Bozeman Landfill Selected Alternative Report

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PRESENTED TO

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TABLE OF CONTENTS

LIST OF FIGURES

ACRONYMS/ABBREVIATIONS

Acronyms/Abbreviations	Definition
AI	Air Injection
ARM	Administrative Rules of Montana
AS	Air Sparging
BTU	British Thermal Unit
CMA	Corrective Measures Assessment
DEQ	Montana Department of Environmental Quality
GPS	Groundwater Protection Standards
LFG	Landfill Gas
PCE	TetraChloroethene
POTW	Publicly Owned Treated Works
PSIG	Pounds Per Square Inch Gage
SCFM	Standard Cubic Feet per Minute
SVE	Soil Vapor Extraction
UST	Underground Storage Tank
VZAI	Vadose Zone Air Injection
Volatile Organic Compounds	Volatile Organic Compounds

1.0 INTRODUCTION

This Selected Remedy Report describes the design and implementation of Alternative F as described in Tetra Tech's Corrective Measures Assessment (CMA), September 4, 2014, which was approved by DEQ on March 31, 2015. The following discussion pertains to how the DEQ-approved remedy (Alternative F) meets the standards outlined in Administrative Rules of Montana (ARM) 17.50.1309 (2) through (4).

Alternative F includes two main sets of activities. The first is the installation of six new Landfill Gas (LFG) extraction wells within the unlined cell waste mass. These wells will be installed during July or August of 2015. The second is the installation of a Soil Vapor Extraction (SVE) system and Vadose Zone Air Injection (AI)/Air Sparging (AS) system along the southern boundary of the landfill. The SVE and AI/AS wells are expected to be installed during late 2015 or early 2016, and the systems commissioned by mid-2016.

2.0 REMEDIAL APPROACH, OBJECTIVES AND GOALS

As outlined in the investigations conducted at the site, LFG generated as a result of historic waste disposal in the unlined landfill cell has resulted in the detection of volatile organic compounds (VOCs) in groundwater and soil gas at the southern boundary of the unlined cell and in certain downgradient areas.

In March 2015, a comprehensive risk assessment was completed by CPF Associates on behalf of the City to evaluate potential human health exposures down gradient of the landfill in the Bridger Creek Phase 3 community. Based on the results of that risk assessment, CPF concluded that VOC concentrations pose no unacceptable risks to adjacent residential receptors. Further, natural attenuation processes are evident, with concentration declines in petroleum hydrocarbon and chlorinated solvent constituents observed in groundwater and soil gas.

Assessment of the fate and transport of constituents in soil gas indicates that soil vapors detected down gradient of the landfill are primarily a result of soil gas transport from the landfill (based on pressure and temperature gradients) with partitioning of constituents from groundwater into soil gas a secondary contributor. Based on this conceptual site model, the remedial approach has been developed to meet the following goals and objectives.

2.1 GOALS

The primary goal of Alternative F is to achieve compliance with Groundwater Protection Standards (GPS) at downgradient groundwater monitoring wells (compliance points).

Secondary remedial goals associated with Alternative F include:

- Reducing flux of landfill gas leaving the southern boundary of the site and support the ongoing attenuation of groundwater impacts downgradient of the landfill; and
- Maintaining and enhancing source control measures within the landfill to remove VOC mass and potential flux downgradient from the landfill.

2.2 OBJECTIVES

To achieve the goals described above, the design of Alternative F has been prepared with the following measureable objectives used in development of the remedial strategy and design:

- Produce measureable reductions of VOCs in groundwater at downgradient groundwater monitoring wells.
- Produce measureable reductions in the flux of constituents in soil gases leaving the southern boundary of the site.

- Produce a measureable increase in source control (the collection and destruction of LFG gas from the waste prism) through the installation of additional LFG wells and improved operation of the LFG collection system.
- Design and build operational flexibility into all remediation components so that their operation can be adjusted or additional components can be added over time. This includes ensuring additional capacity in all components for expansion of or adjustment to the system in the future if necessary.

3.0 GENERAL OVERVIEW OF REMEDIAL COMPONENTS

As described above, the remedy consists of two major components focused on addressing the flux of landfill gas, impacted groundwater and soil gas from the landfill site. In combination with these active treatment activities, natural attenuation processes in groundwater and soil gas will continue to facilitate declines in constituent concentrations downgradient of the landfill.

3.1 INSTALLATION OF ADDITIONAL LFG WELLS

The presence of LFG constituents (VOCs) in soil gas off-site is an indication that the LFG being generated within the waste mass is not being fully captured by the existing LFG wells. To address the limitations of the existing system, the collection efficiency of the existing landfill gas extraction system will be increased through the installation of six additional LFG extraction wells. **Figure 3-1** depicts the proposed LFG extraction well locations relative to the existing extraction wells.

In addition to improving the capture of LFG, the additional LFG extraction wells will:

- Enhance LFG collection efficiency in the southeast corner of the waste mass where the highest concentrations of perchloroethylene (PCE) have been detected;
- Improve the quality and British Thermal Unit (BTU) content of the LFG that is extracted, allowing the flare to operate more reliably; and
- Make it easier to optimize LFG collection in the southern portion of the unlined cell, as each well will be collecting from a smaller, more defined area of the waste mass.

3.2 INSTALLATION OF SVE AND AI/AS WELLS ALONG SOUTHERN LANDFILL BOUNDARY

To further address the potential flux of constituents off-site, SVE and AI/AS wells will be installed along the southern boundary of the landfill property. **Figure 3-1** shows a conceptual layout of the SVE and AI/AS wells.

The proposed spacing between SVE wells is based on the results of the pilot test program, with wells to be installed in both the higher permeability (gravelly sands) and medium permeability (silt, sandy silt) units to maximize capture of soil gases.

As shown on **Figure 3-1**, AI/AS wells are proposed to be installed south of the SVE wells so that carrier gas flow (primarily ambient air) can be intercepted by SVE wells before reaching the waste prism. In addition, AS wells are proposed to be installed where there is sufficient saturated thickness and no impediments to the vertical movement of air and its capture by the SVE system. In order to properly balance the treatment of groundwater with the need to ensure that air injected into the saturated zones is appropriately captured, the precise placement and construction of the AS wells will need to be decided in the field based on geological conditions encountered at the site. The AI/AS wells will likely be pulsed to provide efficient stripping and effective capture by the SVE wells.

A compressor will be used to deliver air to the AI/AS wells. Gases and potentially condensate will be extracted by a vapor extraction system and directed to a treatment skid, where condensate will be separated and stored and gases treated in the landfill gas flare. It is proposed that condensate will be sampled and will be incorporated into an industrial pretreatment permit issued by the City of Bozeman. This industrial pretreatment permit application package will be submitted to DEQ prior to the commencement of activities.

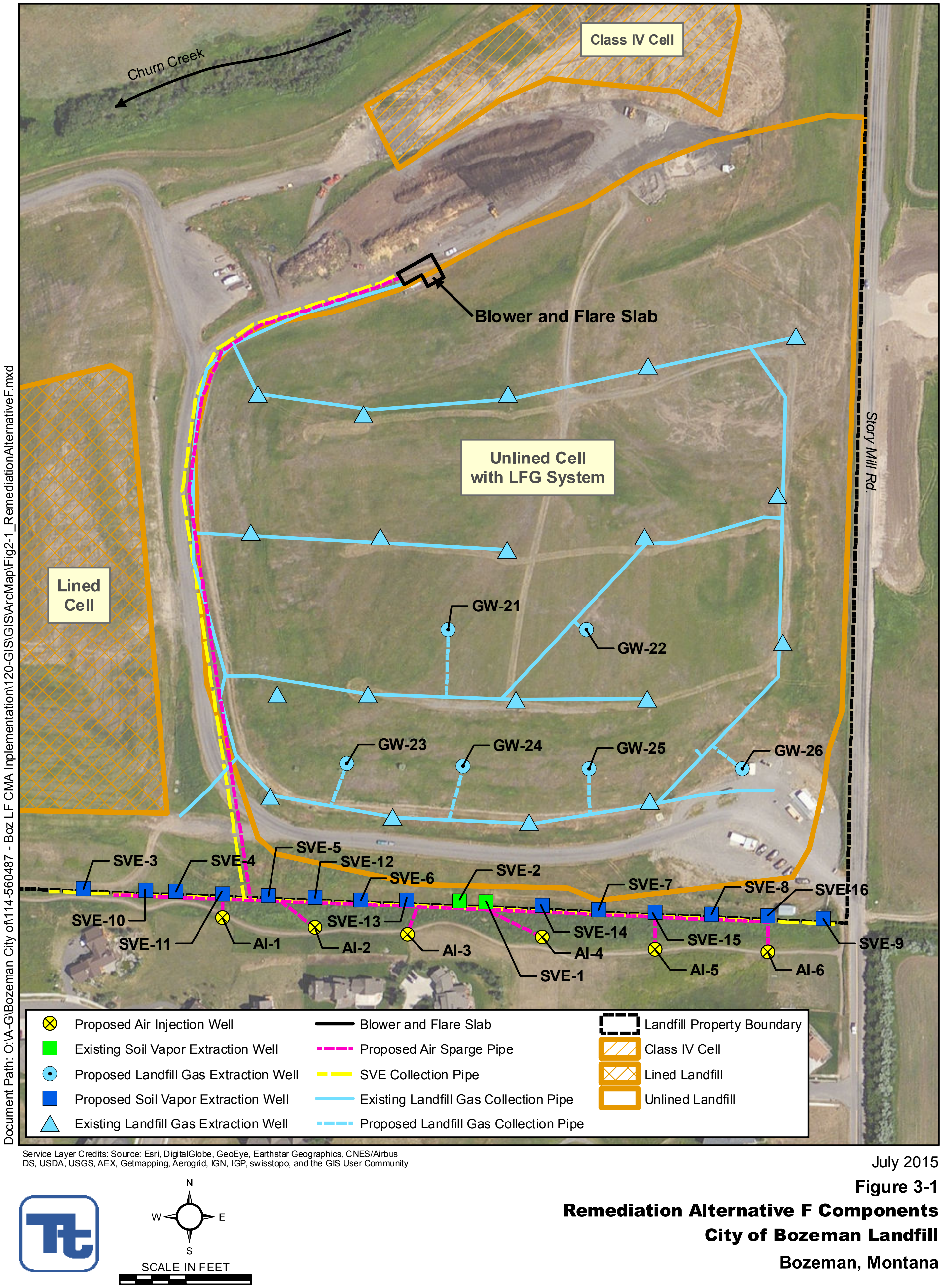

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Figure 3-1

Remediation Alternative F Components

City of Bozeman Landfill

Bozeman, Montana

4.0 HOW SELECTED REMEDY WILL SATISFY ARM STANDARDS

The following discussion addresses each of the criteria set forth in ARM 1750.1309 (2) through (4) and describes how the selected remedy will meet those criteria.

4.1 BE PROTECTIVE OF HUMAN HEALTH AND ENVIRONMENT (ARM 1750-1309[2][A])

The human health risk assessment referenced in Section 2.0 above indicates that VOCs are generally present at very low concentrations and pose no unacceptable risks to human health or the environment.

The selected remedies will provide continued protection of human health and the environment through a combination of active treatment of the source, management of flux at the boundary, and natural attenuation processes in downgradient areas. Operation of the enhanced LFG recovery wells will remove additional VOC mass from the landfill and provide additional containment of landfill gases, while operation of the SVE, AI and AS wells will mitigate the flux of vapor phase and dissolved phase constituents beyond the boundaries of the site. In response to operation of these systems and natural attenuation processes, VOC concentrations in groundwater and soil vapor are anticipated to decline.

4.2 ATTAIN THE GROUNDWATER PROTECTION STANDARDS (ARM 1750-1309[2][B])

The selected remedies are expected to achieve compliance with Groundwater Protection Standards (GPS) for the constituents of concern at the southern property boundary of the landfill and at down gradient compliance points. The amount of time to achieve compliance with GPS depends on the increased efficiency of LFG removal in the unlined cell, the flux reduction achieved by the SVE/AI/AS system, as well as the extent and rate at which natural attenuation remediates groundwater conditions downgradient of the property boundary.

4.3 CONTROL THE SOURCE(S) OF RELEASES (ARM 1750-1309[2][C])

The selected remedies provide multiple levels of source control that will mitigate continued flux of constituents in soil gas and groundwater downgradient of the site. The selected remedies will increase the collection efficiency of the existing LFG extraction system and will remove VOCs from the vadose zone and reduce the potential flux of constituents to groundwater. In addition, the movement of air will facilitate removal of VOC mass from groundwater within the landfill area.

At the southern boundary of the landfill, the SVE/AI/AS system will remediate the vadose zone and upper saturated zone, reducing the flux of constituents to downgradient areas.

4.4 COMPLY WITH STANDARDS FOR MANAGEMENT OF WASTES (ARM 1750-1309[2][D])

The selected remedies will comply with standards for management of wastes. The additional LFG collected by the expanded LFG extraction system and soil gas collected by the SVE/AI/AS system will undergo thermal destruction with an upgraded thermal destruction system (i.e., enclosed flare). This type of system is designed to achieve a 99% destruction efficiency and will have an emission quantity that will comply with air quality regulations and the landfill air quality permit.

4.5 SHORT- AND LONG-TERM EFFECTIVENESS AND PROTECTIVENESS (ARM 1750-1309[3][A])

Operation of the selected remedies will result in both short- and long-term effectiveness and protectiveness. The proposed remediation activities will be effective because they combine: 1) enhanced LFG collection and control of potential flux to groundwater down gradient of the landfill, 2) removal of VOCs in the vadose zone at the boundary of the site, and 3) removal of VOCs from the groundwater at the boundary of the site.

By adding six new LFG wells within the waste mass in the unlined cell, reductions in the off-site migration of LFG are expected immediately. In addition, modeling indicates that LFG concentrations will continue to decline over time in response to decomposition of the waste materials.

The SVE/AI/AS system is similarly expected to be immediately effective at mitigating the flux of vapor and dissolved phase constituents off of the landfill site. As discussed above, the system has been designed with SVE wells at multiple depths (to address differences in soil air permeability with depth) and both AI and AS wells to address the varying saturated thickness of the gravel unit.

VOC concentrations in the vadose zone along the southern landfill boundary are expected to rapidly decline after the SVE system is put into operation, but may rebound after the system is turned off (due to slow back diffusion of volatile constituents out of the soil). Reductions in groundwater concentrations are also anticipated in response to operation of the AI and AS wells, although reductions in concentrations may be slower than that observed in the soil vapor extracted by the SVE wells.

Pulsed operation of the SVE system and AI/AS systems is proposed to maximize VOC removal efficiencies with extended episodes of shutdown conducted to facilitate vapor rebound and efficient cleanup.

In addition to these short-term results, the system will provide long-term effectiveness as the management of flux from the site will allow for natural attenuation of the VOCs already downgradient of the site. Once compliance with the GPS is achieved, the SVE and AI/AS systems will be shut down or operated intermittently. The LFG collection system will continue to be operated at the site for the foreseeable future and well after shutdown of the SVE and AI/AS systems.

4.5.1 Magnitude of Reduction of Existing Risks (3)(a)(i)

Human exposure to impacted groundwater is not expected because residences down gradient of the landfill site are connected to municipal water. Similarly, based on the risk assessment described in Section 2.0 above, VOCs in soil gas south of the landfill are in concentrations that do not present an unacceptable indoor air risk, and residences in down gradient areas have been equipped with operating vapor mitigation systems in any event. The selected remedies will ensure that any potential existing risks, however small, continue to remain within acceptable risk ranges.

4.5.2 Magnitude of Residual Risks (3)(a)(ii)

See Section 4.5.1 above. In addition, any residual risks will continue to diminish over time due to natural aging processes at the landfill.

4.5.3 Type and Degree of Long-Term Management Required (3)(a)(iii)

The LFG collection system and SVE/AI/AS system will each require operational adjustments, monitoring, and maintenance to ensure continuous, effective, and long-term operation. These requirements are expected to decrease over time once the GPS is achieved and the SVE/AI/AS system is either shut down or operated intermittently.

4.5.4 Short-Term Risks from Implementation of the Remedy (3)(a)(iv)

Short-term risks from implementation of the remedy would be similar to any construction project and include physical safety hazards that workers may be exposed to during drilling, trenching, and use of heavy equipment. In addition, workers installing the additional LFG wells and trenching through the waste would have potential exposure to LFG containing methane, hydrogen sulfide, and trace VOCs. Concentrations of methane may pose an explosion or fire hazard within the immediate vicinity of the LFG wells and system. These potential hazards will be greatly diminished for the trenching and installation of the SVE/AI/AS wells and ancillary equipment outside of the waste prism.

During routine operation and maintenance of the system, workers would have potential exposure to low levels of LFG. Typical hazards would be present in the operation, maintenance, and monitoring of the remedy. The potential for cross-media impacts should be minimal because VOCs in extracted LFG and soil gas (from the SVE/AI/AS system) would undergo thermal destruction at the enclosed flare.

4.5.5 Time Until Full Protection is Achieved (3)(a)(v)

The flux of constituents in soil gas and groundwater will be mitigated upon commissioning of the selected remedies and the systems, in combination with natural attenuation processes, and are expected to achieve the GPS downgradient of the site over time. The time period for achievement of GPS in downgradient wells is uncertain but is anticipated to be less than 5 years.

Even after GPS are achieved, the LFG collection system will likely operate continuously initially but at some future date may operate intermittently until the landfill no longer generates significant quantities of gas and full protection is achieved without gas extraction. Based on modeling, it is anticipated that the system will operate at least 10 more years.

4.5.6 Potential for Exposure to Humans and the Environment to Remaining Wastes, Considering the Potential Threat to Human Health and the Environment (3)(a)(vi)

As discussed above, the potential for exposure to humans and the environment to VOCs in soil gas and groundwater is considered negligible. The combination of capping, fencing, and natural attenuation processes limit potential exposures to VOCs within the landfill and downgradient areas.

In addition, implementation and operation of the selected remedies will mitigate the flux of VOCs downgradient of the landfill site, further diminishing any negligible threat to human health and the environment associated with the remaining wastes in the landfill.

4.5.7 Long-Term Reliability of the Engineering and Institutional Controls (3)(a)(vii)

The remedy selection and engineering design have been conducted to ensure long-term reliability. The six new LFG wells proposed to be installed within the unlined cell will increase the overall BTU content of the LFG thermally destroyed by the flare, which should in turn increase the long-term reliability and efficiency of the collection system.

In addition, SVE/AI/AS systems have been operated extensively across the US for greater than 30 years and have proven to be effective and operationally reliable. The components of SVE/AI/AS systems are also readily available, and integration of the SVE and LFG extraction components into the enclosed flare provides a highly reliable means of destruction of VOCs in soil gas.

Institutional controls are already in place and being implemented at the landfill. These include the following: 1) maintaining the final cover; 2) making any necessary repairs to address subsidence, erosion, and other similar events; 3) maintaining run-on and run-off grades and structures; 4) maintaining the groundwater monitoring system; 5) monitoring the groundwater; 6) maintaining the perimeter methane monitoring system; and 7) monitoring methane levels in perimeter methane monitoring wells.

4.5.8 Potential Need for Replacement of the Remedy (3)(a)(viii)

The remedies selected for the landfill are proven remedies used at other landfills and facilities with similar impacts to soil and groundwater. The remedies selected were among a variety of available remedies considered. It is anticipated that these remedies will be effective. No consideration is given to another remedy or remedies at the present time.

4.5.9 The Effectiveness of the Remedy in Controlling the Source to Reduce Further Releases (3)(b)

See Sections 4.3 and 4.5 above.

4.5.10 The Extent to which Contaminant Practices will Reduce Further Releases (3)(b)(i)

Contaminant practices are considered to be the remedies selected. Further releases could be from LFG produced in the unlined cell and additional leaching of constituents to groundwater within the cell. The addition of LFG extraction wells in the unlined cell will provide for greater containment of the LFG, preventing migration beyond the cell boundary and removing VOC mass that could potentially leach to groundwater. The SVE/VZAI/AS system will reduce VOC concentrations in soil gas and groundwater migrating beyond the landfill boundary.

4.5.11 The Extent to which Treatment Technologies will be Used (3)(b)(ii)

The treatment technologies will be used extensively to achieve measurable reductions of VOCs in soil gas and groundwater. The treatment technologies proposed and designed are considered standard practice technologies and have been demonstrated to be effective in controlling the source.

4.5.12 The Ease or Difficulty in Implementing Potential Remedies, Based on Consideration of the Following Factors (3)(c)

The selected remedies can be installed and implemented with relative ease.

4.5.12.1 Degree of Difficulty Associated with Constructing the Technologies (3)(c)(i)

Construction of the selected remedies is not considered difficult. It is anticipated that if construction is conducted during summer or fall, then excavations and piping installations would not face the challenges of working in freezing weather.

4.5.12.2 Expected Operational Reliability of the Technologies (3)(c)(ii)

The selected remedies are expected to be reliable if operated correctly. With regard to the LFG extraction system in the unlined cell, addition of the higher BTU LFG from the six new LFG wells will increase the overall BTU content of the LFG destroyed by the flare. In addition, an enclosed flare is proposed to replace the existing candlestick flare currently treating the extracted LFG. Together, the anticipated increase in BTU content and the new enclosed flare should significantly increase the operational reliability of the collection system.

Like the LFG collection system, SVE and AI/AS systems have proven to be effective and operationally reliable at numerous contaminated sites across the country and in a variety of environments and climates. The same is expected here.

4.5.13 Need to Coordinate with and Obtain Necessary Approvals and Permits from Other Agencies (3)(c)(iii)

There is a need to coordinate with and obtain necessary approvals and permits from Montana Department of Environmental Quality (DEQ). DEQ will review all documents and permit requests and provide approval. This will pertain to design and construction of the selected remedies. DEQ will conduct review of an air permit modification for the new flare and emission of treated LFG.

4.5.14 Availability of Necessary Equipment and Specialists (3)(c)(iv)

There is availability of necessary equipment and specialists to construct the remediation systems. A drilling company specializing in LFG collection wells must be brought in from out of state; otherwise, a Montana driller and a local general contractor can install the SVE and AI/AS wells, valving, and piping.

4.5.15 Available Capacity and Location of Needed Treatment, Storage and Disposal Facilities (3)(c)(v)

Treatment (thermal destruction) of the LFG and extracted soil gas would be on site. Condensate produced during operation of the systems would be stored in an existing 4,000-gallon Underground Storage Tank (UST). The condensate would be conveyed to the City of Bozeman water reclamation facility for treatment in accordance with the industrial pretreatment permit referenced in Section 3.2. The UST has sufficient storage capacity to accommodate the anticipated condensate production rates.

4.5.16 Practical Capability of the Owner or Operator, Including Consideration of Technical and Economic Capability (3)(d)

The City of Bozeman has been operating the existing LFG collection system at the landfill for almost 20 years. With assistance from its remediation consultants and contractors, the City has the technical capability to implement the selected remedies. The City also has the financial capability to implement the selected remedies, with financial assistance for capital construction costs provided by the Montana Water Pollution Control State Revolving Fund (WPCSRF).

4.5.17 The Degree to which Community Concerns are Addressed by the Potential Remedies

It is believed that community concerns regarding the presence of VOCs in soil vapor and groundwater down gradient of the landfill site will be addressed by implementation of the selected remedies. A recent public meeting where remedial alternatives were discussed and justification of the selected remedies provided indicated that there was acceptance by the community.

5.0 REMEDIATION SCHEDULE

The selected alternative relies on two separate mechanisms to effect remediation. The first of these is an active component consisting of the installation and operation of all of the remedial components, including LFG wells, SVE wells, AI/AS wells and a new enclosed flare for disposal of collected LFG. This active component provides source control and reduces off-site flux of VOCs. The second component is a passive component that relies on diffusion, dispersion, dilution and natural degradation to achieve reductions in VOCs that have migrated off-site.

The anticipated remedial schedule for both of these components is described in the following paragraphs. This schedule has been determined based on all the factors in ARM 17.50.1309(4), and implements the remedial activities as quickly as possible given existing permitting, contracting, funding, and manufacturing constraints.

5.1 ACTIVE REMEDIATION

The schedule for active remediation (consisting of installation of Alternative F and its operation) is relatively short and has been initiated as of the date of this writing. Plans and specifications for construction of the Alternative F components have been prepared and submitted to DEQ for approval. Following DEQ approval, the City will advertise for bids to construct the system and proceed to construction and operation of the selected alternative. **Figure 5-1** shows an estimated schedule for construction of the Alternative F components.

Most of the construction is slated to begin in mid-October of 2015 and will conclude in early April of 2016. However, it is anticipated that new LFG wells will be installed and connected to the existing blower and flares during July or August of 2015. This schedule is dictated by a number of factors that could affect the construction schedule, including the need to obtain authorization from DEQ to construct and install the new flare.

In addition, there is a significant lead time for some major equipment items. SVE blowers and related equipment will be manufactured off-site, mounted on a skid, and delivered by truck to the site. According to the manufacturer, delivery of the skid would be anticipated 16-20 weeks following placement of an order. These two items (air permitting and skid manufacture and delivery), both of which are not controlled by the City, dictate the schedule for completion of Alternative F.

5.2 PASSIVE REMEDIATION

The active system described above will remediate VOCs that are under or adjacent to the landfill, but will not remediate VOCs that have migrated off-site in soil vapor or groundwater south of the landfill. To remediate these VOCs, Alternative F relies on natural mechanisms such as diffusion, dilution, dispersion and degradation. These natural processes are already working at the site and will be enhanced upon implementation of the active remediation measures described above.

Figure 5-1
Estimated Timeline for Alternative F Implementation