators. Predominance of common spikerush and inland bluegrass in the south portion of the wetland meets the hydrophytic vegetation criteria. At the time of the wetland delineation, the depression in the north portion of the wetland was inundated to a depth of 10 inches. In the south portion of the wetland, saturation was present within 12 inches of the surface. Both of these observations are primary indicators for wetland hydrology. The typical soil profiles observed in the wetland met the hydric soil criteria for Depleted Matrix.

Wetland 2

Palustrine emergent persistent

0.40 acre total

Wetland 2 is another impounded riverine wetland located along Stream 1, located in the south portion of the site (Appendix C, Maps 6 and 9). Wetland 2 receives seasonal overbank flow from Stream 1 and surface flows from other seasonal drainages that discharge into the wetland. Water in Wetland 2 is impounded by a road berm along the north wetland boundary of the wetland; one culvert is located in the road berm at an elevation at least 6 feet higher than the high water line observed in the wetland; this culvert likely acts as a high-flow outlet during extreme precipitation events. The north portion of Wetland 2 corresponds to a PABFh wetland mapped in the NWI (USFWS 2012).

Wetland 2 is a palustrine, emergent wetland that also has a narrow band of twoscale saltbrush surrounding an unvegetated depression. At the time of the wetland delineation, no inundation, high water table or saturation was observed. However, aerial photos of Wetland 2 indicate that Wetland 2 is inundated through early summer, and aquatic invertebrates were observed in the unvegetated depression. Both of these are primary indicators of wetland hydrology, therefore wetland hydrology is assumed to be present during the early part of the growing season. The typical soil profile observed in the wetland met the hydric soil criteria for Depleted Matrix.

Wetland 3

Palustrine emergent persistent

0.10 acre total

Wetland 3 is a partially impounded riverine wetland located along Stream 1, located in the north portion of the site (Appendix C, Map 3). Wetland 3 receives seasonal overbank flow from Stream 1 and surface flows from other seasonal drainages that discharge into the wetland. Surface water in Wetland 3 is partially impounded by a shallow two-track berm located along the north wetland boundary; however, one culvert located under the two-track occurs at a low enough elevation in relation to Wetland 3 that it likely allows flow-through of surface water from Wetland 3.

Wetland 3 is a palustrine, emergent wetland dominated by fox-tail barley (*Hordeum jubatum*) and common spikerush, with other grass and emergent species. At the time of the wetland delineation, no inundation, high water table or saturation was observed. However, oxidized rhizospheres on living roots, a primary indicator of wetland hydrology, were observed. The typical soil profile observed in the wetland met the hydric soil criteria for Depleted Matrix.

Minor Wetlands Associated with Stream 1(Wetlands 2a, 2b, 2c, 4, 7, 7a and 7b)

Several other small wetlands adjoining Stream 1 were identified; the approximate boundaries of these wetlands were mapped (Appendix C, Maps 3, 5, 6, 9, 12 and 16); however, formal sample plots were not established due to field time constraints. These wetlands were dominated by hydrophytic vegetation such as common spikerush, fox-tail barley, and narrowleaf cattail (*Typha angustifolia*). Primary indicators of wetland hydrology included water-stained leaves; secondary indicators of wetland hydrology included drainage patterns and geomorphic position.

Wetland 5

Palustrine emergent persistent

0.10 acre total

Wetland 5 is a depressional wetland located upslope of Drainage 4 West on the west-central portion of the project site (Appendix C, Map 6). Wetland 5 likely receives hydrology from surface and subsurface flows from surrounding uplands. There was no distinct outlet observed in Wetland 5; however, some sheetflow likely discharges to Drainage 4 West during large precipitation events. Due to field time constraints, formal wetland delineation plots were not established at this wetland. Wetland 5 is a palustrine, emergent wetland dominated by narrowleaf cattail. At the time of the wetland delineation, no inundation, high water table or saturation was observed. However, water-stained leaves, which is a primary indicator of wetland hydrology, were observed in the wetland.

Wetland 6

Palustrine emergent persistent

0.30 acre total

Wetland 6 is a slope wetland, located upslope from the southwest corner of Wetland 1 (Appendix C, Maps 8 and 9). Wetland 6 receives subsurface groundwater discharge from seeps, and surface water discharges through a defined channel downslope and east of Wetland 6, ultimately draining to Wetland 1. Surface flow was visible in the channel during the October 2012 wetland delineation.

Wetland 6 is a palustrine, emergent wetland dominated by saltmarsh club-rush (*Schoenoplectus maritimus*), and twoscale saltbush, with scattered toad rush (*Juncus bufonius*) and fox-tail barley, most of which appeared grazed. At the time of the wetland delineation, inundation to a depth of 1 inch was observed in pockets throughout Wetland 6, and free water was present within 10 inches of the surface. Salt crust was also observed on some of the emergent and grass stems. All of these observations are primary indicators of wetland hydrology. The typical soil profile observed in the wetland met the hydric soil criteria for Depleted Matrix.

3.3 Streams

The study area is located in the Blue Creek Watershed, located in the Upper Yellowstone-Lake Basin Watershed (USGS HUC 17010204) (USEPA 2012). Table 2 summarizes the size and primary characteristics of streams and drainages identified in the study area (Figure 2).

Table 2. Summary of Streams in the Study Area

Stream/ Tributary Name	Tributary to	USACE Jurisdiction[a,b]	Stream Characteristics in Project Reach	Average Width in Study Area (ft)[e]	Approximate Length in Study Area (ft)[e]
Stream 1	Blue Creek	RPW	• Seasonal, second-order stream • No fish presence documented in project reach of stream[c]	5-10	8,770
Drainage 1 East	Stream 1	Tributary to RPW[d]	• Seasonal, first-order drainage • No fish presence documented in project reach of stream	2-3	139
Drainage 2 East	Stream 1	Tributary to RPW	• Seasonal, first-order drainage • No fish presence documented in project reach of stream	1	210
Drainage 3 East	Stream 1	Tributary to RPW	• Seasonal, first-order drainage • No fish presence documented in project reach of stream	<1	38
Drainage 4 East	Stream 1	Tributary to RPW	• Seasonal, first-order drainage • No fish presence documented in project reach of stream	2	525
Drainage 5 East	Stream 1	Tributary to RPW	• Seasonal, first-order drainage • No fish presence documented in project reach of stream	<1	150
Drainage 6 East	Stream 1	Tributary to RPW	• Seasonal, first-order drainage • No fish presence documented in project reach of stream	3	272

Table 2. Continued

Stream/ Tributary Name	Tributary to	USACE Jurisdiction[a,b]	Stream Characteristics in Project Reach	Average Width in Study Area (ft)[e]	Approximate Length in Study Area (ft)[e]
Drainage 7 East	Stream 1	Tributary to RPW	• Seasonal, first-order drainage • No fish presence documented in project reach of stream	2	111
Drainage 8 East	Stream 1	Tributary to RPW	• Seasonal, first-order drainage • No fish presence documented in project reach of stream	2	328
Drainage 9 East	Stream 1	Tributary to RPW	• Seasonal, first-order drainage • No fish presence documented in project reach of stream	4	198
Drainage 10 East	Stream 1	Tributary to RPW	• Seasonal, first-order drainage • No fish presence documented in project reach of stream	2	445
Drainage 11 East	Stream 1	Tributary to RPW	• Seasonal, first-order drainage • No fish presence documented in project reach of stream	2	198
Drainage 12 East	Stream 1	Tributary to RPW	• Seasonal, first-order drainage • No fish presence documented in project reach of stream	7	318
Drainage 13 East	Stream 1	Tributary to RPW	• Seasonal, first-order drainage • No fish presence documented in project reach of stream	2	581
Drainage 14 East	Stream 1	Tributary to RPW	• Seasonal, first-order drainage • No fish presence documented in project reach of stream	<1	114
Drainage 15 East	Stream 1	Tributary to RPW	• Seasonal, first-order drainage • No fish presence documented in project reach of stream	1	104

Table 2. Continued

Stream/ Tributary Name	Tributary to	USACE Jurisdiction[a,b]	Stream Characteristics in Project Reach	Average Width in Study Area (ft)[e]	Approximate Length in Study Area (ft)[e]
Drainage 1 West	Stream 1	Tributary to RPW	• Seasonal, first-order drainage • No fish presence documented in project reach of stream	1	107
Drainage 2 West	Stream 1	Tributary to RPW	• Seasonal, first-order drainage • No fish presence documented in project reach of stream	1-3	490
Drainage 3 West	Stream 1	Tributary to RPW	• Seasonal, first-order drainage • No fish presence documented in project reach of stream	1-3	362
Drainage 4 West	Stream 1	Tributary to RPW	• Seasonal, first-order drainage • No fish presence documented in project reach of stream	2	168
Drainage 5 West	Stream 1	Tributary to RPW	• Seasonal, first-order drainage • No fish presence documented in project reach of stream	1	207
Drainage 6 West	Stream 1	Tributary to RPW	• Seasonal, first-order drainage • No fish presence documented in project reach of stream	2-3	339
Drainage 7 West	Stream 1	Tributary to RPW	• Seasonal, first-order drainage • No fish presence documented in project reach of stream	1-2	178

[a] RPW = Relatively Permanent Water; non navigable tributary with relatively permanent flow year-round or continuous flow seasonally (eg, typically ≥3 months) (USEPA 2007)

[b] Non-RPW = non-navigable tributary that is not relatively permanent

[c] All drainages were dry at the time of the October site visit; however, a determination on whether the drainages were RPW or non-RPW could not be made

[d] Montana Fish Wildlife and Parks 2013

[e] Average widths and approximate lengths were determined based on existing survey data and field observations.

Stream 1

Stream 1 is a second-order stream that originates south of the project boundary and flows 1.5 miles north/northeast through the project site, discharging to Blue Creek through culverts under Blue Creek Road (Figure 2). Stream 1 is not documented to support fish species (MFWP 2013).

Stream 1 has on average a bankfull width of 5-10 feet and has an overall gradient of approximately 2%. The confinement of the stream varies throughout the project reach, ranging from relatively confined to relatively open. The streambanks are relatively shallow and gently-sloped; overbank flow appears to mainly occur concurrent with wetlands found along the drainage. Stream substrate mainly consists of silts, as well as pebbles and small cobbles. There was no surface water flow in any part of the channel during the October 2012 field investigation. It is likely that during springtime flows, aquatic habitat consists of low-gradient riffles, with large, deep pools at the two impoundments associated with Wetlands 1 and 2.

Riparian vegetation communities associated with Stream 1 within the study area consists mainly of two habitat types as defined in the Classification and Management of Montana's Riparian and Wetland Sites (Hansen et al. 1995): (1) Green ash/common chokecherry and habitat type and (2) Rocky Mountain Juniper/Red-Osier Dogwood habitat type. The Green Ash/Common Chokecherry type is a major deciduous riparian habitat type in the Great Plains region of central and eastern Montana, and attracts wildlife for thermal cover, nesting habitat, water source, late summer and winter forage, travel corridors, and hiding cover. The Rocky Mountain Juniper/Red-Osier Dogwood habitat type is less widespread, it does however provide good to excellent structural diversity for both thermal and hiding cover.

Seasonal First-Order Drainages (1 East through 15 East and 1 West through 7 West)

The project site contains 22 first-order seasonal drainages that discharge to Stream 1 (Appendix C, Maps 1 through 18). None of these streams are documented to support fish species (MFWP 2013). Due to field time constraints the ordinary high water mark was not delineated on each drainage; however, the upstream limit of discernible bed and bank was inventoried for each drainage. The average bankfull width of the drainages was between 1 to 3 feet, and average gradient was at least 5%. Drainage substrate mainly consisted of sediment and pebbles. There was no surface water flow in any of the drainages during the October 2012 field visit. Overhanging vegetation along each drainage mainly consisted of Rocky Mountain juniper and Ponderosa pine; little to no margin vegetation was observed. These drainages likely provide both thermal and hiding cover comparable to the Rocky Mountain Juniper riparian habitat in Stream 1.

3.4 Jurisdictional Status/Conclusions

The wetlands and streams documented within the study area and described in this report are all located upstream and have a direct connection to Blue Creek. Blue Creek is a Relatively Permanent Water, or RPW, that directly flows into the Yellowstone River. The US Army Corps of Engineers (USACE) has designated the Yellowstone River as a Traditional Navigable Water, or TNW. Both RPWs and TNWs are jurisdictional under the Clean Water Act. Stream 1, and all adjacent wetlands, including Wetlands 5 and 6, have adjacency to RPWs, and therefore are likely subject to jurisdiction under Section 404 of the Clean Water Act. The USACE is ultimately responsible for all jurisdictional determinations.

This report describes the wetland delineation process as well as the extent and types of wetlands found in the study area that are preliminarily determined to be subject to the jurisdiction of the USACE under authority of Section 404 of the Clean Water Act or under authority of Section 10 of the Rivers and Harbors Act of 1899. By federal law (Clean Water Act) and associated policy, it is necessary to avoid project impacts to wetlands wherever practicable, minimize impact where impact is not avoidable, and in some cases mitigate for the impact.

Permitting activities are not anticipated at this point in project development. The current conceptual design indicates that all wetlands (2.41 acres) would likely be impacted by construction of the expanded landfill facilities. Because the proposed project would affect both wetlands and streams, both wetland and stream mitigation will likely be required to offset adverse impacts. As the project develops, it is likely that a Section 404 Individual Permit will be required for unavoidable impacts to wetlands and streams located within the study area. The permitting process, and required mitigation, if applicable, will be determined at a later date through coordination with the USACE.

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Appendix A – Wetland Delineation Methodology

Wetlands are defined as areas saturated or inundated by surface or groundwater at a frequency and duration sufficient to support, and which under normal circumstances do support, a prevalence of vegetation adapted for life in saturated soil conditions. The methods used to delineate the on-site wetlands conform to methods described in the *Washington State Wetland Identification and Delineation Manual* (Ecology 1997), the *Corps of Engineers Wetland Delineation Manual* (Environmental Laboratory 1987), and the *Regional Supplement to the Corps of Engineers Wetland Delineation Manual: Great Plains Region* (USACE 2010). All delineated wetlands were instrument-surveyed and mapped on project base maps.

To be considered a wetland, an area must have hydrophytic vegetation, hydric soils, and wetland hydrology. HDR staff collected data on these parameters in areas representative of typical site conditions. Staff collected additional data in associated uplands, as needed, to confirm wetland and stream boundaries. Wetland boundaries and wetland data plot locations in the study area were marked with sequentially-numbered flagging.

Vegetation

The dominant plants and their wetland indicator status were evaluated to determine if the vegetation was hydrophytic. To determine which plants were dominate at a sample plot biologists applied the 50/20 rule per USACE recommendations. Under this guidance absolute cover estimates were made for each species found rooted within the sample plot, for each vegetative strata found in the habitat (tree, sapling/shrub, herb, and woody vine). The species that had the most cover was included along with the next species until the absolute cover of these totaled more than 50% of the total absolute cover. Any other species that represented at least 20% of the total absolute cover was also included as a dominant species for that vegetative strata.

Sample plots varied in size depending on site topography and habitat complexity. The objective of establishing a plot was to depict particular plant associations that reflect specific water regimes or other ecological factors. So, on steep-sided riparian areas, a plot may consist of a narrow strip along the waters edge or within a floodplain a plot may be a standard 30-foot circle.

Hydrophytic vegetation is defined as vegetation adapted to wetland conditions. To meet the hydrophytic vegetation criterion, more than 50 percent of the dominant plants in each stratum must be Facultative, Facultative Wetland, or Obligate, based on the wetland indicator category assigned to each plant species by USACE (2013). Table A-1 lists the definitions of the indicator categories.

Table A-1. Definitions of Wetland Plant Indicator Categories used to Determine the Presence of Hydrophytic Vegetation

Wetland Indicator Category	Symbol	Definition
Obligate Wetland Plants	OBL	Plants that almost always (> 99% of the time) occur in wetlands, but which may rarely (< 1% of the time) occur in non-wetlands.
Facultative Wetland Plants	FACW	Plants that often (67 to 99% of the time) occur in wetlands, but sometimes (1 to 33% of the time) occur in non-wetlands.
Facultative Plants	FAC	Plants with a similar likelihood (34 to 66% of the time) of occurring in both wetlands and non-wetlands.
Facultative Upland Plants	FACU	Plants that sometimes (1 to 33% of the time) occur in wetlands, but occur more often (67 to 99% of the time) in non-wetlands.
Upland Plants	UPL	Plants that rarely (< 1% of the time) occur in wetlands, and almost always (> 99% of the time) occur in non-wetlands.

Source: Lichvar et al. (2012).

HDR biologists identified plants to species in the field and estimated percent cover of dominant plants. Scientific and common plant names follow currently accepted nomenclature. Names are consistent with PLANTS Database (USDA NRCS 2013b). During the field investigation, staff observed and recorded the dominant plant species on data sheets for each data plot.

Soils

Generally, an area must contain hydric soils to be a wetland. Hydric soil forms when soils are saturated, flooded, or ponded long enough during the growing season to develop anaerobic conditions in the upper part (12 inches). Biological activities in saturated soil result in reduced oxygen concentrations and organisms turn to anaerobic processes for metabolism. Over time, anaerobic biological processes result in certain soil color patterns, which are used as indicators of hydric soil. Typically, low-chroma colors are formed in the soil matrix, and bright-colored redoximorphic features form within the matrix. Other important hydric soil indicators include organic matter accumulations in the surface horizon, reduced sulfur odors, and organic matter staining in the subsurface (USDA NRCS 2010).

HDR staff examined soils by excavating sample pits to a depth of 20 inches to observe soil profiles, colors, and textures. In some case, a shallower soil pit was adequate to document hydric soil indicators. Munsell color charts (Munsell Color 2009) were used to describe soil colors.

Hydrology

HDR Engineering, Inc. staff examined the area for evidence of hydrology. Wetland hydrology criteria were considered to be satisfied if it appeared that the soil was seasonally inundated or saturated to the surface for a consecutive number of days greater than or equal to 12.5 percent of the growing season (Environmental Laboratory 1987). The growing season generally begins when the soil reaches a temperature of 41 degrees Fahrenheit in the zone of root penetration or when certain indicators of plant biological activity are evident (USACE 2010). The growing season in the project area can be approximated using the long-term climatological data reported in WETS tables available from the USDA NRCS National Water and Climate Center (2002). At Billings WSO, the growing season is estimated to occur between April 18 and October 7 (172 days).

Wetland hydrology indicators are divided into two categories – primary and secondary indicators (USACE 2010). Primary indicators of hydrology include surface inundation, high water table, saturated soils, algal mat or crusts, and inundation visible on aerial imagery. The presence of one primary indicator is sufficient to conclude that wetland hydrology is present. If the absence of a primary indicator, observation of two or more secondary indicators is required to conclude that wetland hydrology is present. Secondary indicators of hydrology include surface soils cracks, sparsely vegetated concave surface, and geomorphic position (USACE 2010).

Appendix B – Wetland Delineation Data Sheets

WETLAND DETERMINATION DATA FORM – Great Plains Region

Project/Site: Billings landfill expansion City/County: Yellowstone Co. Sampling Date: 10/8/14

Applicant/Owner: City of Billings State: MT Sampling Point: SP 1-1 (W)

Investigator(s): L Danielski / J Schick Section, Township, Range: S29 T1S R26E

Landform (hillslope, terrace, etc.): depression Local relief (concave, convex, none): concave Slope (%): ______

Subregion (LRR): G Western Great Plains Lat: 45.7152 Long: -108.5398 Datum: WGS1984

Soil Map Unit Name: Ln Lismas clay NWI classification: POW

Are climatic / hydrologic conditions on the site typical for this time of year? Yes X No ____ (If no, explain in Remarks.)

Are Vegetation X, Soil ____, or Hydrology _ significantly disturbed? Are "Normal Circumstances" present? Yes X No ____

Are Vegetation ____, Soil ____, or Hydrology ____ naturally problematic? (If needed, explain any answers in Remarks.)

SUMMARY OF FINDINGS – Attach site map showing sampling point locations, transects, important features, etc.

Hydrophytic Vegetation Present?	Yes ____ No X	**Is the Sampled Area within a Wetland?** Yes X No ____
Hydric Soil Present?	Yes X No ____	
Wetland Hydrology Present?	Yes X No ____	

Remarks: Sample plot is near lowest point in unvegetated portion of wetland.

VEGETATION – Use scientific names of plants.

	Absolute % Cover	Dominant Species?	Indicator Status
Tree Stratum (Plot size: N/A)			
1.			
2.			
3.			
4.			
	____ = Total Cover		
Sapling/Shrub Stratum (Plot size: N/A)			
1.			
2.			
3.			
4.			
5.			
	____ = Total Cover		
Herb Stratum (Plot size: 5' r)			
1.			
2.			
3.			
4.			
5.			
6.			
7.			
8.			
9.			
10.			
	____ = Total Cover		
Woody Vine Stratum (Plot size: ____)			
1.			
2.			
	____ = Total Cover		
% Bare Ground in Herb Stratum ____			

Dominance Test worksheet:

Number of Dominant Species That Are OBL, FACW, or FAC (excluding FAC−): ____ (A)

Total Number of Dominant Species Across All Strata: ____ (B)

Percent of Dominant Species That Are OBL, FACW, or FAC: ____ (A/B)

Prevalence Index worksheet:

Total % Cover of:		Multiply by:
OBL species	____	x 1 = ____
FACW species	____	x 2 = ____
FAC species	____	x 3 = ____
FACU species	____	x 4 = ____
UPL species	____	x 5 = ____
Column Totals:	____ (A)	____ (B)

Prevalence Index = B/A = ____

Hydrophytic Vegetation Indicators:

- __ 1 - Rapid Test for Hydrophytic Vegetation
- __ 2 - Dominance Test is >50%
- __ 3 - Prevalence Index is ≤3.0[1]
- __ 4 - Morphological Adaptations[1] (Provide supporting data in Remarks or on a separate sheet)
- __ Problematic Hydrophytic Vegetation[1] (Explain)

[1]Indicators of hydric soil and wetland hydrology must be present, unless disturbed or problematic.

Hydrophytic Vegetation Present? Yes ____ No X

Remarks: No vegetation within sampled area. Area upslope of unvegetated portion dominated by Atriplex heterosperma & Xanthium strumarium. (Photo ... (Schick))

SOIL

Sampling Point: 11 (wl)

Profile Description: (Describe to the depth needed to document the indicator or confirm the absence of indicators.)

Depth (inches)	Matrix Color (moist)	%	Redox Features Color (moist)	%	Type[1]	Loc[2]	Texture	Remarks
0-8	2.5Y 4/2		10YR 4/6	12	C	M	clay	
8-20	2.5Y 4/1		7.5YR 4/6	20	C	M	clay	

[1]Type: C=Concentration, D=Depletion, RM=Reduced Matrix, CS=Covered or Coated Sand Grains [2]Location: PL=Pore Lining, M=Matrix.

Hydric Soil Indicators: (Applicable to all LRRs, unless otherwise noted.)

- __ Histosol (A1)
- __ Histic Epipedon (A2)
- __ Black Histic (A3)
- __ Hydrogen Sulfide (A4)
- __ Stratified Layers (A5) **(LRR F)**
- __ 1 cm Muck (A9) **(LRR F, G, H)**
- __ Depleted Below Dark Surface (A11)
- __ Thick Dark Surface (A12)
- __ Sandy Mucky Mineral (S1)
- __ 2.5 cm Mucky Peat or Peat (S2) **(LRR G, H)**
- __ 5 cm Mucky Peat or Peat (S3) **(LRR F)**
- __ Sandy Gleyed Matrix (S4)
- __ Sandy Redox (S5)
- __ Stripped Matrix (S6)
- __ Loamy Mucky Mineral (F1)
- __ Loamy Gleyed Matrix (F2)
- __ Depleted Matrix (F3)
- __ Redox Dark Surface (F6)
- X Depleted Dark Surface (F7)
- __ Redox Depressions (F8)
- __ High Plains Depressions (F16) **(MLRA 72 & 73 of LRR H)**

Indicators for Problematic Hydric Soils[3]:

- __ 1 cm Muck (A9) **(LRR I, J)**
- __ Coast Prairie Redox (A16) **(LRR F, G, H)**
- __ Dark Surface (S7) **(LRR G)**
- __ High Plains Depressions (F16) **(LRR H outside of MLRA 72 & 73)**
- __ Reduced Vertic (F18)
- __ Red Parent Material (TF2)
- __ Very Shallow Dark Surface (TF12)
- __ Other (Explain in Remarks)

[3]Indicators of hydrophytic vegetation and wetland hydrology must be present, unless disturbed or problematic.

Restrictive Layer (if present):

Type: ______

Depth (inches): ______

Hydric Soil Present? Yes X No ___

Remarks: Soils [illegible] from [illegible]

HYDROLOGY

Wetland Hydrology Indicators:

Primary Indicators (minimum of one required; check all that apply)

- __ Surface Water (A1)
- __ High Water Table (A2)
- __ Saturation (A3)
- __ Water Marks (B1)
- __ Sediment Deposits (B2)
- __ Drift Deposits (B3)
- X Algal Mat or Crust (B4)
- __ Iron Deposits (B5)
- X Inundation Visible on Aerial Imagery (B7)
- __ Water-Stained Leaves (B9)
- __ Salt Crust (B11)
- __ Aquatic Invertebrates (B13)
- __ Hydrogen Sulfide Odor (C1)
- __ Dry-Season Water Table (C2)
- __ Oxidized Rhizospheres on Living Roots (C3) **(where not tilled)**
- __ Presence of Reduced Iron (C4)
- __ Thin Muck Surface (C7)
- __ Other (Explain in Remarks)

Secondary Indicators (minimum of two required)

- X Surface Soil Cracks (B6)
- X Sparsely Vegetated Concave Surface (B8)
- __ Drainage Patterns (B10)
- __ Oxidized Rhizospheres on Living Roots (C3) **(where tilled)**
- __ Crayfish Burrows (C8)
- __ Saturation Visible on Aerial Imagery (C9)
- __ Geomorphic Position (D2)
- __ FAC-Neutral Test (D5)
- __ Frost-Heave Hummocks (D7) **(LRR F)**

Field Observations:

Surface Water Present?	Yes ___	No X	Depth (inches): ______
Water Table Present?	Yes ___	No X	Depth (inches): ______
Saturation Present? (includes capillary fringe)	Yes ___	No X	Depth (inches): ______

Wetland Hydrology Present? Yes X No ___

Describe Recorded Data (stream gauge, monitoring well, aerial photos, previous inspections), if available:

Remarks: Approximately 8" [illegible] of water in lowest portion of depression.

WETLAND DETERMINATION DATA FORM – Great Plains Region

Project/Site: Billings Landfill Expansion City/County: Yellowstone Co Sampling Date: 10/8/12
Applicant/Owner: City of Billings State: MT Sampling Point: SP 1-2 (U)
Investigator(s): L. Danielski / J. Schick Section, Township, Range: S29 T1S R26E
Landform (hillslope, terrace, etc.): Hillslope Local relief (concave, convex, none): Convex Slope (%): ~15
Subregion (LRR): G - Western Great Plains Lat: 45.7154 Long: -108.5389 Datum: WGS1984
Soil Map Unit Name: Ln Lismas clay NWI classification: POW
Are climatic / hydrologic conditions on the site typical for this time of year? Yes X No ____ (If no, explain in Remarks.)
Are Vegetation ____, Soil ____, or Hydrology ____ significantly disturbed? Are "Normal Circumstances" present? Yes X No ____
Are Vegetation ____, Soil ____, or Hydrology ____ naturally problematic? (If needed, explain any answers in Remarks.)

SUMMARY OF FINDINGS – Attach site map showing sampling point locations, transects, important features, etc.

Hydrophytic Vegetation Present?	Yes ____ No X	Is the Sampled Area within a Wetland? Yes ____ No X
Hydric Soil Present?	Yes X No ____	
Wetland Hydrology Present?	Yes ____ No X	

Remarks: Sample plot is located upslope of the northeast portion of the wetland.
Area does not meet indicators for 2 out of 3 criteria

VEGETATION – Use scientific names of plants.

	Absolute % Cover	Dominant Species?	Indicator Status
Tree Stratum (Plot size: 30'r)			
1. Juniperus osteosperma	25%	YES	UPL
2.			
3.			
4.			
	25% = Total Cover		
Sapling/Shrub Stratum (Plot size: 15'r)			
1. Symphoricarpus albus	T	No	UPL
2. Artemisia tridentata	T	No	UPL
3.			
4.			
5.			
	T = Total Cover		
Herb Stratum (Plot size: 5'r)			
1. Elymus repens	50%	yes	FACU
2. Panicum spp.	30%	yes	UPL
3. Artemisia cana	5%	NO	FACU
4. Festuca spp	5%	NO	UPL
5.			
6.			
7.			
8.			
9.			
10.			
	90% = Total Cover		
Woody Vine Stratum (Plot size: ____)			
1.			
2.			
	____ = Total Cover		
% Bare Ground in Herb Stratum ____			

Dominance Test worksheet:

Number of Dominant Species That Are OBL, FACW, or FAC (excluding FAC−): 0 (A)
Total Number of Dominant Species Across All Strata: 3 (B)
Percent of Dominant Species That Are OBL, FACW, or FAC: 0 (A/B)

Prevalence Index worksheet:

Total % Cover of:		Multiply by:
OBL species		x 1 =
FACW species		x 2 =
FAC species		x 3 =
FACU species	55%	x 4 = 220
UPL species	60%	x 5 = 300
Column Totals:	115% (A)	550 (B)

Prevalence Index = B/A = 4.78

Hydrophytic Vegetation Indicators:

___ 1 - Rapid Test for Hydrophytic Vegetation
___ 2 - Dominance Test is >50%
___ 3 - Prevalence Index is ≤3.0[1]
___ 4 - Morphological Adaptations[1] (Provide supporting data in Remarks or on a separate sheet)
___ Problematic Hydrophytic Vegetation[1] (Explain)

[1]Indicators of hydric soil and wetland hydrology must be present, unless disturbed or problematic.

Hydrophytic Vegetation Present? Yes ____ No ✓

Remarks: Vegetation does not meet dominance or prevalence test.

SOIL

Sampling Point: SP1-2 (U)

Profile Description: (Describe to the depth needed to document the indicator or confirm the absence of indicators.)

Depth (inches)	Matrix Color (moist)	Matrix %	Redox Features Color (moist)	Redox %	Type[1]	Loc[2]	Texture	Remarks
0-12	10YR 4/2	95	7.5YR4/6	<5	C	M	sandy clay loam	
12-22	2.5Y 4/1	95	10YR 4/6	5-7	C	M	sandy clay loam	

[1]Type: C=Concentration, D=Depletion, RM=Reduced Matrix, CS=Covered or Coated Sand Grains. [2]Location: PL=Pore Lining, M=Matrix.

Hydric Soil Indicators: (Applicable to all LRRs, unless otherwise noted.)

- ___ Histosol (A1)
- ___ Histic Epipedon (A2)
- ___ Black Histic (A3)
- ___ Hydrogen Sulfide (A4)
- ___ Stratified Layers (A5) **(LRR F)**
- ___ 1 cm Muck (A9) **(LRR F, G, H)**
- ___ Depleted Below Dark Surface (A11)
- ___ Thick Dark Surface (A12)
- ___ Sandy Mucky Mineral (S1)
- ___ 2.5 cm Mucky Peat or Peat (S2) **(LRR G, H)**
- ___ 5 cm Mucky Peat or Peat (S3) **(LRR F)**
- ___ Sandy Gleyed Matrix (S4)
- ___ Sandy Redox (S5)
- ___ Stripped Matrix (S6)
- ___ Loamy Mucky Mineral (F1)
- ___ Loamy Gleyed Matrix (F2)
- ✓ Depleted Matrix (F3)
- ___ Redox Dark Surface (F6)
- ___ Depleted Dark Surface (F7)
- ___ Redox Depressions (F8)
- ___ High Plains Depressions (F16) **(MLRA 72 & 73 of LRR H)**

Indicators for Problematic Hydric Soils[3]:

- ___ 1 cm Muck (A9) **(LRR I, J)**
- ___ Coast Prairie Redox (A16) **(LRR F, G, H)**
- ___ Dark Surface (S7) **(LRR G)**
- ___ High Plains Depressions (F16) **(LRR H outside of MLRA 72 & 73)**
- ___ Reduced Vertic (F18)
- ___ Red Parent Material (TF2)
- ___ Very Shallow Dark Surface (TF12)
- ___ Other (Explain in Remarks)

[3]Indicators of hydrophytic vegetation and wetland hydrology must be present, unless disturbed or problematic.

Restrictive Layer (if present):
Type: ______
Depth (inches): ______

Hydric Soil Present? Yes ✓ No ___

Remarks:

HYDROLOGY

Wetland Hydrology Indicators:

Primary Indicators (minimum of one required; check all that apply)

- ___ Surface Water (A1)
- ___ High Water Table (A2)
- ___ Saturation (A3)
- ___ Water Marks (B1)
- ___ Sediment Deposits (B2)
- ___ Drift Deposits (B3)
- ___ Algal Mat or Crust (B4)
- ___ Iron Deposits (B5)
- ___ Inundation Visible on Aerial Imagery (B7)
- ___ Water-Stained Leaves (B9)
- ___ Salt Crust (B11)
- ___ Aquatic Invertebrates (B13)
- ___ Hydrogen Sulfide Odor (C1)
- ___ Dry-Season Water Table (C2)
- ___ Oxidized Rhizospheres on Living Roots (C3) **(where not tilled)**
- ___ Presence of Reduced Iron (C4)
- ___ Thin Muck Surface (C7)
- ___ Other (Explain in Remarks)

Secondary Indicators (minimum of two required)

- ___ Surface Soil Cracks (B6)
- ___ Sparsely Vegetated Concave Surface (B8)
- ___ Drainage Patterns (B10)
- ___ Oxidized Rhizospheres on Living Roots (C3) **(where tilled)**
- ___ Crayfish Burrows (C8)
- ___ Saturation Visible on Aerial Imagery (C9)
- ___ Geomorphic Position (D2)
- ___ FAC-Neutral Test (D5)
- ___ Frost-Heave Hummocks (D7) **(LRR F)**

Field Observations:

Surface Water Present? Yes ___ No ✓ Depth (inches): ______
Water Table Present? Yes ___ No ✓ Depth (inches): ______
Saturation Present? (includes capillary fringe) Yes ___ No ✓ Depth (inches): ______

Wetland Hydrology Present? Yes ___ No ✓

Describe Recorded Data (stream gauge, monitoring well, aerial photos, previous inspections), if available:

Remarks: No 1° or 2° indicators of wetland hydrology.

Photo pt / soil plot 002

WETLAND DETERMINATION DATA FORM – Great Plains Region

Project/Site: Billings Landfill Expansion City/County: Yellowstone Co. Sampling Date: 10/8/12

Applicant/Owner: City of Billings State: MT Sampling Point: WL2-1

Investigator(s): L. Danielski / J. Schick Section, Township, Range: S29 T1S R26E

Landform (hillslope, terrace, etc.): Depression Local relief (concave, convex, none): concave Slope (%): 3-5%

Subregion (LRR): G - Western great Plains Lat: 45.71559 Long: -108.53865 Datum: WGS1984

Soil Map Unit Name: Ln - Lismas clay NWI classification: PAB-1

Are climatic / hydrologic conditions on the site typical for this time of year? Yes ✓ No ____ (If no, explain in Remarks.)

Are Vegetation N, Soil N, or Hydrology N significantly disturbed? Are "Normal Circumstances" present? Yes ✓ No ____

Are Vegetation N, Soil N, or Hydrology N naturally problematic? (If needed, explain any answers in Remarks.)

SUMMARY OF FINDINGS – Attach site map showing sampling point locations, transects, important features, etc.

Hydrophytic Vegetation Present?	Yes ✓ No ____	Is the Sampled Area within a Wetland? Yes ✓ No ____
Hydric Soil Present?	Yes ✓ No ____	
Wetland Hydrology Present?	Yes ✓ No ____	

Remarks: Area meets indicators for all 3 criteria
Located in north portion of wetland

VEGETATION – Use scientific names of plants.

Tree Stratum (Plot size: 30'r)	Absolute % Cover	Dominant Species?	Indicator Status
1.			
2.			
3.			
4.			
	____ = Total Cover		
Sapling/Shrub Stratum (Plot size: 15'r)			
1.			
2.			
3.			
4.			
5.			
	____ = Total Cover		
Herb Stratum (Plot size: 5'r)			
1. Atriplex micrantha	5%	yes	UPL
2. Artemisia biennis	2%	yes	FACU
3. Xanthium strumarium	T	NO	FAC
4.			
5.			
6.			
7.			
8.			
9.			
10.			
	7% = Total Cover		
Woody Vine Stratum (Plot size: ____)			
1.			
2.			
	____ = Total Cover		

% Bare Ground in Herb Stratum 95%

Dominance Test worksheet:

Number of Dominant Species That Are OBL, FACW, or FAC (excluding FAC–): 0 (A)

Total Number of Dominant Species Across All Strata: 2 (B)

Percent of Dominant Species That Are OBL, FACW, or FAC: 0 (A/B)

Prevalence Index worksheet:

Total % Cover of:		Multiply by:
OBL species	____	x 1 = ____
FACW species	____	x 2 = ____
FAC species	____	x 3 = ____
FACU species	2%	x 4 = 8
UPL species	5%	x 5 = 25
Column Totals:	7% (A)	33 (B)

Prevalence Index = B/A = 4.71

Hydrophytic Vegetation Indicators:

- ___ 1 - Rapid Test for Hydrophytic Vegetation
- ___ 2 - Dominance Test is >50%
- ___ 3 - Prevalence Index is ≤3.0[1]
- ___ 4 - Morphological Adaptations[1] (Provide supporting data in Remarks or on a separate sheet)
- ✓ Problematic Hydrophytic Vegetation[1] (Explain)

[1]Indicators of hydric soil and wetland hydrology must be present, unless disturbed or problematic.

Hydrophytic Vegetation Present? Yes ✓ No ____

Remarks:
The plant community is dominated by FACU or UPL plants; however, because hydric soils and primary indicators of wetland hydrology were observed, the plant community is determined to be hydrophytic.

SOIL

Sampling Point: WL2-1

Profile Description: (Describe to the depth needed to document the indicator or confirm the absence of indicators.)

Depth (inches)	Matrix Color (moist)	Matrix %	Redox Color (moist)	Redox %	Type[1]	Loc[2]	Texture	Remarks
0-12	2.5Y 4/1		7.5YR4/6	10	C	M	siltclay	
12-16	5Y 4/1		7.5YR 4/6	15	C	M		extremely hard layer/compact

[1]Type: C=Concentration, D=Depletion, RM=Reduced Matrix, CS=Covered or Coated Sand Grains. [2]Location: PL=Pore Lining, M=Matrix.

Hydric Soil Indicators: (Applicable to all LRRs, unless otherwise noted.)

- ___ Histosol (A1)
- ___ Histic Epipedon (A2)
- ___ Black Histic (A3)
- ___ Hydrogen Sulfide (A4)
- ___ Stratified Layers (A5) (**LRR F**)
- ___ 1 cm Muck (A9) (**LRR F, G, H**)
- ___ Depleted Below Dark Surface (A11)
- ___ Thick Dark Surface (A12)
- ___ Sandy Mucky Mineral (S1)
- ___ 2.5 cm Mucky Peat or Peat (S2) (**LRR G, H**)
- ___ 5 cm Mucky Peat or Peat (S3) (**LRR F**)
- ___ Sandy Gleyed Matrix (S4)
- ___ Sandy Redox (S5)
- ___ Stripped Matrix (S6)
- ___ Loamy Mucky Mineral (F1)
- ___ Loamy Gleyed Matrix (F2)
- ✓ Depleted Matrix (F3)
- ___ Redox Dark Surface (F6)
- ___ Depleted Dark Surface (F7)
- ___ Redox Depressions (F8)
- ___ High Plains Depressions (F16) (**MLRA 72 & 73 of LRR H**)

Indicators for Problematic Hydric Soils[3]:

- ___ 1 cm Muck (A9) (**LRR I, J**)
- ___ Coast Prairie Redox (A16) (**LRR F, G, H**)
- ___ Dark Surface (S7) (**LRR G**)
- ___ High Plains Depressions (F16) (**LRR H outside of MLRA 72 & 73**)
- ___ Reduced Vertic (F18)
- ___ Red Parent Material (TF2)
- ___ Very Shallow Dark Surface (TF12)
- ___ Other (Explain in Remarks)

[3]Indicators of hydrophytic vegetation and wetland hydrology must be present, unless disturbed or problematic.

Restrictive Layer (if present):
Type: ______
Depth (inches): ______

Hydric Soil Present? Yes ✓ No ___

Remarks: Soils meet Depleted Matrix

photos 26,27

HYDROLOGY

Wetland Hydrology Indicators:

Primary Indicators (minimum of one required; check all that apply)

- ___ Surface Water (A1)
- ___ High Water Table (A2)
- ___ Saturation (A3)
- ___ Water Marks (B1)
- ___ Sediment Deposits (B2)
- ___ Drift Deposits (B3)
- ___ Algal Mat or Crust (B4)
- ___ Iron Deposits (B5)
- ✓ Inundation Visible on Aerial Imagery (B7)
- ___ Water-Stained Leaves (B9)
- ___ Salt Crust (B11)
- ✓ Aquatic Invertebrates (B13)
- ___ Hydrogen Sulfide Odor (C1)
- ___ Dry-Season Water Table (C2)
- ___ Oxidized Rhizospheres on Living Roots (C3) (**where not tilled**)
- ___ Presence of Reduced Iron (C4)
- ___ Thin Muck Surface (C7)
- ___ Other (Explain in Remarks)

Secondary Indicators (minimum of two required)

- ✓ Surface Soil Cracks (B6)
- ✓ Sparsely Vegetated Concave Surface (B8)
- ___ Drainage Patterns (B10)
- ___ Oxidized Rhizospheres on Living Roots (C3) (**where tilled**)
- ___ Crayfish Burrows (C8)
- ✓ Saturation Visible on Aerial Imagery (C9)
- ✓ Geomorphic Position (D2)
- ___ FAC-Neutral Test (D5)
- ___ Frost-Heave Hummocks (D7) (**LRR F**)

Field Observations:

Surface Water Present? Yes ___ No ✓ Depth (inches): ______
Water Table Present? Yes ___ No ✓ Depth (inches): ______
Saturation Present? (includes capillary fringe) Yes ___ No ✓ Depth (inches): ______

Wetland Hydrology Present? Yes ✓ No ___

Describe Recorded Data (stream gauge, monitoring well, aerial photos, previous inspections), if available:

Remarks:
Shallow aquitard present.
Presence of 1° & 2° indicators of wetland hydrology are present

WETLAND DETERMINATION DATA FORM – Great Plains Region

Project/Site: Billings Landfill Expansion City/County: Yellowstone Co Sampling Date: 10/8/12

Applicant/Owner: City of Billings State: MT Sampling Point: SP 2-2 (U)

Investigator(s): L. Daniels, J. Schick Section, Township, Range: S29 T1S R26E

Landform (hillslope, terrace, etc.): Hillslope Local relief (concave, convex, none): convex Slope (%): ~5-10

Subregion (LRR): G- Western Great Plains Lat: 45.7173 Long: -108.5355 Datum: WGS1984

Soil Map Unit Name: ______ NWI classification: upland grasses

Are climatic / hydrologic conditions on the site typical for this time of year? Yes ____ No ____ (If no, explain in Remarks.)

Are Vegetation ____, Soil ____, or Hydrology ____ significantly disturbed? Are "Normal Circumstances" present? Yes ____ No ____

Are Vegetation ____, Soil ____, or Hydrology ____ naturally problematic? (If needed, explain any answers in Remarks.)

SUMMARY OF FINDINGS – Attach site map showing sampling point locations, transects, important features, etc.

Hydrophytic Vegetation Present?	Yes ____ No X	Is the Sampled Area within a Wetland? Yes ____ No X
Hydric Soil Present?	Yes ____ No X	
Wetland Hydrology Present?	Yes ____ No X	

Remarks: Sample plot located upslope of the NE portion of the site

VEGETATION – Use scientific names of plants.

Tree Stratum (Plot size: ____)	Absolute % Cover	Dominant Species?	Indicator Status
1.			
2.			
3.			
4.			
	____ = Total Cover		
Sapling/Shrub Stratum (Plot size: ____)			
1.			
2.			
3.			
4.			
5.			
	____ = Total Cover		
Herb Stratum (Plot size: ____)			
1. Artemisia cana	15%	Y	FACU
2. Atriplex micrantha	10%	Y	UPL
3. Elymus repens	15%	Y	FACU
4.			
5.			
6.			
7.			
8.			
9.			
10.			
	40% = Total Cover		
Woody Vine Stratum (Plot size: ____)			
1.			
2.			
	____ = Total Cover		
% Bare Ground in Herb Stratum 60			

Dominance Test worksheet:

Number of Dominant Species That Are OBL, FACW, or FAC (excluding FAC-): 1 (A)

Total Number of Dominant Species Across All Strata: 3 (B)

Percent of Dominant Species That Are OBL, FACW, or FAC: 33% (A/B)

Prevalence Index worksheet:

Total % Cover of:		Multiply by:
OBL species		x 1 =
FACW species		x 2 =
FAC species	10	x 3 = 30
FACU species	30	x 4 = 120
UPL species		x 5 =
Column Totals:	40 (A)	150 (B)

Prevalence Index = B/A = 3.75

Hydrophytic Vegetation Indicators:

- __ 1 - Rapid Test for Hydrophytic Vegetation
- __ 2 - Dominance Test is >50%
- __ 3 - Prevalence Index is ≤3.0[1]
- __ 4 - Morphological Adaptations[1] (Provide supporting data in Remarks or on a separate sheet)
- __ Problematic Hydrophytic Vegetation[1] (Explain)

[1]Indicators of hydric soil and wetland hydrology must be present, unless disturbed or problematic.

Hydrophytic Vegetation Present? Yes ____ No X

Remarks: Vegetation does not meet dominance or prevalence test

SOIL

Sampling Point: ___________

Profile Description: (Describe to the depth needed to document the indicator or confirm the absence of indicators.)

Depth (inches)	Matrix Color (moist)	Matrix %	Redox Features Color (moist)	Redox %	Type[1]	Loc[2]	Texture	Remarks
0-8	7.5 YR 4/2	98	10YR 4/6	2	C	M	Silty Clay loam	
8-18+	7.5 YR 4/1	98	10YR 4/6	2	C	M	silty clay loam	

[1]Type: C=Concentration, D=Depletion, RM=Reduced Matrix, CS=Covered or Coated Sand Grains. [2]Location: PL=Pore Lining, M=Matrix.

Hydric Soil Indicators: (Applicable to all LRRs, unless otherwise noted.)

__ Histosol (A1)
__ Histic Epipedon (A2)
__ Black Histic (A3)
__ Hydrogen Sulfide (A4)
__ Stratified Layers (A5) (**LRR F**)
__ 1 cm Muck (A9) (**LRR F, G, H**)
__ Depleted Below Dark Surface (A11)
__ Thick Dark Surface (A12)
__ Sandy Mucky Mineral (S1)
__ 2.5 cm Mucky Peat or Peat (S2) (**LRR G, H**)
__ 5 cm Mucky Peat or Peat (S3) (**LRR F**)
__ Sandy Gleyed Matrix (S4)
__ Sandy Redox (S5)
__ Stripped Matrix (S6)
__ Loamy Mucky Mineral (F1)
__ Loamy Gleyed Matrix (F2)
__ Depleted Matrix (F3)
__ Redox Dark Surface (F6)
__ Depleted Dark Surface (F7)
__ Redox Depressions (F8)
__ High Plains Depressions (F16) (**MLRA 72 & 73 of LRR H**)

Indicators for Problematic Hydric Soils[3]:

__ 1 cm Muck (A9) (**LRR I, J**)
__ Coast Prairie Redox (A16) (**LRR F, G, H**)
__ Dark Surface (S7) (**LRR G**)
__ High Plains Depressions (F16) (**LRR H outside of MLRA 72 & 73**)
__ Reduced Vertic (F18)
__ Red Parent Material (TF2)
__ Very Shallow Dark Surface (TF12)
__ Other (Explain in Remarks)

[3]Indicators of hydrophytic vegetation and wetland hydrology must be present, unless disturbed or problematic.

Restrictive Layer (if present):

Type: ___________

Depth (inches): ___________

Hydric Soil Present? **Yes** ____ **No** X

Remarks: Soils do not meet indicators for hydric soils

HYDROLOGY

Wetland Hydrology Indicators:

Primary Indicators (minimum of one required; check all that apply)

__ Surface Water (A1)
__ High Water Table (A2)
__ Saturation (A3)
__ Water Marks (B1)
__ Sediment Deposits (B2)
__ Drift Deposits (B3)
__ Algal Mat or Crust (B4)
__ Iron Deposits (B5)
__ Inundation Visible on Aerial Imagery (B7)
__ Water-Stained Leaves (B9)
__ Salt Crust (B11)
__ Aquatic Invertebrates (B13)
__ Hydrogen Sulfide Odor (C1)
__ Dry-Season Water Table (C2)
__ Oxidized Rhizospheres on Living Roots (C3) (**where not tilled**)
__ Presence of Reduced Iron (C4)
__ Thin Muck Surface (C7)
__ Other (Explain in Remarks)

Secondary Indicators (minimum of two required)

__ Surface Soil Cracks (B6)
__ Sparsely Vegetated Concave Surface (B8)
__ Drainage Patterns (B10)
__ Oxidized Rhizospheres on Living Roots (C3) (**where tilled**)
__ Crayfish Burrows (C8)
__ Saturation Visible on Aerial Imagery (C9)
__ Geomorphic Position (D2)
__ FAC-Neutral Test (D5)
__ Frost-Heave Hummocks (D7) (**LRR F**)

Field Observations:

Surface Water Present? Yes ____ No X Depth (inches): ______

Water Table Present? Yes ____ No X Depth (inches): ______

Saturation Present? (includes capillary fringe) Yes ____ No X Depth (inches): ______

Wetland Hydrology Present? Yes ____ **No** X

Describe Recorded Data (stream gauge, monitoring well, aerial photos, previous inspections), if available:

Remarks: No 1° or 2° indicators of hydrology

WETLAND DETERMINATION DATA FORM – Great Plains Region

Project/Site: Billings Landfill Expansion City/County: Yellowstone Co. Sampling Date: 10/9/12

Applicant/Owner: City of Billings State: MT Sampling Point: SP3 - 1WL

Investigator(s): L. Danielski / J. Schick Section, Township, Range: S29 T1S R26E

Landform (hillslope, terrace, etc.): Depression Local relief (concave, convex, none): concave Slope (%): 2-4%

Subregion (LRR): G - Western Great Plains Lat: 45.72182 Long: -108.53280 Datum: WGS1984

Soil Map Unit Name: Ln - Lismas clay NWI classification: PEM - 1

Are climatic / hydrologic conditions on the site typical for this time of year? Yes ✓ No ___ (If no, explain in Remarks.)

Are Vegetation N, Soil N, or Hydrology N significantly disturbed? Are "Normal Circumstances" present? Yes ✓ No ___

Are Vegetation N, Soil N, or Hydrology N naturally problematic? (If needed, explain any answers in Remarks.)

SUMMARY OF FINDINGS – Attach site map showing sampling point locations, transects, important features, etc.

Hydrophytic Vegetation Present? Yes ✓ No ___	Is the Sampled Area within a Wetland?	Yes ✓ No ___
Hydric Soil Present? Yes ✓ No ___		
Wetland Hydrology Present? Yes ✓ No ___		

Remarks: Area has indicators for all 3 criteria. Sample plot located near South end of Wetland 3

VEGETATION – Use scientific names of plants.

	Absolute % Cover	Dominant Species?	Indicator Status
Tree Stratum (Plot size: ___)			
1.			
2.			
3.			
4.			
		= Total Cover	
Sapling/Shrub Stratum (Plot size: ___)			
1.			
2.			
3.			
4.			
5.			
		= Total Cover	
Herb Stratum (Plot size: ___)			
1. Hordeum jubatum	50%	yes	FACW
2. Eleocharis palustris	30%	yes	OBL
3. Elymus spp.	15%	NO	UPL
4. Alopecurus pratensis	3%	NO	FACW
5. Typha angustifolia	2%	NO	OBL
6.			
7.			
8.			
9.			
10.			
	100%	= Total Cover	
Woody Vine Stratum (Plot size: ___)			
1.			
2.			
		= Total Cover	
% Bare Ground in Herb Stratum ___			

Dominance Test worksheet:

Number of Dominant Species That Are OBL, FACW, or FAC (excluding FAC−): 2 (A)

Total Number of Dominant Species Across All Strata: 2 (B)

Percent of Dominant Species That Are OBL, FACW, or FAC: 100% (A/B)

Prevalence Index worksheet:

Total % Cover of:		Multiply by:
OBL species	32	x 1 = 32
FACW species	53	x 2 = 106
FAC species		x 3 =
FACU species		x 4 =
UPL species	15	x 5 = 75
Column Totals:	100 (A)	213 (B)

Prevalence Index = B/A = 2.13

Hydrophytic Vegetation Indicators:

- ___ 1 - Rapid Test for Hydrophytic Vegetation
- ✓ 2 - Dominance Test is >50%
- ✓ 3 - Prevalence Index is ≤3.0[1]
- ___ 4 - Morphological Adaptations[1] (Provide supporting data in Remarks or on a separate sheet)
- ___ Problematic Hydrophytic Vegetation[1] (Explain)

[1]Indicators of hydric soil and wetland hydrology must be present, unless disturbed or problematic.

Hydrophytic Vegetation Present? Yes ✓ No ___

Remarks: Area meets dominance + prevalence test.

SOIL

Sampling Point: SP3-1

Profile Description: (Describe to the depth needed to document the indicator or confirm the absence of indicators.)

Depth (inches)	Matrix Color (moist)	Matrix %	Redox Color (moist)	Redox %	Type[1]	Loc[2]	Texture	Remarks
0-2	10YR 4/1		7.5YR 5/8	7	C	PL	Silty clay loam	
2-10	7.5YR 4/1		7.5YR 4/6	20	C	PL&M	Silty clay loam	
10-16	10YR 4/1		10YR 5/8	10	C	PL&M	Silty clay loam	

[1]Type: C=Concentration, D=Depletion, RM=Reduced Matrix, CS=Covered or Coated Sand Grains. [2]Location: PL=Pore Lining, M=Matrix.

Hydric Soil Indicators: (Applicable to all LRRs, unless otherwise noted.)

- ___ Histosol (A1)
- ___ Histic Epipedon (A2)
- ___ Black Histic (A3)
- ___ Hydrogen Sulfide (A4)
- ___ Stratified Layers (A5) (**LRR F**)
- ___ 1 cm Muck (A9) (**LRR F, G, H**)
- ___ Depleted Below Dark Surface (A11)
- ___ Thick Dark Surface (A12)
- ___ Sandy Mucky Mineral (S1)
- ___ 2.5 cm Mucky Peat or Peat (S2) (**LRR G, H**)
- ___ 5 cm Mucky Peat or Peat (S3) (**LRR F**)
- ___ Sandy Gleyed Matrix (S4)
- ___ Sandy Redox (S5)
- ___ Stripped Matrix (S6)
- ___ Loamy Mucky Mineral (F1)
- ___ Loamy Gleyed Matrix (F2)
- ✓ Depleted Matrix (F3)
- ___ Redox Dark Surface (F6)
- ___ Depleted Dark Surface (F7)
- ___ Redox Depressions (F8)
- ___ High Plains Depressions (F16) (**MLRA 72 & 73 of LRR H**)

Indicators for Problematic Hydric Soils[3]:

- ___ 1 cm Muck (A9) (**LRR I, J**)
- ___ Coast Prairie Redox (A16) (**LRR F, G, H**)
- ___ Dark Surface (S7) (**LRR G**)
- ___ High Plains Depressions (F16) (**LRR H outside of MLRA 72 & 73**)
- ___ Reduced Vertic (F18)
- ___ Red Parent Material (TF2)
- ___ Very Shallow Dark Surface (TF12)
- ___ Other (Explain in Remarks)

[3]Indicators of hydrophytic vegetation and wetland hydrology must be present, unless disturbed or problematic.

Restrictive Layer (if present):

Type: ______

Depth (inches): ______

Hydric Soil Present? Yes ✓ No ___

Remarks: Soils meet Depleted Matrix Indicators

photo 36 & 37

HYDROLOGY

Wetland Hydrology Indicators:

Primary Indicators (minimum of one required; check all that apply)

- ___ Surface Water (A1)
- ___ High Water Table (A2)
- ___ Saturation (A3)
- ___ Water Marks (B1)
- ___ Sediment Deposits (B2)
- ___ Drift Deposits (B3)
- ___ Algal Mat or Crust (B4)
- ___ Iron Deposits (B5)
- ___ Inundation Visible on Aerial Imagery (B7)
- ___ Water-Stained Leaves (B9)
- ___ Salt Crust (B11)
- ___ Aquatic Invertebrates (B13)
- ___ Hydrogen Sulfide Odor (C1)
- ___ Dry-Season Water Table (C2)
- ✓ Oxidized Rhizospheres on Living Roots (C3) (**where not tilled**)
- ___ Presence of Reduced Iron (C4)
- ___ Thin Muck Surface (C7)
- ___ Other (Explain in Remarks)

Secondary Indicators (minimum of two required)

- ___ Surface Soil Cracks (B6)
- ___ Sparsely Vegetated Concave Surface (B8)
- ✓ Drainage Patterns (B10)
- ___ Oxidized Rhizospheres on Living Roots (C3) (**where tilled**)
- ___ Crayfish Burrows (C8)
- ___ Saturation Visible on Aerial Imagery (C9)
- ✓ Geomorphic Position (D2)
- ___ FAC-Neutral Test (D5)
- ___ Frost-Heave Hummocks (D7) (**LRR F**)

Field Observations:

Surface Water Present? Yes ___ No ✓ Depth (inches): ______

Water Table Present? Yes ___ No ✓ Depth (inches): ______

Saturation Present? (includes capillary fringe) Yes ___ No ✓ Depth (inches): ______

Wetland Hydrology Present? Yes ✓ No ___

Describe Recorded Data (stream gauge, monitoring well, aerial photos, previous inspections), if available:

Remarks: 1° + 2° indicators of wetland hydrology are present

WETLAND DETERMINATION DATA FORM – Great Plains Region

Project/Site: Billings Landfill Expansion City/County: Yellowstone Co. Sampling Date: 10/9/12

Applicant/Owner: City of Billings State: MT Sampling Point: SP3-2 (UPL)

Investigator(s): L. Danielski / J. Schick Section, Township, Range: S29 T1S R26E

Landform (hillslope, terrace, etc.): ____ Local relief (concave, convex, none) ____ Slope (%) ____

Subregion (LRR): G - Western Great Plains Lat: 45.72183 Long: -108.53277 Datum: WGS1984

Soil Map Unit Name: Ln - Lismas clay NWI classification: N/A

Are climatic / hydrologic conditions on the site typical for this time of year? Yes ✓ No ____ (If no, explain in Remarks.)

Are Vegetation N, Soil N, or Hydrology N significantly disturbed? Are "Normal Circumstances" present? Yes ✓ No ____

Are Vegetation N, Soil N, or Hydrology N naturally problematic? (If needed, explain any answers in Remarks.)

SUMMARY OF FINDINGS – Attach site map showing sampling point locations, transects, important features, etc.

Hydrophytic Vegetation Present? Yes ____ No ✓	Is the Sampled Area within a Wetland?	Yes ____ No ✓
Hydric Soil Present? Yes ____ No ✓		
Wetland Hydrology Present? Yes ____ No ✓		

Remarks: Upland SP ~2-3' upslope of wetland

Area lacks indicators for all 3 criteria.

VEGETATION – Use scientific names of plants.

Tree Stratum (Plot size: 30')	Absolute % Cover	Dominant Species?	Indicator Status
1. Populus deltoides (overhang)	15	yes	FAC
2.			
3.			
4.			
	15 = Total Cover		
Sapling/Shrub Stratum (Plot size: ____)			
1. Juniperus osteosperma	40	yes	UPL
2. Rosa woodsii	5	NO	FACU
3.			
4.			
5.			
	45 = Total Cover		
Herb Stratum (Plot size: ____)			
1. Bromus arvensis	40	yes	FACU
2. Agrostis capillaris	40	yes	FAC
3. Elymus repens	20	yes	FACU
4.			
5.			
6.			
7.			
8.			
9.			
10.			
	100 = Total Cover		
Woody Vine Stratum (Plot size: ____)			
1.			
2.			
	____ = Total Cover		
% Bare Ground in Herb Stratum ____			

Dominance Test worksheet:

Number of Dominant Species That Are OBL, FACW, or FAC (excluding FAC-): 2 (A)

Total Number of Dominant Species Across All Strata: 5 (B)

Percent of Dominant Species That Are OBL, FACW, or FAC: 40% (A/B)

Prevalence Index worksheet:

Total % Cover of:		Multiply by:
OBL species		x 1 =
FACW species		x 2 =
FAC species	55	x 3 = 165
FACU species	65	x 4 = 260
UPL species	40	x 5 = 200
Column Totals:	160 (A)	625 (B)

Prevalence Index = B/A = 3.9

Hydrophytic Vegetation Indicators:

- ___ 1 - Rapid Test for Hydrophytic Vegetation
- ___ 2 - Dominance Test is >50%
- ___ 3 - Prevalence Index is ≤3.0[1]
- ___ 4 - Morphological Adaptations[1] (Provide supporting data in Remarks or on a separate sheet)
- ___ Problematic Hydrophytic Vegetation[1] (Explain)

[1]Indicators of hydric soil and wetland hydrology must be present, unless disturbed or problematic.

Hydrophytic Vegetation Present? Yes ____ No ✓

Remarks: Area is heavily grazed.

Area does not meet dominance or prevalence test

SOIL

Sampling Point: SP3-2

Profile Description: (Describe to the depth needed to document the indicator or confirm the absence of indicators.)

Depth (inches)	Matrix Color (moist)	Matrix %	Redox Features Color (moist)	Redox %	Type[1]	Loc[2]	Texture	Remarks
0-18"	10YR4/1	99	5YR4/8	1	C	M	Siltyclay	

[1]Type: C=Concentration, D=Depletion, RM=Reduced Matrix, CS=Covered or Coated Sand Grains. [2]Location: PL=Pore Lining, M=Matrix

Hydric Soil Indicators: (Applicable to all LRRs, unless otherwise noted.)

- ___ Histosol (A1)
- ___ Histic Epipedon (A2)
- ___ Black Histic (A3)
- ___ Hydrogen Sulfide (A4)
- ___ Stratified Layers (A5) (**LRR F**)
- ___ 1 cm Muck (A9) (**LRR F, G, H**)
- ___ Depleted Below Dark Surface (A11)
- ___ Thick Dark Surface (A12)
- ___ Sandy Mucky Mineral (S1)
- ___ 2.5 cm Mucky Peat or Peat (S2) (**LRR G, H**)
- ___ 5 cm Mucky Peat or Peat (S3) (**LRR F**)
- ___ Sandy Gleyed Matrix (S4)
- ___ Sandy Redox (S5)
- ___ Stripped Matrix (S6)
- ___ Loamy Mucky Mineral (F1)
- ___ Loamy Gleyed Matrix (F2)
- ___ Depleted Matrix (F3)
- ___ Redox Dark Surface (F6)
- ___ Depleted Dark Surface (F7)
- ___ Redox Depressions (F8)
- ___ High Plains Depressions (F16) (**MLRA 72 & 73 of LRR H**)

Indicators for Problematic Hydric Soils[3]:

- ___ 1 cm Muck (A9) (**LRR I, J**)
- ___ Coast Prairie Redox (A16) (**LRR F, G, H**)
- ___ Dark Surface (S7) (**LRR G**)
- ___ High Plains Depressions (F16) (**LRR H outside of MLRA 72 & 73**)
- ___ Reduced Vertic (F18)
- ___ Red Parent Material (TF2)
- ___ Very Shallow Dark Surface (TF12)
- ___ Other (Explain in Remarks)

[3]Indicators of hydrophytic vegetation and wetland hydrology must be present, unless disturbed or problematic.

Restrictive Layer (if present):

Type: ______

Depth (inches): ______

Hydric Soil Present? Yes ___ No ✓

Remarks: Soils do not meet hydric soil indicators

photo 38

HYDROLOGY

Wetland Hydrology Indicators:

Primary Indicators (minimum of one required; check all that apply)

- ___ Surface Water (A1)
- ___ High Water Table (A2)
- ___ Saturation (A3)
- ___ Water Marks (B1)
- ___ Sediment Deposits (B2)
- ___ Drift Deposits (B3)
- ___ Algal Mat or Crust (B4)
- ___ Iron Deposits (B5)
- ___ Inundation Visible on Aerial Imagery (B7)
- ___ Water-Stained Leaves (B9)
- ___ Salt Crust (B11)
- ___ Aquatic Invertebrates (B13)
- ___ Hydrogen Sulfide Odor (C1)
- ___ Dry-Season Water Table (C2)
- ___ Oxidized Rhizospheres on Living Roots (C3) (**where not tilled**)
- ___ Presence of Reduced Iron (C4)
- ___ Thin Muck Surface (C7)
- ___ Other (Explain in Remarks)

Secondary Indicators (minimum of two required)

- ___ Surface Soil Cracks (B6)
- ___ Sparsely Vegetated Concave Surface (B8)
- ___ Drainage Patterns (B10)
- ___ Oxidized Rhizospheres on Living Roots (C3) (**where tilled**)
- ___ Crayfish Burrows (C8)
- ___ Saturation Visible on Aerial Imagery (C9)
- ___ Geomorphic Position (D2)
- ___ FAC-Neutral Test (D5)
- ___ Frost-Heave Hummocks (D7) (**LRR F**)

Field Observations:

Surface Water Present? Yes ___ No ✓ Depth (inches): ______

Water Table Present? Yes ___ No ✓ Depth (inches): ______

Saturation Present? (includes capillary fringe) Yes ___ No ✓ Depth (inches): ______

Wetland Hydrology Present? Yes ___ No ✓

Describe Recorded Data (stream gauge, monitoring well, aerial photos, previous inspections), if available:

Remarks: No 1° or 2° indicators

WETLAND DETERMINATION DATA FORM – Great Plains Region

Project/Site: Billings Landfill Expansion City/County: Yellowstone Co. Sampling Date: 10/9/12

Applicant/Owner: City of Billings State: MT Sampling Point: 6-1 (WL)

Investigator(s): L. Danielski / T. Schick Section, Township, Range: S29 T1S R26E

Landform (hillslope, terrace, etc.): ______ Local relief (concave, convex, none): ______ Slope (%): ______

Subregion (LRR): G-Western Great Plains Lat: 45.71588 Long: -108.54308 Datum: WGS1984

Soil Map Unit Name: Ln-Lismas clay NWI classification: PEM-1

Are climatic / hydrologic conditions on the site typical for this time of year? Yes ✓ No ____ (If no, explain in Remarks.)

Are Vegetation N, Soil N, or Hydrology N significantly disturbed? Are "Normal Circumstances" present? Yes ✓ No ____

Are Vegetation N, Soil N, or Hydrology N naturally problematic? (If needed, explain any answers in Remarks.)

SUMMARY OF FINDINGS – Attach site map showing sampling point locations, transects, important features, etc.

Hydrophytic Vegetation Present? Yes ✓ No ____	Is the Sampled Area within a Wetland?	Yes ✓ No ____
Hydric Soil Present? Yes ✓ No ____		
Wetland Hydrology Present? Yes ✓ No ____		

Remarks: Wetland in swale, discharge coming from hillslope

Area has indicators for all 3 criteria

VEGETATION – Use scientific names of plants.

Tree Stratum (Plot size: ____)	Absolute % Cover	Dominant Species?	Indicator Status
1.			
2.			
3.			
4.			
		= Total Cover	
Sapling/Shrub Stratum (Plot size: ____)			
1.			
2.			
3.			
4.			
5.			
		= Total Cover	
Herb Stratum (Plot size: ____)			
1. Schoenoplectus maritimus	60	yes	OBL
2. Atriplex micrantha	30	yes	UPL
3. Juncus bufonius	5	NO	OBL
4. Hordeum jubatum	5	NO	FACW
5.			
6.			
7.			
8.			
9.			
10.			
	100	= Total Cover	
Woody Vine Stratum (Plot size: ____)			
1.			
2.			
		= Total Cover	
% Bare Ground in Herb Stratum ____			

Dominance Test worksheet:

Number of Dominant Species That Are OBL, FACW, or FAC (excluding FAC-): 1 (A)

Total Number of Dominant Species Across All Strata: 2 (B)

Percent of Dominant Species That Are OBL, FACW, or FAC: 50% (A/B)

Prevalence Index worksheet:

Total % Cover of:		Multiply by:
OBL species	65	x 1 = 65
FACW species	5	x 2 = 10
FAC species		x 3 =
FACU species		x 4 =
UPL species	30	x 5 = 150
Column Totals:	100 (A)	225 (B)

Prevalence Index = B/A = 2.25

Hydrophytic Vegetation Indicators:

- ___ 1 - Rapid Test for Hydrophytic Vegetation
- ___ 2 - Dominance Test is >50%
- ✓ 3 - Prevalence Index is ≤3.0[1]
- ___ 4 - Morphological Adaptations[1] (Provide supporting data in Remarks or on a separate sheet)
- ___ Problematic Hydrophytic Vegetation[1] (Explain)

[1]Indicators of hydric soil and wetland hydrology must be present, unless disturbed or problematic.

Hydrophytic Vegetation Present? Yes ✓ No ____

Remarks: Grazed vegetation.

Vegetation meets prevalence test and SP has hydric soil + wetland hydrology.

SOIL

Sampling Point: 6-1(WL)

Profile Description: (Describe to the depth needed to document the indicator or confirm the absence of indicators.)

Depth (inches)	Matrix Color (moist)	%	Redox Features Color (moist)	%	Type[1]	Loc[2]	Texture	Remarks
0-14	5Y4/1	5	10YR4/6	5	C	PL/M	clay	

[1]Type: C=Concentration, D=Depletion, RM=Reduced Matrix, CS=Covered or Coated Sand Grains. [2]Location: PL=Pore Lining, M=Matrix.

Hydric Soil Indicators: (Applicable to all LRRs, unless otherwise noted.)

- __ Histosol (A1)
- __ Histic Epipedon (A2)
- __ Black Histic (A3)
- __ Hydrogen Sulfide (A4)
- __ Stratified Layers (A5) (**LRR F**)
- __ 1 cm Muck (A9) (**LRR F, G, H**)
- __ Depleted Below Dark Surface (A11)
- __ Thick Dark Surface (A12)
- __ Sandy Mucky Mineral (S1)
- __ 2.5 cm Mucky Peat or Peat (S2) (**LRR G, H**)
- __ 5 cm Mucky Peat or Peat (S3) (**LRR F**)
- __ Sandy Gleyed Matrix (S4)
- __ Sandy Redox (S5)
- __ Stripped Matrix (S6)
- __ Loamy Mucky Mineral (F1)
- __ Loamy Gleyed Matrix (F2)
- ✓ Depleted Matrix (F3)
- __ Redox Dark Surface (F6)
- __ Depleted Dark Surface (F7)
- __ Redox Depressions (F8)
- __ High Plains Depressions (F16) (**MLRA 72 & 73 of LRR H**)

Indicators for Problematic Hydric Soils[3]:

- __ 1 cm Muck (A9) (**LRR I, J**)
- __ Coast Prairie Redox (A16) (**LRR F, G, H**)
- __ Dark Surface (S7) (**LRR G**)
- __ High Plains Depressions (F16) (**LRR H outside of MLRA 72 & 73**)
- __ Reduced Vertic (F18)
- __ Red Parent Material (TF2)
- __ Very Shallow Dark Surface (TF12)
- __ Other (Explain in Remarks)

[3]Indicators of hydrophytic vegetation and wetland hydrology must be present, unless disturbed or problematic.

Restrictive Layer (if present):
Type: ______
Depth (inches): ______

Hydric Soil Present? Yes ✓ No ____

Remarks: Soil sample taken from wedge (too wet to sample pit). Most of iron suspended in water, so faint mottling. Soil started oxidizing upon exposure to air. Photo 43

HYDROLOGY

Wetland Hydrology Indicators:

Primary Indicators (minimum of one required; check all that apply)

- ✓ Surface Water (A1)
- ✓ High Water Table (A2)
- ✓ Saturation (A3)
- __ Water Marks (B1)
- __ Sediment Deposits (B2)
- __ Drift Deposits (B3)
- __ Algal Mat or Crust (B4)
- __ Iron Deposits (B5)
- __ Inundation Visible on Aerial Imagery (B7)
- __ Water-Stained Leaves (B9)
- ✓ Salt Crust (B11)
- __ Aquatic Invertebrates (B13)
- __ Hydrogen Sulfide Odor (C1)
- __ Dry-Season Water Table (C2)
- __ Oxidized Rhizospheres on Living Roots (C3) (**where not tilled**)
- __ Presence of Reduced Iron (C4)
- __ Thin Muck Surface (C7)
- __ Other (Explain in Remarks)

Secondary Indicators (minimum of two required)

- __ Surface Soil Cracks (B6)
- __ Sparsely Vegetated Concave Surface (B8)
- __ Drainage Patterns (B10)
- __ Oxidized Rhizospheres on Living Roots (C3) (**where tilled**)
- __ Crayfish Burrows (C8)
- __ Saturation Visible on Aerial Imagery (C9)
- __ Geomorphic Position (D2)
- __ FAC-Neutral Test (D5)
- __ Frost-Heave Hummocks (D7) (**LRR F**)

Field Observations:

Surface Water Present?	Yes ✓	No ____	Depth (inches): 1" in (pockets)
Water Table Present?	Yes ✓	No ____	Depth (inches): 10"
Saturation Present? (includes capillary fringe)	Yes ✓	No ____	Depth (inches): ______

Wetland Hydrology Present? Yes ✓ No ____

Describe Recorded Data (stream gauge, monitoring well, aerial photos, previous inspections), if available:

Remarks: Salt crust visible
1° indicators of hydrology are present

WETLAND DETERMINATION DATA FORM – Great Plains Region

Project/Site: Billings Landfill Expansion City/County: Yellowstone Co, Sampling Date: 10/9/12

Applicant/Owner: City of Billings State: MT Sampling Point: SP6-2(U)

Investigator(s): L. Danielski / J. Schick Section, Township, Range: S29 T1S R26E

Landform (hillslope, terrace, etc.): hillslope Local relief (concave, convex, none): convex Slope (%): 5

Subregion (LRR): G - Western Great Plains Lat: 45.71562 Long: -108.54287 Datum: WGS1984

Soil Map Unit Name: Ln-Lismas clay NWI classification: N/A

Are climatic / hydrologic conditions on the site typical for this time of year? Yes ✓ No ___ (If no, explain in Remarks.)

Are Vegetation Y, Soil N, or Hydrology N significantly disturbed? Are "Normal Circumstances" present? Yes ✓ No ___

Are Vegetation N, Soil N, or Hydrology N naturally problematic? (If needed, explain any answers in Remarks.)

SUMMARY OF FINDINGS – Attach site map showing sampling point locations, transects, important features, etc.

Hydrophytic Vegetation Present?	Yes ✓ No ___	Is the Sampled Area within a Wetland? Yes ___ No ✓
Hydric Soil Present?	Yes ___ No ✓	
Wetland Hydrology Present?	Yes ___ No ✓	

Remarks: area is significantly grazed & disturbed.

Indicators for 2 of 3 criteria are not present

VEGETATION – Use scientific names of plants.

	Absolute % Cover	Dominant Species?	Indicator Status
Tree Stratum (Plot size: 30 r)			
1.			
2.			
3.			
4.			
		= Total Cover	
Sapling/Shrub Stratum (Plot size: 15' r)			
1. Artemisia tridentata	T	NO	UPL
2.			
3.			
4.			
5.			
		= Total Cover	
Herb Stratum (Plot size: 5 r')			
1. Panicum virgatum	30	yes	FAC
2. Festuca pratensis	T	NO	FACU
3. Grindelia squarrosa	T	NO	UPL
4. Opuntia polyacantha	T	NO	UPL
5. Artemisia cana	T	NO	FACU
6.			
7.			
8.			
9.			
10.			
	30	= Total Cover	
Woody Vine Stratum (Plot size: ___)			
1.			
2.			
		= Total Cover	
% Bare Ground in Herb Stratum ___			

Dominance Test worksheet:

Number of Dominant Species That Are OBL, FACW, or FAC (excluding FAC−): 1 (A)

Total Number of Dominant Species Across All Strata: 1 (B)

Percent of Dominant Species That Are OBL, FACW, or FAC: 1 (A/B)

Prevalence Index worksheet:

Total % Cover of:		Multiply by:
OBL species		x 1 =
FACW species		x 2 =
FAC species	30	x 3 = 90
FACU species		x 4 =
UPL species		x 5 =
Column Totals:	30 (A)	90 (B)

Prevalence Index = B/A = 3

Hydrophytic Vegetation Indicators:

- ___ 1 - Rapid Test for Hydrophytic Vegetation
- ✓ 2 - Dominance Test is >50%
- ✓ 3 - Prevalence Index is ≤3.0[1]
- ___ 4 - Morphological Adaptations[1] (Provide supporting data in Remarks or on a separate sheet)
- ___ Problematic Hydrophytic Vegetation[1] (Explain)

[1]Indicators of hydric soil and wetland hydrology must be present, unless disturbed or problematic.

Hydrophytic Vegetation Present? Yes ✓ No ___

Remarks: Vegetation meets dominance & prevalence test.

SOIL

Sampling Point: SP6-2

Profile Description: (Describe to the depth needed to document the indicator or confirm the absence of indicators.)

Depth (inches)	Matrix Color (moist)	%	Redox Features Color (moist)	%	Type[1]	Loc[2]	Texture	Remarks
0-3	10YR 4/2		—	—	—	—	Siltyclayloam	
3-10	10YR 5/2		—	—	—	—	Siltyclayloam	
10-16	10YR 5/2	80	—	—	—	—	siltyclayloam	
	10YR 6/1	20				—		salt concentrations

[1]Type: C=Concentration, D=Depletion, RM=Reduced Matrix, CS=Covered or Coated Sand Grains. [2]Location: PL=Pore Lining, M=Matrix.

Hydric Soil Indicators: (Applicable to all LRRs, unless otherwise noted.)

- __ Histosol (A1)
- __ Histic Epipedon (A2)
- __ Black Histic (A3)
- __ Hydrogen Sulfide (A4)
- __ Stratified Layers (A5) **(LRR F)**
- __ 1 cm Muck (A9) **(LRR F, G, H)**
- __ Depleted Below Dark Surface (A11)
- __ Thick Dark Surface (A12)
- __ Sandy Mucky Mineral (S1)
- __ 2.5 cm Mucky Peat or Peat (S2) **(LRR G, H)**
- __ 5 cm Mucky Peat or Peat (S3) **(LRR F)**
- __ Sandy Gleyed Matrix (S4)
- __ Sandy Redox (S5)
- __ Stripped Matrix (S6)
- __ Loamy Mucky Mineral (F1)
- __ Loamy Gleyed Matrix (F2)
- __ Depleted Matrix (F3)
- __ Redox Dark Surface (F6)
- __ Depleted Dark Surface (F7)
- __ Redox Depressions (F8)
- __ High Plains Depressions (F16) **(MLRA 72 & 73 of LRR H)**

Indicators for Problematic Hydric Soils[3]:

- __ 1 cm Muck (A9) **(LRR I, J)**
- __ Coast Prairie Redox (A16) **(LRR F, G, H)**
- __ Dark Surface (S7) **(LRR G)**
- __ High Plains Depressions (F16) **(LRR H outside of MLRA 72 & 73)**
- __ Reduced Vertic (F18)
- __ Red Parent Material (TF2)
- __ Very Shallow Dark Surface (TF12)
- __ Other (Explain in Remarks)

[3]Indicators of hydrophytic vegetation and wetland hydrology must be present, unless disturbed or problematic.

Restrictive Layer (if present):

Type: ________

Depth (inches): ________

Hydric Soil Present? Yes ____ No ✓

Remarks: Soils do not meet hydric soil indicators

photo42

HYDROLOGY

Wetland Hydrology Indicators:

Primary Indicators (minimum of one required; check all that apply)

- __ Surface Water (A1)
- __ High Water Table (A2)
- __ Saturation (A3)
- __ Water Marks (B1)
- __ Sediment Deposits (B2)
- __ Drift Deposits (B3)
- __ Algal Mat or Crust (B4)
- __ Iron Deposits (B5)
- __ Inundation Visible on Aerial Imagery (B7)
- __ Water-Stained Leaves (B9)
- __ Salt Crust (B11)
- __ Aquatic Invertebrates (B13)
- __ Hydrogen Sulfide Odor (C1)
- __ Dry-Season Water Table (C2)
- __ Oxidized Rhizospheres on Living Roots (C3) **(where not tilled)**
- __ Presence of Reduced Iron (C4)
- __ Thin Muck Surface (C7)
- __ Other (Explain in Remarks)

Secondary Indicators (minimum of two required)

- __ Surface Soil Cracks (B6)
- __ Sparsely Vegetated Concave Surface (B8)
- __ Drainage Patterns (B10)
- __ Oxidized Rhizospheres on Living Roots (C3) **(where tilled)**
- __ Crayfish Burrows (C8)
- __ Saturation Visible on Aerial Imagery (C9)
- __ Geomorphic Position (D2)
- __ FAC-Neutral Test (D5)
- __ Frost-Heave Hummocks (D7) **(LRR F)**

Field Observations:

Surface Water Present? Yes ____ No ✓ Depth (inches): ____

Water Table Present? Yes ____ No ✓ Depth (inches): ____

Saturation Present? (includes capillary fringe) Yes ____ No ✓ Depth (inches): ____

Wetland Hydrology Present? Yes ____ No ✓

Describe Recorded Data (stream gauge, monitoring well, aerial photos, previous inspections), if available

Remarks: NO positive hydrology indicators

WETLAND DETERMINATION DATA FORM – Great Plains Region

Project/Site: Billings Landfill Expansion City/County: Yellowstone Co. Sampling Date: 10/8/12

Applicant/Owner: City of Billings State: MT Sampling Point: 3 (in WL 7)

Investigator(s): L. Dancelski / J. Schick Section, Township, Range: S29 T1S R26E

Landform (hillslope, terrace, etc.): Swale Local relief (concave, convex, none): concave Slope (%): 2

Subregion (LRR): G-Western Great Plains Lat: 45.7218 Long: -108 5325 Datum: WGS1984

Soil Map Unit Name: Ln Lismas clay NWI classification: PEM-1

Are climatic / hydrologic conditions on the site typical for this time of year? Yes ✓ No ___ (If no, explain in Remarks.)

Are Vegetation N, Soil N, or Hydrology N significantly disturbed? Are "Normal Circumstances" present? Yes ✓ No ___

Are Vegetation N, Soil N, or Hydrology N naturally problematic? (If needed, explain any answers in Remarks.)

SUMMARY OF FINDINGS – Attach site map showing sampling point locations, transects, important features, etc.

Hydrophytic Vegetation Present? Yes ✓ No ___	Is the Sampled Area within a Wetland?	Yes ✓ No ___
Hydric Soil Present? Yes ✓ No ___		
Wetland Hydrology Present? Yes ✓ No ___		

Remarks: Late season investigation, hydrology likely present in spring.

Area has indicators for all 3 criteria

VEGETATION – Use scientific names of plants.

	Absolute % Cover	Dominant Species?	Indicator Status
Tree Stratum (Plot size: ___)			
1.			
2.			
3.			
4.			
= Total Cover			
Sapling/Shrub Stratum (Plot size: ___)			
1. Symphoricarpos albus	2%	yes	UPL
2. Rosa	T	NO	UPL
3.			
4.			
5.			
= Total Cover			
Herb Stratum (Plot size: ___)			
1. Carex deweyana	30%	yes	FACU
2. Oryzopsis sp.	20%	yes	UPL
3. Elymus repens	10%	NO	FACU
4. Solidago canadensis	T	NO	FACU
5.			
6.			
7.			
8.			
9.			
10.			
= Total Cover	60%		
Woody Vine Stratum (Plot size: ___)			
1.			
2.			
= Total Cover			
% Bare Ground in Herb Stratum 40%			

Dominance Test worksheet:

Number of Dominant Species That Are OBL, FACW, or FAC (excluding FAC−): ∅ (A)

Total Number of Dominant Species Across All Strata: 3 (B)

Percent of Dominant Species That Are OBL, FACW, or FAC: ∅ (A/B)

Prevalence Index worksheet:

Total % Cover of:		Multiply by:
OBL species	∅	x 1 =
FACW species	∅	x 2 =
FAC species	∅	x 3 =
FACU species	40%	x 4 = 160
UPL species	22%	x 5 = 110
Column Totals:	62% (A)	270 (B)

Prevalence Index = B/A = 4.35

Hydrophytic Vegetation Indicators:

- ___ 1 - Rapid Test for Hydrophytic Vegetation
- ___ 2 - Dominance Test is >50%
- ___ 3 - Prevalence Index is ≤3.0[1]
- ___ 4 - Morphological Adaptations[1] (Provide supporting data in Remarks or on a separate sheet)
- ✓ Problematic Hydrophytic Vegetation[1] (Explain)

[1]Indicators of hydric soil and wetland hydrology must be present, unless disturbed or problematic.

Hydrophytic Vegetation Present? Yes ✓ No ___

Remarks: Problematic vegetation - dominant vegetation is not FAC or wetter. However, presence of hydric soils + wetland hydrology inc

SOIL

Sampling Point: 3

Profile Description: (Describe to the depth needed to document the indicator or confirm the absence of indicators.)

Depth (inches)	Matrix Color (moist)	Matrix %	Redox Features Color (moist)	Redox %	Type[1]	Loc[2]	Texture	Remarks
0-2	2.5Y 4/1	90	7.5YR 4/6	10	C	M	Sandy clay loam	highly compacted
2-16	2.5Y 4/1	97	7.5YR 4/6	3	C	M	Sandy clay loam	highly compacted

[1]Type: C=Concentration, D=Depletion, RM=Reduced Matrix, CS=Covered or Coated Sand Grains. [2]Location: PL=Pore Lining, M=Matrix.

Hydric Soil Indicators: (Applicable to all LRRs, unless otherwise noted.)

- __ Histosol (A1)
- __ Histic Epipedon (A2)
- __ Black Histic (A3)
- __ Hydrogen Sulfide (A4)
- __ Stratified Layers (A5) (**LRR F**)
- __ 1 cm Muck (A9) (**LRR F, G, H**)
- __ Depleted Below Dark Surface (A11)
- __ Thick Dark Surface (A12)
- __ Sandy Mucky Mineral (S1)
- __ 2.5 cm Mucky Peat or Peat (S2) (**LRR G, H**)
- __ 5 cm Mucky Peat or Peat (S3) (**LRR F**)
- __ Sandy Gleyed Matrix (S4)
- __ Sandy Redox (S5)
- __ Stripped Matrix (S6)
- __ Loamy Mucky Mineral (F1)
- __ Loamy Gleyed Matrix (F2)
- ✓ Depleted Matrix (F3)
- __ Redox Dark Surface (F6)
- __ Depleted Dark Surface (F7)
- __ Redox Depressions (F8)
- __ High Plains Depressions (F16) (**MLRA 72 & 73 of LRR H**)

Indicators for Problematic Hydric Soils[3]:

- __ 1 cm Muck (A9) (**LRR I, J**)
- __ Coast Prairie Redox (A16) (**LRR F, G, H**)
- __ Dark Surface (S7) (**LRR G**)
- __ High Plains Depressions (F16) (**LRR H outside of MLRA 72 & 73**)
- __ Reduced Vertic (F18)
- __ Red Parent Material (TF2)
- __ Very Shallow Dark Surface (TF12)
- __ Other (Explain in Remarks)

[3]Indicators of hydrophytic vegetation and wetland hydrology must be present, unless disturbed or problematic.

Restrictive Layer (if present):

Type: ______

Depth (inches): ______

Hydric Soil Present? Yes ✓ No ____

Remarks: Soils meet Depleted Matrix indicators

photo # 7

HYDROLOGY

Wetland Hydrology Indicators:

Primary Indicators (minimum of one required; check all that apply)

- __ Surface Water (A1)
- __ High Water Table (A2)
- __ Saturation (A3)
- __ Water Marks (B1)
- __ Sediment Deposits (B2)
- __ Drift Deposits (B3)
- __ Algal Mat or Crust (B4)
- __ Iron Deposits (B5)
- __ Inundation Visible on Aerial Imagery (B7)
- __ Water-Stained Leaves (B9)
- __ Salt Crust (B11)
- __ Aquatic Invertebrates (B13)
- __ Hydrogen Sulfide Odor (C1)
- __ Dry-Season Water Table (C2)
- __ Oxidized Rhizospheres on Living Roots (C3) (**where not tilled**)
- __ Presence of Reduced Iron (C4)
- __ Thin Muck Surface (C7)
- __ Other (Explain in Remarks)

Secondary Indicators (minimum of two required)

- ✓ Surface Soil Cracks (B6)
- __ Sparsely Vegetated Concave Surface (B8)
- __ Drainage Patterns (B10)
- __ Oxidized Rhizospheres on Living Roots (C3) (**where tilled**)
- __ Crayfish Burrows (C8)
- __ Saturation Visible on Aerial Imagery (C9)
- ✓ Geomorphic Position (D2)
- __ FAC-Neutral Test (D5)
- __ Frost-Heave Hummocks (D7) (**LRR F**)

Field Observations:

Surface Water Present? Yes ____ No ✓ Depth (inches): ______

Water Table Present? Yes ____ No ✓ Depth (inches): ______

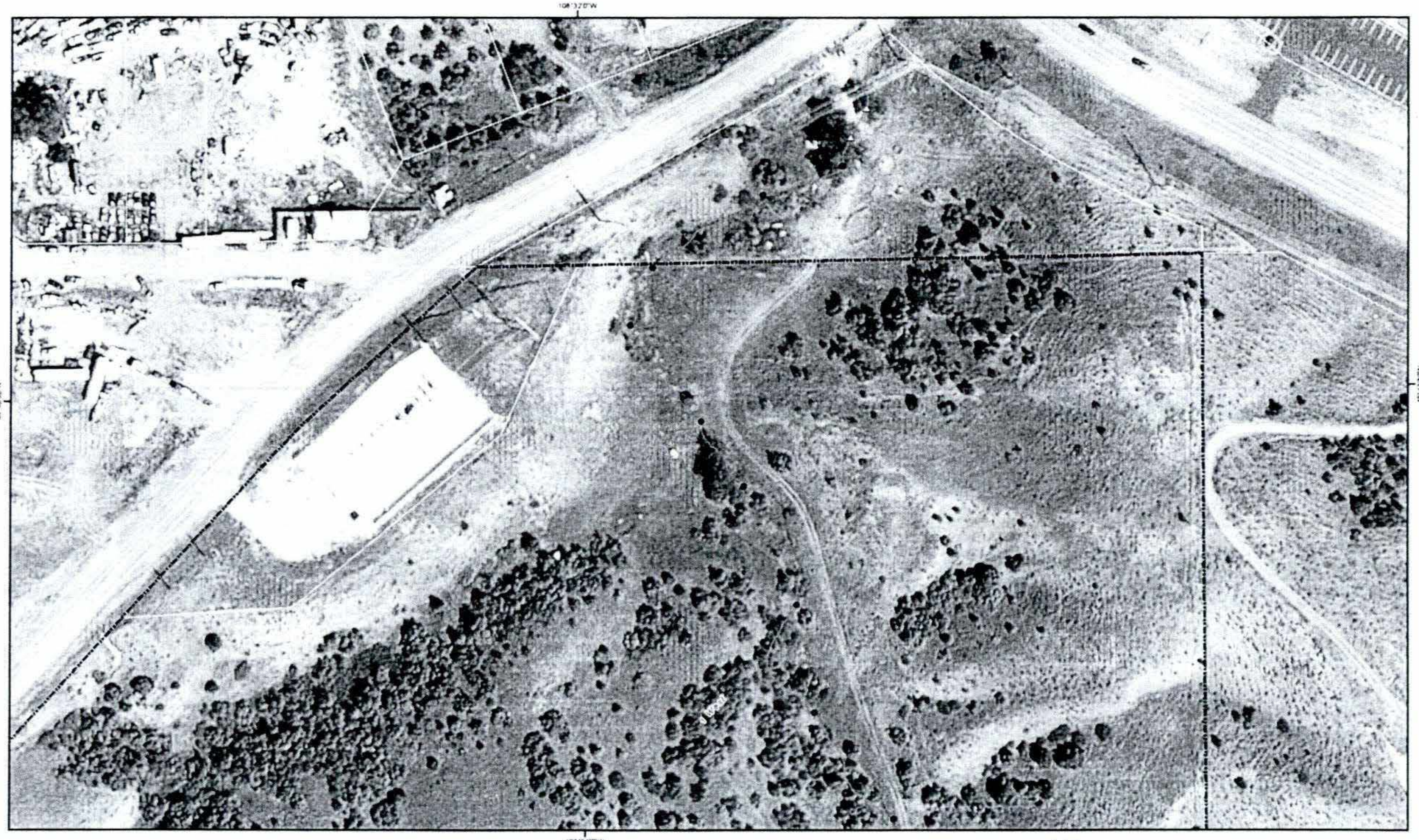
Saturation Present? (includes capillary fringe) Yes ____ No ✓ Depth (inches): ______

Wetland Hydrology Present? Yes ✓ No ____

Describe Recorded Data (stream gauge, monitoring well, aerial photos, previous inspections), if available:

Remarks: Presence of 2° indicators for wetland hydrology.

Appendix C – Wetland Delineation Maps



DATE: August 21, 2013
SOURCES: ESRI, HDR Inc., Yellowstone Co. GIS
PROJECTION: NAD_1983_StatePlane_Montana_FIPS_2500_Feet
AUTHOR: HDR Engineering, Inc.

0 25 50 100 150 200
Feet

LEGEND

Wetlands (HDR)
Stream Centerline
Stream Centerline (approximate)
Streambank
Study Area

GPS Field Data
Sample Plot
Edge of Streambank
Stream Centerline
Wetland Boundary
Culvert

MAP LOCATION

CITY OF BILLINGS LANDFILL EXPANSION
Wetland and Stream Delineation Report
MAP 1

DATE: August 21, 2013
SOURCES: ESRI, HDR Inc., Yellowstone Co. GIS
PROJECTION: NAD_1983_StatePlane_Montana_FIPS_2500_Feet
AUTHOR: HDR Engineering, Inc.

0 25 50 100 150 200
Feet

LEGEND

- Wetlands (HDR)
- Stream Centerline
- Stream Centerline (approximate)
- Streambank
- Study Area

GPS Field Data
- Sample Plot
- Edge of Streambank
- Stream Centerline
- Wetland Boundary
- Culvert

MAP LOCATION

			1
		2	3
		4	5
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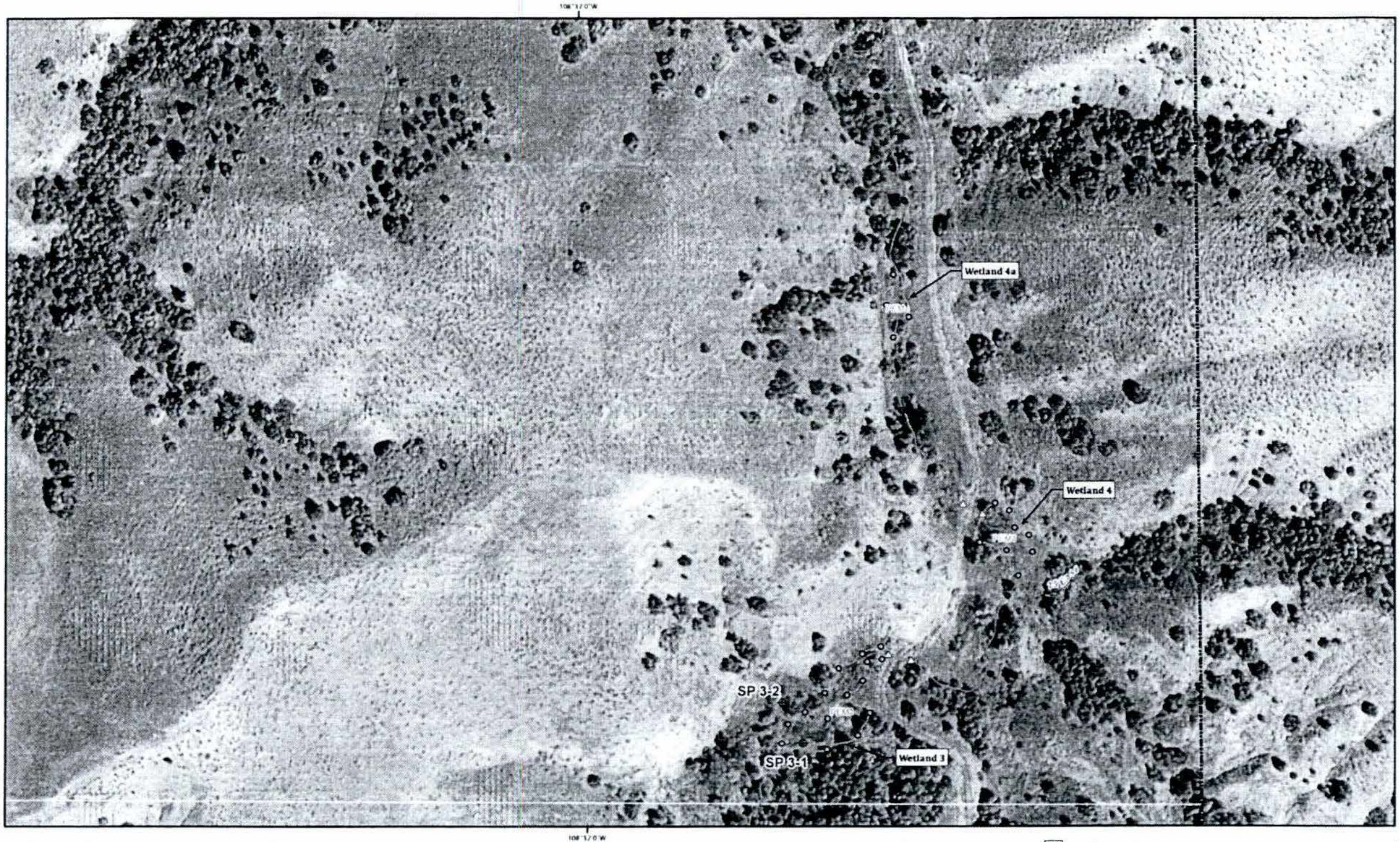
	8	9	10
11	12	13	14
15	16	17	18

CITY OF BILLINGS LANDFILL EXPANSION
Wetland and Stream Delineation Report
MAP 2



DATE: August 21, 2013
SOURCES: ESRI, HDR Inc., Yellowstone Co. GIS
PROJECTION: NAD_1983_StatePlane_Montana_FIPS_2500_Feet
AUTHOR: HDR Engineering, Inc.

0 25 50 100 150 200
Feet

LEGEND

Wetlands (HDR)
Stream Centerline
Stream Centerline (approximate)
Streambank
Study Area

GPS Field Data
Sample Plot
Edge of Streambank
Stream Centerline
Wetland Boundary
Culvert

MAP LOCATION

CITY OF BILLINGS LANDFILL EXPANSION
Wetland and Stream Delineation Report
MAP 3

DATE: August 21, 2013
SOURCES: ESRI, HDR Inc., Yellowstone Co. GIS
PROJECTION: NAD_1983_StatePlane_Montana_FIPS_2500_Feet
AUTHOR: HDR Engineering, Inc.

0 25 50 100 150 200
Feet

LEGEND

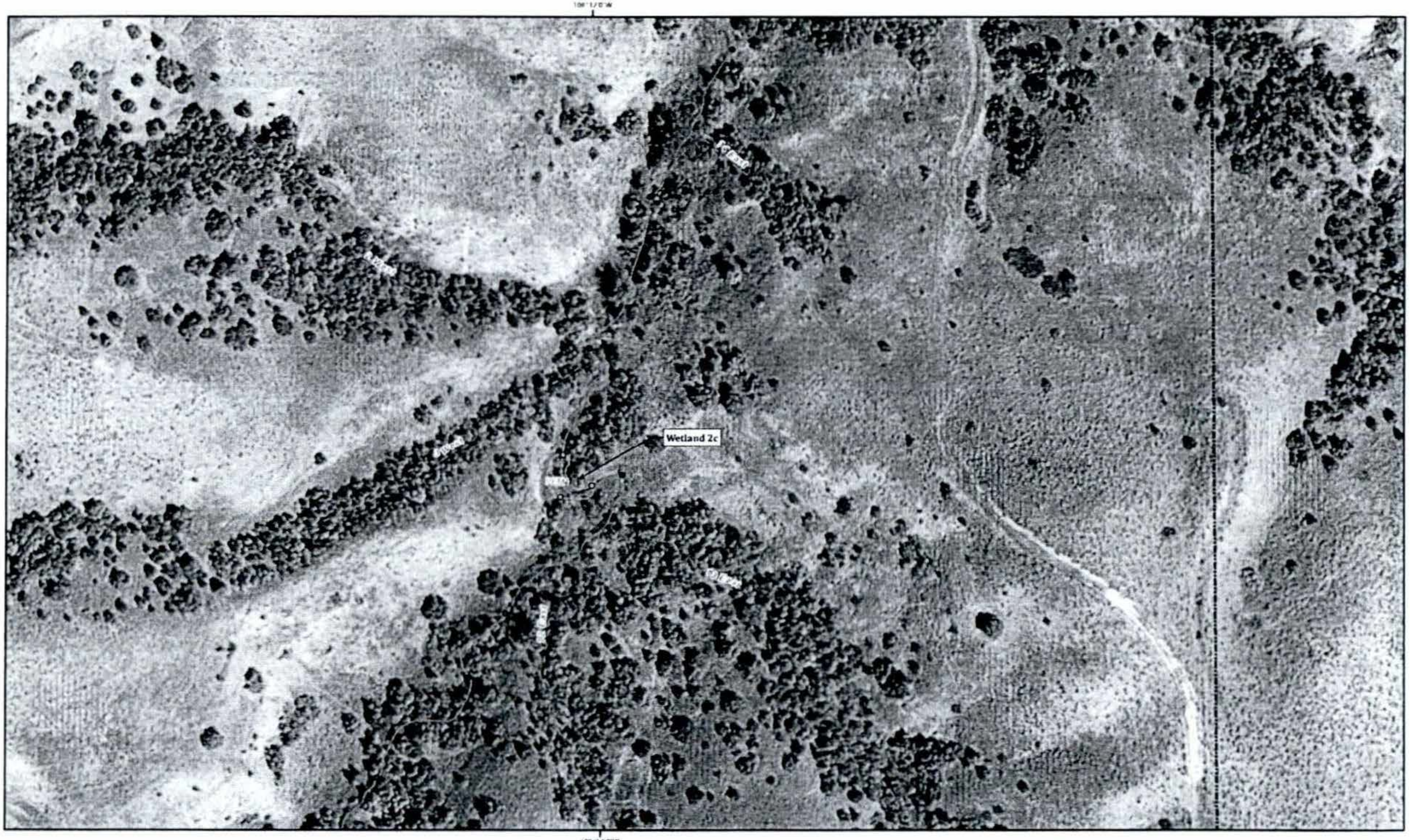
- Wetlands (HDR)
- Stream Centerline
- Stream Centerline (approximate)
- Streambank
- Study Area

GPS Field Data

- Sample Plot
- Edge of Streambank
- Stream Centerline
- Wetland Boundary
- Culvert

MAP LOCATION

CITY OF BILLINGS LANDFILL EXPANSION
Wetland and Stream Delineation Report
MAP 4



DATE: August 21, 2013
SOURCES: ESRI, HDR Inc., Yellowstone Co. GIS
PROJECTION: NAD_1983_StatePlane_Montana_FIPS_2500_Feet
AUTHOR: HDR Engineering, Inc.

0 25 50 100 150 200
Feet

LEGEND

Wetlands (HDR)
Stream Centerline
Stream Centerline (approximate)
Streambank
Study Area

GPS Field Data
Sample Plot
Edge of Streambank
Stream Centerline
Wetland Boundary
Culvert

MAP LOCATION

CITY OF BILLINGS LANDFILL EXPANSION
Wetland and Stream Delineation Report
MAP 5

DATE: August 21, 2013
SOURCES: ESRI, HDR Inc., Yellowstone Co. GIS
PROJECTION: NAD_1983_StatePlane_Montana_FIPS_2500_Feet
AUTHOR: HDR Engineering, Inc.

0 25 50 100 150 200
Feet

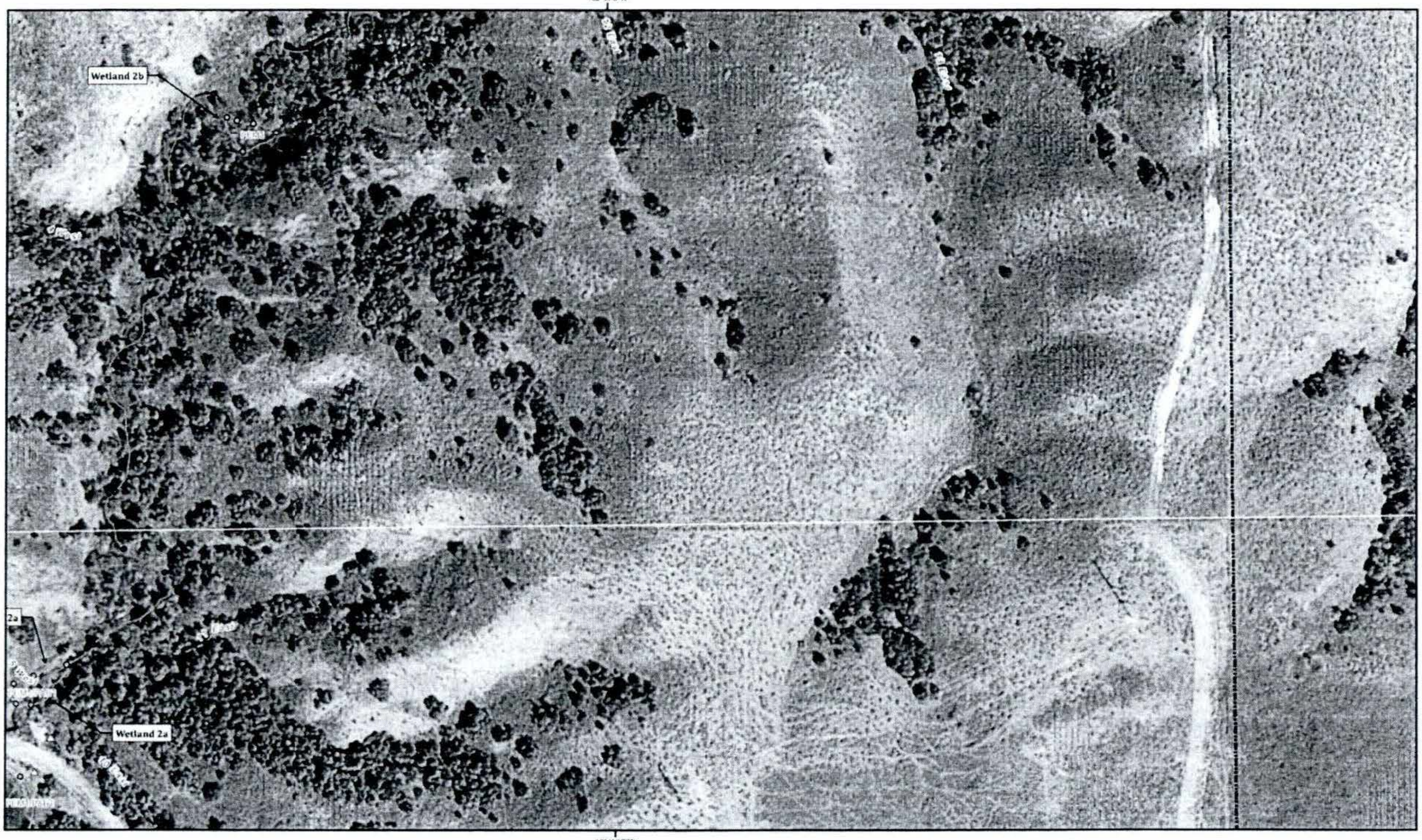
LEGEND

- Wetlands (HDR)
- Stream Centerline
- Stream Centerline (approximate)
- Streambank
- Study Area

GPS Field Data
- Sample Plot
- Edge of Streambank
- Stream Centerline
- Wetland Boundary
- Culvert

MAP LOCATION

CITY OF BILLINGS LANDFILL EXPANSION
Wetland and Stream Delineation Report
MAP 6



DATE: August 21, 2013
SOURCES: ESRI, HDR Inc., Yellowstone Co. GIS
PROJECTION: NAD_1983_StatePlane_Montana_FIPS_2500_Feet
AUTHOR: HDR Engineering, Inc.

0 25 50 100 150 200
Feet

LEGEND

- Wetlands (HDR)
- Stream Centerline
- Stream Centerline (approximate)
- Streambank
- Study Area

GPS Field Data
- Sample Plot
- Edge of Streambank
- Stream Centerline
- Wetland Boundary
- Culvert

MAP LOCATION

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	2	3
	4	5
	6	7
8	9	10
11	12	13	14
15	16	17	18

CITY OF BILLINGS LANDFILL EXPANSION
Wetland and Stream Delineation Report
MAP 7

DATE: August 21, 2013
SOURCES: ESRI, HDR Inc., Yellowstone Co. GIS
PROJECTION: NAD_1983_StatePlane_Montana_FIPS_2500_Feet
AUTHOR: HDR Engineering, Inc.

0 25 50 100 150 200 Feet

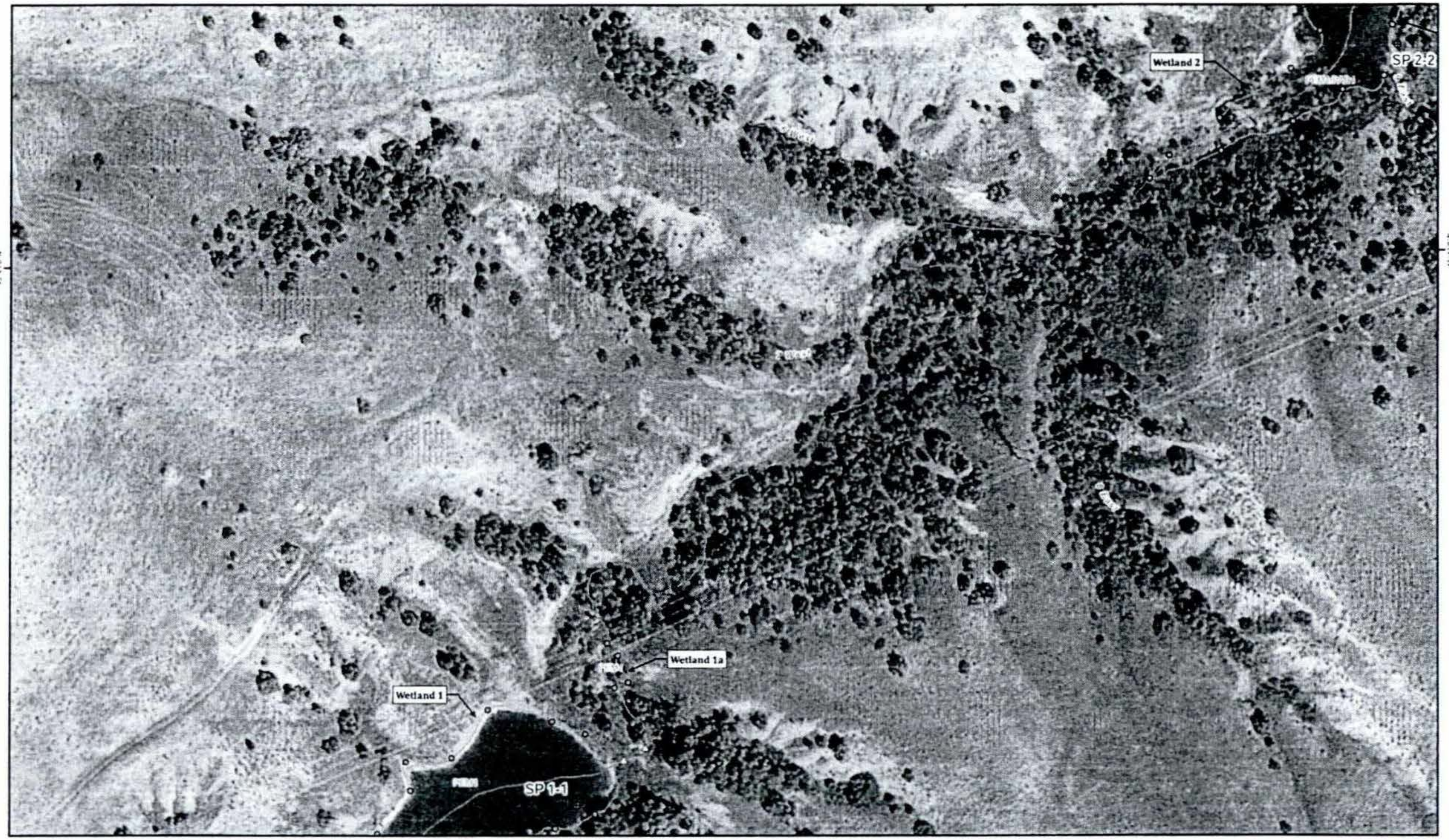
LEGEND

- Wetlands (HDR)
- Stream Centerline
- Stream Centerline (approximate)
- Streambank
- Study Area

GPS Field Data
- Sample Plot
- Edge of Streambank
- Stream Centerline
- Wetland Boundary
- Culvert

MAP LOCATION

CITY OF BILLINGS LANDFILL EXPANSION
Wetland and Stream Delineation Report
MAP 8



DATE: August 21, 2013
SOURCES: ESRI, HDR Inc., Yellowstone Co. GIS
PROJECTION: NAD_1983_StatePlane_Montana_FIPS_2500_Feet
AUTHOR: HDR Engineering, Inc.

0 25 50 100 150 200 Feet

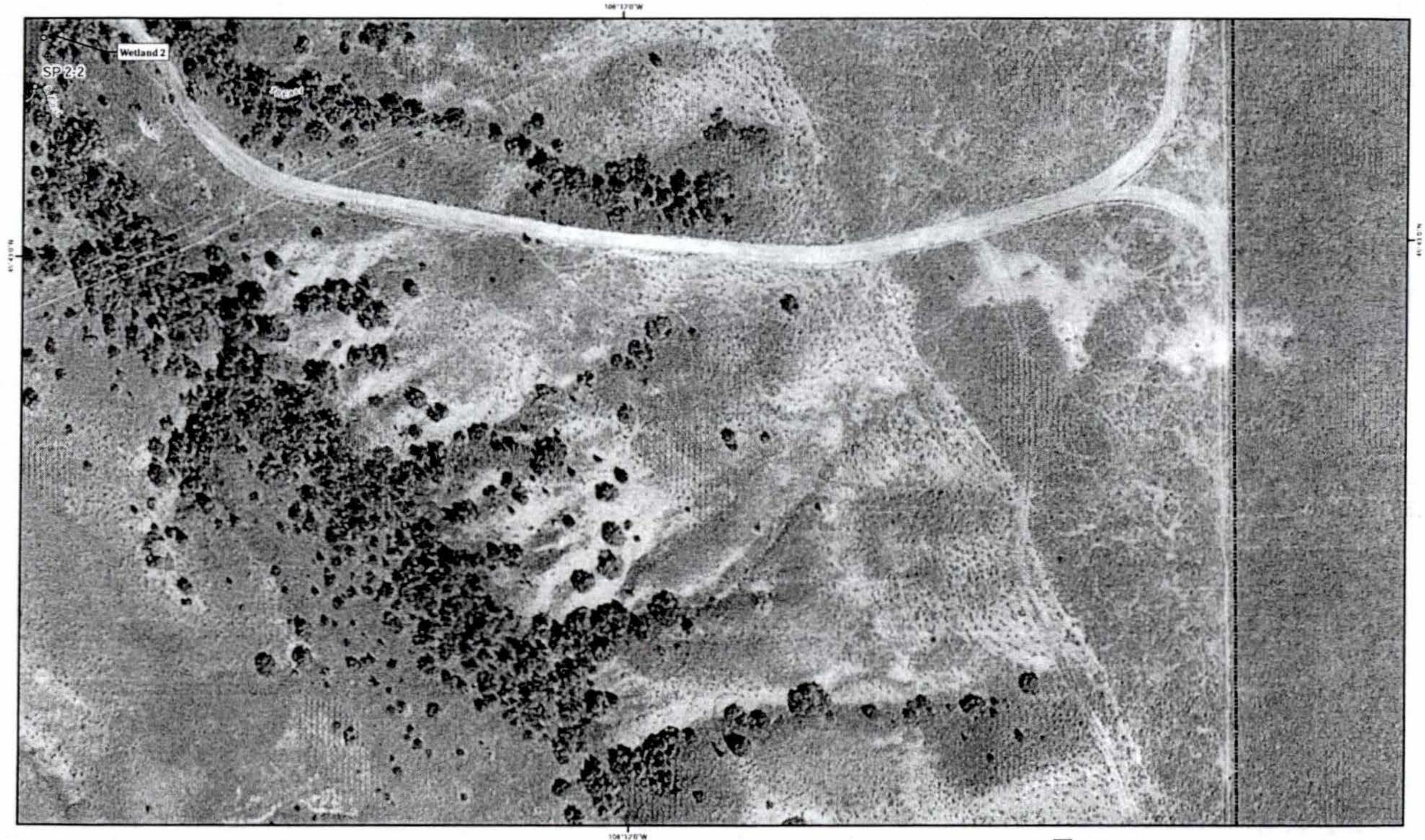
LEGEND

- Wetlands (HDR)
- Stream Centerline
- Stream Centerline (approximate)
- Streambank
- Study Area

GPS Field Data
- Sample Plot
- Edge of Streambank
- Stream Centerline
- Wetland Boundary
- Culvert

MAP LOCATION

CITY OF BILLINGS LANDFILL EXPANSION
Wetland and Stream Delineation Report
MAP 9



DATE: August 21, 2013
SOURCES: ESRI, HDR Inc., Yellowstone Co. GIS
PROJECTION: NAD_1983_StatePlane_Montana_FIPS_2500_Feet
AUTHOR: HDR Engineering, Inc.

0 25 50 100 150 200
Feet

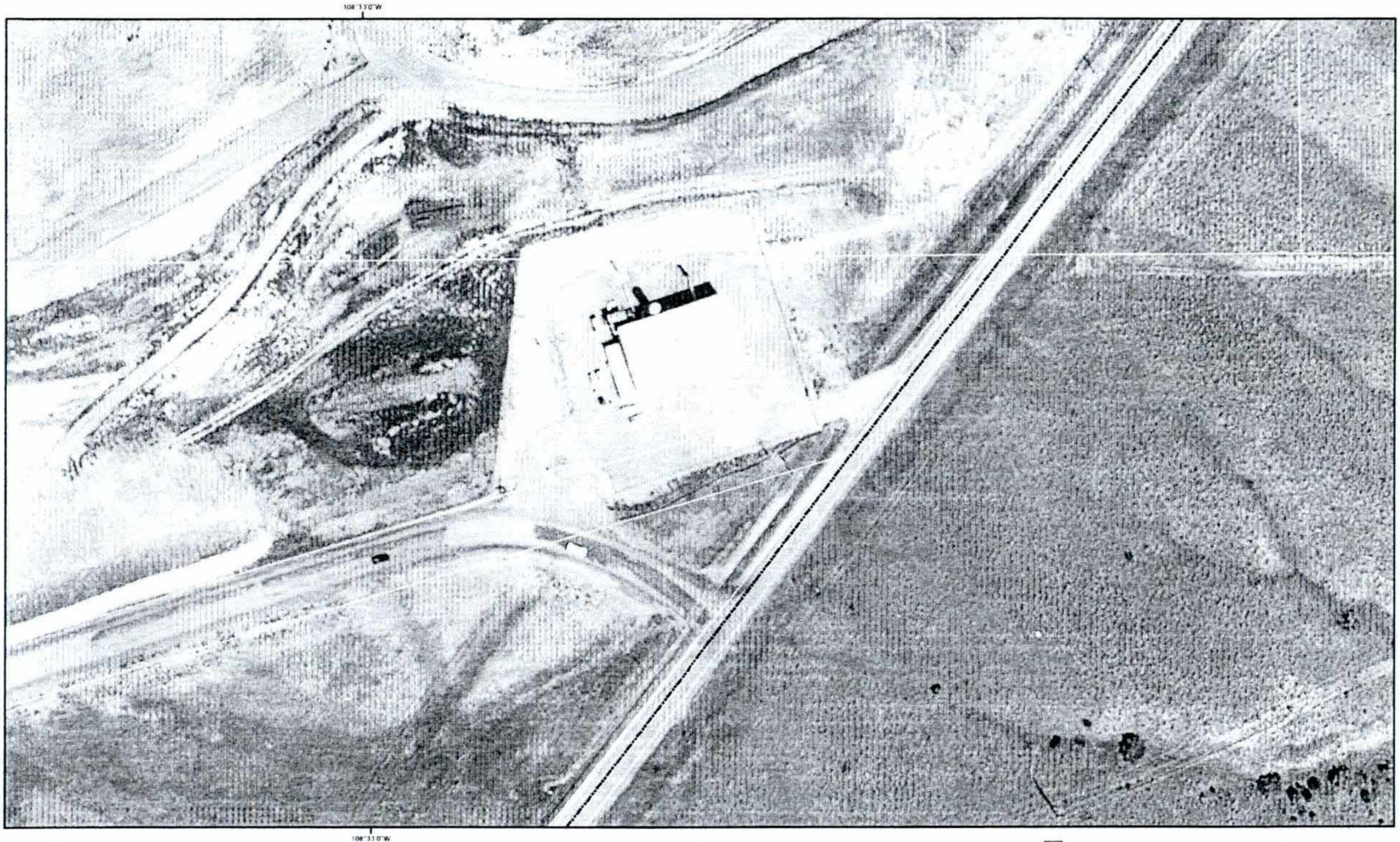
LEGEND

- Wetlands (HDR)
- Stream Centerline
- Stream Centerline (approximate)
- Streambank
- Study Area

GPS Field Data
- Sample Plot
- Edge of Streambank
- Stream Centerline
- Wetland Boundary
- Culvert

MAP LOCATION

CITY OF BILLINGS LANDFILL EXPANSION
Wetland and Stream Delineation Report
MAP 10



DATE August 21, 2013
SOURCES ESRI, HDR Inc., Yellowstone Co. GIS
PROJECTION NAD_1983_StatePlane_Montana_FIPS_2500_Feet
AUTHOR HDR Engineering, Inc.

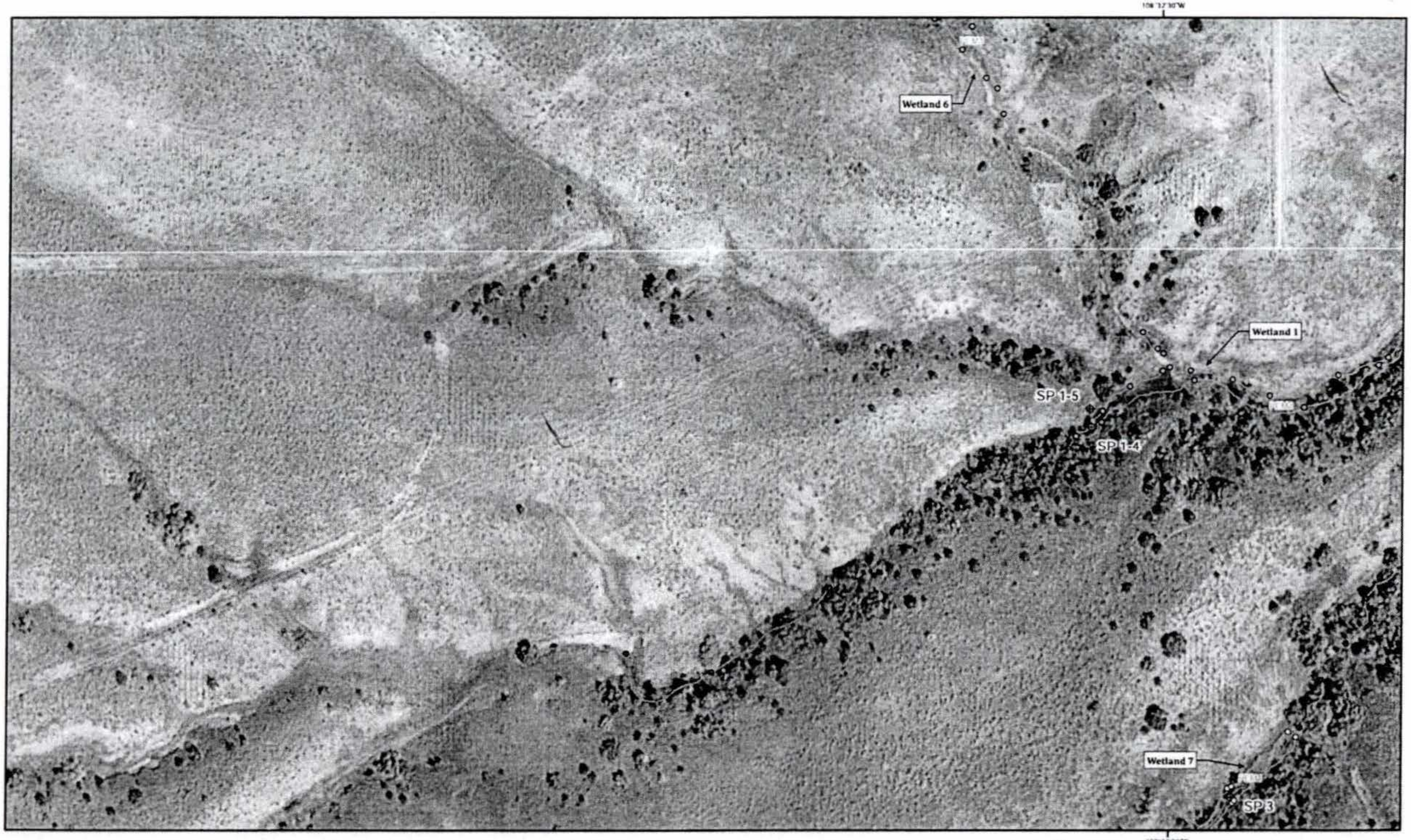
LEGEND

Wetlands (HDR)
Streambank
Stream Centerline
Study Area
Stream Centerline (approximate)

GPS Field Data
Sample Plot
Edge of Streambank
Stream Centerline
Wetland Boundary
Culvert

MAP LOCATION

CITY OF BILLINGS LANDFILL EXPANSION
Wetland and Stream Delineation Report
MAP 11



DATE: August 21, 2013
SOURCES: ESRI, HDR Inc., Yellowstone Co. GIS
PROJECTION: NAD_1983_StatePlane_Montana_FIPS_2500_Feet
AUTHOR: HDR Engineering, Inc.

0 25 50 100 150 200
Feet

LEGEND

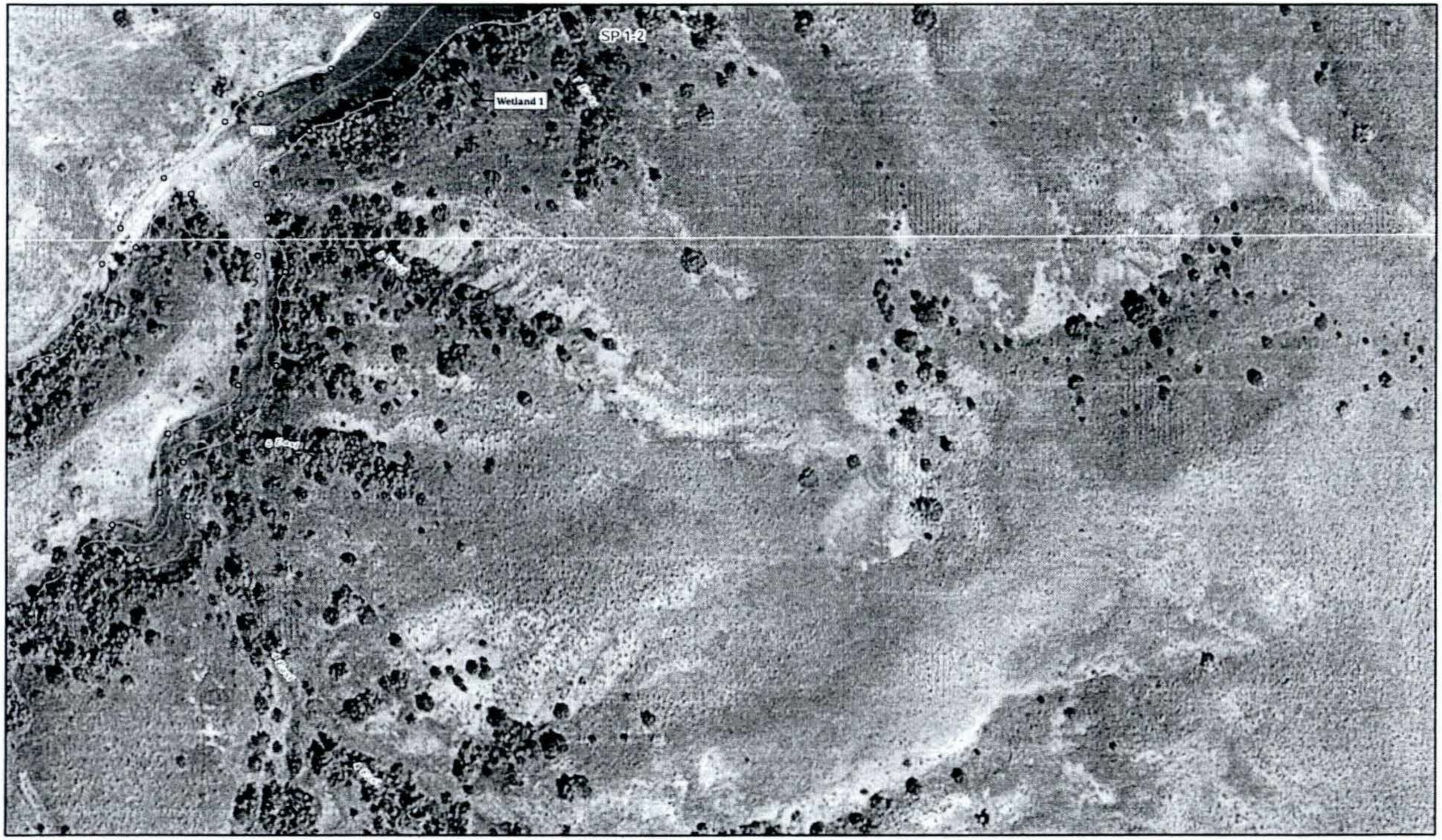
- Wetlands (HDR)
- Stream Centerline
- Stream Centerline (approximate)
- Streambank
- Study Area

GPS Field Data
- Sample Plot
- Edge of Streambank
- Stream Centerline
- Wetland Boundary
- Culvert

MAP LOCATION

				1
			2	3
			4	5
			6	7
		8	9	10
11	12	13	14	
15	16	17	18	

CITY OF BILLINGS LANDFILL EXPANSION
Wetland and Stream Delineation Report
MAP 12



DATE: August 21, 2013
SOURCES: ESRI, HDR Inc., Yellowstone Co. GIS
PROJECTION: NAD_1983_StatePlane_Montana_FIPS_2500_Feet
AUTHOR: HDR Engineering, Inc.

0 25 50 100 150 200
Feet

LEGEND

Wetlands (HDR)
Stream Centerline
Stream Centerline (approximate)
Streambank
Study Area

GPS Field Data
Sample Plot
Edge of Streambank
Stream Centerline
Wetland Boundary
Culvert

MAP LOCATION

CITY OF BILLINGS LANDFILL EXPANSION
Wetland and Stream Delineation Report
MAP 13

DATE: August 21, 2013
SOURCES: ESRI, HDR Inc., Yellowstone Co. GIS
PROJECTION: NAD_1983_StatePlane_Montana_FIPS_2500_Feet
AUTHOR: HDR Engineering, Inc.

0 25 50 100 150 200
Feet

LEGEND

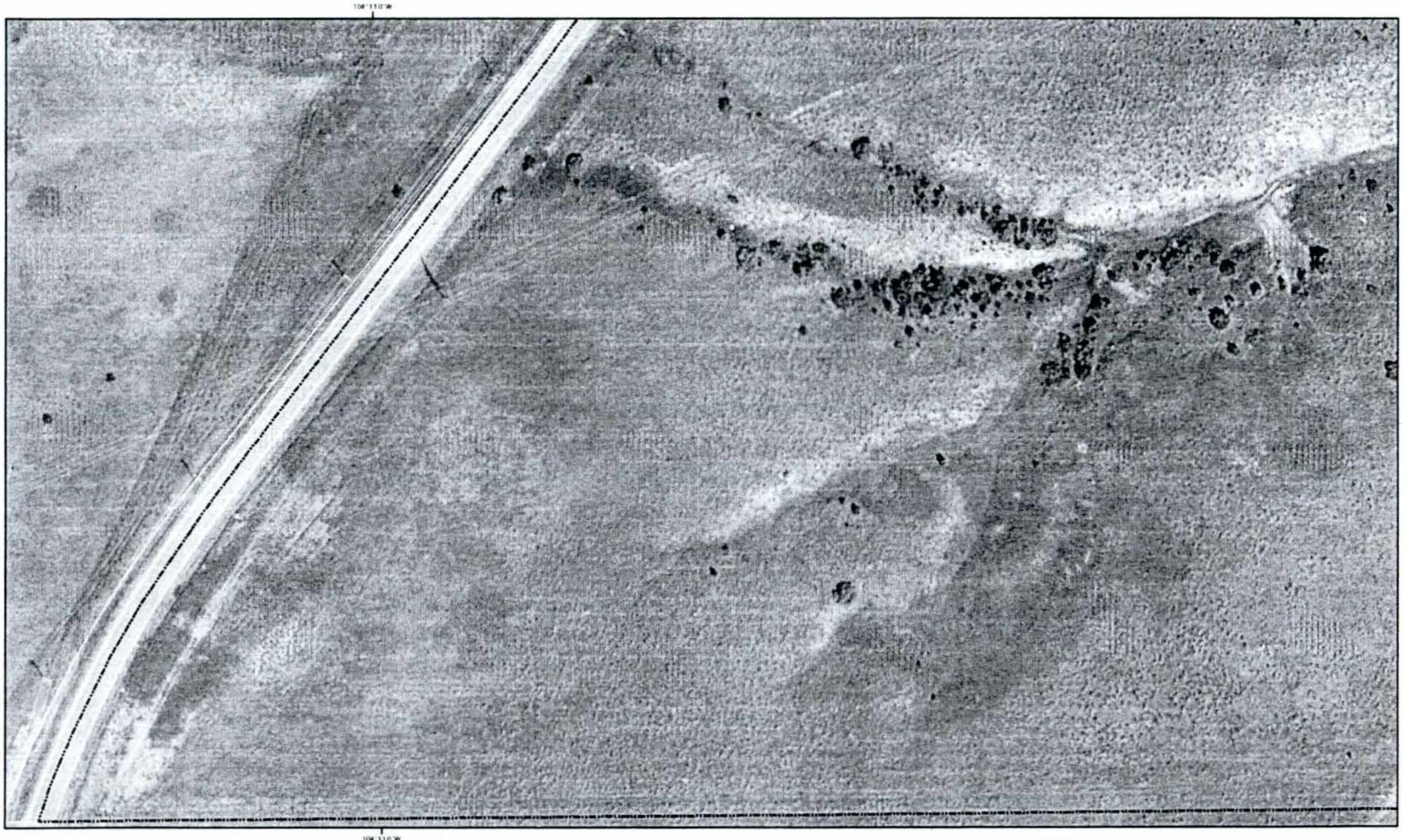
Wetlands (HDR)
Stream Centerline
Stream Centerline (approximate)
Streambank
Study Area

GPS Field Data
Sample Plot
Edge of Streambank
Stream Centerline
Wetland Boundary
Culvert

MAP LOCATION

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18

CITY OF BILLINGS LANDFILL EXPANSION
Wetland and Stream Delineation Report
MAP 14



DATE: August 21, 2013
SOURCES: ESRI, HDR Inc., Yellowstone Co. GIS
PROJECTION: NAD_1983_StatePlane_Montana_FIPS_2500_Feet
AUTHOR: HDR Engineering, Inc.

0 25 50 100 150 200
Feet

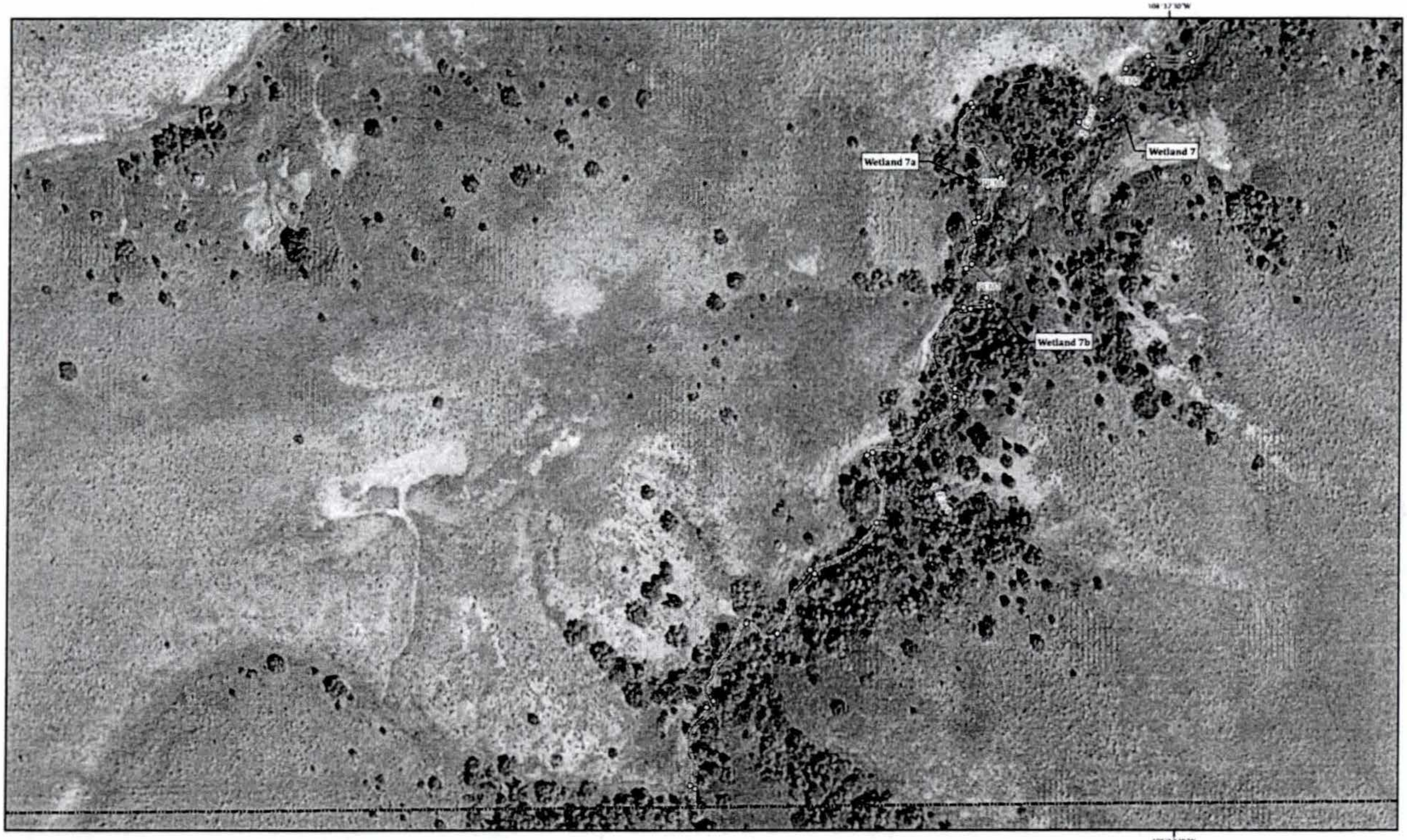
LEGEND

- Wetlands (HDR)
- Stream Centerline
- Stream Centerline (approximate)
- Streambank
- Study Area

GPS Field Data
- Sample Plot
- Edge of Streambank
- Stream Centerline
- Wetland Boundary
- Culvert

MAP LOCATION

CITY OF BILLINGS LANDFILL EXPANSION
Wetland and Stream Delineation Report
MAP 15



DATE: August 21, 2013
SOURCES: ESRI, HDR Inc., Yellowstone Co. GIS
PROJECTION: NAD_1983_StatePlane_Montana_FIPS_2500_Feet
AUTHOR: HDR Engineering, Inc.

0 25 50 100 150 200 Feet

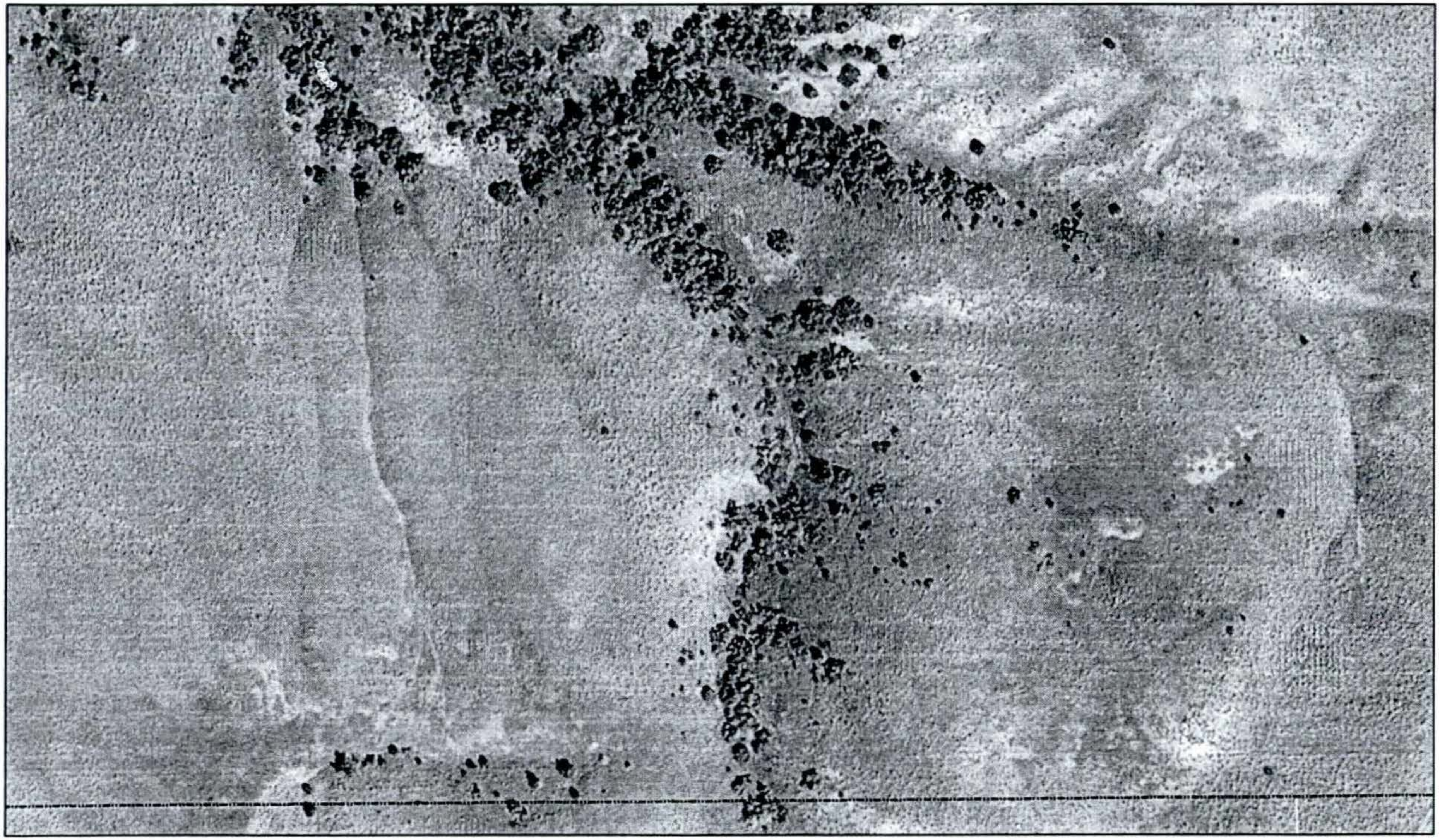
LEGEND

- Wetlands (HDR)
- Stream Centerline
- Stream Centerline (approximate)
- Streambank
- Study Area

GPS Field Data
- Sample Plot
- Edge of Streambank
- Stream Centerline
- Wetland Boundary
- Culvert

MAP LOCATION

CITY OF BILLINGS LANDFILL EXPANSION
Wetland and Stream Delineation Report
MAP 16



DATE: August 21, 2013
SOURCES: ESRI, HDR Inc., Yellowstone Co. GIS
PROJECTION: NAD_1983_StatePlane_Montana_FIPS_2500_Feet
AUTHOR: HDR Engineering, Inc.

0 25 50 100 150 200
Feet

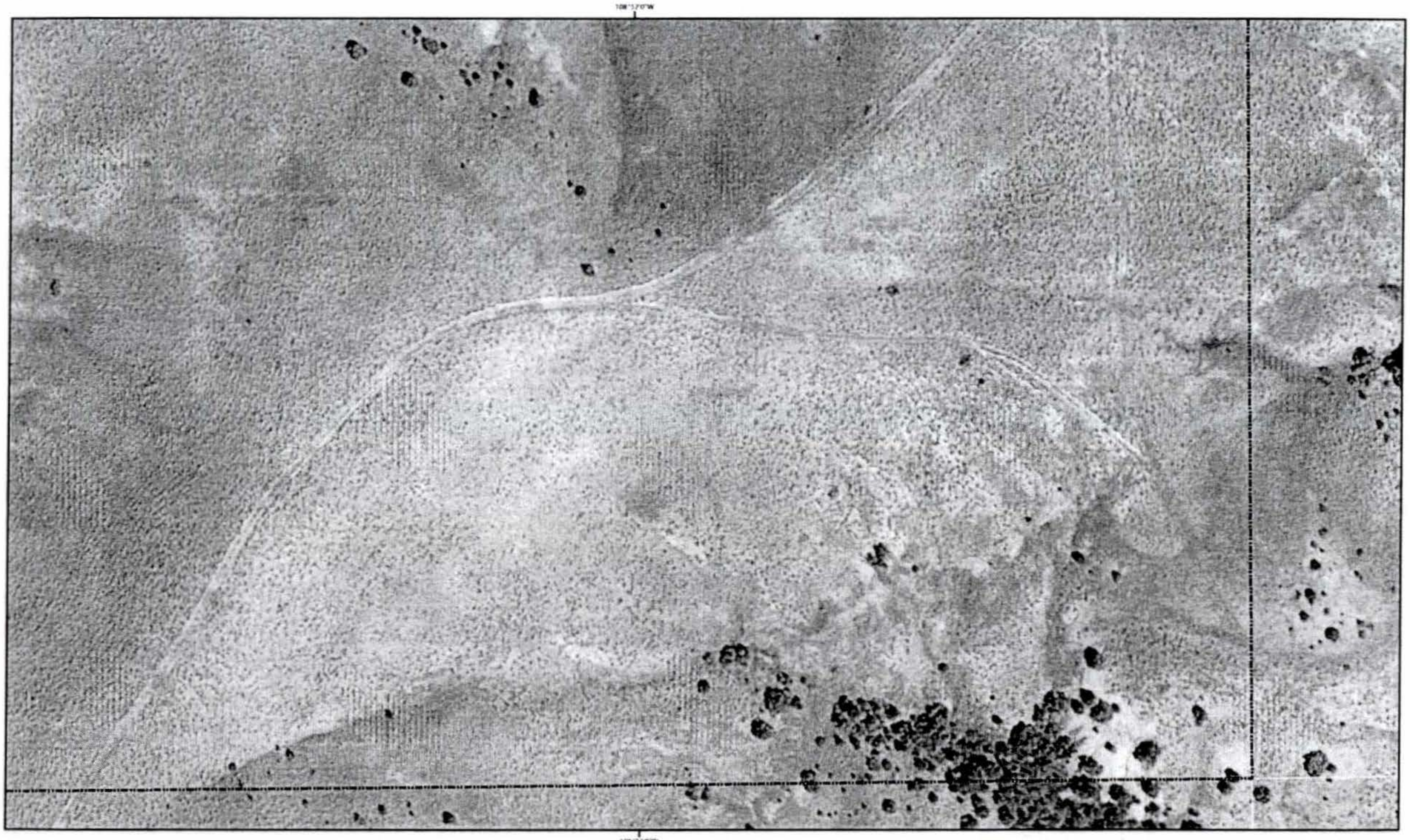
LEGEND

Wetlands (HDR)
Stream Centerline
Stream Centerline (approximate)
Streambank
Study Area

GPS Field Data
Sample Plot
Edge of Streambank
Stream Centerline
Wetland Boundary
Culvert

MAP LOCATION

CITY OF BILLINGS LANDFILL EXPANSION
Wetland and Stream Delineation Report
MAP 17



DATE: August 21, 2013
SOURCES: ESRI, HDR Inc., Yellowstone Co. GIS
PROJECTION: NAD_1983_StatePlane_Montana_FIPS_2500_Feet
AUTHOR: HDR Engineering, Inc.

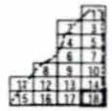
0 25 50 100 150 200
Feet

LEGEND

Wetlands (HDR)
Stream Centerline
Stream Centerline (approximate)
Streambank
Study Area

GPS Field Data
Sample Plot
Edge of Streambank
Stream Centerline
Wetland Boundary
Culvert

MAP LOCATION



CITY OF BILLINGS LANDFILL EXPANSION
Wetland and Stream Delineation Report
MAP 18

Appendix D – Site Photos

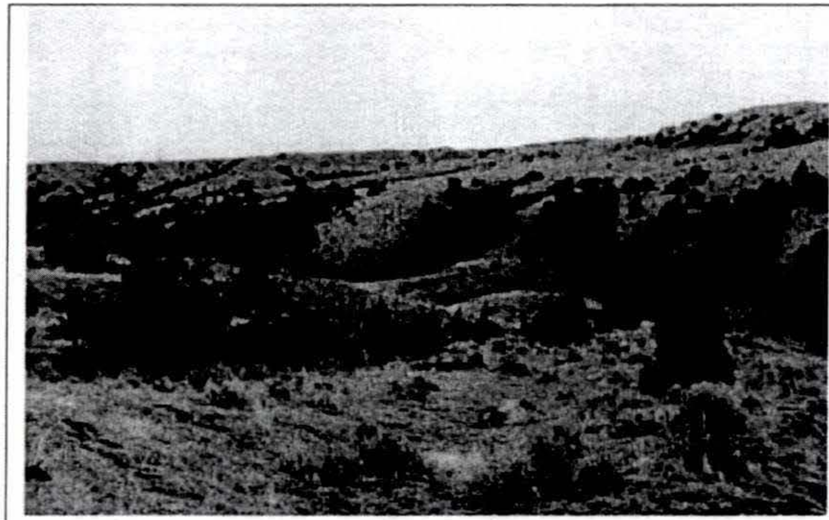
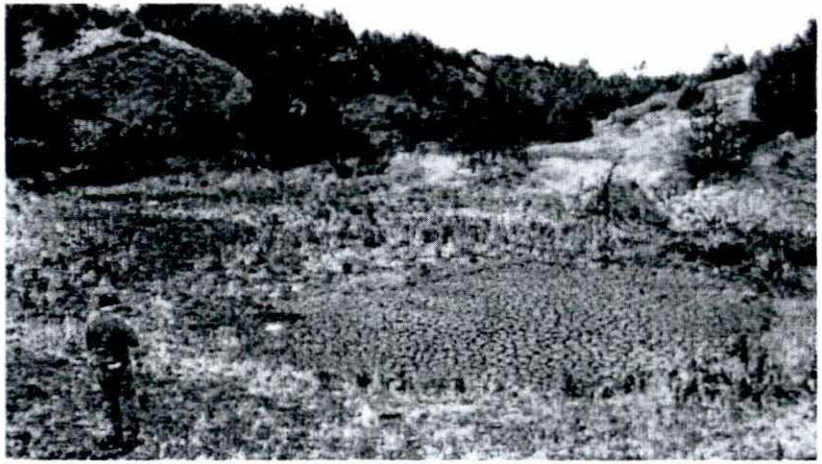


Photo 1. Overview of south-central portion of project site, looking northeast. Wetland 1 is visible in the background (October 8, 2012).

Photo 2. Overview of north portion of the project site, looking south (October 8, 2012)

Photo 3. Wetland 1, unvegetated depression ringed by twoscale saltbush and rough cocklebur, in north portion of the site (October 8, 2012)

Photo 4. Wetland 1, southwest portion of wetland with *Schoenoplectus* spp. and common spikerush (October 8, 2012)



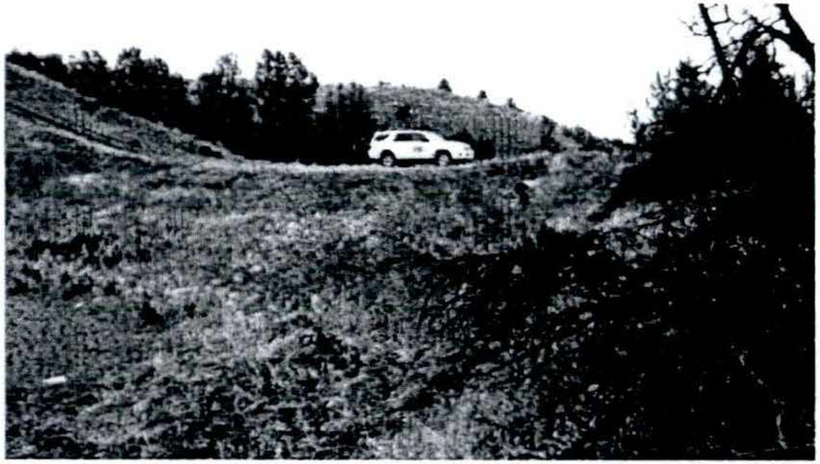


Photo 5. Wetland 2, looking south from north berm (October 8, 2012).

Photo 6. Wetland 2, road berm on north side of wetland and high-flow culvert (October 8, 2012)

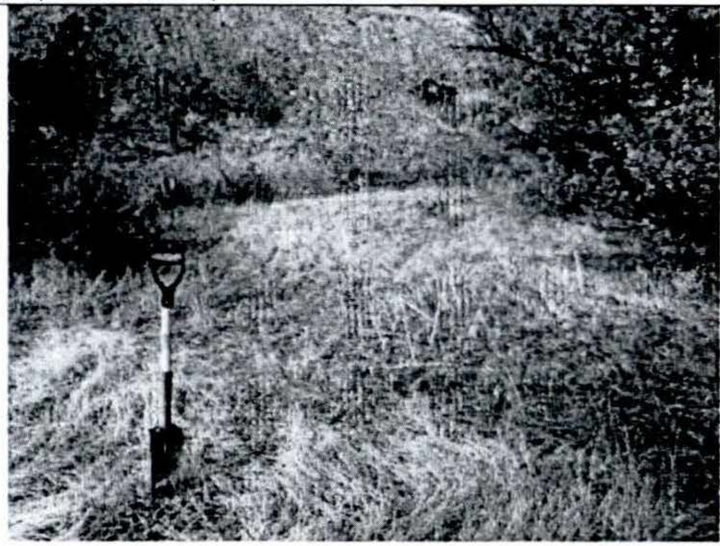


Photo 7. Wetland 3, looking north from south portion of wetland (October 9, 2012)

Photo 8. Wetland 2b, dominated by narrowleaf cattail and common spikerush (October 8, 2012). Numerous other minor wetlands along Stream 1 had similar vegetation communities.

Photo 9. Wetland 5, looking east. Wetland is dominated by narrowleaf cattail (October 9, 2012).

Photo 10. Wetland 6, looking east. Wetland is dominated by saltmarsh club-rush. (October 8, 2012)

Photo 11. Stream 1, typical bed and bank conditions in the south portion of the project site (October 8, 2012).

Photo 12. Stream 1, culvert outlet at Blue Creek Road, where Stream 1 discharges to Blue Creek (October 9, 2012).

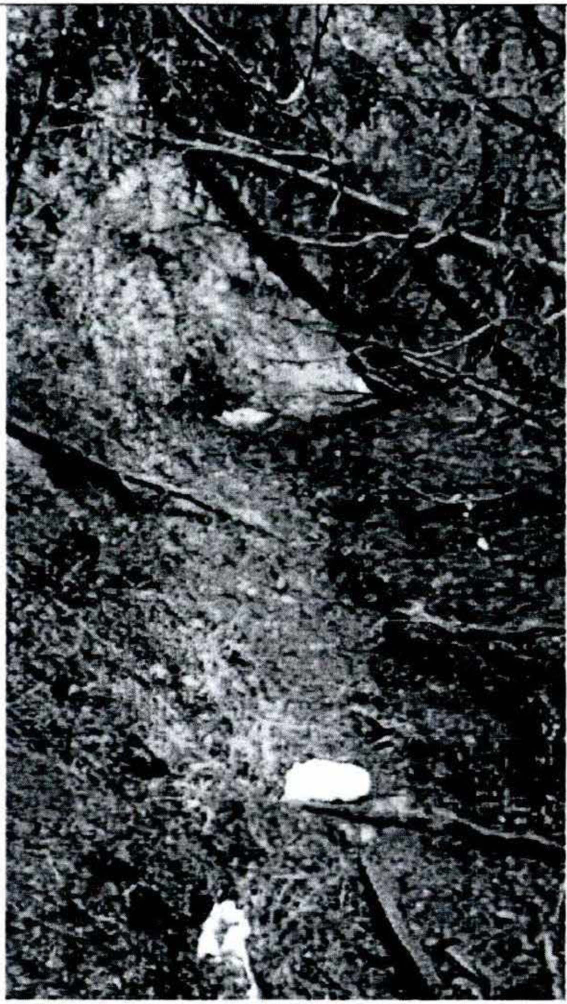


Photo 13. Drainage 7 East, looking downstream. Stream channel conditions were typical of other seasonal drainages inventoried in the project area (October 9, 2012).	Photo 14. Drainage 2 West looking downstream (October 9, 2012).

APPENDIX E

Road Improvements Alternatives Analysis
(Prepared by Great West Engineering and HDR Engineering
for the City of Billings)

To:	Will Robbins, Staff Engineer Vester Wilson, Solid Waste Superintendent		
From:	Great West Engineering | HDR	Technical Memorandum:	Traffic and Roadway Alternatives
Date:		Job No.:	W.O. 12-29 – City of Billings Solid Waste Management Plan

BACKGROUND

The team of Great West Engineering and HDR Engineering has been hired by the City of Billings to prepare a Solid Waste Management Plan. The scope of the project includes an evaluation of future landfill expansion alternatives to provide disposal capacity for the City once the existing landfill has reached capacity. The City owns approximately 350 acres adjacent to the existing landfill which appears suitable for licensing of a landfill expansion. Two primary landfill expansion alternatives were evaluated as defined below and discussed in detail in a separate document.

Landfill Alternative 1

Stand Alone Facility is designed to place a new landfill separate from the existing landfill across Hillcrest Road. This facility will stand alone from the existing landfill. The foot print is situated in a manner that maximizes space while allowing for set-back from the property lines, and to direct the stormwater run-on around the landfill to the northwest via a drainage ditch.

Landfill Alternative 2

Overlap Facility is designed to overlap onto the existing landfill and remove Hillcrest Road. This alternative capitalizes on the airspace gained with the overlap of the existing fill which will allow more capacity in the early life of this alternative. The foot print is also situated in a manner that maximizes space while allowing for set-back from the property lines, and to direct the stormwater run-on around the landfill to the southeast via a large drainage ditch.

PURPOSE OF TECHNICAL MEMORANDUM

The purpose of the Traffic and Roadways Alternatives Evaluation is to identify critical issues that may influence the selection of landfill expansion alternatives and to identify routes that may be utilized to access the expansion. This memorandum also provides a preliminary comparative ranking between roadway alternatives which is provided to help assist the City in selection of the preferred alternative. This memorandum is intended to be a high level review of the routes, but is not to be construed as a detailed Corridor Study. Once the City has selected a preferred landfill expansion and roadway alternative the engineer is contracted in another task to prepare documents for licensing of the expansion. This will include a detailed Traffic Impact Study which will support the environmental documentation which will be submitted to the Montana DEQ. Eventually this documentation will be included in the State's environmental review of the licensing documentation and available for public review.

EXISTING TRAFFIC DATA

Great West Engineering conducted a preliminary traffic review of the area around the Billings Landfill to determine potential impacts associated with modifying or changing the primary route to the landfill. This technical memorandum does not replace a Traffic Impact Statement, but it is adequate to identify critical issues that should be considered in alternative route selection.

The existing primary route for vehicles arriving at the landfill is to travel south on Blue Creek Road then turn west onto Jellison Road. The right turn movement at this intersection utilizes a dedicated right turn lane. The landfill entrance is located approximately 0.7 miles along Jellison Road to the south.

A count was conducted at the intersection of Blue Creek Road and Jellison Road on Wednesday morning, 10/17/2012 from 7:30 am to 9:30 am. Counting times were selected based on traffic counts conducted by the City of Billings and are intended to pick up the highest impact to the intersection. Counts completed by the City of Billings will be included in the Traffic Impact Study.

The peak hour of traffic within this count is from 7:30 am to 8:30 am. The intersection is unsignalized and has one stop sign on Jellison Road. Jellison does not have an eastbound approach resulting in a "T" intersection.

Table 1 is adapted from the Highway Capacity Manual to identify the Level of Service based on control delay for unsignalized intersections.

Table 1: Level of Service Criteria for Unsignalized Intersections

Level of Service	Control Delay per Vehicle (seconds per vehicle)	Impact on Minor Street Traffic
A	≤ 10	Little or no delay
B	> 10 ≤ 15	Short traffic delays
C	> 15 ≤ 25	Average traffic delays
D	> 25 ≤ 35	Long traffic delays
E	> 35 ≤ 50	Very long traffic delays
F	> 50	Unacceptable traffic delays

Source: *Highway Capacity Manual (HCM 2000)*

Presented in Table 2 is the Level of Service data for the intersection of Blue Creek Road and Jellison Road. McTrans HCS+ was used for the analysis.

**

Table 2: AM Peak Levels of Service: Unsignalized Intersections								
Intersection	PM PEAK LOS							
(Major/Minor)	EB		WB		NB		SB	
	Ex.	**	Ex.	**	Ex.	**	Ex.	**
Blue Creek Rd. (N~S) & Jellison Road (E~W)	B	*B*	~	~	A	*A*	A	*A*
Control Delay (sec)	11.5	*14.6*	~	~	7.5	*7.5*		

Resultant LOS without the dedicated Right Turn Lane.

As identified above, the eastbound movement operates at a Level of Service B, but is close to operating at LOS A. Directing landfill traffic from Jellison to Hillcrest or Collier is not anticipated to significantly impact these intersections, but will be further evaluated with the Traffic Impact Study.

The Billings Landfill collects vehicle data at the scale site year round. A summary of the date is shown in Table 3. The data used in the LOS analysis showed southbound right turns at 54 vph (0.67 peak hour factor) and eastbound left turns at 79 vph (0.76 peak hour factor). The unadjusted 2011 peak hour volume at the landfill during the fall is 80 vph and 147 vph in the spring. A correlation with landfill/non landfill traffic will be created with the Traffic Impact Study. The average day vehicle counts are accurate, however some of the vehicles were not classified as residential or commercial.

Table 3
Landfill Traffic Summary

2011	Day	Hour	Residential Hour	Commercial Hour	Residential Day	Commercial Day
Average vehicles/year	395	44	31	11	280	99
Average vehicles/summer	500	56	39	14	355	125
Average vehicles/spring	440	49	35	12	312	110
Average vehicles/fall	354	39	28	10	251	88
Average vehicles/winter	266	30	21	7	189	67
Average vehicles/winter spring fall	358	40	28	10	254	89

2011	Day	Hour	Residential Hour	Commercial Hour	Residential Day	Commercial Day
Max vehicles/year	1,057	147	104	37	750	264
Max vehicles/summer	733	102	72	25	520	183
Max vehicles/spring	1,057	147	104	37	750	264
Max vehicles/fall	574	80	57	20	408	144
Max vehicles/winter	551	77	54	19	391	138
Max vehicles/winter spring fall	1,057	147	104	37	750	264

The Montana Department of Transportation maintains yearly count data on Blue Creek Road and is summarized below:

Location: S. Billings Blvd (Blue Creek Road), N of Yellowstone Rv Bridge
Site ID: 56-4A-188
Dept. Route: U-1033
Corridor: C000416
Owner: MDT
County: Yellowstone
AADT 2009: 9650 (Estimated)
AADT 2010: 9700 (Actual)
AADT 2011: 9660 (Estimated)

Location: S-416 (Blue Creek Road), RP 2, 1.5 mi SE of Yellostone Rv Bridge
Site ID: 56-4-10
Dept. Route: S-416
Corridor: C000416
Owner: MDT
County: Yellowstone
AADT 2009: 4200 (Actual)
AADT 2010: 4190 (Estimated)
AADT 2011: 4850 (Actual)

Changing the primary approach to the landfill is expected to occur within the bounds of the two traffic counts shown above. No change of data is expected until service areas are expanded. Traffic and crash data will be obtained from MDT during the Traffic Impact Study.

OVERVIEW OF ALTERNATE ROUTES

Field and topographical map reconnaissance were conducted to determine potential alternate routes to accommodate expansion of the landfill south across Hillcrest Road while still providing acceptable levels of service. Hillcrest is a collector County road that serves residential and ranching properties to the south of Blue Creek Road. An electrical substation, overhead power, buried telephone lines, gas mains, and a commercial property are located along Hillcrest Road. Existing curve data and the roadway function were used to determine a design speed of 45 mph. This design speed is used for all roadway alternatives.

Roadway Alternative 1

Reconstruction of Hillcrest Road
Refer to the attached plan sheets for an overview of this alternative: 1 (Key Map), 2 (Plan& Profile of Hillcrest), 3 (Blue Creek Road Intersection and Substation), and 7 (Typical Section Details). This roadway alternative is not compatible with the Landfill Overlap Alternative.

This alternative will maintain the existing horizontal alignment, but will improve the typical section to include two foot shoulders as well as improving the cut/fill slopes to meet existing County Road standards. The intersection of Hillcrest and Blue Creek Road does not provide adequate grades or sight distances. This alternative includes the construction of an approach landing along Hillcrest Road to meet MDT standards resulting in an approximate ten foot cut adjacent to the substation. This cut creates the need for a retaining wall separating the lowered Hillcrest Road from the substation to minimize impacts. Utility relocation will be required.

The alternative includes reconstruction of approximately 1100 feet of Blue Creek Road to improve the intersection sight distance to meet minimum MDT requirements.

The right turn lane found at the intersection of Blue Creek and Jellison does not appear to be warranted based on traffic count data alone, but is likely there due to accident data. During the field reconnaissance, a crash occurred that was caused by a north turning vehicle on Jellison unable to see north on Blue Creek due to the presence of a large commercial vehicle. This Technical Memorandum includes the addition of a dedicated right turn lane from Blue Creek Road to Hillcrest Road.

If landfill roads are required for crossing the reconstructed Hillcrest, they should be located where there is adequate sight distance. A two way stop controlled intersection should be appropriate based on the estimated traffic counts.

The estimated cost of this alternative is $5.3 million. Property acquisition will be required on the eastern end of Hillcrest on the north side of the road.

Roadway Alternative 2

Reroute of Hillcrest Road

Refer to the attached plan sheets for an overview of this alternative: 1 (Key Map), 4 (Plan& Profile of Rerouted Hillcrest Road), 5 (Blue Creek Road Intersection), and 7 (Typical Section Details). This roadway alternative is compatible with the landfill overlap alternative and the landfill standalone alternative.

Hillcrest Road will be rerouted along the perimeter of the proposed expansion. This reroute will need to cross an existing drainage. The proposed landfill expansion will include rerouting the drainage for stormwater run-on control. Under the Landfill overlap alternative the drainage ditch will be constructed to the south and east of the landfill footprint. Should this alternative be selected for advancement, the drainage ditch and roadway design can be combined to reduce the overall excavation and subsequently costs.

Hillcrest can be maintained as a landfill road as appropriate until the landfill expansion will no longer allow. At this time, the asphalt can be milled to improve internal landfill roads as the opportunity arises.

Rerouting Hillcrest will add approximately 0.75 miles of roadway, causing a delay of emergency services of approximately one minute to locations along Stratton Road and on Hillcrest Road south of this new intersection.

The relocation of Hillcrest will also require modifying the existing intersection at Blue Creek Road. This modification increases the distance available for a right turn lane, provides access to the substation, and improves the sight distance on Blue Creek Road. See sheet 5 for more information. Minor utility relocation may be required with this alternative.

An option for this route is to maintain Hillcrest as the thru road and tee Stratton into Hillcrest. Sight distance concerns will be evaluated and the option will be further explored in the design phase if this alternative is selected.

The estimated cost of this alternative is $7.5 million. Property acquisition will be required near the new intersection with Blue Creek Road.

Roadway Alternative 3

Reroute of Hillcrest to Collier Road

Refer to the attached plan sheets for an overview of this alternative: 1 (Key Map), 6 (Plan & Profile of Extension), and 7 (Typical Section Details). This alternative is compatible with the Landfill Overlap Alternative and the Landfill Standalone Alternative.

This roadway alternative reroutes Hillcrest Road from the intersection of Stratton Road to Collier Road, and then reconstructs Collier to meet current County Road standards. This alternative maintains the existing Blue Creek/Hillcrest intersection for access to existing private approaches on the east end of Hillcrest while shifting the remaining traffic to Collier Road. This alternative will not capitalize on the stormwater run-on ditch construction to the extent of Roadway Alternative 2 but there will be some reduction in construction costs in the Landfill Overlap alternative by coordinating the design of the road and run-on drainage ditch.

This reconstruction adds approximately 1.5 miles to Stratton Road and the southern reach of Hillcrest Road causing a delay of emergency services of approximately two minutes, but improves the northern reach of Collier Road. This improvement will result in a slight improvement in response time to residents on Collier Road. A dedicated right turn lane is recommended from Blue Creek onto Collier, and sight distance appears to be adequate. Utility relocation may be required for roadway improvements.

An option for this route is to maintain Hillcrest as the thru road and tee Collier into Hillcrest. This option will be further explored in the design phase if this alternative is selected.

The estimated cost of this alternative is $7.0 million. Significant property acquisition will be required.

SUMMARY

The existing alignment along Blue Creek Road does not provide adequate sight distance for vehicles on Hillcrest, but is adequate for vehicles on Collier Road. A dedicated right turn lane on Blue Creek is recommended for accident reduction. Two way stop control is likely adequate for landfill traffic crossing Hillcrest.

Selection of the roadway alternative is based not only on the construction costs, but on traffic safety, emergency response times, landfill benefits and public opinion. Table 4 is an example matrix that could be used to select the roadway alternate in conjunction with landfill expansion. Capital costs are ranked using a statistics-based formula. In this matrix, reconstruction of Hillcrest is the highest scoring alternative. However, this alternative is not technically feasible should the City select Landfill Overlap Alternative. In addition, the City may weight and rank these alternatives differently than shown in this draft report. The City may also have additional criteria in the selection of the preferred roadway alternative. Alternative selection will ultimately be determined by the City of Billings.

TABLE 4
CITY OF BILLINGS LANDFILL
ROADWAY ALTERNATIVE SELECTION MATRIX

CRITERIA →	Capital Cost		Safety		Emergency Response		Landfill Benefits		Public Opinion		Total
WEIGHTING FACTOR →	25		25		10		10		10		
ALTERNATIVE	Score	Wgt Score	Score	Wgt Score	Score	Wgt Score	Score	Wgt Score	Score	Wgt Score	Score
Alternative 1 Reconstruct Hillcrest	6.5	163	8	200	10	100	10	100	10	100	663
Alternative 2 Perimeter Road	4.2	105	7	175	9	90	8	80	8	80	530
Alternative 3 Collier Road	3.5	88	10	250	8	80	9	90	9	90	598

TABLE 5 CITY OF BILLINGS LANDFILL ROADWAY ALTERNATIVE SELECTION MATRIX #2		
CRITERIA →	Capital Cost	Emergency Response
ALTERNATIVE		Increase
Alternative 1 Reconstruct Hillcrest	$5.3 Million	No Change
Alternative 2 Perimeter Road	$7.5 Million	1 minute
Alternative 3 Collier Road	$7.0 Million	2 minutes

Great West Engineering

2501 Belt View Dr.
Helena, MT 59601
406-449-8627

Project Number: 1-12150
Serial Number: D4-4853
Counted By: C. Laity
Other Notes (Weather, Day of Week):

File Name : Not Named 10
Site Code : 00000000
Start Date : 10/17/2012
Page No : 1

Groups Printed- Passenger Vehicles - Trucks

	BLUE CREEK From North					BLUE CREEK From South					JELLISON From West					
Start Time	Right	Thru	Left	Peds	App. Total	Right	Thru	Left	Peds	App. Total	Right	Thru	Left	Peds	App. Total	Int. Total
07:30 AM	13	26	0	0	39	0	107	0	0	107	1	0	26	0	27	173
07:45 AM	13	38	0	0	51	0	110	0	0	110	0	0	19	0	19	180
Total	26	64	0	0	90	0	217	0	0	217	1	0	45	0	46	353
08:00 AM	8	31	0	0	39	0	90	0	0	90	0	0	15	0	15	144
08:15 AM	20	36	0	0	56	0	84	0	0	84	0	0	19	0	19	159
08:30 AM	21	25	0	0	46	0	64	0	0	64	0	0	22	0	22	132
08:45 AM	13	22	0	0	35	0	50	1	0	51	0	0	20	0	20	106
Total	62	114	0	0	176	0	288	1	0	289	0	0	76	0	76	541
09:00 AM	20	26	0	0	46	0	56	0	0	56	0	0	25	0	25	127
09:15 AM	14	29	0	0	43	0	35	2	0	37	0	0	15	0	15	95
Grand Total	122	233	0	0	355	0	596	3	0	599	1	0	161	0	162	1116
Apprch %	34.4	65.6	0	0		0	99.5	0.5	0		0.6	0	99.4	0		
Total %	10.9	20.9	0	0	31.8	0	53.4	0.3	0	53.7	0.1	0	14.4	0	14.5	
Passenger Vehicles	77	221	0	0	298	0	572	1	0	573	1	0	124	0	125	996
% Passenger Vehicles	63.1	94.8	0	0	83.9	0	96	33.3	0	95.7	100	0	77	0	77.2	89.2
Trucks	45	12	0	0	57	0	24	2	0	26	0	0	37	0	37	120
% Trucks	36.9	5.2	0	0	16.1	0	4	66.7	0	4.3	0	0	23	0	22.8	10.8

Great West Engineering

2501 Belt View Dr.
Helena, MT 59601
406-449-8627

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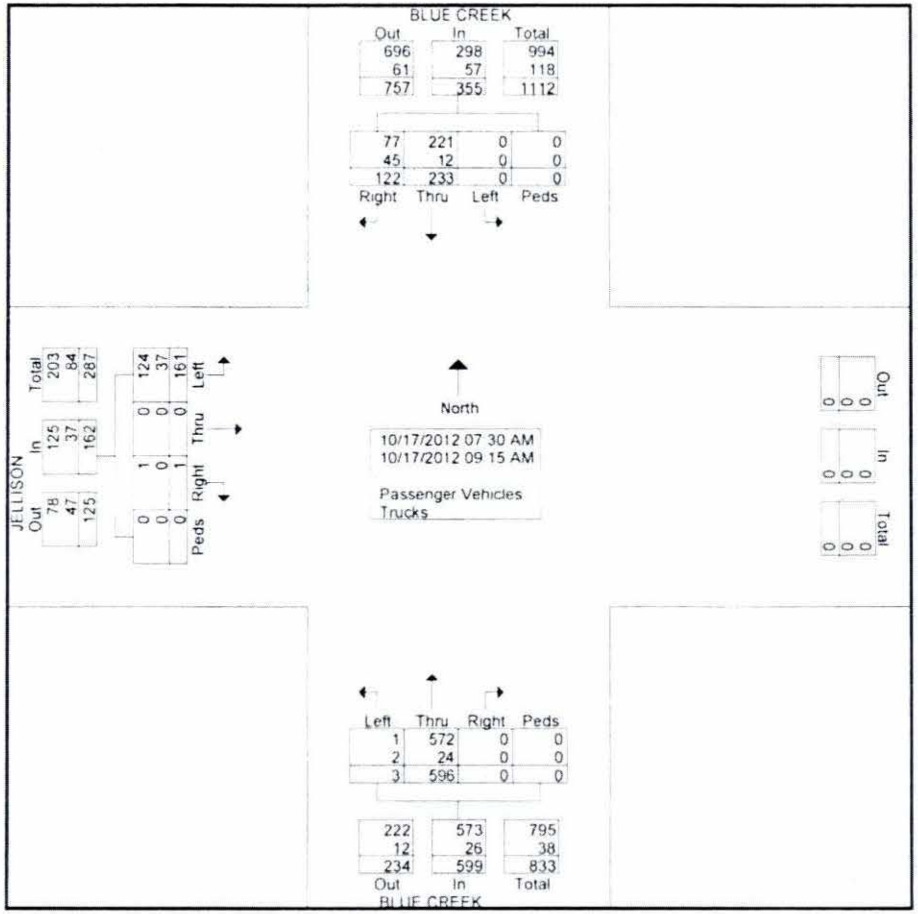
File Name : Not Named 10
Site Code : 00000000
Start Date : 10/17/2012
Page No : 2



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Other Notes (Weather, Day of Week):

File Name : Not Named 10
Site Code : 00000000
Start Date : 10/17/2012

	BLUE CREEK From North					BLUE CREEK From South					JELLISON From West					
Start Time	Right	Thru	Left	Peds	App. Total	Right	Thru	Left	Peds	App. Total	Right	Thru	Left	Peds	App. Total	Int. Total
Peak Hour Analysis From 07:30 AM to 09:15 AM - Peak 1 of 1																
Peak Hour for Entire Intersection Begins at 07:30 AM																
07:30 AM	13	26	0	0	39	0	107	0	0	107	**1**	0	**26**	0	**27**	173
07:45 AM	13	**38**	0	0	51	0	**110**	0	0	**110**	0	0	19	0	19	**180**
08:00 AM	8	31	0	0	39	0	90	0	0	90	0	0	15	0	15	144
08:15 AM	**20**	36	0	0	**56**	0	84	0	0	84	0	0	19	0	19	159
Total Volume	54	131	0	0	185	0	391	0	0	391	1	0	79	0	80	656
% App. Total	29.2	70.8	0	0		0	100	0	0		1.2	0	98.8	0		
PHF	.675	.862	.000	.000	.826	.000	.889	.000	.000	.889	.250	.000	.760	.000	.741	.911

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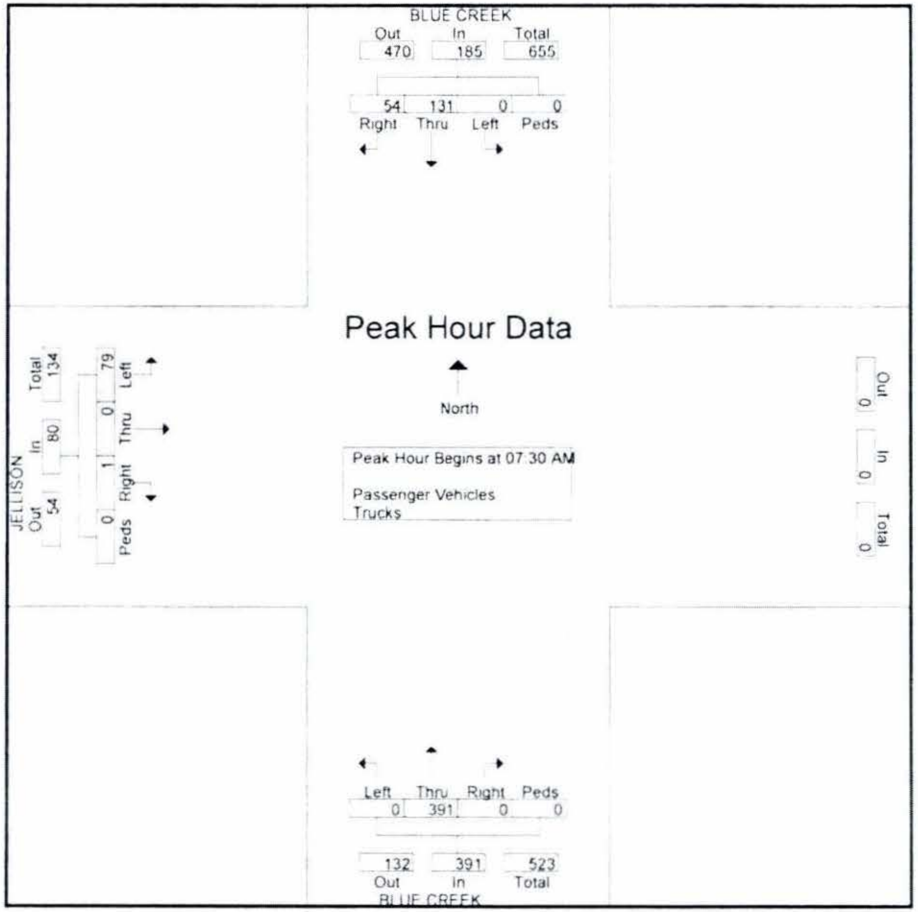
Start Date : 10/17/2012
Page No : 4



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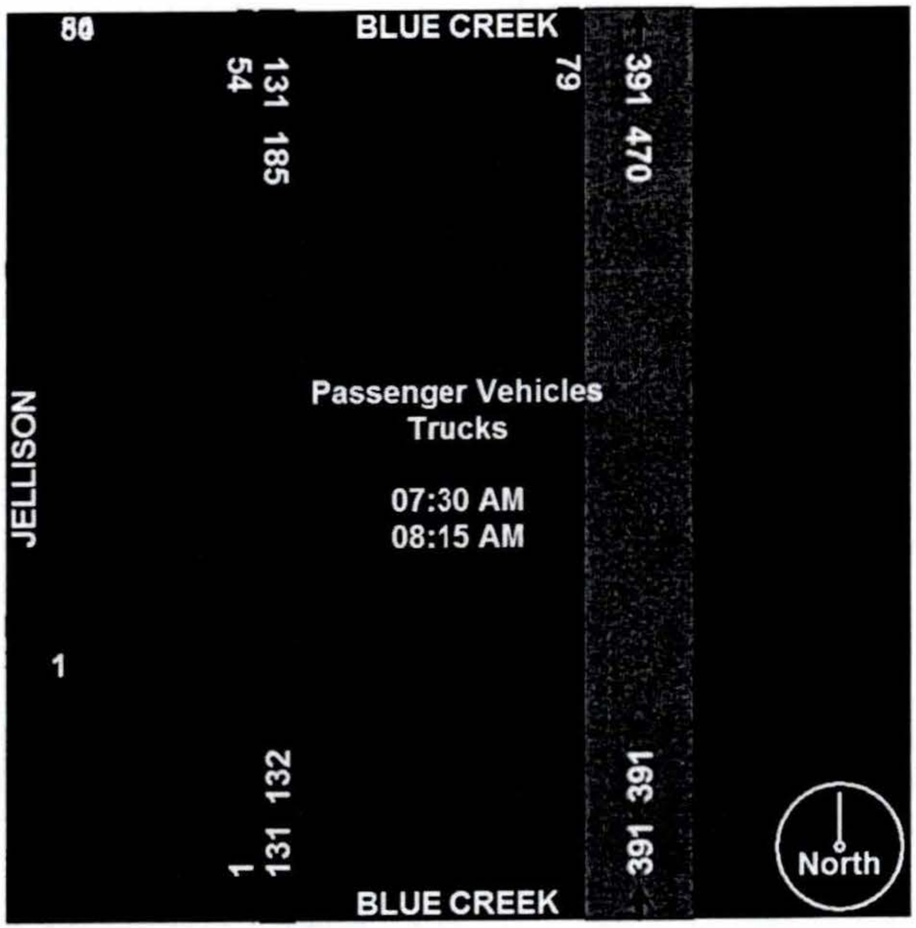
Site Code : 00000000
Start Date : 10/17/2012
Page No : 5



TWO-WAY STOP CONTROL SUMMARY

General Information		Site Information	
Analyst	C. Laity	Intersection	Blue Creek / Jellison
Agency/Co.		Jurisdiction	
Date Performed	11/11/2012	Analysis Year	2012
Analysis Time Period	7:30-8:30 10/17 - Wednesday		

Project Description 1-12150

East/West Street: Jellison	North/South Street: Blue Creek
Intersection Orientation: North-South	Study Period (hrs): 0.25

Vehicle Volumes and Adjustments

Major Street	Northbound			Southbound		
Movement	1	2	3	4	5	6
	L	T	R	L	T	R
Volume (veh/h)	0	391			131	54
Peak-Hour Factor, PHF	1.00	0.89	1.00	1.00	0.86	0.68
Hourly Flow Rate, HFR (veh/h)	0	439	0	0	151	79
Percent Heavy Vehicles	0	--	--	0	--	--
Median Type	Two Way Left Turn Lane					
RT Channelized			0			1
Lanes	0	1	0	0	1	1
Configuration	LT				T	R
Upstream Signal		0			0	

Minor Street	Eastbound			Westbound		
Movement	7	8	9	10	11	12
	L	T	R	L	T	R
Volume (veh/h)	79	0	1			
Peak-Hour Factor, PHF	0.76	1.00	0.25	1.00	1.00	1.00
Hourly Flow Rate, HFR (veh/h)	103	0	4	0	0	0
Percent Heavy Vehicles	0	0	0	0	0	0
Percent Grade (%)		0			0	
Flared Approach		N			N	
Storage		0			0	
RT Channelized			0			0
Lanes	0	1	0	0	0	0
Configuration		LTR				

Delay, Queue Length, and Level of Service

Approach	Northbound	Southbound	Westbound			Eastbound		
Movement	1	4	7	8	9	10	11	12
Lane Configuration	LT						LTR	
v (veh/h)	0						107	
C (m) (veh/h)	1442						657	
v/c	0.00						0.16	
95% queue length	0.00						0.58	
Control Delay (s/veh)	7.5						11.5	
LOS	A						B	
Approach Delay (s/veh)	--	--				11.5		
Approach LOS	--	--				B		

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Great West

DRAFT OPINION OF PROBABLE COST

PROJECT	OWNER	COUNTY	DATE
City of Billings - Roadway Alternative #2 (Perimeter Road: 45 MPH)	***City of Billings***	***Yellowstone***	***10/24/2012***

ITEM NO.	DESCRIPTION	UNIT	QUANTITY	PRICE	AMOUNT
1	Mobilization	Lump Sum	1	$552,000.00	$552,000.00
2	Soil Erosion and Pollution Control	Lump Sum	1	$15,000.00	$15,000.00
3	Excavation & Grading	Cubic Yard	325000	$8.00	$2,600,000.00
4	Geotextile Separation Fabric	Square Yard	45191	$4.00	$181,000.00
5	3" Minus Pitrun Material	Cubic Yard	17268	$30.00	$518,000.00
6	1 1/2" Minus Crushed Gravel	Cubic Yard	3343	$35.00	$117,000.00
7	Hot Asphalt Concrete Pavement	Tons	4166	$100.00	$417,000.00
8	CMP Cross-Drain Culverts (18" Diameter)	Linear Foot	780	$45.00	$35,000.00
9	RCP Drainage Culverts (36" Diameter)	Linear Foot	250	$120.00	$30,000.00
10	Seeding	Acre	22	$750.00	$16,000.00
11	Guardrail	Linear Foot	4000	$25.00	$100,000.00
12	Fencing - 3 strand barb wire	Linear Foot	300	$3.00	$1,000.00
[redacted]					
15	Ditch Blocks Permanent Erosion (Sections w/grade >5%)	Sta	30	$500.00	$15,000.00
16	Traffic Control	Lump Sum	1	$15,000.00	$15,000.00
17	Right Turn Lane on Blue Creek Road	Lump Sum	1	$175,000.00	$175,000.00
18	Reconstruct of Blue Creek Road	Lump Sum	1	$380,000.00	$380,000.00
19	Roadway Obliteration on Hillcrest	Linear Foot	500	$40.00	$20,000.00
20	Spur Road to Hillcrest	Lump Sum	1	$30,000.00	$30,000.00
		TOTAL CONSTRUCTION			$5,517,000.00
		CONTINGENCY (15%)			$828,000.00
		ENGINEERING (10%)			$552,000.00
		CONSTRUCTION MANAGEMENT (10%)			$552,000.00
		TOTAL PROJECT COST			$7,449,000.00

GreatWest

DRAFT OPINION OF PROBABLE COST

PROJECT	OWNER	COUNTY	DATE
City of Billings - Roadway Alternative #3 (Perimeter Road to Collier Road: 45 MPH)	***City of Billings***	***Yellowstone***	***10/24/2012***

ITEM NO.	DESCRIPTION	UNIT	QUANTITY	PRICE	AMOUNT
1	Mobilization	Lump Sum	1	$516,000.00	$516,000.00
2	Soil Erosion and Pollution Control	Lump Sum	1	$16,500.00	$17,000.00
3	Embankment & Grading	Cubic Yard	320000	$8.00	$2,560,000.00
4	Geotextile Separation Fabric	Square Yard	50567	$4.00	$202,000.00
5	3" Minus Pitrun Material	Cubic Yard	19322	$30.00	$580,000.00
6	1 1/2" Minus Crushed Gravel	Cubic Yard	3741	$35.00	$131,000.00
7	Hot Asphalt Concrete Pavement	Tons	4662	$100.00	$466,000.00
8	CMP Cross-Drain Culverts (18" Diameter)	Linear Foot	680	$45.00	$31,000.00
9	RCP Drainage Culverts (36" Diameter)	Linear Foot	250	$120.00	$30,000.00
10	RCP Drainage Culverts (48" Diameter)	Linear Foot	300	$150.00	$45,000.00
11	Seeding	Acre	20	$750.00	$15,000.00
12	Guardrail	Linear Foot	5000	$25.00	$125,000.00
13	Fencing - 3 strand barb wire	Linear Foot	3000	$3.00	$9,000.00
[redacted]					
16	Ditch Blocks Permanent Erosion (Sections w/grade >6%)	Sta	32	$500.00	$16,000.00
17	Traffic Control	Lump Sum	1	$40,000.00	$40,000.00
18	Cul-De-Sac on Hillcrest Road	Lump Sum	1	$20,000.00	$20,000.00
19	Right Turn Lane (On Blue Creek Road)	Lump Sum	1	$200,000.00	$200,000.00
		TOTAL CONSTRUCTION			$5,153,000.00
		CONTINGENCY (15%)			$773,000.00
		ENGINEERING (10%)			$515,000.00
		CONSTRUCTION MANAGEMENT (10%)			$515,000.00
		TOTAL PROJECT COST			$6,956,000.00

DRAFT OPINION OF PROBABLE COST

PROJECT	OWNER	COUNTY	DATE
City of Billings - Roadway Alternative #1 (Reconstruction of Hillcrest Road: 45 MPH)	***City of Billings***	***Yellowstone***	***10/24/2012***

ITEM NO.	DESCRIPTION	UNIT	QUANTITY	PRICE	AMOUNT
1	Mobilization	Lump Sum	1	$390,000.00	$390,000.00
2	Soil Erosion and Pollution Control	Lump Sum	1	$10,000.00	$10,000.00
3	Roadway Excavation	Cubic Yard	14881	$12.00	$179,000.00
4	Excavation & Grading	Cubic Yard	74674	$8.00	$597,000.00
5	Retaining Wall	Square Yard	800	$350.00	$280,000.00
6	Geotextile Separation Fabric	Square Yard	29611	$4.00	$118,000.00
7	3" Minus Pitrun Material	Cubic Yard	11315	$30.00	$339,000.00
8	1 1/2" Minus Crushed Gravel	Cubic Yard	2167	$35.00	$76,000.00
9	Hot Asphalt Concrete Pavement	Tons	2730	$100.00	$273,000.00
10	CMP Cross-Drain Culverts (18" Diameter)	Linear Foot	320	$45.00	$14,000.00
11	Seeding	Acre	4	$750.00	$3,000.00
12	Reconstruct of Blue Creek Road	Lump Sum	1	$380,000	$380,000.00
13	Guardrail (Length of retaining wall+100')	Linear Foot	800	$25.00	$20,000.00
14	Fencing - 3 strand barb wire	Linear Foot	2000	$3.00	$6,000.00
[redacted]					
17	Ditch Blocks Permanent Erosion (Sections w/grade >5%)	Sta	48	$500.00	$24,000.00
18	Right Turn Lane on Blue Creek Road	Lump Sum	1	$175,000.00	$175,000.00
19	Misc. Stratton Road Upgrades	Lump Sum	1	$10,000.00	$10,000.00
20	Traffic Control	Lump Sum	1	$140,000.00	$140,000.00
21	Driveway Approach Modifications	Lump Sum	1	$150,000.00	$150,000.00
		TOTAL CONSTRUCTION			$3,934,000.00
		CONTINGENCY (15%)			$590,000.00
		ENGINEERING (10%)			$393,000.00
		CONSTRUCTION MANAGEMENT (10%)			$393,000.00
		TOTAL PROJECT COST			$5,310,000.00

APPENDIX F

Acronyms

AFC – Alternative Final Cover

ARM - Administrative Rules of Montana

AADT - Annual Average Daily Traffic

BMP's - Best Management Practices

BP - Before Present

CFR - Code of Federal Regulations

COB - City of Billings

CQA/CQC - Construction Quality Assurance/Construction Quality Control

DEQ - Montana Department of Environmental Quality

EA - Environmental Assessment

EIS - Environmental Impact Statement

E&P - Exploration and Production

ESA - Endangered Species Act

ET - Evapotranspiration

FA - Financial Assurance

FML - Flexible Membrane Liner

FWP - Montana Department of Fish, Wildlife, and Parks

GCCS - Gas Collection and control System

GWIC - Ground Water Information Center

HDPE - High Density Polyethylene

HELP - Hydrologic Evaluation of Landfill Performance

IWMA - Integrated Waste Management Act

LCRS - Leachate Collection and Removal System

LEL - Lower Explosive Limit

LFG - Landfill Gas

LLDPE - Low Linear Density Polyethylene

MAQP - Montana Air Quality Permit

MBMG - Montana Bureau of Mines and Geology

MCA - Montana Code Annotated

MDT - Montana Department of Transportation

MEPA - Montana Environmental Policy Act

MNHP - Montana Natural Heritage Program

MPDES – Montana Pollutant Discharge Elimination System

MSL – Montana State Library

MSW – Municipal Solid Waste

NAAQS – National Ambient Air Quality Standards

NMOC – Non-Methane Organic Compound

NMD – No-Migration Demonstration

NOI – Notification of Intent

NRCS – Natural Resource Conservation Service

O&M – Operation and Maintenance

OHWM – Ordinary High-Water Mark

PCB – Polychlorinated Biphenyls

PCC – Post-Closure Care

RCRA – Resource Conservation and Recovery Act

RPOC – Relevant Point of Compliance

SHPO – State Historic Preservation Office

SpW – Special Waste

SWMA – Montana Solid Waste Management Act

SWMS – Solid Waste Management System

SWP – Montana DEQ Solid Waste Program

SWPPP – Storm Water Pollution Prevention Plan

SWS – Montana DEQ Solid Waste Section

TDS – Total Dissolved Solids

TENORM – Technologically Enhanced Naturally Occurring Radioactive Material

TPY – Tons Per Year

TSCA – Toxic Substance Control Act

USACE – United States Army Corps of Engineers

USEPA – United States Environmental Protection Agency

USFWS – United States Fish and Wildlife Service

USGS – United States Geological Survey

APPENDIX G

Response to Comments

Response to Comments on Draft Environmental Assessment Proposed City of Billings (COB) Class II Landfill Expansion Project – Billings, MT

The comment period on the draft EA started December 16, 2016. DEQ received several requests to extend the comment period. DEQ extended the comment period to March 16, 2017.

During the comment period, DEQ received approximately 585 comments on the draft EA. DEQ read and considered each comment. Because large numbers of comments addressed similar topics or themes, DEQ developed general-themed responses to address many of those related comments in one place. DEQ grouped comments by major topic and provided general responses to those topics. In some cases, specific comments were noted and responded to. This part of the document presents these responses. DEQ made changes to the final EA in response to some of the comments we received. This is reflected in the responses and the final EA is amended.

General Comment Categories

Public Notification and the MEPA Process

1:

Comment: *Why are public comments closed after January 30, (thank you for the 45-day extension) when we have another 20 to 25 years before expansion is necessary? What is the rush to move so quickly? There is no need for the facility now or in the foreseeable future given that the current facility is sufficient for at least the next 40 years.*

Response: According to the Montana Environmental Policy Act (MEPA), there is no requirement for public comment nor a specified length time for comment on an EA. The In this instance, DEQ extended the comment period to provide additional time for comment. DEQ thoroughly evaluates and analyzes public comment on EA documents and incorporates necessary changes to address substantive issues raised during the comment period. Landfill expansions are often contemplated and applied for far in advance because landfills are dynamic. Airspace in landfills is constantly filling up as long as solid waste is being accepted at landfills. Therefore, in preparation of the inevitable closure of current landfill, licensure of the expansion area in advance assures that when the current landfill closes, the expansion area will have been constructed and can begin operations to replace the closed landfill and continue to manage solid waste disposal in an environmentally sound manner. COB plans to relocate the composting operations that are currently conducted along the southern boundary of the active landfill to the expansion area within one to five years.

2:

Comment: *The EA cover letter states that DEQ will hold a public meeting to accept public comments on this proposal on January 10, 2016, from 6:30 to 8:30 p.m. in the gymnasium of Blue Creek School. The meeting was not open for public comment until 7:30 although the audience requested a question and answer period at approximately 6:45, which was denied. Why?*

Response: MEPA does not specify how agencies must conduct meetings. Instead, it provides agencies with discretion to tailor the process to each specific situation. The plan outlined for the public meeting was thoroughly discussed and the agenda agreed upon by the DEQ participants and management prior to the event. Based on past experiences, DEQ has found that an hour is usually enough time for concerns to be voiced if the participants may limit themselves to approximately 3 minutes per person. The agenda, which was distributed to the public at the door, included an open house, at which members of the public had an hour and a half to visit with the applicant, their consultants, and DEQ staff to ask questions and resolve issues of concern prior to the formal receipt of public comment. Public comments were recorded by a court reporter and a transcript was produced and placed in the facility file at DEQ. We often adjust timeframes according to the dynamics of the situation during the public meetings, as we did that evening.

3:

Comment: *Members of the public indicated that they expected some type of question and answer process and some feedback from DEQ during the public meeting on the draft EA, but there was none.*

Response: MEPA does not specify how agencies must conduct meetings. Instead, it provides agencies with discretion to tailor the process to each specific situation DEQ held an open-house style meeting so that interested persons could meet with technical experts on a one-on-one basis to individually discuss the COB proposal. The open-house was conducted prior to accepting oral comments. The oral comments received during the meeting were recorded to produce a transcript. In addition, written comments were accepted during both the meeting and the extended comment period. DEQ responds to substantive public comments in writing so a clear and definitive response to public concerns is provided. Although some verbal DEQ response may be expected during the meeting, we have realistically found that time does not reasonably allow for complete verbal responses by DEQ. Many questions require some research and extended discussion, which is why DEQ issues a written response to comments to give thorough and detailed responses to public comment and concern.

4:

Comment: *Why does the Montana Solid Waste Management Act (SWMA) establish the minimum rather than the maximum requirements for the development of Solid Waste Management Systems?*

Response: Montana's Solid Waste Management Act (SWMA) is largely based on parallel federal EPA regulations. Those federal regulations (known as RCRA subtitle D) establish many minimum requirements for solid waste management, including location, operation, design, groundwater monitoring, corrective action, closure and post-closure care, and financial assurance. In 1993, the U.S. EPA published the "Solid Waste Disposal Criteria—Technical Manual" guidance document (EPA 530-R-93-017) to further clarify the meaning and federal policy on the minimum requirements.

Under the Montana SWMA, DEQ may not adopt a rule implementing Montana solid waste laws that is more stringent than comparable federal requirements in the same circumstances unless it is required to do so by law or it first makes a specific written finding after public hearing and comment (Section 75-10-107, MCA). Because DEQ has not made a specific written finding for solid waste rules, DEQ's solid waste regulations may not be more stringent than comparable federal regulations or guidelines under the same circumstances. It should be noted, however, that many of the administrative rules adopted under the SWMA have no federal EPA counterpart and provide "stand-alone" regulation for segments of solid waste management systems licensing actions.

5:

Comment: *The EA states that the applicant's main objective is to provide for the continued economical disposal of solid wastes for the City of Billings and residents of Yellowstone County. Does this mean that the COB is looking to bring in more trash for economic gain? Does the DEQ permit and approve this course of action?*

Response: DEQ's regulatory authority does not extend to planning or site selection by the counties or solid waste management districts. The powers and duties of DEQ to license and regulate solid waste management activities are largely prescribed by *Montana Code Annotated (MCA) 75-10-204, Powers and duties of department*, which can be found on the Solid Waste Program Laws and Rules website. Duties and responsibilities require DEQ to adopt rules governing solid waste management systems that must include, but are not limited to, requiring the plan of operation and maintenance be submitted with an application and determining suitability of the site from a public health standpoint.

6:

Comment: *The DEQ did not consider sufficient alternatives to the COB proposal and did not sufficiently explain the ones dismissed, especially the possible relocation of the landfill. One commenter asked why Alternative 3 (stand-alone facility) doesn't meet the purpose as stated in Section 1.2 of the EA.*

Response: According to MEPA, alternatives are different ways to accomplish the same objective as the proposed action. MEPA requires agencies to consider only alternatives that are realistic, technologically available, and that represent a course of action that bears a logical relationship to the proposal being evaluated. According to ARM 17.4.603(2)(a), "alternative" means:

(i) an alternate approach or course of action that would appreciably accomplish the same objectives or results as the proposed action;

(ii) design parameters, mitigation, or controls other than those incorporated into a proposed action by an applicant or by an agency prior to preparation of an EA or draft EIS;

(iii) no action or denial; and

(iv) for agency-initiated actions, a different program or series of activities that would accomplish other objectives or a different use of resources than the proposed program or series of activities. -

In addition, Section 75-1-220, MCA, states that for a project that is not a state-sponsored project, an alternatives analysis does not include an alternative facility or an alternative to the proposed project itself. Therefore, DEQ only considered the approval or denial of the proposed design, operation, closure, post-closure care, and financial assurance alternatives based on site conditions applicable to the proposed facility at the proposed location. As explained above (under powers and duties), DEQ cannot consider for acceptance or dismissal any alternatives based on planning, site selection, cost, or other applicant-specific project concerns.

In all, six alternatives, including the proposed action and the no action alternative, were evaluated by the applicant as discussed in Section 2.1.1 and Appendix A of the EA. COB considered four alternatives for site configuration prior to the submittal of the application for expansion of the current landfill. COB's analysis of each alternative considered the benefits of each alternative based on site conditions, soil balance, landfill waste capacity, expansion cost, closure cost and cost per ton. These alternatives were fully discussed in the COB's February 2014 Solid Waste Alternatives Analysis as presented to residents at previous City meetings.

Three of the alternatives evaluated by COB during the did not meet the purpose and need of the applicant. COB's Alternatives 1 and 2 would require the excavation of hard rock for the construction of a large perimeter stormwater ditch to control run-on. In addition, COB Alternative 2 would require the removal of Hillcrest Road, resulting in the acquisition of additional property for the replacement of Hillcrest Road. COB determined that construction of the ditch and the costs associated with the replacement of Hillcrest Road was economically infeasible and impractical, and further evaluation of these alternatives were dismissed. COB's Alternative 3 was a stand-alone facility, but due to its configuration, COB determined that it did not provide adequate technical or financial advantages needed to justify development of an entirely new site due to the reduced design capacity and resulting limited lifespan. Therefore, COB rejected COB Alternative 3 from further consideration versus advantages found in those same project elements based on the lateral expansion adjacent to the existing facility (the proposed action).

As indicated above, an alternatives analysis under MEPA does not include an alternative facility or an alternative to the proposed project itself. COB's Alternatives 1, 2, and 3 are each an alternative facility or an alternative to COB's proposed project itself. Therefore, DEQ considered but dismissed COB's Alternatives 1, 2, and 3 without detailed analysis.

In addition to the no action alternative and the proposed action, DEQ considered, but dismissed, two additional alternatives during the evaluation of the application, which include the prescriptive liner design and the prescriptive final cover system design. These alternatives are discussed in Section 2.1.1 of the EA. DEQ dismissed these alternatives from further analysis because DEQ found that the performance-based design for the liner and final cover that COB proposed were each demonstrated as equivalent to the prescriptive designs by documents provided in the application.

7:

Comment: *What is considered the "resource analysis area"? Are Blue Creek Road and the South Yellowstone River Bridge included? Has DEQ considered the wider ecosystem (Blue Creek / Yellowstone River) that will be affected by Landfill expansion? Any answers to this question should consider flora & fauna as well as water and air quality.*

Response: According to ARM 17.4.603 (12), "Human environment" includes, but is not limited to biological, physical, social, economic, cultural, and aesthetic factors that interrelate to form the environment. An "impact" is any change to an environmental condition (resource) caused by the proposed action. A "resource analysis area" is the project area, and any surrounding area, where the existing environmental conditions could be impacted by the proposed action, regardless of significance. The extent of the resource area is defined for each type of resource in a manner that would capture any potential effects (primary, secondary, or cumulative impacts) caused by the proposed action for the resource under evaluation. The size of the resource analysis area may vary depending on the level and extent of the impact that could be expected for a resource. The department has found that one mile outside the project area boundary is generally the maximum extent necessary for analysis of potential impacts on natural resources surrounding landfills. One mile was chosen for this site specifically because of its distance outside city limits and the proximity of residences surrounding the expansion area. However, socioeconomic impacts may extend farther into nearby communities. DEQ conclusions in the EA on significance of impact to each resource is based on analysis that considers wider areas outside and surrounding the proposed site. For example, excavation of soils and stockpiling during construction of a landfill unit would directly impact soils on-site, but a secondary impact of fugitive dust may affect adjacent properties if dust was not controlled (mitigated) by operational techniques such as the application of water or soil-wetting agents during use of heavy equipment. Thus, the resource analysis area for the effects of airborne dust in the air is larger than the resource analysis area for the direct disturbance or removal of soils. Similarly, Blue Creek Road and the South Yellowstone River Bridge are included in the EA traffic analysis, but the area by the bridge is outside the resource analysis area for flora and fauna due to its distance from the landfill expansion area being over one mile.

8:

Comment: *DEQ should conduct an EIS. One commenter stated: "DEQ has preliminarily determined that there are no significant impacts from this project that would require the preparation of an Environmental Impact Statement. I strongly object to DEQ's statement that adherence to waste, water, and air regulations would mitigate any of the ... potential harmful consequences based on the EAS document." Another stated, "It is our opinion that both the city's application and the DEQ's Draft EA are lacking far too many details to move forward with approval of the permit at this time. The information in the EA, as well as that provided by the engineers and landfill personnel at the meeting, is currently only general in nature. True impacts on things such as the environment ... cannot be determined until details are known." Another asked, "Has DEQ collected baseline data so that any subsequent pollution from an expanded landfill will be identifiable?"*

Response: According to MEPA, impacts may be adverse, beneficial, or both. The EA was prepared to determine if the proposed action would result in significant impacts based upon evaluation of the criteria in ARM 17.4.608 (in Section 4.2 of the EA) for each resource. No significant impacts were identified for the proposed action that would require the development of an Environmental Impact Statement (EIS).

The EPA Subtitle-D regulations, and DEQ Solid Waste Section were formed in recognition that the health and welfare of Montana citizens are endangered by the improper operation of solid waste management systems or the unregulated disposal of wastes. The SWMA and associated administrative rules regulate solid waste management systems to ensure that the criteria intended to control and mitigate potential contaminant releases, protect public health and safety, and conserve natural resources whenever possible are met. In addition to providing for the continued economical disposal of solid wastes, the basic objectives of COB's expansion proposal are to establish a solid waste management system that safely controls the disposal of solid wastes, monitor the facility as required, and install the final vegetative cover prior to any final use of the area.

Using the factors set forth in ARM 17.4.608, DEQ determined that while the proposed action would provide the essential controls necessary to protect all resources of the human environment (in Section 3 of the EA), the proposed action would still impact some resources. However, these impacts would not significantly affect the quality of the human environment, both within the facility and resource analysis area. DEQ's findings for each resource involving the influence of all factors associated with the proposed action are contained in Section 4.2 of the final EA. When a facility is licensed and built, the long-term effects of all waste, leachate, landfill gas, dust, stormwater, and other associated control systems (Section 2.1 of the EA) are regularly monitored according to detailed plans, including sampling, lab analyses, statistics, performance evaluation, and corrective actions designed to minimize or remedy any release of pollution to the environment as outlined in Section 2.3.9 of the EA.

Vegetation and Habitat

9:

Comment: *Many existing terrestrial wildlife species were not specifically identified (e.g. some residents have observed large wandering species that include black bear, wolf, mountain lion, and moose). Further, the survey of vegetation was inadequate, and there were no "boots on the ground" surveys. One commenter asked for "proof that there would be no additional impacts to* *terrestrial and aquatic life and habitats? How do you know this?" How will a noxious weed plan implemented during all phases of the project be implemented and approved? And is it like the one currently used on county roads?*

Response: As noted in Sections 3.3 and 3.6 of the final EA, a record search of the Montana Natural Heritage Program (MNHP) database revealed that there were no threatened, endangered, species of concern (SOC) or special status (SS) designated plant or animal species identified within the landfill expansion area. The species impact analysis (provided in Sections 3.3 and 3.6 of the Final EA) is focused, as required, on impacts to threatened, endangered, SOC or SS plant and animal species identified by MNHP. Several residents have noted additional species that have been observed on or near the site, but not noted in the MNHP for the area, such as the Northern Goshawk and the Golden Eagle. MNHP has been a reliable sole source for identifying all species, while highlighting threatened and endangered species, and species of concern in the resource analysis area.

Six of the Solid Waste Program (SWP) staff have made visits to the site at various times of the year. Each of these SWP staff have different scientific backgrounds and made assessments of the property for a myriad of MEPA related observations and to evaluate and confirm the MNHP assessment of vegetation and overall habitat. Transient wildlife populations, including whitetail deer, mule deer, mountain lion, moose and many bird species, occupy the habitat within and surrounding the proposed facility boundary. Transient, by definition, means "lasting only for a short time", or "impermanent". These species exhibit transient behavior, relocating regularly and rarely remaining in one area for long periods of time. Construction and operation of the proposed facility would cause transient populations to relocate to habitats surrounding the proposed facility boundary. This is especially true in areas with regular, recurring human activity. The displacement of avian and terrestrial wildlife habitat caused by construction and operation of the facility may alter the movement of local wildlife. The proposed action would likely result in shifts in species composition from wildlife that is less tolerant of disturbance to species that adapt more readily to disturbance and increased human presence.

During landfill construction and operation, vegetation would eventually be removed from the 119-acre area of the 293-acre site that will be used for waste disposal. As stated above, there were no threatened, endangered, species of concern, or special status plant species identified by MNHP. The progressive closure along with the maintenance of runoff control systems through the life of the facility would improve vegetation and control erosion of the disturbed areas relative to the current natural condition of the site. As a result, a small gain in the amount of grazing habitat is anticipated at closure.

While any resident or transient wildlife that currently occupies the proposed expansion area may be forced to relocate from the area during construction and operation of the area, animals will also retain access to unused areas of the expansion site and gain access to closed areas of the current landfill site.

The pictures provided from nearby residents during the comment period show the presence, (as noted above in the comment) of common transient migratory species (e.g. mule deer, goshawk, golden eagle) that are clearly able to adapt to increases in the human population and all that entails (homes, schools, etc.). The same species would remain nearby to active areas, while accessing inactive areas populated by other adaptive species attracted to the site (e.g. mice, prairie dogs, rabbits, coyotes, crows, and skunks which attract raptors and large carnivores). Common animal species that inhabit these specific wooded areas (e.g. mice, squirrels, nuthatches, chickadees, downy and hairy woodpeckers, flickers, crows), and the associated wandering species also noted in the comment (fox squirrels, porcupines, cottontails, pheasants, great-horned owls, saw-whet owls, waxwings, sharp-shinned hawks, red-tailed hawks, Townsend's warblers, cedar waxwings), would be displaced into the wooded areas remaining in the second and third order side drainages flanking the landfill, even after revegetation of the landfill facility upon closure. However, considering the vast amount of similar habitat also surrounding the proposed facility boundary, the cumulative impacts anticipated for resident or transient species seen in the area are likely to be negligible.

The largest direct and cumulative impacts from the proposed COB landfill expansion will be on the limited onsite tree cover where sparse ponderosa pine, juniper, and cottonwood trees are removed along the axis of the first, second, and third order drainages located within the total 293-acre site. Fifty acres of watershed will retain the limited tree cover in the ephemeral natural drainages that remain on the property. Limited tree cover also exists in the drainages of abundant similar landscape surrounding the site to the south and east. The total impact on the local Great Plains Ponderosa Pine Woodland and Savanna or Great Plains Wooded Draw and Ravine ecotypes of the local area is anticipated to be minor.

A biological field survey for wetlands habitat was completed during the three-day investigation (October 7 - 9, 2012) of the site. The report is provided in Appendix D and discussed in Sections 3.3.2 and 3.3.3 of the final EA. There were no critical, protected, or unique habitat features identified for the site other than the small wetlands identified during the 2012 field investigation. The 14 wetlands that were identified encompass a total area of 2.41 acres; 9 of the identified wetlands are less than 0.05 acres each, and 4 are less than 0.4 acres. Only one of the wetland areas identified is greater than one-acre in size. Of the 14 wetlands, 12 are riverine wetlands associated with flow in Stream 1, a seasonal tributary to Blue Creek. Of the remaining two wetlands, one is a depressional wetland and one is a slope wetland. The wetlands are seasonal features that fluctuate based upon flow in Stream 1, precipitation, dry seasons, and drought. Any future disturbance of the wetlands for landfill construction requires that COB obtain a Section 404 permit from the U.S Army Corps of Engineers (USACE) to allow for the substitution of replacement wetlands to offset the removal of those found on site.

The noxious weed control plan will be approved by the county and monitored by the COB contractors during all phases of construction. The noxious weed control is determined by the county weed control program.

Site Access and Transportation

10:

Comment: *The traffic study should instead involve projections estimating growth in types of area traffic over the period until landfill startup and address some necessary road improvements as follows: (1) Prior to its use as the access road to the landfill expansion area, a left-turn lane should be required from Hillcrest Road to access Blue Creek Road. (2) An additional northbound lane on Blue Creek Road may be required to relieve congestion caused by garbage trucks turning south on Blue Creek Road from Hillcrest Road. (3) A left-turn lane should be required from Collier Road onto Blue Creek Road for the rerouting non-landfill traffic to avoid Hillcrest Road.*

Response: Projections of traffic flows, especially for many years into the future based on estimated development, would not be useful in determining modifications that are also many years in the future. The current traffic study provided in the Section 3.10 of the final EA provides a baseline for comparison with a future traffic study that will be required for modifications to Hillcrest Road and Blue Creek Road prior the construction of any necessary modification. In addition, any modifications to the design of the current roads based upon this future traffic study cannot be made unless approved by the Montana Department of Transportation (MDT) and Yellowstone County prior to landfill construction. The increases in traffic observed between the initial traffic study and the future study prior to the time when modifications are necessary would greatly assist in providing an accurate assessment of the improvements necessary to allow for the safe flow of all traffic at that time. The change in ratio of landfill destined traffic to total traffic flow on Blue Creek Road would be a sensitive indicator of the relative improvements necessary for landfill traffic on Hillcrest Road versus the normal traffic increases on Blue Creek Road and Collier Road due to the future development that may occur in the area.

11:

Comment: *Hillcrest Road is currently not properly designed to accommodate traffic to the proposed expansion area.*

Response: DEQ agrees. A discussion of traffic can be found in Section 3.10 of the final EA and in Attachment 10 of the final EA.

As discussed in the final EA, changes in access to the COB Class II Landfill expansion area will require modifications to Hillcrest Road. Hillcrest Road is a county collector road that serves residential and ranching properties to the south of Blue Creek Road. For the expansion application, the reconstruction of Hillcrest Road was presented as COB's preferred alternative to meet the project goal of maintaining a cost-effective method of solid waste management and providing safe access to all site users.

The level of traffic on a newly reconstructed Hillcrest Road would increase because of the expansion, but the goal of the road reconstruction efforts is to accommodate all increases in traffic. The redesign of Hillcrest Road and modifications to Blue Creek Road will be subject to review and approval by MDT and Yellowstone County. According to MDT, Blue Creek Road is an "On-System Urban Route." As a result, any work done on the roadway is under the jurisdiction of the Montana Transportation Commission. COB would be required to obtain all necessary permits prior to commencing any modifications to either road.

According to the EA, "Since modifications to Hillcrest Road are not expected to occur for 20 to 25 years, all plans for road reconstruction will first be approved by MDT and Yellowstone County as required prior to construction. As a result, any plan for future modifications to Blue Creek Road and Hillcrest Road will likely require a new traffic analysis, conducted MDT, based upon conditions at the time of landfill development." The traffic study conducted in October 2012 by MDT provided a baseline for current traffic conditions.

Blue Creek Road would be modified to approach Hillcrest Road, which is the proposed route to the landfill expansion area. Because construction of the landfill expansion area will not occur for another 20 to 25 years, a new traffic study will be conducted by MDT prior to construction of the landfill expansion area. At that time, new traffic patterns will be examined, and Blue Creek Road and Hillcrest Road will be designed according to that updated traffic study.

The currently operating landfill will be closed when the expansion has been constructed and begins operating. Therefore, all landfill operations will cease at the current landfill and will relocate to the landfill expansion area. Traffic will not double due to landfilling activities. Traffic in the area may increase due to future development of the area. When the traffic study is conducted by MDT in 20 to 25 years, data collected from that study will be used to determine what improvements will be necessary to Blue Creek Road and Hillcrest Road accommodate safe travel to the landfill expansion area at that time.

Facility Location and Property Values

12:

Comment: *The proposed landfill expansion site should be located elsewhere. One commenter stated, "According to statements made at the meeting, the current landfill is expected to reach its capacity in 30-40 years. With so much time being available, the COB should be forced to assess multiple options before being granted a permit. Options that should be considered and documented in the COB's application, as well as the DEQ EA, should include but not be limited to multiple locations."*

Response: The final site location was selected by the applicant after evaluation of several site options. DEQ does not have authority to select sites (Section 75-10-204, MCA). DEQ's evaluation of the proposed solid waste management system license application is based upon assumed compliance with the solid waste regulations and the potential impacts of the proposed facility at the proposed location. DEQ is not involved in the waste management planning processes of Yellowstone County or the City of Billings. As noted in Section 1.2 of the EA, DEQ is required under MEPA to disclose the potential impacts to the human environment that may result from the agency action (see response provided above to comments requesting an EIS). A MEPA document does not result in a certain decision, but rather serves to identify the potential effect of a state action within the confines of the existing regulations governing such proposed activities so that agencies make informed decisions. Analysis of potential impacts must be restricted to the proposed site, not some other future possibility.

13:

Comment: *The City of Billings has said that a landfill buffer zone would be maintained, yet homes will be very close to the northeast corner of the proposed expansion area.*

Response: A landfill buffer is not required by the solid waste regulations. The establishment and maintenance of a buffer zone is the choice and responsibility of COB.

14:

Comment: *Expansion of the COB landfill will cause property values for homes in the Blue Creek development, and for other homes in the areas surrounding the landfill, to decline significantly. One commenter said that her realtor claimed that the decrease in her home value was caused by the landfill.*

Response: DEQ regulates over 145 solid waste management systems statewide. Many of the large Class II landfills are located near residential subdivisions and neighborhoods with more than 20 residences. In the past 30 years, various research has been done on the effects of landfills on property values. These studies have yielded inconsistent results. Typically, hedonic regression models have been used to try to isolate the effects of landfills on property values holding all other variables constant. Surveys have also been used in studies. Some studies show statistically significant adverse effects of landfills on property values and some do not. Generally, larger effects on property values are seen from larger landfills, less modern landfills, landfills that accept hazardous waste or pose health risks, areas with negative perceptions of landfills, landfills that are more visible, and higher end properties. However, even these effects are not robust across all studies and not all of these effects were studied in every study.

The existing landfill in Billings has been accepting similar amounts of garbage for many years, having an effect all that time on existing homes within two to three miles of that facility.

Additional adverse effects from a similar landfill next to the existing one are hard to quantify and are likely less than they would be for a new landfill. Also, this is a municipal solid waste landfill and not hazardous waste facility, potentially lowering any effect on houses. Thus, it is hard to say what the impacts would be on homes. Clearly, mitigating factors such as distance from homes, visual breaks, location away from the denser Billings city limit and an existing landfill already incorporated into existing home price would lower any effect that occurs. Likewise, evidence of the lowering of a single home's value, in the absence of the type of study addressed herein, would not provide adequate proof of the effect of the Billings landfill expansion on home values in the area surrounding the site.

Surface Water and Ground Water

15:

Comment: *How will the surface water quality be monitored to ensure that the landfill expansion would not cause degradation? How can we know that landfill waste will not end up in the Yellowstone River, since the current water flow from the hills around the proposed expansion empties into Blue Creek and then into the Yellowstone River?*

Response: All runoff from the facility will be routed to the storm water detention ponds to ensure that sediment is not released if/when a discharge is necessary, as noted in Sections 2.3.21 of the EA. The landfill operator must sample the ponds for total dissolved solids and total iron before any storm water is released from the ponds and flows downstream into Blue Creek and the Yellowstone River. These actions will be required according to the facility's storm water discharge permit requirements regulated by DEQ's Water Protection Bureau. The quality of the storm water released during a controlled event from the storm water ponds is expected to be better than the quality of storm water that currently occurs naturally from the undeveloped site because it will not contain the sediment that is currently contained in the runoff from the site.

16:

Comment: *Movement of landfill structures on slippery wetted bentonite could break pipe couplings and cause leachate to flow down the coulee and onward into Blue Creek.*

Response: The proposed COB landfill site is not located in a seismic impact zone where earthquake hazards are elevated, according to the U.S. Geological Survey studies and maps.

The quality assurance procedures to be implemented during the COB landfill liner construction requires notification to DEQ if excessive moisture is encountered during excavation of the landfill base and slopes. DEQ must approve any modification of the liner or leachate system design resulting from changes in subsurface conditions before any modification may occur. As noted in the Sections 2.3.3., 2.3.4, and 2.3.5 of the final EA, the engineering design provides for base grading that will not exceed one foot of rise (or drop) over a four-foot horizontal distance, to ensure the stability of the composite liner design. The 60-mil thick, plastic flexible geomembrane liner is also textured on both sides to prevent slippage on the bentonite rich subgrade or side slopes. Textured liner has been validated for seismic stability in western Montana. As also shown in those EA sections, the leachate collected by the liner will flow to the sump and drain into a double-walled pipe that conveys leachate, by gravity, to the leachate pond. All pipe couplings will be fusion welded, creating a homogeneous joint that has been tested and the strength verified in similar applications. The leachate ponds will also be monitored for leaks.

17:

Comment: *The current contaminant impacts on groundwater and homes in Bozeman, located downhill of the landfill, have caused some concern by several commenters that a release of* *leachate by landfill seepage or overflow from the leachate ponds may pass into the central coulee that discharges downslope onto their property.*

Response: The contamination from the Bozeman landfill referenced in the comment is from an old, unlined landfill waste disposal unit at that facility. Unlike the Bozeman landfill, the Class II disposal units in COB's expansion area will be lined and are designed to contain the waste above a composite liner system that consists of a 60-mil high-density polyethylene liner placed in contact with an underlying 6-in clay liner formed by re-compacting the uppermost, highly impermeable, natural bentonite material that already exists in the ground below. A composite liner ensures that operation of the landfill would not result in contamination of any detected subsurface saturated zone. Furthermore, there is no shallow aquifer found beneath the proposed site and infiltration through the shale to the deep aquifer has been demonstrated to be highly unlikely.

In addition, as noted in EA Sections 2.3.5 and 2.3.21, the landfill includes general site grading and the construction of storm water diversion ditches, berms, and detention ponds to effectively control storm water. Lined leachate retention ponds are designed and will be constructed to store and evaporate leachate; it is unlikely that there will be discharges of leachate from the lined leachate pond. All storm water would be detained in the storm water ponds so that solids are settled before any storm water is released from a controlled event in accordance with the conditions of the facility discharge permit issued by DEQ's Water Protection Bureau. All practices noted above ensure further protection of groundwater and surface water at the proposed landfill and surrounding properties.

18:

Comment: *Why is there not a water source at the landfill? There is no mention of a proposed water source at the expansion site? And will DEQ provide hydrogeological data on the groundwater adjoining the expansion? Please describe how developing a groundwater monitoring network would be impractical in laymen's terms. This document does not offer proof of the groundwater no-migration determination.*

Response: The current landfill has a city water main supplying a potable water source. The expansion facility will also have a water main extended to it for a water source. Conditions documented during the hydrogeological and soils study, included in Appendix C in the Alternative Liner Demonstration and Geotechnical Report, support the assertion that groundwater is not contiguous, is locally recharged, and occurs as isolated, perched water-bearing zones. These are the same conditions that are dominant at the existing landfill, which is immediately adjacent to the proposed expansion area. The overall conclusion from the hydrogeologic investigation is that the property and surrounding upland areas do not present an identifiable connecting groundwater system that would allow for the placement of either background wells or downgradient wells. These conditions also exist to the immediate south and west of the expansion area and are apparent by the fact that many homes built in this area do not have wells but have cisterns and potable water is hauled in due to the lack of available groundwater.

The DEQ-approved groundwater monitoring program at the current COB has not indicated any contaminates which can be attributed to landfill leachate. Also, a search of the Montana Bureau of Mines and Geology Groundwater Information Center database revealed there are 46 wells within one mile of the proposed expansion. Forty-two wells are generally very shallow and along the alluvial aquifer related to the Blue Creek surface water drainages to the north and east of the expansion area. The remaining four wells penetrated the Mowry shale, which underlies the Belle Fourche Formation found at the landfill, one at 32 feet (unused), one at 65 feet (domestic well), one at 245 feet (use is unlisted), and one at 1,291 feet (stock water).

The speed of movement of leachate migration and landfill gas diffusion within the shale located beneath the adjacent Phase V of the existing landfill was calculated using the POLLUTE version 7.11 model software, included in Appendix C. The model has a 15-year history, and functions on the integration of data to develop rates of flow and contaminant concentrations based on diffusion. The model assumes, as a conservative input, that there is no liner and that there is no attenuation, both of which are not the circumstance at the proposed expansion area; the landfill units will be lined and natural attenuation occurs. The minimum possible travel time calculated estimated from the model output of migration time of the leachate and landfill gas to the perched groundwater was 150 years. This estimate is well beyond the expected life of the expansion plus the required 30-year post closure period.

Air Quality

19:

Comment: *Many commenters voiced their concern about fire control, dust control, and noise. Furthermore, commenters voiced concern about a fire that took place in 2016 at the current COB landfill.*

Response: Section 3.7.3.2 of the final EA discusses air quality. That discussion includes fire control and dust control.

The fire referenced by commenters was a surface fire that occurred on April 8, 2016, in the compost and brush pile area in the northeast corner of the landfill. That area occupies approximately 1.5 acres and is isolated from the rest of the landfill. It is open to landfill users for the disposal of grass clippings, and it is also where brush and yard wastes are shredded, combined with grass clippings, and eventually composted. Surface fires generally burn at relatively low temperatures and are characterized by the emission of dense white smoke and the products of incomplete combustion. In the case referenced, landfill personnel believed that the fire started from a cigarette that was discarded in the area. COB implemented their fire response plan and began an immediate response. Landfill personnel trenched around the compost/brush pile area to confine the fire. Several ladder trucks and water trucks from the Billings Fire Department and Blue Creek Fire Department responded to the fire. The fire was contained by 3:00 p.m. on the day it ignited. Fire officials decided to let the material smolder after they battled the large flames on a pile of brush. On April 13, 2016, flames flared up because of high winds in the area. Private helicopter support provided water to extinguish the flames. COB maintained a water tender on site after the Fire Department left the site and turned the response back to the COB Incident Commander. DEQ personnel inspected the landfill on April 18, 2016, to determine the extent of the smoke plume and damage from the fire. Areas of the pile were still smoldering, but the smoke was not thick and was confined to a narrow corridor from the compost/brush pile area towards the south, across Hillcrest Road. COB reported that the fire was completely extinguished by April 20, 2017.

If citizens observe smoke or fires after hours, they are requested to call 911.

A discussion of dust control can be found in the final EA in Section 2.3.19 and on page 26 in Attachment 1. The EA states, "If dust from construction becomes a problem, dust control measures, such as wetting the surface before working on it, must be initiated as required for large earthwork activities, such as road construction." Additionally, "Fugitive dusts generated from disposal activities would be mitigated by adequate dust control measures on the interior roads and applying a dust palliative or water to the waste materials before disposal. Traffic within the proposed expansion area due to continued landfill operations would cause an increase in the levels of airborne dust during the dry months of the year, but those levels would be like the dust levels at the current COB landfill. Dust control measures on the interior roads, such as applying a dust palliative or water, would lessen the impact of airborne dust generated because of landfill operations." The areas where dust could become problematic are at the operational face of the landfill (where garbage is deposited), the daily cover excavation area (where the soil is stockpiled and later moved and placed over the garbage), and along landfill access roads. Some methods used to control dust on access roads include gravel on road surfaces, water spraying via water truck, and magnesium chloride application to non-paved road surfaces. These would limit impacts to make them minor.

Operation and Maintenance

20:

Comment: *Who is responsible for air quality at the present landfill and how often has it been monitored? What is currently being done to monitor the air quality of the surrounding areas of the landfill?*

Response: The COB Landfill currently does not hold a Montana Air Quality Permit, which would be subject to regulation and inspection by DEQ's Air Quality Bureau. COB does not operate an incinerator or exceed the emissions threshold limit. The COB has recently requested an operating permit under ARM 17.8.12, also known as Title V of the Clean Air Act. Subchapter 12 operating permits are required for major sources of air pollution and are state and federally enforceable. A final version of the Subchapter 12 operating permit was issued in 2018. A Subchapter 12 permit program must incorporate all applicable air quality regulations and a renewal application must be submitted every five years so that the operating permit remains current. The operating permit identifies all air quality rules and regulations applicable to a facility. For the COB landfill, the operating permit specifies limits applicable to methane emissions and fugitive dust emissions.

DEQ operates an air monitor on Coburn Road, on the southeast side of Billings, that measures sulfur dioxide and weather readings such as temperature, humidity, and wind speed. DEQ also operates an air monitor east of Billings in Lockwood, MT, that takes weather readings. Additional non-regulatory monitoring of volatile organic compounds, nitrogen oxides, and ozone occurs at the Lockwood site. Billings and the project area meet the current Montana and national ambient air quality standards for all regulated pollutants.

21:

Comment: *Are disposal units areas where dumping occurs?*

Response: That is correct.

22:

Comment: *What is friable asbestos? And what are the disposal requirements for friable asbestos and dead animals?*

Response: Friable asbestos is any material that contains more than one percent asbestos by weight or area, and is material that can be crumbled, pulverized or reduced to powder by the pressure of a human hand. COB's disposal requirements for asbestos-containing waste are that asbestos be transported in 6-mil leak-tight plastic containers and that it must be delivered by appointment only. The following is from the COB's February 2015 Operations and Maintenance (O&M) Plan for the landfill expansion, which is included in Attachment 1 of the Final EA.

The COB Landfill is concerned with two major issues with asbestos management; 1) release of fibers to the environment and protection of persons at the facility, and 2) recordkeeping for compliance with state rules and federal regulations. Both issues are interconnected. The Federal regulations on the National Emissions Standards for Hazardous Air Pollutants (NESHAP), Occupational Safety and Health Administration (OSHA), and State requirements as outlined in the

"Montana Asbestos Work Practices and Procedures Manual of 2005 (the Montana Manual)" all work to provide a comprehensive framework for asbestos management. The Billings Landfill must provide a reasonable and safe working environment for its employees, so all asbestos-containing waste (ACW) will be subject to scrutiny and proper management, regardless of their source.

The process starts at the construction, renovation, or demolition site. While individual homeowners are exempt from federal regulation under the NESHAP, the landfill will still be required to manage the ACW properly to protect workers and the users of the facility. The Billings Landfill manages all ACW the same, regardless of the source, for the protection of workers and users of the facility. All transportation and disposal of ACW, no matter the source, is regulated.

ACW from multi-family and commercial facilities are subject to the federal and state regulations and require inspections and proper management. The results of these inspections should be presented to the scale operator at the time the load arrives at the landfill. To prevent delays while the scale operator determines the acceptability of the waste and its proper placement within the facility, commercial contractors will be urged to present inspection certifications to the landfill office prior to sending wastes to the facility. All inspection certifications will be placed in the landfill's operating record.

All ACW will be covered at the end of the working day with a minimum of two feet of soil. The City's heavy equipment will be equipped with positive pressure cabins so that any dust from asbestos wastes cannot easily enter the cabin. Dust masks will be also made available for the operators. Finally, operators will be instructed to cover the wrapped asbestos waste without disturbing the wrapping if possible.

Dead animals are buried as soon as practical by digging a hole in the waste and covering the carcass.

23:

Comment: *Many commenters voiced their concerns about noise coming from the landfill.*

Response: A discussion of noise can be found in Section 3.12 of the EA and page 27 of Attachment 1.

There is noise associated with the current landfill operations. The current landfill location will cease operation once the proposed landfill expansion area is constructed. Therefore, no additional long-term impacts to noise are anticipated. There may be a temporary increase in noise generated from construction activities. Any noise coming from the proposed landfill expansion area will be similar to noise coming from the current landfill facility. There are noise limitations imposed by the Department of Labor and Industry to protect workers from hearing damage. Procedures to be implemented to minimize noise include using proper mufflers on vehicles and operating equipment and limiting operating hours. Because it is a landfill, there will be some noise associated with operation and maintenance of the facility. Additionally, most residences are more than a half a mile away from the proposed site, minimizing the noise that can be heard from the landfill. Therefore, noise effects would be minor.

24:

Comment: *Many commenters voiced their concerns about the compliance with and oversight of the operation and maintenance plan that COB is required to follow.*

Response: A discussion of the O&M plan can be found in Section 2.3.9 of the EA and in Attachment 1.

COB's O&M plan is a DEQ-approved document which governs the daily operation of the facility. The O&M plan is required to be updated as needed, but at least every five years, to accommodate updated operations, new disposal techniques, regulatory changes, or designs modifications. When adhered to, the O&M plan ensures compliance with state and federal regulations at licensed solid waste management systems.

The O&M plan for the proposed expansion is divided into six different categories:

- General site description
- Landfill design
- Landfill operations
- Facility maintenance
- Operations and maintenance task list
- Contingency plans
- Methane, Stormwater, and Leachate Monitoring

Some specific items in the O&M plan include:

- General operating procedures
- Fire protection program
- Dust control
- Noise control
- Waste diversion
- Waste screening
- Litter control

DEQ inspects each licensed Montana landfill at least twice annually to ensure compliance with its DEQ-approved O&M plan. In many cases, landfills are inspected multiple times a year. When violations are noted during inspections, DEQ provides compliance assistance and provides a specific timeframe for the landfill to return to compliance. The public is encouraged to inform DEQ's Solid Waste Program or Enforcement Division of any violations at a landfill. When notified, DEQ will conduct inspections to verify the complaint and assist the facility back into compliance in a timely manner. If a facility fails to comply, it will be referred to DEQ's Enforcement Division where further measure may be taken to ensure that compliance is reached and sustained.

COB's proposed O&M plan includes daily, weekly, monthly, quarterly, semi-annual, and annual tasks to ensure ongoing compliance.

To address ongoing off-site litter issues at the current landfill, COB has committed to the construction of a transfer station at the Jellison Road entrance to the facility. Waste arriving at the landfill will be delivered to the transfer station, where it will be compacted before being taken by COB employees to the working face for final disposal. These improvements will greatly assist in controlling litter at the current landfill and the proposed expansion area.

25:

Comment: *How is the waste screening process going to be implemented by COB?*

Response: A discussion of waste screening can be found in Section 2.3.14 of the EA and pages 6 and 7 in Attachment 1.

COB will be responsible for ensuring that any identified hazardous or prohibited wastes will be set aside and dealt with appropriately, rather than being landfilled. This program includes a multi-tiered waste screening program including:

- Visual screening at the scale via TV cameras

- Questioning by the scale operators
- Inspection of the waste by facility equipment operators at the working face
- Random comprehensive load inspections at the scale house

Random load inspections will be initiated at the scale house. The minimum frequency of random load inspections will be 1% of all commercial/industrial vehicles. Furthermore, COB will inspect haulers which have had compliance issues more frequently. Records of the random load inspections will be maintained by COB.

The waste screening program outlines actions to be taken by the staff and management of the landfill in the event of hazardous or prohibited wastes being discovered.

Other

26:

Comment: *Does the DEQ permit the COB to accept trash from outside Yellowstone County? There are some conflicts between the EA and the city's website.*

Response: Yes, COB is permitted to accept trash from outside Yellowstone County.

27:

Comment: *The City of Billings is not in compliance with required litter control today; how can it be trusted for further expanding the source of the problem?*

Response: Adequate litter control is required according to approved procedures in the landfill Operation and Maintenance (O&M) Plan. The active COB landfill submitted an updated plan for improved litter control that includes special provisions for windy periods. The updated plan was reviewed and approved by DEQ. In accordance with the approved plan, the City has purchased and is using additional wind screens to capture litter around the active working face where garbage is deposited. It has also reduced the size of the working face to minimize the potential for windblown litter. The City has indicated that most of the litter originates while garbage is being unloaded by residents or dump trucks. Keeping the working face limited to a smaller area will reduce the volume of loose, uncovered wastes during working hours. The City is also currently evaluating the conditions necessary to suspend delivery and disposal of waste when the potential for the generation of uncontrolled windblown litter is high. An irrigation system was installed, and trees and bushes were planted along the north side of Hillcrest Road between March and May 2017. Not only will this provide a visual barrier, but it will also help prevent litter from migrating toward the south side of Hillcrest Road. Finally, the City has stated it is fully committed to reducing windblown litter issues at the landfill. To that end, they are currently completing the design of an indoor drop-off facility at the current landfill. The drop-off facility will provide a more manageable waste stream by having residents and commercial trucks unload inside an enclosed building.

28:

Comment: *The City should focus more on alternatives for waste reduction and recycling versus bringing in more waste from wider area and landfill expansion.*

Response: The consideration of alternatives for the planning of waste management activities is outside the scope of regulated environmental issues that are considered by DEQ during its review and decision on any application to license a solid waste management facility. Thus, any decision to encourage or develop waste reduction and recycling activities is the sole responsibility of the City.

There are currently three private recyclers in the Billings area that offer options to the public. These recyclers charge a fee for the collection activities, but the service is offered, and the recyclers do have a customer base that is willing to pay for the service. The City also provides drop off bins for newspaper and aluminum cans and currently distributes curbside bins for composting and yard waste. The City has a partnership with Yellowstone E-Waste for electronics recycling and regularly hosts events for the collection of household hazardous waste. The landfill has drop-off sites for cardboard, used oil, and antifreeze.

29:

Comment: *Given the landfill will rise above the existing grade, what are the effects on view-shed for the Cedar Park and Briarwood subdivisions? What are the current and final elevation for the expansion? One commenter remarked that the landfill would always remain visible from the higher elevation of their property, which is west of Hillcrest Road and south of the proposed expansion. No qualitative or quantitative data analysis was involved, such as BLM Visual Resource Management. Another stated that, "In my opinion, the expansion will provide the valley floor of the COB with a great view of a mega landfill."*

Response: The elevation of the landfill will rise very little relative to surrounding natural grade at a modest three-to-one slope. By filling the coulee, the peak 3,550-foot elevation of ultimate grade at closure is about 150 feet above Hillcrest Road adjacent to the north. According to analysis of potential visual impacts in Section 3.11.3.2, most of the operations will not be visible as the base and slopes of the coulee is filled with waste. Trees would be planted along the north perimeter of the landfill, south of Hillcrest Road. These vegetative barriers would be developed prior to commencement of the southern landfill expansion to shield the distant view from homes located in Cedar Park or Briarwood north of Blue Creek Road. The trees would also shield the view of drivers heading south along Hillcrest Road approaching the landfill from the north.

Views from homes west of Hillcrest Road that are located more than one-half mile south to southwest of the landfill expansion are partially blocked by elevated topography located east of Hillcrest Road. These have only limited northward views of the southernmost perimeter of the facility. The topographic barriers to views of the proposed landfill area would limit the effects on viewshed. Thus, there will be very limited views for a short time period. In view lines from the distances and locations noted above, the closed landfill would appear as a small grassy knob rising within and blending into the surrounding largely grassy rangeland. The objective of the Bureau of Land Management (BLM) Visual Resource Management is to manage public lands in a manner which will protect the quality of the scenic values of these lands as required by Federal law. The analysis provided in the final EA and supported by this response meets the same goals.

30:

Comment: *Landfilling activities are not allowed on the expansion property that is located adjacent to the Hillcrest Natural Area Foundation property, and COB may not conduct daily landfill operations in a manner such that they are visible from the Hillcrest Natural Area.*

Response: In January 1997, the City of Billings and the Hillcrest Natural Area Foundation completed a land exchange where 30 acres of City-owned property was exchanged for 17.45 acres of Foundation-owned property. The terms of the exchange prohibit the City from extending landfilling operations into the 17.45-acre parcel. The parcel at issue in that land exchange is separate from the expansion area, and, thus, the prohibition against landfilling activities described by commenters does not apply to the expansion area. The terms also require that COB conduct its landfilling activities at the existing landfill in such a manner that daily operations are not visible from the Hillcrest Natural Area.

31:

Comment: *One commenter noted, "I have been told by several people who have lived in Billings for many years, that in their memory, dinosaur remains have been found near the landfill. Some feel these sites are now covered under the present landfill as well as some sites adjacent to the landfill on Hillcrest. Would this previous knowledge not be available from the National Register of Historic Places or some other agency that the DEQ is familiar in knowing of these matters? If this is true is it not logical to archeologically investigate for dinosaur remains on the proposed expansion site?*

Response: In its research concerning this application and EA, DEQ found no evidence to support this theory of dinosaur fossil beds. If they are found, the facility will be required to contact the proper authority to do further investigation and receive instruction on how to proceed once remains have been discovered.

32:

Comment: *One commenter stated, "I intend this letter to be not only a statement about the EA, but also a complaint about the way the City of Billings is operating the present Billings Landfill. I demand that you investigate this continual trash and litter situation fully and take all appropriate legal action against the City of Billings with respect to its operation of the Billings Landfill."*

Response: DEQ has written violation letters to COB for litter, cover, monitoring, and other performance issues, but has not found it necessary to request an enforcement action. COB has corrected the problem in each incident. It has also committed to the construction of a transfer station at the lower entrance to the facility. This additional operation will collect and compact all waste delivered to the landfill before it is taken to the working face. These improvements will greatly assist in litter and other problems of the past.

33:

Comment: *The statement that the expansion will not take place for decades is incorrect and the actual expansion will start in 3 to 5 years.*

Response: A discussion of the timeframe for the construction of the expansion area can be found in Section 1.1 of the final EA.

"COB will relocate the composting operations that are currently conducted along the southern boundary of the active landfill to the expansion area within one to five years." Essentially, the blended materials (yard waste, wood waste, etc.) would be transported to the expansion area to be composted. "Construction of new disposal units and associated appurtenances within the proposed expansion are is not expected to commence for another 20 to 25 years."