Final Design Report
Environmental Components for
Globeville Landing Outfall Project

Vasquez Boulevard/Interstate 70 Site,
Operable Unit #2 Removal Action

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TABLE OF CONTENTS

1 INTRODUCTION .......................................................................................................................... 1
  1.1 Background ............................................................................................................................... 1
  1.2 Purpose and Objectives ............................................................................................................. 1
  1.3 Report Organization ................................................................................................................. 2
2 OVERVIEW OF GLOBEVILLE LANDING OUTFALL PROJECT ............................................. 3
  2.1 GLOP Overview ....................................................................................................................... 3
  2.2 Environmental Components ..................................................................................................... 4
3 WASTE MATERIAL MANAGEMENT ......................................................................................... 7
  3.1 Nature and Extent ..................................................................................................................... 7
  3.2 Screening, Staging, and Disposal ............................................................................................... 8
4 IMPERMEABLE BARRIER SYSTEM DESIGN ............................................................................ 10
  4.1 Objectives ................................................................................................................................. 10
  4.2 Subsoil Stabilization ................................................................................................................. 10
  4.3 Geogrid and Strengthening Layer ............................................................................................. 12
  4.4 Impact to Groundwater Flux ................................................................................................... 12
  4.5 Impermeable Barrier ............................................................................................................... 13
5 DEWATERING AND TREATMENT DESIGN ............................................................................. 14
  5.1 Dewatering .............................................................................................................................. 14
  5.2 Dewatering Water Management/Treatment ............................................................................ 19
6 DELIVERY STRATEGY ................................................................................................................ 25
  6.1 Procurement ............................................................................................................................. 25
  6.2 Construction Management ...................................................................................................... 25
7 COST AND SCHEDULE ............................................................................................................. 26
  7.1 Cost ........................................................................................................................................ 26
  7.2 Schedule ................................................................................................................................. 26
REFERENCES ................................................................................................................................. 27

LIST OF TABLES

Table 1 – Simulated and Recommended Dewatering Flow Rates and Durations
Table 2 – Comparison of Simulated and Recommended Dewatering Flow Rates and Durations
Table 3 – Groundwater Constituents of Concern vs Stream Standards
Table 4 – Treatability Test Results
Table 5 – Cost Estimate
Table 6 – Implementation Schedule

LIST OF FIGURES

Figure 1 – Potentiometric Surface Map, July 2015
Figure 2 – Simulated Potentiometric Surface Map Post-Construction
Figure 3 – Organizational Structure
TABLE OF CONTENTS (continued)

LIST OF APPENDICES

Appendix A - Materials Management Plan
Appendix B - Health and Safety Plan
Appendix C - Methane, Odor, and Dust Control Plan
Appendix D - Subsoil Stabilization and Barrier Material Evaluations
Appendix E - Groundwater Modeling Studies
Appendix F - CDPHE WQCD Discharge Permits
Appendix G - Drawings
Appendix H - Specifications
Appendix I - Liner Construction QA Plan
# LIST OF ACRONYMS

<table>
<thead>
<tr>
<th>Acronym</th>
<th>Description</th>
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<tbody>
<tr>
<td>bgs</td>
<td>Below ground surface</td>
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<tr>
<td>BMPs</td>
<td>Best Management Procedures</td>
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<tr>
<td>CABI</td>
<td>Certified Asbestos Building Inspector</td>
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<tr>
<td>CDOT</td>
<td>Colorado Department of Transportation</td>
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<td>Colorado Department of Public Health and Environment</td>
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<td>CDPS</td>
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<tr>
<td>cfs</td>
<td>Cubic feet per second</td>
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<tr>
<td>COC</td>
<td>Constituent of Concern</td>
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<td>Denver Arapahoe Disposal Site</td>
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<td>Data Summary Report</td>
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<td>ELLS</td>
<td>Electrical Leak Location System</td>
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<td>Engineering Management Support, Inc.</td>
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<tr>
<td>ft amsl</td>
<td>Feet above mean sea level</td>
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<tr>
<td>GAC</td>
<td>Granular Activated Carbon</td>
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<td>GLOP</td>
<td>Globeville Landing Outfall Project</td>
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<td>IC</td>
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<td>Linear Low-Density Polyethylene</td>
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<td>Materials Management Plan</td>
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<td>OU-2</td>
<td>Operable Unit #2</td>
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<tr>
<td>oz/sy</td>
<td>Ounce per square yard</td>
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<tr>
<td>PCE</td>
<td>Tetrachloroethene</td>
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<tr>
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<tr>
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<td>TCE</td>
<td>Trichloroethene</td>
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<tr>
<td>Abbreviation</td>
<td>Full Form</td>
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<td>--------------</td>
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</tr>
<tr>
<td>ug/L</td>
<td>Micrograms per liter</td>
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<tr>
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<tr>
<td>VC</td>
<td>Vinyl Chloride</td>
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<tr>
<td>VOCs</td>
<td>Volatile Organic Compounds</td>
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1 INTRODUCTION

1.1 Background

On behalf of The City and County of Denver (Respondent), Engineering Management Support, Inc. (EMSI) in conjunction with R.K. Frobel & Associates and Itasca Denver, Inc., has prepared this Pre-Final Design Report for “environmental components” of the Globeville Landing Outfall Project (GLOP). The GLOP entails installation of a stormwater drainage feature through a portion of Operable Unit 2 (OU 2) of the VB/I70 Superfund Site. OU 2 consists of portions of the Denver Coliseum property, adjacent commercial properties, and Globeville Landing Park.

The Respondent is implementing the “environmental components” pursuant to an Administrative Settlement Agreement and Order on Consent for Removal Action (Agreement) with the United States Environmental Protection Agency (USEPA). The stormwater drainage feature is part of a larger project that is intended to reduce flooding in the Park Hill and Montclair drainage basins and address stormwater management needs associated with projects being developed by Regional Transportation District (RTD), Colorado Department of Transportation (CDOT), and the Respondent.

The “environmental components” addressed in this design document consist of:

- Management and handling of waste material encountered during construction of the GLOP through the Denver Coliseum parking lot and Globeville Landing Park;
- Mitigation of methane gas, odors, and fugitive dust that may be released during construction of the GLOP;
- Design and construction of an impermeable barrier system to prevent contaminants remaining within the boundaries of the OU-2 from adversely impacting stormwater retained within and conveyed by the GLOP, as well as prevent stormwater infiltration into contaminated media remaining beneath or surrounding the GLOP; and
- Management and treatment of dewatering liquids produced during construction of the GLOP.

1.2 Purpose and Objectives

In accordance with Statement of Work attached to the Agreement, this design submittal contains the following elements:

- Design criteria and pertinent monitoring and material management plans;
- Incorporation of comments from USEPA and Colorado Department of Public Health and Environment (CDPHE) on the Draft Design Report (EMSI, 2015a), Pre-Final Design Report (EMSI, 2015b), pre-Final Materials Management Plan (EMSI, 2015c), and pre-Final Methane, Odor, and Dust Control Plan (EMSI, 2015d);
- Pre-Final drawings and specifications;
• An updated project delivery strategy;
• An updated construction schedule; and
• An updated construction cost estimate.

1.3 Report Organization

This design report contains seven sections and nine appendices. Following this introduction, the remaining sections consist of:

• Section 2 – Overview of Globeville Landing Outfall Project
• Section 3 – Waste Material Management
• Section 4 – Barrier System Design
• Section 5 – Dewatering and Treatment System Design
• Section 6 – Delivery Strategy
• Section 7 – Cost and Schedule

Supporting appendices consist of:

• Appendix A - Materials Management Plan
• Appendix B - Health and Safety Plan
• Appendix C - Methane, Odor, and Dust Control Plan
• Appendix D - Subsoil Stabilization and Barrier Material Evaluations
• Appendix E - Groundwater Modeling Studies
• Appendix F - CDPHE WQCD Discharge Permits
• Appendix G - Drawings
• Appendix H - Specifications
• Appendix I - Liner Construction QA Plan
2 OVERVIEW OF GLOBEVILLE LANDING OUTFALL PROJECT

The GLOP is the furthest downstream component of a larger drainage project in north Denver referred to as the Two Basin Drainage Project. The Two Basin Drainage Project will provide drainage improvements that will alleviate known flooding problems in the Park Hill and Montclair drainage basins, support construction of the RTD North Metro Line, support the redevelopment of the National Western Complex, and redirect runoff away from the future below-grade section of Interstate 70 (I-70) between Brighton and Colorado Boulevards.

The estimated flow associated with the 100-year precipitation event affecting the combined drainage basins has been modeled to produce a peak flow of approximately 3,750 cubic feet per second (cfs) (Merrick, 2015). The estimated flows from the 100-year precipitation event and 10-year precipitation event (2,500 cfs) are the primary bases of design for the GLOP conveyance structures (Merrick, 2015).

Other design objectives for the GLOP include, but are not limited to, improvement of stormwater quality from the drainage basin, enhancement of ecological habitat, and provision for a recreational amenity that is aesthetically pleasing. These additional objectives will be met by:

- Incorporating an open-channel feature that can passively treat water via sinuous flow through constructed wetlands;
- Vegetating the open-channel features with a variety of grasses and shrubs in low-lying areas and trees and shrubs in upland areas;
- Creating a wildlife movement corridor; and
- Constructing a visually-attractive feature that can be observed by visitors walking or bicycling on trails adjacent to the open channel.

2.1 GLOP Overview

The GLOP is located within Operable Unit 2 of the VB/I70 Superfund Site, on property owned by the Respondent. Operable Unit 2 encompasses the Denver Coliseum parking lot, adjacent commercial properties, and Globeville Landing Park. The Coliseum parking lot is underlain by a landfill that predates the Resource Conservation and Recovery Act (RCRA) of 1984. The Globeville Landing Park is underlain by soil mixed with construction debris. The general alignment of the GLOP passes through both the Coliseum parking lot and Globeville Landing Park, as shown on Sheet EC-2 in Appendix G.

Design of the GLOP conveyance structures is being provided by Merrick and Company (Merrick), who is under contract to Urban Drainage and Flood Control District. Geotechnical engineering for the GLOP is being provided by CTL Thompson under subcontract to Merrick. These and other companies are working collaboratively with the Urban Drainage and Flood Control District, North Denver Cornerstone Collaborative,
Denver Parks, Denver Transportation Department, Denver Public Works, and Denver Department of Environmental Health (Environmental Quality Division) to address the design objectives stated above. The GLOP can be described as follows:

Starting at the southeastern boundary of the Denver Coliseum parking lot, stormwater will be conveyed through cast-in-place, double 15’ wide x 8’ high reinforced concrete box (RCB) conduits (see Cross-Sections D and E on Sheets EC-10 and EC-11, respectively, in Appendix G). The downstream end of the RCB conduit will be widened to about 60’ wide by 4’ high to reduce velocities for frequent storm events by distributing flow across a wider area. This will also enhance the visual appearance of the outlet. From the RCB conduits, flow will enter an open channel structure where it will be routed through constructed wetlands. The open channel system will extend from the RCB conduit outlet through the southern end of the Coliseum parking lot into Globeville Landing Park (see Cross-Sections A and B on Sheet EC-9 in Appendix G). In the Park, drainage from an existing 32’ wide x 6’ high RCB conduit outfall that passes beneath the Pepsi Bottling facility and Arkins Court will be rerouted from its current outfall alignment to the new open channel. The open-channel bottom will have an approximate 1% slope to its sides with a longitudinal slope of approximately 0.4% to 0.7%. Side slopes will be 4H:1V or flatter and terraced where feasible (Merrick, 2015).

Combined flows passing through the open channel segment in the Globeville Landing Park will exit to a vertical drop inlet structure positioned at the downstream end of the open channel. This location is immediately east of two large-diameter sanitary sewer lines (77” brick pipe and 78” concrete pipe). The inlet structure will convey drainage vertically downward into about a 32’ wide x 4’ high box culvert that will extend beneath both sanitary sewers. Discharge from the box culverts will enter a second open channel feature that will route flow to the South Platte River (Merrick, 2015). See Cross-Section D on Sheet EC-10.

The vertical inlet structure and box culvert are designed to convey the 10-year storm flow. Flow from higher recurrence intervals will be routed through an overflow berm over the top of the sanitary sewers where water will be allowed to “sheet flow” to the South Platte River. A portion of the overflow will be conveyed to the outfall channel downstream from the box culvert to the South Platte River. The outfall channel is designed to convey the 10-year low-flow and the 100-year flood-flow. Ground conditions over and downstream from the sanitary sewers will be protected to prevent soil erosion over the sewers, and downstream from (west of) the sewers (Merrick, 2015).

2.2 Environmental Components

Design of the “environmental components” of the GLOP is being provided by EMSI in conjunction with its team members R.K. Frobel & Associates and Itasca Denver, Inc. Pertinent geotechnical engineering services are being provided by CTL Thompson as part of its work for Merrick. These companies are also working collaboratively with the Urban Drainage and Flood Control District, North Denver Cornerstone Collaborative, Denver Parks, Denver Transportation Department, Denver Public Works, and Denver
Department of Environmental Health (Environmental Quality Division) to address the “environmental components” discussed below:

- **Removal and off-site disposal of waste material from the Coliseum parking lot (Materials Management Plan provided by EMSI).** Waste material that occupies the volume of the RCB conduit and open channel segment, plus associated lay-back and any over-excavation volumes will need to be removed and properly disposed.

- **Removal and on-site beneficial use and/or off-site disposal of “soil and debris” from Globeville Landing Park (Materials Management Plan provided by EMSI).** Soil and debris that occupies the volume of the open channel segment, box culvert beneath the sanitary sewers, and outfall channel downstream of the box culvert, plus associated lay-back and over-excavation volumes will need to be removed and properly managed.

- **Strengthening of waste material in the Coliseum parking lot beneath the RCB conduit and open channel segments to support the weight of the conveyance structures (design provided by CTL Thompson under contract to Merrick).** Strengthening of underlying waste material is considered an “environmental component” because without it, underlying waste material would need to be removed and replaced with competent fill. The more cost-effective alternative to removal and replacement is strengthening with engineered columns or piers (CTL Thompson, 2015b). Accordingly, two types of columns are being proposed by CTL Thompson:
  
  o Use of compacted grout columns beneath the RCB conduits. These columns will extend from the top of bedrock to the base of the RCB conduits to enhance the compressive strength of the underlying waste material; and
  
  o Use of Vibro-Stone columns beneath the segment of open channel that passes through the Coliseum parking lot. Vibro-Stone columns are caissons constructed of gravel that are vibrated into place. Beneath the open channel, Vibro-Stone columns are preferred over compacted grout columns because the in-place gravel will be more permeable than grout columns. The higher permeability is needed to maintain the natural direction of groundwater movement beneath the Coliseum parking lot (discussed further in Section 4 of this report).

- **An impermeable barrier system beneath the open channel system through both the Coliseum parking lot and Globeville Landing Park (design provided by R.K Frobel & Associates).** The impermeable barrier system will prevent discharge of contaminated groundwater to surface water, and minimize surface water infiltration to groundwater (Frobel, 2015a). In the Coliseum Parking lot, the barrier system will minimize surface water infiltration to groundwater from stormwater flows up to the 100-year recurrence interval (Merrick, 2015). In the
Globeville Landing Park, the barrier system will minimize surface water infiltration to groundwater from stormwater flows up to the 2-year recurrence interval (Merrick, 2015). The latter objective is less stringent than the former because: 1) soil conditions in the Park are less permeable than those in the parking lot, which translates to less surface water infiltration to groundwater; 2) the Park surface is currently landscaped with irrigated turf, as opposed to being covered with an impermeable parking lot – thus engineered measures to mitigate percolation/infiltration beyond that which currently occurs is not necessary, and 3) the duration of stormwater flows in excess of the 2-year recurrence interval are relatively short – thus additional engineered measures to mitigate relatively short-term infiltration to groundwater are not necessary.

- **Pumping and treatment of dewatering liquids produced during construction (dewatering design provided by Itasca Denver and water treatment conceptual design provided by EMSI).** Because the base elevations of each conveyance structure will be at or below the current groundwater table, temporary lowering of the water table by up to 10 feet at some locations will be required to maintain dry working conditions. Extracted water may be: a) treated on-site and released to the South Platte River or Toll Gate Creek under discharge permits issued by the Colorado Department of Public Health and Environment Water Quality Control Division (CDPHE WQCD); b) treated on-site and beneficially used on-site; c) trucked off-site to a licensed industrial treatment facility; and/or d) if an industrial treatment facility is available, trucked off-site to Resource Conservation and Recovery Act (RCRA) Subtitle C treatment facility, even though the groundwater is not a hazardous waste.

- **Methane, odor, and dust control throughout the project (Methane, Odor, and Dust Control Plan provided by EMSI).** Mitigation measures for methane, odor, and fugitive dust releases during construction, and for potential methane releases following construction will be required. Such measures are described in a Methane, Odor, and Dust Control Plan that is appended to this Design Report.

Designs and plans for all of these environmental components are addressed in the following sections of this report.
3 WASTE MATERIAL MANAGEMENT

This section reviews the nature and extent, management, disposal, and methane/odor/dust control measures needed for the waste materials that will be encountered.

3.1 Nature and Extent

Detailed assessments of the nature and extent of waste material beneath the Denver Coliseum parking lot and “soil and debris” beneath the Globeville Landing Park are presented in the Data Summary Report (DSR) (EMSI, 2015e). Information contained in that document is critical to the basis of design for the “environmental components” of the GLOP. Additional characterization of waste material and “soil and debris” was performed by Brown and Caldwell (2010) and CTL Thompson (2011). Consequently, the DSR, Brown and Caldwell (2010), and CTL Thompson (2011) reports are incorporated into this Design Report by reference. Conclusions and recommendations from these documents are summarized below:

Waste material from the Coliseum parking lot, and “soil and debris” from the Globeville Landing Park are neither listed hazardous wastes nor hazardous waste by characteristic. Constituents that were tested, but were either not detected or detected at concentrations below EPA’s Risk-Based Screening levels, consisted of volatile organic compounds (VOCs), semi-volatile organic compounds (SVOCs), polychlorinated biphenyls (PCBs), and metals. In addition, the samples passed the paint filter test. However, waste material from the Coliseum parking lot contains decomposing organic material that originated from past landfilling activities (pre-RCRA). Therefore, in the absence of Regulated Asbestos-Containing Soils (RACS), waste material excavated from the Coliseum parking lot may be profiled as a special non-hazardous, non-RACS solid waste that will require disposal at a RCRA Subtitle D landfill. The Denver Arapahoe Disposal Site (DADS) will provide this service.

“Soil and debris” samples from the Globeville Landing Park contain soil and construction debris. In the absence of RACS, this material may also be considered non-hazardous, non-RACS, but because it does not contain putrescible waste material, it is not considered a waste that must be disposed in a RCRA-permitted landfill. In addition, the compounds of concern in “soil and debris” other than RACS are limited to those of waste material in the Coliseum parking lot (metals only). Therefore, provided 1) the material does not contain RACS, 2) “debris” is limited to relatively inert material such as fragmented asphalt, bricks, concrete, glass, or plastics, 3) the geotechnical properties of “soil and debris” meet the technical specification of the intended reuse of the material within the GLOP, and 4) public health is adequately protected, “soil and debris” from the Globeville Landing Park may be beneficially reused within the GLOP.

From a regulatory perspective, beneficial reuse of “soil and debris” in both areas is acceptable because the “area of contamination” is defined by the boundaries of Operable Unit 2, which encompass both the Coliseum parking lot and the Globeville Landing Park. Possible beneficial use may include, but is not limited to, reuse as construction backfill or
landscaping subsoil that is ultimately covered with clean soil. Alternatively, if on-site reuse opportunities are not available, the material may be disposed in a RCRA Subtitle D landfill as a special waste.

A small amount of “soil and debris” from one boring in the Globeville Landing Park contained asbestos. Even though the asbestos content was less than 1% of the material sampled, it was determined to be a RACS. It should be noted that this detection of RACS in the Globeville Landing Park is consistent with asbestos detections by others in waste material beneath the Coliseum parking lot (CTL-Thompson, 2013). Consequently, when waste material from the Coliseum parking lot and “soil and debris” from the Globeville Landing Park are excavated, a Certified Asbestos Building Inspector (CABI) will need to be present to 1) observe for the presence of RACS, and 2) if determined to be RACS, manage the material in accordance with the Materials Management Plan (MMP), which is attached as Appendix A to this Design Report. RACS may also be disposed at DADS under special-waste manifest in accordance with the handling and disposal protocol detailed in the MMP.

The quality of groundwater beneath the GLOP is discussed in the MMP and in Section 5 of this report.

3.2 Screening, Staging, and Disposal

As mentioned above and discussed in the MMP, the contractor removing waste material from the Coliseum parking lot and “soil and debris” from Globeville Landing Park is responsible for placing a “Competent Person”, whose qualifications include a CABI, on-site to oversee all excavation activities to witness any variation in the exhumed waste that would require additional characterization prior to a) acceptance of the waste material and “soil and debris” (if it contains RACS) at DADS, and b) reuse of “soil and debris” on-site.

Excavated waste material and “soil and debris” will be temporarily staged in the areas shown on Sheet EC-3 (Appendix G) or as designated by the Site Superintendent. Four staging subareas will be delineated, as necessary, to account for the four general types of material anticipated to be encountered:

- “Soil and Debris” that is non-hazardous and non-RACS and can be reused on-site;
- Non-hazardous, non-RACS material for disposal at DADS;
- Non-hazardous, RACS material for disposal at DADS; and
- Potentially hazardous waste that will need further analysis.

“Soil and Debris” that is non-hazardous and non-RACS and can be reused on-site will be tested for the required geotechnical properties of the intended use prior to excavation. If the material is suitable for the intended use, it will be staged in an area designated by the Site Superintendent and properly covered or conditioned to prevent release of fugitive odors and dust. Best Management Procedures (BMPs) for odor and dust control are
discussed in the MMP and Methane, Odor, and Dust Control Plan (MODCP), presented in Appendices A and C, respectively.

Non-hazardous, non-RACS material that will be disposed at DADS will also be staged and properly covered or conditioned both while it is being managed onsite, and during transport to DADS. BMPs for monitoring and control of fugitive emissions are discussed in the MODCP.

Identification, monitoring, testing, handling, loading, transport, and manifesting of asbestos-containing material and RACS, and potentially hazardous waste will be conducted in accordance with the means and methods described in the MMP and MODCP.

The “Competent Person” will monitor the excavation, handling, and stockpiling of solids for emissions of VOCs, methane, odor, and fugitive dust. Threshold VOC and methane levels are discussed in the Health and Safety Plan presented in Appendix B. Malodors and visible fugitive dust will be monitored by the “Competent Person” monitoring the work, and by designated “Environmental Monitors” whose functions and responsibilities are described in the MODCP. If VOC or methane threshold levels are exceeded, the material is excessively malodorous, or visible fugitive dust is observed at the site boundary, appropriate BMPs will be performed, such as spraying the material with water, slowing down excavation or loading operations, tarping the source area, or applying foaming agents. These and other BMPs are discussed in the MODCP.

As shown on Sheet EC-3 it is anticipated that transport vehicles will enter the site via McFarland Drive, turn around in the Coliseum parking lot, be loaded from the north side of the Solids Staging Area, then depart via the eastbound lane of McFarland Drive. Final routing of vehicles will be determined by the contractor in consultation with Denver personnel. During loading of the trucks, a site inspector will monitor the solids for evidence of free liquids and if observed, he/she will direct the material to be placed back on the stockpile for further drainage.

Vehicular traffic will also conform to Site Rules to promote safe and efficient operations. Site Rules are as follows:

- Maximum speed limit for all vehicles/equipment on-site is 15 miles per hour.
- Vehicle and pedestrian traffic must yield to heavy equipment at all times.
- Contractor's vehicles must have orange survey flagging wrapped around interior rear view mirror to distinguish them as Superfund Site activity-related vehicle traffic.
- No vehicle will be allowed to idle for more than 5 minutes (Title II – Revised Municipal Code, Chapter 4, Article IV, Sec 4-43) unless it is required to perform a specific construction function.
4 IMPERMEABLE BARRIER SYSTEM DESIGN

This section reviews the objectives, design, and implementation of the subsoil stabilization and impermeable barrier systems that will be installed as environmental components of the GLOP.

4.1 Objectives

As stated in Section 1, the functional objectives of the impermeable barrier system through the Coliseum parking lot and Globeville Landing Park are to prevent contaminants remaining within the boundaries of the drainage feature from adversely impacting stormwater retained within and conveyed by the drainage feature. They also include prevention of stormwater infiltration into contaminated media remaining beneath or immediately surrounding the feature. To accomplish these objectives, the following specific objectives need to be addressed:

- Stabilize waste material beneath the Coliseum parking lot to improve its compressive strength such that it will support the weight of the RCB conduit and open channel system, and minimize differential settlement;
- Stabilize “soil and debris” in the Globeville Landing Park that is exposed as the foundation layer to the open channel system to support the weight of heavy equipment during construction, and to minimize differential settlement long-term.
- Minimize changes to groundwater flux beneath the GLOP that might occur due to subsoil stabilization measures;
- Temporarily depress the groundwater table to beneath the base of the impermeable barrier system to create dry working conditions to construct the impermeable barrier; and
- Assure that the impermeable barrier system and other constructed features do not create a preferential pathway for groundwater movement toward the South Platte River.

Designs of the subsoil stabilization program and barrier system are discussed in the following paragraphs. Design of the dewatering and treatment systems is discussed in Section 5 of this report.

4.2 Subsoil Stabilization

Engineering studies conducted by CTL Thompson (2015a) assessed the construction risks of building the RCBs and open channel through the Coliseum parking lot. Based on their assessment, CTL Thompson determined that some form of ground improvement is necessary to prevent settlement and differential movement of the channel subgrade that could result in grade interruptions and possibly damage the liner system. They analyzed the options of 1) removing all waste material down to bedrock and replacing it with structural fill to support the RCB conduit and open channel, and 2) stabilizing in-place waste material with some combination of compaction grouting and/or Vibro-Stone columns. They concluded that the latter option of in-place stabilization would be more
Accordingly, the design criteria described below for compaction grouting and Vibro-Stone columns were provided by CTL Thompson for ground improvement through the buried waste material.

**Compaction Grouting:**

Low mobility compaction grout techniques ([http://www.haywardbaker.com/WhatWeDo/Techniques/Grouting/CompactionGrouting/default.aspx](http://www.haywardbaker.com/WhatWeDo/Techniques/Grouting/CompactionGrouting/default.aspx)) were selected for stabilizing waste material below the RCB conduit. To provide sufficient resistive pressures for compaction grouting, CTL Thompson recommended installing the compacted grout columns prior to excavating for the conduit. The grouting is done by pneumatically driving injection piping down to firm soil or bedrock and then injecting cement grout. During injection the grout displaces the soft waste material resulting in densification of the surrounding materials. The lateral zone of influence from each injection point is typically about 5 feet. The densification improves the strength of the subsurface materials, increases bearing pressure and reduces the risk and amount of future differential and total settlement (CTL Thompson, 2015b).

CTL Thompson recommended installation of compaction grout columns at the locations shown on Sheet EC-4, at the spacing shown on Sheet EC-5. They also recommend sequencing of primary and secondary locations, as shown on Sheet EC-5, with grout injection starting at the bottom of the borehole, advancing upward to the subgrade of the RCB conduit. Their grouting specifications and injection details are presented in Appendix H.

**Vibro-Stone Columns:**

Vibro-Stone columns ([http://www.haywardbaker.com/WhatWeDo/Techniques/GroundImprovement/VibroPiers/default.aspx](http://www.haywardbaker.com/WhatWeDo/Techniques/GroundImprovement/VibroPiers/default.aspx)) were selected by CTL Thompson for stabilizing waste material below the open channel liner, down to the top of bedrock. A Bottom Feed Down-Hole stone column system is recommended by CTL Thompson (2015b). The Vibro-Stone column system uses a down hole vibrator and tremie pipe to advance the aggregate to the bottom of the stone column. In that manner, gravel is placed from the bottom of the hole upward.

According to CTL Thompson, the technique of installing the stone columns using Down Hole Vibratory methods has the advantage of densifying the subsurface material while advancing the vibratory delivery system. Placement of the aggregate is done in 12 inch lifts while continuing to vibrate the material in place. This results in densifying and laterally displacing the aggregate. Aggregate placement will continue until the vibratory equipment is at grade. Typically, the vibratory pier has a completed diameter of about 30 inches.

Also according to CTL Thompson, installation of the Vibro-Stone columns should be done prior to overburden removal, at the locations shown on Sheet EC-4. Their recommended spacing is discussed in Appendix D and shown on Sheet EC-5. Their material specifications and installation procedures are presented in Appendix H.
4.3 Geogrid and Strengthening Layer

Beneath the open channel in the Coliseum parking lot and Globeville Landing Park, CTL Thompson and Frobel and Associates recommended installation of a Strengthening Layer consisting of a geogrid base layer overlain by 18 inches of Class 57 coarse concrete aggregate in the parking lot, and 12 inches Class 57 coarse concrete aggregate in the park. The Strengthening Layer will be placed 1) immediately over the Vibro-Stone columns, and 2) immediately over “soil and debris” in the Globeville Landing Park that will be exposed following overburden removal (CTL Thompson, 2015b and Frobel, 2015b). The purpose for this Strengthening Layer over the Vibro-Stone columns is to minimize differential settlement between columns (CTL Thompson, 2015b and Frobel, 2015b). The purpose for the Strengthening Layer in the Globeville Landing Park is to enhance the bearing strength of exposed, soft material to support heavy equipment during construction and to minimize differential settlement long-term (CTL Thompson, 2015b and Frobel, 2015b).

As shown on Sheet EC-6, CTL Thompson recommended that the geogrid be a Tensar TX or equivalent. Per their recommendation, the geogrid should be placed with the long direction perpendicular to the center line of the channel with a minimum 2 foot overlap at the seams. The Class 57 concrete aggregate should be placed over the geogrid. Placement should be from stable areas and/or perimeter limits of the geogrid or areas that have already received the aggregate. Construction traffic should not be allowed on geogrid without the cover of aggregate. Material specifications and placement details from CTL Thompson and Frobel and Associates for the geogrid and aggregate layer are presented in the Strengthening Layer specification in Appendix H.

As discussed in the next subsection, the Strengthening Layer has the potential to create a preferential pathway for groundwater migration toward the South Platte River beneath the impermeable barrier. To mitigate this potential, a “check-dam” comprised of low-permeable clay soil will be constructed within the Strengthening Layer across the full width of the Strengthening Layer, at the western end of the Vibro-Stone columns (see Sheets EC-6 and EC-8 for details and location, respectively. Material and performance specifications and placement details from CTL Thompson are also included in the Strengthening Layer specifications (Appendix H).

Construction Quality Assurance protocol for placement and testing of the geogrid material are presented in the Construction Quality Assurance Plan in Appendix I.

4.4 Impact to Groundwater Flux

As shown on Figure 1 the current direction of groundwater flow beneath the Coliseum parking lot is to the north-northwest. The combined hydraulic effects of the compaction grout columns, Vibro-stone columns and Strengthening Layer equipped with a “check-dam” were modeled by Itasca Denver using the commercially-available MODFLOW-SURFACT, which is an enhanced version of the U.S. Geological Survey’s MODFLOW finite-difference code. The long-term potentiometric impacts identified by Itasca are
illustrated on Figure 2. Comparison of the potentiometric surface shown on Figure 1 to that shown on Figure 2 indicates that 1) mounding behind the compacted grout columns should not exceed several feet, 2) the directions of flow beneath the Coliseum parking lot will not be significantly different than those inferred from current potentiometric conditions (Figure 1), and 3) there will be no apparent preferential pathway for groundwater movement within the Strengthening Layer toward the Globeville Landing Park. Details of the Itasca modeling efforts are reported in Appendix E.

4.5 Impermeable Barrier

A discussion of design considerations and commercially-available geomembrane materials for the impermeable barrier are presented in a Technical Memorandum by R. Frobel in Appendix D. In summary, to most cost-effectively meet the functional objectives of the impermeable barrier, and considering the GLOP geotechnical conditions and groundwater and soils sampling results, the following liner details are recommended by Frobel:

- The geomembrane lining system shown on Sheet EC-6 must cover the channel lining area shown on Sheet EC-3, and be anchored to perimeter concrete walls using the conventional stainless steel anchor bolt/batten bar mechanical details shown on Sheet EC-7.
- The geomembrane lining system shall be a 60 mil thick LLDPE-T in consideration of the Technical Memorandum issues presented in Appendix D, and in particular, potential for subsidence, differential settlement, slope stability, and interaction with subsurface waste components.
- The lining system should be installed on a minimum 16 ounce per square yard (oz/sy) non-woven needle-punched geotextile to provide separation, protection from puncture and abrasion as well as gas/air transmission under the liner. Additionally, the geotextile provides a clean working surface for geomembrane installation (enhancing installation quality).
- A protection layer consisting of a composite geonet should be installed over the LLDPE-T geomembrane for protection of the geomembrane during soil cover placement and to provide a drainage pathway for water detained within the drainage medium overlying the impermeable barrier, toward the vertical drop structure in the Globeville Landing Park.
- The lining system installation should be subjected to strict Quality Control guidelines and specifications as regards to material selection, placement, geomembrane installation seaming, and testing, per the Construction QA Plan in Appendix I.
- The final lining system Construction QA should incorporate Electrical Leak Location Survey (ELLS) over 100% of the lined channel area, per the Construction QA Plan in Appendix I.

All of these recommendations are incorporated into the design drawings presented on Sheets EC-6 through EC-10, in the technical specifications presented in Appendix H, and in the Construction QA Plan presented in Appendix I.
5 DEWATERING AND TREATMENT DESIGN

This section reviews the objectives, design, and implementation of the dewatering and treatment systems needed to maintain dry working conditions during construction of the Strengthening Layer and impermeable barrier system.

5.1 Dewatering

Objectives and layout of the dewatering system, pumping rates and durations, and decommissioning of the system are discussed below.

5.1.1 Objectives and Approach

The objectives of the dewatering system are to depress the groundwater table sufficiently to create dry working conditions at:

- The base of the RBC Conduit;
- The base of the impermeable barrier system;
- The base of the vertical drop inlet structure immediately upstream of the sanitary sewers;
- The base of the box culvert beneath the existing sanitary sewers; and
- The base of the outfall channel downstream from the sanitary sewers.

The means and methods of meeting these objectives will be the construction contractor’s responsibility. The following approach and details are offered as options for the contractor’s consideration. The contractor’s approach and plans to achieve these objectives will be reviewed by the Respondent during the procurement process. Respondent’s approval of the dewatering plans will be required prior to contractor’s mobilization to the site.

For planning purposes, the Respondent retained Itasca Denver to conduct a numerical groundwater flow modeling study using the MODFLOW-SURFACT model to evaluate the efficacy and cost-effectiveness of different groundwater management options at a feasibility level. The model was constructed to simulate shallow groundwater flow above bedrock and was sufficiently discretized to represent all of the features of interest (e.g., channel cross section, individual pumping wells, layering within the substrate, etc.). Modeling results, which are presented in Appendix E, were used to provide a basis for determining the best approach for dewatering.

Five geographic dewatering zones were simulated, with each zone requiring a specific dewatering depth to achieve the objectives identified above. The five zones are illustrated on Sheet EC-12 and their dewatering profiles are shown on Sheet EC-13. Pertinent dewatering parameters are summarized below.
<table>
<thead>
<tr>
<th>Zone</th>
<th>Location</th>
<th>Description of Target Depth</th>
<th>Depth Water Table is to be Lowered (feet)</th>
<th>Target Elevation of Lowered Water Table (ft amsl)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>South Platte River to Outlet of Box Culvert</td>
<td>Base of Outlet Apron</td>
<td>2.4 – 9.4 (Avg. 5.9)</td>
<td>5138.5 – 5141.0</td>
</tr>
<tr>
<td>2</td>
<td>Box Culvert Outlet to Top of Vertical Pipe</td>
<td>Base of Box Culvert</td>
<td>7.6 – 10.1 (Avg. 8.9)</td>
<td>5142.5 – 5145.5</td>
</tr>
<tr>
<td>3a</td>
<td>Open Channel in Globeville Landing Park</td>
<td>1 foot Below Geogrid Layer</td>
<td>3.0 – 5.6 (Avg 4.5)</td>
<td>5148.0 – 5149.0</td>
</tr>
<tr>
<td>3b</td>
<td>Open Channel in Coliseum Parking Lot</td>
<td>Geogrid Layer</td>
<td>3.1 – 4.2 (Avg. 3.5)</td>
<td>5149.0 – 5150.0</td>
</tr>
<tr>
<td>4</td>
<td>Conduit in Coliseum Parking Lot</td>
<td>2 feet Below Bottom of RCB conduit</td>
<td>0.3 – 4.0 (Avg. 2.5)</td>
<td>5151.0 – 5152.5</td>
</tr>
</tbody>
</table>

Source: Itasca, 2015 a and b (Appendix E)

Following calibration, Itasca applied the model to simulate four different dewatering scenarios to lower the water table to the targeted elevations. The four scenarios consist of:

**Scenario 1.** Use of a network of shallow pumping wells to dewater the corridor in which the channel will be excavated;

**Scenario 2.** Use of lateral drains (one along each side of the channel) to dewater the intervening corridor in which the channel will be excavated;

**Scenario 3.** Use of longitudinal drains along the center of the channel to dewater the ground ahead of the excavation, and abandoned the drains following construction of each channel segment; and

**Scenario 4.** Use of a longitudinal drains within the center of the channel to dewater ahead of the excavation in combination with sheet-pile “walls” in Zones 1 and 2 to limit the amount of lateral groundwater inflow.
Itasca determined the most cost-effective approach to be a combination of the third and fourth scenarios (see Itasca Technical Memorandum dated October 26, 2015 in Appendix E). Both scenarios utilize French drains that are connected to sumps (“wet wells”) at the down-gradient end of each segment, as shown on Sheet EC-12. Each sump is equipped with a pump to remove the collected water and bring it to the surface for treatment. Note - the method(s) of water transport between the sumps and treatment plant (such as piping, alignment, and tankage) are the responsibility of the water treatment contractor and are not addressed here.

Conceptually, the drains and sumps are designed to be temporary features, which will operate for a period of weeks to months prior to construction of the surface-drainage infrastructure to lower the water table to the target depths, and during initial construction to maintain dry working conditions, per the above-stated objectives. Following and/or in conjunction with initial construction, all or parts of the dewatering system are to be removed or abandoned, as discussed in Appendix H.

The simulated dewatering flow rates to reach the target groundwater elevations for each zone are summarized in Table 1 (Itasca, 2015a and b). Simulated rates for the first week of pumping (initial rates), final rates of pumping (rates to maintain the target groundwater elevation when steady state is achieved), and median rates of pumping are shown in the table. These rates are then multiplied by 2 to account for modeling uncertainties. The higher rates are recommended for planning purposes (Itasca, 2015c). Based on the higher values presented in the Table, if pumping from all zones begins at the same time, a worst-case combined rate of approximately 100 gpm is recommended for planning purposes. When steady-state conditions are achieved in all zones, a combined flow rate of approximately 40 gpm is recommended for planning purposes. A median combined flow rate of approximately 50 gpm is also recommended for planning purposes.

Durations of pumping to reach the target groundwater elevations for each zone are also summarized in Table 1 (Itasca, 2015a and b). These simulated durations may also be impacted by model uncertainties, and should be applied with caution. With that said, the simulated duration to reach the target groundwater elevations in Zones 1 and 2 is approximately 1 week. Dewatering Zone 3a may take approximately 10 weeks, and dewatering Zones 3b and 4 may take approximately 3 weeks and 7 weeks, respectively (Itasca, 2015 a and b).

The simulated volumes of groundwater extraction by zone to reach the target groundwater elevations are also shown in Table 1 (Itasca, 2015a and b). For planning purposes, these volumes should also be multiplied by 2 to account for modeling uncertainties (Itasca, 2015c).

It should be stressed that these pumping rates, durations, and volumes are estimated to achieve the target groundwater elevations, only. Additional pumping at the recommended “final rates” will be necessary for the timeframe necessary to complete “dry-construction” beneath the current groundwater elevations.
5.1.2 Optional Dewatering Approach

Following review of the dewatering rates, volumes, and durations listed in Table 1, Itasca was tasked to simulate the effectiveness of two additional dewatering scenarios consisting of:

1. Application of Scenario 4 above, in combination with sheet pile “walls” along both sides of Zones 3a, 3b, and 4; and

2. Application of Scenario 4 above in combination with a sheet pile “wall” along only the upgradient side of Zones 3a, 3b, and 4.

Simulation details and results are presented Itasca’s Technical Memorandum dated January 25, 2016, in Appendix E. Results are summarized in Table 2 and discussed below:

1. “If flow-barrier walls are placed around the perimeter of dewatering Zones 3a, 3b, and 4 and the dewatering system is installed and operated within those walls for a period of 18 weeks, then approximately 1,289,400 gallons of groundwater are expected to be produced. This amount is approximately 30% less than the volume of groundwater that would be generated if the dewatering system is operated without the barrier walls (approximately 1,847,200 gallons). The reduction in total produced groundwater comes primarily from lower inflows to Zones 3a and 3b and secondarily from reductions of inflow into Zones 4 and 2.”

2. “The flow-barrier walls will result in a lower maximum weekly-total dewatering rate of approximately 43 gpm* (instead of 47 gpm)* and a quicker decrease in the weekly-total dewatering rates relative to the case without the flow-barrier walls in place prior to dewatering. The weekly-average dewatering rates in Zone 1 will not be appreciably affected if the assumed perimeter walls are used; however, in all other zones, the dewatering rates will be less if the flow-barrier walls are employed, due to their effectiveness in limiting recharge to the construction area.”

* As discussed above, these rates should be doubled for planning purposes.

3. “A line of flow-barrier walls along the upgradient boundary of Zones 3a, 3b, and 4, by itself, is insufficient to block the ambient groundwater flow and produce the downgradient hydraulic heads that would lower water levels in the construction area to the target elevations. Hence, the upgradient flow-barrier walls with no subsurface dewatering system would be ineffective in dewatering the construction area as needed, regardless of the amount of time that transpires.”

5.1.3 Design, Operations, and Abandonment

Based on Itasca’s assessment of dewatering Scenario 1 through 4, plus the two optional modifications discussed above, and recognizing that the construction contractor will be responsible for the means and methods of dewatering to meet the dewatering objectives
stated above, the following paragraphs present details of one potential dewatering approach for consideration by the contractor. Conceptual layouts for each dewatering zone are shown on Sheet EC-12, profiles are shown on Sheet EC-13, and possible construction details are shown on Sheet EC-14.

**Zones 1 and 2:**

It is assumed that Zones 1 and 2 will be protected with sheet piles driven to and keyed into bedrock a) along the western boundary of Zone 1 (adjacent to the South Platte River) to minimize inflow from river alluvium; and b) around the northern, eastern, and southern perimeters of Zone 2 to stabilize excavation sidewalls and minimize lateral inflow while the box culvert and vertical pipe are being constructed. Under these conditions, dewatering would consist of two parallel drains excavated to the top of bedrock or to the elevation shown on Sheet EC-13, and would connect to a wet well adjacent to the South Platte River.

**Zone 3a:**

In Zone 3a, dewatering would be accomplished with three parallel trench drains. The trenches would be constructed following removal of dry overburden soils down to 2 feet above the current water table. The base of the drain trenches would be three feet below the target elevation of the lowered water table. When the dewatered depth is achieved, construction of the Strengthening Layer would proceed over the dewatering drains. Construction would begin at the upstream end of the zone and as it approaches the cleanouts and wet well, these components would be abandoned.

**Zone 3b:**

In Zone 3b, dewatering would be accomplished with two parallel drains. Similar to Zone 3a, the trenches would be constructed following removal of dry overburden waste material down to 2 feet above the current water table. To avoid the potential for creation of a preferential pathway for groundwater movement between the Coliseum parking lot and Globeville Landing Park, the drain trenches in Globeville Landing Park would be separated by a minimum lateral distance of 20 feet from those within the Coliseum parking lot (see offset configuration shown on Sheet EC-12). Like Zone 3a, construction would begin at the upstream end of the zone and as it approaches the cleanouts and wet well, these components would be abandoned.

**Zone 4:**

Finally, in Zone 4, dewatering would be accomplished with two parallel drains. Construction, operation, and abandonment would be the same as for Zone 3a, except in this dewatering zone, a Strengthening Layer will not be built. Rather, the base of the RCB conduit will be constructed immediately on top of the compacted grout columns. Consequently, abandonment of the dewatering system would follow construction of the base layer.
Possible materials of construction, construction procedures, and abandonment protocol for all of the dewatering zones are discussed in Appendix H.

5.2 Dewatering Water Management/Treatment

Water management options are discussed in the MMP (Appendix A). A summary of options and treatment objectives, discharge limits, influent water quality, potential treatment processes to meet discharge limits, operational and compliance monitoring, and decommissioning are presented in the following paragraphs.

5.2.1 Management Options and Treatment Objectives

In conjunction with collecting water from dewatering operations, dewatering water management options consist of: 1) collection of the water in tanks and hauling the untreated water to a permitted industrial pretreatment facility or RCRA Subtitle C treatment facility; 2) on-site treatment followed by discharge to a receiving water body; and 3) on-site treatment followed by beneficial use on-site. The means and methods of managing dewatering water in accordance with the MMP will be the construction contractor’s responsibility.

Metro Wastewater Reclamation District, which is the closest and perhaps most viable Publicly Owned Treatment Works (POTW) for treatment of extracted groundwater, will not accept contaminated groundwater from this site. Similarly, a currently-available, licensed industrial wastewater pretreatment facility is not available in the Denver-Metro area. Costs for hauling to and treatment at a RCRA Subtitle C treatment facility are typically on the order of $1.00 per gallon. If these costs are determined to be comparable to on-site treatment and release to a surface water body or beneficial reuse on-site, the procedures detailed for offsite disposal in the MMP will be followed.

Available groundwater quality data are discussed in the DSR (EMSI, 2015e) and MMP (Appendix A). Available dewatering flow estimates (discussed above), permitted discharge limits (Appendix F), and treatability testing results (pending) will also be shared with prospective construction contractors. Prospective contractors’ approaches and plans to comply with the MMP will be reviewed by the Respondent during the procurement process. Respondent’s approval of approach(es) and plan(s) will be required prior to contractor’s mobilization to the site.

However, for purposes of this Design Report, on-site treatment and subsequent discharge to a nearby surface water body or beneficial reuse on-site are assumed to be the more cost-effective approaches. Therefore, for planning purposes, the objective for a treatment system discussed in the following paragraphs is to remove constituents from dewatering water to levels that comply with the numeric standards specified in discharge permits issued by the CDPHE WQCD.
5.2.2  Discharge Permits

A Colorado’s General Permit COG315000 for Remediation Activities Discharging to Surface Water, and Certification Number COG315386 for release of GLOP dewatering water to the South Platte River and Toll Gate Creek under the General Permit are provided in Appendix F. The first outfall is located at the current outfall structure in Globeville Landing Park where the outfall structure meets the South Platte River. Stream standards for Segment 14 of the Upper South Platte River basin apply at this location. The second outfall is located on Toll Gate Creek, approximately 0.5 miles upstream of its confluence with Sand Creek, and approximately 10 miles from the site. Stream standards for Segment 16h of the Upper South Platte River basin apply at this location.

5.2.3  Influent Water Quality

Influent dewatering water quality and flow rates will depend on which dewatering zones are being pumped at what rates, as discussed above. For purposes of conceptual design, however, a range of influent water quality was estimated based on groundwater quality data reported in the DSR. Average, minimum, and maximum values for metals, inorganics, and VOCs that might exceed stream standards are summarized in Table 3. Based on this screen, constituents of concern whose average concentration might exceed Segment 14 or 16h standards consist of:

<table>
<thead>
<tr>
<th>Constituents</th>
<th>Exceeds Segment 14 Stream Standard?</th>
<th>Exceeds Segment 16h Stream Standard?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arsenic</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Cadmium</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Iron</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Manganese</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Lead</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Ammonia</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Chloride</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Sulfate</td>
<td>No (see note below)</td>
<td>No</td>
</tr>
<tr>
<td>Sulfide</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Tetrachloroethene</td>
<td>No, but equals standard</td>
<td>No, but equals standard</td>
</tr>
<tr>
<td>Trichloroethene</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Vinyl Chloride</td>
<td>Unknown, cannot quantify</td>
<td>No</td>
</tr>
</tbody>
</table>

Note:  This screen should be applied carefully, because while the average sulfate concentration of all dewatering zones is less than 250 mg/L, the sulfate concentration of Zones 1 and 2 (277 mg/L) exceeds the standard. If water from these zones is not blended with water from other zones, the discharge limit would be exceeded. Thus, sulfate is included in this table.

5.2.4  Treatment Train

Based on the above comparison, if treated dewatering water were to be discharged to the South Platte River, the metals arsenic, cadmium, iron, manganese, and lead; the
inorganics ammonia, chloride, sulfate (possibly), and sulfide; and the volatile organic compounds (VOCs) tetrachloroethene (PCE) (possibly), trichloroethene (TCE), and vinyl chloride (VC) (possibly) would require removal. If treated dewatering water were to be discharged to Toll Gate Creek, removal of the same constituents of concern as the South Platte River except for cadmium, manganese, chloride, sulfate, and vinyl chloride would be required. If treated dewatering water were to be reused on-site, removal of the same constituents of concern as the South Platte River would be required, except for chloride and sulfate. This is because chloride and sulfate limits for on-site use are 2,500 mg/L each (CDPHE, 2015). Further discussion of beneficial reuse options for treated dewatering water is provided in the MMP (Appendix A).

The following processes are typically employed in construction dewatering treatment trains to remove these constituents of concern:

- Oxidation of sulfide to elemental sulfur or sulfate ion;
- Air stripping at elevated pH or breakpoint chlorination for ammonia removal;
- Oxidation of dissolved iron and manganese to form solid ferric oxide and manganese dioxide precipitates that can be subsequently settled or filtered out of the dewatering water;
- Manganese greensand filtration (stabilized glauconite greensand or special-density silica sand substrate with an active manganese oxide coating) in conjunction with a continuous feed of an oxidant such as chlorine to oxidize, precipitate, and remove iron and manganese within the greensand media;
- Adsorbent media for removal of arsenic, cadmium, lead, and other metals such as chromium, copper, mercury, nickel, and zinc;
- Granular activated carbon (GAC) adsorption for removal of VOCs and other organic compounds; and
- Reverse osmosis or other membrane technologies for removal of inorganics such as chloride and sulfate that cannot be more readily or cost-effectively removed via chemical precipitation, media absorption, or ion exchange processes.

The following unit processes are anticipated to be required for dewatering water treatment prior to discharge to Segment 14 or 16h, or reuse on-site, as shown on the Process Flow Diagram on Sheet EC-15:

- Chemical injection of sodium hypochlorite and/or gaseous injection of ozone (and/or introduction of another oxidant) to assist in the removal of iron, manganese, sulfide, and ammonia;
- Chemical mixing/oxidation/settling tanks (e.g., weir tanks) to provide reaction time for oxidation of dissolved iron and manganese and sulfide; contact of the
chlorine/ozone with ammonium; and for settling of any suspended solids and iron precipitates;

- Manganese greensand oxidizing filter media for removal of iron and manganese (the media would be periodically backwashed and the filter backwash collected in a backwash storage tank, decanted, and decant liquid pumped to a location upstream of the chemical mixing/oxidation/settling tanks);

- Bag filtration to remove any suspended particles and prevent clogging or buildup on downstream absorbent media contactors;

- Granular carbonaceous cation adsorption media (in a pair of fixed-bed contactors operated in series) for absorption of dissolved metal cations such as cadmium and lead (e.g., Evoqua Water Technologies’ SCU absorptive media);

- Granular arsenic adsorption media (in a pair of fixed-bed contactors operated in series) for absorption of arsenic (e.g., Evoqua Water Technologies’ ASG absorptive media);

- Liquid-phase GAC (in a pair of fixed-bed contactors operated in series) for adsorption of remaining VOCs;

- Bag filtration to remove particles greater in size than 1 micron prior to discharge (without reverse osmosis treatment); and

- Air stripping at elevated pH for residual ammonia removal, followed by pH reduction.

If removal of aqueous salts such as chloride or sulfate is required:

- Ultrafiltration to remove particles down to 0.1 micron in size prior to treatment by reverse osmosis; and

- Removal of aqueous salts via reverse osmosis.

Treatability testing for metals removal only was recently performed by Rain for Rent, a turnkey vendor of tanks and temporary wastewater treatment equipment for construction dewatering projects. Composite groundwater samples collected on September 3, 2015 were treated using cation and arsenic adsorption media operated in series. Two composite samples were tested - one with groundwater from monitoring wells SWDI-13 and -14; the second with groundwater from wells and SWDI-1, -4, -7, -8, and -10. Well locations are shown on Figure 1. These wells were selected in an attempt to provide samples that would be representative of dewatering water from Zones 1 and 2 (first composite), and from Zones 3a, 3b, and 4 (second composite).

Results from the treatability testing are provided in Table 4 and indicate that, for both composite samples, total arsenic and iron and dissolved iron, manganese and lead are all
removed to less than the stream standards for both Segments 14 and 16h using the cation and arsenic adsorption media operated in series. Dissolved cadmium in both samples was removed from < 5 to < 1, which is less than the stream standard for Segment 16h. Unfortunately, the detection limit for cadmium used in the treatability testing (1 ug/L) was greater than the cadmium standard for Segment 14 (0.8 ug/L); therefore removal to less than the standard could not be quantified.

Treatability testing for ammonia and sulfide removal using chlorination and ozone was also conducted. During chlorination testing, liquid sodium hypochlorite at a 10% concentration was added to 1-liter vessels containing equal volumes of groundwater from piezometers SWDI-9, -10, and -12 in chlorine doses of 0.5, 1, 2, 4, 5, and 10 mg/L and mixed for 30 minutes at a neutral pH. Samples for laboratory analysis of total and dissolved manganese; ammonia, nitrite, and nitrate nitrogen; and sulfide were collected at the end of each test. Dissolved manganese was reduced by approximately 60% during the 5 and 10 mg/L dose tests. Ammonia was reduced approximately 15% during the 10 mg/L dose test. Sulfide was not removed during any of the tests. A free chlorine residual ranging from 0.1 to 0.4 mg/L remained at the end of all tests, except for the 0.5 mg/L dose test where no residual chlorine was detected.

During the ozone treatability testing, ozone at a 5% concentration (produced using 95% oxygen) was added at a constant dose of 20 grams/hour to two 4-gallon composite samples of equal volumes of groundwater from piezometers SWDI-9, -10, and -12 and monitoring well CTL MW-06 (to simulate water quality from dewatering Zone 3a). During testing of the first composite sample, ozone was introduced to the groundwater using an eductor/pump/recirculating piping system equivalent to a 10 foot deep mixing tank, and the pH of the sample was neutral (ambient). Pre- and post-test samples were analyzed for total and dissolved manganese; ammonia, nitrite, and nitrate nitrogen; sulfate; chloride; and sulfide. Post-test samples were collected after 3, 60, 120, and 180 minutes of contact with ozone. Ozone saturation was determined using drops of orthotolidine (OTO). No saturation was measured after 3 minutes of mixing; some was measured at 60 minutes; and total ozone saturation was observed after 70 minutes. Test results indicated:

- No detection of sulfide after 60, 120, and 180 minutes of ozone contact;
- 73% reduction of dissolved manganese after 60 minutes, and a 92% reduction after 180 minutes of ozone contact; and
- 11% reduction of ammonia after 120 minutes, and a 28% reduction after 180 minutes of ozone contact.

Ozone testing of the second composite sample involved introducing ozone via a 6-inch long porous aeration stone located on the bottom of the contact vessel. Prior to ozonation, pH was raised to approximately 12 standard units (su) using a solution of sodium hydroxide prepared with laboratory-grade sodium hydroxide and distilled water. Post-test samples were analyzed for total and dissolved manganese; ammonia, nitrite, and nitrate nitrogen; sulfate; chloride; and sulfide after 60, 120, and 180 minutes of contact time. Total ozone saturation was also observed after 70 minutes of contact time. The
pH of the composite samples measured 11.6, 10.7, and 10.8 su after 60, 120, and 180 minutes of contact time, respectively. Test results indicated:

- No detection of sulfide after 60, 120, and 180 minutes of ozone contact;
- 98% reduction of dissolved manganese after 60 minutes, and a 99% reduction after 180 minutes of ozone contact; and
- 15% reduction of ammonia after 120 minutes, and a 25% reduction after 180 minutes of ozone contact.

Treatability testing for VOC removal has not been initiated, nor has air stripping for residual ammonia removal.

As indicated above, treatability testing reports will be made available to prospective construction contractors. If on-site treatment is determined by the contractor to be a viable alternative, it is anticipated that the treatment facility would be located on a gravel pad within a chain-link security fenced-in area, as shown on Sheet EC-3. Secondary containment would be provided. Process piping from dewatering sump locations to the treatment facility, and from the treatment facility to the discharge location at Segment 14 would be aboveground and supported.

A performance-based specification for dewatering water treatment requiring the contractor to propose a dewatering water treatment system and guarantee that the system will remove constituents from dewatering water such that the limits for discharge to either Segment 14 or 16h are met is provided in Appendix H.

5.2.5 Monitoring

If on-site treatment with discharge to the South Platte River or Toll Gate Creek is selected as the management option for dewatering water, weekly monitoring of treatment plant effluent, and quarterly monitoring of treatment plant influent, as well as monthly reporting to the CDPHE WQCD would be performed by the construction contractor in accordance the reporting requirements of the discharge permits (Appendix F) and performance specification for dewatering water treatment (Appendix H). If the treated dewatering water were to be reused on-site only, weekly monitoring of treatment plant effluent and quarterly monitoring of treatment plant influent would still need to be conducted, but analytical and operating results would only be reported to the Respondent. During this period of no discharge to a receiving water body, a discharge monitoring report would need to be submitted to CDPHE WQCD indicating “no discharge”.

5.2.6 Secondary Waste Streams

Management and disposal of secondary waste streams including, but not limited to, solids and sludges, filter backwash and rinseate, greensand and spend adsorptive media, spent activated carbon, and brines from reverse osmosis (if required) would be performed in accordance with procedures prescribed in the MMP (Appendix A).
6 DELIVERY STRATEGY

6.1 Procurement

Procurement of a construction contractor will be performed by Denver’s Integrated Contractor, who will solicit competitive bids for the “environmental components” as part of the overall GLOP construction package.

6.2 Construction Management

Construction management of the “environmental components” will be performed by Denver’s Integrated Contractor (IC), under contract to the City and County of Denver (Denver). Quality Assurance (QA) will be provided by contractors who are retained by Denver, but are independent from the IC. An organization chart showing separate lines of authority and communication is presented in Figure 3.

Construction and associated quality control will be performed by construction contractors in accordance with the Plans and Specifications of this design package. Construction contractors will report to the Construction Manager, who will report to the IC Program Manager. A project Health and Safety officer will also report to the Construction Manager.

Quality Assurance will be provided by independent contractors who report to Denver’s Project Coordinator. The Project Coordinator reports to the USEPA remedial project manager and communicates with the IC Program Manager. Quality Assurance leads will perform independent audits on work performed by construction contractors. Their findings will be reported to the QA Official, who will communicate the findings and recommendations to the Project Coordinator. When an audit finding has been addressed to the satisfaction of the QA Lead, the audit report will be closed and documented in the QA files. The Project Coordinator will then submit a copy of the closed audit report to USEPA.
7  COST AND SCHEDULE

7.1  Cost

An estimate of probable construction costs for the environmental components is provided in Table 5.

7.2  Schedule

A schedule for procurement, mobilization, and construction of environmental components is provided in Table 6.
REFERENCES


CDPHE, 2015. Personal communication with F. Apostolopoulos, Numerous dates.

CTL Thompson, Inc., 2011. Limited Phase II Environmental Site Assessment, 40th Street Outfall, South Platte River to Blake Street, Denver, CO, prepared for WHPacific, Inc. May 10, 2011.


CTL Thompson, Inc., 2015b. Personal communication with Mark E. Cleveland, P.E. (Vice President and principal) and Benny I. Lujan, P.E. (project engineer). Numerous dates.


Itasca, 2015c. Personal communication with D. Stone, PhD (principal hydrogeologist), Itasca Denver, Numerous dates.

Merrick, 2015. Personal communication with Jeanne M. Boyle, P.E. (senior engineer) with McLaughlin Water Engineers, a Division of Merrick & Company. Numerous dates.
<table>
<thead>
<tr>
<th>Zone</th>
<th>Initial (Simulated)</th>
<th>Initial (Recommended*)</th>
<th>Final (Simulated)</th>
<th>Final (Recommended*)</th>
<th>Median (Simulated)</th>
<th>Median (Recommended*)</th>
<th>Simulated Time to Dewater to Target Elevation (days)</th>
<th>Simulated Volume Removed to Target Elevation (gal)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>5.9</td>
<td>12</td>
<td>5.9</td>
<td>12</td>
<td>5.9</td>
<td>12</td>
<td>5</td>
<td>42,300</td>
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<tr>
<td>2</td>
<td>5.8</td>
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<td>5.8</td>
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<td>12</td>
<td>7</td>
<td>57,900</td>
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<tr>
<td>3a</td>
<td>14</td>
<td>28</td>
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<td>6</td>
<td>4</td>
<td>8</td>
<td>68</td>
<td>489,500</td>
</tr>
<tr>
<td>3b</td>
<td>16</td>
<td>32</td>
<td>3.9</td>
<td>8</td>
<td>7.7</td>
<td>15</td>
<td>23</td>
<td>329,400</td>
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<tr>
<td>4</td>
<td>6.4</td>
<td>13</td>
<td>1.4</td>
<td>3</td>
<td>2</td>
<td>4</td>
<td>50</td>
<td>192,800</td>
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<tr>
<td>Total</td>
<td>48.1</td>
<td>97</td>
<td>19.6</td>
<td>41</td>
<td>25.4</td>
<td>51</td>
<td></td>
<td>1,111,900</td>
</tr>
</tbody>
</table>

* Recommended Flow Rates contain a 2x safety factor over the simulated Flow Rates.
### Table 2 – Comparison of Simulated and Recommended Dewatering Flow Rates and Durations

**DEWATERING SCENARIO 4**

<table>
<thead>
<tr>
<th>Zone</th>
<th>Initial (Simulated)</th>
<th>Initial (Recommended*)</th>
<th>Final (Simulated)</th>
<th>Final (Recommended*)</th>
<th>Median (Simulated)</th>
<th>Median (Recommended*)</th>
<th>Simulated Time to Dewater to Target Elevation (days)</th>
<th>Simulated Volume Removed after 18 Weeks (gal)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>5.9</td>
<td>12</td>
<td>5.9</td>
<td>12</td>
<td>5.9</td>
<td>12</td>
<td>5</td>
<td>122,061</td>
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<tr>
<td>2</td>
<td>5.8</td>
<td>12</td>
<td>5.8</td>
<td>12</td>
<td>5.8</td>
<td>12</td>
<td>7</td>
<td>219,035</td>
</tr>
<tr>
<td>3a</td>
<td>14</td>
<td>28</td>
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<td>4</td>
<td>8</td>
<td>68</td>
<td>642,028</td>
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<tr>
<td>3b</td>
<td>16</td>
<td>32</td>
<td>3.9</td>
<td>8</td>
<td>7.7</td>
<td>15</td>
<td>23</td>
<td>556,441</td>
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<tr>
<td>4</td>
<td>6.4</td>
<td>13</td>
<td>1.4</td>
<td>3</td>
<td>2</td>
<td>4</td>
<td>50</td>
<td>307,647</td>
</tr>
<tr>
<td>Total</td>
<td>48.1</td>
<td>97</td>
<td>19.6</td>
<td>41</td>
<td>25.4</td>
<td>51</td>
<td>51</td>
<td>1,847,212</td>
</tr>
</tbody>
</table>

* Recommended Flow Rates contain a 2x safety factor over the simulated Flow Rates.

**DEWATERING SCENARIO 4 WITH SHEETPILING ALONG BOTH SITES OF ZONES 3a, 3b, and 4**

<table>
<thead>
<tr>
<th>Zone</th>
<th>Initial (Simulated)</th>
<th>Initial (Recommended*)</th>
<th>Final (Simulated)</th>
<th>Final (Recommended*)</th>
<th>Median (Simulated)</th>
<th>Median (Recommended*)</th>
<th>Simulated Time to Dewater to Target Elevation (days)</th>
<th>Simulated Volume Removed After 18 Weeks (gal)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>5.8</td>
<td>12</td>
<td>5.8</td>
<td>12</td>
<td>5.8</td>
<td>12</td>
<td>5</td>
<td>121,896</td>
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<tr>
<td>2</td>
<td>6.1</td>
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<td>12</td>
<td>6.1</td>
<td>12</td>
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<td>180,532</td>
</tr>
<tr>
<td>3a</td>
<td>12.8</td>
<td>26</td>
<td>1.4</td>
<td>3</td>
<td>3</td>
<td>6</td>
<td>65</td>
<td>451,333</td>
</tr>
<tr>
<td>3b</td>
<td>13.9</td>
<td>28</td>
<td>3.1</td>
<td>6</td>
<td>7</td>
<td>14</td>
<td>15</td>
<td>281,062</td>
</tr>
<tr>
<td>4</td>
<td>6.2</td>
<td>12</td>
<td>1.2</td>
<td>2</td>
<td>1.9</td>
<td>4</td>
<td>47</td>
<td>254,579</td>
</tr>
<tr>
<td>Total</td>
<td>44.8</td>
<td>90</td>
<td>17.6</td>
<td>35</td>
<td>23.8</td>
<td>48</td>
<td>48</td>
<td>1,289,402</td>
</tr>
</tbody>
</table>

*Recommended Flow Rates contain a 2x safety factor over the simulated Flow Rates.
Table 3: Groundwater Constituents of Concern vs Stream Standards

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Fraction</th>
<th>Units</th>
<th>Segment 14</th>
<th>Segment 16h</th>
<th>Average</th>
<th>Min</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arsenic</td>
<td>Total recoverable</td>
<td>ug/L</td>
<td>3</td>
<td>7.6</td>
<td>1,162</td>
<td>16</td>
<td>11,000</td>
</tr>
<tr>
<td>Arsenic</td>
<td>Potentially Dissolved</td>
<td>ug/L</td>
<td>340</td>
<td>340</td>
<td>181</td>
<td>9</td>
<td>2,000</td>
</tr>
<tr>
<td>Cadmium</td>
<td>Dissolved</td>
<td>ug/L</td>
<td>0.8</td>
<td>1.2</td>
<td>0.9</td>
<td>0.3</td>
<td>6.9</td>
</tr>
<tr>
<td>Iron</td>
<td>Dissolved</td>
<td>ug/L</td>
<td>300</td>
<td>no limit</td>
<td>1,774</td>
<td>22</td>
<td>12,000</td>
</tr>
<tr>
<td>Iron</td>
<td>Total recoverable</td>
<td>ug/L</td>
<td>1,000</td>
<td>1,000</td>
<td>699,471</td>
<td>51,000</td>
<td>1,600,000</td>
</tr>
<tr>
<td>Manganese</td>
<td>Dissolved</td>
<td>ug/L</td>
<td>190</td>
<td>2,618</td>
<td>2,123</td>
<td>350</td>
<td>6,000</td>
</tr>
<tr>
<td>Lead</td>
<td>Dissolved</td>
<td>ug/L</td>
<td>7</td>
<td>11</td>
<td>12.2</td>
<td>0.2</td>
<td>160</td>
</tr>
<tr>
<td>Ammonia (as N)</td>
<td></td>
<td>mg/L</td>
<td>1.3</td>
<td>1.3</td>
<td>40</td>
<td>0.18</td>
<td>140</td>
</tr>
<tr>
<td>Chloride</td>
<td></td>
<td>mg/L</td>
<td>250</td>
<td>no limit</td>
<td>291</td>
<td>150</td>
<td>840</td>
</tr>
<tr>
<td>Sulfate</td>
<td></td>
<td>mg/L</td>
<td>250</td>
<td>no limit</td>
<td>136</td>
<td>0.9</td>
<td>320</td>
</tr>
<tr>
<td>Sulfide (H$_2$S)</td>
<td></td>
<td>mg/L</td>
<td>0.1 $^{a/}$</td>
<td>0.1 $^{a/}$</td>
<td>15</td>
<td>0.8</td>
<td>74</td>
</tr>
<tr>
<td>Benzene</td>
<td></td>
<td>ug/L</td>
<td>2.2</td>
<td>no limit</td>
<td>0.6</td>
<td>0.2</td>
<td>6.0</td>
</tr>
<tr>
<td>Tetrachloroethene</td>
<td></td>
<td>ug/L</td>
<td>5</td>
<td>5</td>
<td>5.0</td>
<td>0.2</td>
<td>19</td>
</tr>
<tr>
<td>Trichloroethene</td>
<td></td>
<td>ug/L</td>
<td>2.5</td>
<td>2.5</td>
<td>2.7</td>
<td>0.2</td>
<td>8.3</td>
</tr>
<tr>
<td>Vinyl chloride</td>
<td></td>
<td>ug/L</td>
<td>0.023</td>
<td>2.3</td>
<td>&lt;0.3</td>
<td>&lt;0.1</td>
<td>2.4</td>
</tr>
</tbody>
</table>

Note: Minimum and average computations include non-detected values at the method detection limit.

$a/\text{ Stream standard is 0.002 mg/L, but discharge limit is based on method detection limit.}$
<table>
<thead>
<tr>
<th>Parameter</th>
<th>Fraction</th>
<th>Units</th>
<th>Stream Standard (Cert No. COG315386)</th>
<th>SWDI-1, -4, -7, -8, and -10 Sample</th>
<th>SWDI-13 and -14 Sample</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Segment 14</td>
<td>Segment 16h</td>
<td>Untreated Concentration</td>
</tr>
<tr>
<td>Arsenic</td>
<td>Total recoverable</td>
<td>ug/L</td>
<td>3</td>
<td>7.6</td>
<td>9</td>
</tr>
<tr>
<td>Cadmium</td>
<td>Dissolved</td>
<td>ug/L</td>
<td>0.8</td>
<td>1.2</td>
<td>&lt; 5</td>
</tr>
<tr>
<td>Iron</td>
<td>Dissolved</td>
<td>ug/L</td>
<td>300</td>
<td>no limit</td>
<td>&lt; 500</td>
</tr>
<tr>
<td>Iron</td>
<td>Total recoverable</td>
<td>ug/L</td>
<td>1,000</td>
<td>1,000</td>
<td>&lt; 500</td>
</tr>
<tr>
<td>Manganese</td>
<td>Dissolved</td>
<td>ug/L</td>
<td>190</td>
<td>2,618</td>
<td>&lt; 500</td>
</tr>
<tr>
<td>Lead</td>
<td>Dissolved</td>
<td>ug/L</td>
<td>7</td>
<td>11</td>
<td>&lt; 5</td>
</tr>
</tbody>
</table>
## Table 5 - Estimate of Probable Cost

<table>
<thead>
<tr>
<th>Item No.</th>
<th>Item Description</th>
<th>Additional Info</th>
<th>UOM</th>
<th>Qty</th>
<th>Unit Cost</th>
<th>Total Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>a. Landfill Material Removal and Disposal from Coliseum Parking Lot</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>COMPETENT WASTE PROFESSIONAL AND ASBESTOS BUILDING INSPECTOR (CABI)</td>
<td>Full time monitor of waste and “soil and debris” during excavation, staging, and loading. Asbestos sampling, as needed.</td>
<td>DAY</td>
<td>55</td>
<td>$1,500</td>
<td>$82,500</td>
</tr>
<tr>
<td>2</td>
<td>REMOVAL OF WASTE MATERIAL AND TRANSPORT TO DADS</td>
<td>Excavation to subgrade, stage, load, and haul waste material containing RACS (99%) to DADS. Disposal cost reported below.</td>
<td>TON</td>
<td>53,000</td>
<td>$30</td>
<td>$1,590,000</td>
</tr>
<tr>
<td>3</td>
<td>REMOVAL AND DISPOSAL OF HAZ WASTE AT CLEAN HARBORES</td>
<td>Excavate to subgrade, stage, profile, haul, and dispose of hazardous waste (1%) at Clean Harbors, Last Chance, CO</td>
<td>TON</td>
<td>535</td>
<td>$270</td>
<td>$144,545</td>
</tr>
<tr>
<td>4</td>
<td>ENVIRONMENTAL MONITORING and HEALTH &amp; SAFETY</td>
<td>Two technicians for Environmental Monitoring, Personnel Protection Equipment, Instrumentation, Communication, and Lab Analyses</td>
<td>DAY</td>
<td>95</td>
<td>$2,500</td>
<td>$237,500</td>
</tr>
<tr>
<td>5</td>
<td>SECURITY FENCE</td>
<td>Temporary 6’ High Chain Link Construction Fencing/Gates, incl. fabric screen material, and removal of Fencing/Gates after Construction</td>
<td>LF</td>
<td>2,000</td>
<td>$25</td>
<td>$50,000</td>
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<tr>
<td><strong>Subtotal Landfill Removal and Disposal - Coliseum Parking Lot</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>$2,105,000</td>
</tr>
<tr>
<td><strong>b. Landfill Material Removal and Disposal Within Globeville Landing Park</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>COMPETENT WASTE PROFESSIONAL AND ASBESTOS BUILDING INSPECTOR (CABI)</td>
<td>Full time monitor of waste and “soil and debris” during excavation, staging, and loading. Asbestos sampling, as needed.</td>
<td>DAY</td>
<td>170</td>
<td>$1,500</td>
<td>$255,000</td>
</tr>
<tr>
<td>2</td>
<td>REMOVAL OF NON-RACS SOIL AND DEBRIS AND TRANSPORT TO DADS</td>
<td>Excavation to subgrade, stage, load, and haul non-RACS soil and debris (49%) to DADS. Disposal cost reported below.</td>
<td>TON</td>
<td>65,500</td>
<td>$20</td>
<td>$1,310,000</td>
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<tr>
<td>3</td>
<td>REMOVAL OF RACS SOIL AND DEBRIS AND TRANSPORT TO DADS</td>
<td>Excavation to subgrade, stage, load, and haul RACS soil and debris (50%) to DADS. Disposal cost reported below.</td>
<td>TON</td>
<td>66,800</td>
<td>$30</td>
<td>$2,004,000</td>
</tr>
<tr>
<td>4</td>
<td>REMOVAL AND DISPOSAL OF HAZ WASTE AT CLEAN HARBORES</td>
<td>Excavate to subgrade, stage, profile, haul, and dispose of hazardous waste (1%) at Clean Harbors, Last Chance, CO</td>
<td>TON</td>
<td>1,340</td>
<td>$270</td>
<td>$361,800</td>
</tr>
<tr>
<td>5</td>
<td>ENVIRONMENTAL MONITORING and HEALTH &amp; SAFETY</td>
<td>Two technicians for Environmental Monitoring, Personnel Protection Equipment, Instrumentation, Communication, and Lab Analyses</td>
<td>DAY</td>
<td>295</td>
<td>$2,500</td>
<td>$737,500</td>
</tr>
<tr>
<td>6</td>
<td>SECURITY FENCE</td>
<td>Temporary 6’ High Chain Link Construction Fencing/Gates, incl. fabric screen material, and removal of Fencing/Gates after Construction</td>
<td>LF</td>
<td>4,000</td>
<td>$25</td>
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<td>$4,768,000</td>
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<td><strong>c. Dewatering and Treatment (Combined Areas)</strong></td>
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<td>DEWATERING SYSTEM</td>
<td>4100 LF trench + 17 cleanouts + 4 sumps + H&amp;S</td>
<td>LS</td>
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<td>180</td>
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<td>WATER TREATMENT SYSTEM MOB SETUP DEMOB (EXCLUDING REVERSE OSMOSIS)</td>
<td>Gravel pad, modularized treatment plant with pumps, piping, process vessels, monitoring equipment, and secondary containment without RO</td>
<td>LS</td>
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<td>3a</td>
<td>REVERSE OSMOSIS MOB SETUP DEMOB</td>
<td>Addition of RO equipment to back-end of plant</td>
<td>LS</td>
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<td>4</td>
<td>WATER TREATMENT OPERATIONS, MAINTENANCE, AND WASTE DISPOSAL</td>
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<td>6</td>
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<td>4a</td>
<td>REVERSE OSMOSIS OPERATIONS, MAINTENANCE, AND BRINE DISPOSAL</td>
<td>RO Treatment with brine disposal</td>
<td>MONTH</td>
<td>6</td>
<td>$210,000</td>
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<td>DISCHARGE PERMIT COMPLIANCE</td>
<td>Per sampling and reporting requirements of the discharge permit</td>
<td>MONTH</td>
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<td>SOIL IMPROVEMENT BY Vibro-Stone Columns</td>
<td>Vibro Stone Columns in Coliseum Parking Lot</td>
<td>LF</td>
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<td>OVERBURDEN PENETRATION FOR Compaction Grouting</td>
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<td>In Coliseum Parking Lot and in Globeville Landing Park over Vibro Stone Columns</td>
<td>SF</td>
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<td>CY</td>
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<td>GEONET COMPOSITE</td>
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<td>GEOTEXTILE</td>
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<td>Stainless Steel Batten</td>
<td>Liner attachment to wall</td>
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<td>Cutoff Trench for Channel</td>
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<td>11</td>
<td>CAST-IN-PLACE SPECIAL STRUCTURE</td>
<td>Concrete Wall for Liner in Coliseum and Park</td>
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<td>1,230</td>
<td>$ 40</td>
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<td>CAST-IN-PLACE SPECIAL STRUCTURE</td>
<td>Drop Inlet Box for Liner in Park (50% of cost)</td>
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**Subtotal Barrier System** $1,802,000

**Total Estimate of Probable Construction Costs without Contingency, Disposal Cost, and without RO Treatment** $10,562,000

**Total Estimate of Probable Construction Costs with Contingency and Disposal Cost, but without RO Treatment** $12,283,000

**Total Estimate of Probable Construction Costs with Contingency** $12,900,000

**Total Estimate of Probable Construction Costs with Contingency and Disposal Cost, and with RO Treatment** $15,000,000

**Total Fees Paid Separately By City** $1,730,000

**Total Estimate of Probable Construction Costs with Contingency and Disposal Cost, but with RO Treatment** $17,230,000

**Total Estimate of Probable Construction Costs with Contingency and Disposal Cost, and with RO Treatment** $19,730,000

Notes:
1. Waste and "soil and debris" quantity estimates are from Merrick
2. Security Fencing quantities and unit rates are from Merrick
3. Water treatment system mob/set-up/demob lump-sum unit rates are from Rain for Rent
4. Water treatment O&M unit rates are from Rain for Rent
5. Soil improvement costs are from CTL Thompson and Merrick
6. Geogrid, Geotextile, and LLDPE quantities are from Merrick and unit rates are from Colorado Lining
7. Imported Clay and Cast-in-place special structures costs are from Merrick
8. Clean soil with objects less than 6" in any dimension assumed to be 49% in Park, and 0% in Coliseum Parking Lot, per City
9. Soil with Friable Asbestos assumed to be 50% in Park and 99% in Coliseum Parking Lot, per City
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<td>Demobilization</td>
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<tr>
<td>Construction Closeout</td>
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</table>
FIGURES
LEGEND

- Limits of Fill Material Within the Coliseum Parking Area as Defined During the OU2 Remedial Investigation (EMSI, 2009)
- Sanitary Sewer
- Stormwater Channel Center Alignment
- Surface Cut for Open Channel
- Surface Cut for Box Culvert
- Simulated Water-Level Elevation (ft amsl)
- Groundwater Flow

Figure 2
SIMULATED STEADY-STATE POST-CONSTRUCTION GROUNDWATER ELEVATIONS
OPERABLE UNIT #2, VB I70 SUPERFUND SITE

EMSI Engineering Management Support, Inc.
Figure 3
Organizational Structure
VB/I70 Operable Unit #2 GLOP Implementation

**USEPA**
D. Zinner (RMP)
TBD (OSC)

**Project Coordinator for Environmental Components**
L. Farrell (Denver)

**Construction QA**
- Geosynthetics CQAM (TBD)
- Soils and Aggregate (TBD)
- Materials Management (TBD)

**Integrated Construction Program Manager**
Brian McLaren, PE (Denver)

**Health and Safety**
TBD

**Construction Management**
TBD (Kiewit)

**Key Contractors**
- Geosynthetics Installation (TBD)
- Subsoil Stabilization (TBD)
- General Earthwork (TBD)
- Solid Waste and ACM Disposal (WM-DADS)
- Hazardous/Industrial Waste Disposal (Clean Harbors)
- Dewatering and Water Treatment (TBD)
- Barrier Construction (TBD)
- Odor Control (TBD)
- Others (TBD)

**Field Engineers and Environmental Monitors**
- Field Engineers (TBD)
- Competent HW Person + CABI (TBD)
- Methane/Odor/Dust Monitor (TBD)

**Quality Control Testing**
- Liner and Geofabric Testing
- Grain Size/Atterberg Limits
- Soil Compaction
- Surface Soil Characterization
- Waste Characterization (if needed)
- Asbestos Testing (if needed)
- Concrete Testing
- Air Quality Testing (if needed)
- Visual Inspections
- Others

**Community Monitor**
TBD

**Field Engineers and Environmental Monitors**
- Field Engineers (TBD)
- Competent HW Person + CABI (TBD)
- Methane/Odor/Dust Monitor (TBD)

**Integrated Construction Program Manager**
Brian McLaren, PE (Denver)

**Health and Safety**
TBD

**Construction Management**
TBD (Kiewit)

**Key Contractors**
- Geosynthetics Installation (TBD)
- Subsoil Stabilization (TBD)
- General Earthwork (TBD)
- Solid Waste and ACM Disposal (WM-DADS)
- Hazardous/Industrial Waste Disposal (Clean Harbors)
- Dewatering and Water Treatment (TBD)
- Barrier Construction (TBD)
- Odor Control (TBD)
- Others (TBD)
APPENDIX A
Materials Management Plan
Appendix A

Final Materials Management Plan
Globeville Landing Outfall Project

Vasquez Boulevard/Interstate 70 Site,
Operable Unit #2 Removal Action

Prepared for:

City and County of Denver
Environmental Quality Division
200 West 14th Ave, Suite 310
Denver, Colorado 80204

Prepared by:

Engineering Management Support, Inc.
7220 W. Jefferson Ave., Suite 406
Lakewood, Colorado 80235

January 25, 2016
TABLE OF CONTENTS

1 INTRODUCTION ........................................................................................................................................... 1
  1.1 OBJECTIVES AND GOALS .................................................................................................................. 1
  1.2 PLAN ORGANIZATION ....................................................................................................................... 1

2 WASTE MATERIAL AND CONSTITUENTS OF CONCERN .............................................................. 1
  2.1 WASTE MATERIAL ............................................................................................................................ 1
  2.2 GROUNDWATER ............................................................................................................................... 1

3 REGULATORY CRITERIA ......................................................................................................................... 1
  3.1 WASTE MATERIAL ............................................................................................................................ 1
  3.1.1 Non-Hazardous Solid Waste ........................................................................................................ 1
  3.1.2 Asbestos-Containing Material ...................................................................................................... 2
  3.1.3 Hazardous Waste .......................................................................................................................... 4
  3.2 GROUNDWATER .................................................................................................................................. 6
  3.2.1 Release to the South Platte River or Toll Gate Creek ....................................................................... 6
  3.2.2 Off-Site Disposal .......................................................................................................................... 6
  3.3 OFF-SITE RULE .................................................................................................................................. 7

4 MATERIALS MANAGEMENT ................................................................................................................ 9
  4.1 WASTE MATERIAL ............................................................................................................................ 9
  4.1.1 Non-Hazardous, non-RACS Waste Material .................................................................................. 9
  4.1.2 Asbestos-Containing Material ....................................................................................................... 9
  4.1.3 Hazardous Waste .......................................................................................................................... 10
  4.2 GROUNDWATER .................................................................................................................................. 11
  4.2.1 On-site Treatment and Release to Surface Water ......................................................................... 11
  4.2.2 Off-Site Disposal .......................................................................................................................... 12
  4.2.3 On-Site Treatment and Reuse ....................................................................................................... 12

5 REFERENCES ............................................................................................................................................... 14

LIST OF TABLES

Table A-1 Groundwater Quality – Metals
Table A-2 Groundwater Quality – Inorganics
Table A-3 Groundwater Quality – Detected Volatile Organic Compounds
Table A-4a Groundwater Quality – Metals vs South Platte River Numeric Limits
Table A-4b Groundwater Quality – Metals vs Toll Gate Creek Numeric Limits
Table A-5 Groundwater Quality – Inorganics vs Numeric Limits for Both Outfalls
Table A-6 Groundwater Quality – Detected VOCs vs Numeric Limits for Both Outfalls
Table A-7 TCLP Limits vs Groundwater Constituents of Concern

LIST OF FIGURES

Figure A-1 Base Map
LIST OF APPENDICES

Appendix A-1  CDPS Discharge Permits
## LIST OF ACRONYMS

<table>
<thead>
<tr>
<th>Acronym</th>
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<tr>
<td>ACM</td>
<td>Asbestos-Containing Material</td>
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<td>ARARs</td>
<td>Applicable or Relevant and Appropriate Requirements</td>
</tr>
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<td>bgs</td>
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<td>BMPs</td>
<td>Best Management Practices</td>
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<td>CDPHE</td>
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<td>CDPS</td>
<td>Colorado Discharge Permit System</td>
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<td>CMU</td>
<td>Concrete Masonry Unit</td>
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<td>TCLP</td>
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<td>VOCs</td>
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1 INTRODUCTION

Work under this Removal Action entails implementation of the “environmental components” of the Globeville Landing Outfall Project (GLOP), which is a stormwater drainage feature to be constructed through Operable Unit 2 of the VB/I70 Superfund site. The alignment, profile, and cross-sections of the GLOP are presented in the Design Document to which this Materials Management Plan (MMP) is appended.

1.1 Objectives and Goals

Objectives of this MMP consist of providing for safe handling and disposal of waste material and management of groundwater and perched liquids that are encountered during construction of the GLOP. These solids and liquids are to be managed in a manner that complies with applicable environmental regulations, EPA guidelines, and applicable or relevant and appropriate requirements (ARARs). Accordingly, this plan describes the handling, treatment, and disposal procedures that pertain to these media.

Specific goals consist of:

- Removal and disposal of waste material as soon as possible following excavation to minimize health risk involved with on-site storage;
- Maximize on-site reuse of excavated material that does not need to disposed off-site in a manner that is protective of public health and the environment;
- Minimize the volume of liquids that need to be managed by routing non-contact stormwater around the construction area and expediting excavation and backfilling of material below the groundwater table; and
- Assess and implement the most cost-effective management of liquids from construction dewatering and liquids that contact waste material.

1.2 Plan Organization

This MMP contains five sections, including this introduction. Compounds of concern associated with waste material and groundwater are described in Section 2. Applicable regulatory criteria are presented in Section 3. Management of waste material, groundwater, and investigative-derived wastes is presented in Section 4, and references are presented in Section 5.

The text is followed by one appendix that contain remediation dewatering permits.
2  WASTE MATERIAL AND CONSTITUENTS OF CONCERN

2.1 Waste Material

Waste material beneath the Denver Coliseum parking lot and “soil and debris” from the Globeville Landing Park were characterized in the Data Summary Report (DSR) (EMSI, 2015a), which is incorporated by reference into this MMP. Additional characterization of waste material and “soil and debris” was performed by Brown and Caldwell (2010) and CTL Thompson (2011); their reports are also incorporated into this MMP by reference. Conclusions and recommendations from the DSR and reports by others are summarized below:

Waste material from the Coliseum parking lot, and “soil and debris” from the Globeville Landing Park are not listed hazardous wastes, and all waste and “soil and debris” samples tested negative for hazardous waste characteristics. Constituents that were tested, but were either not detected or detected at concentrations below EPA’s Risk-Based Screening Levels, consisted of volatile organic compounds (VOCs), semi-volatile organic compounds (SVOCs), polychlorinated biphenyls (PCBs), and metals. In addition, the samples passed the paint filter test. However, waste material samples from the Coliseum parking lot contained a fair amount of putrescible organic matter that likely originated from past landfilling activities (pre-Resource Conservation and Recovery Act [RCRA]).

“Soil and debris” samples from the Globeville Landfill Park contained soil, construction debris, and some naturally-occurring woody material and river-bottom organics, but no apparent landfilled organic waste.

A small amount of asbestos was present in a “soil and debris” sample from one boring in the Globeville Landing Park. Even though the asbestos content was less than 1% of the material sampled, it was determined to be a Regulated Asbestos-Containing Soil (RACS). It should be noted that this RACS detection is consistent with asbestos detections by others in waste material sampled beneath the Coliseum parking lot (CTL-Thompson, 2013).

2.2 Groundwater

Groundwater quality was also characterized in the DSR. Sampling locations are shown on Figure A-1. Summary detections for metals, inorganics, and volatile organic compounds (VOCs) are presented in Tables A-1, A-2, and A-3, respectively.
3 REGULATORY CRITERIA

3.1 Waste Material

As reported in the DSR, most waste material beneath the Coliseum parking lot and “soil and debris” from the Globeville Landing Park may be characterized non-hazardous, non-RACS solid waste. Some material may be characterized as non-hazardous solid waste with RACS. In addition, the potential exists for hazardous waste to be encountered. Regulations governing the determination and handing of non-hazardous solid waste, RACS, and hazardous waste are discussed below.

3.1.1 Non-Hazardous Solid Waste

As indicated in the previous Section, waste material from the Coliseum parking lot, and “soil and debris” from the Globeville Landing Park are not listed hazardous wastes and tested negative for hazardous waste characteristics. In addition, the samples passed the paint filter test. Waste material samples from the Coliseum parking lot contained a fair amount of decomposing organic material that likely originated from past landfilling activities. Therefore, in the absence of RACS, waste material from the Coliseum parking lot may be profiled as non-hazardous, non-RACS solid waste that may be disposed in a RCRA Subtitle D landfill.

“Soil and debris” samples from the Globeville Landing Park contained soil and construction debris. In the absence of RACS, this material may also be considered non-hazardous, non-RACS, but because it does not contain putrescible waste material, it is not considered a waste that must be disposed in a RCRA-permitted landfill. In addition, the compounds of concern in “soil and debris” other than RACS are limited to those of waste material in the Coliseum parking lot (metals only). Therefore, provided 1) the material does not contain the items identified below as RACS, 2) “debris” is limited to relatively inert material such as fragmented asphalt, bricks, concrete, glass, or plastics, 3) the geotechnical properties of “soil and debris” meet the technical specification of the intended reuse of the material within the GLOP, and 4) public health is adequately protected, “soil and debris” from the Globeville Landing Park may be beneficially reused within the GLOP. For clarification, such beneficial reuse is not applicable to areas outside the GLOP.

From a regulatory perspective, beneficial reuse of “soil and debris” in both areas is acceptable because the “area of contamination” is defined by the boundaries of Operable Unit 2, which encompass both the Coliseum parking lot and the Globeville Landing Park. Possible beneficial use may include, but is not limited to, reuse as construction backfill or landscaping subsoil that is ultimately covered with clean soil. Alternatively, if on-site reuse opportunities are not available, the material may be disposed in a RCRA Subtitle D landfill as a special waste.
3.1.2 Asbestos-Containing Material

The substantive requirements of CDPHE’s Asbestos Contaminated Soil regulations and guidance are relevant to this site. The regulations are incorporated into Section 5.5 (Management of Regulated Asbestos-Contaminated Soil) of the State’s Solid Waste Regulations and can be down-loaded from: https://www.colorado.gov/pacific/sites/default/files/Part%201%20eff%2001-14-15.pdf. Guidance documents can be found at: https://www.colorado.gov/pacific/sites/default/files/HM_sw-asbestos-waste-disposal_0.pdf and https://www.colorado.gov/pacific/sites/default/files/HM_sw-reggs-sect-5-asbestos.pdf

Two types of asbestos-containing material (ACM) may be encountered consisting of RACS, and non-RACS. Descriptions of each, as well as protocol for a RACS-Determination, are discussed below:

**RACS is defined as:**

Soil, ash or debris (plus six (6) inches in all directions of surrounding soil or other matrix material) containing:

1) Friable ACM as determined in the field by a Certified Asbestos Building Inspector (CABI) through a RACS determination (defined below);
2) Previously non-friable ACM(s) that have been rendered friable as determined in the field by a CABI(s) through a RACS determination;
3) Non-friable ACM(s) that have a high probability of releasing fibers based on the forces expected to act upon the material during soil disturbance as determined in the field by a CABI(s) through a RACS determination;
4) Deteriorated non-friable ACM(s) that are in poor condition resulting in a high probability to release fibers due to weathering, historical mechanical impact, fire damage (by evidence of ACM within an ash layer) or other factors as determined in the field by a CABI(s) through a RACS determination; and
5) If determined by the CABI to potentially-contain ACM, the following broken, resized, or damaged material are also RACS:

   a. Asbestos cement materials;
   b. Plaster;
   c. Brittle caulking, glazing and sealants;
   d. Powdery Concrete Masonry Unit (CMU) sealant;
   e. Powdery floor leveling compound;
   f. Drywall/wallboard and associated joint compound material;
   g. Firebrick; and
h. Other material as determined by CDPHE Solid Waste Division, at the request of the owner or person disturbing debris, to have a high probability to release fibers.

Non-RACS is defined as:

Soil or debris that contains only:

1) Intact non-damaged, non-friable ACM; or,

2) Damaged non-friable ACM(s) that do not have a high probability to release fibers based on the forces expected to act upon the material during disturbance as determined in the field by a CABI(s) through a “RACS Determination”. The following ACM(s) are predetermined to be Non-RACS:

   a. Resin based materials including, but not limited to, phenolic-plastic (Bakelite), used in electrical and mechanical parts;

   b. Resilient flooring (vinyl, asphalt, rubber) excluding non-tar impregnated friable felt backing on sheet vinyl flooring (linoleum);

   c. Tar impregnated or asphaltic materials in good condition that have not become brittle;

   d. Elastic, pliable, or rubberized materials, including but not limited to:

      i. Pliable duct sealant;

      ii. Pliable fiberglass insulation sealant;

      iii. Pliable fire-stop caulking/sealants;

      iv. Pliable window and door caulking; and

   v. Extremely hard materials, coatings and sealants including but not limited to:

      • Laboratory countertops and sinks;

      • Epoxy type Concrete Masonry Unit (CMU) coatings;

      • Epoxy type panel adhesive;

      • Duct sealant;

      • Ceiling tile adhesive; and

      • Other ACM(s) as approved by CDPHE Solid Waste Division at the request of the owner or person disturbing debris, to not have a high probability to release fibers.

A “RACS Determination” is defined as:

A determination, conducted in the field by a CABI, of the friability of ACM and the probability of non-friable ACM to release fibers based on the condition of the material and the forces that are expected to act on it during disturbance. Determinations of friability shall
be based on the requirements for such determinations set forth in Air Quality Control
Commission Regulation No. 8 (5 CCR 1001-10, Part B). Determinations of the probability
for nonfriable ACM to release fibers during disturbance shall be based on the following:

1) The condition of the material prior to disturbance, based on observations of
weathering, the integrity of the material, historical mechanical impact, or fire
damage;

2) The potential for the material to be broken, resized or damaged during planned
disturbance;

3) The material shall be considered RACS if the planned disturbance includes any of
the following:
   a. Augers;
   b. Rotary style trenchers;
   c. Driving on ACM lying on the surface (vehicles or equipment);
   d. Blasting or other detonation;
   e. Intentional burning;
   f. Other types of direct mechanical impact which are:
      i. In direct contact with ACM or result in observation of ACM after
disturbance; and
      ii. Causing damage to the ACM.

Section 5.5 of the Solid Waste Regulations (6 CCR 1007-2) includes regulations for the
management of RACS, including:

- Worker Training (Subsection 5.5.3);
- Response to Unplanned RACS Discovery (Subsection 5.5.4);
- Response to Planned RACS Management (Subsection 5.5.5);
- Remediation of Asbestos in Soil (Subsection 5.5.6);
- Standard Requirements for the Disturbance of RACS (Subsection 5.5.7); and
- Packaging and Disposition of RACS (Subsection 5.5.8).

The substantive requirements of all of these regulations apply to this project.

3.1.3 Hazardous Waste

To the extent that hazardous waste may be encountered, regulations concerning the
identification and listing of hazardous waste are specified under 40 CFR Parts 260 through
261, and 6 CCR 1007-3 Parts 260 through 261. Applicable portions of these regulations
include the definition of hazardous waste (Part 261.3); hazardous waste exclusions (Part
261.4); and the characteristics of hazardous waste, including ignitability (Part 261.21),
corrosivity (Part 261.22), reactivity (Part 261.23), and toxicity (Part 261.24). Based on the age of the landfill material present within OU-2, and on the characterization data available to date, buried material will probably not be listed hazardous waste.

Regulations concerning standards applicable to generators of hazardous waste are specified under 40 CFR Part 262, and 6 CCR 1007-3 Part 262. Applicable portions of these regulations include the hazardous waste determination requirements in accordance with Part 262.11.

Should hazardous wastes be present at the site, a hazardous waste generator identification number will need to be obtained from CDPHE. This number will be applied to all off-site shipments of hazardous waste in accordance with Part 262.12. Similarly, use of manifest documents as described in Part 262.20; packaging, labeling, marking, and placarding requirements described in Parts 262.30 through 262.33; and recordkeeping and reporting requirements described in Parts 262.40 through 262.42 will be applicable in the event that hazardous wastes are sent off-site for disposal.

Regulations pertaining to the operating and performance standards for container storage of hazardous waste are specified in 40 CFR Part 264, Subpart I; and 6 CCR 1007-3 Part 264, Subpart I. Containers holding hazardous waste, such as drums, will be in good condition or will be overpacked if discovered to not be in good condition (Part 264.171). Drums specified for use in Subsection 4.6 of this plan are constructed with materials that are compatible with the wastes being stored (Part 264.172). Containers will be kept closed during storage, and will not be handled in a manner that may rupture the container or cause it to leak (Part 264.173). Weekly inspections of containers stored on-site will need to be performed (Part 264.174). Containers with ignitable or reactive waste (if encountered) will be stored more than 50 feet from the site property line (Part 264.176), and incompatible waste will not be placed in the same container, in an unwashed container that previously held an incompatible waste or material, or stored near other containers of incompatible wastes or materials (Part 264.177).

Regulations concerning the handling of potentially incompatible wastes are specified in 40 CFR Part 265.17, and 6 CCR 1007-3 Part 265.17. Precautions should be taken to prevent accidental ignition or reaction of wastes, and incompatible wastes (if encountered) will be separated and protected from sources of ignition or reaction (Part 265.17). Regulations concerning LDRs are specified in 40 CFR Part 268, and 6 CCR 1007-3 Part 268. These regulations will apply to off-site treatment and disposal of hazardous wastes.

As discussed above, procedures for planning and implementing off-site response actions under CERCLA are specified in 40 CFR Part 300.44, known as the Off-Site Rule. This regulation applies to off-site treatment and disposal of hazardous wastes that cannot be managed on-site. Further discussion of the Off-Site Rule is presented in Section 3.3, below.
3.2 Groundwater

Groundwater, which includes perched water, will require dewatering to provide for “dry” working conditions to construct the impermeable barrier and to install cast-in-place concrete structures. Two management scenarios are considered. The first is release of the water to the South Platte River or Toll Gate Creek under Colorado’s General Permit for Construction Dewatering or Remediation. The second is disposal of the water off-site as an industrial or hazardous waste in a licensed RCRA treatment, storage, or disposal facility (TSDF). Both options are discussed below.

3.2.1 Release to the South Platte River or Toll Gate Creek

Under this option, coverage under Colorado’s General Permit for Construction Dewatering or Remediation is required from the Water Quality Control Division (WQCD) of the Colorado Department of Public Health and Environment (CDPHE). Such coverage is required any time groundwater, including groundwater that is commingled with stormwater or surface water, is encountered during construction activities where the water needs to be discharged to surface water or back to the ground, or any time groundwater, including groundwater that is commingled with stormwater or surface water, is encountered during construction activities and the water quality is known or suspected to contain constituents in excess of one-half the allowable discharge limit, where the water needs to be discharged to surface water or back to the ground. It should be noted that if surface water is diverted around a construction area and no pollutants are introduced during the diversion, permit coverage is not required. This applies to pumped diversions. However, if the diverted water enters the construction area and contacts pollutant sources (e.g., disturbed soil, concrete washout, etc.), permit coverage is required.

Copies of the Certification to Discharge to the South Platte River and Toll Gate Creek under the Colorado Discharge Permit System (CDPS) General Permit for Remediation Activities Discharging to Surface Waters, plus a copy of the General Permit, are presented in Appendix A-1. Treatment of site waters will be required to meet the numeric effluent limitations listed in the Certification to Discharge (Discharge Permit) and General Permit. Effluent limitations, as well as monitored parameters, monitoring frequencies, sample types, and reporting requirements listed in the two permits shall be complied with whenever site waters are released to the South Platte River or Toll Gate Creek.

3.2.2 Off-Site Disposal

If site waters cannot be cost-effectively treated to meet numeric effluent limitations, off-site disposal will be considered. The off-site disposal option involves an initial assessment of RCRA-hazardous or non-hazardous status. Based on historic and process knowledge, the dewatering waters are not listed wastes. Therefore, the hazardous determination will be based on RCRA characteristics and toxicity characteristic leaching procedure (TCLP) toxicity. An initial assessment of available groundwater quality data is presented in Section
4.2.2 of this MMP.

If dewatering water is not cost-effective to treat on-site, and is determined to be RCRA non-hazardous, it may be manifested as a non-hazardous waste, transported off-site to a Clean Harbors facility where it will be stabilized (solidified) for disposal in a RCRA Subtitle D landfill, or transported off-site to a RCRA Subtitle D landfill where it will be land-applied in accordance with the landfill’s prescreening land-application criteria.

If dewatering water is determined to be RCRA hazardous it will be transported to Clean Harbor’s Deer Trail facility for stabilization (solidification) and buried as a hazardous waste. If LDRs preclude such burial, the water may be treated in a Subtitle C facility, or incinerated at Clean Harbor’s Kimball, Nebraska facility.

As discussed above, procedures for planning and implementing off-site response actions under CERCLA are specified in 40 CFR Part 300.44, known as the Off-Site Rule. This regulation applies to off-site treatment and disposal of contaminated water that cannot be managed on-site. Further discussion of the Off-Site Rule is presented in Subsection 3.3, below.

3.3 Off-Site Rule

The Off-Site Rule indicates that EPA will determine the acceptability of any off-site facility that has been selected for treatment, storage or disposal of CERCLA wastes. The proposed receiving facility must be operating in compliance with all applicable federal, state, and local regulations, and there must be no relevant violations affecting the receiving unit. In addition, there must be no releases from the receiving unit, and contamination from prior releases at the receiving unit must be addressed as appropriate. Releases from other units located within the receiving facility boundaries must also be addressed as appropriate.

Respondent will, prior to any off-site shipment of waste material from the site to an out-of-state waste management facility, provide written notification to the appropriate state environmental official in the receiving facility’s state and to the EPA Project Coordinator of such shipment of waste material. However, this notification requirement does not apply to any off-site shipments when the total volume of all such shipments does not exceed ten (10) cubic yards.

Respondent will include in the written notification the following information, where available: (1) the name and location of the facility to which the waste material is to be shipped; (2) the type and quantity of the waste material to be shipped; (3) the expected schedule for the shipment of the waste material; (4) the method of transportation; and (5) the route to be traveled. The Respondent will notify the state in which the planned receiving facility is located of major changes in the shipment plan, such as a decision to ship the waste material to another facility within the same state, or to a facility in another state.
The identity of the receiving facility and state will be determined by the Respondent following the award of a services agreement for off-site transportation, treatment, storage, and disposal services. The Respondent will provide the name and location of the receiving facility(ies) to the appropriate state environmental official in the receiving facility’s state and to the EPA Project Coordinator as soon as practicable after the award of the contract and no less than sixty (60) days before the waste material is actually shipped.

Before shipping any hazardous substances, pollutants, or contaminants from the Site to an off-site location, Respondent will obtain EPA’s certification that the proposed receiving facility is operating in compliance with the requirements of CERCLA Section 121(d)(3), 42 U.S.C. § 9621(d)(3), and 40 C.F.R. § 300.440. Respondent will only send hazardous substances, pollutants, or contaminants from the Site to an off-site facility that complies with the requirements of the statutory provision and regulations cited in the preceding sentence.
4 MATERIALS MANAGEMENT

4.1 Waste Material

The contractor excavating waste material from the Coliseum parking lot and “soil and debris” from Globeville Landing Park is responsible for placement of a competent person, whose qualifications include a CABI, on-site to oversee all excavation activities. The competent person performing the oversight should be equipped with instrumentation that can monitor changes in the waste stream for organic compounds and ACM, and maintain visual contact with the excavation to identify potentially hazardous wastes if encountered.

4.1.1 Non-Hazardous, non-RACS Waste Material

Waste material from the Coliseum parking lot that is determined to be non-hazardous and non-RACS will be temporarily staged on-site, then trucked off-site for disposal at the Denver Arapahoe Disposal Site (DADS) under manifest issued by Waste Management of Colorado, Inc.

“Soil and debris” from the Globeville Landing Park that is determined to be non-hazardous and non-RACS will be temporarily staged on-site for possible reuse on-site, as determined appropriate by the project engineer, or for off-site disposal at DADS. “Soil and debris” that is designated for reuse will be stockpiled on-site and managed to minimize generation of fugitive dust. Management options consist of tarping, wetting, covering with a minimum of six inches of clean soil and vegetating, applying foam, and other Best Management Practices options that are discussed in the Methane, Odor, and Dust Control Plan (EMSI, 2015b).

“Soil and debris” that remains in place and is exposed on side slopes of the open channels will ultimately be covered with a minimum of six inches of clean soil to prevent human contact with the material. If on-site reuse opportunities are not available, the material will disposed at DADS under manifest issued by Waste Management of Colorado, Inc.

4.1.2 Asbestos-Containing Material

If the competent person witnesses variation in the exhumed material that might indicate the presence of RACS, the CABI will inspect the material and if RACS is potentially identified the CABI will decide how the material is to be managed in accordance with Subsections 5.5.7 and 5.5.8 of the Colorado’s Solid Waste Regulations, as clarified below:

1) Scenario 1: Assumes all material is non-RACS until determined otherwise by the CABI. Note – all soil disturbing personnel will have received awareness training prior to the start of construction that will require them to stop work if potential RACS is encountered. Then the CABI will assess the material to determine if the material is potential RACS. If the CABI determines it is not, the material will be
stockpiled and managed in accordance with Subsection 5.5.7.H.1.c.i. If the CABI determines it is potential RACS, Scenario 2 protocol will be applied.

2) Scenario 2: Assumes a limited area of potential RACS is found. A small regulated work area (RWA) will be identified and managed in accordance with Subsections 5.5.7.F (2) or (3), and (4). The potential RACS will be stockpiled, managed, packaged, and disposed in accordance with all other pertinent Subsections of 5.5.7 and 5.5.8. The non-RACS material will be stockpiled and managed in accordance with Subsection 5.5.7.H.1.c.i.

3) Scenario 3: Assumes a large area of potential RACS is discovered. The material will be excavated and managed within one large RWA in accordance with pertinent Subsections of 5.5.7, and packaged and disposed in accordance with pertinent Subsections of 5.5.8. With this scenario, a materials management program will be prepared and submitted to CDPHE for review and approval.

In the event that Scenarios 2 or 3 occurs, air monitoring will be performed in accordance with Subsection 5.5.7.E (2) or (3). In addition, background monitoring for Phase Contract Microscopy will be conducted on-Site before work begins to establish pre-construction baseline conditions.

**Off-Site Disposal**

If RACS contains putrescible material, the material will be packaged, manifested, and transported to DADS for disposal within their municipal solid waste landfill in a special cell designated for asbestos disposal by DADS personnel. RACS that does not contain putrescible material will be manifested as such, transported to DADS and disposed in their asbestos monofill.

**Documentation**

Asbestos discovered during excavation will be communicated to CDPHE. The CABI is responsible for documenting all asbestos inspection observations and sampling activities. Detailed, complete, and accurate records will be documented. The CABI will also be responsible for maintaining a photographic log and the project field logbook. The purpose of the field logbook is to document a semi-narrative record of the field conditions, activities, and events relevant to the field program on a daily basis. Information to be documented in the logbook includes air monitoring, wind stoppage events, decontamination procedures, ACM and/or RACS handling, sample collection, and any other pertinent information.

**4.1.3 Hazardous Waste**

If the competent person witnesses variation in the exhumed material that might indicate the presence of a “special waste” or hazardous waste, the material will be temporarily staged in a separate area and sampled for additional characterization. Specific examples of materials that would require additional characterization include, but are not limited to:
• Battery casings;
• Drums or barrels;
• Materials with excessive odor or discoloration;
• Tanks;
• Transformers, including carcasses;
• Materials with free liquids (can include waste materials with intrusive water);
• Containers greater than 5 gallons in size containing chemicals or unidentifiable waste material;
• Previously uncharacterized petroleum contaminated materials or what appears to be industrial-type wastes; and
• Ash.

If the material is determined to be a non-hazardous “special waste” and can be disposed at DADS, it will be manifested separately and disposed at DADS in accordance with disposal conditions that are listed in Waste Management’s Waste Approval form. Similarly if the material is determined to be a “universal waste” that can be recycled, an off-site RCRA-licensed recycling firm will be contacted to pick up and properly recycle the waste.

If the material is determined to be a hazardous waste, it will be profiled, packaged, manifested, and transported off-site to a RCRA-licensed TSDF in accordance with the regulations discussed in Section 3.1.3 of this MMP.

4.2 Groundwater

As discussed previously, groundwater extracted from dewatering operations may be treated and released to the South Platte River or Toll Gate Creek in accordance with the Discharge Permit and General Permit presented in Appendix A-1. Alternatively, extracted groundwater may be disposed off-site or reused on-site for dust control or revegetation. All three management options are discussed below.

4.2.1 On-site Treatment and Release to Surface Water

As shown in the Tables A-4a, A-4b, A-5, and A-6 treatment of dewatering water will be required to reduce concentrations of metals, inorganics, and VOCs to meet permitted discharge limits. Treatment will likely involve:

• Chemical injection of sodium hypochlorite prior to water entering weir tanks;
• Solids settling and oxidation in weir tanks;
• Greensand filtration for removal of iron and manganese;
• Bag filtration to remove suspended solids to 25 microns;
• Cationic IX resin for removal of all metals except As;
• Arsenic-specific IX resin for As removal;
• Activated Carbon for organic removals;
• Additional Bag filtration (1 micron); and
• Treatment prior to discharge to the South Platte River may also require addition of reverse osmosis for chloride and sulfate reduction.

All of these processes can be performed on-site using mobile treatment equipment. Design of the treatment train, operations and compliance monitoring programs, and decommissioning are addressed in the Design Documents. Some blending of water from the various dewatering zones, whether prior to treatment or following treatment, may be necessary to achieve the discharge limits specified in the discharge permits. The need for and type of blending will be determined in the field by a professional engineer or certified treatment plant operator who is familiar with the treatment processes, their removal efficiencies, and the effluent quality requirements. If blending is desired, it will be performed in frac tanks or treatment vessels that will be protected with secondary containment, and if needed, covered to minimize release of odors.

Secondary waste streams will be characterized for hazardous characteristics (ignitability, corrosivity, reactivity, reactive cyanides and sulfides, oxidizer, and paint-filter test), and TCLP toxicity. The waste will be manifested and disposed off-site in an appropriate RCRA-licensed TSDF.

4.2.2 Off-Site Disposal

If on-site treatment and release of dewatering water is found to be cost-prohibitive, off-site disposal will be considered. Based on historic characterization of on-site groundwater quality, TCLP toxicity parameters are limited to RCRA metals and VOCs. A summary of detected groundwater analytes, as reported in the DSR, is screened against TCLP regulatory limits in Table A-7. As shown, only unfiltered groundwater, as represented by “total recoverable” and “total” metals fractions, might exceed regulatory levels for arsenic, cadmium, and lead. If groundwater is pretreated by gravity settling or filtration, as represented by “dissolved” and “potentially dissolved” fractions, all metals including arsenic, cadmium, and lead should pass TCLP regulatory levels. All VOCs should pass TCLP levels regardless of pretreatment. If off-site disposal is to be further considered, additional evaluation of water quality data from wells that are representative of actual groundwater being extracted, should be performed in the manner discussed above.

4.2.3 On-Site Treatment and Reuse

If on-site treatment without reverse osmosis can treat site waters to meet all of the permitted discharge limits except chloride and sulfate, the treated effluent may be beneficially used on-site provided chloride and sulfate concentrations do not exceed 2,500 mg/L, each (CDPHE, 2015). As shown in Table A-5, the average and maximum concentrations of chloride in site groundwater are 291 mg/L and 840 mg/L, respectively. The average and maximum concentrations of sulfate in site groundwater are 136 mg/L and 320 mg/L, respectively. Therefore, removal of chloride and sulfate from site groundwater for on-site reuse should not
be necessary.

Reuse options are limited to non-potable use such as dust control, equipment decontamination, and possibly revegetation provided the chloride and sulfate levels are suitable for the intended use. Care shall be taken during application of reuse water to prevent ponding and/or runoff of the water to a receiving surface water body.

4.3 Investigative-Derived and Decontamination Waste

Solid investigative-derived waste (IDW) and residual solids from decontamination activities will be collected and managed as discussed in Sections 4.1 (waste materials excavated) and 4.2 (secondary waste streams from water treatment).

Liquid IDW and decontamination waters will be either evaporated on-site, or collected and managed as discussed in Section 4.2.
5 REFERENCES


CDPHE, 2015. Personal communication between F. Apostolopoulos (CDPHE) and T. Shangraw (EMSI) on December 3, 2015.


CTL Thompson, Inc., 2011. Limited Phase II Environmental Site Assessment, 40th Street Outfall, South Platte River to Blake Street, Denver, CO, prepared for WHPacific, Inc. May 10, 2011.


TABLES
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<td>0.27</td>
<td>U</td>
<td>ug/L</td>
<td>&lt;0.02</td>
<td>U</td>
<td>mg/L</td>
<td>900</td>
<td>ug/L</td>
<td>&lt;0.033</td>
<td>U</td>
<td>mg/L</td>
<td>15</td>
<td>ug/L</td>
</tr>
<tr>
<td></td>
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<td>110000</td>
<td>ug/L</td>
<td>123000</td>
<td>mg/L</td>
<td>280000</td>
<td>U</td>
<td>mg/L</td>
<td>110000</td>
<td>ug/L</td>
<td>150000</td>
<td>U</td>
<td>mg/L</td>
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<tr>
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<td>U</td>
<td>ug/L</td>
<td>&lt;0.02</td>
<td>U</td>
<td>mg/L</td>
<td>900</td>
<td>ug/L</td>
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<td>ug/L</td>
<td>123000</td>
<td>mg/L</td>
<td>280000</td>
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<td>mg/L</td>
<td>110000</td>
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<td>mg/L</td>
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<td>mg/L</td>
<td>900</td>
<td>ug/L</td>
<td>&lt;0.033</td>
<td>U</td>
<td>mg/L</td>
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<td>ug/L</td>
</tr>
<tr>
<td></td>
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<td>ug/L</td>
<td>150000</td>
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<td>mg/L</td>
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<td>mg/L</td>
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<td>&lt;0.033</td>
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<td>mg/L</td>
<td>280000</td>
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<td>U</td>
<td>ug/L</td>
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<td>mg/L</td>
<td>900</td>
<td>ug/L</td>
<td>&lt;0.033</td>
<td>U</td>
<td>mg/L</td>
<td>15</td>
<td>ug/L</td>
</tr>
<tr>
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<td>110000</td>
<td>ug/L</td>
<td>123000</td>
<td>mg/L</td>
<td>280000</td>
<td>U</td>
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<td>ug/L</td>
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<td>mg/L</td>
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<td><strong>SWDI-11</strong></td>
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<td>U</td>
<td>ug/L</td>
<td>&lt;0.02</td>
<td>U</td>
<td>mg/L</td>
<td>900</td>
<td>ug/L</td>
<td>&lt;0.033</td>
<td>U</td>
<td>mg/L</td>
<td>15</td>
<td>ug/L</td>
</tr>
<tr>
<td></td>
<td>Total Recovered</td>
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<td>ug/L</td>
<td>123000</td>
<td>mg/L</td>
<td>280000</td>
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<td>mg/L</td>
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<td>ug/L</td>
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<td>mg/L</td>
<td>900</td>
<td>ug/L</td>
<td>&lt;0.033</td>
<td>U</td>
<td>mg/L</td>
<td>15</td>
<td>ug/L</td>
</tr>
<tr>
<td></td>
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<td>ug/L</td>
<td>123000</td>
<td>mg/L</td>
<td>280000</td>
<td>U</td>
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<td>ug/L</td>
<td>150000</td>
<td>U</td>
<td>mg/L</td>
<td>3700</td>
</tr>
<tr>
<td>Sample ID</td>
<td>Fraction</td>
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<td>Cadmium</td>
<td>Copper</td>
<td>Cr (III)</td>
<td>Cr (VI)</td>
<td>Iron</td>
<td>Lead</td>
<td>Manganese</td>
<td>Nickel</td>
<td>Selenium</td>
<td>Silver</td>
<td>Uranium</td>
<td>Zinc</td>
</tr>
<tr>
<td>-----------</td>
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<td>---------</td>
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<td>Result</td>
<td>Unit</td>
<td>Result</td>
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<td>Unit</td>
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<td>Result</td>
<td>Result</td>
<td>Result</td>
<td>Result</td>
<td>Unit</td>
</tr>
<tr>
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<td>mg/L</td>
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</tr>
<tr>
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<td>ug/L</td>
<td>&lt;0.02</td>
<td>U</td>
<td>mg/L</td>
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</tr>
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<td></td>
<td></td>
<td></td>
<td>1400</td>
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<td></td>
<td></td>
</tr>
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<td>SWDI-14</td>
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<td>ug/L</td>
<td>0.86</td>
<td>mg/L</td>
<td>&lt;0.004</td>
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<td>ug/L</td>
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<td></td>
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<td>11</td>
<td>u</td>
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<td>ug/L</td>
<td>3.8</td>
<td>mg/L</td>
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<td>ug/L</td>
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<td></td>
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<td></td>
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<td></td>
</tr>
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<td>ug/L</td>
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<td>mg/L</td>
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<td>0.033</td>
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<td>u</td>
<td>4900</td>
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<tr>
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<td>Total</td>
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<td>1.2</td>
<td>mg/L</td>
<td>&lt;0.02</td>
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<td>mg/L</td>
<td>180000</td>
<td>ug/L</td>
<td>53</td>
<td>ug/L</td>
</tr>
<tr>
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<td>150</td>
<td>ug/L</td>
<td>13</td>
<td>ug/L</td>
<td>&lt;0.02</td>
<td>U</td>
<td>mg/L</td>
<td>540000</td>
<td>ug/L</td>
<td>430</td>
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</tr>
<tr>
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<td>800</td>
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<td>0.93</td>
<td>mg/L</td>
<td>&lt;0.02</td>
<td>U</td>
<td>mg/L</td>
<td>540000</td>
<td>ug/L</td>
<td>110</td>
<td>ug/L</td>
</tr>
</tbody>
</table>

Notes:
- U = The analyte was analyzed for and is not present above the reported LSL.
- J = The analyte was analyzed for and was positively identified, but the associated numerical value may not be consistent with the amount actually present in the environmental sample. The data should be considered as a basis for decision-making and are useful.
- J+ = The analyte was analyzed for and was positively identified, but the associated numerical value may not be consistent with the amount actually present in the environmental sample and validation indicates a positive bias. The data should be considered.
- J- = The analyte was analyzed for and was positively identified, but the associated numerical value may not be consistent with the amount actually present in the environmental sample and validation indicates a negative bias. The data should be considered.
- R = Rejected
Table A-2: Groundwater Quality - Inorganics

<table>
<thead>
<tr>
<th>Sample ID</th>
<th>Ammonia as N</th>
<th>Chloride</th>
<th>Nitrate as N</th>
<th>Nitrite as N</th>
<th>Sulfate</th>
<th>Sulfide (H₂S)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Result</td>
<td>Unit</td>
<td>Result</td>
<td>Unit</td>
<td>Result</td>
<td>Unit</td>
</tr>
<tr>
<td>CTL-MW6</td>
<td>31</td>
<td>mg/L</td>
<td>290</td>
<td>mg/L</td>
<td>4.5</td>
<td>mg/L</td>
</tr>
<tr>
<td>SWDI-1</td>
<td>120</td>
<td>mg/L</td>
<td>390</td>
<td>mg/L</td>
<td>0.16 J</td>
<td>mg/L</td>
</tr>
<tr>
<td>SWDI-2</td>
<td>4.2</td>
<td>mg/L</td>
<td>270</td>
<td>mg/L</td>
<td>12</td>
<td>mg/L</td>
</tr>
<tr>
<td>SWDI-3</td>
<td>45</td>
<td>mg/L</td>
<td>160</td>
<td>mg/L</td>
<td>&lt;0.042</td>
<td>U mg/L</td>
</tr>
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<td>150</td>
<td>mg/L</td>
<td>5.9</td>
<td>mg/L</td>
</tr>
<tr>
<td>SWDI-5</td>
<td>33 J+</td>
<td>mg/L</td>
<td>250</td>
<td>mg/L</td>
<td>0.16 J</td>
<td>mg/L</td>
</tr>
<tr>
<td>SWDI-5D</td>
<td>33 J+</td>
<td>mg/L</td>
<td>250</td>
<td>mg/L</td>
<td>0.41 J</td>
<td>mg/L</td>
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<tr>
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<td>mg/L</td>
<td>400</td>
<td>mg/L</td>
<td>0.15 J</td>
<td>mg/L</td>
</tr>
<tr>
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<td>mg/L</td>
<td>0.27 J</td>
<td>mg/L</td>
</tr>
<tr>
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<td>mg/L</td>
<td>0.098 J</td>
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<td>mg/L</td>
<td>0.56 J</td>
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<td>mg/L</td>
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<td>mg/L</td>
</tr>
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<td>mg/L</td>
<td>9.4</td>
<td>mg/L</td>
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<td>150</td>
<td>mg/L</td>
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<td>mg/L</td>
</tr>
<tr>
<td>SWDI-14</td>
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<td>190</td>
<td>mg/L</td>
<td>9</td>
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</tr>
<tr>
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<td>mg/L</td>
<td>9.7</td>
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</tr>
<tr>
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<td>190</td>
<td>mg/L</td>
<td>4.7</td>
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</tr>
</tbody>
</table>

Notes:

U = The analyte was analyzed for and is not present above the reported SQL.

J = The analyte was analyzed for and was positively identified, but the associated numerical value may not be consistent with the amount actually present in the environmental sample. The data should be considered as a basis for decision-making and are usable for many purposes.

J+ = The analyte was analyzed for and was positively identified, but the associated numerical value may not be consistent with the amount actually present in the environmental sample and validation indicates a positive bias. The data should be considered as a basis for decision-making and are usable for many purposes.
# Table A-3: Groundwater Quality - Detected Volatile Organic Compounds

<table>
<thead>
<tr>
<th>Sample ID</th>
<th>Benzene</th>
<th>Chlorobenzene</th>
<th>Chloroform</th>
<th>Ethylbenzene</th>
<th>Tetrachloroethene</th>
<th>Toluene</th>
<th>Trichloroethene</th>
<th>Vinyl chloride</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Result</td>
<td>Unit</td>
<td>Result</td>
<td>Unit</td>
<td>Result</td>
<td>Unit</td>
<td>Result</td>
<td>Unit</td>
</tr>
<tr>
<td>CTL-MW6</td>
<td>&lt;0.16 U</td>
<td>ug/L</td>
<td>&lt;0.17 U</td>
<td>ug/L</td>
<td>&lt;0.16 U</td>
<td>ug/L</td>
<td>&lt;0.17 U</td>
<td>ug/L</td>
</tr>
<tr>
<td>SWDI-1</td>
<td>6 ug/L</td>
<td>11 ug/L</td>
<td>&lt;0.16 U</td>
<td>2.9 ug/L</td>
<td>0.47 J</td>
<td>ug/L</td>
<td>0.5 J</td>
<td>ug/L</td>
</tr>
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<td>0.2 J</td>
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<td>&lt;0.16 U</td>
<td>0.92 J</td>
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<td>8.3 ug/L</td>
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<tr>
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<td>&lt;0.17 U</td>
<td>&lt;0.16 U</td>
<td>&lt;0.16 U</td>
<td>ug/L</td>
<td>0.18 J</td>
<td>0.31 J</td>
</tr>
<tr>
<td>SWDI-5D</td>
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<td>&lt;0.16 U</td>
<td>1.1 J</td>
<td>ug/L</td>
<td>0.17 J</td>
<td>0.3 J</td>
</tr>
<tr>
<td>SWDI-6</td>
<td>0.25 J</td>
<td>ug/L</td>
<td>&lt;0.17 U</td>
<td>&lt;0.16 U</td>
<td>&lt;0.16 U</td>
<td>ug/L</td>
<td>&lt;0.2 U</td>
<td>0.3 J</td>
</tr>
<tr>
<td>SWDI-7</td>
<td>0.27 J+</td>
<td>ug/L</td>
<td>0.21 J+</td>
<td>ug/L</td>
<td>&lt;0.16 U</td>
<td>ug/L</td>
<td>5.2 J+</td>
<td>3 J+</td>
</tr>
<tr>
<td>SWDI-8</td>
<td>&lt;0.16 U</td>
<td>ug/L</td>
<td>&lt;0.17 U</td>
<td>&lt;0.16 U</td>
<td>&lt;0.16 U</td>
<td>ug/L</td>
<td>&lt;0.17 U</td>
<td>6.2 ug/L</td>
</tr>
<tr>
<td>SWDI-9</td>
<td>&lt;0.16 U</td>
<td>ug/L</td>
<td>&lt;0.17 U</td>
<td>&lt;0.16 U</td>
<td>&lt;0.16 U</td>
<td>ug/L</td>
<td>&lt;0.2 U</td>
<td>&lt;0.16 U</td>
</tr>
<tr>
<td>SWDI-10</td>
<td>&lt;0.16 U</td>
<td>ug/L</td>
<td>&lt;0.17 U</td>
<td>&lt;0.16 U</td>
<td>1.1 ug/L</td>
<td>&lt;0.17 U</td>
<td>&lt;0.16 U</td>
<td>0.46 J</td>
</tr>
<tr>
<td>SWDI-12</td>
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<td>ug/L</td>
<td>&lt;0.17 U</td>
<td>0.56 J</td>
<td>&lt;0.16 U</td>
<td>ug/L</td>
<td>&lt;0.17 U</td>
<td>5 ug/L</td>
</tr>
<tr>
<td>SWDI-13</td>
<td>&lt;0.16 U</td>
<td>ug/L</td>
<td>&lt;0.17 U</td>
<td>0.18 J</td>
<td>&lt;0.16 U</td>
<td>ug/L</td>
<td>2.1 ug/L</td>
<td>1 ug/L</td>
</tr>
<tr>
<td>SWDI-14</td>
<td>&lt;0.16 U</td>
<td>ug/L</td>
<td>&lt;0.17 U</td>
<td>0.36 J</td>
<td>&lt;0.16 U</td>
<td>ug/L</td>
<td>0.18 J</td>
<td>2.4 ug/L</td>
</tr>
<tr>
<td>SWDI-15</td>
<td>&lt;0.16 U</td>
<td>ug/L</td>
<td>&lt;0.17 U</td>
<td>0.22 J</td>
<td>&lt;0.16 U</td>
<td>ug/L</td>
<td>5.2 ug/L</td>
<td>2.3 ug/L</td>
</tr>
<tr>
<td>SWDI-16</td>
<td>&lt;0.16 U</td>
<td>ug/L</td>
<td>&lt;0.17 U</td>
<td>&lt;0.16 U</td>
<td>&lt;0.16 U</td>
<td>ug/L</td>
<td>&lt;0.17 U</td>
<td>5.7 ug/L</td>
</tr>
</tbody>
</table>

**Notes:**

- **U** = The analyte was analyzed for and is not present above the reported SQL.
- **J** = The analyte was analyzed for and was positively identified, but the associated numerical value may not be consistent with the amount actually present in the environmental sample. The data should be considered as a basis for decision-making and are usable for many purposes.
- **J+** = The analyte was analyzed for and was positively identified, but the associated numerical value may not be consistent with the amount actually present in the environmental sample and validation indicates a positive bias. The data should be considered as a basis for decision-making and are usable for many purposes.
Table A-4a: Groundwater Quality - Metals vs South Platte River Numeric Limits

<table>
<thead>
<tr>
<th>Sample ID</th>
<th>Fraction</th>
<th>Arsenic</th>
<th>Cadmium</th>
<th>Copper</th>
<th>Cr (III)</th>
<th>Cr (VI)</th>
<th>Iron</th>
<th>Lead</th>
<th>Manganese</th>
<th>Nickel</th>
<th>Selenium</th>
<th>Silver</th>
<th>Uranium</th>
<th>Zinc</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Result</td>
<td>Unit</td>
<td>Result</td>
<td>Unit</td>
<td>Result</td>
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<td>Unit</td>
<td>Result</td>
<td>Unit</td>
<td>Result</td>
<td>Result</td>
<td>Unit</td>
</tr>
<tr>
<td>South Platte River Numeric Limits</td>
<td>Dissolved</td>
<td>0.8 ug/L</td>
<td>54 ug/L</td>
<td>0.157 mg/L</td>
<td>0.011 mg/L</td>
<td>300 ug/L</td>
<td>7 ug/L</td>
<td>190 ug/L</td>
<td>113 ug/L</td>
<td>4.6 ug/L</td>
<td>0.4 ug/L</td>
<td>30 ug/L</td>
<td>271 ug/L</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Potentially Dissolved</td>
<td>20.8 ug/L</td>
<td>0.164 mg/L</td>
<td>0.05 mg/L</td>
<td>1,000 ug/L</td>
<td>50 ug/L</td>
<td>100 ug/L</td>
<td>30 ug/L</td>
<td>21.6 ug/L</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Total Recoverable</td>
<td>340 (Daily Max) ug/L</td>
<td>20.8 ug/L</td>
<td>0.164 mg/L</td>
<td>0.05 mg/L</td>
<td>1,000 ug/L</td>
<td>50 ug/L</td>
<td>100 ug/L</td>
<td>30 ug/L</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Average</td>
<td>Dissolved</td>
<td>0.9 ug/L</td>
<td>2.1 ug/L</td>
<td>0.05 mg/L</td>
<td>0.004 mg/L</td>
<td>1,474 ug/L</td>
<td>12.2 ug/L</td>
<td>2,123 ug/L</td>
<td>7.0 ug/L</td>
<td>1.5 ug/L</td>
<td>0.10 ug/L</td>
<td>21.6 ug/L</td>
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</tr>
<tr>
<td></td>
<td>Potentially Dissolved</td>
<td>181 ug/L</td>
<td>134 ug/L</td>
<td>0.05 mg/L</td>
<td>97 ug/L</td>
<td>2.4 ug/L</td>
<td>0.12 ug/L</td>
<td>25 ug/L</td>
<td>6.4 ug/L</td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Total Recoverable</td>
<td>1,162 ug/L</td>
<td>699,471 ug/L</td>
<td>14,513 ug/L</td>
<td>21,108 ug/L</td>
<td>295 ug/L</td>
<td>15.2 ug/L</td>
<td>19.4 ug/L</td>
<td>148 ug/L</td>
<td>17,619 ug/L</td>
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<td></td>
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<tr>
<td>Minimum</td>
<td>Dissolved</td>
<td>0.3 ug/L</td>
<td>0.6 ug/L</td>
<td>0.02 mg/L</td>
<td>0.004 mg/L</td>
<td>22 ug/L</td>
<td>0.2 ug/L</td>
<td>36 ug/L</td>
<td>2.9 ug/L</td>
<td>0.7 ug/L</td>
<td>0.03 ug/L</td>
<td>4 ug/L</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Potentially Dissolved</td>
<td>0.04 ug/L</td>
<td>0.04 ug/L</td>
<td>0.02 mg/L</td>
<td>0.004 mg/L</td>
<td>2.3 ug/L</td>
<td>6.1 ug/L</td>
<td>1 ug/L</td>
<td>0.7 ug/L</td>
<td></td>
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<td></td>
</tr>
<tr>
<td></td>
<td>Total Recoverable</td>
<td>0.06 ug/L</td>
<td>51,000 ug/L</td>
<td>200 ug/L</td>
<td>840 ug/L</td>
<td>20 ug/L</td>
<td>2.1 ug/L</td>
<td>0.94 ug/L</td>
<td>8.6 ug/L</td>
<td>160 ug/L</td>
<td>17,619 ug/L</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Maximum</td>
<td>Dissolved</td>
<td>6.9 ug/L</td>
<td>11 ug/L</td>
<td>0.2 mg/L</td>
<td>0.008 mg/L</td>
<td>12,000 ug/L</td>
<td>365 ug/L</td>
<td>6,000 ug/L</td>
<td>20 ug/L</td>
<td>4.2 ug/L</td>
<td>0.81 ug/L</td>
<td>58 ug/L</td>
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<tr>
<td></td>
<td>Potentially Dissolved</td>
<td>2,000 ug/L</td>
<td>900 ug/L</td>
<td>2,800 ug/L</td>
<td>270 ug/L</td>
<td>6.2 ug/L</td>
<td>1.3 ug/L</td>
<td>160 ug/L</td>
<td>25,000 ug/L</td>
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<tr>
<td></td>
<td>Total Recoverable</td>
<td>11,000 ug/L</td>
<td>1,600,000 ug/L</td>
<td>4,000 ug/L</td>
<td>2,800 ug/L</td>
<td>270 ug/L</td>
<td>6.2 ug/L</td>
<td>1.3 ug/L</td>
<td>160 ug/L</td>
<td>25,000 ug/L</td>
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<tr>
<td></td>
<td>Total</td>
<td>11,000 ug/L</td>
<td>2,500 ug/L</td>
<td>23,000 ug/L</td>
<td>2.4 mg/L</td>
<td>1,800,000 ug/L</td>
<td>160,000 ug/L</td>
<td>60,000 ug/L</td>
<td>1,700 ug/L</td>
<td>58 ug/L</td>
<td>138 ug/L</td>
<td>83,000 ug/L</td>
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</tr>
</tbody>
</table>

Legend:
- Will likely meet Numeric Limits without treatment
- Will likely exceed Numeric Limits without treatment

Note: Statistics used the method detection limit when metal was not detected.
## Table A-4b: Groundwater Quality - Metals vs Toll Gate Creek Numeric Limits

<table>
<thead>
<tr>
<th>Sample ID</th>
<th>Fraction</th>
<th>Arsenic</th>
<th>Cadmium</th>
<th>Copper</th>
<th>Cr (III)</th>
<th>Cr (VI)</th>
<th>Iron</th>
<th>Lead</th>
<th>Manganese</th>
<th>Nickel</th>
<th>Selenium</th>
<th>Silver</th>
<th>Uranium</th>
<th>Zinc</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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<td>Result</td>
<td>Unit</td>
</tr>
<tr>
<td>Toll Gate Creek</td>
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<td>Numeric Limits</td>
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<td></td>
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<td></td>
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</tr>
<tr>
<td>Average</td>
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<td>2.8</td>
<td>0.02</td>
<td>0.104</td>
<td>0.004</td>
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<td>12</td>
<td>2.123</td>
<td>7.8</td>
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<td>0.10</td>
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</tr>
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<td>Recoverable</td>
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<td></td>
</tr>
<tr>
<td>Minimum</td>
<td>Dissolved</td>
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<td>0.03</td>
<td>0.004</td>
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<td>350</td>
<td>0.7</td>
<td>0.03</td>
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<td>Potentially</td>
<td>9</td>
<td>2.8</td>
<td>6.1</td>
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<td>0.02</td>
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<tr>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>17</td>
<td>51,000</td>
<td>51,000</td>
<td>840</td>
<td>20</td>
<td>0.94</td>
<td>8.6</td>
<td>230</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maximum</td>
<td>Dissolved</td>
<td>6.9</td>
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<td>0.23</td>
<td>0.008</td>
<td>12,000</td>
<td>6</td>
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<td>0.83</td>
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<td></td>
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<tr>
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<td>2.850</td>
<td>6.2</td>
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<td>25,000</td>
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</tr>
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<td>11,000</td>
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<tr>
<td></td>
<td>Total</td>
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<td>60,000</td>
<td>60,000</td>
<td>1,700</td>
<td>53</td>
<td>62</td>
<td>380</td>
<td>83,000</td>
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</tr>
</tbody>
</table>

### Legend
- Will likely meet Numeric Limits without treatment
- Will likely exceed Numeric Limits without treatment

### Note
- Statistics used the method detection limit when metal was not detected.
Table 5: Groundwater Quality - Inorganics vs Numeric Limits for Both Outfalls

<table>
<thead>
<tr>
<th>Sample ID</th>
<th>Ammonia as N</th>
<th>Chloride</th>
<th>Nitrate as N</th>
<th>Nitrite as N</th>
<th>Sulfate</th>
<th>Sulfide (H₂S)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>South Platte River Numeric Limits</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>30-Day Avg.</td>
<td>1.3 mg/L</td>
<td>250 mg/L</td>
<td></td>
<td></td>
<td>250 mg/L</td>
<td>0.002 mg/L</td>
</tr>
<tr>
<td>7-Day Avg.</td>
<td>NA</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Daily Max.</td>
<td>5.7 mg/L</td>
<td>10 mg/L</td>
<td>0.5 mg/L</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Toll Gate Creek Numeric Limits</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>30-Day Avg.</td>
<td>1.3 mg/L</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.002 mg/L</td>
</tr>
<tr>
<td>7-Day Avg.</td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Daily Max.</td>
<td>5.7 mg/L</td>
<td></td>
<td>0.5 mg/L</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Average</td>
<td>39.9 mg/L</td>
<td>291 mg/L</td>
<td>3.5 mg/L</td>
<td>0.13 mg/L</td>
<td>136 mg/L</td>
<td>11.6 mg/L</td>
</tr>
<tr>
<td>Minimum</td>
<td>0.18 mg/L</td>
<td>150 mg/L</td>
<td>0.04 mg/L</td>
<td>0.05 mg/L</td>
<td>0.9 mg/L</td>
<td>0.8 mg/L</td>
</tr>
<tr>
<td>Maximum</td>
<td>140 mg/L</td>
<td>840 mg/L</td>
<td>12 mg/L</td>
<td>0.61 mg/L</td>
<td>320 mg/L</td>
<td>74 mg/L</td>
</tr>
</tbody>
</table>

Legend
- **Green**: Will likely meet Numeric Limits for South Platte River and Toll Gate Creek without treatment
- **Yellow**: Will likely meet Numeric Limit for Toll Gate Creek, but not South Platte River, without treatment
- **Red**: Will likely exceed Numeric Limits for South Platte River and Toll Gate Creek without treatment
Table 6: Groundwater Quality - Detected Volatile Organic Compounds vs Numeric Limits for Both Outfalls

<table>
<thead>
<tr>
<th>Sample ID</th>
<th>Benzene</th>
<th>Tetrachloroethene</th>
<th>Trichloroethene</th>
<th>Vinyl chloride</th>
</tr>
</thead>
<tbody>
<tr>
<td>South Platte River</td>
<td>2.2 ug/L</td>
<td>5 ug/L</td>
<td>2.5 ug/L</td>
<td>0.023 ug/L</td>
</tr>
<tr>
<td>Numeric Limits</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Toll Gate Creek</td>
<td>none</td>
<td>none</td>
<td>none</td>
<td>2.3 ug/L</td>
</tr>
<tr>
<td>Numeric Limits</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Average</td>
<td>0.55 ug/L</td>
<td>5.01 ug/L</td>
<td>2.67 ug/L</td>
<td>0.28 ug/L</td>
</tr>
<tr>
<td>Minimum</td>
<td>0.16 ug/L</td>
<td>0.20 ug/L</td>
<td>0.16 ug/L</td>
<td>0.10 ug/L</td>
</tr>
<tr>
<td>Maximum</td>
<td>6.00 ug/L</td>
<td>19.00 ug/L</td>
<td>8.30 ug/L</td>
<td>2.40 ug/L</td>
</tr>
</tbody>
</table>

Legend:
- Green: Will likely meet Numeric Limits for South Platte River and Toll Gate Creek without treatment
- Yellow: Will likely meet Numeric Limit for Toll Gate Creek, but not South Platte River, without treatment
- Red: Will likely exceed Numeric Limits for South Platte River and Toll Gate Creek without treatment
### Table A-7: TCLP Limits vs Groundwater Constituents of Concern

<table>
<thead>
<tr>
<th>Constituent</th>
<th>TCLP Regulatory Level (ug/L)</th>
<th>Dissolved (ug/L)</th>
<th>Potentially Dissolved (ug/L)</th>
<th>Total Recoverable (ug/L)</th>
<th>Total (ug/L)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Min</td>
<td>Avg</td>
<td>Max</td>
<td>Min</td>
<td>Avg</td>
</tr>
<tr>
<td><strong>Metals</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Arsenic</td>
<td>5,000</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>9</td>
</tr>
<tr>
<td>Barium</td>
<td>100,000</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>Cadmium</td>
<td>1,000</td>
<td>&lt;1</td>
<td>&lt;1</td>
<td>6.9</td>
<td>&lt;1</td>
</tr>
<tr>
<td>Chromium</td>
<td>5,000</td>
<td>&lt;1</td>
<td>&lt;1</td>
<td>&lt;1</td>
<td>NA</td>
</tr>
<tr>
<td>Lead</td>
<td>5,000</td>
<td>&lt;1</td>
<td>12.2</td>
<td>160</td>
<td>2.3</td>
</tr>
<tr>
<td>Mercury</td>
<td>200</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>Selenium</td>
<td>1,000</td>
<td>&lt;1</td>
<td>1.5</td>
<td>4.2</td>
<td>1</td>
</tr>
<tr>
<td>Silver</td>
<td>5,000</td>
<td>&lt;1</td>
<td>&lt;1</td>
<td>&lt;1</td>
<td>&lt;1</td>
</tr>
<tr>
<td><strong>VOCs</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Benzene</td>
<td>500</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Carbon Tetrachloride</td>
<td>500</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chlorobenzene</td>
<td>100,000</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chloroform</td>
<td>6,000</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1,4-Dichlorobenzene</td>
<td>7,500</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1,2-Dichloroethane</td>
<td>500</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1,1-Dichloroethene</td>
<td>700</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MEK</td>
<td>200,000</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tetrachloroethene</td>
<td>700</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Trichloroethene</td>
<td>500</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vinyl Chloride</td>
<td>200</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Legend**
- **Passes TCLP regulatory level without treatment**
- **Exceeds TCLP regulatory level without treatment**
- **N** = Not Analyzed
Sanitary Sewer

LEGEND

Limits of Fill Material Within the Coliseum Parking Area as Defined During the OU2 Remedial Investigation (EMSI, 2009)
SS Sanitary Sewer
Temporary Piezometer Location by Respondent
Monitoring Well Location
Boring by EMSI, 2009
Boring by Respondent
Boring by CTL Thompson
Boring by Metro Wastewater
Stormwater Channel Center Alignment
Surface Cut for Open Channel
Surface Cut for Box Culvert

Figure A-1
BASE MAP
OPERABLE UNIT #2, VB I70 SUPERFUND SITE
EMSI Engineering Management Support, Inc.
Appendix A-1

- COG 315386 - Certification to Discharge to the South Platte River and Toll Gate Creek Under the Colorado Discharge Permit System (CDPS) General Permit COG315000

- COG 315000 - CDPS General Permit; Remediation Activities Discharging to Surface Water
Memorandum

TO: Denver City and County

FROM: Mark Pollock, Permit Writer 303-692-3635
       or (contacts) Debbie Jessop Tech IV 303-692-3590, Karen Harford 303-691-4019, Loretta Houk 303-692-3531

DATE: 10/16/2015

RE: Certification, Colorado Discharge Permit System - Remediation Activities Discharging to Surface Water
Fact Sheet and Information for Permit Number COG315000  Certification Number: COG315386
Permittee-Facility: Denver City and County - VB I70 Operable Unit 2 Removal Action

ATTACHMENTS:
   Certification COG315386
   CDPS General Permit for Remediation Activities Discharging to Surface Water

The Water Quality Control Division (the division) has reviewed the application submitted for the VB I70 Operable Unit 2 Removal Action facility and determined that it qualifies for coverage under the CDPS General Permit for Remediation Activities Discharging to Surface Water (the permit).

Attached is your Certification to discharge under the CDPS General Permit for Remediation Activities Discharging to Surface Water along with a copy of the general permit. This Certification authorizes you to discharge in accordance with the conditions of the general permit and provides site-specific monitoring requirements per Part I.B of the permit. You are required to comply with the requirements included in the general permit as well as the Certification.

Discharge Specific Information
The discharge is to an existing outfall structure with flow to the South Platte River within Segment COSPUS14 of the Upper South Platte River Sub-basin, South Platte River Basin, found in the Classifications and Numeric Standards for the South Platte River Basin (Regulation No. 38) (COSPUS14). Segment 14 is Reviewable, and is classified for the following beneficial uses: Aquatic Life, Class 1 Warm; Recreation Class E; Water Supply; and Agriculture.

The discharge is also to a storm sewer with flow to Toll Gate Creek within Segment COSPUS16h of the Upper South Platte River Sub-basin, South Platte River Basin, found in the Classifications and Numeric Standards for the South Platte River Basin (Regulation No. 38) (COSPUS16h). Segment 16h is Reviewable, and is classified for the following beneficial uses: Aquatic Life, Class 2 Warm; Recreation Class E; and Agriculture.

Antidegradation Review
The antidegradation review is not appropriate for this discharge because the discharge is considered short-term/intermittent, and short-term/intermittent (temporary) impacts are exempt from the AD review.

Basis for Site Specific Parameters
The division completed a qualitative Reasonable Potential (RP) analysis for this discharge based on the data submitted with the permit application. A quantitative RP analysis was not conducted as there were not enough data available. Effluent limitations and monitoring requirements have been added to the certification for pollutants that have a reasonable potential to exceed water quality standards.
Fact Sheet  Permit COG315386 - VB 170 Operable Unit 2 Removal Action

The RP analysis involved a comparison of the maximum detected chemical concentrations in the source water to one-half the most stringent applicable water quality standard. The division reviewed water quality data for seventeen samples (CTL-MW6, SWDI-1 through SWDI-10, SWDI-12 through SDWDI-16, and SWDI-5D) which were identified by the permit applicant as representative of the source water that will be treated and discharged under the permit certification. The water quality standards used for comparison were derived from the most stringent applicable standards listed in Regulation 31 and Regulation 38 for the South Platte River (COSPUS14) and Toll Gate Creek (COSPUS16h). Additionally, because of the timeframe of the project, analytical data was also compared to applicable water quality standards provided in the newly amended version of Regulation 38, which will become effective on 12/31/15.

In order to calculate the hardness-dependent stream standards used in the RP analysis for the discharge to the South Platte River (Outfall 001-A), the division used a mean in-stream hardness value of 263 mg/l based on sampling data collected from WQCD Station 5170 (South Platte River upstream Burlington Ditch Headgate) between November 2008 and April 2011. In order to calculate the hardness-dependent stream standards used in the RP analysis for the discharge to Toll Gate Creek (Outfall 002-A), the division used a mean in-stream hardness value of 261 mg/l based on sampling data collected from USGS Station 394329104490101 (Toll Gate Creek above 6th Ave) between April 2009 and June 2011.

**Outfall 001-A - Discharge to the South Platte River (Segment COSPUS14)**

For outfall 001-A, the division determined that RP exists for the parameters presented below:

- The maximum detected concentration of **Ammonia** was 140 mg/l. The applicable standards for this parameter were calculated using the Ammonia Toxicity Model (AMMTOX) software program, which requires site specific effluent pH and temperature data over a period of at least one year in order to calculate applicable standards. However, because this was a new application, there was no site specific pH or temperature effluent data that could be used as adequate input for the AMMTOX model. Without site specific pH and temperature data, the division standard procedure is to rely on statistically-based regionalized data compiled from Wastewater Treatment Facilities (WWTFs). Using this input data, the division calculated Ammonia standards of 1.3 mg/l (chronic - April 1 and August 31), 1.6 mg/l (chronic - September 1 and March 31), and 5.7 mg/l (acute). The division made a qualitative determination of RP based on a comparison of the maximum detected concentration to one-half of the most stringent chronic standard (0.8 mg/l). Effluent limitation(s) for this parameter have been added to the permit certification.

- The maximum detected concentration of **Chloride** was 840 mg/l. The applicable standard for this parameter was taken directly from Regulation 38, which provides a water supply standard of 250 mg/l (chronic). There is no acute standard. The division made a qualitative determination of RP based on a comparison of the maximum detected concentration of Chloride to one-half the water supply standard (125 mg/l). Effluent limitation(s) for this parameter have been added to the permit certification.

- The maximum detected concentration of **Nitrate** was 12 mg/l. The applicable standard for this parameter was taken directly from Regulation 38, which provides a numeric standard of 10 mg/l (acute). There is no chronic standard. The division made a qualitative determination of RP based on a comparison of the maximum detected concentration of Nitrate to one-half the acute standard (5 mg/l). Effluent limitation(s) for this parameter have been added to the permit certification.

- The maximum detected concentration of **Nitrite** was 0.61 mg/l. The applicable standard for this parameter was taken directly from Regulation 38, which provides a numeric standard of 0.5 mg/l (acute). There is no chronic standard. The division made a qualitative determination of RP based on a comparison of the maximum detected concentration of Nitrite to one-half the acute standard (0.25 mg/l). Effluent limitation(s) for this parameter have been added to the permit certification.

- The maximum detected concentration of **Sulfate** was 320 mg/l. The applicable standard for this parameter was taken directly from Regulation 38, which provides a water supply standard of 250 mg/l (chronic). There is no acute standard. The division made a qualitative determination of RP based on a comparison of the maximum detected concentration of Sulfate to one-half the water supply standard (125 mg/l). Effluent limitation(s) for this parameter have been added to the permit certification.
Fact Sheet Permit COG315386 - VB 170 Operable Unit 2 Removal Action

- The maximum detected concentration of **Sulfide** was 74 mg/l. The applicable standard for this parameter was taken directly from Regulation 38, which provides a numeric standard of 0.002 mg/l (chronic). There is no acute standard. The division made a qualitative determination of RP based on a comparison of the maximum detected concentration of Sulfide to one-half the chronic standard (0.001 mg/l). Effluent limitation(s) for this parameter have been added to the permit certification.

- The maximum detected concentration of **Benzene** was 6 μg/l. The applicable standard for this parameter was taken directly from The Basic Standards and Methodologies for Surface Water (Regulation 31), which provides numeric standards of 2.2 μg/l (chronic) and 5300 μg/l (acute). The division made a qualitative determination of RP based on a comparison of the maximum detected concentration to one-half of the chronic standard (1.1 µg/l). Effluent limitation(s) for this parameter have been added to the permit certification.

- The maximum detected concentration of **Tetrachloroethylene** was 19 µg/l. The applicable standard for this parameter was taken directly from Regulation 31, which provides numeric standards of 5 µg/l (chronic) and 5280 µg/l (acute). The division made a qualitative determination of RP based on a comparison of the maximum detected concentration to one-half of the chronic standard (2.5 µg/l). Effluent limitation(s) for this parameter have been added to the permit certification.

- The maximum detected concentration of **Trichloroethylene** was 8.3 µg/l. The applicable standard for this parameter was taken directly from Regulation 31, which provides numeric standards of 2.5 µg/l (chronic) and 45000 µg/l (acute). The division made a qualitative determination of RP based on a comparison of the maximum detected concentration to one-half of the chronic standard (1.25 µg/l). Effluent limitation(s) for this parameter have been added to the permit certification.

- The maximum detected concentration of **Vinyl Chloride** was 2.4 µg/l. The applicable standard for this parameter was taken directly from Regulation 31, which provides a numeric standard of 0.023 µg/l (chronic). There is no acute standard. The division made a qualitative determination of RP based on a comparison of the maximum detected concentration to one-half of the chronic standard (0.0115 µg/l). Effluent limitation(s) for this parameter have been added to the permit certification.

- The maximum detected concentration of **Total Recoverable Arsenic** was 11000 µg/l. The applicable standard for this parameter was taken directly from Regulation 38, which provides a numeric standard of 3 µg/l (chronic). This is based on a temporary modification of the standard which is effective until 12/31/2021. There is no acute standard. The division made a qualitative determination of RP based on a comparison of the maximum detected concentration to one-half of the chronic standard (1.5 µg/l). Effluent limitation(s) for this parameter have been added to the permit certification.

- The maximum detected concentration of **Potentially Dissolved Arsenic** was 2000 µg/l. The applicable standard for this parameter was taken directly from Regulation 38, which provides a numeric standard of 340 µg/l (acute). There is no chronic standard. The division made a qualitative determination of RP based on a comparison of the maximum detected concentration to one-half of the chronic standard (170 µg/l). Effluent limitation(s) for this parameter have been added to the permit certification.

- The maximum detected concentration of **Total Recoverable Cadmium** was 2600 µg/l. The currently effective version of Regulation 38 does not provide a standard for this parameter. However, the amended version of Regulation 38 effective 12/31/15, provides a numeric standard of 5.0 µg/l (acute). There is no chronic standard. The division made a qualitative determination of RP based on a comparison of the maximum detected concentration to one-half the acute standard (2.5 µg/l). Effluent limitation(s) for this parameter have been added to the permit certification with an effective date of 12/31/15.

- The maximum detected concentration of **Potentially Dissolved Cadmium** was 900 µg/l. The applicable standard for this parameter is shown in Regulation 38 as a Table Value Standard (TVS) which must be derived from equations that depend on the receiving stream hardness or species of fish present. Using the in-stream mean hardness value of 263 mg/l, the division calculated Potentially Dissolved Cadmium standards of 0.88 µg/l (chronic) and 6.4 µg/l (acute). The division made a qualitative determination of RP based on a comparison of the maximum detected concentration to one-half of the chronic standard (0.44 µg/l). Effluent limitation(s) for this parameter have been added to the permit certification.
In accordance with Regulation 38, the division applied the sum of the maximum detected total recoverable trivalent and hexavalent chromium results of 2310 μg/l to the Total Recoverable Chromium water supply standard of 50 μg/l (acute). There is no chronic standard. The division made a qualitative determination of RP based on a comparison of the maximum detected concentration to one-half the acute standard (25 μg/l). Effluent limitation(s) for this parameter have been added to the permit certification.

The maximum detected concentration of Dissolved Hexavalent Chromium was 5.9 μg/l. The applicable standard for this parameter is shown in Regulation 38 as a TVS which must be derived from equations that depend on the receiving stream hardness or species of fish present. Using the in-stream mean hardness value of 263 mg/l, the division calculated Dissolved Hexavalent Chromium standards of 11 μg/l (chronic) and 16 μg/l (acute). The division made a qualitative determination of RP based on a comparison of the maximum detected concentration to one-half of the chronic standard (5.5 μg/l). Effluent limitation(s) for this parameter have been added to the permit certification.

The maximum detected concentration of Total Recoverable Trivalent Chromium was 2200 μg/l. The applicable standard for this parameter was taken directly from Regulation 38, which provides numeric standards of 50 μg/l (acute). There is no chronic standard. The division made a qualitative determination of RP based on a comparison of the maximum detected concentration to one-half of the chronic standard (25 μg/l). Effluent limitation(s) for this parameter have been added to the permit certification.

Analytical data for potentially dissolved trivalent chromium were not provided in the permit application; therefore, the division conservatively applied the available total recoverable trivalent chromium data to the Potentially Dissolved Trivalent Chromium stream segment standard. The maximum detected concentration of total recoverable trivalent chromium was 2200 μg/l. The currently effective version of Regulation 38 does not provide a standard for this parameter. However, the amended version of Regulation 38 effective 12/31/15 provides a TVS for this parameter which must be derived from equations that depend on the receiving stream hardness or species of fish present. Using the in-stream mean hardness value of 263 mg/l, the division calculated Potentially Dissolved Trivalent Chromium standards of 164 μg/l (chronic) and 1258 μg/l (acute). The division made a qualitative determination of RP based on a comparison of the maximum detected concentration of total recoverable trivalent chromium to one-half the potentially dissolved chronic standard (82 μg/l). Effluent limitation(s) for this parameter have been added to the permit certification with an effective date of 12/31/15.

Analytical data for potentially dissolved copper were not provided in the permit application; therefore, the division conservatively applied the available total recoverable copper data to the Potentially Dissolved Copper stream segment standard. The maximum detected concentration of total recoverable copper was 23000 μg/l. The applicable standard for this parameter is shown in currently effective version of Regulation 38 as a TVS which must be derived from equations that depend on the receiving stream hardness or species of fish present. Regulation 38 also provides a temporary modification to the copper standard. Specifically, the modified standard is equal to 2.7 times the TVS, effective until 12/31/15. Using the in-stream mean hardness value of 263 mg/l and applying the temporary modification, the division calculated Potentially Dissolved Copper standards of 54 μg/l (chronic) and 89.1 μg/l (acute). The division made a qualitative determination of RP based on a comparison of the maximum detected concentration of total recoverable copper to one-half of the modified potentially dissolved chronic standard (27 μg/l). On 12/31/15, the amended version of Regulation 38 becomes effective, and the applicable standards for Potentially Dissolved Copper will be 20.8 μg/l (chronic) and 31.5 μg/l (acute). Effluent limitation(s) for this parameter have been added to the permit certification.

The maximum detected concentration of Total Recoverable Iron was 1800000 μg/l. The applicable standard for this parameter was taken directly from Regulation 38, which provides a numeric standard of 1000 μg/l (chronic). There is no acute standard. The division made a qualitative determination of RP based on a comparison of the maximum detected concentration to one-half of the chronic standard (500 μg/l). Effluent limitation(s) for this parameter have been added to the permit certification.

The maximum detected concentration of Dissolved Iron was 12000 μg/l. The applicable standard for this parameter was taken directly from Regulation 38, which provides a water supply standard of 300 μg/l (chronic). There is no acute standard. The division made a qualitative determination of RP based on a
comparison of the maximum detected concentration of Dissolved Iron to one-half the water supply standard (150 μg/l). Effluent limitation(s) for this parameter have been added to the permit certification.

- The maximum detected concentration of **Total Recoverable Lead** was 160000 μg/l. The currently effective version of Regulation 38 does not provide a standard for this parameter. However, the amended version of Regulation 38 effective 12/31/15, provides a numeric standard of 50 μg/l (acute). There is no chronic standard. The division made a qualitative determination of RP based on a comparison of the maximum detected concentration to one-half the acute standard (25 μg/l). Effluent limitation(s) for this parameter have been added to the permit certification with an effective date of 12/31/15.

- The maximum detected concentration of **Potentially Dissolved Lead** was 2800 μg/l. The applicable standard for this parameter is shown in Regulation 38 as a TVS which must be derived from equations that depend on the receiving stream hardness or species of fish present. Using the in-stream mean hardness value of 263 mg/l, the division calculated Potentially Dissolved Lead standards of 7.1 μg/l (chronic) and 182 μg/l (acute). The division made a qualitative determination of RP based on a comparison of the maximum detected concentration to one-half of the chronic standard (3.55 μg/l). Effluent limitation(s) for this parameter have been added to the permit certification.

- The maximum detected concentration of **Dissolved Manganese** was 6000 μg/l. The applicable standard for this parameter was taken directly from Regulation 38, which provides a numeric standard of 190 μg/l (chronic). There is no acute standard. The division made a qualitative determination of RP based on a comparison of the maximum detected concentration to one-half the numeric standard (95 μg/l). Effluent limitation(s) for this parameter have been added to the permit certification.

- Analytical data for potentially dissolved manganese were not provided in the permit application; therefore, the division conservatively applied the available total recoverable manganese data to the **Potentially Dissolved Manganese** stream segment standard. The maximum detected concentration of total recoverable manganese was 60000 μg/l. The applicable standard for this parameter is shown in Regulation 38 as a TVS which must be derived from equations that depend on the receiving stream hardness or species of fish present. Using the in-stream mean hardness value of 263 mg/l, the division calculated a Potentially Dissolved Manganese standard of 4120 μg/l (acute). The potentially dissolved chronic standard of 2276 μg/l does not apply because the dissolved chronic standard listed above is more stringent. The division made a qualitative determination of RP based on a comparison of the maximum detected concentration of total recoverable manganese to one-half the potentially dissolved acute standard (2060 μg/l). Effluent limitation(s) for this parameter have been added to the permit certification.

- The maximum detected concentration of **Total Recoverable Nickel** was 1700 μg/l. The currently effective version of Regulation 38 does not provide a standard for this parameter. However, the amended version of Regulation 38 effective 12/31/15, provides a numeric standard of 100 μg/l (chronic). There is no acute standard. The division made a qualitative determination of RP based on a comparison of the maximum detected concentration to one-half the chronic standard (50 μg/l). Effluent limitation(s) for this parameter have been added to the permit certification with an effective date of 12/31/15.

- The maximum detected concentration of **Potentially Dissolved Nickel** was 270 μg/l. The applicable standard for this parameter is shown in Regulation 38 as a TVS which must be derived from equations that depend on the receiving stream hardness or species of fish present. Using the in-stream mean hardness value of 263 mg/l, the division calculated Potentially Dissolved Nickel standards of 118 μg/l (chronic) and 1061 μg/l (acute). The division made a qualitative determination of RP based on a comparison of the maximum detected concentration to one-half of the chronic standard (59 μg/l). Effluent limitation(s) for this parameter have been added to the permit certification.

- The maximum detected concentration of **Potentially Dissolved Selenium** was 6.2 μg/l. The applicable standard for this parameter is shown in Regulation 38 as a TVS which must be derived from equations that depend on the receiving stream hardness or species of fish present. Using the in-stream mean hardness value of 263 mg/l, the division calculated Potentially Dissolved Selenium standards of 4.6 μg/l (chronic) and 18.4 μg/l (acute). The division made a qualitative determination of RP based on a comparison of the maximum
The maximum detected concentration of **Potentially Dissolved Silver** was 1.7 µg/l. The applicable standard for this parameter is shown in Regulation 38 as a TVS which must be derived from equations that depend on the receiving stream hardness or species of fish present. Using the in-stream mean hardness value of 263 mg/l, the division calculated Potentially Dissolved Silver standards of 1.7 µg/l (chronic) and 11 µg/l (acute). The division made a qualitative determination of RP based on a comparison of the maximum detected concentration to one-half of the chronic standard (0.85 µg/l). Effluent limitation(s) for this parameter have been added to the permit certification.

The maximum detected concentration of **Total Recoverable Uranium** was 380 µg/l. The applicable standard for this parameter was taken directly from Regulation 38, which provides a numeric standard of 30 µg/l (chronic). There is no acute standard. The division made a qualitative determination of RP based on a comparison of the maximum detected concentration to one-half the chronic standard (15 µg/l). Effluent limitation(s) for this parameter have been added to the permit certification.

The maximum detected concentration of **Potentially Dissolved Zinc** was 25000 µg/l. The applicable standard for this parameter is shown in Regulation 38 as a TVS which must be derived from equations that depend on the receiving stream hardness or species of fish present. Using the in-stream mean hardness value of 263 mg/l, the division calculated Potentially Dissolved Zinc standards of 283 µg/l (chronic) and 386 µg/l (acute). The division made a qualitative determination of RP based on a comparison of the maximum detected concentration to one-half of the chronic standard (141.5 µg/l). Effluent limitation(s) for this parameter have been added to the permit certification.

### Outfall 002-A - Discharge to the Toll Gate Creek (Segment COSPUS16h)

For outfall 002-A, the division determined that RP exists for the parameters presented below:

1. The maximum detected concentration of **Ammonia** was 140 mg/l. The applicable standards for this parameter were calculated using the Ammonia Toxicity Model (AMMTOX) software program, which requires site specific effluent pH and temperature data over a period of at least one year in order to calculate applicable standards. However, because this was a new application, there was no site specific pH or temperature effluent data that could be used as adequate input for the AMMTOX model. Without site specific pH and temperature data, the division standard procedure is to rely on statistically-based regionalized data compiled from Wastewater Treatment Facilities (WWTFs). Using this input data, the division calculated Ammonia standards of 1.3 mg/l (chronic - April 1 and August 31), 1.6 mg/l (chronic - September 1 and March 31), and 5.7 mg/l (acute). The division made a qualitative determination of RP based on a comparison of the maximum detected concentration to one-half of the most stringent chronic standard (0.8 mg/l). Effluent limitation(s) for this parameter have been added to the permit certification.

2. The maximum detected concentration of **Nitrite** was 0.61 mg/l. The applicable standard for this parameter was taken directly from Regulation 38, which provides a numeric standard of 0.5 mg/l (acute). There is no chronic standard. The division made a qualitative determination of RP based on a comparison of the maximum detected concentration of Nitrite to one-half the acute standard (0.25 mg/l). Effluent limitation(s) for this parameter have been added to the permit certification.

3. The maximum detected concentration of **Sulfide** was 74 mg/l. The applicable standard for this parameter was taken directly from Regulation 38, which provides a numeric standard of 0.002 mg/l (chronic). There is no acute standard. The division made a qualitative determination of RP based on a comparison of the maximum detected concentration of Sulfide to one-half the chronic standard (0.001 mg/l). Effluent limitation(s) for this parameter have been added to the permit certification.

4. The maximum detected concentration of **Vinyl Chloride** was 2.4 µg/l. The applicable standard for this parameter was taken directly from Regulation 31, which provides a numeric standard of 2.3 µg/l (chronic). There is no acute standard. The division made a qualitative determination of RP based on a comparison of the maximum detected concentration to one-half of the chronic standard (1.15 µg/l). Effluent limitation(s) for this parameter have been added to the permit certification.
The maximum detected concentration of **Total Recoverable Arsenic** was 11000 µg/l. The applicable standard for this parameter was taken directly from Regulation 38, which provides a numeric standard of 7.6 µg/l (chronic). There is no acute standard. The division made a qualitative determination of RP based on a comparison of the maximum detected concentration to one-half the chronic standard (3.8 µg/l). Effluent limitation(s) for this parameter have been added to the permit certification.

The maximum detected concentration of **Potentially Dissolved Arsenic** was 2000 µg/l. The applicable standard for this parameter was taken directly from Regulation 38, which provides a numeric standard of 340 µg/l (acute). There is no chronic standard. The division made a qualitative determination of RP based on a comparison of the maximum detected concentration to one-half of the chronic standard (170 µg/l). Effluent limitation(s) for this parameter have been added to the permit certification.

The maximum detected concentration of **Potentially Dissolved Cadmium** was 900 µg/l. The applicable standard for this parameter is shown in Regulation 38 as a Table Value Standard (TVS) which must be derived from equations that depend on the receiving stream hardness or species of fish present. Using the in-stream mean hardness value of 261 mg/l, the division calculated Potentially Dissolved Cadmium standards of 0.87 µg/l (chronic) and 6.3 µg/l (acute). The division made a qualitative determination of RP based on a comparison of the maximum detected concentration to one-half of the chronic standard (0.435 µg/l). Effluent limitation(s) for this parameter have been added to the permit certification.

The maximum detected concentration of **Dissolved Hexavalent Chromium** was 5.9 µg/l. The applicable standard for this parameter is shown in Regulation 38 as a TVS which must be derived from equations that depend on the receiving stream hardness or species of fish present. Using the in-stream mean hardness value of 261 mg/l, the division calculated Dissolved Hexavalent Chromium standards of 11 µg/l (chronic) and 16 µg/l (acute). The division made a qualitative determination of RP based on a comparison of the maximum detected concentration to one-half of the chronic standard (5.5 µg/l). Effluent limitation(s) for this parameter have been added to the permit certification.

Analytical data for potentially dissolved trivalent chromium were not provided in the permit application; therefore, the division conservatively applied the available total recoverable trivalent chromium data to the **Potentially Dissolved Trivalent Chromium** stream segment standard. The maximum detected concentration of total recoverable trivalent chromium was 2200 µg/l. The applicable standard for this parameter is shown in Regulation 38 as a TVS which must be derived from equations that depend on the receiving stream hardness or species of fish present. Using the in-stream mean hardness value of 261 mg/l, the division calculated Potentially Dissolved Trivalent Chromium standards of 163 µg/l (chronic) and 1250 µg/l (acute). The division made a qualitative determination of RP based on a comparison of the maximum detected concentration of total recoverable trivalent chromium to one-half the potentially dissolved chronic standard (81.5 µg/l). Effluent limitation(s) for this parameter have been added to the permit certification.

Analytical data for potentially dissolved copper were not provided in the permit application; therefore, the division conservatively applied the available total recoverable copper data to the **Potentially Dissolved Copper** stream segment standard. The maximum detected concentration of total recoverable copper was 23000 µg/l. The applicable standard for this parameter is shown in Regulation 38 as a TVS which must be derived from equations that depend on the receiving stream hardness or species of fish present. Using the in-stream mean hardness value of 261 mg/l, the division calculated Potentially Dissolved Copper standards of 20 µg/l (chronic) and 33 µg/l (acute). The division made a qualitative determination of RP based on a comparison of the maximum detected concentration to one-half of the chronic standard (10 µg/l). Effluent limitation(s) for this parameter have been added to the permit certification.

The maximum detected concentration of **Total Recoverable Iron** was 1800000 µg/l. The applicable standard for this parameter was taken directly from Regulation 38, which provides a numeric standard of 1000 µg/l (chronic). There is no acute standard. The division made a qualitative determination of RP based on a comparison of the maximum detected concentration to one-half of the chronic standard (500 µg/l). Effluent limitation(s) for this parameter have been added to the permit certification.
- The maximum detected concentration of Potentially Dissolved Lead was 2800 μg/l. The applicable standard for this parameter is shown in Regulation 38 as a TVS which must be derived from equations that depend on the receiving stream hardness or species of fish present. Using the in-stream mean hardness value of 261 mg/l, the division calculated Potentially Dissolved Lead standards of 7 μg/l (chronic) and 180 μg/l (acute). The division made a qualitative determination of RP based on a comparison of the maximum detected concentration to one-half of the chronic standard (3.5 μg/l). Effluent limitation(s) for this parameter have been added to the permit certification.

- Analytical data for potentially dissolved manganese were not provided in the permit application; therefore, the division conservatively applied the available total recoverable manganese data to the Potentially Dissolved Manganese stream segment standard. The maximum detected concentration of total recoverable manganese was 60000 μg/l. The applicable standard for this parameter is shown in Regulation 38 as a TVS which must be derived from equations that depend on the receiving stream hardness or species of fish present. Using the in-stream mean hardness value of 261 mg/l, the division calculated a Potentially Dissolved Manganese standards of 2271 μg/l (chronic) 4110 μg/l (acute). The division made a qualitative determination of RP based on a comparison of the maximum detected concentration of total recoverable manganese to one-half the potentially dissolved chronic standard (1135.5 μg/l). Effluent limitation(s) for this parameter have been added to the permit certification.

- The maximum detected concentration of Potentially Dissolved Nickel was 270 μg/l. The applicable standard for this parameter is shown in Regulation 38 as a TVS which must be derived from equations that depend on the receiving stream hardness or species of fish present. Using the in-stream mean hardness value of 261 mg/l, the division calculated Potentially Dissolved Nickel standards of 117 μg/l (chronic) and 1054 μg/l (acute). The division made a qualitative determination of RP based on a comparison of the maximum detected concentration to one-half of the chronic standard (58.5 μg/l). Effluent limitation(s) for this parameter have been added to the permit certification.

- The maximum detected concentration of Potentially Dissolved Silver was 1.7 μg/l. The applicable standard for this parameter is shown in Regulation 38 as a TVS which must be derived from equations that depend on the receiving stream hardness or species of fish present. Using the in-stream mean hardness value of 261 mg/l, the division calculated Potentially Dissolved Silver standards of 1.7 μg/l (chronic) and 11 μg/l (acute). The division made a qualitative determination of RP based on a comparison of the maximum detected concentration to one-half of the chronic standard (0.85 μg/l). Effluent limitation(s) for this parameter have been added to the permit certification.

- The maximum detected concentration of Potentially Dissolved Zinc was 25000 μg/l. The applicable standard for this parameter is shown in Regulation 38 as a TVS which must be derived from equations that depend on the receiving stream hardness or species of fish present. Using the in-stream mean hardness value of 261 mg/l, the division calculated Potentially Dissolved Zinc standards of 282 μg/l (chronic) and 383 μg/l (acute). The division made a qualitative determination of RP based on a comparison of the maximum detected concentration to one-half of the chronic standard (141 μg/l). Effluent limitation(s) for this parameter have been added to the permit certification.

Additives:

- Sodium Hypochlorite may be used as a chemical additive for oxidation. As such, effluent limitations for Total Residual Chlorine will be added and imposed upon the effective date of the permit.

Site Specific Effluent Limitations

Applicable sampling and monitoring requirements are provided in the general permit. In addition, site specific effluent limitations for Ammonia, Chloride, Nitrate, Nitrite, Sulfate, Sulfide, Benzene, Tetrachloroethylene, Trichloroethylene, Vinyl Chloride, Total Recoverable Arsenic, Potentially Dissolved Arsenic, Total Recoverable Cadmium, Potentially Dissolved Cadmium, Total Recoverable Chromium, Dissolved Hexavalent Chromium, Total Recoverable Trivalent Chromium, Potentially Dissolved Trivalent Chromium, Potentially Dissolved Copper, Total Recoverable Iron, Dissolved Iron, Total Recoverable Lead, Potentially Dissolved Lead, Dissolved Manganese, Potentially Dissolved Manganese, Total Recoverable Nickel, Potentially Dissolved Nickel, Potentially Dissolved Selenium, Potentially Dissolved Silver, Total Recoverable Uranium, Potentially Dissolved Zinc, and Total Residual Chlorine were determined based on the methodology described above and are included in the permit certification.
Potential Source of Contamination
The project is located within the Vasquez Blvd/I-70 Superfund Site, and a portion of the project footprint is located over an historic fill area.

Treatment
Appropriate treatment options shall be selected and implemented as necessary to ensure compliance with permit effluent limitations. The proposed treatment system will consist of the following:

- Chemical injection of sodium hypochlorite prior to water entering weir tanks
- Solids settling and oxidation in weir tanks
- Greensand filtration for removal of iron and manganese
- Bag filtration to remove suspended solids to 25 microns
- Cationic IX resin for removal of all metals except As
- Arsenic-specific IX resin for As removal
- Activated Carbon for organic removals
- Additional Bag filtration (1 micron)
- Discharges to the South Platte may also include use of reverse osmosis for chloride and sulfate removal

In accordance with Part I.C.4.A.iv of the permit, the Remediation Activities Management Plan (Plan) must be kept current to reflect the description of all current pollutant control practices.

Chemical Usage
The permittee requested the use of chemicals for treating the source water. The division has reviewed and approved the use of the chemicals listed in the following table, provided they are used in accordance with all state and federal regulations and in strict accordance with the manufacturer’s specifications.

<table>
<thead>
<tr>
<th>Chemical Name</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hydrochloric Acid</td>
<td>pH adjustment</td>
</tr>
<tr>
<td>Sodium Hydroxide</td>
<td>pH adjustment</td>
</tr>
<tr>
<td>Sodium Hypochlorite</td>
<td>oxidation</td>
</tr>
</tbody>
</table>

Per the Remediation Activities general permit, the addition of any chemicals in the treatment process or waste stream requires notification to and approval from the division prior to use and subsequent discharge.

General Information
The Annual Fee for this certification is $1,840.00 [Category 7, Subcategory 8 Oil and gas cleanup/groundwater remediation per CRS 25-8-502] and is invoiced every July. Do Not Pay This Now. The initial invoice will be prorated and sent to the legal contact shortly.

Discharge Monitoring Reports (DMRs)
DMR forms will be mailed out within the next month. Reports must be submitted monthly as long as the certification is in effect. The permittee shall provide the division with any additional monitoring data on the permitted discharge collected for entities other than the division. If forms have not been received, please contact the division at 303-692-3517.

The division now has the ability to allow facilities to submit their DMRs electronically. For more information, please call the NetDMR team at 303-691-4046 or CDPHE.WQNetDMRHelp@state.co.us

Influent Screening Analytical Results
Influent screening is required under this permit certification. The analytical results for each influent screen must be submitted to the division with a completed Submittal Form for COG315000/COG316000 Influent Screening Data. The required Submittal Form is available for download on the division’s webpage at https://www.colorado.gov/pacific/cdphe/clean-water-construction-compliance-assistance-and-guidance. Influent screening results are not submitted on DMRs.
Fact Sheet Permit COG315386 - VB I70 Operable Unit 2 Removal Action

Certification Records Information
The following information is what the division records show for this certification.
For any changes to Contacts - Legal, Local, Billing, or DMR - a “Notice of Change of Contacts form” must be submitted to the division. This form is also available on our web site and must be signed by the legal contact.

Facility: VB I70 Operable Unit 2 Removal Action                                      County: Denver
Activity Description: construction of regional stormwater conveyance system    SIC Code: 1799
Other CDPS Permits for this Facility: Stormwater Discharges Associated with Construction Activity:
Legal Contact Receives all legal documentation, pertaining to the permit certification. [including invoice; is contacted for any questions relating to the facility; and receives DMRs as appropriate ]
Bob McDonald, Interim Exec Dir
Denver City and County
200 W 14 Ave Dept 310
Denver, CO 80204
Phone number: 720-865-5479
Email: bob.mcdonald@denvergov.org

Facility Contact (contacted for general inquiries regarding the facility):
Tim Shangraw, PM
Engineering Management Support Inc
7220 W Jefferson Ave Ste 406
Lakewood, CO 80235
Phone number: 303-940-3426
Email: timeshangraw@emsidenver.com

Billing Contact (receives the invoice pertaining to the permit certification):
Lisa Farrell, PM
Denver City and County
200 W 14 Ave Ste 310
Denver, CO 80204
Phone number: 720-865-5439
Email: lisa.farrell@denvergov.org

DMR Contact:
Tim Shangraw, PM
Engineering Management Support Inc
7220 W Jefferson Ave Ste 406
Lakewood, CO 80235
Phone number: 303-940-3426
Email: timeshangraw@emsidenver.com
CERTIFICATION TO DISCHARGE UNDER CDPS GENERAL PERMIT COG315000 REMEDIATION ACTIVITIES
DISCHARGING TO SURFACE WATERS
Certification Number COG315386
This Certification to Discharge specifically authorizes:
Denver City and County
to discharge from the facility identified as

**VB I70 Operable Unit 2 Removal Action**
**to: South Platte River and Toll Gate Creek**

**Facility Located at:** Arkins Ct and McFarland Dr Denver, CO 80216, Denver County
Center Point Latitude 39.776 Longitude -104.997

<table>
<thead>
<tr>
<th>Defined Discharge Outfall(s) to Surface Water</th>
<th>Outfall(s) Lat Long</th>
<th>Discharge Outfall(s) Description</th>
<th>Receiving Stream</th>
<th>Flow (gpm)</th>
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</thead>
<tbody>
<tr>
<td>Outfall Number 001-A</td>
<td>39.776476, -104.977580</td>
<td>The remediation dewatering effluent will be discharged to an existing outfall structure with flow to the South Platte River. Sampling shall occur after the implementation of any best management practice or treatment and prior to discharge into the outfall structure.</td>
<td>South Platte River</td>
<td>200</td>
</tr>
<tr>
<td>Outfall Number 002-A</td>
<td>39.743811, -104.826477</td>
<td>The remediation dewatering effluent will be discharged to a storm sewer with flow to Toll Gate Creek. Sampling shall occur after the implementation of any best management practice or treatment and prior to discharge into the storm sewer.</td>
<td>Toll Gate Creek</td>
<td>200</td>
</tr>
</tbody>
</table>

*All discharges must comply with the lawful requirements of federal agencies municipalities, counties, drainage districts and other local agencies regarding any discharges to storm drain systems, conveyances, or other water courses under their jurisdiction.*

1. **Permit Limitations and Monitoring Requirements apply to Outfall 001-A as outlined in the Part I.B.2 of the Permit**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Units</th>
<th>Discharge Limitations Maximum Concentrations</th>
<th>Monitoring Frequency</th>
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*Applicable to all Discharges*
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**Chemical Parameters**

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**Site Specific Parameters**

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<td>ug/l</td>
<td></td>
<td>11</td>
<td>NA</td>
<td>16</td>
</tr>
<tr>
<td>Weekly Grab</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Parameter</td>
<td>Measurement</td>
<td>Unit</td>
<td>Limit</td>
<td>Frequency</td>
</tr>
<tr>
<td>--------------------------------------------------------------------------</td>
<td>-------------</td>
<td>------</td>
<td>---------</td>
<td>-----------</td>
</tr>
<tr>
<td>Chromium, Trivalent (Total Recoverable), 04262</td>
<td>ug/l</td>
<td>NA</td>
<td>NA</td>
<td>50</td>
</tr>
<tr>
<td>Chromium, Trivalent (Potentially Dissolved), (effective 12/31/15)**, 01314</td>
<td>ug/l</td>
<td>164</td>
<td>NA</td>
<td>1258</td>
</tr>
<tr>
<td>Copper (Potentially Dissolved), (expires 12/31/15)***, 01306</td>
<td>ug/l</td>
<td>54</td>
<td>NA</td>
<td>89.1</td>
</tr>
<tr>
<td>Copper (Potentially Dissolved), (effective 12/31/15)**, 01306</td>
<td>ug/l</td>
<td>20.8</td>
<td>NA</td>
<td>31.5</td>
</tr>
<tr>
<td>Iron (Total recoverable), 00980</td>
<td>ug/l</td>
<td>1000</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>Iron (Dissolved), 01046</td>
<td>ug/l</td>
<td>300</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>Lead (Total recoverable), (effective 12/31/15)**, 01114</td>
<td>ug/l</td>
<td>NA</td>
<td>NA</td>
<td>50</td>
</tr>
<tr>
<td>Lead (Potentially Dissolved), 01318</td>
<td>ug/l</td>
<td>7.1</td>
<td>NA</td>
<td>182</td>
</tr>
<tr>
<td>Manganese (Dissolved), 01056</td>
<td>ug/l</td>
<td>190</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>Manganese (Potentially Dissolved), 01319</td>
<td>ug/l</td>
<td>NA</td>
<td>NA</td>
<td>4120</td>
</tr>
<tr>
<td>Nickel (Total recoverable), (effective 12/31/15)**, 01074</td>
<td>ug/l</td>
<td>100</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>Nickel (Potentially Dissolved), 01322</td>
<td>ug/l</td>
<td>118</td>
<td>NA</td>
<td>1061</td>
</tr>
<tr>
<td>Selenium (Potentially Dissolved), 01323</td>
<td>ug/l</td>
<td>4.6</td>
<td>NA</td>
<td>18.4</td>
</tr>
<tr>
<td>Silver (Potentially Dissolved), 01304</td>
<td>ug/l</td>
<td>1.7</td>
<td>NA</td>
<td>11</td>
</tr>
<tr>
<td>Uranium (Total recoverable), 22708</td>
<td>ug/l</td>
<td>30</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>Zinc (Potentially Dissolved), 01303</td>
<td>ug/l</td>
<td>283</td>
<td>NA</td>
<td>386</td>
</tr>
</tbody>
</table>
Total Residual Chlorine, 50060

mg/l  0.011  NA  0.019  Weekly  Grab

* If a visible sheen is observed, a grab sample shall be collected and analyzed for oil and grease.

** These parameters will become effective on 12/31/15 along with the amended version of Regulation 38. See permit certification fact sheet for additional information.

*** This limit is based on a temporary modification for copper on this stream segment which will expire on 12/31/15. See permit certification fact sheet for additional information.

2. Permit Limitations and Monitoring Requirements apply to Outfall 002-A as outlined in the Part I.B.2 of the Permit

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Units</th>
<th>Discharge Limitations</th>
<th>Monitoring Frequency</th>
<th>Sample Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH, (Minimum-Maximum) 00400</td>
<td>s.u.</td>
<td>NA</td>
<td>NA</td>
<td>6.5-9.0</td>
</tr>
<tr>
<td>Total Suspended Solids, 00530</td>
<td>mg/l</td>
<td>30</td>
<td>45</td>
<td>NA</td>
</tr>
<tr>
<td>Flow, 50050</td>
<td>gpm</td>
<td>200</td>
<td>NA</td>
<td>200</td>
</tr>
<tr>
<td>Oil and Grease*, 03582</td>
<td>mg/l</td>
<td>NA</td>
<td>NA</td>
<td>10*</td>
</tr>
<tr>
<td>Oil and Grease Visual 84066</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>Weekly</td>
</tr>
<tr>
<td><strong>Site Specific Parameters</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ammonia (4/1 - 8/31) 00610</td>
<td>mg/l</td>
<td>1.3</td>
<td>NA</td>
<td>5.7</td>
</tr>
<tr>
<td>Ammonia (9/1 - 3/31) 00610</td>
<td>mg/l</td>
<td>1.6</td>
<td>NA</td>
<td>5.7</td>
</tr>
<tr>
<td>Nitrite, 00615</td>
<td>mg/l</td>
<td>NA</td>
<td>NA</td>
<td>0.5</td>
</tr>
<tr>
<td>Sulfide, 51202</td>
<td>mg/l</td>
<td>0.002</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>Vinyl Chloride 39175</td>
<td>ug/l</td>
<td>2.3</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>Arsenic (Total recoverable), 00978</td>
<td>ug/l</td>
<td>7.6</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>Arsenic (Potentially Dissolved), 01309</td>
<td>ug/l</td>
<td>NA</td>
<td>NA</td>
<td>340</td>
</tr>
<tr>
<td>Cadmium (Potentially Dissolved), 01313</td>
<td>ug/l</td>
<td>0.87</td>
<td>NA</td>
<td>6.3</td>
</tr>
<tr>
<td>Chromium, Hexavalent (Dissolved), 01220</td>
<td>ug/l</td>
<td>11</td>
<td>NA</td>
<td>16</td>
</tr>
</tbody>
</table>
### Parameter Specifications

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Parameter Units</th>
<th>Discharge Limitations Maximum Concentrations</th>
<th>Monitoring Frequency</th>
<th>Sample Type</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>30-Day Average</td>
<td>7-Day Average</td>
<td>Daily Max.</td>
</tr>
<tr>
<td>Base, Neutral, Acids (BNAs) Screen</td>
<td>ug/l</td>
<td>Report*</td>
<td>NA</td>
<td>Report²</td>
</tr>
<tr>
<td>Volatile Organic Compounds (VOC) Screen</td>
<td>ug/l</td>
<td>Report*</td>
<td>NA</td>
<td>Report²</td>
</tr>
<tr>
<td>Metals Screen</td>
<td>mg/l</td>
<td>Report*</td>
<td>NA</td>
<td>Report²</td>
</tr>
</tbody>
</table>

* Only one influent sample representative of both outfall 001-A and 002-A will be required for each quarterly sampling event.

² Influent screening data required under this permit certification should be submitted using the division's “Influent Screening Data Submittal Form.” This form can be found at www.coloradowaterpermits.com: Click on Construction, then Other permitting requests, then Influent data submittal form.

³ The initial influent sample shall be collected within the first month (e.g. 30 days) of the discharge commencing.
Certification is issued 10/16/2015  Effective 10/16/2015  General Permit Expired: 09/30/2016

This certification under the permit requires that specific actions be performed at designated times. The certification holder is legally obligated to comply with all terms and conditions of the permit.

This certification was approved by:
Lillian Gonzalez, Unit Manager
Permits Section
Water Quality Control Division
CDPS GENERAL PERMIT COG315000

REMEDIATION ACTIVITIES DISCHARGING TO SURFACE WATER

AUTHORIZATION TO DISCHARGE UNDER THE

COLORADO DISCHARGE PERMIT SYSTEM

In compliance with the provisions of the Colorado Water Quality Control Act, (25-8-101 et seq., CRS, 1973 as amended) and the Federal Water Pollution Control Act, as amended (33 U.S.C. 1251 et seq.; the "Act"), Remediation Activities are authorized to discharge treated water from authorized locations throughout the State of Colorado to specified surface waters of the State. Such discharges shall be in accordance with the conditions of this general permit.

This permit specifically authorizes the entity(s) listed on page 1 of this document (also known as the permit certification) to discharge process generated wastewaters, as of the effective dates stated on page 1 of the certification, in accordance with the permit requirements and conditions set forth in Parts I and II hereof. All discharges authorized herein shall be consistent with the terms and conditions of this permit.

The applicant may demand an adjudicatory hearing within thirty (30) days of the date of issuance of the final permit determination, per the Colorado Discharge Permit System Regulations, 61.7(1). Should the applicant choose to contest any of the effluent limitations, monitoring requirements or other conditions contained herein, the applicant must comply with Section 24-4-104 CRS and the Colorado Discharge Permit System Regulations. Failure to contest any such effluent limitation, monitoring requirement, or other condition, constitutes consent to the condition by the Applicant.

This permit and the authorization to discharge shall expire at midnight September 30, 2016

Modified and Signed this day 20th day of May, 2014

COLORADO DEPARTMENT OF PUBLIC HEALTH AND ENVIRONMENT

Janet Kieler, Permits Section Manager
WATER QUALITY CONTROL DIVISION

Permit Action Summary:
Minor Modification #1—Issued September 1, 2011, Effective October 1, 2011
Originally Issued and Signed: August 3, 2011, Effective October 1, 2011

Table of Contents
10. Severability ........................................................................................................................................................................ 37
11. Renewal Application ................................................................................................................................................................. 37
12. Confidentiality ............................................................................................................................................................................. 37
13. Fees .......................................................................................................................................................................................... 38
14. Duration of Permit .................................................................................................................................................................... 38
15. Section 307 Toxics .................................................................................................................................................................... 38
16. Effect of Permit Issuance ......................................................................................................................................................... 38
PART I

A. COVERAGE UNDER THIS PERMIT

1. **Activities Covered**

This permit authorizes the discharge from Remediation Activities from authorized locations throughout the State of Colorado to surface waters of the state. Remediation Activities means treatment and/or remedial activities of groundwater, alluvial water, stormwater, and/or surface water (the source water). RAs occur at facilities including, but are not limited to: Industrial Sites, Leaking Underground Storage Tanks (LUSTs), Gasoline Stations, Dry Cleaners and Construction Dewatering sites where contaminated groundwater, alluvial water, stormwater, and/or surface water is encountered.

2. **Limitations on Coverage**

Discharges from Remediation Activities may be covered under this permit provided that the applicant can provide representative data of the contaminated source water at the time of application. If the applicant is not able to provide the representative data, determinations will be made on a case-by-case basis as to whether coverage can be authorized under this general permit. These case-by-case determinations are based on resources and relevant information available to accurately evaluate and identify the potential contaminants in the source water. If it is determined that resources and relevant information are not available, an individual permit may be required.

There are some discharges from Remediation Activities that cannot be covered under this general permit and must apply for coverage under another general permit or under an individual permit. These exclusions include discharges to receiving waters designated as “outstanding waters” discharges that are land applied or otherwise released to groundwater and discharges that include domestic related wastewater.

3. **Application Requirements**

In order to apply for certification under this general permit, the applicant shall submit an application form as provided by the Division by mail or hand delivery at least 45 days before the anticipated date of discharge. The application in its entirety shall be submitted to:

Colorado Department of Public Health and Environment
Water Quality Control Division
Permits Section, WQCD-PCP-B2
4300 Cherry Creek Drive South
Denver, Colorado 80246-1530

Following review of the application, the Division may request additional information or deny the authorization to discharge under this general permit. If the Division determines that a new facility does not fall under the authority of the general permit, then the information received will be processed for an individual permit, and the applicant shall be notified of such a determination. If during the renewal process, the Division determines that a facility no longer qualifies for the general permit, then the certification may be revoked or the facility may be allowed to discharge under the general permit, with additional conditions in the amended certification, until an individual permit is issued.

A permittee desiring continued coverage under the general permit must reapply **at least 180 days in advance of this permit expiration**. If this permit is not reissued or replaced prior to the expiration date, it will be administratively continued and remain in force and effect. If a permittee was authorized to discharge under this permit prior to the expiration date, any discharges authorized under this permit will automatically remain covered by this permit until the earliest of:

a. Authorization for coverage under a reissued permit or a replacement of this permit following the timely
and appropriate submittal of a complete application requesting authorization to discharge under the new permit and compliance with the requirements of the application;

b. The issuance and effect of a termination issued by the Division;

c. The issuance or denial of an individual permit for the facility’s discharges;

d. A formal permit decision by the Division not to reissue this general permit, at which time the Division will identify a reasonable time period for covered dischargers to seek coverage under an alternative general permit or an individual permit. Coverage under this permit will cease when coverage under another permit is granted/authorized; or

e. The Division has informed the permittee that they are no longer covered under this permit.

4. **Terminating Coverage**

To terminate permit coverage, the legal permit applicant or duly authorized agent must submit a complete and accurate Notice of Termination Form, to the address listed in Part I.A.3. The authorization to discharge under this permit terminates at midnight of the day that the termination is effective as notified by the Division. The permittee is responsible for meeting the terms of this permit until the authorization is terminated. The Notice of Termination must be signed in accordance with Part I.E.7 of this permit.

5. **Modifying Existing Permit Coverage**

To modify an existing permit certification, the legal permit contact or duly authorized agent must submit a complete and accurate Modification Form, to the address listed in Part I.A.3. This form must be submitted to the Division at least 45 days prior to implementing any requested modifications that result in a discharge to state waters. The permittee is not authorized to discharge under the modified conditions until the modified certification is issued and effective. Modifications include but are not limited to: adding or removing discharge outfalls, adding new or additional chemicals to the treatment process or effluent, modifying treatment in a manner that would result in a new or altered discharge in terms of location or effluent quality, etc. The modification form must be signed in accordance with Part I.E.7 of this permit.

B. **EFFLUENT LIMITATIONS AND MONITORING REQUIREMENTS**

1. **Permitted Outfall(s)**

Beginning no earlier than the effective date listed on the permit certification and lasting through the expiration date of this permit, the permittee identified on the permit certification is authorized to discharge from the Outfall(s) listed on the permit certification, provided that all conditions of this permit are met.

2. **Numeric Effluent Limitations, Monitoring Frequencies, and Sample Types**

In accordance with the Water Quality Control Commission Regulations for Effluent Limitations, Section 62.4, and the Colorado Discharge Permit System Regulations, Section 61.8(2), 5.C.C.R. 1002-61, the permitted discharge shall not contain effluent parameter concentrations which exceed the limitations specified in Table B.1 or B.2 and the permit certification.

The permittee must monitor the effluent for all listed parameters at the frequency and sample types specified in Table B.1 or B.2 below. Additional site specific parameters along with the discharge limitations and monitoring conditions may be included in the permit certification. Such monitoring will begin immediately and last for the life of the permit unless otherwise noted. The results of such monitoring must be reported on the Discharge Monitoring Report (DMR) form (See Part I.E). Facilities with continuous discharges may request a reduction in the monitoring frequency through the modification process. The Division will evaluate if a reduction in monitoring frequency can be made in accordance with the Division’s Baseline Monitoring Frequency, Sample Type, and Reduced Monitoring Frequency Policy.

Long-term discharges to State waters designated as ‘Reviewable’ are subject to an antidegradation (AD)
review. Consideration of dilution, ambient water quality, or an AD alternatives analysis is not applicable under this general permit as all limits are end of pipe. As such, long-term discharges to designated reviewable segments will get 15% of the water quality standard and the AD limits will be noted in the permit certification. For additional information on the AD review see Part I.VI.A.2.a of the Permit Fact Sheet.

Table B.1, Numeric Effluent Limitations and Monitoring Requirements for Continuous Discharges or Flow-Through Treatment

<table>
<thead>
<tr>
<th>Parameter</th>
<th>ICIS Code</th>
<th>Discharge Limitations</th>
<th>Monitoring Conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flow, mgd¹</td>
<td>50050</td>
<td>Limit</td>
<td>Continuous Recorder</td>
</tr>
<tr>
<td>Total Suspended Solids, mg/l</td>
<td>00530</td>
<td>30</td>
<td>Weekly Grab</td>
</tr>
<tr>
<td>Oil and Grease²</td>
<td>84066</td>
<td>45</td>
<td>Weekly Visual</td>
</tr>
<tr>
<td>Oil and Grease², mg/l</td>
<td>80382</td>
<td>10</td>
<td>Weekly Grab</td>
</tr>
<tr>
<td>pH, s.u.</td>
<td>00400</td>
<td>6.5-9.0</td>
<td>Weekly In-situ</td>
</tr>
<tr>
<td>Total Dissolved Solids³, mg/l</td>
<td>70295</td>
<td>Report</td>
<td>Monthly Grab</td>
</tr>
<tr>
<td>Total Phosphorus⁴, mg/l, as P</td>
<td>00665</td>
<td>Limit in Certification</td>
<td>Monthly Grab</td>
</tr>
<tr>
<td>Total Phosphorus⁴, mg/l, as P</td>
<td>00665</td>
<td>Report</td>
<td>Monthly Grab</td>
</tr>
<tr>
<td>WET⁵, acute</td>
<td>TCP6C</td>
<td>LC50 ≥ 100% (daily min)</td>
<td>Quarterly Grab</td>
</tr>
<tr>
<td>WET⁵, chronic</td>
<td>TCP3B</td>
<td>NOEC or IC25 &gt;100%</td>
<td>Quarterly 3 Grabs/test</td>
</tr>
<tr>
<td>Site Specific⁶ Metals, Organics, Inorganics, Temperature, RADs</td>
<td>Report</td>
<td>Report</td>
<td>Weekly Grab</td>
</tr>
<tr>
<td>Site Specific⁶ Metals, Organics, Inorganics, RADS</td>
<td>Limit in Certification</td>
<td>Limit in Certification</td>
<td>Weekly Grab</td>
</tr>
</tbody>
</table>
## Table B.2. Numeric Effluent Limitations and Monitoring Requirements for Intermittent Discharges including Batch Treatment

<table>
<thead>
<tr>
<th>Parameter</th>
<th>ICIS Code</th>
<th>Discharge Limitations</th>
<th>Monitoring Conditions</th>
<th>Sample Type</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>30-Day Average</td>
<td>7-Day Average</td>
<td>Daily Maximum</td>
</tr>
<tr>
<td>Flow, mgd¹</td>
<td>50050</td>
<td>Limit</td>
<td>----</td>
<td>Limit</td>
</tr>
<tr>
<td>Total Suspended Solids, mg/l</td>
<td>00530</td>
<td>30</td>
<td>45</td>
<td>-----</td>
</tr>
<tr>
<td>Oil and Grease²</td>
<td>84066</td>
<td>----</td>
<td>----</td>
<td>----</td>
</tr>
<tr>
<td>Oil and Grease², mg/l</td>
<td>03582</td>
<td>----</td>
<td>10</td>
<td>Weekly</td>
</tr>
<tr>
<td>pH, s.u.</td>
<td>00400</td>
<td>----</td>
<td>6.5-9.0</td>
<td>Weekly</td>
</tr>
<tr>
<td>Total Dissolved Solids³, mg/l</td>
<td>70295</td>
<td>Report</td>
<td>----</td>
<td>Report</td>
</tr>
<tr>
<td>Total Phosphorus⁴, mg/l, as P</td>
<td>00665</td>
<td>Limit in Certification</td>
<td>----</td>
<td>----</td>
</tr>
<tr>
<td>Total Phosphorus⁴, mg/l, as P</td>
<td>00665</td>
<td>Report</td>
<td>----</td>
<td>Report</td>
</tr>
<tr>
<td>WET⁵, acute</td>
<td>TAN6C</td>
<td>LC50 Stare 96Hr Acute</td>
<td>Pimpephales</td>
<td>LC50 &gt; 100%</td>
</tr>
<tr>
<td></td>
<td>LC50 Stare 96Hr Acute</td>
<td>Pimpephales</td>
<td>LC50 &gt; 100%</td>
<td>Quarterly</td>
</tr>
<tr>
<td>WET⁵, chronic</td>
<td>TCP6C</td>
<td>Static Renewal 7 Day</td>
<td>Chronic</td>
<td>NOEC or IC25</td>
</tr>
<tr>
<td></td>
<td>TCP3B</td>
<td>7 Day Chronic</td>
<td>Ceriodaphnia</td>
<td>NOEC or IC25</td>
</tr>
<tr>
<td>Site Specific⁶</td>
<td>Metals, Organics, Inorganics, Temperature, RADs</td>
<td>Report</td>
<td>----</td>
<td>Report</td>
</tr>
<tr>
<td>Site Specific⁶</td>
<td>Metals, Organics, Inorganics, RADS</td>
<td>Limit in Certification</td>
<td>----</td>
<td>Limit in Certification</td>
</tr>
</tbody>
</table>

### Notes:

¹*Flow Limit*—The chronic flow limit will be based on the design capacity of the treatment as provided in the permit application and will be stated on the certification.

²*Oil and Grease*—A visual observation of the discharge for each permitted outfall must be made once a week. In the event an oil sheen or floating oil is observed, a composite sample shall be collected weekly, analyzed, and reported on the DMR. In addition, corrective action shall be taken immediately to mitigate the discharge of oil.
and grease. A description of the corrective action taken must be included with the DMR.

3Total Dissolved Solids (TDS)—Analysis for salinity, measured as TDS, will be required in all permits that discharge in the Colorado River Basin. Following the submittal of the initial six sets of monthly data, the Division shall determine whether the permittee is required to submit a report addressing salt removal in accordance with the Colorado River Salinity Standards, Regulation No. (5CCR 1002-39). If the salinity report is required, the Division shall so advise the permittee by letter or through the inclusion of a compliance schedule and the report shall be submitted within 180 days.

4Total Phosphorus—Analysis for Total Phosphorus, as P, will be required for discharges to waters with a control regulation for P. In accordance with the Dillon Reservoir Control Regulation (Regulation 71), monitoring for Total Phosphorus is required. In accordance with the Cherry Creek Reservoir Control Regulation (Regulation 72), monitoring and compliance with the Total Phosphorus chronic numeric effluent limit of 0.05mg/l is required. In accordance with the Chatfield Reservoir Control Regulation (Regulation 73), monitoring and compliance with the Total Phosphorus chronic numeric effluent limit of 1.0 mg/l is required. In accordance with the Bear Creek Watershed Control Regulation (Regulation 74), monitoring for Total Phosphorus is required.

5Whole Effluent Toxicity (WET) Testing—A site specific determination will be made as to whether WET testing will be required and will be stated in the permit certification. See Part I.C.7 for WET testing requirements and Part VI.A.4 of the Fact Sheet for the discussion on determining when WET testing is required.

6Site Specific Parameters—Upon review of the analytical data supplied with the permit application, site specific parameters will be added to the permit certification based on the type and concentrations of contaminants present. This may include monitoring requirements for Temperature, if there is potential for the permittee to containerize the effluent for extended periods of time. Additional site specific parameters may be added to the permit certification in accordance with Part I.B.3.

3. Monitoring Frequencies and Sample Types for Influent Parameters

The permittee must monitor the influent for all listed parameters at the frequency and sample types specified in Table B.3 below. Such monitoring shall be conducted after the discharge has commenced, but within the first month of discharge, and shall continue on a quarterly basis. The results of such monitoring must be reported on the Discharge Monitoring Report (DMR) form (See Part I.E) under Permitted Feature 300I.

After the review of the influent data, the Division may require a modification to the permit certification to include additional monitoring requirements and numeric effluent limitations, as established in Part I.B. The permittee will be notified if the Division requires any such modification.

In addition, the permittee must follow the procedures identified in Part I.C.6 if there is a potential exceedance of water quality standards at the permitted outfall, for a parameter not subject to an effluent limit in the permit/permit certification.

The influent sampling requirement established in Part I.B.3 may be waived on a case-by-case basis if the Division deems the pollutants in the source water have been well characterized or other pertinent information has been provided to the Division. This may be the case for fixed facilities treating a specific pollutant source, or for facilities with substantial historical groundwater data.

If after the submittal of four quarters of influent data substantiating constituents are not detected in concentrations more than one half the surface water standards, the permittee can request relief from the influent monitoring requirements.
Outfall: 300I

Table B.3, Monitoring Frequency and Sample Type Influent Parameters for Continuous and Intermittent Discharges including Batch Treatment

<table>
<thead>
<tr>
<th>Parameter</th>
<th>ICIS Code</th>
<th>Discharge Limitations</th>
<th>Monitoring Conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Semi Volatile Organic Compounds</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Screen¹</td>
<td></td>
<td>30-Day Average Report</td>
<td>Quarterly</td>
</tr>
<tr>
<td></td>
<td></td>
<td>7-Day Average Report</td>
<td>Grab</td>
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<tr>
<td>Volatile Organic Compounds</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Screen²</td>
<td></td>
<td>30-Day Average Report</td>
<td>Quarterly</td>
</tr>
<tr>
<td></td>
<td></td>
<td>7-Day Average Report</td>
<td>Grab</td>
</tr>
<tr>
<td>Metals Screen³</td>
<td></td>
<td>30-Day Average Report</td>
<td>Quarterly</td>
</tr>
<tr>
<td></td>
<td></td>
<td>7-Day Average Report</td>
<td>Grab</td>
</tr>
</tbody>
</table>

Notes:

¹ **Semi-Volatile Organic Compound Screen**—The permittee shall sample the influent once per quarter in accordance with Part I.B.3 and have it analyzed for Semi-Volatile Organic Compounds listed in the Influent Screening Requirements found in Part III of the permit. Pesticides, herbicides, and PCBs do not need to be included in this analysis.

² **Volatile Organic Compound Screen**—The permittee shall sample the influent once per quarter in accordance with Part I.B.3 and have it analyzed for Volatile Organic Compounds listed in the Influent Screening Requirements found in Part III of the permit.

³ **Metals Screen**—The permittee shall sample the influent once per quarter in accordance with Part I.B.3 and have it analyzed for all metals listed in the Influent Screening Requirements found in Part III of the permit. The Metals analyses shall be performed for the extraction (Total Recoverable, Potentially Dissolved, and/or Dissolved form) identified in Part III of the permit.

C. TERMS AND CONDITIONS

1. **Compliance Schedule**
   Existing dischargers may be granted compliance schedules for any new effluent limitations applicable to the discharge. Some items requiring a compliance schedule may require an individual permit.

2. **Ensure Numeric Effluent Limits Can Be Met**
   Prior to the commencement of any discharge, an initial batch representative of the effluent from each permitted outfall must be sent through the treatment system. The effluent from the treatment must be sampled using composite method for all parameters listed in the permit certification with a numeric limitation. All effluent must be contained until analyses have confirmed that all numeric effluent limitations have been met. If the results of the initial sampling exceed any numeric effluent limitation, additional treatment shall be completed and additional sampling must be collected, post-treatment, to confirm compliance with the limitations. Additional sampling and treatment shall be repeated, and all water shall be collected and retained, until monitoring results for the treated effluent verify compliance with the numeric effluent limitations identified in the permit certification. Monitoring may be conducted and samples collected to meet the requirements of this section prior to certification under the general permit. This requirement will not be imposed for WET testing or for parameters where report only is required.

The initial containment of the effluent requirement established in Part I.C.2 may be waived for existing permittee’s on a case-by-case basis. The case-by-case determination will be made based on numeric effluent limitation permit compliance history.
3. **Remediation Activities Practices**
   The permittee shall develop and implement remediation activities practices for each facility covered by this permit in accordance with the requirements of this section. The remediation activities practices shall be documented in a Remediation Activities Management Plan in accordance with I.C.4. The practices shall include:

   a. **Pollutant Control Practices**: The permittee shall implement pollutant control practices to meet all numeric effluent limitations in accordance with good engineering, hydrologic and pollution control practices. Specifically, the permittee must ensure all pollutant control practices are designed, implemented, and maintained with proper hydraulic and pollutant removal capacity to ensure consistent compliance with the permit effluent limits. Practices shall include all treatment, schedules of activities, prohibitions of practices, maintenance procedures, monitoring practices used to document the capability of the treatment practices to remove pollutants, including residual solids treatment, handling and disposal practices, and other management practices necessary to meet the numeric effluent limits.

   b. **Materials Handling and Spill Prevention**: The permittee shall implement practices for material handling and spill prevention to prevent discharges that contain effluent parameter concentrations which exceed the limitations specified in Table B.1, Table B.2, and the permit certification, as well as discharges not authorized by a CDPS discharge permit. The permittee shall implement secondary containment for all bulk storage structures for petroleum products and any other chemicals associated with the pollutant control practices (e.g., fuel for pumps, chemicals used in the treatment process), or provide equivalent adequate protection so as to contain all spills and prevent any spilled material from entering the effluent stream or State waters.

4. **Remediation Activities Management Plan**
   a. **Remediation Activities Management Plan (Plan)** shall document the following information:

   i) **Plan Administrator**: The Plan shall identify a specific individual(s), position or title who is responsible for developing, implementing, maintaining, and revising the Plan. The activities and responsibilities of the administrator shall address all aspects of the facility’s Plan.

   ii) **Facility Certified Operator**: As documented in Regulation 100, all water and wastewater facilities in Colorado shall be under the supervision of an operator certified at or above the classification of the facility. The Plan shall identify a specific individual holding a certificate that meets the requirements of Regulation 100. If the permittee is not aware of the class of certification needed, contact the Division’s Facility-Operator Program.

   iii) **Site Map**: The Plan shall include a legible site map(s), showing the entire site, identifying:

   i) The source of the discharge or dewatering excavations (if applicable)—Dewatering excavations can be described as locations where ground disturbing activities result in uncovering of groundwater
   ii) Containment Location(s) if present,
   iii) Location of structural treatment practices, including but not limited to tanks, filter systems, etc.
   iv) Sampling Locations
   v) Discharge Point(s)/Outfall(s)
   vi) Identification of the conveyance into which the discharge point(s)/outfall(s) are directed (e.g., surface water, storm sewer, ditch, etc.)
iv) **Description of Pollutant Control Practices:** The Plan shall describe the installation and implementation specifications for each practice implemented in accordance with Part I.C.3.a. The description shall address the proper implementation and operation of the practice. The description shall include general information related to hydraulic and pollutant removal capacity of the pollutant treatment system, with related monitoring practices used to document the capability of the treatment practices to remove pollutants, including residual solids treatment, handling and disposal practices. The Plan shall clearly describe the inspection and maintenance procedures implemented at the site to maintain all pollutant control practices in good and effective operating condition.

v) **Description of Materials Handling and Spill Prevention:** The Plan shall identify the practices implemented for Materials Handling and Spill Prevention in accordance with Part I.C.3.b. The description shall identify the capacity and location of secondary containment implemented for all bulk storage structures. If equivalent adequate protection is implemented in lieu of secondary containment, the plan shall provide a description of the practices to be used.

b. **Plan Preparation and Implementation:** The Plan does not need to be completed prior to submitting a permit application. However, the Plan shall be completed and documented prior to commencement of the discharge. The Plan shall be maintained and implemented until expiration or inactivation of permit coverage.

c. **Plan Retention Requirements:** A copy of the Plan must be retained on site unless another location, specified by the permittee, is approved by the Division.

d. **Plan Availability:** A copy of the Plan shall be provided upon request to the Division or EPA in accordance with Part II.B.2. All Plans required under this permit are considered reports that shall be available to the public under Section 308(b) of the CWA and Section 61.5(4) of the Colorado Discharge Permit System Regulations. The permittee shall make plans available to members of the public upon request. However, the permittee may claim any portion of a Plan as confidential in accordance with 40 CFR Part 2.

e. **Plan Review/Changes:** The Plan must reflect current field conditions. Any changes in the pollutant control practices implemented at the site must be reflected in the Plan and may trigger additional requirements as established in Part II.A.2 of the permit. Plan changes shall be made prior to changes in the site conditions, except as allowed for in paragraph f, below.

f. **Responsive Plan Changes:** Plan changes addressing pollutant control practices are often required to be made in response to changing conditions, or when current practices are determined ineffective. The majority of Plan revisions to address these changes can be made immediately with quick in-the-field revisions to the plan. In the less common scenario where more complex development of materials to modify the Plan is necessary, Plan revisions shall be made in accordance with the following requirements:

   i) the Plan shall be revised as soon as practicable, but in no case more than 72 hours after the change(s) in the pollutant control practices at the site, and

   ii) a notation must be included in the Plan prior to the site change(s) that includes the time and date of the change(s) in the field, an identification of the changes in pollutant control practices.
5. **Discharge Log**

   The permittee shall maintain a documented weekly Discharge Log identifying for each week (Sunday through Saturday) the following information for each permitted outfall:

   i) the dates and times when a discharge commences and/or ends,
   ii) records for monitoring as required by Part I.E.4.

   The entries can be based off data obtained from the flow recorder. The log must be updated within 72 hours of the occurrence of any activity requiring documentation in accordance with this subsection.

6. **Practices for Discharges in Exceedance of Applicable Water Quality Standards**

   The Division expects that compliance with the effluent limits in this permit will control discharges as necessary to meet applicable water quality standards. If at any time the permittee becomes aware that at the permitted outfall, pollutant concentrations for an effluent parameter **not** subject to an effluent limitation in Part I.B or the permit certification exceeds any applicable water quality standard for the receiving water, the permittee shall:

   a. Halt or reduce any activity if necessary to prevent the discharge of an effluent parameter(s), at the permitted outfall, in concentrations which exceed the applicable water quality standards for the receiving water;

   b. Report the exceedance of an acute effluent limitation and/or an exceedance of toxic substance listed in Part III of the permit orally within twenty-four (24) hours from the time the permittee becomes aware of the circumstances; and

   c. Mail a written report to the Division containing all relevant monitoring data and the information consistent with that required for noncompliance in Part II.A.4 (a) within five (5) days after becoming aware of the exceedance.

   Coverage under this general permit may be modified, suspended, or terminated by the Division if necessary to effectively implement protection of waters of the State. If the Division finds that such new or altered discharge might be inconsistent with the conditions of the permit, the Division shall require a new or revised permit application, or require coverage under an individual permit, and shall follow the procedures specified in Sections 61.5 through 61.6, and 61.15 of the Colorado Discharge Permit System Regulations.

   The Division expects that compliance with the effluent limits in this permit will control discharges as necessary to meet applicable water quality standards. If at any time the permittee becomes aware that at the permitted outfall, pollutant concentrations for an effluent parameter subject to an effluent limitation in Part I.B or the permit certification exceeds any applicable water quality standard for the receiving water, the permittee shall follow the requirements stated in Part II., specifically Part II.A.4,10, and 14.

7. **WET Testing-Outfall(s)**

   When the Division determines WET testing is required due to the expected pollutants in the discharge, variability in the discharge, and chemical usage chronic WET testing will normally be required (see Part VI.A.4 of Fact Sheet for Reasonable Potential to include WET). However, where the discharge is intermittent, as defined in Part I.D, acute WET may be substituted for chronic WET testing. The basis for this is that the aquatic life would not have chronic exposure to the effluent.

   The following minimum dilution series should be used for both chronic and acute testing: 0% effluent (control), 20%, 40%, 60%, 80%, and 100% effluent. If the permittee uses more dilutions than prescribed, and accelerated testing is to be performed, the same dilution series shall be used in the accelerated testing as was
used in the failed test.

Tests shall be done at the frequency listed in Part I.B.2. Test results shall be reported along with the Discharge Monitoring Report (DMR) submitted for the end of the reporting period when the sample was taken. (i.e., WET testing results for the calendar quarter ending March 31 shall be reported with the DMR due April 28, etc.) The permittee shall submit all laboratory statistical summary sheets, summaries of the determination of a valid, invalid or inconclusive test, and copies of the chain of custody forms, along with the DMR for the reporting period.

If a test is considered invalid, the permittee is required to perform additional testing during the monitoring period to obtain a valid test result. Failure to obtain a valid test result during the monitoring period shall result in a violation of the permit for failure to monitor.

a. **Acute WET Testing**
   i) **General Acute WET Testing and Reporting Requirements:** The permittee shall conduct an acute 48-hour WET test using Ceriodaphnia dubia, and an acute 96-hour WET test using fathead minnows (*Pimephales promelas*). Acute tests shall be conducted as a static replacement test using a single effluent grab sample. The permittee shall conduct each acute WET test in accordance with the 40 CFR Part 136 methods described in *Methods for Measuring the Acute Toxicity of Effluents and Receiving Water to Freshwater and Marine Organisms*, Fifth Edition, October 2002 (EPA-821-R-02-012) or its most current edition.

   ii) **Acute WET Violations of the Permit Limit and Division Notification:** An acute WET test is failed whenever the LC50, which represents an estimate of the effluent concentration which is lethal to 50% of the test organisms in the time period prescribed by the test, is found to be less than or equal to 100% effluent. The permittee must provide written notification of the failure of a WET test to the Division, along with a statement as to whether accelerated testing or a Toxicity Identification Evaluation (TIE) is being performed, unless otherwise exempted, in writing, by the Division. Notification must be received by the Division within 14 calendar days of the permittee receiving notice of the WET testing results.

   iii) **Automatic Compliance Response:** The permittee is responsible for implementing the automatic compliance response provisions of this permit when one of the following occurs:

   - there is a violation of the permit limit (the LC50 endpoint is less than the applicable IWC)
   - the permittee is otherwise informed by the Division that a compliance response is necessary

   When one of the above listed events occurs, the following automatic compliance response shall apply. The permittee shall either:

   - conduct accelerated testing using the single species found to be more sensitive
   - conduct a Toxicity Identification Evaluation / Toxicity Reduction Evaluation (TIE/TRE) investigation as described in Part I.C.7.a.iii.b.

a. **Accelerated Testing**

   If accelerated testing is being performed, testing will be at least once every two weeks for up to five tests, at the appropriate IWC. Accelerated testing shall continue until: 1) two consecutive tests fail or three of five tests fail, in which case a pattern of toxicity has been demonstrated or 2) two consecutive tests pass or three of five tests pass, in which case no
pattern of toxicity has been found. Note that the same dilution series should be used in the accelerated testing as was used in the initial test(s) that result in the accelerated testing requirement.

If no pattern of toxicity is found the toxicity episode is considered to be ended and routine testing is to resume. If a pattern of toxicity is found, a TIE/TRE investigation is to be performed. If a pattern of toxicity is not demonstrated but a significant level of erratic toxicity is found, the Division may require an increased frequency of routine monitoring or some other modified approach. The permittee shall provide written notification of the results within 14 calendar days of completion of the Pattern of Toxicity/No Toxicity demonstration.

b. Toxicity Identification Evaluation / Toxicity Reduction Evaluation (TIE/TRE)—(applicable to both acute and chronic WET testing)

If a TIE/TRE is being performed, the results of the investigation are to be received by the Division within 180 days of the demonstration of acute WET in the routine test, as defined above, or if accelerated testing was performed, the date the pattern of toxicity is demonstrated. A status report is to be provided to the Division at the 60 and 120 day points of the TIE/TRE investigation. The Division may extend the time frame for investigation where reasonable justification exists. A request for an extension must be made in writing and received prior to the 180 day deadline. Such request must include a justification and supporting data for such an extension.

Under a TIE, the permittee may use the time for investigation to conduct a preliminary TIE (PTIE) or move directly into the TIE. A PTIE consists of a brief search for possible sources of WET, where a specific parameter(s) is reasonably suspected to have caused such toxicity, and could be identified more simply and cost effectively than a formal TIE. If the PTIE allows resolution of the WET incident, the TIE need not necessarily be conducted in its entirety. If, however, WET is not identified or resolved during the PTIE, the TIE must be conducted within the allowed 180 day time frame.

The Division recommends that the EPA guidance documents regarding TIEs be followed. If another method is to be used, this procedure should be submitted to the Division prior to initiating the TIE.

If the pollutant(s) causing toxicity is/are identified, and is/are controlled by a permit effluent limitation(s), this permit may be modified upon request to adjust permit requirements regarding the automatic compliance response.

If the pollutant(s) causing toxicity is/are identified, and is/are not controlled by a permit effluent limitation(s), the Division may develop limitations the parameter(s), and the permit may be reopened to include these limitations.

If the pollutant causing toxicity is not able to be identified, or is unable to be specifically identified, or is not able to be controlled by an effluent limit, the permittee will be required to perform either item 1 or item 2 below.

1) Conduct an investigation which demonstrates actual instream aquatic life conditions upstream and downstream of the discharge, or identify, for Division approval, and conduct an alternative investigation which demonstrates the actual instream impact. This
should include WET testing and chemical analyses of the ambient water. Depending on the results of the study, the permittee may also be required to identify the control program necessary to eliminate the toxicity and its cost. Data collected may be presented to the WQCC for consideration at the next appropriate triennial review of the stream standards;

2) Move to a TRE by identifying the necessary control program or activity and proceed with elimination of the toxicity so as to meet the WET effluent limit.

If toxicity spontaneously disappears in the midst of a TIE, the permittee shall notify the Division within 10 days of such disappearance. The Division may require the permittee to conduct accelerated testing to demonstrate that no pattern of toxicity exists, or may amend the permit to require an increased frequency of WET testing for some period of time. If no pattern of toxicity is demonstrated through the accelerated testing or the increased monitoring frequency, the toxicity incident response will be closed and normal WET testing shall resume.

The control program developed during a TRE consists of the measures determined to be the most feasible to eliminate WET. This may happen through the identification of the toxicant(s) and then a control program aimed specifically at that toxicant(s) or through the identification of more general toxicant treatability processes. A control program is to be developed and submitted to the Division within 180 days of beginning a TRE. Status reports on the TRE are to be provided to the Division at the 60 and 120 day points of the TRE investigation.

If toxicity spontaneously disappears in the midst of a TRE, the permittee shall notify the Division within 10 days of such disappearance. The Division may require the permittee to conduct accelerated testing to demonstrate that no pattern of toxicity exists, or may amend the permit to require an increased frequency for some period of time. If no pattern of toxicity is demonstrated through the accelerated testing or the increased monitoring frequency, the toxicity incident response will be closed and normal WET testing shall resume.

iv) Toxicity Reopener (applicable to both acute and chronic WET testing): This permit may be reopened and modified to include additional or modified numerical permit limitations, new or modified compliance response requirements, changes in the WET testing protocol, the addition of both acute and chronic WET requirements, or any other conditions related to the control of toxicants.

b. Chronic WET Testing

i) General Chronic WET Testing and Reporting Requirements: The permittee shall conduct the chronic WET test using Ceriodaphnia dubia and fathead minnows (*Pimephales promelas*), as a static renewal 7-day test using three separate grab samples. The permittee shall conduct each chronic WET test in accordance with the 40 CFR Part 136 methods described in *Short-term Methods for Estimating the Chronic Toxicity of Effluents and Receiving Water to Freshwater Organisms*, Fourth Edition, October 2002 (EPA-821-R-02-013) or the most current edition, except as modified by the most current Division Guidance document entitled *Guidelines for Conducting Whole Effluent Toxicity Tests*. 
ii) Chronic WET Violations of the Permit Limit, Failure of One Test Statistical Endpoint and Division Notification:
A chronic WET test is considered a violation of a permit limitation when both the NOEC and the IC25 are at any effluent concentration less than the IWC. The IWC for this permit has been determined to be 100% effluent. The permit applicant will need to apply for an individual permit for consideration of a lower IWC percentage.

A chronic WET test is considered to have failed one of the two statistical endpoints when either the NOEC or the IC25 are at any effluent concentration less than the IWC. The IWC for this permit has been determined to be 100% effluent. The permit applicant will need to apply for an individual permit for consideration of a lower IWC percentage.

In the event of a permit violation, or when two consecutive reporting periods have resulted in failure of one of the two statistical endpoints (regardless of which statistical endpoints are failed), the permittee must provide written notification to the Division. Such notification should explain whether it was a violation or two consecutive failures of a single endpoint, and must indicate whether accelerated testing or a Toxicity Identification Evaluation or Toxicity Reduction Evaluation (TIE or TRE) is being performed, unless otherwise exempted, in writing, by the Division. Notification must be received by the Division within 14 calendar days of the permittee receiving notice of the WET testing results.

iii) Automatic Compliance Response: The permittee is responsible for implementing the automatic compliance response provisions of this permit when one of the following occurs:

- there is a violation of the permit limit (both the NOEC and the IC25 endpoints are less than the applicable IWC)
- two consecutive monitoring periods have resulted in failure of one of the two statistical endpoints (either the IC25 or the NOEC)
- the permittee is otherwise informed by the Division that a compliance response is necessary

When one of the above listed events occurs, the following automatic compliance response shall apply. The permittee shall either:

- conduct accelerated testing using the single species found to be more sensitive
- conduct a Toxicity Identification Evaluation / Toxicity Reduction Evaluation (TIE/TRE) investigation as described in Part I.C.7.b.iii.b.

a. Accelerated Testing

If accelerated testing is being performed, testing will be at least once every two weeks for up to five tests, using only the IC25 statistical endpoint to determine if the test passed or failed at the appropriate IWC. Accelerated testing shall continue until: 1) two consecutive tests fail or three of five tests fail, in which case a pattern of toxicity has been demonstrated or 2) two consecutive tests pass or three of five tests pass, in which case no pattern of toxicity has been found. Note that the same dilution series should be used in the accelerated testing as was used in the initial test(s) that result in the accelerated testing requirement.

If accelerated testing is required due to failure of one statistical endpoint in two consecutive monitoring periods, and in both of those failures it was the NOEC endpoint that was failed, then the NOEC shall be the only statistical endpoint used to determined whether the
accelerated testing passed or failed at the appropriate IWC. Note that the same dilution series should be used in the accelerated testing as was used in the initial test(s) that result in the accelerated testing requirement.

If no pattern of toxicity is found the toxicity episode is considered to be ended and routine testing is to resume. If a pattern of toxicity is found, a TIE/TRE investigation is to be performed. If a pattern of toxicity is not demonstrated but a significant level of erratic toxicity is found, the Division may require an increased frequency of routine monitoring or some other modified approach. The permittee shall provide written notification of the results within 14 calendar days of completion of the Pattern of Toxicity/No Toxicity demonstration.

b. Toxicity Identification Evaluation / Toxicity Reduction Evaluation (TIE/TRE)—See Section C.7.a.iii.b for TIE/TRE Requirements


8. Chemical Additions
No chemicals are to be added that have the potential to be present in the permitted discharge, including, but not limited to, chemical additions at any point in the treatment process, unless the Division grants permission for the use of the specific chemical(s). The permit applicant must submit a list of proposed chemicals, including dosage rates, used in the treatment process. Additionally, a MSDS for each chemical proposed for use must be provided. In granting the use of such chemicals, additional limitations and monitoring requirements may be imposed.

Chemicals used in waters that will or may be discharged to waters of the State must be used in accordance with all state and federal regulations, and in strict accordance with the manufacturer’s site-specific instructions.

9. Discharge Point
All waters shall be discharged in a manner to prevent erosion, scouring, or damage to stream banks, streambeds, or ditches.

10. Discharges to Conveyances
All dischargers must comply with the lawful requirements of counties; drainage districts and other state or local agencies regarding any discharges to storm drain systems or other watercourses under their jurisdiction.

11. Mixing Zone
For this general permit, all numeric effluent limitations are assigned as end of pipe limits based on the Water Quality Standards. Dilution (i.e. mixing zone) considerations are not applicable in this permit. Dischargers who want consideration of a mixing allowance should apply for an individual permit.

12. Discharges to Waters with Total Maximum Daily Loads (TMDLs)
Discharges to State waters for which an approved or established TMDL has been developed may be authorized provided there are sufficient remaining wasteload allocations in the approved or established TMDL. If sufficient remaining wasteload allocations are not available, coverage under an Individual permit may be required. Additional effluent limitations or other terms and conditions may be imposed for discharges to segments for which a TMDL has been completed. The determination whether compliance with numeric effluent limitations will be required will be made on case-by-case basis. Factors that will be taken into consideration when making this determination include the plausibility that the pollutant for which the TMDL was developed will be in the discharge, and duration and frequency of the discharge.
13. **Discharges to 303(d) Listed Waters**

Sampling, monitoring and compliance with numeric effluent limitations may be required for discharges to 303(d) listed waters that are impaired for the specified pollutant(s). The determination whether compliance with the numeric effluent limitation will be required will be made on case-by-case basis. Factors that will be taken into consideration when making this determination include the plausibility that the pollutant listed on the 303(d) list will be in the discharge, and duration and frequency of the discharge.

**D. DEFINITIONS OF TERMS**

1. "**Acute Toxicity**" - The acute toxicity limitation is exceeded if the LC50 is at any effluent concentration less than or equal to the IWC indicated in this permit.

2. "**Antidegradation (AD)**" means waters designated as reviewable (or undesignated water) must be maintained and protected at their existing water quality unless a determination is made that degrading water quality is necessary. These waters have water quality that is, in general, better than the water quality standards and is to be maintained and protected. The AD review applies only to activities with new or increased water quality impacts. Additional AD information can be found in Section 31.8 of [The Basic Standards and Methodologies for Surface Water](#).

3. "**Chronic toxicity**", which includes lethality and growth or reproduction, occurs when the NOEC and IC25 are at an effluent concentration less than the IWC indicated in this permit.

4. "**Composite**" sample is a minimum of four (4) grab samples collected at equally spaced two (2) hour intervals and proportioned according to flow. For intermittent discharges or discharges lasting less than 8 hours, a composite sample is defined as sampling three (3) equal aliquots during the beginning, middle and end of the discharge period.

5. "**Continuous**" measurement is a measurement obtained from an automatic recording device which continually provides measurements.

6. "**Daily Maximum limitation**" for all parameters except temperature, means the limitation for this parameter shall be applied as an instantaneous maximum (or, for pH or DO, instantaneous minimum) value. The instantaneous value is defined as the analytical result of any individual sample. DMRs shall include the maximum (and/or minimum) of all instantaneous values within the calendar month. Any instantaneous value beyond the noted daily maximum limitation for the indicated parameter shall be considered a violation of this permit.

7. "**Daily Maximum Temperature (DM)**" is defined in the Basic Standards and Methodologies for Surface Water 1002-31, as the highest two-hour average water temperature recorded during a given 24-hour period. This will be determined using a rolling 2-hour maximum temperature. If data is collected every 15 minutes, a 2 hour maximum can be determined on every data point after the initial 2 hours of collection. Note that the time periods that overlap days (Wednesday night to Thursday morning) do not matter as the reported value on the DMR is the greatest of all the 2-hour averages.

For example data points collected at:
08:15, 08:30, 08:45, 09:00, 09:15, 09:30, 09:45, 10:00, would be averaged for a single 2 hour average data point
08:30, 08:45, 09:00, 09:15, 09:30, 09:45, 10:00, 10:15, would be averaged for a single 2 hour average data point
08:45, 09:00, 09:15, 09:30, 09:45, 10:00, 10:15, 10:30, would be averaged for a single 2 hour average data point
This would continue throughout the course of a calendar day. The highest of these 2 hour averages over a month would be reported on the DMR as the daily maximum temperature. At the end/beginning of a month, the collected data should be used for the month that contains the greatest number of minutes in the 2-hour maximum.

Data from 11 pm to 12:59 am, would fall in the previous day. Data collected from 11:01 pm to 1:00 am would fall in the new month.

8. "Dissolved (D) metals fraction" is defined in the Basic Standards and Methodologies for Surface Water 1002-31, as that portion of a water and suspended sediment sample which passed through a 0.40 or 0.45 UM (micron) membrane filter. Determinations of "dissolved" constituents are made using the filtrate. This may include some very small (colloidal) suspended particles which passed through the membrane filter as well as the amount of substance present in true chemical solution.

9. "Geometric mean" for E. coli bacteria concentrations, the thirty (30) day and seven (7) day averages shall be determined as the geometric mean of all samples collected in a thirty (30) day period and the geometric mean of all samples taken in a seven (7) consecutive day period respectively. The geometric mean may be calculated using two different methods. For the methods shown, a, b, c, d, etc. are individual sample results, and n is the total number of samples.

**Method 1:**

\[
\text{Geometric Mean} = \left(\frac{1}{n}\right) \left( \text{a} \times \text{b} \times \text{c} \times \text{d} \times \ldots \right) \]

"*" - means multiply

**Method 2:**

\[
\text{Geometric Mean} = \text{antilog} \left( \frac{\log(a)+\log(b)+\log(c)+\log(d)+\ldots}{n} \right)
\]

Graphical methods, even though they may also employ the use of logarithms, may introduce significant error and may not be used.

In calculating the geometric mean, for those individual sample results that are reported by the analytical laboratory to be "less than" a numeric value, a value of 1 should be used in the calculations. If all individual analytical results for the month are reported to be less than numeric values, then report "less than" the largest of those numeric values on the monthly DMR. Otherwise, report the calculated value.

For any individual analytical result of "too numerous to count" (TNTC), that analysis shall be considered to be invalid and another sample shall be promptly collected for analysis. If another sample cannot be collected within the same sampling period for which the invalid sample was collected (during the same month if monthly sampling is required, during the same week if weekly sampling is required, etc.), then the following procedures apply:

i. A minimum of two samples shall be collected for coliform analysis within the next sampling period.

ii. **If the sampling frequency is monthly or less frequent:** For the period with the invalid sample results, leave the spaces on the corresponding DMR for reporting coliform results empty and attach to the DMR a letter noting that a result of TNTC was obtained for that period, and explain why another sample for that period had not been collected.
If the sampling frequency is more frequent than monthly: Eliminate the result of TNTC from any further calculations, and use all the other results obtained within that month for reporting purposes. Attach a letter noting that a result of TNTC was obtained, and list all individual analytical results and corresponding sampling dates for that month.

10. "Grab" sample, is a single "dip and take" sample so as to be representative of the parameter being monitored.

11. "In-situ" measurement is defined as a single reading, observation or measurement taken in the field at the point of discharge.

12. "Instantaneous" measurement is a single reading, observation, or measurement performed on site using existing monitoring facilities.

13. To be considered an “Intermittent Discharge” one of the following must apply:
   A) the maximum discharge frequency is less than 3 consecutive days (72 hours), and less than 3 days per 7 day period, and less than 10 days total per month
   B) the maximum discharge frequency is less than 5 consecutive days (120 hours) and less than 5 total days per month
   C) It can be shown that discharge frequency and duration is tied solely to precipitation events, where the discharge starts and stops shortly after the precipitation event starts/stops.

14. "Material handling activities" include: storage, loading and unloading of any raw material, intermediate product, finished product, by-product, or waste product where such products could come in contact with precipitation.

15. "Maximum Weekly Average Temperature (MWAT)" is defined in the Basic Standards and Methodologies for Surface Water 1002-31, as an implementation statistic that is calculated from field monitoring data. The MWAT is calculated as the largest mathematical mean of multiple, equally spaced, daily temperatures over a seven-day consecutive period, with a minimum of three data points spaced equally through the day. For lakes and reservoirs, the MWAT is assumed to be equivalent to the maximum WAT from at least three profiles distributed throughout the growing season (generally July-September).

The MWAT is calculated by averaging all temperature data points collected during a calendar day, and then averaging the daily average temperatures for 7 consecutive days. This 7 day averaging period is a rolling average, i.e. on the 8th day, the MWAT will be the averages of the daily averages of days 2-8. The value to be reported on the DMR is the highest of all the rolling 7-day averages throughout the month. For those days that are at the end/beginning of the month, the data shall be reported for the month that contains 4 of the 7 days.

Day 1: Average of all temperature data collected during the calendar day.
Day 2: Average of all temperature data collected during the calendar day.
Day 3: Average of all temperature data collected during the calendar day.
Day 4: Average of all temperature data collected during the calendar day.
Day 5: Average of all temperature data collected during the calendar day.
Day 6: Average of all temperature data collected during the calendar day.
Day 7: Average of all temperature data collected during the calendar day.

1st MWAT Calculation as average of previous 7 days
Day 8: Average of all temperature data collected during the calendar day.
2nd MWAT Calculation as average of previous 7 days
Day 9: Average of all temperature data collected during the calendar day.
3rd MWAT Calculation as average of previous 7 days
16. "Metals Screen" means an analysis using an EPA approved method found in 40 CFR Part 136, and with an analyte list which includes all metals found in the Influent Screening Requirements found in Part III of the permit. The metals analyses must be performed for the extraction (Total Recoverable, Potentially Dissolved, Dissolved form) identified in Part III of the permit.

17. "Potentially dissolved (PD) metals fraction" is defined in the Basic Standards and Methodologies for Surface Water 1002-31, as that portion of a constituent measured from the filtrate of a water and suspended sediment sample that was first treated with nitric acid to a pH of 2 or less and let stand for 8 to 96 hours prior to sample filtration using a 0.40 or 0.45-UM (micron) membrane filter. Note the "potentially dissolved" method cannot be used where nitric acid will interfere with the analytical procedure used for the constituent measured.

18. "Practical Quantitation Limit (PQL)" means the minimum concentration of an analyte (substance) that can be measured with a high degree of confidence that the analyte is present at or above that concentration. The use of PQL in this document may refer to those PQLs shown in Part I.D of this permit or the PQLs of an individual laboratory.

19. "Quarterly measurement frequency" means samples may be collected at any time during the calendar quarter if a continual discharge occurs. If the discharge is intermittent, then samples shall be collected anytime during the quarter that the discharge occurs. Calendar quarters are defined as January-March, April-June, July-September, and October-December.

20. "Recorder" requires the continuous operation of a chart and/or totalizer (or drinking water rotor meters or pump hour meters where previously approved.)

21. "Semi-Volatile Organic Screen" means an analysis using an EPA approved method found in 40 CFR part 136, and with an analyte list which includes the base, neutral, acid, dioxane organic compounds listed in the Influent Screening Requirements found in Part III of the permit. Pesticides, herbicides, and PCBs do not need to be included in this analysis.

22. "Seven (7) day average" means, with the exception of fecal coliform or E. coli bacteria (see geometric mean), the arithmetic mean of all samples collected in a seven (7) consecutive day period. Such seven (7) day averages shall be calculated for all calendar weeks, which are defined as beginning on Sunday and ending on Saturday. If the calendar week overlaps two months (i.e. the Sunday is in one month and the Saturday in the following month), the seven (7) day average calculated for that calendar week shall be associated with the month that contains the Saturday. Samples may not be used for more than one (1) reporting period. (See the “Analytical and Sampling Methods for Monitoring and Reporting Section in Part I.E.3 for guidance on calculating averages and reporting analytical results that are less than the PQL)."

23. "Significant materials" include but are not limited to: raw materials; fuels; materials such as metallic products; hazardous substances designated under section 101(14) of CERCLA; any chemical the facility is required to report pursuant to section 313 of SARA III; fertilizers; pesticides; and waste products such as ashes, slag and sludge that have the potential to be released with stormwater discharge.

24. "State Waters" means any and all surface or subsurface waters which are contained in or flow in or through this state, but does not include waters in sewage systems, waters in treatment works of disposal systems, waters in potable water distribution systems, and all water withdrawn for use until use and treatment have been completed.

25. "State Surface Waters" means all surface waters that meet the definition of “State Waters,” including ground
water that is hydrologically connected to surface water.

26. "Thirty (30) day average" means, except for fecal coliform or E. coli bacteria (see geometric mean), the arithmetic mean of all samples collected during a thirty (30) consecutive-day period. The permittee shall report the appropriate mean of all self-monitoring sample data collected during the calendar month on the Discharge Monitoring Reports. Samples shall not be used for more than one (1) reporting period. (See the “Analytical and Sampling Methods for Monitoring and Reporting Section in Part I.E.3 for guidance on calculating averages and reporting analytical results that are less than the PQL).

27. "Total Metals" means the concentration of metals determined on an unfiltered sample following vigorous digestion (Section 4.1.3), or the sum of the concentrations of metals in both the dissolved and suspended fractions, as described in Manual of Methods for Chemical Analysis of Water and Wastes, U.S. Environmental Protection Agency, March 1979, or its equivalent.

28. "Total Recoverable Metals" means that portion of a water and suspended sediment sample measured by the total recoverable analytical procedure described in Methods for Chemical Analysis of Water and Wastes, U.S. Environmental Protection Agency, March 1979 or its equivalent.

29. "Twenty four (24) hour composite" sample is a combination of at least eight (8) sample aliquots of at least 100 milliliters, collected at equally spaced intervals during the operating hours of a facility over a twenty-four (24) hour period. For volatile pollutants, aliquots must be combined in the laboratory immediately before analysis. The composite must be flow proportional; either the time interval between each aliquot or the volume of each aliquot must be proportional to either the wastewater or effluent flow at the time of sampling or the total wastewater or effluent flow since the collection of the previous aliquot. Aliquots may be collected manually or automatically.

30. "Twice Monthly" monitoring frequency means that two samples shall be collected each calendar month on separate weeks with at least one full week between the two sample dates. Also, there shall be at least one full week between the second sample of a month and the first sample of the following month.

31. "Visual" observation is observing the discharge to check for the presence of a visible sheen or floating oil.

32. "Volatile Organic Compound Screen" means an analysis using an EPA approved method found in 40 CFR part 136, and with an analyte list which includes the volatile organic compounds listed in the Influent Screening Requirements found in Part III of the permit.

33. "Water Quality Control Division" or "Division" means the state Water Quality Control Division as established in 25-8-101 et al.)

34. "Weekly measurement frequency" means samples may be collected at any time during the week as defined as beginning on Sunday and ending on Saturday. If the discharge is intermittent, a sample must be collected for each week (as defined above) that the discharge occurs. A minimum of one sample must be collected for discharges lasting less than one week. For example, if an intermittent discharge begins on Wednesday, February 2nd and ends on Friday, February 4th, one sample must collected on the 2nd, 3rd, or 4th. If the discharge resumes on Sunday, February 13 and is intermittent through Monday, February 14th an additional sample must be collected on the 13th or the 14th.
E. GENERAL MONITORING, SAMPLING AND REPORTING REQUIREMENTS

1. **Routine Reporting of Data**
   Reporting of data gathered in compliance with Part I.B.2 shall be on a **monthly** basis. Reporting of all data gathered shall comply with the requirements of Part I.E. (General Requirements). Monitoring results shall be summarized for each calendar month and reported on Division approved discharge monitoring report (DMR) forms (EPA form 3320-1).
   The permittee must submit these forms either by mail, or by using the Division’s Net-DMR services (when available). DMRs must be received by the Division no later than the 28th day of the month following the monitoring period (for example, the DMR for the first calendar quarter must be received by the Division by April 28th). If no discharge occurs during the reporting period, "No Discharge" shall be reported on the DMR.

   If being mailed, the original signed copy of each discharge monitoring report (DMR) shall be submitted to the Division at the following address:

   Colorado Department of Public Health and Environment
   Water Quality Control Division
   WQCD-P-B2
   4300 Cherry Creek Drive South
   Denver, Colorado 80246-1530

   The Discharge Monitoring Report forms shall be filled out accurately and completely in accordance with requirements of this permit and the instructions on the forms. They shall be signed by an authorized person as identified in Part I.E.7.

2. **Representative Sampling**
   Discharge points shall be designed or modified so that a sample of the effluent can be obtained at a point after the final treatment process and prior to discharge to state waters. Samples and measurements taken as required herein shall be representative of the volume and nature of the monitored discharge. All samples shall be taken at the monitoring points specified in this permit and, unless otherwise specified, before the effluent joins or is diluted by any other wastestream, body of water, or substance. Monitoring points shall not be changed without notification to and approval by the Division. The permittee shall provide access to the Division to sample the discharge at these points.

3. **Analytical and Sampling Methods for Monitoring and Reporting**
   The permittee shall install, calibrate, use and maintain monitoring methods and equipment, including biological and indicated pollutant monitoring methods. All sampling shall be performed by the permittee according to specified methods in 40 C.F.R. Part 136; methods approved by EPA pursuant to 40 C.F.R. Part 136; or methods approved by the Division, in the absence of a method specified in or approved pursuant to 40 C.F.R. Part 136 (see text below for specifics on nonylphenol monitoring).

   If the permit contains a numeric effluent limit for a parameter, the analytical method and PQL selected for all monitoring conducted in accordance with this permit for that parameter shall be the one that can measure at or below the numeric effluent limit. If all specified analytical methods and corresponding PQLs are greater than the numeric effluent limit, then the analytical method with the lowest PQL shall be used.
If the permit contains a report only requirement for a parameter, the analytical method and PQL chosen shall be one that can measure at or below the potential numeric effluent limit(s). If all analytical methods and corresponding PQLs are greater than the potential numeric effluent limit(s), then the analytical method with the lowest PQL shall be used.

If the permit contains an interim effluent limitation (a limit is report until such time as a numeric effluent limit becomes effective) for a parameter, the analytical method and PQL chosen for all monitoring conducted in accordance with this permit for the parameter shall be one that can measure to the final numeric effluent limit. If all analytical methods and corresponding PQLs are greater than the final numeric effluent limit(s), then the analytical method with the lowest PQL shall be used.

For parameters such as TIN, the analytical methods chosen shall be those that can measure to the potential or final numeric effluent limit, based on the sum of the PQLs for nitrate, nitrite and ammonia.

When the analytical method which complies with the above requirements has a PQL greater than the permit limit, and the permittee’s analytical result is less than the PQL, the permittee shall report "BDL" on the DMR. Such reports will not be considered as violations of the permit limit, as long as the lowest available PQL is used for the analysis. When the analytical method which complies with the above requirements has a PQL that is equal to or less than the permit limitation, and the permittee’s analytical result is less than the PQL, “< X” (where X = the actual PQL achieved by the laboratory) shall be reported on the DMR. For parameters that have a report only limitation, and the permittee’s analytical result is less than the PQL, “< X” (where X = the actual PQL achieved by the laboratory) shall be reported on the DMR.

In the calculation of average concentrations (i.e. 7-day average, 30-day average, 2-year rolling average) any individual analytical result that is less than the PQL shall be considered to be zero for the calculation purposes. When reporting:

If all individual analytical results are less than the PQL, the permittee shall report either “BDL” or “<X” (where X = the actual PQL achieved by the laboratory), following the guidance above.

If one or more individual results is greater than the PQL, an average shall be calculated and reported. Note that it does not matter if the final calculated average is greater or less than the PQL, it must be reported as a value.

Note that when calculating T.I.N. for a single sampling event, any value less than the PQL (for total ammonia, total nitrite, or total nitrate) shall be treated as zero. The T.I.N. concentration for a single sampling event shall then be determined as the sum of the analytical results (zeros if applicable) of same day sampling for total ammonia and total nitrite and total nitrate. From these calculated T.I.N. concentrations, the daily maximum and thirty day average concentrations shall be calculated and must be reported as a value.

The present lowest PQLs for specific parameters, as determined by the State Laboratory (November 2008) are provided below. If the analytical method cannot achieve a PQL that is less than or equal to the permit limit, then the method, or a more precise method, must achieve a PQL that is less than or equal to the PQL in the table below. A listing of the PQLs for organic parameters that must meet the above requirement can be found in the Division’s Practical Quantitation Limitation Guidance Document, July 2008.

For nonylphenol, until such time as there is an EPA 40 CFR Part 136 method, the State is approving use of ASTM Methods D7065 and D7485. Until a statewide PQL has been developed, the permittee shall use either the default PQLs listed in the table below, or develop their own site-specific PQL in accordance with the Practical Quantitation Limitation Guidance Document (July 2008) for Organic Parameters. This document is available on the Division’s website at www.coloradowaterpermits.com. The delayed effective date for the monitoring requirement allows time for the permittee to develop a site-specific PQL.

For hexavalent chromium, samples must be unacidified so dissolved concentrations will be measured rather than potentially dissolved concentrations.
### Records

The permittee shall establish and maintain records. The records shall include the following:

a. The date, type, exact location, and time of sampling or measurements;
b. The individual(s) who performed the sampling or measurements;
c. The date(s) the analyses were performed;
d. The individual(s) who performed the analyses;
e. The analytical techniques or methods used;
f. The results of such analyses; and

g. Any other observations which may result in an impact on the quality or quantity of the discharge as indicated in 40 CFR 122.44 (i)(1)(iii).

The permittee shall retain for the duration of permit coverage or a minimum of three (3) years (whichever is greater) records of all monitoring information, including all original strip chart recordings for continuous monitoring instrumentation, all calibration and maintenance records, laboratory data sheets, copies of all reports required by this permit and records of all data used to complete the application for this permit. This period of retention shall be extended during the course of any unresolved litigation regarding the discharge of pollutants by the permittee or when requested by the Division or EPA. These records must be retained at the facility during
active treatment. Once active treatment is complete, the records shall be maintained and made available at the request of the Division.

5. **Additional Monitoring by Permittee**
   If the permittee, using the approved analytical methods, monitors any parameter more frequently than required by this permit, then the results of such monitoring shall be included in the calculation and reporting of the values required in the Discharge Monitoring Report Form or other forms as required by the Division. Such increased frequency shall also be indicated.

6. **Flow Measuring Device**
   If not already a part of the permitted facility, within ninety (90) days after the effective date of the permit, a flow measuring device shall be installed to give representative values of effluent quantities at the respective discharge point(s). Unless specifically exempted, or modified in the permit certification, a flow measuring device will be applicable at all designated discharge points.

   At the request of the Division, the permittee shall show proof of the accuracy of any flow-measuring device used in obtaining data submitted in the monitoring report. The flow-measuring device must indicate values within ten (10) percent of the actual flow being discharged from the facility.

7. **Signatory and Certification Requirements**
   a. All applications must be signed and certified for accuracy as follows:
      
      (i) In the case of corporations, by a responsible corporate officer. For purposes of this section, the responsible corporate officer is responsible for the overall operation of the facility from which the discharge described in the form originates;

      (ii) In the case of a partnership, by a general partner;

      (iii) In the case of a sole proprietorship, by the proprietor;

      (iv) In the case of a municipal, state, or other public facility, by either a principal executive officer or ranking elected official. For purposes of this section, a principal executive officer has responsibility for the overall operation of the facility from which the discharge originates.

   b. All reports and other information required by the Division, shall be signed and certified for accuracy by the permittee in accord with the following criteria:

      i) In the case of corporations, by a responsible corporate officer. For purposes of this section, the responsible corporate officer is responsible for the overall operation of the facility from which the discharge described in the form originates;

      ii) In the case of a partnership, by a general partner;

      iii) In the case of a sole proprietorship, by the proprietor;

      iv) In the case of a municipal, state, or other public facility, by either a principal executive officer, or ranking elected official. For purposes of this section, a principal executive officer has responsibility for the overall operation of the facility from which the discharge originates;

      v) By a duly authorized representative of a person described above, only if:
1) The authorization is made in writing by a person described in i, ii, iii, or iv above;

2) The authorization specifies either an individual or a position having responsibility for the overall operation of the regulated facility or activity such as the position of plant manager, operator of a well or a well field, superintendent, position of equivalent responsibility, or an individual or position having overall responsibility for environmental matters for the company. (A duly authorized representative may thus be either a named individual or any individual occupying a named position); and,

3) The written authorization is submitted to the Division.

c. If an authorization as described in this section is no longer accurate because a different individual or position has responsibility for the overall operation of the facility, a new authorization satisfying the requirements of this section must be submitted to the Division prior to or together with any reports, information, or applications to be signed by an authorized representative.

The permittee, or the duly authorized representative shall make and sign the following certification on all such documents:

"I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is to the best of my knowledge and belief, true, accurate and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations."

PART II

A. NOTIFICATION REQUIREMENTS

1. Notification to Parties
   All notification requirements under this section shall be directed as follows:

   a. Oral Notifications, during normal business hours shall be to:

      Water Quality Protection Section - Industrial Compliance Program
      Water Quality Control Division
      Telephone: (303) 692-3500

   b. Written notification shall be to:

      Water Quality Protection Section - Industrial Compliance Program
      Water Quality Control Division
      Colorado Department of Public Health and Environment
      WQCD-WQP-B2
      4300 Cherry Creek Drive South
      Denver, CO 80246-1530
2. **Change in Discharge or Wastewater Treatment**  
The permittee shall notify the Division in writing, of any planned physical alterations or additions to the permitted facility, to include the treatment process. Notice is required when:

a. The alteration or addition is likely to result in a new or altered discharge either in terms of location or effluent quality prior to the occurrence of the new or altered discharge, or;

b. The alteration or addition results in a significant change in the permittee's sludge use or disposal practices, and such alteration, addition, or change may justify the application of permit conditions that are different from or absent in the existing permit, including notification of additional use or disposal sites not reported pursuant to an approved land application plan.

The permittee shall give advance notice to the Division of any planned changes in the permitted facility or activity which may result in noncompliance with permit requirements. For any pollutant for which monitoring requirements are not included in the permit certification, the permittee shall notify the Division as soon as it becomes aware that the pollutant(s) are present in the source water, influent, or effluent in concentrations greater than originally identified in the application.

Whenever notification of any planned physical alterations or additions to the permitted facility is required pursuant to this section, the permittee shall furnish the Division such plans and specifications which the Division deems reasonably necessary to evaluate the effect on the discharge, the stream, or ground water.

If the Division finds that such new or altered discharge might be inconsistent with the conditions of the permit, the Division shall require a new or revised permit application and shall follow the procedures specified in Sections 61.5 through 61.6, and 61.15 of the Colorado Discharge Permit System Regulations.

3. **Special Notifications - Definitions**

a. **Bypass:** The intentional diversion of waste streams from any portion of a treatment facility.

b. **Severe Property Damage:** Substantial physical damage to property at the treatment facilities which causes them to become inoperable, or substantial and permanent loss of natural resources which can reasonably be expected to occur in the absence of a bypass. It does not mean economic loss caused by delays in production.

c. **Upset:** An exceptional incident in which there is unintentional and temporary noncompliance with permit effluent limitations because of factors beyond the reasonable control of the permittee. An upset does not include noncompliance to the extent caused by operational error, improperly designed treatment facilities, inadequate treatment facilities, lack of preventative maintenance, or careless or improper operation.

4. **Noncompliance Notification**

a. If, for any reason, the permittee does not comply with or will be unable to comply with any discharge limitations or standards specified in this permit, the permittee shall, at a minimum, provide the Division and EPA with the following information:

i) A description of the discharge and cause of noncompliance;

ii) The period of noncompliance, including exact dates and times and/or the anticipated time when the discharge will return to compliance; and

iii) Steps being taken to reduce, eliminate, and prevent recurrence of the noncomplying discharge.
PART III

b. The permittee shall report the following circumstances **orally within twenty-four (24) hours** from the time the permittee becomes aware of the circumstances, and shall mail to the Division a written report containing the information requested in Part II.A.4 (a) **within five (5) days** after becoming aware of the following circumstances:

i) Circumstances leading to any noncompliance which may endanger health or the environment regardless of the cause of the incident;

ii) Circumstances leading to any unanticipated bypass which exceeds any effluent limitations in the permit;

iii) Circumstances leading to any upset which causes an exceedance of any effluent limitation in the permit;

iv) Daily maximum violations for any of the pollutants limited by Part I.A of this permit and specified as requiring 24-hour notification. This includes any toxic pollutant or hazardous substance or any pollutant specifically identified as the method to control any toxic pollutant or hazardous substance.

c. Unless otherwise indicated in this permit, the permittee shall report instances of non-compliance which are not required to be reported within 24-hours at the time Discharge Monitoring Reports are submitted. The reports shall contain the information listed in sub-paragraph (a) of this section.

5. **Other Notification Requirements**

Reports of compliance or noncompliance with, or any progress reports on, interim and final requirements contained in any compliance schedule in the permit shall be submitted no later than fourteen (14) days following each scheduled date, unless otherwise provided by the Division.

The permittee shall notify the Division, in writing, thirty (30) days in advance of a proposed transfer of permit as provided in Part II.B.3.

The permittee's notification of all anticipated noncompliance does not stay any permit condition.

All existing manufacturing, commercial, mining, and silvicultural dischargers must notify the Division as soon as they know or have reason to believe:

a. That any activity has occurred or will occur which would result in the discharge, on a routine or frequent basis, of any toxic pollutant which is not limited in the permit, if that discharge will exceed the highest of the following "notification levels":

i) One hundred micrograms per liter (100 µg/l);

ii) Two hundred micrograms per liter (200 µg/l) for acrolein and acrylonitrile; five hundred micrograms per liter (500 µg/l) for 2.4-dinitrophenol and 2-methyl-4.6-dinitrophenol; and one milligram per liter (1.0 mg/l) for antimony;

iii) Five (5) times the maximum concentration value reported for that pollutant in the permit application in accordance with Section 61.4(2)(g).
iv) The level established by the Division in accordance with 40 C.F.R. § 122.44(f).

b. That any activity has occurred or will occur which would result in any discharge, on a non-routine or infrequent basis, of a toxic pollutant which is not limited in the permit, if that discharge will exceed the highest of the following "notification levels":

i) Five hundred micrograms per liter (500 µg/l);

ii) One milligram per liter (1 mg/l) for antimony; and

iii) Ten (10) times the maximum concentration value reported for that pollutant in the permit application.

iv) The level established by the Division in accordance with 40 C.F.R. § 122.44(f).

6. **Bypass Notification**
   If the permittee knows in advance of the need for a bypass, a notice shall be submitted, at least ten days before the date of the bypass, to the Division. The bypass shall be subject to Division approval and limitations imposed by the Division. Violations of requirements imposed by the Division will constitute a violation of this permit.

7. **Upsets**
   a. **Effect of an Upset**
      An upset constitutes an affirmative defense to an action brought for noncompliance with permit effluent limitations if the requirements of paragraph (b) of this section are met. No determination made during administrative review of claims that noncompliance was caused by upset, and before an action for noncompliance, is final administrative action subject to judicial review.

   b. **Conditions Necessary for a Demonstration of Upset**
      A permittee who wishes to establish the affirmative defense of upset shall demonstrate through properly signed contemporaneous operating logs, or other relevant evidence that:

      i) An upset occurred and that the permittee can identify the specific cause(s) of the upset; and

      ii) The permitted facility was at the time being properly operated and maintained; and

      iii) The permittee submitted proper notice of the upset as required in Part II.A.4. of this permit (24-hour notice); and

      iv) The permittee complied with any remedial measure necessary to minimize or prevent any discharge or sludge use or disposal in violation of this permit which has a reasonable likelihood of adversely affecting human health or the environment.

      In addition to the demonstration required above, a permittee who wishes to establish the affirmative defense of upset for a violation of effluent limitations based upon water quality standards shall also demonstrate through monitoring, modeling or other methods that the relevant standards were achieved in the receiving water.

   c. **Burden of Proof**
      In any enforcement proceeding, the permittee seeking to establish the occurrence of an upset has the burden of proof.
8. **Discharge Point**
   Any discharge to the waters of the State from a point source other than specifically authorized by this permit is prohibited.

9. **Proper Operation and Maintenance**
   The permittee shall at all times properly operate and maintain all facilities and systems of treatment and control (and related appurtenances) which are installed or used by the permittee as necessary to achieve compliance with the conditions of this permit. Proper operation and maintenance includes effective performance and adequate laboratory and process controls, including appropriate quality assurance procedures (40 CFR 122.41(e)). This provision requires the operation of back-up or auxiliary facilities or similar systems which are installed by the permittee only when necessary to achieve compliance with the conditions of the permit.

10. **Minimization of Adverse Impact**
   The permittee shall take all reasonable steps to minimize or prevent any discharge of sludge use or disposal in violation of this permit which has a reasonable likelihood of adversely affecting human health or the environment. As necessary, accelerated or additional monitoring to determine the nature and impact of the noncomplying discharge is required.

11. **Removed Substances**
   Solids, sludges, or other pollutants removed in the course of treatment or control of wastewaters shall be disposed of in accordance with applicable state and federal regulations and in a manner that will prevent the removed pollutant(s) from entering waters of the State.

   For all domestic wastewater treatment works, at industrial facilities, the permittee shall dispose of sludge in accordance with all State and Federal regulations.

12. **Submission of Incorrect or Incomplete Information**
   Where the permittee failed to submit any relevant facts in a permit application, or submitted incorrect information in a permit application or report to the Division, the permittee shall promptly submit the relevant information which was not submitted or any additional information needed to correct any erroneous information previously submitted.

13. **Bypass**
   a. Bypasses are prohibited and the Division may take enforcement action against the permittee for bypass, unless:

      i) The bypass is unavoidable to prevent loss of life, personal injury, or severe property damage;

      ii) There were no feasible alternatives to bypass such as the use of auxiliary treatment facilities, retention of untreated wastes, or maintenance during normal periods of equipment downtime. This condition is not satisfied if adequate back-up equipment should have been installed in the exercise of reasonable engineering judgment to prevent a bypass which occurred during normal periods of equipment downtime or preventive maintenance; and

      iii) Proper notices were submitted in compliance with Part II.A.4.

   b. "Severe property damage" as used in this Subsection means substantial physical damage to the treatment facilities which causes them to become inoperable, or substantial and permanent loss of natural resources
which can reasonably be expected to occur in the absence of a bypass. Severe property damage does not mean economic loss caused by delays in production.

c. The permittee may allow a bypass to occur which does not cause effluent limitations to be exceeded, but only if it also is for essential maintenance or to assure optimal operation. These bypasses are not subject to the provisions of paragraph (a) above.

d. The Division may approve an anticipated bypass, after considering adverse effects, if the Division determines that the bypass will meet the conditions specified in paragraph (a) above.

14. Reduction, Loss, or Failure of Treatment Facility
The permittee has the duty to halt or reduce any activity if necessary to maintain compliance with the effluent limitations of the permit. Upon reduction, loss, or failure of the treatment facility, the permittee shall, to the extent necessary to maintain compliance with its permit, control production, control sources of wastewater, or all discharges, until the facility is restored or an alternative method of treatment is provided. This provision also applies to power failures, unless an alternative power source sufficient to operate the wastewater control facilities is provided.

It shall not be a defense for a permittee in an enforcement action that it would be necessary to halt or reduce the permitted activity in order to maintain compliance with the conditions of this permit.
B. RESPONSIBILITIES

1. **Inspections and Right to Entry**
   The permittee shall allow the Division and/or the authorized representative, upon the presentation of credentials:

   a. To enter upon the permittee's premises where a regulated facility or activity is located or in which any records are required to be kept under the terms and conditions of this permit;

   b. At reasonable times to have access to and copy any records required to be kept under the terms and conditions of this permit and to inspect any monitoring equipment or monitoring method required in the permit; and

   c. To enter upon the permittee's premises in a reasonable manner and at a reasonable time to inspect and/or investigate, any actual, suspected, or potential source of water pollution, or to ascertain compliance or non-compliance with the Colorado Water Quality Control Act or any other applicable state or federal statute or regulation or any order promulgated by the Division. The investigation may include, but is not limited to, the following: sampling of any discharge and/or process waters, the taking of photographs, interviewing of any person having knowledge related to the discharge permit or alleged violation, access to any and all facilities or areas within the permittee's premises that may have any affect on the discharge, permit, or alleged violation. Such entry is also authorized for the purpose of inspecting and copying records required to be kept concerning any effluent source.

   d. The permittee shall provide access to the Division to sample the discharge at a point after the final treatment process but prior to the discharge mixing with state waters upon presentation of proper credentials.

   In the making of such inspections, investigations, and determinations, the Division, insofar as practicable, may designate as its authorized representatives any qualified personnel of the Department of Agriculture. The Division may also request assistance from any other state or local agency or institution.

2. **Duty to Provide Information**
   The permittee shall furnish to the Division, within a reasonable time, any information which the Division may request to determine whether cause exists for modifying, revoking and reissuing, or terminating this permit, or to determine compliance with this permit. The permittee shall also furnish to the Division, upon request, copies of records required to be kept by this permit.

3. **Transfer of Ownership or Control**
   a. Except as provided in paragraph b. of this section, a permit may be transferred by a permittee only if the permit has been modified or revoked and reissued as provided in Section 61.8(8) of the Colorado Discharge Permit System Regulations, to identify the new permittee and to incorporate such other requirements as may be necessary under the Federal Act.

   b. A permit may be automatically transferred to a new permittee if:

      i) The current permittee notifies the Division in writing 30 days in advance of the proposed transfer date; and

      ii) The notice includes a written agreement between the existing and new permittee(s) containing a specific date for transfer of permit responsibility, coverage and liability between them; and
iii) The Division does not notify the existing permittee and the proposed new permittee of its intent to modify, or revoke and reissue the permit.

iv) Fee requirements of the Colorado Discharge Permit System Regulations, Section 61.15, have been met.

4. **Availability of Reports**

Except for data determined to be confidential under Section 308 of the Federal Clean Water Act and the Colorado Discharge Permit System Regulations 5 CCR 1002-61, Section 61.5(4), all reports prepared in accordance with the terms of this permit shall be available for public inspection at the offices of the Division and the Environmental Protection Agency.

The name and address of the permit applicant(s) and permittee(s), permit applications, permits and effluent data shall not be considered confidential. Knowingly making false statements on any such report may result in the imposition of criminal penalties as provided for in Section 309 of the Federal Clean Water Act, and Section 25-8-610 C.R.S.

5. **Modification, Suspension, Revocation, or Termination of Permits By the Division**

The filing of a request by the permittee for a permit modification, revocation and reissuance, termination or a notification of planned changes or anticipated noncompliance, does not stay any permit condition.

a. A permit may be modified, suspended, or terminated in whole or in part during its term for reasons determined by the Division including, but not limited to, the following:

i) Violation of any terms or conditions of the permit;

ii) Obtaining a permit by misrepresentation or failing to disclose any fact which is material to the granting or denial of a permit or to the establishment of terms or conditions of the permit; or

iii) Materially false or inaccurate statements or information in the permit application or the permit.

iv) A determination that the permitted activity endangers human health or the classified or existing uses of state waters and can only be regulated to acceptable levels by permit modifications or termination.

b. A permit may be modified in whole or in part for the following causes, provided that such modification complies with the provisions of Section 61.10 of the Colorado Discharge Permit System Regulations:

i) There are material and substantial alterations or additions to the permitted facility or activity which occurred after permit issuance which justify the application of permit conditions that are different or absent in the existing permit.

ii) The Division has received new information which was not available at the time of permit issuance (other than revised regulations, guidance, or test methods) and which would have justified the application of different permit conditions at the time of issuance. For permits issued to new sources or new dischargers, this cause includes information derived from effluent testing required under Section 61.4(7)(e) of the Colorado Discharge Permit System Regulations. This provision allows a modification of the permit to include conditions that are less stringent than the existing permit only to the extent allowed under Section 61.10 of the Colorado Discharge Permit System Regulations.
iii) The standards or regulations on which the permit was based have been changed by promulgation of amended standards or regulations or by judicial decision after the permit was issued. Permits may be modified during their terms for this cause only as follows:

(A) The permit condition requested to be modified was based on a promulgated effluent limitation guideline, EPA approved water quality standard, or an effluent limitation set forth in 5 CCR 1002-62, § 62 et seq.; and

(B) EPA has revised, withdrawn, or modified that portion of the regulation or effluent limitation guideline on which the permit condition was based, or has approved a Commission action with respect to the water quality standard or effluent limitation on which the permit condition was based; and

(C) The permittee requests modification after the notice of final action by which the EPA effluent limitation guideline, water quality standard, or effluent limitation is revised, withdrawn, or modified; or

(D) For judicial decisions, a court of competent jurisdiction has remanded and stayed EPA promulgated regulations or effluent limitation guidelines, if the remand and stay concern that portion of the regulations or guidelines on which the permit condition was based and a request is filed by the permittee in accordance with this Regulation, within ninety (90) days of judicial remand.

iv) The Division determines that good cause exists to modify a permit condition because of events over which the permittee has no control and for which there is no reasonable available remedy.

v) The permittee has received a variance.

vi) When required to incorporate applicable toxic effluent limitation or standards adopted pursuant to § 307(a) of the Federal act.

vii) When required by the reopener conditions in the permit.

viii) As necessary under 40 C.F.R. 403.8(e), to include a compliance schedule for the development of a pretreatment program.

ix) When the level of discharge of any pollutant which is not limited in the permit exceeds the level which can be achieved by the technology-based treatment requirements appropriate to the permittee under Section 61.8(2) of the Colorado Discharge Permit System Regulations.

x) To establish a pollutant notification level required in Section 61.8(5) of the Colorado Discharge Permit System Regulations.

xi) To correct technical mistakes, such as errors in calculation, or mistaken interpretations of law made in determining permit conditions, to the extent allowed in Section 61.10 of the Colorado State Discharge Permit System Regulations.

xii) When required by a permit condition to incorporate a land application plan for beneficial reuse of sewage sludge, to revise an existing land application plan, or to add a land application plan.

xiii) For any other cause provided in Section 61.10 of the Colorado Discharge Permit System Regulations.
c. At the request of a permittee, the Division may modify or terminate a permit and issue a new permit if the following conditions are met:

i) The Regional Administrator has been notified of the proposed modification or termination and does not object in writing within thirty (30) days of receipt of notification,

ii) The Division finds that the permittee has shown reasonable grounds consistent with the Federal and State statutes and regulations for such modifications or termination;

iii) Requirements of Section 61.15 of the Colorado Discharge Permit System Regulations have been met, and

iv) Requirements of public notice have been met.

d. Permit modification (except for minor modifications), termination or revocation and reissuance actions shall be subject to the requirements of Sections 61.5(2), 61.5(3), 61.6, 61.7 and 61.15 of the Colorado Discharge Permit System Regulations. The Division shall act on a permit modification request, other than minor modification requests, within 180 days of receipt thereof. Except for minor modifications, the terms of the existing permit govern and are enforceable until the newly issued permit is formally modified or revoked and reissued following public notice.

e. Upon consent by the permittee, the Division may make minor permit modifications without following the requirements of Sections 61.5(2), 61.5(3), 61.7, and 61.15 of the Colorado Discharge Permit System Regulations. Minor modifications to permits are limited to:

i) Correcting typographical errors; or

ii) Increasing the frequency of monitoring or reporting by the permittee; or

iii) Changing an interim date in a schedule of compliance, provided the new date of compliance is not more than 120 days after the date specific in the existing permit and does not interfere with attainment of the final compliance date requirement; or

iv) Allowing for a transfer in ownership or operational control of a facility where the Division determines that no other change in the permit is necessary, provided that a written agreement containing a specific date for transfer of permit responsibility, coverage and liability between the current and new permittees has been submitted to the Division; or

v) Changing the construction schedule for a discharger which is a new source, but no such change shall affect a discharger's obligation to have all pollution control equipment installed and in operation prior to discharge; or

vi) Deleting a point source outfall when the discharge from that outfall is terminated and does not result in discharge of pollutants from other outfalls except in accordance with permit limits.

f. When a permit is modified, only the conditions subject to modification are reopened. If a permit is revoked and reissued, the entire permit is reopened and subject to revision and the permit is reissued for a new term.
g. The filing of a request by the permittee for a permit modification, revocation and reissuance or termination does not stay any permit condition.

h. All permit modifications and reissuances are subject to the antibacksliding provisions set forth in 61.10(e) through (g).

6. **Oil and Hazardous Substance Liability**
   Nothing in this permit shall be construed to preclude the institution of any legal action or relieve the permittee from any responsibilities, liabilities, or penalties to which the permittee is or may be subject to under Section 311 (Oil and Hazardous Substance Liability) of the Clean Water Act.

7. **State Laws**
   Nothing in this permit shall be construed to preclude the institution of any legal action or relieve the permittee from any responsibilities, liabilities, or penalties established pursuant to any applicable State law or regulation under authority granted by Section 510 of the Clean Water Act. Nothing in this permit shall be construed to prevent or limit application of any emergency power of the division.

8. **Permit Violations**
   Failure to comply with any terms and/or conditions of this permit shall be a violation of this permit. The discharge of any pollutant identified in this permit more frequently than or at a level in excess of that authorized shall constitute a violation of the permit. Except as provided in Part I.E and Part II.A or B, nothing in this permit shall be construed to relieve the permittee from civil or criminal penalties for noncompliance (40 CFR 122.41(a)(1)).

9. **Property Rights**
   The issuance of this permit does not convey any property or water rights in either real or personal property, or stream flows, or any exclusive privileges, nor does it authorize any injury to private property or any invasion of personal rights, nor any infringement of Federal, State or local laws or regulations.

10. **Severability**
    The provisions of this permit are severable. If any provision of this permit, or the application of any provision of this permit to any circumstance, is held invalid, the application of such provision to other circumstances and the application of the remainder of this permit shall not be affected.

11. **Renewal Application**
    If the permittee desires to continue to discharge, a permit renewal application shall be submitted at least one hundred eighty (180) days before this permit expires. If the permittee anticipates there will be no discharge after the expiration date of this permit, the Division should be promptly notified so that it can terminate the permit in accordance with Part II.B.5.

12. **Confidentiality**
    Any information relating to any secret process, method of manufacture or production, or sales or marketing data which has been declared confidential by the permittee, and which may be acquired, ascertained, or discovered, whether in any sampling investigation, emergency investigation, or otherwise, shall not be publicly disclosed by any member, officer, or employee of the Commission or the Division, but shall be kept confidential. Any person seeking to invoke the protection of this Subsection (12) shall bear the burden of proving its applicability. This section shall never be interpreted as preventing full disclosure of effluent data.
13. Fees
The permittee is required to submit payment of an annual fee as set forth in the 2005 amendments to the Water Quality Control Act. Section 25-8-502 (l) (b), and the Colorado Discharge Permit System Regulations 5 CCR 1002-61, Section 61.15 as amended. Failure to submit the required fee when due and payable is a violation of the permit and will result in enforcement action pursuant to Section 25-8-601 et. seq., C.R.S. 1973 as amended.

14. Duration of Permit
The duration of a permit shall be for a fixed term and shall not exceed five (5) years. Filing of a timely and complete application shall cause the expired permit to continue in force to the effective date of the new permit. The permit's duration may be extended only through administrative extensions and not through interim modifications.

15. Section 307 Toxics
If a toxic effluent standard or prohibition, including any applicable schedule of compliance specified, is established by regulation pursuant to Section 307 of the Federal Act for a toxic pollutant which is present in the permittee's discharge and such standard or prohibition is more stringent than any limitation upon such pollutant in the discharge permit, the Division shall institute proceedings to modify or revoke and reissue the permit to conform to the toxic effluent standard or prohibition.

16. Effect of Permit Issuance
a. The issuance of a permit does not convey any property rights or any exclusive privilege.

b. The issuance of a permit does not authorize any injury to person or property or any invasion of personal rights, nor does it authorize the infringement of federal, state, or local laws or regulations.

c. Except for any toxic effluent standard or prohibition imposed under Section 307 of the Federal act or any standard for sewage sludge use or disposal under Section 405(d) of the Federal act, compliance with a permit during its term constitutes compliance, for purposes of enforcement, with Sections 301, 302, 306, 318, 403, and 405(a) and (b) of the Federal act. However, a permit may be modified, revoked and reissued, or terminated during its term for cause as set forth in Section 61.8(8) of the Colorado Discharge Permit System Regulations.

d. Compliance with a permit condition which implements a particular standard for sewage sludge use or disposal shall be an affirmative defense in any enforcement action brought for a violation of that standard for sewage sludge use or disposal.
PART III

PRIORITY POLLUTANTS AND HAZARDOUS SUBSTANCES
ORGANIC TOXIC POLLUTANTS IN EACH OF FOUR FRACTIONS IN ANALYSIS BY GAS CHROMATOGRAPHY/MASS SPECTROSCOPY (GC/MS)
(SEE TABLE II, OF 40 CFR 122 APPENDIX D)

Volatiles | Base/Neutral | Acid Compounds | Pesticides |
-----------|-------------|---------------|------------|
acrolein | acenaphthene | 2-chlorophenol | aldrin |
acrylonitrile | acenaphthylene | 2,4-dichlorophenol | alpha-BHC |
benzene | anthracene | 2,4-dimethylphenol | beta-BHC |
bromine | benzinine | 4,6-dinitro-o-cresol | gamma-BHC |
carbon tetrachloride | benzo(a)anthracene | 2,4-dinitrophenol | delta-BHC |
chlorobenzene | benzo(a)pyrene | 2-nitrophenol | chlorodane |
chlorodibromomethane | 3,4-benzofluoranthene | 4-nitrophenol | 4,4-DDT |
chloroethane | benzo(ghi)perylene | p-chloro-m-cresol | 4,4'-DDE |
2-chloroethylvinyl ether | benzo(k)fluoranthene | pentachlorophenol | phenol |
chloroform | bis(2-chloroethyl)methane | 2,4,6-trichlorophenol | dieldrin |
dichlorobromomethane | bis(2-chloroethyl)ether | ||
1,1-dichloroethane | bis(2-chloroisopropyl)ether | ||
1,2-dichloroethane | bis(2-ethylhexyl)phthalate | ||
1,1-dichloroethylene | 4-bromophenyl phenyl ether | ||
1,2-dichloropropane | butylbenzyl phthalate | ||
1,3-dichloropropylene | 2-chloronaphthalene | ||
ethylbenzene | 4-chlorophenyl phenyl ether | ||
methyl bromide | chrysene | ||
methyl chloride | dibenz(o,h)anthracene | ||
methylene chloride | 1,2-dichlorobenzene | ||
tetrachloroethylene | 1,4-dichlorobenzene | ||
toluene | 3,3-dichlorobenzidine | ||
1,2,2,2-tetrachloroethane | diethyl phthalate | ||
1,1,1-trichloroethane | dimethyl phthalate | ||
1,1,2-trichloroethane | di-n-butylnaphthalate | ||
trichloroethylene | 2,4-dinitrotoluene | ||
vinylic chloride | 2,6-dinitrotoluene | ||
  | di-n-octyl phthalate | ||
  | 1,2-diphenylhydrazine (as azobenzene) | ||
  | fluorene | ||
  | fluoranthene | ||
  | hexachlorobenzene | ||
  | hexachlorobutadiene | ||
  | hexachlorocyclopentadiene | ||
  | hexachloroethane | ||
  | indeno(1,2,3-cd)pyrene | ||
  | isophorone | ||
  | naphthalene | ||
  | nitrobenzene | ||
  | N-nitrosodimethylamine | ||
  | N-nitrosodi-n-propylamine | ||
  | N-nitrosodiphenylamine | ||
  | phenanthrene | ||
  | pyrene | ||
  | 1,2,4-trichlorobenzene | ||

OTHER TOXIC POLLUTANTS
(METALS AND CYANIDE) AND TOTAL PHENOLS
(SEE TABLE III, OF 40 CFR 122 APPENDIX D)

<table>
<thead>
<tr>
<th>Antimony, Total</th>
<th>Total Recoverable Thallium, mg/l</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arsenic, Total</td>
<td>Silver, Total</td>
</tr>
<tr>
<td>Beryllium, Total</td>
<td>Thallium, Total</td>
</tr>
<tr>
<td>Cadmium, Total</td>
<td>Zinc, Total</td>
</tr>
<tr>
<td>Chromium, Total</td>
<td>Cyanide, Total</td>
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<tr>
<td>Copper, Total</td>
<td>Phenols, Total</td>
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<td>Lead, Total</td>
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<tr>
<td>Mercury, Total</td>
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<tr>
<td>Nickel, Total</td>
<td></td>
</tr>
<tr>
<td>Selenium, Total</td>
<td></td>
</tr>
</tbody>
</table>
Toxic Pollutants
Asbestos

Hazardous Substances
Acetaldehyde
Allyl alcohol
Allyl chloride
Amyl acetate
Aniline
Benzonitrile
Benzyl chloride
Butyl acetate
Butylamine
Captan
Carbaryl
Carbofuran
Carbon disulfide
Chlorpyrifos
Coumaphos
Cresol
Crotonaldehyde
Cyclohexane
2,4-D (2,4-Dichlorophenoxy acetic acid)
Diazinon
Dicamba
Dichlobenil
Dichlone
2,2-Dichloropropionic acid
Dichlorvos
Diethyl amine
Dimethyl amine
dinitrobenzene
Diquat
Disulfoton
Diuuron
Epichlorohydrin
Ethanolamine
Ethion
Ethylene diamine
Ethylene dibromide
Formaldehyde
Furfural
Guthion

Isoprene
Isopropanolamine
Keithane
Kepone
Malathion
Mercaptodimethur
Methoxychlor
Methyl mercaptan
Methyl methacrylate
Methyl parathion
Mexacarbate
Monoethyl amine
Monomethyl amine
Naled
Napthenic acid
Nitrotoluene
Parathion
Phenolsulfanate
Phosgene
Propargite
Propylene oxide
Pyrethrins
Quinoline
Resorcinol
Strophanthin
Styrene
TDE (Tetrachlorodiphenylethane)
2,4,5-T (2,4,5-Trichlorophenoxy acetic acid)
2,4,5-TP [2-(2,4,5-Trichlorophenoxy) propanoic acid]
Trichlorofan
Triethylamine
Trimethylamine
Uranium
Vandium
Vinyl acetate
Xylene
Xylenol
Zirconium
### INFLUENT SCREENING REQUIREMENTS

<table>
<thead>
<tr>
<th>Volatiles</th>
<th>Semi-Volatile Organic Compounds</th>
<th>Metals</th>
</tr>
</thead>
<tbody>
<tr>
<td>acrolein</td>
<td>acenaphthene</td>
<td>Aluminum-Trec*</td>
</tr>
<tr>
<td>acrylonitrile</td>
<td>acenaphthylene</td>
<td>Antimony-Trec</td>
</tr>
<tr>
<td>benzene</td>
<td>anthracene</td>
<td>Arsenic-Trec and PD*</td>
</tr>
<tr>
<td>bromoform</td>
<td>benzidine</td>
<td>Barium-Trec</td>
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<td>carbon tetrachloride</td>
<td>benzo(a)anthracene</td>
<td>Beryllium-Trec</td>
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<tr>
<td>chlorobenzene</td>
<td>benzo(a)pyrene</td>
<td>Cadmium-Trec and PD</td>
</tr>
<tr>
<td>chlorodibromomethane</td>
<td>3,4-benzofluoranthene</td>
<td>Chromium III-Trec and PD</td>
</tr>
<tr>
<td>chloroethane</td>
<td>benz(o)ghi)perylene</td>
<td>Chromium VI-Trec and Diss*</td>
</tr>
<tr>
<td>2-chloroethylvinyl ether</td>
<td>bis(2-chloroethoxy)methane</td>
<td>Copper-Trec and PD</td>
</tr>
<tr>
<td>chloroform</td>
<td>bis(2-chloroethyl)ether</td>
<td>Iron-Trec and Diss</td>
</tr>
<tr>
<td>dichlorobromomethane</td>
<td>bis(2-chloroisopropyl)ether</td>
<td>Lead-Trec and PD</td>
</tr>
<tr>
<td>1,1-dichlorethane</td>
<td>bis(2-ethylhexyl)phthalate</td>
<td>Manganese-Trec and Diss</td>
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<td>1,2-dichlorethane</td>
<td>2-chloronaphthalene</td>
<td>Molybdenum-Trec</td>
</tr>
<tr>
<td>1,1,2,2-tetrachloroethane</td>
<td>4-chlorophenyl phenyl ether</td>
<td>Nickel-Trec and PD</td>
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<tr>
<td>tetrachloroethylene</td>
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<td>dibenz(o,a)anthracene</td>
<td>Silver-Trec and PD</td>
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<td>1,2-trans-dichloroethylene</td>
<td>1,2-dichlorobenzene</td>
<td>Thallium-Trec and PD</td>
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<td>di-n-octyl phthalate</td>
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<td></td>
<td>1,2-diphenyldihydrazine (as azobenzene)</td>
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<td>fluorene</td>
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<td>hexachloroethane</td>
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<td>N-nitrosodimethylamine</td>
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</tr>
<tr>
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<td>4-nitrophenol</td>
<td></td>
</tr>
<tr>
<td></td>
<td>pentachlorophenol</td>
<td></td>
</tr>
<tr>
<td></td>
<td>phenol</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2,4,6-trichlorophenol</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1,4-Dioxane</td>
<td></td>
</tr>
</tbody>
</table>
I. TYPE OF PERMIT

Master General, NPDES, Surface Water, Fifth Renewal, Statewide

II. SCOPE OF THE GENERAL PERMIT

A. SIC Code: 1799  Special Trade Contractors, Not Elsewhere Classified
               1629  Heavy Construction, Not Elsewhere Classified

B. Major Changes from Last Renewal:

The current general permit, which expired on October 31, 2010 and has been administratively extended by the Water Quality Control Division (Division), provides coverage for 25 Facilities with Remediation Activities. This renewed general permit is needed to continue to provide coverage for these established dischargers and for new groundwater remediation facilities that are operating throughout Colorado. Major changes from last renewal include the following:

- Inclusion of requirements to develop, document, and implement a Remediation Discharge Activities Management Plan in accordance with good engineering, hydrologic and pollution control practices to ensure compliance with effluent limitations and other permit conditions.
- Inclusion of a provision that requires dischargers to contain the initial effluent until analyses have confirmed that all numeric effluent limitations have been met. The Division has been including this condition in certifications under the current permit.
- Quarterly influent screen for Base, Neutral, Acids, Volatile Organic Compounds, and Metals to detect changes in discharge.
- Inclusion of practices required for discharges in exceedance of water quality standards.
- Limitations on coverage to exclude discharges to groundwater or to outstanding waters.

C. Facilities Covered:

This general permit is to authorize discharges from Remediation Activities to surface waters of the State in Colorado. Only facilities with activities that meet the definition of Remediation Activities are eligible for coverage under the general permit.

Table II-1 lists the 25 entities currently covered under the administratively extended Groundwater Remediation General Permit. The Division has received renewal applications for these 25 facilities.

<table>
<thead>
<tr>
<th>Certification</th>
<th>Facility</th>
<th>Discharge Flow Rate</th>
<th>Receiving Stream(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>COG315025</td>
<td>Municipal Service Center</td>
<td>001A-16.4 GPM</td>
<td>Little Dry Creek, within segment 16c Upper South Platte River Sub-basin</td>
</tr>
<tr>
<td>COG315144</td>
<td>Blanton Mountain Mart</td>
<td>001A-30 GPM</td>
<td>Tributary to Illinois River, within segment 4 of the North Platte River Sub-basin</td>
</tr>
<tr>
<td>COG315146</td>
<td>Hamilton Sundstrand Facility</td>
<td>001A-145 GPM 002A-6.6 GPM</td>
<td>Little Dry Creek and Kalcevic Gulch, both within segment 16b of the Clear Creek Sub-basin</td>
</tr>
<tr>
<td>COG315147</td>
<td>Olde's Texaco Service Facility</td>
<td>001A-10 GPM</td>
<td>Tributary to Bear Creek, within Segment 1a of the Bear Creek Sub-basin</td>
</tr>
<tr>
<td>COG315157</td>
<td>RTD Tunnel 16 Groundwater Treatment Facility</td>
<td>003A-350 GPM</td>
<td>South Platte River, within Segment 14 of the Upper South Platte River Sub-basin</td>
</tr>
<tr>
<td>COG315161</td>
<td>Dietrich Standard Corporation</td>
<td>001A-40 GPM</td>
<td>Tributary to Dry Creek, within Segment 6 of the St. Vrain Sub-basin</td>
</tr>
<tr>
<td>COG315165</td>
<td>12000 W Cedar Dr Lot</td>
<td>001A-30 GPM</td>
<td>Lakewood Gulch, Segment 16c of the Upper South Platte River Sub-basin</td>
</tr>
<tr>
<td>COG315169</td>
<td>CDOT Materials Testing Lab</td>
<td>001A-1.5 GPM</td>
<td>Cherry Creek, Segment 03 of the Cherry Creek Sub-basin</td>
</tr>
<tr>
<td>COG315176</td>
<td>Raytheon Boulder Facility</td>
<td>001A-12 GPM 002A-36 GPM</td>
<td>Both to tributaries to Dry Creek, within Segment 6 of the St. Vrain Sub-basin</td>
</tr>
<tr>
<td>COG315179</td>
<td>A and W Loveland Quick Trip Lust</td>
<td>001A-30 GPM</td>
<td>Big Barnes Ditch, within Segment 6 of the Big Thompson River Sub-basin</td>
</tr>
<tr>
<td>COG315180</td>
<td>Broderick Wood Prod Superfund</td>
<td>001A-67 GPM 001B-67 GPM 002A-80 GPM</td>
<td>Clear Creek, within Segment 15 of the Clear Creek Sub-basin</td>
</tr>
<tr>
<td>COG315182</td>
<td>BP Service Station 12001</td>
<td>001A-10 GPM</td>
<td>Clear Creek, within Segment 15 of the Clear Creek Sub-basin</td>
</tr>
<tr>
<td>COG315183</td>
<td>Former Redfield site</td>
<td>001A-40 GPM</td>
<td>Unnamed ditch tributary to Goldsmith Gulch, within Segment 4 of the Cherry Creek Sub-basin</td>
</tr>
<tr>
<td>COG315197</td>
<td>400 E 104 Ave Lot</td>
<td>001A-5 GPM</td>
<td>Grange Hall Creek-tributary to the South Platte River, within Segment 16c of the Upper South Platte River Sub-</td>
</tr>
</tbody>
</table>
D. **Limitations on Coverage:**

The Division included a limitation of coverage related to having representative data of the contaminated source water in order to characterize the waste stream and to identify all parameters which will require monitoring and/or numeric effluent limitations.

There are some discharges from Remediation Activities that cannot be covered under this general permit and must apply for coverage under another general permit or under an individual permit. These exclusions include discharges from Remediation Activities that:

- include other wastewaters (i.e., domestic wastewaters),
- are land applied or otherwise released to groundwater, or
- are to receiving waters designated as “outstanding waters”
Discharges that include other wastewaters such as domestic wastewaters are excluded on the basis that there may be additional pollutants of concern and other discharge characteristics that were not evaluated in the development of this general permit.

Land application or other discharges to groundwater are excluded from this permit. There are two current facilities with certifications authorizing discharges to groundwater. The Division will work directly with these two facilities to determine the best permitting approach for these discharges.

The Division requires that discharges to outstanding waters be authorized only by an individual permit, since a site specific evaluation is needed to meet the antidegradation requirements of Regulation 31.

E. Application Requirements:

Remediation facilities can apply for coverage under this general permit upon the issuance and effective date of the permit by submitting a complete and accurate application at least 45 days prior to the anticipated discharge. Following review of the application, the Division may request additional information. Upon receipt of the additional information, the Division shall have additional time to issue or deny the authorization to discharge.

Existing facilities with certifications under the administratively extended Groundwater Remediation General Permit (COG-315000) that have submitted renewal applications and qualify for coverage under the new general permit will automatically be transferred. Coverage will be transferred to the new general permit without a lapse of coverage (i.e. discharging without a permit) and without loss of fee payments.

The CDPS general permit for Construction Dewatering activities (COG-070000) authorizes discharges from similar activities as this general permit, but for which Remediation Activities are not conducted. As part of the Division’s review of an application for coverage under COG-070000, or based on the availability of new information for facilities with existing coverage, the Division will assess the potential for various sources of contamination to be present in the discharge. Water quality based effluent limits may be required based on a Reasonable Potential Analysis (see Part VI.A.2.g) due to the presence of contaminants in the source water. Coverage under COG-070000 will not be authorized by the Division if remediation activities will be conducted for the discharge based on these water quality based effluent limits. If the applicant wishes to obtain coverage under the Remediation Activities general permit for the discharge, the following information must be submitted to the Division:

- a statement requesting that the information received in the Construction Dewatering application be applied towards the Remediation Activities Permit application,
- source water characterization data, and
- a description of the treatment utilized in order to meet limitations
- additional information as requested by the Division

All information must be submitted by the permit applicant legal contact and signed in accordance with Part I.E.7 of the permit.

III. RECEIVING STREAM

The Division has identified the stream segments to which the facilities with current certifications under the general permit discharge. The Division expects to continue coverage for these facilities under this general permit since the stream standards and designations are consistent with the limitations on coverage in the general...
permit (i.e. none of the segments are designated as outstanding waters). The Division will also evaluate discharges to stream segments with established TMDLs, discharges to 303(d) listed waters, and other receiving water information as appropriate.

IV. SECTOR DESCRIPTION

A. Industry Description

Facilities with Remediation Activities in Colorado can be described as facilities engaged in Remediation Activities of groundwater, alluvial water, stormwater, and/or surface water (the source water) that will be discharged to surface waters and that is:

- Contaminated from specific industrial sources to include former dry cleaners, gasoline stations, industrial manufacturing facilities, etc.
- Contaminated from an unknown sources.
- Contaminated with naturally occurring constituents at concentrations that trigger water quality based effluent limits for discharges to surface water based on a Reasonable Potential Analysis (see Part VI.A.2.g).

B. Chemical Usage

Facilities potentially use a variety of chemicals during the treatment process for discharges from Remediation Activities. For this general permit the Division has required applicants to submit a list of proposed chemicals, including dosage rates, used in the treatment process. Additionally, a MSDS for each chemical proposed for use must be provided so that the Division can determine the appropriate effluent limitations and conditions to include in the certification. Additional sampling and monitoring requirements may be imposed based on the chemicals used.

The permittee shall notify the Division of any change in chemical usage associated with the permitted discharge in accordance with Part II.A.2 of the Permit.

V. COMPLIANCE HISTORY

The Division reviewed DMR data for the 25 facilities covered under this general permit. Some facilities received compliance advisories for failure to submit DMRs. A few facilities have continual numeric effluent limitation violations. The Division will evaluate whether these facilities will have to modify their treatment and contain their effluent until the modified treatment has confirmed that the effluent limitations have been met.

Coverage under this renewed general permit may not be certified for a current permittee if compliance information from the previous permit term indicates that effluent limits in accordance with the permit do not ensure compliance with applicable water quality standards, control regulations, and the State and federal acts.

DMR review indicated that there were exceedances for various parameters including: Manganese, Iron, 1,4 Dioxane, Oil and Grease, MTBE, pH, Vinyl Chloride, 1,1,2,2-Tetrachloroethane, Chloroform, 1,2-Dichloroethane, Methylene Chloride, Carbon tetrachloride, Bromodichloromethane, 1,2-Dichloropropane, N-Nitrosodi-N-propylamine, Whole Effluent Toxicity Testing, Methyl tert-butyl ether, and Total Suspended Solids.
The Division had determined that a root cause for the high rate of exceedances of effluent limits in certifications under the previous permit was the implementation of treatment systems inadequate to remove pollutants as necessary to comply with those effluent limits. The Division has determined that for facilities covered under this permit, relying only on design calculation to determine if a facility will be capable of complying with effluent limits is inadequate to ensure compliance with applicable water quality standards, control regulations, and the State and federal acts. This iteration of the permit therefore requires containment of an initial batch of effluent until analyses have confirmed that all numeric effluent limitations have been met.

VI. TERMS AND CONDITIONS OF THE PERMIT

A. Discussion of Numeric Effluent Limitations

1. Technology Based Limitations

   a. Federal Effluent Limitation Guidelines – There are no Federal Effluent Limitation Guidelines for this category of discharge.

   b. Regulation 62: Regulations for Effluent Limitations – These Regulations include effluent limitations that apply to all discharges of wastewater to State waters. These regulations are applicable to the discharge from the Remediation Activities.

      i. Total Suspended Solids - The Division’s current permit includes numeric technology-based limits for TSS based on Regulation 62. The Division has retained those more stringent requirements in this renewal permit for all dischargers as required by the anti-backsliding provision in CWA § 402(o). These limitations are the same as those contained in the previous permit and are imposed upon the effective date of this permit.

      ii. Oil and Grease – The oil and grease limitations from the Regulations for Effluent Limitations are applied as they are the most stringent limitations. These limitations are the same as those contained in the previous permit and are imposed upon the effective date of this permit.

      iii. pH - The pH limitation specified in the Regulations for Effluent Limitations is not the most stringent and thus is not used.

2. Water Quality Regulations, Policies, and Guidance Documents

   a. Antidegradation – As stated in The Basic Standards and Methodologies for Surface Water, Section 31.8, an antidegradation (AD) analysis is required for all discharges to waters designated “reviewable”, except in cases where the regulated activity will result in only temporary or short term changes in water quality. Therefore, short-term and intermittent discharges will be considered a temporary impact and exempted from the AD review.

      Under this general permit, long-term, continuous discharges to waters designated “reviewable” will get 15% of the water quality standard. This AD standard will be identified as a site specific limitation in the certification. If the permittee requests consideration of dilution, ambient water quality, or an AD alternatives analysis, then the permit applicant will need to apply for an individual permit.
b. **Determination of Total Maximum Daily Loads (TMDLs)** – Upon reissuance of the renewal certifications under this revised general permit, the Division will assess whether or not any permitted facility discharges to segments for which a TMDL has been completed. The Division has included a provision in the general permit that authorizes the inclusion of additional effluent limits and other terms and conditions in a certification for discharges to segments for which a TMDL has been completed. The determination whether compliance with numeric effluent limitations will be required will be made on a case by case basis.

c. **Determination of Discharges to 303(d) Listed Waters**—Upon reissuance of the renewal certifications under this revised general permit, the Division will assess whether or not any permitted facility discharges to segments on the 303(d) list of impaired waters. The Division has included a provision in the general permit that authorizes the inclusion of additional effluent limits and other terms and conditions in a certification for discharges to segments that are on the 303(d) list of impaired waters.

d. **Colorado Mixing Zone Regulations** – For this general permit, mixing zone regulations will not apply for discharges from Remediation Activities as all limitations are assigned as end of pipe limits based on the Water Quality Standards and Technology Based Limitations. The rationale for not applying mixing zone regulations is due to Division resource limitations and the time required to conduct a thorough analysis of the receiving stream and its’ assimilative capacity. In addition, this level of analysis is more appropriate for the individual permit process in order to include public notice and comment opportunities. Not applying the mixing zone regulations is consistent with the previous iteration of the permit.

e. **Total Phosphorus** – As noted in the general permit, the Division will implement effluent limitations and monitoring conditions in the certification in accordance with the Phosphorus Control Regulations (Regulations, 71, 72, 73, and 74).

f. **Flow**—Flow limitations will be based on the capacity of the treatment system(s).

g. **Reasonable Potential Analysis** – An analysis must be performed to determine whether to include WQBELs in the permit. This reasonable potential (RP) analysis is based on the Determination of the Requirement to Include Water Quality Standards-Based Limits in CDPS Permits Based on Reasonable Potential, dated December, 2002. This guidance document utilizes both quantitative and qualitative approaches to establish RP depending on the amount of available data.

3. **Pollutants Limited by Water Quality Standards**

a. **pH** – pH was determined to be a potential pollutant of concern for discharges from Remediation Activities based on the frequent occurrence in groundwater contaminated by a variety of potential contaminants of pH levels that do not meet surface water standards and the variety of chemicals used in the treatment process that can result in further modification of pH levels.

    This parameter is limited by the water quality standards of 6.5-9.0 s.u., as this range is more stringent than the range specified under the Regulations for Effluent Limitations. This limitation is the same as that contained in the previous permit and is imposed effective immediately.
b. **Temperature**—Temperature was evaluated to determine whether or not it was considered a potential pollutant of concern. The Division decided not to include monitoring for temperature on a permit-wide basis as facilities generally do not add heat during their processes. However, a case-by-case determination will be made as to whether or not temperature monitoring is required for facilities that containerize the effluent for extended periods of time causing the potential for temperature to be a pollutant of concern.

c. **Metals**—A case-by-case determination will be made as to whether or not metals are potential pollutants of concern that must be limited and/or monitored to protect the classified uses assigned to the receiving water. The case-by-case determination will be made based on the source water for the remedial activity discharge, chemicals used in the remedial process, concentrations of naturally occurring metals, the potential for the characterization of the source water to change due to locations of contaminant plumes, and data supplied with the permit application used to characterize the potential source water.

The limitations for metals are based upon the water quality standards and will come directly from the basin regulations (Regulations 32-38) and the Basic Standards and Methodologies for Surface Water (Regulation 31). Standards for metals in the basin regulations that are shown as Table Value Standards (TVS) must be derived from equations that depend on the receiving stream hardness or species of fish present. These equations can be found in the basin regulations (Regulations 32-38).

d. **Volatile Organic Compounds (VOCs) and Semi-Volatile Organic Compounds (SVOCs)**—A case-by-case determination will be made as to whether or not VOCs and/or SVOCs are potential pollutants of concern that must be limited and/or monitored to protect the classified uses assigned to the receiving water. The case-by-case determination will be made based on the source water for the remedial activity discharge, chemicals used in the remedial process, the potential for the characterization of the source water to change due to locations of contaminant plumes, and data supplied with the permit application used to characterize the potential source water.

The limitations for VOCs and SVOCs are based upon the water quality standards that come directly from the Basic Standards and Methodologies for Surface Water (Regulation 31). The numeric effluent limitations implemented are dependent on the beneficial use of the receiving stream.

4. **Whole Effluent Toxicity (WET) Testing**

   a. **Purpose of WET Testing** – The Water Quality Control Division has established the use of WET testing as a method for identifying and controlling toxic discharges from wastewater treatment facilities. WET testing is being utilized as a means to ensure that there are no discharges of pollutants "in amounts, concentrations or combinations which are harmful to the beneficial uses or toxic to humans, animals, plants, or aquatic life" as required by Section 31.11 (1) of the Basic Standards and Methodologies for Surface Waters.

   b. **Reasonable Potential (RP) for Including WET Testing in Certifications**—A case-by-case determination will be made as to whether or not WET testing will be required based on
reasonable potential for the effluent to be toxic to aquatic life. The case-by-case determination will be made based on the following criteria:

i. Expected pollutants in the discharge—Facilities that have limited number of toxic pollutants that are adequately controlled through chemical specific effluent limits will have a lower RP. Facilities that have toxic pollutants for which there are no numeric water quality standards, or have a higher number of toxic pollutants and therefore an increased potential for synergistic effects, will have higher potential for RP.

ii. Variability of the discharge, in regards to WET test data or other toxic pollutants—Facilities that have a higher level of variability in WET testing results or other toxic pollutants will have a higher potential for RP.

iii. Chemical Usage—Facilities that use chemicals in the treatment process at dosages that are toxic to aquatic life will have a higher potential for RP.

c. Acute VS Chronic WET Requirements—This general permit is not implementing the mixing zone regulations as described in Part VI.A.2.d, therefore the low flow is considered zero and the end of pipe limitations apply. In accordance with the Division’s, Implementation of the Narrative Standard for Toxicity in Discharge Permits Using Whole Effluent Toxicity (WET) Testing policy (WET Policy), when end of pipe limitations apply, chronic WET requirements will normally be implemented. However, as documented in the WET Policy, where the discharge is intermittent, as defined in the permit, acute WET testing may be substituted for chronic WET testing. The basis for this is that the aquatic life would not have chronic exposure to the effluent.

d. Acute WET Monitoring—Monitoring for WET is being required using Ceriodaphnia dubia and fathead minnows. The permittee shall report the LC50 for each test.

e. Chronic WET Monitoring—Monitoring for WET chronic toxicity will be required using Ceriodaphnia sp. and fathead minnows. The results of the testing are to be reported on Division approved forms. The permittee will be required to conduct two types of statistical derivations on the data, one looking for any statistically significant difference in toxicity between the control and the effluent concentrations and the second identifying the IC25, should one exist. Both sets of calculations will look at the full range of toxicity (lethality, growth and reproduction).

5. Salinity Regulations – In compliance with the Colorado River Salinity Standards and the Colorado Discharge Permit System Regulations, for discharges to the Colorado River Basin, the permittee shall monitor for total dissolved solids on a Monthly basis.

B. Terms and Conditions Necessary to Assure Compliance

Regulation 61.8(3)(f) includes a requirement for permits to include such terms and conditions as the Division determines to be necessary to ensure compliance with applicable control regulations, water quality standards, and the state and federal Act. The Division has determined that the following conditions are necessary for discharges authorized by this permit.
1. Containing Discharge to Ensure Numeric Effluent Limits Can Be Met: Due to the history of non-compliance with effluent limitations and the variability of the source water being treated, Part I.C.2 of this iteration of the permit requires containment of the initial batch of the effluent until analyses have confirmed that all numeric effluent limitations have been met. If the initial sample exceeds any limitations, additional treatment shall be completed prior to discharge to ensure compliance with the limitations. An additional sample must be collected, post-treatment, to confirm compliance with the limitations. Additional sampling and treatment shall be repeated, and all water shall be collected and retained, until monitoring results for the treated effluent verify compliance with the numeric effluent limitations identified in the permit certification.

This provision may be waived for existing permittees on a case-by-case basis if the discharger has been able to demonstrate consistent compliance with the permit numeric effluent limitations. Prior to issuing renewal permits for existing permittees, the Division will review facility DMR data to verify whether or not the facility has demonstrated compliance with the permit numeric effluent limits. The permit certification will specifically state if this provision has been waived.

2. Remediation Activity Practices: Regulation 61.8(3)(r) includes a requirement for permits to include conditions for best management practices to control or abate the discharge of pollutants when the practices are reasonably necessary to achieve effluent limitations and standards. The Division has identified the common occurrence of failure to design and implement practices as necessary to ensure continuous compliance with the effluent limits. The Part I.C.3 permit therefore includes a requirement that management practices be implemented in accordance with good engineering, hydrologic and pollution control practices. The permit specifically identifies the need to ensure that control mechanisms are designed, implemented, and maintained with proper hydraulic and pollutant removal capacities. This requirement would make it a violation for a structural pollutant removal control to be operated in such a way that is outside of its design tolerances intended to ensure compliance with the numeric effluent limits. Examples would include failure to operate at the proper flow rate, maintain necessary capacity and holding time, apply proper rates and quantities of chemicals, and replace filters as necessary for proper function. Failure to properly implement and maintain practices can result in variations in pollutant removal ability of controls such that exceedance of numeric effluent limits may not be identified by the intermittent sampling required by the permit and therefore the requirement to implement practices is necessary to ensure ongoing compliance with numeric effluent limits. The specific requirement that remediation activity practices to be implemented in with good engineering, hydrologic and pollution control practices removal is intended to require consistent pollutant removal through proper operation of treatment controls.

3. Remediation Activities Management Plan: Part I.C.4 of this iteration of the permit also includes a requirement to develop, document, and implement a Remediation Activities Management Plan (Plan). The requirement for the Plan ensures that the practices implemented at the site are documented so that it is clear to the permittee, operator, and Division how the remediation practices at the site are to be implemented to maintain compliance with the permit. The plan is also required to describe practices that will be implemented to meet additional conditions of the permit, and to enable effective compliance oversight of the permitted facility.

4. Discharge Log: Discharges authorized by this permit often occur irregularly. This irregular nature can result in confusion for both the permittee and the Division in determining monitoring frequency and the application of both daily and averaged effluent limitations. A discharge monitoring log is therefore required by Part I.C.5 of the permit to identify when discharges are occurring from
permitted outfalls. This requirement applies to all dischargers but is intended to not result in a significant tracking and record keeping burden for those discharges that are on-going.

5. Practices for Discharges in Exceedance of Applicable Water Quality Standards: Pollutant concentrations in the influent for discharges authorized by this permit can change significantly over time. These changes can be impossible to predict and therefore makes it likely that the permittee will not be able to notify the Division of the change in discharge as required by Part II.A.2 of the permit prior to the change occurring. Without this notification and the ability to respond proactively, the Division does not have the ability to determine if the altered discharge is consistent with the conditions of the permit and whether or not the permit continues to ensure compliance with applicable control regulations, water quality standards, and the state and federal Act.

The previous iteration of this permit addressed this concern by not authorizing any pollutant not identified in the permit certification. The Division has determined that this requirement is infeasible since it would result in a violation for pollutants that were present even when there is no potential for an exceedance of a water quality standard or when the permittee is unaware of the pollutants’ presence. Therefore, Part I.C.7 of the permit includes requirements for the permittee to respond to changes in discharge only when the permittee becomes aware that pollutant concentrations in the discharge exceed any applicable water quality standards for the receiving water for a pollutant not subject to an effluent limitation in the permit certification. The permit also provides additional conditions that would allow a discharge to continue in compliance with the permit if the permittee can prevent the exceedance at the outfall. However, notification to the Division is required. The occurrence of an exceedance of a water quality standard at the outfall for a pollutant without an effluent limitation will likely result in the Division requiring a new or revised permit application and shall follow the procedures specified in Sections 61.5 through 61.6, and 61.15 of the Colorado Discharge Permit System Regulations.

C. Monitoring

1. Effluent Monitoring – Effluent monitoring will be required as shown in the general permit. The monitoring frequencies for some parameters deviate from the Baseline Monitoring Frequency, Sample Type, and Reduced Monitoring Frequency Policy (Monitoring Policy). However, according to the Monitoring Policy, intermittent type discharges such as batch type discharges are not subject the Monitoring Policy. Since discharges permitted under this general permit have the potential to be both continuous and of batch type, the Division established the monitoring frequencies based on the variability of the source water and type of activity resulting in the discharge to State waters. However, the monitoring frequencies are consistent with the previous iteration of the permit.

Monitoring locations will be authorized in the permit certification. Facilities wanting to request a reduction in monitoring frequency must request so through the modification process. The Division will evaluate if a reduction in monitoring frequency can be made in accordance with the Monitoring Policy. Subsequently, upon permit renewal, facilities that have previously been granted a reduction in monitoring frequency will be re-evaluated against the criteria set forth in the Policy to determine if monitoring reductions can continue.

2. Influent Monitoring—Since the source water being discharged under this general permit has the high potential to change based on proximity to groundwater contaminant plumes and groundwater flow, quarterly influent monitoring is required. The Division established the influent monitoring
frequency based on potential for variability of the source water and the type of activity producing the discharge.

D. Reporting

1. Discharge Monitoring Report – Facilities authorized under this general permit must submit Discharge Monitoring Reports (DMRs) on a monthly basis to the Division. These reports should contain the required summarization of the test results for all parameters and monitoring frequencies shown in Part I.B of the permit. See the permit, Part I.B, C, D and/or E for details on such submission.

2. Special Reports – Special reports are required in the event of an upset, bypass, or other noncompliance. Please refer to Part II.A. of the permit for reporting requirements. Submittal of these reports to the US Environmental Protection Agency Region VIII is no longer required.

E. Spills

Spill requirements apply to materials spilled that result in their presence in the discharge authorized under this permit. Spills that may cause pollution of state waters that are not discharged through an outfall authorized under this general permit are not within the scope of this general permit and are required to be reported in accordance with the Colorado Water Quality Control Act 25-8-601(2), since the Division views these actions as not authorized under the scope of a discharge permit. Additional information regarding reporting of unauthorized spills is contained in the Division’s Guidance for Reporting Spills.

F. Compliance Schedules

Compliance schedules are authorized to be included in certifications as needed. The Division anticipates that a compliance schedule may be appropriate for implementation of the more restrictive Antidegradation limitations for example. All information and written reports required by a compliance schedule should be directed to the Permits Section for final review unless otherwise stated.

G. Additional Terms and Conditions

1. Signatory and Certification Requirements – Signatory and certification requirements for reports and submittals are discussed in Part I.E.7. of the permit.
VII. REFERENCES

A. Colorado Department of Public Health and Environment, Water Quality Control Division Files, for facilities currently authorized under this permit.


J. Baseline Monitoring Frequency, Sample Type, and Reduced Monitoring Frequency Policy for Domestic and Industrial Wastewater Treatment Facilities, Water Quality Control Division Policy WQP-20, May 1, 2007.


VIII. PUBLIC NOTICE COMMENTS

The City and County of Denver (CCoD) provided the only written comments during the Public Notice Period. Summaries of these comments and the Division’s response are provided below. The full comments and supporting documents are contained in the permit file and available upon request from the Division’s Records Center.
Comment 1—Part I.B.3, Monitoring Frequencies and Sample Types for Influent Parameters
The requirement that a permittee seeking relief from influent sampling substantiate that constituents are not present in influent at concentrations more than one half the underlying surface water standard seems unreasonable and excessive. The text should clarify that this requirement applies only to constituents that are not already in the permit.

Response 1—Because the source of the discharge authorized under this general permit is highly variable due to changes in ground water flow from the pumping of ground water, the Division does not consider this requirement to be unreasonable or excessive. Contrary, the Division feels this requirement is necessary in order to maintain compliance with Part I.C.6 of the permit. The permit requires influent monitoring and reporting for parameters listed in Table B.3 (See Part III of the permit for each listed parameter) including those parameters with a numeric effluent limit in the permit (certification). Monitoring of constituents in the influent with a numeric effluent limit in the permit (certification) is required to identify changes that could result in the necessity for revised treatment and to meet the intent of Part II.A.2 of the permit to identify any changes that could result in an altered discharge.

Comment 2—Part I.B.3, Monitoring Frequencies and Sample Types for Influent Parameters
The permit should include a provision allowing the permittee to demonstrate that constituents in influent that are not included in the permit will not result in an exceedance of a water quality standard in the receiving water. The demonstration could be performed by evaluating the assimilative capacity of the receiving water, in-stream monitoring, or modeling. The permittee could then petition the Division for relief from influent monitoring requirements.

Response 2—Consistent with Part. I.C.11 of the permit, all effluent limitations are assigned as end of pipe limits based on the Water Quality Standards. An assessment to determine the assimilative capacities for the receiving stream for each pollutant of concern is not applicable to this permit. Dischargers who want consideration of a mixing allowance or ambient stream conditions should apply for an individual permit.

Comment 3—Part I.B.3, Monitoring Frequencies and Sample Types for Influent Parameters
Section 3 is confusing. Clarification is needed on influent monitoring frequency.

Response 3—The Division reworded the footnotes to state that the influent must be monitored once per quarter and in accordance with Part I.B.3. of the permit.

Comment 4—Part I.C.7, WET Testing-Outfall(s)
We recommend adding a reference to the Fact Sheet for clarity regarding reasonable potential for WET.

Response 4—The Division has added a reference to the Fact Sheet which explains the reasonable potential for inclusion of WET testing as a permit requirement.

Comment 5—Part I.C.7, WET Testing-Outfall(s), 4th paragraph
WET tests are typically performed by an outside party, and there is the potential for control failure during tests. CCoD recommends adding the italicized text to the permit language:
If a test is considered invalid, the permittee is required to perform additional testing during the monitoring period to obtain a valid test result. **Unless demonstrated that the permittee took appropriate steps to acquire valid WET test results**, failure to obtain a valid test result during the monitoring period shall result in a violation of the permit for failure to monitor.

**Response 5** — The Division’s expectation is that permittees comply with the terms and conditions of the permit and exercise proper operation and maintenance which includes adequate laboratory controls and quality assurance procedures. **If for any reason a permittee is unable to comply with the WET testing requirements or is unable to obtain valid WET test results, the permittee shall provide the Division with the proper noncompliance notification demonstrating that they exercised due diligence and there were factors beyond their control that prevented them from obtaining valid WET test results. The suggested language was not be added to the permit.**

**Comment 6** — Part I.C.7.a.iii, Automatic Compliance Response

The listed permit reference for the description of the Toxicity Identification Evaluation / Toxicity Reduction Evaluation (TIE/TRE) investigation does not seem correct.

**Response 6** — The Division corrected the reference to TIE/TRE in the permit.

**Comment 7** — Part I.C.7.b, Chronic WET Testing

Would it take an Individual Permit or just a modified General Permit to change the IWC from 100% to something that may be more appropriate for a given project? If it can be demonstrated that the discharge is a small percentage of minimum instream flows (i.e., <5%), would this not justify a lower IWC percentage?

**Response 7** — As in previous iterations of this general permit, the IWC is set to 100%. In order to change the IWC from 100% to a lower IWC percentage, a discharger would have to apply for an individual permit. Additional language was added to the permit stating that the permittee should apply for an individual permit for consideration of a lower IWC percentage.

**Comment 8** — Part I.C.8, Chemical Additions

The proposed revised permit states that no chemicals are to be added to the discharge unless the WQCD first grants permission. Please define at which point in the treatment system that the water is considered ‘discharge’.

**Response 8** — The Division reworded the language to clarify that the requirement addresses chemicals that have the potential to be present in the permitted discharge. This would include, but is not limited to, chemical additions at any point in the treatment system.

**Comment 9** — Part I.D, Definition of Terms

Information contained in the definition of antidegradation limits appears to be a requirement for permittees to implement and not a definition. CCoD suggests moving the text to a more suitable location in the permit and rewording the requirements so that they are clearer.

**Response 9** — The Division removed the “Antidegradation limits” definition since the definition described the method for calculating the two year rolling average. An “Antidegradation” definition was added.
Comment 10—Part I.E.3, Analytical and Sampling Methods for Monitoring
The analytical sampling text on calculation of average concentrations does not appear to be consistent with the definitions of “seven day average” and “thirty day average” and should be modified to avoid confusion.

Response 10—The Division reworded the language within Part I.E.3 as it pertains to calculating average concentrations. Text within the “Seven (7) day average” and “Thirty (30) day average” definitions pertaining to calculating the Seven (7) day and Thirty (30) day averages was removed and language referencing Part I.E.3 (Analytical and Sampling Methods for Monitoring and Reporting) was added.

Comment 11—Part II.A.5, Other Notification Requirements
The text notes that manufacturing, commercial, mining, and silvicultural dischargers must notify the Division when certain criteria are or are expected to be reached. CCoD recommends removing the text as it does not appear to be relevant to this permit.

Response 11—Part II.A.5 is boiler plate language which exists in all CDPS industrial general permits. Since the language does not cause any conflict with the permit requirements, the language will not be removed.

Comment 12—Will the changes in the new permit be implemented through permit revisions or will existing permits remain unchanged until the permit is renewed?

Response 12—Existing permit certifications will remain unchanged until the permit becomes issued and effective. All existing permittee’s wishing to continue permit coverage under the revised permit were required to have filed a permit renewal application. Once the revised permit is issued, each existing permittee with a renewal application on file will be issued a new permit certification with an effective date set to that of the effective date of the revised general permit. Where a permit certification has new or more stringent limitations, where necessary and in accordance with Regulation 61, the facility will be given a schedule for compliance that will include specific deadlines for the facility to achieve compliance with the new or more stringent limitation(s) as soon as possible.

Comment 13—What will be the agency’s response time to new permits and requested modifications? CCoD recommends that the current 30 day review time remain in place so as not to delay development projects or redevelopment of Brownfields sites and subsequently potentially affecting the economics of the projects.

Response 13—As stated in Part I.A.3 of the permit, the Division has changed the application deadline from 30 days to 45 days before the anticipated date of discharge. The longer review period is necessary for the Division to complete the certification issuance process.

Comment 14—It seems that the proposed revised permit treats all sites the same as a water treatment facility regardless of size, including the need for a certified operator to run the treatment facility. If that is WQ’s intent, that may not be appropriate for all types of discharges from remediation activities. It is not clear how the proposed permit requirements can be practically, or cost effectively, implemented for smaller remediate projects. CCoD recommends that CDPHE WQCD propose and implement a subset of the permit requirements for smaller projects.
Response 14—It is the Division’s intent to treat all sites (regardless of size) the same that are discharging
treated or remediated ground water, alluvial water, stormwater, and/or surface water. The nature of a
general permit is to regulate a category of discharge and is not based on the quantity of discharge or size of
the project. According to Regulation 61, Colorado Discharge Permit System Regulations, the general
permit shall be written to regulate a category of point sources if the sources all a) involve the same or
substantially similar types of operations; b) discharge the same types of wastes; c) require the same effluent
limitations or operating conditions; d) require the same or similar monitoring; and e) in the opinion of the
Director, are more appropriately controlled under a general permit than under individual permits.

Nicole Rolfe
July 26, 2011
COLORADO DISCHARGE PERMIT SYSTEM (CDPS)
RATIONALE FOR MODIFICATION 1
REMEDIATION ACTIVITIES DISCHARGING TO SURFACE WATER
CDPS PERMIT NUMBER COG-315000

TABLE OF CONTENTS
TABLE OF CONTENTS ........................................................................................................ 1
I. TYPE OF PERMIT ........................................................................................................ 1
II. GENERAL PERMIT INFORMATION ........................................................................... 1
III. PURPOSE OF MODIFICATION ................................................................................ 1
IV. CHANGES MADE AS A RESULT OF THE AMENDMENT ........................................ 1

I. TYPE OF PERMIT
Modification #1 (Minor Modification) to the Remediation Activities Discharging to Surface Water Master General Permit

II. GENERAL PERMIT INFORMATION
A. Activities Covered: Discharges from remediation activities to surface waters of the state.
B. Fee Category: Oil and Gas Cleanup, Category 7, Subcategory 8
   Annual Fee: $1,840 per year
   Amendment Fee: $0.00

III. PURPOSE OF MODIFICATION
Upon certification reissuance, the Division discovered:

1. The Acute Whole Effluent Toxicity (WET) parameter citations and limitations within the Numeric Effluent Limitations and Monitoring Requirements Tables B.1 and B.2 were incorrect and inconsistent with the narrative language in the permit. Table B.1 and Table B.2 listed the parameter for Acute WET as Pimephales lethality and Ceriodaphnia lethality. Both with Daily Maximum limitations of Report LC50. Since Acute testing requires a 48 hour WET test using Ceriodaphnia and an acute 96-hour WET test using Pimephales, the correct Acute WET parameter citation should state LC50 Statre 96Hr Acute using Pimephales and LC50 statre 48Hr Acute using Ceriodaphnia. The limitations for both should be LC50 >100% as a Daily Minimum rather than Report LC50. Existing language in Part I.C.7 of the permit, WET Testing-Outfalls, accurately describes the Acute WET Testing requirements.

2. The Chronic WET parameter citations and limitations within the Numeric Effluent Limitations and Monitoring Requirements Tables B.1 and B.2 were incorrect and inconsistent with the narrative language in the permit. Table B.1 and Table B.2 listed the parameter for Chronic WET as Pimephales lethality and toxicity and Ceriodaphnia lethality and toxicity. Both with Daily Maximum limitations of Report Stat Diff and IC25. Since Chronic testing must be conducted using a static 7-day test on both Ceriodaphnia and Pimephales, the correct Chronic WET parameter citation should state Static Renewal 7 Day Chronic using Pimephales and Static Renewal 7 Day Chronic using Ceriodaphnia. The Daily Minimum limitations for both should be NOEC or IC25 >100% rather than Report Stat Diff and IC25. Existing language in Part I.C.7 of the permit, WET Testing-Outfalls, accurately describes the Chronic WET Testing requirements.

IV. CHANGES MADE AS A RESULT OF THE AMENDMENT
The Division made the necessary modification to the Numeric Effluent Limitations and Monitoring Requirements Tables B.1 and B.2 of permit to correct the WET parameter citations and limitations.

Nicole Rolfe
September 1, 2011

COLORADO DISCHARGE PERMIT SYSTEM (CDPS)
RATIONALE FOR MODIFICATION 1
REMEDIATION ACTIVITIES DISCHARGING TO SURFACE WATER
CDPS PERMIT NUMBER COG-315000

TABLE OF CONTENTS
TABLE OF CONTENTS ........................................................................................ 1
I. TYPE OF PERMIT ................................................................................................. 1
II. GENERAL PERMIT INFORMATION .................................................................... 1
III. PURPOSE OF MODIFICATION ......................................................................... 1
IV. CHANGES MADE AS A RESULT OF THE AMENDMENT ................................. 1

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The Division made the necessary modification to the Numeric Effluent Limitations and Monitoring Requirements Tables B.1 and B.2 of permit to correct the WET parameter citations and limitations.

Nicole Rolfe
September 1, 2011

COLORADO DISCHARGE PERMIT SYSTEM (CDPS)
FACT SHEET TO PERMIT NUMBER COG315000
GENERAL PERMIT FOR DISCHARGES FROM REMEDIATION ACTIVITIES

TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>I.</th>
<th>TYPE OF PERMIT</th>
<th>1</th>
</tr>
</thead>
<tbody>
<tr>
<td>II.</td>
<td>SCOPE OF THE GENERAL PERMIT</td>
<td>1</td>
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</tbody>
</table>

I.  TYPE OF PERMIT

Master General, NPDES, Surface Water, Fifth Renewal, Statewide

II. SCOPE OF THE GENERAL PERMIT

A.  SIC Code:
   1799  Special Trade Contractors, Not Elsewhere Classified
   1629  Heavy Construction, Not Elsewhere Classified

B. Minor Modification #2

Division initiated minor changes were made to the language in Part I(E)(1) of the permit, to clarify the submittal date for monthly and quarterly DMRs.

Margo Griffin
May 5, 2014
APPENDIX B
Health and Safety Plan
(See Appendix E, Removal Action Work Plan, EMSI, June 19, 2015)
APPENDIX C
Methane, Odor, and Dust Control Plan
Appendix C

Methane, Odor, and Dust Control Plan
Globeville Landing Outfall Project

Vasquez Boulevard/Interstate 70 Site,
Operable Unit #2 Removal Action

Prepared for:

City and County of Denver
Environmental Quality Division
200 West 14th Ave, Suite 310
Denver, Colorado 80204

Prepared by:

Engineering Management Support, Inc.
7220 W. Jefferson Ave., Suite 406
Lakewood, Colorado 80235

December 15, 2015
# TABLE OF CONTENTS

1 INTRODUCTION ................................................................................................................. 1
  1.1 PURPOSE .................................................................................................................. 1
  1.2 OBJECTIVES ........................................................................................................... 2
  1.3 PLAN ORGANIZATION ........................................................................................... 2

2 MONITORING METHODS, PROCEDURES, AND TRAINING ........................................... 3
  2.1 COMBUSTIBLE GAS ................................................................................................. 3
    2.1.1 Monitoring Methods ......................................................................................... 3
    2.1.2 Methane Monitoring Procedures ................................................................. 3
    2.1.3 Methane Monitoring Training ......................................................................... 4
  2.2 ODORS ....................................................................................................................... 5
    2.2.1 Odor Monitoring Methods .............................................................................. 5
    2.2.2 Odor Monitoring Procedures ......................................................................... 5
    2.2.2.1 Background Monitoring ........................................................................... 7
    2.2.2.2 Action Levels ............................................................................................. 7
    2.2.3 Odor Monitor Training ..................................................................................... 7
  2.3 FUGITIVE DUST ....................................................................................................... 8
    2.3.1 Fugitive Dust Monitoring Procedures ............................................................ 8
    2.3.2 Fugitive Dust Monitor Training ..................................................................... 9

3 RESPONSE ACTIONS ..................................................................................................... 10
  3.1 COMBUSTIBLE GAS ............................................................................................... 10
  3.2 ODOR ....................................................................................................................... 10
  3.3 FUGITIVE DUST .................................................................................................... 11

4 COMMUNICATIONS AND REPORTING ....................................................................... 12
  4.1 COMMUNICATION MECHANISMS .......................................................................... 12
  4.2 COMPLAINT RESPONSE PROCEDURES ............................................................. 13
  4.3 ROUTINE AND SPECIAL REPORTING ................................................................. 13
  4.4 DATA REPORTING ................................................................................................. 13

5 REFERENCES ............................................................................................................... 15

# LIST OF FIGURES

Figure C-1 General Location Map
Figure C-2 Outreach Monitoring Boundary

# LIST OF APPENDICES

Appendix C-1 Monitoring Forms and Logs
# LIST OF ACRONYMS

<table>
<thead>
<tr>
<th>Acronym</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>AQCC</td>
<td>Air Quality Control Commission</td>
</tr>
<tr>
<td>BTEX</td>
<td>Benzene, Toluene, Ethylbenzene, and Xylenes</td>
</tr>
<tr>
<td>D/T</td>
<td>Dilution – to – Threshold</td>
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<tr>
<td>LEL</td>
<td>Lower Explosive Limit</td>
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<tr>
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<td>Colorado Department of Transportation</td>
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<td>CDPHE</td>
<td>Colorado Department of Public Health and Environment</td>
</tr>
<tr>
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<td>Engineering Management Support, Inc.</td>
</tr>
<tr>
<td>GLOP</td>
<td>Globeville Landing Outfall Project</td>
</tr>
<tr>
<td>MODCP</td>
<td>Methane, Odor, and Dust Control Plan</td>
</tr>
<tr>
<td>OSHA</td>
<td>Occupational Safety and Health Administration</td>
</tr>
<tr>
<td>OU-2</td>
<td>Operable Unit #2</td>
</tr>
<tr>
<td>RTD</td>
<td>Regional Transportation District</td>
</tr>
<tr>
<td>UEL</td>
<td>Upper Explosive Limit</td>
</tr>
<tr>
<td>USEPA</td>
<td>United States Environmental Protection Agency</td>
</tr>
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</table>
1 INTRODUCTION

This Methane, Odor, and Dust Control Plan (MODCP) has been developed by Engineering Management Support, Inc. (EMSI) on behalf of the City and County of Denver (Respondent). It contains the steps that will be taken to manage potential releases of combustible gases (primarily methane), odors, and fugitive dust resulting from implementation of the “environmental components” of the Globeville Landing Outfall Project (GLOP).

The GLOP consists of installation of a stormwater drainage feature through a portion of Operable Unit 2 (OU-2) of the VB/I70 Superfund Site. The stormwater drainage feature is part of a larger project that is intended to reduce flooding in the Park Hill and Montclair drainage basins and address stormwater management needs associated with projects being developed by Regional Transportation District (RTD), Colorado Department of Transportation (CDOT), and the Respondent. Locations of OU-2, boundaries of property owned by the Respondent within OU-2, and the general layout of the GLOP drainage features within Respondent-owned property, are shown on Figure C-1.

The Respondent is implementing the “environmental components” pursuant to an Administrative Settlement Agreement and Order on Consent for Removal Action (Agreement) with the United States Environmental Protection Agency (USEPA). Please refer to the Final Design Report (EMSI, 2016) for a description of the “environmental components” that are being constructed.

Activities detailed in this MODCP will be performed to:

- Provide fast detection and response to release of combustible gases to protect worker health and safety on-site, and by inference, public health and safety off-site; and

- Provide fast detection and response to releases of odors and fugitive dust, including reaching out to surrounding commercial and residential communities to inform them of the potential for odor and fugitive dust releases, and to respond to their complaints in the event such releases occur.

1.1 Purpose

Due to the nature of the waste material in the Coliseum parking lot, and “soil and debris” in the Globeville Landing Park, combustible gases, odors, and fugitive dust may be released as the materials are excavated, stockpiled, reused on-site (“soil and debris” only), or loaded into transport trucks and hauled off-site. Although combustible gases should dissipate to safe levels within a short distance from the source, and fugitive dust will be controlled such that it does not extend beyond site boundaries, nuisance odors may travel further and therefore trigger a need for additional odor monitoring and control measures. This document is
intended to detail protocol for monitoring of combustible gases, odors, and fugitive dust, to identify mitigation measures for these parameters, and to present plans for communicating with the communities that could be affected by nuisance odors and fugitive dust.

1.2 Objectives

The objectives of the MODCP are the following:

- To comply with relevant Occupational Safety and Health Administration (OSHA) exposure limits for combustible gases that may be released from material excavated during GLOP construction;

- To control release of nuisance odors and comply with the substantive requirements of Regulation No. 2 of the Colorado Department of Public Health Air Quality Control Commission (CDPHE AQCC), and Article II of Chapter 4 of Denver’s Municipal Ordinance Code;

- To comply with the substantive requirements for monitoring and control of fugitive dust emissions under Regulation No. 1 of the CDHE AQCC, and Article III of Chapter 4 of the Denver Revised Municipal Code (DRMC); and

- To implement a community outreach program that focuses on residential and commercial areas that may be affected by nuisance odors and fugitive dust.

1.3 Plan Organization

This MODCP contains five sections, including this introduction. Monitoring methods, procedures, and training requirements are described in Section 2. Response actions are described in Section 3, and communications and reporting mechanisms are described in Section 4. References are presented in Section 5.

The text is followed by an appendix that contains monitoring forms and logs.
2 MONITORING METHODS, PROCEDURES, AND TRAINING

2.1 Combustible Gas

Combustible gases such as methane may be present in waste material from beneath the Coliseum parking lot and possibly in “soil and debris” from the Globeville Landing Park. The minimum concentration of a combustible gas necessary to support combustion in air is defined as the Lower Explosive Limit (LEL) for that gas or vapor. Below this level, the mixture is too “lean” to burn. The maximum concentration of a gas or vapor that will burn in air is defined as the Upper Explosive Limit (UEL). Above this level, the mixture is too “rich” to burn. The range between the LEL and UEL is known as the flammable range for that gas or vapor.

Methane is the predominant combustible gas in waste material and possibly “soil and debris”. At room temperature and atmospheric pressure, the LEL of methane is 5% by volume in air; its UEL is 15%. Therefore, monitoring for and control of combustible gases in the working space down to an LEL of 5% is necessary for protection of worker health and safety on-site, and for protection of public health and safety off-site.

2.1.1 Monitoring Methods

Monitoring for combustible gases will utilize a hand-held meter that has the ability to detect the LEL of combustible gases. The LEL detection range will be from 0 to a minimum of 50%. In addition, and for worker protection, the hand-held meter will have an oxygen sensor to check that the working environment is not oxygen deficient. Accessory devices and supplies will include a two-way radio and a cellular phone.

2.1.2 Methane Monitoring Procedures

The following monitoring procedures will be implemented when excavating and handling waste material and “soil and debris” from the GLOP.

- A combustible gas indicator will be utilized at all times to monitor air quality when working within ten (10) feet of an open excavation or stockpile.

- Before personnel are permitted to enter an excavation or trench, the breathing space air will be monitored to ensure that combustible gas is not present at an LEL greater than 1%, and that the oxygen concentration is no less than 19.5%.

- When in an excavation or trench, each work party will work no more than five (5) feet from a continuous combustible gas and oxygen monitor.
• Blowers or fans will be used to ventilate excavations or stockpiles that show LELs greater than 5%, or an oxygen concentration less than 19.5%.

• When excavating or trenching more than two (2) feet into waste material or “soil and debris”, and in the presence of combustible gas greater than 5% of the LEL, the material will be wetted and the operating equipment will be equipped with spark proof exhausts (discussed further in Section 3.1).

• Personnel within or near an excavation or stockpile will be fully clothed, and wear shoes with non-metallic soles, a hard hat and safety goggles or glasses.

• No open flames, including smoking, will be permitted in any area within one hundred (100) feet of an excavation or stockpile.

• A dry chemical fire extinguisher, ABC rated, will be provided on all equipment used to handle waste material and “soil and debris”.

• Personnel will remain upwind of any open excavation unless the excavation is continuously monitored and shown to have an LEL of 5% or less and an oxygen content of 19.5% or more.

• All other applicable Safety and Health Regulations for Construction, as promulgated in 29 CFR by the OSHA, will be met. Applicable regulations include, but may not be limited to, the confined space standard (Part 1926.21(b)(6)(i) and (ii) in Subpart C); gases, vapors, fumes, dusts and mists (Part 1926.55 in Part 1926 Subpart E); fire protection and prevention (Part 1926 Subpart F); and trenching and excavation (Part 1926 Subpart P).

• If work in a confined space is required, personnel will comply OSHA’s confined space requirements for general industry, as promulgated in 29 CFR 1910.146 and Appendices A-F.

2.1.3 Methane Monitoring Training

The professional monitoring for combustible gases and oxygen will have a minimum of one year of experience with the operation, maintenance, and calibration of the hand-held meter being used, and be current with OSHA training requirements under 29 CFR 1910.120. Personnel will also be responsible for adherence to applicable state and local regulations regarding health and safety training.
2.2 Odors

In accordance with Part A.1.A of the CDPHE AQCC Regulation No. 2, and Article II of Chapter 4 of Denver’s Municipal Ordinance Code, areas used predominantly for residential or commercial purposes cannot be exposed to nuisance odors that can be detected after the odorous air has been diluted with seven (7) or more volumes of odor-free air. Chapter 4 also requires that odor mitigation measures be implemented if five or more complaints are received from nearby residences within a 12-hour period. Note – the 12-hour timeframe is currently being reevaluated by Denver and may be extended by the time the GLOP is implemented. If so, the longer timeframe will apply. In addition, the Respondent intends to be a good neighbor for area businesses and residents by mitigating odors that are determined by the Site Superintendent or Community Relations Officer to be overly obnoxious, regardless of the dilution-to-threshold (D/T) concentration. Therefore, in addition to normal odor control measures that will be implemented during GLOP construction, this MODCP has adopted triggers for additional control measures to enhance protection of site workers and the well-being of nearby communities. The triggers consist of:

- A D/T concentration method in accordance with Colorado Regulation No. 2 to measure odor concentrations at the Respondent’s property boundary within Operable Unit 2;
- A criterion for odor complaints received from nearby residences; and
- A judgement call as to whether the odor is overly obnoxious.

2.2.1 Odor Monitoring Methods

Odor concentration measurements will be conducted by certified personnel using a Barneby-Sutcliffe Scentometer or Nasal Ranger Field Olfactometer to assess odor intensity at the Denver property boundary and beyond it. Odor complaints will be monitored through use of a project hotline and Denver’s 311 call center. The degree of odor nuisance will be a subjective determination made by the Site Superintendent or Community Relations Officer. Accessory devices and supplies may include a two-way radio, cellular phone, compass, wind direction indicator, maps, and odor observation data sheets. Wind speed will be obtained from a hand-held anemometer.

2.2.2 Odor Monitoring Procedures

The following odor monitoring procedures will be implemented when excavating and handling waste material and “soil and debris” from the GLOP.

- Figure C-1 shows the OU-2 boundaries and boundaries of property owned by the Respondent within OU-2. Odor monitoring will occur along both the OU-2 and Respondent’s property boundaries, as well as public access (parking and walkways).
to the Denver Coliseum. Monitoring will occur at positions along these boundaries that are down-wind from open excavations, material stockpiles, and truck-loading operations. When determining the source of an odor, it will be necessary to record the presence/absence/detectability of the odor at both up- and down-wind locations.

- One odor reading will be taken at each designated stop. If an odor reading exceeds the 7/1 D/T factor for concentration, a second reading – timed at least 15 minutes apart but within the same 1-hour period – will be taken.

- The time, odor concentration, odor characteristics (type of odor), wind speed and direction, and meteorological conditions will be recorded at each monitoring location on an Odor Monitoring Form (Appendix C-1). Meteorological conditions that may affect odor detection include temperature and humidity. Even if odors are not detected, the time and wind direction will be recorded regardless of the presence of odors. Odor readings will be taken and recorded in the form of dilution factors 0, 2/1, 7/1, 14/1, 31/1, and 170/1. For example, a dilution factor of 14/1 represents one part of odor at the actual concentration present diluted with 14 parts of odor-free air. A 0 reading indicates a non-detect, and 170/1 indicates the highest dilution factor measured by this instrument.

- The odor characteristics may be a short list of words such as “rotten eggs, musty, ammonium etc.”

- All Odor Monitors will use the same log when recording data during the odor monitoring circuit. The log (Appendix C-1) includes space for the time, numerical codes for odor intensity, a space for odor characteristics, and a space for wind direction and weather conditions.

- If the odor intensity is 0 or “not detectable” then it is assumed that the odor characteristic is “N/A.” Results will be documented completely, even though it may seem repetitious.

- The Odor Monitor’s vehicle will be shut off so that exhaust fumes do not influence the ability to detect odors. Exhaust or dust from nearby vehicles should be cleared before conducting the odor monitoring at the location.

- At least two to three minutes will be spent at each stop on the odor monitoring circuit to allow for minor wind shifts that may transport odors either toward or away from the location.

- If the Odor Monitor discovers an odor that is attributable to GLOP activities, the Site Superintendent will be notified immediately.

- If residents or business representatives approach an Odor Monitor while conducting
the odor monitoring circuit, or approach the Site Superintendent or Community Relations Officer to complain about the odor at that location, the resident, business, or employee’s complaint will be documented by the Odor Monitor regardless if the Odor Monitor, Site Superintendent, or Community Relations Officer verifies the odor at that location. The number of complaints will be tracked by the Odor Monitor and will be reported to the Site Superintendent regularly, as well as when the number exceeds five within the time period specified in Article II of Chapter 4 of Denver’s Municipal Ordinance Code that is in effect at the time.

- As indicated above, odor characteristics such as “rotten eggs, musty, ammonium etc.” will be monitored by the Odor Monitor. Site workers will also monitor for these and other types of odors. If the Odor Monitor or Site workers detect an overly obnoxious and persistent odor, they will notify the Site Superintendent or Community Relations Officer and request a second opinion. If confirmed, the Site Superintendent will immediately increase the level of odor control measures, as discussed in Section 3.2

2.2.2.1 Background Monitoring

Prior to the start of excavation, the Respondent’s contractor will monitor odors up-wind and down-wind of the Respondent’s property within OU-2 (Figure C-1), and within the community Outreach area delineated on Figure C-2 to evaluate background conditions. These data will then be taken into consideration when evaluating odor concentrations along the OU-2 boundaries, within the Respondent’s property boundary, and within the Outreach area during GLOP construction. Background monitoring will be conducting utilizing the techniques described above. The data will be recorded on the same form discussed above (Appendix C-1) and will be available for public review.

2.2.2.2 Action Levels

Action levels consist of 1) detection of a nuisance odor at concentrations greater than a 7/1 D/T at the Respondent’s property boundary, 2) five or more community complaints received within the time period specified in Article II of Chapter 4 of Denver’s Municipal Ordinance Code that is in effect at the time, or 3) the on-site presence and persistence of an overly obnoxious odor. Any one of these conditions will trigger the need for additional odor control measures.

2.2.3 Odor Monitor Training

Odor Monitors must hold CDPHE certification as an Odor Monitor, which demonstrates that the individual is trained and certified to determine and grade odors in accordance with Regulation No. 2 and Denver’s Municipal Ordinance Code.
2.3 Fugitive Dust

In accordance with Sections III.D.2.b (Construction Activities) and III.D.2.c (Storage and Handling of Materials) of CDPHE AQCC Regulation No. 1, any owner or operator engaged in clearing or leveling of more than one (1) acre of land in a non-attainment area from which fugitive particulate emissions will be emitted, or the storage and handling of material from which fugitive emissions will be emitted, must use all available practical methods which are technologically feasible and economically reasonable to minimize such emissions. The 20% opacity and no off-property transport emission limitation guidelines apply to these activities.

In accordance with Article III of Chapter 4 of the DRMC, “no person shall allow or cause: (1) any materials to be handled, transported, or stored; (2) a building, including its appurtenances, or a construction haul road to be used, constructed, altered, repaired or demolished; or (3) any unenclosed activity, including demolition, excavation, backfilling, grading, clearing of land, construction or sandblasting without taking all reasonable measures as the department requires to prevent particulate matter from becoming airborne. All persons shall take reasonable measures to prevent the visible discharge of fugitive particulate emissions beyond the lot line of the property on which the emissions originate. The measures taken must be effective in the control of fugitive particulate emissions at all times on the site, including periods of inactivity such as evenings, weekends, and holidays as well as any other period of inactivity.”

Collectively, the State’s 20% opacity requirement and no off-property transport emissions limitation, and Denver’s “no visible discharge of fugitive particulate emissions beyond the lot line of the property” will be substantively addressed by monitoring for the visual presence of fugitive dust at the Respondent’s down-wind property boundary within OU-2, and by applying available, practical response actions that are technologically feasible and economically reasonable should fugitive dust be observed at that property boundary.

In addition, because the duration of GLOP construction and associated dust generation will extend for more than 6 months, the substantive requirements of an Air Pollution Emissions Notice (APEN) for fugitive dust emissions may be applicable. The Construction Contractor will be responsible for submittal of an APEN to the CDPHE Air Quality Control Division. See: https://www.colorado.gov/pacific/sites/default/files/AP_Air-Permits-Step-By-Step.pdf

2.3.1 Fugitive Dust Monitoring Procedures

Figure C-1 shows the Respondent’s property boundaries within OU-2. Wind direction will be continuously monitored and up-wind and down-wind property boundaries will be identified. A Fugitive Dust Monitor will visually observe for the presence of fugitive particulates crossing the down-wind property boundary. Should fugitive dust be observed, the Fugitive Dust Monitor will record the location, time, duration, characteristics (color, density, particle size, distribution), wind direction, and meteorological conditions on a Fugitive Dust Monitoring Form (Appendix C-1). The Fugitive Dust Monitor will then investigate the source of the emission. If visible dust is found to be originating from
construction activities, stockpiles, or any other GLOP source, the Site Superintendent will be notified immediately and the information will be recorded on the Monitoring Form. The Site Superintendent will then implement the appropriate corrective measures, as discussed in Section 3.3. If visible dust if found to be originating from an up-wind source, that information will be recorded on the Monitoring Form, the Site Superintendent will be notified for information purposes, and the Fugitive Dust Monitor will place the completed Form in the project file.

2.3.2 Fugitive Dust Monitor Training

Fugitive Dust Monitors must have successfully completed an EPA Method 9 Certification training course, or have worked under a professional with this certification and be familiar with the fundamental variables that influence fugitive dust observations.
3 RESPONSE ACTIONS

3.1 Combustible Gas

In the event that an LEL greater than 5% is detected anywhere on-Site, work in the source area will cease until the work area can be ventilated and the LEL decreases to 5% or less. Ventilation can be accomplished naturally, or with assistance using blowers or fans. If blowers of fans are to be used, their motors should be UL-listed explosion proof. Other response actions may consist of:

- Minimizing the exposed surface area of the gas-releasing material;
- Applying water to working faces of the excavations;
- Maximizing construction during periods of cooler weather (early mornings, late evenings, and nights); and
- Covering stockpiled material or the working face of an inactive excavation with soil, tarps, or foaming agents such as RusFoam OC 645 [http://www.rusmarinc.com/league/odor-and-emissions](http://www.rusmarinc.com/league/odor-and-emissions).

3.2 Odor

In the event that odor is measured at the down-wind property boundary at a value greater than a 7/1 D/T, five or more community complaints are received, or overly obnoxious and persistent odors are being released from GLOP implementation, operations believed to be contributing to the odor(s) will be identified and readily implementable response actions consisting of those listed above for combustible gas will be considered. Should odors and/or complaints persist, the Project Manager will be informed for further direction. Such direction will follow contingency measures and milestones that the Construction Contractor will have in place prior to mobilization to the Site, and that the Respondent will have pre-approved.

Contingency measures may require use of commercially available products and distribution systems. A vapor-phase essential oil-based counteractant (neutralizer) distributed in a high pressure fogging system may be the most applicable approach. The counteractants are specially formulated mixtures of chemical compounds in liquid form that are mixed or diluted with water and sprayed or fogged into the atmosphere to react with and reduce odorous compounds in the air.

Counteractant formulations vary widely between manufacturers or vendors, but virtually all counteractants contain essential oils that are derived from naturally occurring plant life, an emulsifying or wetting agent, a pH buffer, a preservative, and water. While counteractants are not “masking agents”, they often have a fragrance when concentrated because they are typically combinations of plant oils, such as lemon, lime, and other fragrant oils. A fragrance is sometimes added to odorless product formulations.
Counteractants are sold in two basic forms: (1) a “concentrated solution” usually in quart containers or 5-gallon pails, or (2) a diluted form “standard concentrations” in 55-gallon drums or totes. “Standard Concentration” counteractant formulations generally contain from 2 to 6% by weight of “active ingredients”.

Counteractant formulations are highly proprietary and their chemistries usually require a high quality source of water for dilution. The available potable water source should be adequate.

Most odor control product vendors also supply delivery systems. Delivery systems may consist of skid-mounted mixing and pumping units that can be mobilized to target source area(s), tractor mounted sprayers (used for small area application, such as a working face), back pack sprayers (used to treat “hot spots”), and fixed-based systems that deliver high-pressure mists to large working areas via overhead nozzles. For this project, all of these delivery options may be applicable. A specialty vendor shall be retained by the General Contractor to design and implement the most appropriate system, should one become necessary.

3.3 Fugitive Dust

In the event that visible fugitive dust originating from the Site is found to be crossing a Site boundary, the Fugitive Dust Monitor will notify the Site Superintendent immediately. Operations contributing to the release of fugitive dust will be curtailed or ceased until a response action can be implemented. Possible actions consist of:

- Slowing the rates of excavation, vehicular movement, or handling of loose material;
- Applying water to stockpiled material, open excavations, or materials being handled;
- Increasing the application rates of dust-control water on haul roads;
- Temporarily tarping staged or stockpiled material from which dust is originating;
- Vegetating material stockpiles that are staged for reuse at least 1 year in the future;
- Establishing localized wind-breaks; and
- Revegetating ground that has been final-graded as soon as practicable.
4 COMMUNICATIONS AND REPORTING

Effective communications and reporting procedures are critical for disseminating odor and fugitive dust monitoring results to parties that need to receive them. Appropriate parties must be made aware of results that indicate potentially adverse impacts to off-site populations. Similarly, real-time operational decisions may at times be based on timely and effective communication of monitoring results. This section addresses the mechanisms by which monitoring data and results are communicated to those in need of the information. This approach includes a flowchart to verify that the residents and/or businesses are responded to quickly and effectively.

All community-directed communication efforts will be made available in English and in Spanish.

Respondent will implement a community outreach effort that will focus on residential and commercial areas that may be affected by methane, odor, or fugitive dust conditions and other community impacts. The plan will communicate the following to stakeholders:

- The potential for methane, odors, and dust, and areas that may be affected;
- What means the contractor is taking to keep control these releases;
- Expected duration of possible releases; and
- Mechanisms for the stakeholders to get more information or voice concerns.

Stakeholders include commercial property owners and businesses, and residents within the Outreach area delineated on Figure C-2. Stakeholders will be informed through the communication vehicles listed below. Should complaints arise from areas beyond this Outreach area, additional stakeholder involvement and communications efforts will be developed and the Outreach area will be expanded. Such expanded Outreach will also be culturally relevant and communications will be in English and Spanish.

4.1 Communication Mechanisms

Several communication mechanisms will be provided, as discussed below.

Project Hotline

Callers with complaints, concerns or inquiries should first call the North Denver Cornerstone Collaborative Hotline at 720.865.2900.

Alternatively, callers may contact Denver’s 311 call center, which will direct the call appropriately, either to the Globeville Landing Outfall Project management team for general issues, or to Denver Environmental Health’s complaint system. Normal complaint response procedures will be followed for odor and/or fugitive dust complaints.
Fact Sheet

A general project Fact Sheet will be created that will outline the overall project, schedule for excavation and construction, community impacts (including odors and dust), phone numbers for non-emergency situations and to voice concerns and the website address. The fact sheet will describe the overall project and outline the possibility of odors and dust, means taken to minimize them, how they can get more information and can call with specific complaints to the Project Hotline or Denver 311. The fact sheet will be in both English and Spanish and will be provided to all residents and businesses within the Outreach area (Figure C-2) and beyond, as appropriate.

Personal Visits and/or Phone Calls

Respondent has already met with many local business and land owners surrounding the project to discuss the redevelopment impacts including odors and dust. All will be sent or given a Fact Sheet as well.

City of Denver Newsletter

The North Denver Cornerstone Collaborative newsletter will include information on the project and is published every month. It will include instructions for calling the Project Hotline, Denver 311, and project contacts.

4.2 Complaint Response Procedures

The following steps will be taken in response to complaints from residents and business owners in the Outreach area and beyond, as appropriate. As noted, above, callers with complaints, concerns or inquiries should call the Project Hotline or Denver’s 311 call center.

4.3 Routine and Special Reporting

Whenever the odor action level is exceeded, the Site Supervisor will be notified immediately by Odor Monitoring personnel so that appropriate mitigation actions can be directed to and implemented by the proper parties through the response chain of command. Quarterly summary reports documenting odor monitoring locations, times, and results, as well as meteorological conditions, will be prepared and submitted to the TCHD.

4.4 Data Reporting

Odor monitoring data will be maintained on-site. Data will typically be available to personnel involved in remediation and odor monitoring activities within one week. This
immediate access will allow project personnel to track any existing odors and their impact on operations, and allow for comprehensive quality control checks to be performed on the data.
5 REFERENCES


FIGURES
Appendix C-1
Monitoring Forms and Logs
### Odor Monitoring Log

**Personnel:**

**Date:**

<table>
<thead>
<tr>
<th>Time</th>
<th>Location</th>
<th>D/T</th>
<th>Odor Description</th>
<th>Odor Intensity (strong, med, light)</th>
<th>Notes</th>
</tr>
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<tbody>
<tr>
<td></td>
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<td>0</td>
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<td></td>
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<tr>
<td></td>
<td></td>
<td>170</td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

**Additional Comments:**

**Weather Conditions:**
- Sunny
- Partly Cloudy
- Mostly Cloudy
- Overcast
- Hazy

**Temperature:**

**Relative Humidity:**

**Precipitation:**
- None
- Fog
- Rain
- Sleet
- Snow

**Wind Direction (Blowing From):**
- NW
- N
- NE
- E
- SE
- S

**Wind Description:**
- Calm
- Light (1-5 mph)
- Moderate (5-15 mph)
- Strong (15+ mph)

**Wind Speed:**

**Signature:**

**Date:**
Odor Control and Response Complaint Form

Name of respondent:
Time and Date:
Location of Respondent:
Odor Description:

Questions:
Is there a detectable odor at the location?
Is the odor attributable to site materials handling operations?
Is the complaint location downwind from the site materials handling operations?
Is the odor not attributable to site materials handling operations?

Site Conditions:
Meteorological conditions:
Property boundary point of complaint:
<table>
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<tr>
<th>Source Name</th>
<th>Type of Source</th>
<th>Observation Date</th>
<th>Start Time</th>
<th>End Time</th>
<th>Comments</th>
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<table>
<thead>
<tr>
<th>Address</th>
<th>Sec 0</th>
<th>15</th>
<th>30</th>
<th>45</th>
<th>Minimum</th>
<th>Maximum</th>
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<table>
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<tr>
<th>City</th>
<th>State Zip</th>
<th>Phone (Key Contact)</th>
<th>Source ID Number</th>
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<tr>
<td></td>
<td></td>
<td>Process Equipment</td>
<td>Operating Mode</td>
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<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Control Equipment</td>
<td>Operating Mode</td>
<td>4</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>Describe Emission Point</td>
<td></td>
<td>5</td>
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<tr>
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<td></td>
<td>Height Above Ground Level</td>
<td>Height Relative to Observer</td>
<td>Inclinometer Reading</td>
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<td></td>
<td></td>
<td>Distance From Observer</td>
<td>Direction From Observer</td>
<td>Start</td>
<td>End</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Describe Emissions &amp; Color</td>
<td>Start</td>
<td>End</td>
<td>8</td>
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<tr>
<th>Visible Water Vapor Present? No Yes</th>
<th>Rec determined approximate distance from the start of the test to where the mass was read</th>
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<td>Point in Plume at which Opacity was determined</td>
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</tbody>
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<table>
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<th>Describe Plume Background</th>
<th>Background Color</th>
<th>Start</th>
<th>End</th>
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<td>Sky Conditions Start</td>
<td>End</td>
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<tr>
<td>Wind Speed</td>
<td>Wind Direction From Start</td>
<td>End</td>
<td>14</td>
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</tr>
<tr>
<td>Ambient Temperature</td>
<td>Wet Bulb Temp</td>
<td>RH percent</td>
<td>15</td>
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<td></td>
</tr>
</tbody>
</table>


I have received a copy of these opacity observations
Print Name
Signature
Print Observer's Name
Observer's Signature Date

Date Organization
Certified By Date
VISIBLE EMISSION OBSERVATION FORM

This form is designed to be used in conjunction with EPA Method 9, "Visual Determination of the Opacity of Emissions from Stationary Sources". Temporal changes in emission color, plume water droplet content, background color, sky conditions, observer position, etc., should be noted in the comments section adjacent to each minute of readings. Any information not dealt with elsewhere on the form should be noted under additional information. Following are brief descriptions of the type of information that needs to be entered on the form: for a more detailed discussion of each part of the form, refer to EPA's "Instructions for Use of Visible Emissions Observation Form" (EPA 340/1-86-017).

- **Source Name:** full company name, parent company or division or subsidiary information, if necessary.
- **Address:** street (not mailing or home office) address of facility where VE observation is being made.
- **Phone (Key Contact):** number for appropriate contact.
- **Source ID Number:** number from NEDS, agency file, etc.
- **Process Equipment, Operating Mode:** brief description of process equipment (include type of facility) and operating rate, % opacity, and/or mode (e.g., charging, tapping, shutdown).
- **Control Equipment, Operating Mode:** specify type of control device(s) and % utilization, control efficiency.
- **Describe Emission Point:** for identification purposes, stack or emission point appearance, location, and geometry; and whether emissions are confined (have a specifically designed outlet) or unconfined (fugitive).
- **Height Above Ground Level:** stack or emission point height relative to ground level; can use engineering drawings, Abney level, or clinometer.
- **Height Relative to Observer:** indicate height of emission point relative to the observation point.
- **Distance from Observer:** distance to emission point; can use rangefinder or map.
- **Direction from Observer:** direction plume is traveling from observer.
- **Describe Emissions and Color:** include physical characteristics, plume behavior (e.g., loop, lacy, condensing, fumigating, secondary particle formation, distance plume visible, etc.), and color of emissions (gray, brown, white, red, black, etc.). Note color changes in comments section.
- **Visible Water Vapor Present?** check "yes" if visible water vapor is present.
- **If Present, Is Plume...** check "attached" if water droplet plume forms prior to exiting stack, and "detached" if water droplet plume forms after exiting stack.
- **Point in Plume at Which Opacity was Determined:** describe physical location in plume where readings were made (e.g., 1 ft above stack exit or 10 ft, after dissipation of water plume).
- **Describe Plume Background:** object plume is read against, include texture and atmospheric conditions (e.g., lacy).
- **Background Color:** sky blue, gray-white, new leaf green, etc.
- **Sky Conditions:** indicate cloud cover by percentage or by description (clear, scattered, broken, overcast).
- **Wind Speed:** record wind speed; can use Beaufort wind scale or hand-held anemometer to estimate.
- **Wind Direction From:** direction from which wind is blowing; can use compass to estimate to eight points.
- **Ambient Temperature:** in degrees Fahrenheit or Celsius.
- **Wet Bulb Temperature:** can be measured using a sling psychrometer.
- **RH Percent:** relative humidity measured using a sling psychrometer; use local US Weather Bureau measurements only if nearby.
- **Source Layout Sketch:** include wind direction, sun position, associated stacks, roads, and other landmarks to fully identify location of emission point and observer position.
- **Draw North Arrow:** to determine, point line of sight in direction of emission point, place compass beside circle, and draw in arrow parallel to compass needle.
- **Sun's Location:** point line of sight in direction of emission point, move pen upright along sun location line, mark location of sun when pen's shadow crosses the observer's position.
- **Observation Date:** date observations conducted.
- **Start Time, End Time:** beginning and end times of observation period (e.g., 1635 or 4:35 p.m.).
- **Data Set:** percent opacity to nearest 5%; enter from left to right starting in left column. Use a second (third, etc.) form, if readings continue beyond 30 minutes. Use dash (-) for readings not made; explain in adjacent comment section.
- **Comments:** note changing observation conditions, plume characteristics, and/or reasons for missed readings.
- **Range of Opacity:** note highest and lower opacity number.
- **Observer's Name:** print in full.
- **Observer's Signature, Date:** sign and date after performing VE observation.
- **Organization:** observer's employer.
- **Certified By, Date:** name of "smoke school" certifying observer and date of most recent certification.

Indicates required by Reference 9; other items recommended.

The Division is providing this Visible Emission Observation Form pursuant to C.R.S. § 24-72-204(2)[a][i][x][i][j], without waiving the Investigatory files exemption of C.R.S. § 24-72-204[2][a][i][r] or any other applicable provision of C.R.S. § 24-72-204 for other records relating to your facility. This material does not reflect final agency action under the Administrative Procedure Act or Air Pollution Prevention and Control Act. This material does not create any rights in favor of third parties or impose any requirements upon the Division and is subject to revision at any time without notice to any third party.
APPENDIX D
Barrier Material Evaluations
January 15, 2016

Merrick & Company
2420 Alcott Street
Denver, Colorado 80211

Attention: Mike Galuzzi, PE and Jeanne Boyle, PE

Subject: Geotechnical Memorandum
Lined Channel within the Coliseum Parking Lot
Globeville Landing Outfall
Denver, Colorado
Project No. DN44,666.002-125

At your request, we are providing this letter containing additional geotechnical information relating to design of the lined channel for the Globeville Landing Outfall that will pass through the Denver Coliseum Parking Lot. The parking lot is underlain by an old municipal solid waste (MSW) landfill. Past performance of the Denver Coliseum Parking Lot has been poor, with uneven pavement and closed depressions that have formed due to differential settlement of the landfill. Our Supplemental Geotechnical Investigation for the 40th Street Outfall, Project No. DN44,666.002-125, last revision dated July 22, 2015 contains a discussion of ground improvement to reduce risk of poor performance of the channel and liner system. Additional clarification has been requested, including calculations supporting the ground improvement technique that was chosen by the design team, Vibro Stone Columns (VSC).

The new lined channel typical section is shown on Sheet EC-4 in the 30% Plans for Phase 1 of the project. The lined channel system initiates with a geogrid (Tensar TX-7) laid on prepared subgrade. Successive layers consist of 18 inches of crushed rock aggregate (ASTM C-33 No. 67), a 16-oz geotextile, the 60-mil LLDPE liner, a 10-oz geotextile, and about 3 to 4.5 feet of soil cover that supports the trickle channel. The channel bottom will be about 75 feet wide. The channel section raises elevation toward the edges, terminating with a concrete retaining wall to confine the 100-year flood. Required excavations are up to about 12 feet for the channel bottom, tapering up to a few feet at the edges. Subgrade consists of municipal solid waste (MSW) with intermittent soil cover. We understand the landfill has been in place for more than 50 years. Claystone bedrock is present about 7 to 10 feet below channel bottom. Groundwater in the landfill is about 1 to 2 feet above required excavation depth to install the liner system. Construction dewatering is planned to draw the water level down enough to install the liner system in reasonably dry conditions. Data leads us to assume for design that landfill is present for the entire interval between the excavation for the channel liner system and bedrock.
A key requirement for this project is to provide a reliable lined channel across the landfill that prevents co-mingling of groundwater and surface water. We understand the liner system is expected to perform well as long as it does not experience differential settlement of more than 6 inches. It is and has been our opinion that structures with normal settlement tolerances cannot be reliably built on an existing MSW landfill without ground modification, particularly a landfill mass that is only partially wet and thus degrades very slowly. Options for ground modification that were considered include removal of the landfill and replacement with a stable soil, likely a sand and gravel mixture. This remains the most positive solution from an engineering risk reduction standpoint but may be most costly. In our July 22, 2015 report, we discussed use of compaction grouting, a technique that includes vertical grout columns on a primary and secondary grid spacing to densify the soils as well as provide regularly-spaced, stiff support points for a structure. This method was chosen for the concrete culvert portion of the project. Another ground modification method consists of installing columns of coarse aggregate (stone) at a regular grid spacing to improve the stiffness of the soft ground when considered as a whole. The stone is vibrated and pushed into 24-inch diameter holes that extend down to the bedrock surface and up to the subgrade for the liner system. There are several proprietary methods for VSC and the system is usually installed on a design-build basis. This system has a benefit in that the gravel should not reduce permeability of the landfill mass, an environmental concern for the team. The VSC system is considered to be somewhat less reliable to improve a landfill when compared to compaction grouting because there is relatively less displacement and densification of the landfill mass, and the non-cohesive stone columns will ravel somewhat and follow as the landfill decomposes and settles. VSC reduces potential differential settlements of structures by increasing the stiffness or constrained modulus of the treated area. While VSC may be a less positive ground modification technique compared to soil replacement or compaction grouting, the method should result in enough improvement to give the liner system high reliability. Although VSC may not arrest or stop settlement, it will certainly reduce potential total and differential movements.

We contacted Hayward-Baker, an international ground improvement specialty contractor to help us evaluate the improvement that could be expected with VSC. They install VSC and suggested that most projects of this type would use an 8-foot square grid spacing. They performed a calculation (attached) that predicts the un-modified ground might settle 2.4 inches with the planned liner system, and only about ½ inch after ground improvement, with the VSC spaced at 8-feet. We performed a separate settlement analysis characterizing the channel as a square footing using the Schmertmann Method, and obtained a settlement of about 2.6 inches for the un-modified ground. Our calculations are also attached.

All calculations are sensitive to the accuracy or even conservativeness of the input parameters. The most important and least precisely known parameter for any soil is the stiffness or constrained modulus, usually referred to as a pressure required to compress a solid a certain amount. For landfill masses, constrained modulus is a combination of the behavior of decomposable trash (very soft) and the daily cover soil layers (very stiff). It is difficult or impossible to directly measure constrained modulus of such a
diverse material, so the value is typically estimated as an equivalent soft soil for which ranges of stiffness are published. Hayward-Baker chose a landfill modulus of 50,000 psf/ft (or 25 tcf) for their calculation, similar to materials that behave as a loose sand or medium stiff clay. We used a stiffness of 12,000 psf/ft (or 6 tcf) for our calculation and estimated a similar settlement with a different analysis method. Any calculation of settlement of a landfill has to make assumptions that characterizes decomposing organic materials as a soft soil, when in reality the landfill contains organics, non-decomposable debris and a significant amount of compacted soil. Therefore there are uncertainties that cannot be accounted for. Based only penetration resistance values, it is probable the actual stiffness of the landfill mass is more than we used to model it. We conclude the overall stiffness of the landfill materials will be improved substantially with VSC treatment and potential total and differential settlement will be reduced to a small fraction of the un-mitigated amount. We have confidence that the VSC treatment will provide a reliable substrate for the liner.

We believe this consultation was conducted with that level of skill and care normally used by geotechnical engineers practicing in this area at this time. No warranty, express or implied, is made. If we can be of further service in discussing the contents of this memorandum or in the analysis of the influence of the subsoil conditions on design of the structures, please call.

David A. Glater, P.E. C.P.G.
Principal Geological Engineer

DAG/nn
(1 copy)

Attachments: Settlement Calculations by Hayward Baker and CTL|Thompson, Inc.

Via e-mail:  michael.galuzzi@merrick.com
           Jeannne.boyle@merrick.com
Foundation Type: Spread Footing
Spread Footing Type: General Rectangular Footing
Spread Footing Length:
200.00 ft
Spread Footing Width:
200.00 ft
24,000,000 lbs
Spread Footing Total Load:
600 psf
Bearing Pressure:
2.50 ft
Vibro Pier Diameter:
625
Number of Vibro Piers per Footing:

Vibro Pier Length:
Surface Elevation:
Footing Elevation:
GWT Elevation:
Bottom Elevation:
Stone Unit Weight:
Stone Friction Angle:
Stone Constrained Modulus:

24.0
5166.0
5162.0
5154.0
5140.0
110.0
45.0
3,000,000

ft
ft
ft
ft
ft
pcf
degrees
psf

Soil Profile Input Data
Layer
Number

Soil
Type

1
2
3
4

SC
SC
SC
SC

Elevation of
Top of Layer
(ft)
5166.0
5162.0
5154.0
5146.0

Total
Unit Weight
(pcf)
115.0
115.0
120.0
120.0

Void
Ratio

Friction
Angle

Bottom
Elevation
(ft)
5164.0
5162.0
5160.0
5158.0
5156.0
5154.0
5152.0
5150.0
5148.0
5146.0
5144.0
5142.0
5140.0

Layer
Thickness
(ft)
2.00
2.00
2.00
2.00
2.00
2.00
2.00
2.00
2.00
2.00
2.00
2.00
2.00

Total Unit
Weight
(pcf)
115.0
115.0
115.0
115.0
115.0
115.0
120.0
120.0
120.0
120.0
120.0
120.0
120.0

Void
Ratio

Comp.
Index
Cc

Recomp.
Index
Cr

Max.
Past
Stress
(psf)

Cohesion
(psf)

Constrained
Modulus
(psf)
50,000
50,000
50,000
150,000

Comp.
Index

Recomp.
Index

OCR

Maximum
Past
Stress
(psf)

Poisson's
Ratio
0.35
0.35
0.35
0.35

Number of
Sublayers for
Calculations
2
4
4
3

Sublayer Soil Properties and Stresses
Sublayer
Number

Soil
Type

1
2
3
4
5
6
7
8
9
10
11
12
13

SC
SC
SC
SC
SC
SC
SC
SC
SC
SC
SC
SC
SC

Top
Elevation
(ft)
5166.0
5164.0
5162.0
5160.0
5158.0
5156.0
5154.0
5152.0
5150.0
5148.0
5146.0
5144.0
5142.0

Friction
Angle

Cohesion
(psf)

Constrained
Modulus
(psf)
50,000
50,000
50,000
50,000
50,000
50,000
50,000
50,000
50,000
50,000
150,000
150,000
150,000

Comp.
Index

∆H
(ft)

∆H
(inch)

0.000
0.000
0.024
0.023
0.023
0.022
0.022
0.022
0.021
0.021
0.007
0.007
0.007
0.198

0.00
0.00
0.29
0.28
0.27
0.27
0.26
0.26
0.25
0.25
0.08
0.08
0.08
2.37

Recomp.
Index

OCR

Maximum
Past
Stress
(psf)

Poisson's
Ratio

Dc/Ds

0.35
0.35
0.35
0.35
0.35
0.35
0.35
0.35
0.35
0.35
0.35
0.35
0.35

60.00
60.00
60.00
60.00
60.00
60.00
60.00
60.00
20.00
20.00
20.00

Soil
σv at
mid-layer
(psf)
115
345
575
805
1,035
1,265
1,438
1,553
1,668
1,783
1,898
2,013
2,128

∆s
(inch)

Settlement without VibroPiers
Sublayer
Number
1
2
3
4
5
6
7
8
9
10
11
12
13

Layer
Thickness
(ft)
2.00
2.00
2.00
2.00
2.00
2.00
2.00
2.00
2.00
2.00
2.00
2.00
2.00

Settlement with VibroPiers
Sublayer
Soil
Number
Type
1
2
3
4
5
6
7
8
9
10
11
12
13

Void
Ratio

SC
SC
SC
SC
SC
SC
SC
SC
SC
SC
SC
SC
SC

Constrained
Modulus
(psf)
50,000
50,000
50,000
50,000
50,000
50,000
50,000
50,000
50,000
50,000
150,000
150,000
150,000

ztop
(ft)

0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00
16.00
18.00
20.00

zbottom
(ft)

2.00
4.00
6.00
8.00
10.00
12.00
14.00
16.00
18.00
20.00
22.00

Initial
Vertical
Stress
(psf)
115
345
575
805
1,035
1,265
1,438
1,553
1,668
1,783
1,898
2,013
2,128

Layer
Thickness
(ft)
2.00
2.00
2.00
2.00
2.00
2.00
2.00
2.00
2.00
2.00
2.00
2.00
2.00

ΣW c
(psf)

ΣW s
(psf)

550
770
990
1,210
1,368
1,463
1,558
1,653
1,748
1,843
1,938

115
345
575
805
1,035
1,265
1,438
1,553
1,668
1,783
1,898
2,013
2,128

Vertical
Stress
Increase
(psf)
0
0
594
582
571
560
549
539
529
519
510
500
491
Totals:

Ac/A

Modified
Ac/A

pc/ps

pc
(psf)

0.077
0.077
0.077
0.077
0.077
0.077
0.077
0.077
0.077
0.077
0.077

0.076
0.076
0.076
0.076
0.076
0.076
0.076
0.076
0.075
0.075
0.075

7.654
7.654
7.654
7.654
7.654
7.654
7.654
7.654
7.645
7.645
7.645

3,048
3,048
3,048
3,048
3,048
3,048
3,048
3,048
3,063
3,063
3,063

fd

1.86
2.85
6.04
7.84
7.84
7.84
7.84
7.84
2.62
2.62
2.62

n2

(s/s∞)top

(s/s∞)bottom

∆s
(ft)

2.808
4.292
5.525
5.525
5.525
5.525
5.525
5.525
2.457
2.457
2.457

1.000
0.985
0.970
0.955
0.941
0.927
0.913
0.900
0.888
0.876
0.865

0.985
0.970
0.955
0.941
0.927
0.913
0.900
0.888
0.876
0.865
0.853
Totals:

0.008
0.005
0.004
0.004
0.004
0.004
0.004
0.003
0.003
0.002
0.002
0.044

0.10
0.06
0.05
0.05
0.05
0.04
0.04
0.04
0.03
0.03
0.03
0.52

Column
σv at
mid-layer
(psf)

550
770
990
1,210
1,368
1,463
1,558
1,653
1,748
1,843
1,938

Unit Cell
Area
(ft2)

64.00
64.00
64.00
64.00
64.00
64.00
64.00
64.00
64.00
64.00
64.00

Column
Area
(ft2)

4.91
4.91
4.91
4.91
4.91
4.91
4.91
4.91
4.91
4.91
4.91


**SCHMERTMANN METHOD FOR SETTLEMENT ANALYSIS - AXISYMMETRY (1978)**


**65-foot square footing, no ground improvement**

**FOR SQUARE FOOTINGS/MAT**

<table>
<thead>
<tr>
<th>LAYER</th>
<th>Z/B</th>
<th>Iz</th>
<th>DEPTH (FT)</th>
<th>DEL Z (FT)</th>
<th>N</th>
<th>RATIO</th>
<th>E (TSF)</th>
<th>D Z* Iz/E</th>
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<tr>
<td>1</td>
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<td>0.19</td>
<td>2.00</td>
<td>2.00</td>
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<td>2.00</td>
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<td>0.062812780</td>
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<tr>
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<td>0.28</td>
<td>4.00</td>
<td>2.00</td>
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<td>2.00</td>
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<td>0.092292226</td>
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<tr>
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<td>6.00</td>
<td>2.00</td>
<td>3</td>
<td>2.00</td>
<td>6</td>
<td>0.121771672</td>
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<tr>
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<td>0.40</td>
<td>0.45</td>
<td>8.00</td>
<td>2.00</td>
<td>3</td>
<td>2.00</td>
<td>6</td>
<td>0.151251118</td>
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<tr>
<td>5</td>
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<td>0.54</td>
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<td>2.00</td>
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<td>0.135547923</td>
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<td>0.51</td>
<td>11.00</td>
<td>2.50</td>
<td>60</td>
<td>20.00</td>
<td>200</td>
<td>0.006325570</td>
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<tr>
<td>7</td>
<td>0.70</td>
<td>0.47</td>
<td>15.00</td>
<td>4.50</td>
<td>60</td>
<td>20.00</td>
<td>200</td>
<td>0.010572738</td>
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<tr>
<td>8</td>
<td>0.80</td>
<td>0.43</td>
<td>20.00</td>
<td>22.25</td>
<td>80</td>
<td>20.00</td>
<td>200</td>
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<tr>
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<td>0.90</td>
<td>0.40</td>
<td>59.50</td>
<td>23.00</td>
<td>80</td>
<td>20.00</td>
<td>1600</td>
<td>0.005715604</td>
</tr>
<tr>
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<td>1.00</td>
<td>0.36</td>
<td>66.00</td>
<td>6.50</td>
<td>100</td>
<td>20.00</td>
<td>2000</td>
<td>0.001174749</td>
</tr>
<tr>
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<td>1.10</td>
<td>0.33</td>
<td>72.50</td>
<td>6.50</td>
<td>100</td>
<td>20.00</td>
<td>2000</td>
<td>0.001057274</td>
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<tr>
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<td>79.00</td>
<td>6.50</td>
<td>100</td>
<td>20.00</td>
<td>2000</td>
<td>0.000939799</td>
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<tr>
<td>13</td>
<td>1.30</td>
<td>0.25</td>
<td>85.50</td>
<td>6.50</td>
<td>100</td>
<td>20.00</td>
<td>2000</td>
<td>0.000822324</td>
</tr>
<tr>
<td>14</td>
<td>1.40</td>
<td>0.22</td>
<td>92.00</td>
<td>6.50</td>
<td>100</td>
<td>20.00</td>
<td>2000</td>
<td>0.000704849</td>
</tr>
<tr>
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<td>1.50</td>
<td>0.18</td>
<td>98.50</td>
<td>6.50</td>
<td>100</td>
<td>20.00</td>
<td>2000</td>
<td>0.000587374</td>
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<tr>
<td>16</td>
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<td>0.14</td>
<td>105.00</td>
<td>6.50</td>
<td>100</td>
<td>20.00</td>
<td>2000</td>
<td>0.000469899</td>
</tr>
<tr>
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<td>1.70</td>
<td>0.11</td>
<td>111.50</td>
<td>6.50</td>
<td>100</td>
<td>20.00</td>
<td>2000</td>
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<tr>
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<td>0.07</td>
<td>118.00</td>
<td>6.50</td>
<td>100</td>
<td>20.00</td>
<td>2000</td>
<td>0.000234950</td>
</tr>
<tr>
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<td>124.50</td>
<td>6.50</td>
<td>100</td>
<td>20.00</td>
<td>2000</td>
<td>0.000117475</td>
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<td>0.00</td>
<td>131.00</td>
<td>3.25</td>
<td>100</td>
<td>20.00</td>
<td>2000</td>
<td>0.000000000</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>SOIL TYPE</th>
<th>E / N (TSF)</th>
</tr>
</thead>
<tbody>
<tr>
<td>SILT, SANDY SILT, COHESIVE SILT-SAND MIX</td>
<td>5.00</td>
</tr>
<tr>
<td>CLEAN TO SL. SILTY, FINE AND MEDIUM SAND</td>
<td>8.75</td>
</tr>
<tr>
<td>COARSE SAND AND SAND WITH LITTLE GRAVEL</td>
<td>12.50</td>
</tr>
<tr>
<td>SANDY GRAVEL AND GRAVEL</td>
<td>15.00</td>
</tr>
</tbody>
</table>

PERIOD IN YEARS FOR WHICH THE SETTLEMENT IS TO BE CALCULATED = 1.00

INCREASE IN EFFECTIVE OVERBURDEN AT FOOTING LEVEL FROM TOTAL LOAD (PSF)= 605.00

INCREASE IN EFFECTIVE OVERBURDEN AT FOOTING LEVEL FROM DEADLOAD (PSF)= 559.91

INCREASE IN EFFECTIVE OVERBURDEN AT FOOTING LEVEL FROM LIVE LOAD (PSF)= 45.09

C1, DEPTH EMBEDMENT FACTOR = 0.92

C2, EMPIRICAL CREEP FACTOR = 1.20

ESTIMATED SETTLEMENT DUE TO DEADLOAD (INCH) = 2.38

ESTIMATED SETTLEMENT DUE TO LIVE LOAD (INCH) = 0.19

ESTIMATED SETTLEMENT DUE TO TOTAL LOAD (INCH) = 2.57

References:

August 1978 & May 1970 ASCE Geotechnical Journals, Table 7.1 P236 Ronald Scott "Foundation Analysis", & Table 5.5, P90, Simons & Menzies
Mr. Tim Shangraw  
Engineering Management Support, Inc.  
7220 West Jefferson Ave., # 406  
Lakewood, Colorado 80235  

September 25, 2015

RE: Technical Memorandum – VB/I70 Channel Lining  
Geomembrane Lining System Design Recommendations

Project Background

R. K. Frobel & Associates has been retained by Engineering Management Support, Inc. (EMSI) to assist in the design of the geomembrane lining system proposed for the VB/I70 project. In particular, R. K. Frobel & Associates was tasked to review the current design, design considerations, drawings, geotechnical data, groundwater data, design basis memorandums and reports in an effort to provide guidance in design options and geomembrane system selection for the channel lining. This report is focused on the evaluation of various geomembrane systems acceptable for this project based on review of site conditions, subsurface geology and soil conditions, channel design, construction considerations, and discussions with EMSI.

Introduction

It is understood that the VB/I70 channel lining will encompass approximately 140,000 sq. ft. of lined area located in the Denver Coliseum Parking Lot and Globeville Landing Park. A synthetic geomembrane lining system will be installed under the channel area to prevent excessive seepage loss of water through the bottom and side slopes of the channel as well as to prevent below grade contaminated water from infiltrating the channel section. This memorandum discusses the alternative types of geomembranes considered for this project.

Site Soils and Subsurface Conditions

The Geotechnical Investigation and Boring Logs provided by EMSI were reviewed as part of this work. The geotechnical report and in particular data from borings within the channel section indicates that the soils within the Coliseum Parking Lot excavation area are generally decomposed organics and very soft soils with little compressive strength. The waste deposits are subject to further decomposition and potential settlement. It was determined that due to potential settlements, the channel lining subsoils should be stabilized and dewatered prior to installation of a geomembrane lining system. Soil stabilization options are being evaluated by CTL Thompson and dewatering options are being evaluated by EMSI.

According to the geotechnical report, groundwater was detected in the channel lining area generally at elevation 5156 ft. which may also be subjected to seasonal fluctuation. However, static and fluctuating water levels at or near the channel bottom can be expected. In this regard, no permanent groundwater drainage is recommended as long as
the bottom portion of the geomembrane lining system is ballasted with a minimum of 3.0 to 4.0 ft. of cover soils to counteract groundwater uplift potential. Additionally, sub-soils type and waste deposits will generate gas under the liner. Also, air movement under the liner may occur due to groundwater rise and/or future groundwater fluctuation. In this regard, it is advisable to install a gas/air transmission layer directly under the geomembrane in the form of a geotextile (as a minimum) on the bottom and side slopes with gas vents at the top of slope. Gas vents should be spaced at 50 ft. intervals at the upper slope perimeter of the channel lining.

**Currently Available Geomembrane Materials**

Geosynthetics is a fully accepted design alternative for civil engineering projects and includes a myriad of materials used in Civil Engineering and Geotechnical Engineering. According to ASTM D4439 “Terminology for Geosynthetics”, a geosynthetic is “a planar product manufactured from polymeric material used with soil, rock, earth or other geotechnical engineering related material as an integral part of a man-made project, structure, or system”.

Geosynthetics include a wide variety of types of flexible, polymeric materials commonly referred to by generic names such as geomembranes, geotextiles, geonets, geonet composites, geomats, geocells, geogrids, geosynthetic clay liners, geocomposites, and geopipe. Geosynthetics can also include discrete elements such as polymeric fibers or yarns, which are mixed with soil for soil improvement and geosynthetics can also be made up of materials that are not synthetic polymers but rather biodegradable fibers and fabrics such as jute. Geosynthetics can also be made up of a combination of polymeric or synthetic sheet or fiber and natural material (ie erosion control products and geosynthetic clay liners). In any case, the term “geosynthetic” is the generic name for all man-made polymeric and/or polymeric/natural combinations used in geotechnical engineering applications. The following is a brief overview of the most prominent type of geosynthetic used in water retention, waste or hydrotechnical applications, namely geomembranes. A number of other geosynthetics are also used in hydrotechnical applications and are usually a compliment to geomembranes. Most prominent are nonwoven geotextiles, geonet composites, geocomposites (geomembrane/geotextile combinations), geogrids and geocells. Details of all other types of geosynthetics can be found in publications such as Dr. Robert M. Koerner’s book entitled “Designing with Geosynthetics”, Fifth Edition (2005).

**Geomembranes**

Geomembranes by definition are “an essentially impermeable geosynthetic composed of one or more synthetic sheets” ASTM (2014). Thus, these materials are made up of a “membrane” which generally denotes something thin and flexible and which is used primarily for the purposes of waterproofing or liquid containment. Geomembranes were the first geosynthetic with applications (other than dams) dating back to the 1940’s in canal and small reservoir containments. The earlier (now deprecated) terminology refers to Flexible Membrane Liners (FML’s), pond liners, synthetic liners or simply plastic...
liners. In any event the primary use was in waterproofing of a structure or containment of liquids. As nothing is impermeable, geomembranes are commonly referred to as “very low permeability” synthetic membranes. In comparison to a low permeability soil with $10^{-7}$ cm/s hydraulic conductivity (CCL), a geomembrane’s calculated hydraulic conductivity will range from $10^{-10}$ to $10^{-14}$ cm/s. Geomembranes are manufactured in sheet form from synthetic polymers which generally range in thickness from 20 mil to over 120 mil. Examples of polymers and their acronyms that are the most common to today’s geomembranes are as follows:

- High Density Polyethylene (HDPE)
- Linear Low Density Polyethylene (LLDPE)
- Polyvinyl Chloride (PVC)
- Ethylene-Propylene Diene Monomer (EPDM)
- Chlorosulfonated Polyethylene (CSPE) or Hypalon
- Flexible Polypropylene (fPP)

In addition to the base polymer for which the geomembrane is named, all geomembranes contain additives which perform a myriad of functions. The additives range from simple carbon black (for UV protection) to complicated antioxidant packages used to reduce the effects of oxidation on aging. Other additives are used for processing (processing aides) while some are fillers (inert particles such as clay) to decrease cost or improve production. One common example of an additive is plasticizers which provide the flexibility in PVC (commonly referred to as PVC-soft). Additives range in polymer compound proportion from less than 2% to over 40% depending on the base product. Table 1 provides the generic range of formulations for the most common geomembrane types.

**Table 1. Types of Geomembranes and Percentage Formulations (Koerner, 2005)**

<table>
<thead>
<tr>
<th>Type</th>
<th>Resin</th>
<th>Plasticizer</th>
<th>Fillers</th>
<th>Carbon Black</th>
<th>Additives</th>
</tr>
</thead>
<tbody>
<tr>
<td>HDPE</td>
<td>95-98</td>
<td>0</td>
<td>0</td>
<td>2-3</td>
<td>0.25-1</td>
</tr>
<tr>
<td>LLDPE</td>
<td>94-96</td>
<td>0</td>
<td>0</td>
<td>1-3</td>
<td>0.25-4</td>
</tr>
<tr>
<td>fPP</td>
<td>85-98</td>
<td>0</td>
<td>0-13</td>
<td>2-4</td>
<td>0.25-2</td>
</tr>
<tr>
<td>PVC</td>
<td>50-70</td>
<td>25-35</td>
<td>0-10</td>
<td>2-5</td>
<td>2-5</td>
</tr>
<tr>
<td>CSPE</td>
<td>40-60</td>
<td>0</td>
<td>40-50</td>
<td>5-10</td>
<td>5-15</td>
</tr>
<tr>
<td>EPDM</td>
<td>25-30</td>
<td>0</td>
<td>20-40</td>
<td>20-40</td>
<td>1-5</td>
</tr>
</tbody>
</table>

Some geomembranes are reinforced with a fabric internal to the sheet which results in a three layer composite (two layers of polymer sheet with a middle layer of fabric or scrim) that is highly resistant to tearing, tensile stress, expansion/contraction and puncture. Geomembranes of base material such as CSPE (commonly referred to as Hypalon) and PBGM are always reinforced whereas HDPE, LLDPE, fPP, EPDM, and PVC are reinforced as an option for additional strength and dimensional stability depending on the application. Fabric reinforcement is referred to as “scrim reinforcement” and is a woven fabric of polyester or polypropylene. Polymer geomembranes that are reinforced are
commonly referred to with an “R” in their abbreviations such as CSPE-R, PVC-R, EPDM-R, fPP-R, RPE.

In addition to geomembranes with scrim reinforcement, there are geomembranes with surface configurations that increase surface roughness (friction), provide an integral drain or provide protrusions for embedment in concrete or soil. These geomembranes are commonly manufactured with polyethylene polymers (HDPE, LLDPE) and are either produced by blown film extrusion or by extruded calendared profiles (structured geomembranes). Manufacturing techniques generally consist of the following descriptive processes which are discussed in detail in Koerner (2005):

- **Blown Film Extrusion Process** – HDPE, LLDPE, fPP in widths to 23 ft
- **Extruded Profile Calendared Process** – HDPE, LLDPE in widths to 23 ft
- **Calendared Process** – CSPE-R, fPP, fPP-R, PVC in widths to 10 ft
- **Spread Coating Process** – PBGM

In addition to manufactured roll goods, all geomembranes produced from the calendared process in narrow widths (such as PVC, fPP, fPP-R and CSPE-R) are further fabricated in a fabrication plant into large panels. The geomembranes produced in wide rolls up to 23 ft. width such as HDPE and LLDPE are transported directly to the construction site in roll sizes up to 11,500 sq. ft. for 60 mil thick sheet whereas the prefabricated panels produced from narrow roll goods must first be assembled, folded and rolled for transport to the construction site. However, prefabricated panel sizes can be quite large dependent on weight and handling. Typical maximum size for prefabricated panels is 30,000 sq. ft. for 30 to 40 mil thick sheet. Prefabricated panels can be designed specific for a site configuration and shape in order to minimize field seaming.

In general, all of the geomembrane types shown above have and are being used in hydrotechnical applications and water containment in general. Specifically the following are the primary types and thickness ranges recommended for use in hydrotechnical applications such as water reservoirs, WWTP ponds, industrial waste storage and canals:

- **HDPE** 60 – 100 mil
- **LLDPE** 40 – 100 mil
- **fPP** 40 – 60 mil
- **EPDM** 45 - 60 mil
- **CSPE-R** 36 – 45 mil
- **fPP-R** 36 - 45 mil

Any of the above geomembranes can be selected dependant on specific design considerations and relative costs. To increase life expectancy, it is advisable to cover a polymeric geomembrane with soil or protective ballast. Materials such as PVC are always soil covered. All of the above materials will age well in covered applications and life expectancies can be estimated 50 to 100 years. Exposed applications will decrease the life expectancy due to environmental attack (UV, ozone, oxidation, stress, etc).
Design Considerations for the VB/I70 Channel Lining System

In addition to the obvious driving force of providing an economical seepage barrier, several other design and construction considerations must be evaluated for the system to be efficiently installed and to work effectively for the long term as a seepage barrier. The following are design considerations for the VB/I70 Channel Lining:

Life Expectancy in a Soil Covered Environment. One of the most detrimental effects on all polymers is exposure to environmental stress, UV, temperature extremes, oxidation and mechanical action. Life expectancy for exposed lining material is usually less than 20 years. A soil covered lining system will increase life expectancy to > 50 years and in this regard, any of the above polymers could be considered for the channel lining.

Mechanical Properties and Thickness. The Channel lining system will be subjected to construction installation stress as well as potential movements due to subsidence over time. A non-reinforced geomembrane of minimum 60 mil thickness is required to provide requisite tensile, tear and puncture resistance and stability on 3H:1V side slopes. Additionally, due to subsidence potential, a geomembrane that will allow movement without rupture is recommended. Scrim reinforced geomembranes and HDPE (due to low strain to yield) are not recommended.

Groundwater and Waste Contaminants. Although the relatively low concentrations of groundwater and waste by products will not degrade most of the polymeric geomembranes, it is recommended that a Polyethylene based liner such as HDPE or LLDPE be used to resist any future exposure to low level hydrocarbons or VOC’s. These materials are also commonly used in contaminated sites.

Slope Stability and Interface Shear. Non reinforced materials such as HDPE, LLDPE and fPP are highly resistant to mechanical damage and are designed for use in severe climatic conditions as well as exposure to contaminated groundwater. However, in consideration of soil cover placement, interface shear with geotextiles and general slope stability considerations long term, a textured geomembrane will be required. In this regard, a textured LLDPE geomembrane is recommended (LLDPE-T).

Anchor Trench Perimeter Connection. The anchor trench detail will reflect a minimum 24 inch deep by 18 inch wide trench to accommodate the geomembrane and geotextile. The anchor trench will be set back from the top of slope a minimum of 3.0 ft. This size will also provide requisite pullout resistance once backfilled with soil and compacted to 95% SPD. Maximum stress on the liner will occur during installation and potential wind uplift. Positive anchorage and temporary ballast with sandbags must be provided during installation.

Intimate Contact With Substrates. The geomembrane system design will require as much intimate contact (surface to surface) between the liner and subsoil or geotextile as possible. Thus, a geomembrane that exhibits a high degree of flexibility without excessive wrinkling would be highly desirable. Additionally, once installed, the
geomembrane should lay down (lay flat) without excessive wrinkles even during extremes in temperature fluctuation and in particular during soil cover placement. An LLDPE geomembrane will provide less expansion/contraction and greater flexibility during installation than for example HDPE.

**Installation Efficiency.** In concert with the requirements for being installed without damage and without excessive wrinkling, the design must consider efficiency during installation. This requirement encompasses not only the size of panel or roll but also the type of field seaming and QC requirements. The LLDPE geomembrane roll goods can be delivered to the site in 22.5 ft wide rolls and seamed cross channel from anchor trench to anchor trench. Weld type will be a double fusion weld with air channel to effectively QC test each weld using air pressure.

**Concrete Connection Details.** The geomembrane must be mechanically attached to the concrete penetrations or any structures. It is understood that there will be concrete box culverts and structures as shown on the plans. It is recommended that any pipe be constructed with a concrete collar. In this regard, the geomembrane will be connected to the concrete with conventional stainless steel batten bar and bolts. A typical detail for a flat run-on mechanical connection is attached to this memo as figure 1. Also shown is an optional vertical connection detail (figure 2) for other types of concrete wall or footing connections.

**Field CQA and Electrical Leak Location Testing.** The final product will be a relatively leak free lining system. However, all synthetic lining systems leak to some extent. The number of holes, open seam areas, general damage, etc. will determine the leakage rate from the installation. In this regard, the more efficient QC procedures for geomembrane installation will provide assurance that the owner will be provided with a geomembrane system that works with minimal seepage. Thus, the QC and CQA methods and procedures must be standard and cost effective. It is suggested that the entire lining area be tested by conventional Electrical Leak Location Survey (ELLS) technology once in place using standard ASTM methods. The geomembrane material must be compatible with ELLS methods and procedures.

**Alternative Geomembranes Considered in the Final Design**

In consideration of the above design considerations and based on personal and industry experience in design of large and small impoundments and channel lining systems, the following geomembrane polymer types and thicknesses were considered for final design:

1. 60 mil HDPE-T
2. 60 mil LLDPE-T
3. 40 mil fPP

Table 2 summarizes the alternative geomembrane types considered and comparative properties based on design/construction considerations. Additionally, economic factors for estimated material and installation cost are presented based on currently available
information provided by manufacturers and fabricators. Once the project is released for bid purposes, pricing will change but relative pricing should remain the same.

Table 2

**ALTERNATIVE GEOMEMBRANE COMPARATIVE PROPERTIES**

<table>
<thead>
<tr>
<th>Design/Construction Consideration</th>
<th>HDPE</th>
<th>LLDPE</th>
<th>fPP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minimum Thickness (mil)</td>
<td>60 (1.5mm)</td>
<td>60 (1.5mm)</td>
<td>40 (1.0mm)</td>
</tr>
<tr>
<td>Specific Gravity (density)</td>
<td>0.93 g/cc</td>
<td>0.915 g/cc</td>
<td>0.90 g/cc</td>
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<tr>
<td>Maximum Panel Size (sf)</td>
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<td>11,500</td>
<td>25,000</td>
</tr>
<tr>
<td>Install Rate (sf/day/crew)</td>
<td>50,000</td>
<td>50,000</td>
<td>75,000</td>
</tr>
<tr>
<td>Large Panel Fabrication</td>
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<td>No</td>
<td>Yes</td>
</tr>
<tr>
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<td>Thermal</td>
<td>Thermal</td>
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<tr>
<td>Field Seam Test</td>
<td>Air Channel</td>
<td>Air Channel</td>
<td>Air Channel</td>
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<tr>
<td>(100% of Seam)</td>
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<td></td>
<td></td>
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<tr>
<td>Electrical Leak Testing (100% of Area)</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Conventional CQA</td>
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<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Conventional Attachment to Structures</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
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<tr>
<td>Prior Use – Waste Sites</td>
<td>Yes</td>
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<td>Yes</td>
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<tr>
<td>Intimate Contact Substrate</td>
<td>Poor</td>
<td>Good</td>
<td>Good</td>
</tr>
<tr>
<td>Resistance to Settlements</td>
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<td>Good</td>
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<tr>
<td>Textured Option</td>
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<tr>
<td>Mechanical Properties:</td>
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<tr>
<td>Tensile Strength</td>
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<td>High</td>
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<tr>
<td>Flexibility</td>
<td>Stiff</td>
<td>Good</td>
<td>Excellent</td>
</tr>
<tr>
<td>Thermal COE (Wrinkling)</td>
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<td>Low</td>
<td>Low</td>
</tr>
<tr>
<td>Puncture Resistance</td>
<td>High</td>
<td>High</td>
<td>Moderate</td>
</tr>
<tr>
<td>Soil Cover Durability</td>
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<td>Excellent</td>
<td>Excellent</td>
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<tr>
<td>Stress Crack Potential</td>
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<td>None</td>
<td>None</td>
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<tr>
<td>Life Expenctancy Buried</td>
<td>&gt; 50 years</td>
<td>&gt; 50 years</td>
<td>&gt; 50 years</td>
</tr>
<tr>
<td>Specific Project Warranty:</td>
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<td></td>
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<tr>
<td>Material Only</td>
<td>20 yr</td>
<td>20 yr</td>
<td>20 yr</td>
</tr>
<tr>
<td>Installation</td>
<td>1 - 2 yr</td>
<td>1 - 2 yr</td>
<td>1 – 2 yr</td>
</tr>
<tr>
<td>Economic Factors:</td>
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<tr>
<td>Material $/sf</td>
<td>0.90</td>
<td>0.95</td>
<td>0.75</td>
</tr>
<tr>
<td>ELLS $/sf</td>
<td>0.02</td>
<td>0.02</td>
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</tr>
</tbody>
</table>

Notes: NA = Not Applicable; ELLS = Electrical Leak Location Survey
Summary Recommendations

During the design phase, the decision was made to provide a low permeability channel lining system to prevent excessive seepage out of the I70/VB channel as well as to prevent contaminated groundwater from entering the channel section. Based on review of geotechnical boring logs, groundwater and soils sampling analysis, preliminary design documentation and design considerations, as well as considerations in this report, the following is recommended:

- The geomembrane lining system must cover the channel lining area as required on the design drawings and will be tied into the upper perimeter soils with an anchor trench.
- The geomembrane lining system shall be a 60 mil thick LLDPE-T in consideration of the above factors and in particular potential for subsidence, slope stability and interaction with subsurface waste components.
- The lining system should be installed on a minimum 16 oz/sy non woven needle-punched geotextile to provide separation, protection from puncture and abrasion as well as gas/air transmission under the liner. Additionally, the geotextile provides a clean working surface for geomembrane installation (better QC)
- A protection layer of minimum 10 oz/sy non woven needle-punched geotextile should be incorporated over the LLDPE-T geomembrane for protection from soil cover placement.
- Top of slope perimeter gas vents at 50 ft intervals are recommended.
- Concrete attachment as shown on the attached figures is recommended for concrete structures.
- The lining system installation should be subjected to strict QC guidelines and specifications as regards material selection, placement, geomembrane installation seaming and testing.
- The final lining system CQA should incorporate Electrical Leak Location Survey (ELLS) over 100% of the lined channel area.

References


VB/I70 Channel Lining - Geotechnical Investigation and Design Alternatives, EMSI 2015

Data Summary Report – Environmental Conditions Investigation
VB/I70 Operable Unit # 2 Removal Action
EMSI 2015
Concrete Structure Attachment Details

Notes:

1. Anchor bolts shall be 3/8 inch X 4 ½ inch (min) 316 Stainless Steel
2. Nuts and Washers shall be 316 Stainless Steel.
3. Batten Bar shall be ¼ inch X 2 inch wide 316 Stainless Steel with elongated holes set for 6 inch O.C.
4. Sealing Strip (top, under batten bar) shall be 1/8 inch X 2 inch vulcanized rubber.
5. Sealing Tape (bottom, under geomembrane) shall be 1/8 inch X 2 inch Butyl preformed tape.
6. Sealant shall be Sikaflex 1A Polyurethane (or approved equal).
8. Concrete edge shall be chamfered and smooth.
9. Soil at edge of concrete shall be compacted to min 95% SPD

Figure 1. Concrete Structure Attachment – Flat Run-on (Preferred Method)
Notes:
Same notes as figure 1 except:

1. Provide 45 degree support at edge of wall – all soil compacted to min 95% SPD.

**Figure 2.** Concrete Structure Attachment – Vertical Wall
APPENDIX E
Groundwater Modeling Studies
INTRODUCTION

This technical memorandum describes the numerical groundwater flow modeling that was performed by Itasca Denver, Inc. (Itasca), on behalf of Environmental Management Support, Inc. (EMSI), for the Globeville Landing Outfall Project (GLOP) Construction Dewatering Study. The purpose of this groundwater modeling study was to estimate the rates and duration of dewatering that will be required prior to construction of storm-water drainage infrastructure at the project site.

The groundwater model was calibrated to measurements of site groundwater levels, which were assumed to represent steady-state conditions. Subsequently, the calibrated model was modified to account for the anticipated pre-construction stabilization ground work. The model was then used in transient mode to simulate four dewatering scenarios involving various configurations of subsurface interceptor drains and/or pumping wells; the goal for this was to dewater the construction area to specific targeted depths in the shortest amount of time. Based on the modeling results—which include hydrographs of groundwater elevations, dewatering rates, and the spatial distribution of dewatering times—the best option was identified.

A sensitivity analysis of the groundwater model’s prediction of dewatering rates to the hydraulic conductivity ($K$) parameter indicated that the simulated flow rates moderately depended on the assumed value of $K$. This finding indicates that confidence in the model’s dewatering predictions may be improved by verifying the modeling assumptions for $K$ with site-specific testing data.
DESCRIPTION OF NUMERICAL MODEL

A three-dimensional (3-D) numerical groundwater flow model was developed to simulate groundwater conditions in the vicinity of Denver Coliseum and Globeville Landing Park. The model domain includes the Denver Coliseum, its parking lot, the Globeville Landing Park, the Pepsi Bottling Group property, and other developed properties along Brighton Boulevard, north of the Pepsi property and south of the Denver Coliseum (Figure 1). The model domain coincides with the South Platte River to the west, I-70 and 44th Street to the north, and Brighton Boulevard and 38th Street to the south.

Pertinent aspects of the model are as follows:

1) The numerical modeling code used in this study is MODFLOW-SURFACT, version 4 (HGL 2011), which is an enhanced version of the U.S. Geological Survey’s 3-D finite-difference groundwater flow code, MODFLOW (McDonald and Harbaugh 1988).

2) The model simulates saturated groundwater flow in the natural soils and fill materials above the bedrock surface. The claystone bedrock is assumed to be impermeable and forms the base of the model domain.

3) The model grid consists of 73 rows, 93 columns, and 10 layers, and it has 32,201 active cells (Figure 2). The size of each cell is 30 feet by 30 feet horizontally. Model layers are horizontal and are typically five feet thick; however, some cell thicknesses are less than that in certain areas due to variations in the land surface and top-of-bedrock elevations across the site.

4) The hydrogeologic units in the model represent the natural soils and fill material that are present between the land surface and the top of bedrock. The hydrogeologic units were specified on the basis of historical land-use information (e.g., approximate landfill limits), site well logs (Merrick & Company 2015; EMSI 2015), measured groundwater levels, and interpreted groundwater hydraulic gradients.

Conceptually, the hydrogeologic units are subdivided into one of two types of natural soil and one of three types of fill material. One soil unit is assigned to the Globeville Landing Park area, and the other unit is assigned in places where natural soil occurs in the remainder of the model domain. The three types of fill material were defined on the basis of their depositional locations and their inferred hydraulic characteristics. One unit was assigned to the fill in the Denver Coliseum parking lot, another was assigned to the fill in Globeville Landing Park, and the other was assigned to the fill along Brighton Boulevard. The assumed thickness and distribution of fill were based on site boring logs (Merrick & Company 2015; EMSI 2015). A separate hydrogeologic unit was assigned to the model cells corresponding to the sanitary sewer lines, which are expected to impede groundwater flow; thus, those cells were assigned very low K values.
Figure 3 shows the modeled distribution of the hydrogeologic units at the land surface. Attachment A provides maps showing the distribution of the hydrogeologic units for each model layer.

5) Site-specific measurements of the hydraulic properties of the hydrogeologic units are not available. As a result, plausible ranges of the property values, based on published literature (Reddy et al. 2009; University of Southampton 2015) and professional judgment, were considered and used to constrain the initial estimates of model parameters. The initially assigned parameter values were refined during calibration of the steady-state model and remained within plausible limits at the end of the calibration.

6) The hydraulic boundaries of the model are shown in Figure 2. Three types of boundary conditions are used; they include specified-head boundaries, which are assigned along the South Platte River and at Brighton Boulevard; a head-dependent flux boundary, which is specified along the I-70 portion of the model domain; and specified-flux (no-flow) boundaries, which are used at 44th Street and 38th Street. Collectively, these boundary conditions act to represent regional groundwater flow from the south beneath Brighton Boulevard and direct it to the north and the west, where it ultimately discharges to the South Platte River.

7) Two zones are used to simulate groundwater recharge from the infiltration of precipitation in open-ground portions of the study area (Figure 3). Recharge Zone 1 includes Globeville Landing Park and the area north of the park and east of the river, as well as three small unpaved areas along Brighton Boulevard. The prescribed recharge rate in Zone 1 is 0.063 inch per year, or 0.4 percent (%) of the average annual precipitation in Denver (15.6 inches per year). Recharge Zone 2 represents the open areas (drainage ditch) along McFarland Drive on the south side of the Coliseum parking lot, which collect some of the runoff from the road and parking lot. The modeled recharge rate in Zone 2 is 1.25 inches/year, or 8% of the annual precipitation. Paved areas within the model domain receive no recharge. Evapotranspiration is considered to be negligible and, thus, is not included in the model.

8) In the lowest parts of the planned storm-water drainage system, shortly before it discharges to the South Platte River, the construction activities will require dewatering down to the top of bedrock; it will be necessary to maintain fully dewatered conditions in this reach during the installation of the concrete box culverts and the outfall structure adjacent to the river. It was assumed that vertical sheet piles would be driven into the bedrock in that area and used to limit water inflow from the river and the surrounding areas into the construction zone.

9) Two steady-state models were created. The first model was used for calibration purposes and simulates the current groundwater conditions prior to any ground improvements or other changes at the site; it is referenced as “the calibrated steady-
state model." The second model modifies the calibrated model and simulates steady groundwater conditions after the planned subsurface stabilization improvements (i.e., vibro piers™ and compaction grouting) in the Coliseum parking lot have been completed. The ground improvements will alter the conditions of the fill and native soil beneath the parking lot and change its bulk permeability; therefore, a new set of hydraulic property values is assigned to the stabilized areas in the second model (as discussed below). The second steady-state model was used to generate new steady groundwater levels, which define the initial hydraulic heads for the predictive dewatering simulations; consequently, this model is referenced as "the initial conditions model."

10) The predictive dewatering simulations involved converting the initial conditions model to transient mode, assigning appropriate storage parameter values to the hydrogeologic units, and specifying starting heads from the steady-state initial conditions model run.

CALIBRATION OF MODEL

The steady-state model calibration was based on measured groundwater levels at 19 monitored locations (Figure 4). The reported water levels were assumed to be at equilibrium under pre-construction conditions. Other factors that were considered in the model’s calibration included the overall directions/pattern of groundwater flow and the water budget for the model domain. During the model calibration, the properties of the hydrogeologic units, their spatial distributions, and the boundary conditions were adjusted through an iterative manual-calibration process. The final hydraulic property values that were used in the model are listed in Table 1. Figure 5 illustrates the simulated groundwater elevations in the calibrated steady-state model.

The quality of a groundwater model calibration is typically judged by several statistical parameters, including the mean error (ME), mean absolute error (MAE), root-mean-squared error (RMSE), normalized RMSE (ratio of RMSE to the observed range of hydraulic heads), and the coefficient of determination ($r^2$). For perfect calibrations, the RMSE, MAE, and ME tend to zero, whereas $r^2$ tends to one. The coefficient of determination measures the linear relationship between simulated and measured hydraulic heads; the closer $r^2$ is to 1.0, the better the fit between the measured and modeled data. The RMSE is a measure of the spread of residuals (differences between simulated and measured values). If the normalized RMSE is small, typically less than 10 to 15%, it is generally an indication of a “good” calibration. Table 2 provides calibration statistics for the steady-state model, all of which are considered to be good and indicate that a satisfactory calibration was achieved. In particular, the normalized RMSE equals 0.04 (4%), which is less than the 10 to 15% threshold that is considered indicative of a good calibration, and the correlation between measured and simulated water levels is excellent ($r^2 = 0.98$).
Results of the steady-state calibration are illustrated in two figures; Figure 6 compares simulated and measured water levels for all of the calibration targets and Figure 7 shows the spatial distribution of calibration residuals.

**GROUND IMPROVEMENT BEFORE DEWATERING OPERATION**

Prior to dewatering, ground improvements will be made in the part of the Denver Coliseum parking lot where the drainage system will be installed. The area directly beneath the open channel part of the system will be stabilized using vibro piers™ (aggregate piers), whereas the upstream area beneath the box culverts will be stabilized with compaction grouting to improve support conditions. Due to the fact that the stabilization operations will change the bulk hydraulic properties of the subsurface materials, the property values were adjusted in the model based on the expected changes. It was assumed that the installation of vibro piers™ would increase the hydraulic conductivity of the natural soil in that area by approximately one order of magnitude, relative to the calibrated steady-state model conditions, whereas in the upstream area of compaction grouting, the hydraulic conductivity will decrease by approximately one order of magnitude. Specifically, for the area with vibro piers™, the horizontal hydraulic conductivity \( K_h \) and vertical hydraulic conductivity \( K_v \) values were assigned as 2.5 and 0.25 feet per day (ft/d), respectively, and the specific storage \( S_s \) and specific yield \( S_y \) parameters were set at \( 2 \times 10^{-5} \) per foot (ft\(^{-1}\)) and 0.25 (unitless), respectively. For the areas of compaction grouting, the values of \( K_h, K_v, S_s \), and \( S_y \) were specified as 0.025 ft/d, 0.0025 ft/d, \( 2 \times 10^{-5} \) ft\(^{-1}\), and 0.20, respectively.

The steady-state initial conditions model that incorporated these changes was used to generate a new groundwater flow field after the installation of vibro piers™ and compaction grouting. Figure 8 shows contours of the modeled groundwater elevations after the ground improvements have been made. The new groundwater levels constitute the initial hydraulic heads that were used in the transient simulations of pre-construction dewatering.

**PREDICTIVE DEWATERING SIMULATIONS**

The area that is to be dewatered prior to construction of the storm-water drainage system is subdivided for modeling purposes into four zones: 1, 2, 3a, and 3b (Figure 8). Open channels will be constructed in Zones 1, 3a, and 3b, whereas concrete box culverts will be installed in Zone 2. At the time of this study, it is anticipated that the other segments of the planned drainage system upstream from Zone 3b will be built above the water table; therefore, they will not require pre-construction dewatering.

The drainage system in Zones 3a and 3b will be installed on top of a basal geogrid layer. The geogrid will be in contact with the top of the vibro piers™ in Zone 3b. The targeted dewatering depth is the same as that of the geogrid layer in Zone 3b, and the depth in Zone 3a is one foot below the geogrid layer. In Zones 1 and 2, dry conditions for construction will be required down
to the top-of-bedrock surface, which is the targeted dewatering depth in those zones. To facilitate dry working conditions, it was assumed that vertical sheet piles would be installed cross-ways to the drainage channel at the upstream end of Zone 2 and at the downstream end of Zone 1 (at the river) and also laterally along both sides of Zone 2; thus, the simulated dewatering of Zones 1 and 2 was within a rectangular box formed by the sheet piles, with lateral openings in the box along both sides of Zone 1. The sheet piles were represented in the model by using the Horizontal Flow Barrier (HFB) package for MODFLOW.

Figure 9 shows longitudinal cross-section lines (whose locations are shown in Figure 8) along the two branches (Zones 3a and 3b) of the drainage system, illustrating the vertical relationship of various features that are pertinent to the dewatering discussion. The cross sections show the land surface, the modeled water table prior to dewatering, the geogrid layer, the targeted dewatering depths, the elevations of modeled drains, and the bedrock surface.

Four dewatering options were considered and simulated using the model; they are as follows:

- **Option A** – Single subsurface drain, a longitudinal drain line centered below the open channel, the box culvert, and the outfall segments;
- **Option B** – Parallel subsurface drains, two to three side-by-side longitudinal drain lines spaced approximately 30 feet apart beneath the dewatering-area footprint;
- **Option C** – Lateral subsurface drains, two longitudinal drain lines located along the perimeter of the dewatering-area footprint; and
- **Option D** – Pumping wells, a series of shallow (approximately 15 to 30 feet deep) pumping wells located along the perimeter of the dewatering-area footprint.

The performance of each dewatering option was evaluated based on the simulated dewatering rates and the temporal changes in groundwater levels that resulted from each option. The options were variably successful in dewatering the construction area to the targeted depths in a reasonable amount of time (within four months). The modeling showed that Option B (parallel subsurface drains) produced the best results because it was the only option that achieved the dewatering objectives within a reasonable amount of time; thus, the Option B model simulation and its results are discussed in detail in the section that immediately follows, whereas the simulations and results of the other three options are only briefly summarized in the subsequent section.
PARALLEL SUBSURFACE DRAINS (OPTION B)

MODEL SETTINGS

Option B simulated multiple (maximum of three) parallel drain lines that were installed approximately four feet beneath the geogrid layer in Zone 3a, approximately three feet below the geogrid layer in Zone 3b, and along the top-of-bedrock surface in Zones 1 and 2. The layout of the modeled drain lines is illustrated in Figure 10. The dewatering was accelerated with this configuration of subsurface drains, relative to either Option A or Option C. The use of multiple drain lines was particularly important in Zone 3a in order to achieve reasonable dewatering times in the assumed lower permeability soil and fill in Globeville Landing Park.

Subsurface drains were represented in the model by using the Drain (DRN) package for MODFLOW. The simulated drain elevations are shown in Figure 9. The drain elevations gradually decrease toward the South Platte River and are coincident with the top-of-bedrock surface in Zones 1 and 2. The modeled drains are at elevations of 5138.5 to 5150.0 feet above mean sea level (ft amsl) and fall within model layers 8, 9, and 10. The drain conductance parameter (C) was set to a moderately high value (C = 250 square feet per day) so that there was minimal resistance to the flow of water between the surrounding soils and drain lines. The model drains remove water from the groundwater system wherever they occur. In practice, however, the subsurface drain lines will be constructed with riser pipes at appropriate intervals to allow pumping access for the removal of water that flows into the drain lines.

All drains were activated concurrently at the beginning of the transient simulation. The model calculated the flow rate into each drain based on differences between the hydraulic heads of the surrounding soils and the drain lines and on the assigned properties (C and stage) of the drain cells.

RESULTS

To ensure that the entire construction area is appropriately dewatered, a dewatering target elevation was established for each model cell within the footprint of that area (i.e., within the four dewatering zones). The cells were tracked through time to determine when the groundwater table reached the target elevations. Attachment B provides a map that identifies the cells that were tracked and hydrographs of the water levels in each of those cells.¹ On the basis of the modeling results that are shown in Attachment B, a map of the anticipated times to dewater the construction area was prepared and is presented as Figure 11. Dewatering Zones 1 and 2 and parts of Zones 3a and 3b are predicted to be dewatered within one week.

¹ Note that in Figures B-2a through B-2c of Attachment B, the dewatering zones (1, 2, 3a, and 3b) are each further subdivided into three distinct groups of hydrographs to avoid overcrowding the graphs and to facilitate the interpretation of the data. For example, the title Zone 3a-2 means that the set of hydrographs are within group 2 of Dewatering Zone 3a.
areas along the perimeter of Zone 3b required two to four weeks to dewater, and the longest time to dewater (8 to 10 weeks) occurred in the upper-most reach of Zone 3a.

The modeled weekly average dewatering rates are shown in Figure 12. The average rate in the first week is approximately 40 gallons per minute (gpm). The dewatering rate decreases with time as the hydraulic heads in the overlying and surrounding areas are lowered and the corresponding hydraulic gradients that drive the inflow to the drains diminish. Table 3 summarizes the results of the dewatering simulation using parallel subsurface drains. The table includes a summation of the total volume of water that would be drained from each zone in order to reach the targeted dewatering elevations (note that these volumes do not include any flows that occur after the targeted elevations are reached). The results indicate that a total volume of approximately 1,007,500 gallons would be produced to achieve the pre-construction dewatering objective.

**OTHER DEWATERING OPTIONS (A, C, AND D)**

**MODEL SETTINGS**

The simulated drain layouts for Options A and C and the locations of pumping wells in Option D are shown in Figure 13. Option A consists of drain cells along the centerline of the drainage system, whereas Option C has the drain cells located along the outside (lateral) edges of the dewatering zones. The drain cell properties for Options A and C were the same as those used in Option B.

Option D simulated 21 pumping wells located along the perimeter of the dewatering-area footprint. The modeled well-screen intervals were 5 to 10 feet long, and their bottom elevations varied slightly between locations. In some cases, the bottoms of the well screens were in contact with the top-of-bedrock surface. The wells were simulated using the Fracture Well (FWL4) package for MODFLOW-SURFACT. A feature of the FWL4 package is that it does not allow a well to be over-pumped; as such, if the prescribed pumping rate is higher than the simulated well can sustain, given the available flow of water to the well, then the FWL4 package automatically reduces the pumping from the well to a sustainable rate.

**RESULTS**

For Option A, the average dewatering rate was approximately 21 gpm during the first week and decreased with time thereafter. The groundwater levels in Zone 3b were lowered to the target elevations within two months; however, the groundwater levels in Zones 1, 2, and 3a did not reach the target elevations within four months, due to slow drainage into the single drain line. For Option C, the weekly average drain rate varied from 32 to 4 gpm over the simulation period. As with Option A, the groundwater levels in Zone 3b were lowered to below the target...
elevations (in this case, within 40 days); however, the groundwater levels in Zones 1, 2, and 3a did not reach the target elevations within four months.

For Option D, the simulated pumping wells collectively withdrew water at more than 45 gpm during the first week, and the rate decreased with time. The effects of the pumping wells were similar to those of the drains in Options A and C, in that Option D was effective only in Dewatering Zone 3b. Due to thin saturated thickness (less than 10 feet) in Zones 1, 2, and parts of 3a, and the lower $K$ in those zones, the radii of influence of the wells in those zones were limited to a small distance and, consequently, the groundwater levels decreased slowly at many locations.

**SENSITIVITY ANALYSIS**

**MODEL SETTINGS**

Four model test cases were run to evaluate the sensitivity of the model’s predicted dewatering rates to the specified hydraulic conductivity values. $^2$ Option B, previously discussed, was used as the base case for the sensitivity test. The test consisted of multiplying the base case $K_h$ and $K_v$ values (in order to maintain a consistent anisotropy ratio) by multipliers of 0.1, 0.5, 2, and 10, corresponding to Cases 1, 2, 3, and 4, respectively, and then comparing the simulated weekly average dewatering rates from each case. The tested $K_h$ and $K_v$ values are listed in Table 4. The specified ratio of $K_h:K_v$ in the areas of the vibro piers™ and compaction grouting was 10:1.

**RESULTS**

The dewatering rates for the base case and the four test cases are presented in Figure 14. Increasing $K_h$ and $K_v$ by one order of magnitude resulted in approximately a two-and-one-half times increase in the predicted dewatering rate. Conversely, decreasing $K_h$ and $K_v$ by one order of magnitude resulted in dewatering rates that were approximately one half of the values generated in the base case simulation.

The changes to the hydraulic conductivity parameter that were made in the test cases also affected the modeled dewatering times. For Case 1, Dewatering Zones 1 and 2 were dewatered within a week; however, many of the targets in Zones 3a and 3b were not fully dewatered within four months. For Case 2, the dewatering of Zone 3a took up to four months, and the dewatering of Zone 3b required approximately 45 days. For Cases 3 and 4, the dewatering times increased in Zones 1 and 2, whereas the times to dewater Zones 3a and 3b decreased. The dewatering times for Case 3 were approximately 15, 30, 34, and 14 days for Zones 1, 2, 3a,

---

$^2$ Hydraulic conductivity typically is one of the most sensitive hydraulic parameters (along with recharge) that governs the flow of groundwater in shallow unconfined aquifers.
and 3b, respectively. For Case 4, dewatering took approximately 15, 28, and 8 days for Zones 1, 2, and 3a, respectively, and less than a week for Zone 3b.

The findings of the sensitivity test indicate that the simulated flow rates moderately depended on the assumed value of $K$. This suggests that confidence in the model’s dewatering predictions may be improved by verifying the modeling assumptions for $K$ with site-specific testing data.

**CONCLUSIONS**

Based on the results of the groundwater flow modeling study described in this technical memorandum, Itasca concludes the following:

1) Among the four modeled dewatering options, the parallel subsurface drains configuration (Option B) produced the best results; it was the only option that achieved the dewatering objectives within a reasonable amount of time.

2) For Option B, the model predicted that much of the pre-construction dewatering area would be dewatered within one week, and that the longest time to dewater would be approximately 10 weeks in the slowest draining part of Zone 3a.

3) The predicted maximum weekly average dewatering rate under Option B is approximately 40 gpm, with most of the water being produced by Zones 3a and 3b. The total volume of water removed to achieve the pre-construction dewatering objective is approximately 1,007,500 gallons under Option B.

4) The simulated dewatering rates moderately depended on the assumed value of $K$, which suggests that confidence in the model’s dewatering predictions may be improved by verifying the modeling assumptions for $K$ with site-specific testing data.

**REFERENCES**

EMSI. 2015. Personal communication (email) between Timothy Shangraw (Engineering Management Support, Inc.) and Dan Stone (Itasca Denver, Inc.), 28 August.


University of Southampton. 2015. Hydraulic conductivity of landfilled waste. [https://landss.soton.ac.uk/waste_k](https://landss.soton.ac.uk/waste_k) (accessed 28 August 2015).

Attachments:  Figure 1 - Groundwater Model Study Area

Figure 2 - Map View of Model Grid and Boundary Conditions

Figure 3 - Modeled Distributions of Hydrogeologic Units and Recharge at Ground Surface

Figure 4 - Groundwater Wells Used in Steady-State Model Calibration

Figure 5 - Simulated Steady-State Groundwater Elevations

Figure 6 - Comparison of Simulated and Observed Groundwater Levels

Figure 7 - Spatial Distribution of Model Calibration Residuals

Figure 8 - Pre-Construction Dewatering Zones and Modeled Groundwater Levels After Installing Vibro Piers™ and Compaction Grouting

Figure 9 - Cross Sections Along Dewatering Zones

Figure 10 - Simulated Locations of Parallel Subsurface Drains (Option B)

Figure 11 - Modeled Times to Dewater Construction Areas (Option B)

Figure 12 - Modeled Weekly Average Dewatering Rates (Option B)

Figure 13 - Map view of Other Dewatering Options (A, C, and D)

Figure 14 - Results of Sensitivity Test of Horizontal Hydraulic Conductivity Parameter

Table 1 - Modeled Hydraulic Property Values of Hydrogeologic Units

Table 2 - Steady-State Model Calibration Statistics

Table 3 - Summary of Dewatering Simulation Using Parallel Subsurface Drains

Table 4 - Horizontal Hydraulic Conductivities for Sensitivity Test

Attachment A - Hydraulic Parameter Zones in Model Layers

Attachment B - Hydrographs of Dewatering Targets
Groundwater Model Study Area

Legend
- Sanitary Sewer
- Concrete Box Culvert
- Limits of Fill Material Within the Coliseum Parking Lot
- Study Area
- Boundary

CLIENT: EMSI Engineering Management Support, Inc.

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BY AJ
CHECKED DBS
DRAWN AEM
DRAWING NAME DCHSA_Location
DRAWING DATE Oct. 22, 2015
REVISION DATE

Groundwater Model Study Area

Sanitary Sewer
Concrete Box Culvert
Limits of Fill Material Within the Coliseum Parking Lot
Study Area
Boundary
Map View of Model Grid and Boundary Conditions

Legend

- Sanitary Sewer
- Concrete Box Culvert
- Limits of Fill Material Within the Coliseum Parking Lot
- Study Area Boundary
- Active Cell
- General Head
- Specified Head
- Inactive Cell

Engineering Management Support, Inc. (EMSI)

CLIENT: EMSI
FIGURE NO. 2

PROJECT NO. 4029
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DRAWING DATE Oct. 22, 2015
REVISION DATE
Groundwater Wells Used in Steady-State Model Calibration

Legend
- Sanitary Sewer
- Groundwater Wells
- Concrete Box Culvert
- Limits of Fill Material Within the Coliseum Parking Lot
- Study Area Boundary

CLIENT: EMSI Engineering Management Support, Inc.

FIGURE NO. 4

Groundwater Wells Used in Steady-State Model Calibration

PROJECT NO. 4029
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DRAWN AEM
DRAWING NAME DCHSA_SSTargets
DRAWING DATE Oct. 22, 2015
REVISION DATE
Simulated Steady-State Groundwater Elevations

Legend
- Concrete Box Culvert
- Limits of Fill Material Within the Coliseum Parking Lot
- Study Area Boundary
- Sanitary Sewer
- Simulated Steady-State Water-Level Contours (1-ft Interval)
Comparison of Simulated and Observed Groundwater Levels

\[ R^2 = 0.976 \]
Spatial Distribution of Model Calibration Residuals

Legend
- Concrete Box Culvert
- Limits of Fill Material Within the Coliseum Parking Lot
- Study Area Boundary
- Sanitary Sewer
- Residual (ft)

G:\ARCGIS\DenverColiseum\DCHSA_Residuals.mxd

S. Platte River
W. Brighton Blvd
E. Brighton Blvd
44th St
28th St
20th St

0 410 820 Feet

PROJECT NO. 4029
BY AJ
CHECKED DBS
DRAWN AEM
DRAWING NAME DCHSA_Residuals
DRAWING DATE Oct. 22, 2015
REVISION DATE

CLIENT: EMSI Engineering Management Support, Inc.

FIGURE NO. 7
Pre-Construction Dewatering Zones and Modeled Groundwater Levels After Installing Vibro Piers™ and Compaction Grouting
Simulated Locations of Parallel Subsurface Drains (Option B)

Legend
- Sanitary Sewer
- Cross Section Line
- Dewatering Zone
- Concrete Box Culvert
- Limits of Fill Material Within the Coliseum
- Parking Lot
- Study Area Boundary

Drain Cells
- Zone 1
- Zone 2
- Zone 3a
- Zone 3b

SCALE: 0 180 360 Feet

PROJECT NO. 4029  
CHECKED DBS  
DRAWN AEM  
DRAWING NAME DCHSA_DrainLines  
DRAWING DATE Oct. 23, 2015  
REVISION DATE  

CLIENT: EMSI Engineering Management Support, Inc.  
FIGURE NO. 10

S. Plate River
Modeled Times to Dewater Construction Areas (Option B)

Legend

- **Sanitary Sewer**
- **Cross Section Line**
- **Dewatering Zone**

- **Concrete Box Culvert**
- **Limits of Fill Material Within the Coliseum Parking Lot**
- **Study Area Boundary**

**Dewatering Times**
- 1 Week
- 2 Weeks
- 3 Weeks
- 4 Weeks
- 5 - 7 Weeks
- 8 - 10 Weeks

**Legend**

- **Sanitary Sewer**
- **Cross Section Line**
- **Dewatering Zone**

**Dewatering Times**
- 1 Week
- 2 Weeks
- 3 Weeks
- 4 Weeks
- 5 - 7 Weeks
- 8 - 10 Weeks
Modeled Weekly Average Dewatering Rates (Option B)

Drain rate (gallon per minute)

Time (week)

Zone 1  Zone 2  Zone 3a  Zone 3b

Denver, Inc.

ITASCA™

Management Support, Inc.
Map View of Other Dewatering Options (A, C, and D)
Results of Sensitivity Test of Horizontal Hydraulic Conductivity Parameter

**Graph Description:**
- The graph shows the drain rate (gpm) over time (Week) for different cases.
- The x-axis represents time in weeks ranging from 0 to 20.
- The y-axis represents drain rate in gallons per minute (gpm) ranging from 0 to 120.
- There are five cases labeled as Case 1, Case 2, Case 3, Case 4, and Base Case.

**Legend:**
- Black line: Base Case
- Blue line: Case 1
- Red line: Case 2
- Green line: Case 3
- Purple line: Case 4

**Key Observations:**
- Case 1 shows the highest drain rate initially, dropping sharply and stabilizing around Week 10.
- Case 2 follows a similar trend but with a lower initial rate.
- Case 3 starts with a moderate drain rate, decreasing gradually over time.
- Case 4 exhibits a gradual and consistent decrease in drain rate.
- Base Case has a stable and slow drain rate throughout the duration.

This graph is useful for understanding the effectiveness of different cases in managing hydraulic conductivity in a given scenario.
**TABLE 1**

Modeled Hydraulic Property Values of Hydrogeologic Units

<table>
<thead>
<tr>
<th>Hydrogeologic Units</th>
<th>Hydraulic Conductivity (ft/d)(^1)</th>
<th>Specific Storage, (S_s) (ft(^{-1}))</th>
<th>Specific Yield, (S_y)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Horizontal, (K_h)</td>
<td>Vertical, (K_v)</td>
<td></td>
</tr>
<tr>
<td>Natural Soil in Globeville Landing Park</td>
<td>0.03</td>
<td>0.01</td>
<td>0.00002</td>
</tr>
<tr>
<td>Natural Soil in Denver Coliseum Parking Lot and the Surrounding Areas</td>
<td>0.25</td>
<td>0.03</td>
<td>0.00002</td>
</tr>
<tr>
<td>Fill in Denver Coliseum Parking Lot</td>
<td>2.00</td>
<td>0.20</td>
<td>0.00005</td>
</tr>
<tr>
<td>Fill in Globeville Landing Park</td>
<td>0.10</td>
<td>0.01</td>
<td>0.00005</td>
</tr>
<tr>
<td>Fill near Brighton Blvd</td>
<td>1.50</td>
<td>0.15</td>
<td>0.00005</td>
</tr>
<tr>
<td>Segments with Sanitary Sewer Lines</td>
<td>0.00001</td>
<td>0.001</td>
<td>0.000001</td>
</tr>
</tbody>
</table>

Note:
\(^1\)Based on steady-state model calibration.
TABLE 2

Steady-State Model Calibration Statistics

<table>
<thead>
<tr>
<th>Statistic</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of Targets</td>
<td>19</td>
</tr>
<tr>
<td>Observed Range in Head (ft)</td>
<td>16.23</td>
</tr>
<tr>
<td>Minimum Residual (ft)</td>
<td>-0.87</td>
</tr>
<tr>
<td>Maximum Residual (ft)</td>
<td>0.90</td>
</tr>
<tr>
<td>Mean Error (ft)</td>
<td>-0.15</td>
</tr>
<tr>
<td>Mean Absolute Error (ft)</td>
<td>0.60</td>
</tr>
<tr>
<td>Root-Mean-Squared Error (ft)</td>
<td>0.63</td>
</tr>
<tr>
<td>RMSE/Head Range</td>
<td>0.04</td>
</tr>
<tr>
<td>Coefficient of Determination ($r^2$)</td>
<td>0.98</td>
</tr>
</tbody>
</table>
### TABLE 3

Summary of Dewatering Simulation Using Parallel Subsurface Drains

<table>
<thead>
<tr>
<th>Dewatering Zone</th>
<th>Existing Ground Surface Elevation (feet amsl)</th>
<th>Existing Water Table Elevation (feet amsl)</th>
<th>Target Elevation for Dewatering (feet amsl)</th>
<th>Depth Water Table is to be Lowered (feet)</th>
<th>Simulated Drain Elevation (feet amsl)</th>
<th>Approximate Drain Depth Below Existing Grade (feet)</th>
<th>Time to Dewater to Target Elevation (days)</th>
<th>Weekly Average Dewatering Flow Rates (gallons per minute)</th>
<th>Volume Removed to Dewater to Target (gallons)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 South Platte to Box Culvert Outlet</td>
<td>5142.0 - 5167.7</td>
<td>5140.8 - 5150.4</td>
<td>5138.5 - 5141.0</td>
<td>2.3 - 9.4 (Avg. 5.8)</td>
<td>5138.5 - 5141.0</td>
<td>4 - 27 (Avg. 19)</td>
<td>5</td>
<td>5.8</td>
<td>41,500</td>
</tr>
<tr>
<td>2 Box Culvert Outlet to Top of Vertical Pipe</td>
<td>5164.9 - 5174.0</td>
<td>5150.4 - 5155.2</td>
<td>5142.5 - 5145.5</td>
<td>7.5 - 9.9 (Avg. 8.8)</td>
<td>5142.5 - 5145.5</td>
<td>22 - 30 (Avg. 29)</td>
<td>7</td>
<td>5.7</td>
<td>57,100</td>
</tr>
<tr>
<td>3a Open Channel in Globeville Landing Park</td>
<td>5161.3 - 5179.8</td>
<td>5154.9 - 5156.5</td>
<td>5151.0 - 5152.0</td>
<td>2.9 - 5.5 (Avg. 4.5)</td>
<td>5148.0 - 5149.0</td>
<td>12 - 31 (Avg. 27)</td>
<td>65</td>
<td>13.8</td>
<td>480,600</td>
</tr>
<tr>
<td>3b Open Channel in Coliseum Parking Lot</td>
<td>5164.0 - 5169.3</td>
<td>5155.9 - 5156.5</td>
<td>5152.0 - 5153.0</td>
<td>3.2 - 4.2 (Avg. 3.6)</td>
<td>5149.0 - 5150.0</td>
<td>14 - 20 (Avg. 16)</td>
<td>41</td>
<td>16.3</td>
<td>428,300</td>
</tr>
<tr>
<td>Conduit in Coliseum Parking Lot</td>
<td>No Dewatering Required</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
# TABLE 4

## Horizontal Hydraulic Conductivities for Sensitivity Test

<table>
<thead>
<tr>
<th>HUGs and Multiplier</th>
<th>Dewatering Option B</th>
<th>Sensitivity Analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Case 1</td>
</tr>
<tr>
<td>Multiplier for (K_h)</td>
<td>1</td>
<td>0.1</td>
</tr>
</tbody>
</table>

**Zone and Magnitude of Horizontal Hydraulic Conductivity, \(K_h\) (ft/d)**

<table>
<thead>
<tr>
<th>HUGs and Multiplier</th>
<th>Dewatering Option B</th>
<th>Sensitivity Analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Case 1</td>
</tr>
<tr>
<td>Natural Soil in Globeville Landing Park</td>
<td>0.03</td>
<td>0.003</td>
</tr>
<tr>
<td>Natural Soil in Denver Coliseum Parking Lot and Surrounding Areas</td>
<td>0.25</td>
<td>0.025</td>
</tr>
<tr>
<td>Fill in Denver Coliseum Parking Lot</td>
<td>2.00</td>
<td>0.2</td>
</tr>
<tr>
<td>Fill in Globeville Landing Park</td>
<td>0.10</td>
<td>0.01</td>
</tr>
<tr>
<td>Fill near Brighton Blvd</td>
<td>1.50</td>
<td>0.15</td>
</tr>
<tr>
<td>Segments with Sanitary Sewer</td>
<td>0.00001</td>
<td>0.000001</td>
</tr>
<tr>
<td>Areas for Vibro Piers</td>
<td>2.5</td>
<td>0.25</td>
</tr>
<tr>
<td>Area for Compaction Grouting</td>
<td>0.025</td>
<td>0.0025</td>
</tr>
</tbody>
</table>
Itasca Denver, Inc.

ATTACHMENT A

Hydraulic Parameter Zones in Model Layers
Blank areas correspond to inactive cells

Legend
- Natural Soil
- Natural Soil in Globeville Landing Park
- Sanitary Sewer
- Fill in Coliseum Parking Lot
- Fill in Globeville Landing Park
- Fill near Brighton Blvd.
- Area for Vibro-piers
- Area for Compaction Grouting

Hydraulic Parameter Zones in Model Layer 1

Figure A-1
Blank areas correspond to inactive cells

Legend:
- Natural Soil
- Natural Soil in Globeville Landing Park
- Sanitary Sewer
- Fill in Coliseum Parking Lot
- Fill in Globeville Landing Park
- Fill near Brighton Blvd.
- Area for Vibro-piers
- Area for Compaction Grouting

Hydraulic Parameter Zones in Model Layer 2

Figure A-2
Hydraulic Parameter Zones in Model Layer 3

Legend
- Blank areas correspond to inactive cells
- Natural Soil
- Natural Soil in Globeville Landing Park
- Sanitary Sewer
- HSA Boundary
- Fill in Coliseum Parking Lot
- Fill in Globeville Landing Park
- Fill near Brighton Blvd.
- Area for Vibro-piers
- Area for Compaction Grouting

South Platte River

I-70

44th St

E Brighton Blvd

38th St

0 250 500 1,000 Feet

Feet

Natural Soil in Globeville Landing Park

Fill in Coliseum Parking Lot

Fill in Globeville Landing Park

Fill near Brighton Blvd.

Area for Vibro-piers

Area for Compaction Grouting

PROJECT NO. 4029

BY AJ

CHECKED DBS

DRAWN AJ

DRAWING NAME: Calibrated K zones

DRAWING DATE October 20, 2015

REVISION DATE

Figure A-3
Hydraulic Parameter Zones in Model Layer 4

Legend:
- Blank areas correspond to inactive cells
- HSA Boundary
- Natural Soil
- Natural Soil in Globeville Landing Park
- Fill in Coliseum Parking Lot
- Fill in Globeville Landing Park
- Fill near Brighton Blvd.
- Area for Vibro-piers
- Area for Compaction Grouting

South Platte River
I-70
38th St
E Brighton Blvd
44th St

Figure A-4
Blank areas correspond to inactive cells

Legend

- Natural Soil
- Natural Soil in Globeville Landing Park
- Fill in Coliseum Parking Lot
- Fill in Globeville Landing Park
- Fill near Brighton Blvd.
- Area for Vibro-piers
- Area for Compaction Grouting

Hydraulic Parameter Zones in Model Layer 5

Figure A-5
Hydraulic Parameter Zones in Model Layer 6

Legend

- Blank areas correspond to inactive cells
- Natural Soil
- Natural Soil in Globeville Landing Park
- Fill in Coliseum Parking Lot
- Fill in Globeville Landing Park
- Fill near Brighton Blvd.
- Area for Vibro-piers
- Area for Compaction Grouting
- Sanitary Sewer

Figure A-6
Hydraulic Parameter Zones in Model Layer 7

Legend:
- Blank areas correspond to inactive cells
- Natural Soil
- Natural Soil in Globeville Landing Park
- Fill in Coliseum Parking Lot
- Fill in Globeville Landing Park
- Fill near Brighton Blvd.
- Area for Vibro-piers
- Area for Compaction Grouting
- Sanitary Sewer
- HSA Boundary

Figure A-7

PROJECT NO. 4029
BY AJ
CHECKED DBS
DRAWN AJ
DRAWING NAME Calibrated K zones
DRAWING DATE October 20, 2015
REVISION DATE
Hydraulic Parameter Zones in Model Layer 8

Legend
- Blank areas correspond to inactive cells
- Natural Soil
- Natural Soil in Globeville Landing Park
- Fill in Coliseum Parking Lot
- Fill in Globeville Landing Park
- Fill near Brighton Blvd.
- Area for Vibro-piers
- Area for Compaction Grouting
- Sanitary Sewer
- Border

Figure A-8
Blank areas correspond to inactive cells

Legend

- Natural Soil
- Natural Soil in Globeville Landing Park
- Fill in Coliseum Parking Lot
- Fill in Globeville Landing Park
- Fill near Brighton Blvd.
- Area for Vibro-piers
- Area for Compaction Grouting

Hydraulic Parameter Zones in Model Layer 9

Figure A-9
Blank areas correspond to inactive cells

HSA Boundary

Legend

- Natural Soil
- Natural Soil in Globeville Landing Park
- Fill in Coliseum Parking Lot
- Fill in Globeville Landing Park
- Fill near Brighton Blvd.
- Area for Vibro-piers
- Area for Compaction Grouting

Hydraulic Parameter Zones in Model Layer 10

Figure A-10
Itasca Denver, Inc.

ATTACHMENT B

Hydrographs of Dewatering Targets
Distribution of Dewatering Targets in Transient Model

Legend
- Sanitary Sewer
- Cross Section Line
- Dewatering Zone
- Dewatering Targets
- Model Grid
- Concrete Box Culvert
- Limits of Fill Material Within the Coliseum
- Parking Lot
- Study Area Boundary

PROJECT NO. 4029
BY AJ
CHECKED DBS
DRAWN AEM
DRAWING NAME DCHSA_DewaterTargets
DRAWING DATE Oct. 22, 2015
REVISION DATE

CLIENT: EMSI Engineering Management Support, Inc.
FIGURE NO. B-1

G:\ARCGIS\DenverColiseum\DCHSA_DewaterTargets.mxd
Locations of Dewatering Targets:
R21C25 indicates the target at Row 21, Column 25 in Figure B-1.
Hydrographs of Dewatering Targets

Zone 2 - 2

Zone 2 - 3

Zone 3a - 1

Zone 3a - 2

Locations of Dewatering Targets:
R21C25 indicates the target at Row 21, Column 25 in Figure B-1.
Hydrographs of Dewatering Targets

Locations of Dewatering Targets:
R21C25 indicates the target at Row 21, Column 25 in Figure B-1.

PROJECT NO. 4029
BY
CHECKED DBS
DRAWN RjN
DRAWING NAME HYDRO3
DRAWING DATE 23 OCT 2015
REVISION DATE

CLIENT: EMSI Engineering Management Support, Inc.
FIGURE NO. B-2c
INTRODUCTION

This technical memorandum describes the second phase of a construction dewatering study that was performed by Itasca Denver, Inc. (Itasca) on behalf of Environmental Management Support, Inc. (EMSI) for the Globeville Landing Outfall Project (GLOP). The Phase 2 study tasks discussed herein include two additional numerical groundwater flow model simulations and the development of design and installation details and materials specifications for the proposed dewatering system.

In Phase 1 of the study, Itasca developed and calibrated a numerical groundwater flow model of the GLOP site and then used the model to estimate the dewatering that will be required prior to construction of a storm-water drainage system at the project site (Itasca 2015). Four different options for the groundwater dewatering system—involving various configurations of subsurface drains and/or pumping wells—were evaluated with the model; the option that best met the dewatering objectives was a network of subsurface longitudinal drain lines beneath the construction area. The scope of the initial phase of modeling was limited to the central open-channel portions of the drainage system (Dewatering Zones 3a and 3b) and the lower culverted and open-channel reaches extending to the South Platte River (Zones 1 and 2), as shown in Figure 1.

The Phase 2 groundwater modeling consisted of simulating the dewatering that will be required prior to construction of the reinforced concrete box (RCB) conduits in the southeastern part of the Denver Coliseum parking lot, at the upstream end of the GLOP drainage system (Dewatering Zone 4). The Phase 2 modeling also included the steady-state simulation of the post-construction, equilibrated groundwater potentiometric surface. The modeling
assumptions and results of the Phase 2 simulations are presented in the following sections. Details of the dewatering system design, installation, and materials specifications are provided after the discussion of the model simulations.

SIMULATION OF ZONE 4 DEWATERING

The RCB conduits forming the drainage system in Zone 4 will be installed directly on top of the fill material in the Coliseum parking lot after compaction grouting in that area; installation of a geogrid or other ground improvements will not be required. Dry conditions for the construction in Zone 4 are needed to a depth of two feet below the bottom of the RCB conduit, which is the targeted dewatering depth in that zone. Figure 1 shows the alignment of Zone 4 along with the modeled water levels across the site after installing the Vibro Piers™ in Zone 3b and the compaction grouting in Zone 4. Figure 2 shows a longitudinal profile of Zone 4, which includes the land surface, the modeled water table prior to dewatering, the targeted dewatering depths, the elevations of modeled drains, and the top-of-bedrock surface.

MODEL SETTINGS

The boundary conditions and hydraulic property values for the Zone 4 dewatering simulation were the same as those that were used in Phase 1 and are described in Itasca (2015).

The dewatering of Zone 4 was simulated with two parallel drain lines that were placed three feet below the targeted dewatering depths. Subsurface drains were represented in the model by using the Drain (DRN) package for MODFLOW. The simulated drain elevations are illustrated in Figure 2. The drain elevations gradually decrease from east to west within Zone 4. The modeled drains are at elevations of 5,151 to 5,152.5 feet above mean sea level (ft amsl) and fall within Model Layer 7. The drain conductance parameter (C) was set to a moderately high value (C = 250 square feet per day) so that there was minimal resistance to the flow of water between the surrounding soils and drain lines.

All drains were activated concurrently at the beginning of the transient dewatering simulation. The model calculated the flow rate into each drain based on differences between the hydraulic heads of the surrounding soils and the drain lines and on the assigned properties (C and elevation) of the drain cells.

RESULTS

To ensure that the entire Zone 4 construction area is appropriately dewatered, a dewatering target elevation was established for each model cell within the footprint of that area. The cells were tracked through time to determine when the groundwater table reached the target elevations. Figure 3 identifies the cells that were tracked; hydrographs of the water levels in
each of those cells are provided in Figure 4. Based upon the modeling results, the anticipated time to dewater the Zone 4 construction area is approximately seven weeks.

The modeled weekly average dewatering rates are shown in Figure 5. The average rate in Zone 4 for the first week is approximately six gallons per minute (gpm). The dewatering rate decreases with time as the hydraulic heads in the overlying and surrounding areas are lowered and the corresponding hydraulic gradients that drive the inflow to the drains diminish. Table 1 summarizes the results of the dewatering simulation for all of the zones. The table includes a summation of the total volume of water that would be drained from each zone in order to reach the targeted dewatering elevations (note that these volumes do not include any flows that occur after the targeted elevations are reached). The results indicate that a total volume of approximately 1,111,900 gallons would be produced to achieve the pre-construction dewatering objective.

The dewatering rates shown in Figure 5 and the rates and volumes given in Table 1 for the other zones (Zones 1 through 3b) are different from the values that were previously provided in the Phase 1 document (Itasca 2015). The differences are due to the effects that Zone 4 dewatering has on those other downgradient zones.

SIMULATION OF POST-CONSTRUCTION POTEN TIOMETR I C SURFACE

The subsurface configuration of the post-construction surface-water drainage system is described in EMSI (2015) and is summarized in Figure 6. Upon completion, the drainage system will consist of the following elements within the different dewatering zones:

1. **Zone 1** – an open channel on top of bedrock;
2. **Zone 2** – buried RCBs and a vertical drop inlet structure, which rest on bedrock;
3. **Zone 3a** – an open channel, on top of an impermeable liner, on top of a gravel layer, on top of the geogrid, which rests on existing soil and debris;
4. **Zone 3b** – an open channel, on top of an impermeable liner, on top of a gravel layer, on top of the geogrid, which rests on existing soil and fill supported by Vibro Piers™; and
5. **Zone 4** – buried RCBs resting on existing soil and fill supported by compaction grouting.

In Zones 3a and 3b, a 1.5-foot thick layer of crushed 1.5-inch diameter rock will be placed on top of the geogrid for additional stabilization and strengthening below the impermeable liner. This strengthening layer has the potential to create a preferential pathway for horizontal groundwater migration beneath the liner. To mitigate this potential, a “check dam” consisting

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1 Note that in Figure 4, the dewatering zone has been further subdivided into four distinct groups of hydrographs to avoid overcrowding the graphs and to facilitate the interpretation of the data. For example, the title "Zone 4-2" means that the set of hydrographs are within group 2 of Dewatering Zone 4.
of low-permeability fine-grained soil will be placed within the strengthening layer across its full thickness at the western edge of the Vibro Piers™ columns in Globeville Landing Park (Figure 6).

A geomembrane lining system will be constructed on top of the gravel strengthening layer in Zones 3a and 3b. The lining system will be anchored to perimeter concrete walls and will form an impermeable barrier, such that surface water infiltration to groundwater will be minimized and contaminated groundwater will be prevented from entering the open-channel portions of the surface-water drainage system in Zones 3a and 3b.

MODEL SETTINGS

The post-construction model simulation used the same boundary conditions and hydraulic property values as those that were used in the Zone 4 Dewatering and earlier Phase 1 dewatering simulations (Itasca 2015), except as noted as follows:

1. **Zones 3a and 3b** – model cells that contained the gravel strengthening layer were assigned higher horizontal hydraulic conductivity ($K_h$) and vertical hydraulic conductivity ($K_v$) values of 150 and 0.36 feet per day (ft/d), respectively.
2. **Zones 2 and 4** – model cells that contained the buried RCBs were assigned lower $K_h$ and $K_v$ values of $1 \times 10^{-5}$ ft/d; these are the same values that were assigned to the cells that contain the sanitary sewer lines.

The low-permeability check dam across the strengthening layer was represented in the model by using the Horizontal Flow Barrier (HFB) package for MODFLOW. The flow barriers were assigned to model cells in Layer 6 that border the western edge of the Vibro Piers™ area (location shown in Figure 6). The flow barrier conductance parameter was set to a low value (equivalent to $K_h = 1 \times 10^{-5}$ ft/d for a 1-foot wide barrier) so that there was substantial resistance to the horizontal flow of water in that layer.

For the post-construction simulation, the drains that were used to simulate the dewatering system were turned off, no groundwater discharge was allowed to the open channels above the geomembrane liner in Zones 3a and 3b (those cells were inactivated), and the model was run in steady-state mode to simulate final equilibrium conditions.

RESULTS

The modeled post-construction groundwater levels are illustrated in Figure 7. The simulated post-construction contours of the water-table surface closely resemble those of the pre-construction water table after the ground improvements had been made (cf. Figures 1 and 7). The reduction in groundwater flow created by the compaction grouting in Zone 4, which results in a lower effective $K_h$ in that area, is evident in the concentration of contour lines along the northern part of Zone 4. The increased hydraulic gradient in the northern part of Zone 4 and...
the generally flat surface of the water table to the south of that area are the primary differences between the existing steady-state groundwater conditions and the simulated post-construction conditions (cf. Figure 7 and Figure 5 in Itasca [2015]).

The simulated water table in Globeville Landing Park under post-construction conditions is similar to the existing water table there, except for a small area in the immediate vicinity of Dewatering Zone 2, where the buried RCBs and vertical drop structure slightly distort the water-level contours relative to existing conditions.

DEWATERING SYSTEM DETAILS

A French drain system is proposed for pre-construction dewatering of soil and fill below the alignment of the surface-water drainage-system infrastructure in order to provide sufficiently dry working conditions to permit construction. The dewatering system is designed to be a temporary feature, which will only operate for a period of weeks to months prior to construction of the surface-drainage infrastructure. All or parts of the dewatering system will be removed or abandoned at the end of the construction operations.

In summary, the proposed dewatering system consists of a segmented network of semi-parallel, longitudinal, buried drain lines connected to cisterns (“wet wells”) at the downgradient ends of each segment, which are equipped with pumps to remove the collected water and bring it to the surface for treatment and subsequent discharge to the river (Figure 8). The method(s) of water transport away from the wet wells (such as installed piping or tankage) is not part of the French drain-system design and will need to be separately considered.

Components of the proposed dewatering system include the following:

1. Trenches excavated to depths as designed by the dewatering model, of sufficient width to permit installation of perforated drain pipe and support/filter gravel, and having slopes sufficient to allow drainage to water collection and pumping facilities at specified locations;
2. A perforated drain pipe sufficient to collect and conduct the anticipated dewatering flows and to allow post-installation mechanical cleaning if necessary;
3. A high-permeability engineered fabric covering (“sock”) for the perforated drain pipe to minimize entry of small particulate material into the drain pipe through perforations, thereby allowing the use of relatively coarse support/filter gravel around the drain pipe;
4. Drain pipe cleanouts, to be placed at approximately 200-foot intervals along the drain lines and within 100 feet of wet well connections, or as specified by the engineer;
5. Gravel to provide mechanical support for the drain pipe and to provide a high-permeability, trench-filling material that will assist in collecting and conducting water to the drain pipe;
6. Wet well structures located at the downgradient ends of each segment of the drain lines, containing pumping equipment to remove collected water from the wet wells for subsequent treatment and disposal; and

7. Pumps and related equipment comprising a system adequate to remove accumulated fluid from the wet wells, to operate automatically and require minimal personnel intervention.

The drain-line segments will terminate at the downgradient ends of each dewatering zone, which is where the wet wells will be located (Figure 8). In particular, the start of the downgradient drain lines in Zones 3a (east) will be separated from the terminal ends of the upgradient drain lines in Zone 3b by at least 15 feet across the boundary between those zones, which is coincident with the western limit of the Vibro Pier™ columns. The check dam across the strengthening layer will be positioned along this boundary at the edge of the Vibro Piers™, perpendicular to the direction of the GLOP surface-water drainage.

SPECIFICATIONS

Trenches

Trenches will be excavated to depths and grades as specified by the dewatering plan (see Figure 9); they will be of minimum 1-foot width or more as required by site conditions or as specified by the engineer and will have a flat bottom configuration with all excess loose soil material removed. Buried utility lines and other potential hazards must be located and marked prior to excavation and then avoided. Stabilization of trench walls will be provided as necessary to keep the trench open and allow for construction of the dewatering system. Trench excavation through the area of soil stabilization (in Zone 4 from approximately station 9+00 to station 14+50, and in Zone 3B from approximately station 6+10 to station 8+75) will require the trench alignment to curve around and avoid injection-grouted areas and stone-support columns. Disposal of excavated material will be determined by the engineer.

Drain Pipe

The drain pipe will consist of rigid, perforated, nominal 4-inch I.D. SDR35 polyvinyl chloride (PVC) pipe in 20-foot lengths with solvent-weld bell end connections. Perforations shall be a minimum of two straight rows of ½-inch diameter holes placed along the pipe length parallel to the pipe axis. These two straight rows of holes will be separated at the pipe circumference by approximately 120 degrees of angle. Changes to these drain-pipe specifications will be subject to approval of the engineer.

A ball valve and approximately 20 feet of non-perforated 4-inch PVC pipe should be located at the downgradient end of each drain-line segment just prior to connection with the wet well in order to facilitate shutting off the flow from the drain line while the wet well is being installed.
and connected to the drain line. If possible, the ball valve should remain accessible during dewatering operations.

**Drain Pipe Sock**

Drain pipe filter sock (also known as drain sleeve filter) will be commercially-available material of proper size to fit the specified drain pipe, constructed of suitable permeable material such as polyester fabric, and designed to prevent entry of small particulates into the drain pipe perforations. The filter will be installed on the drain pipe prior to or during pipe installation, per the manufacturer's recommended procedures.

**Drain Pipe Cleanouts**

Drain pipe cleanouts will be constructed as shown in Figure 10 and installed at approximately 200-foot intervals along each drain pipe, oriented to facilitate cleaning of the downstream pipe. Capped tops of the cleanouts will protrude approximately four inches above ground surface elevation, or as directed by the engineer. In all cases, a cleanout must be located on each drain pipe within 100 feet of the wet well and directed towards the wet well connected to the drain pipe.

**Gravel Pack**

Gravel used for trench backfill and support also serves as a partial filter. The gravel should be devoid of fine material and handled in a way to prevent the introduction of soil or other fines into the backfill. The gravel will be a washed rounded rock of ¾-inch minimum (100% retained) and approximately 3-inch maximum screen size, or as approved by the engineer.

**Wet Wells**

**Wet Well Structures**

Wet well structures will be site-fabricated or commercially-available units (see Figure 10) incorporating the following features:

1. Well height sufficient to extend from the drain pipe entry elevation to approximately one foot above surface grade or approximately one foot above the highest existing groundwater level along each drain line, whichever is greater. Extending the well height to above the highest existing groundwater level assures containment of water within the well in the event of pump failure. Well No. 1 (located at the downgradient end of Zone 1 by the river) will require a different approach for water containment in the case of a pump failure; extending the well top to an elevation above the highest August 2015 groundwater level in Zones 1 and 2 would require the well top to be approximately
13.5 feet above grade. A shutoff valve on a blank (non-perforated) inlet pipe section in Zone 1 would suffice, as described above in the “Drain Pipe” section.

2. Well depth must extend sufficiently below the drain pipe entry elevation to provide a sump of adequate size to accommodate a sump pump and to provide sufficient reservoir volume to prevent excessive pump cycling. Projected approximate maximum water inflows, pump capacities, sump volumes, and minimum cycle times for each zone are shown in the table below. Pump-cycle times will change as drainage rates decrease through time. Small, commercial, electrical, submersible sump pumps are readily available in the 15 to 20 gpm flow-rate range for projected lift requirements of 20 to 35 feet.

<table>
<thead>
<tr>
<th>Zone Number</th>
<th>Maximum Inflow Rate (gpm)</th>
<th>Required Pump Capacity (gpm)</th>
<th>Minimum Sump Volume (gallons)</th>
<th>Approximate Cycle Time (minutes)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 and 2</td>
<td>10</td>
<td>15</td>
<td>100</td>
<td>30</td>
</tr>
<tr>
<td>3A</td>
<td>14</td>
<td>15</td>
<td>100</td>
<td>107</td>
</tr>
<tr>
<td>3B</td>
<td>17</td>
<td>20</td>
<td>150</td>
<td>59</td>
</tr>
<tr>
<td>4</td>
<td>6</td>
<td>15</td>
<td>100</td>
<td>28</td>
</tr>
</tbody>
</table>

3. Well diameter will be sufficient to provide a fluid-reservoir volume adequate to prevent excessive pump cycling during operations. For example, a 2-foot diameter well requires 4.3 feet of depth for a 100-gallon reservoir, and a 4-foot diameter well requires 1.06 feet of depth for the same volume.

4. Well construction will be adequate to resist earth pressures resulting from full or partial burial to required depths, and materials used will resist chemical attack by contained fluids for the projected duration of the dewatering project. Well design will allow placement of one or more pipe bulkhead fittings at drain pipe entry points. An oversized bottom flange or other suitable device must be incorporated to act as an anchor to resist buoyant force and to prevent the installed well from moving from its designed installation depth.

5. Covers for the wells must be adequate to prevent fall hazards and the unwanted entry of animals and debris, as well as to provide personnel access and conduits for discharge pipe, electrical power, etc.

The final design of the wet wells will be subject to approval of the engineer.
Pump System

The pumping system will be installed in or near each wet well for the purpose of removing accumulated fluids from the wet wells. The pumping system must be configured to operate automatically, with minimal personnel intervention. It will incorporate the following components:

1. Pumps will be electrical, submersible (sump) type, sized for predicted maximum flow rates for each dewatering zone and associated wet well, at the required pumping heads. Pumps rated at approximately 15 to 20 gpm at 30 to 40 feet of water head should be adequate. Check valves should not be incorporated in the pump or discharge pipe (in the case of integral check valves, a small drain hole can be drilled in the discharge pipe immediately above the pump) in order to allow water to drain back into the well to prevent freezing of the pipe between pumping cycles during cold weather conditions.

2. Pump motor and electrical controls will be properly mounted either inside the well or nearby outside the well, will be weatherproof, and will comply with local electrical codes.

3. Electrical power supply for pump operation will be provided to the well location by others.

4. Pump mounting and/or suspension and a retrieval system will be provided to facilitate pump installation and removal for maintenance and to minimize or eliminate the need for personnel to enter the well.

5. Fluid level controls will be provided to start and stop the pump at preset water levels within the well. The controls should allow sufficient adjustment to fully utilize sump volume and maximize pump-cycle time.

6. Pump discharge pipe and fittings as required, including an easily-accessible, full-opening ball or other type of valve at the surface. The discharge pipe will be securely anchored to the well or other structure to prevent loss of pipe into the well and to facilitate connection to the water transport system (to be provided by others).

CONSTRUCTION PROCEDURES

The following procedures will be followed during construction of the dewatering system, subject to engineer approval.

Drain Lines

1. Trench excavation, support, and material disposal as specified elsewhere.
2. Pipe bedding material will be gravel, as specified elsewhere. A 3-inch minimum thickness of gravel will be placed on the trench bottom. The top surface of the bedding gravel will conform to the designed trench grade.

3. Drain pipe, filter sock, and pipe cleanouts will be assembled and placed in the trench above bedding gravel and centered within the trench. Drain pipe perforations will face downward (see Figure 10).

4. Gravel backfill will be placed around the sides of the drain pipe in a manner that maintains the pipe in the center of the trench, does not damage the pipe or filter sock, and does not leave large void spaces within the backfill. Gravel fill will extend to the top of the trench excavation or to a depth approved by the engineer.

5. Drain pipe equipped with filter sock will extend to within 20 feet of the wet well excavation. Non-perforated pipe will be used for the final segment into the excavation and will be equipped with a ball valve near the wet well location to facilitate pipe connection to the wet well. Well No. 1 may require a different inlet configuration, as described elsewhere.

**Wet Wells**

1. An opening of sufficient dimension to accommodate the wet well and to provide approximately one foot of open space around the sides of the well will be excavated. The excavation will provide adequate access to connect the drain pipe to the well, will extend to a depth sufficient to allow the drain pipe elevation to match the well inlet location, and will allow for approximately one foot of bedding gravel to be placed below the well. The drain pipe inlet bulkhead fitting will be installed at or before this time.

2. The well infrastructure will be lowered into the excavation, assuring that the well maintains a vertical position following installation.

3. The non-perforated portion of the drain pipe will be connected to the well inlet bulkhead fitting.

4. Gravel backfill will be placed around the well. Avoid over-compacting, to prevent collapse of the well, but compact sufficiently to ensure a good contact of the gravel with the excavation walls and well-bottom flange, to resist buoyancy effects.

5. Install pump equipment, pump retrieval equipment, power cable, discharge pipe, and fluid level control equipment.

6. Connect the well discharge pipe to the surface piping or tanks provided by others.

7. Connect electrical power (source provided by others), adjust fluid level controls, and test the system to ensure proper operation and verify reasonable pump-cycle times.
ABANDONMENT PROCEDURES

The following procedures will be followed during abandonment of the dewatering system, subject to engineer approval:

1. Drain lines, trenches, and gravel fill will remain in place.
2. The sequencing of abandonment shall be as follows:
   - Removal of cleanout risers down to a minimum of one to two feet below grade. The remaining portions of the cleanout riser pipes will be capped or plugged and resulting holes will be backfilled with gravel to grade.
   - Excavation of sufficient fill material from around the wells to allow for their removal.
   - Cut the drain pipe extension downstream from the shutoff valve and outside of the well bulkhead fitting. Ensure that the valve is closed or that the drain-line extension is capped or plugged.
   - Remove the wet wells and pumping equipment for disposal, as determined by the engineer.
   - Backfill the excavation with gravel or other fill material approved by the engineer and level the surface of the fill to conform to the surrounding grade.

CONCLUSIONS

Based on the results of the Phase 2 groundwater flow modeling and the development of the dewatering system described in this technical memorandum, Itasca concludes the following:

1. Zone 4 dewatering is expected to take approximately seven weeks and to produce a maximum weekly average flow rate of approximately 6 gpm.
2. The post-construction potentiometric surface is expected to be similar to that of the pre-construction water table after the ground improvements have been made. The primary differences between those groundwater conditions and the conditions that presently exist at the site are an increased hydraulic gradient in the vicinity of the northern part of Zone 4 and the generally flat surface of the water table to the south of that area after construction.
3. A French drain system is proposed for pre-construction dewatering of soil and fill below the alignment of the surface-water drainage-system infrastructure in order to provide sufficiently dry working conditions to permit construction. Details of the dewatering system design, installation, and materials specifications have been provided herein.
REFERENCES


Attachments:  Figure 1 – Construction Dewatering Zones and Modeled Groundwater Levels After Installing Vibro Piers™ and Compaction Grouting
Figure 2 – Longitudinal Profile Along Dewatering Zone 4
Figure 3 – Simulated Locations of Drain Lines and Dewatering Targets
Figure 4 – Hydrographs of Zone 4 Dewatering Targets
Figure 5 – Modeled Weekly Average Dewatering Rates Including Zone 4
Figure 6 – Post-Construction Configuration of Surface-Water Drainage System
Figure 7 – Simulated Steady-State Post-Construction Groundwater Elevations
Figure 8 – Dewatering System Layout
Figure 9 – Dewatering System Profiles
Figure 10 – Dewatering System Details and Typical Sections
Table 1 – Summary of Dewatering Simulation Including Zone 4
Construction Dewatering Zones and Modeled Groundwater Levels After Installing Vibro Piers™ and Compaction Grouting
Simulated Locations of Drain Lines and Dewatering Targets

Legend
- Sanitary Sewer
- Profile Line
- Dewatering Targets
- Drain Cells
  - Limits of Fill Material
  - Within the Coliseum Parking Lot
  - Study Area Boundary
  - Zone 1
  - Zone 2
  - Zone 3a
  - Zone 3b
  - Zone 4

ENGINEERING MANAGEMENT SUPPORT, INC. (EMSI)
Locations of Dewatering Targets:
R50C52 indicates the target at Row 50, Column 52.
Modeled Weekly Average Dewatering Rates Including Zone 4
Post-Construction Configuration of Surface-Water Drainage System

Legend
- Longitudinal Profile Line
- Sanitary Sewer
- Impermeable Barrier
- Limits of Fill Material Within the Coliseum Parking Lot
- Study Area Boundary

Open Channel on Top of Bedrock
Buried RCBs on Top of Bedrock Surface
Check Dam Across Strengthening Layer
Buried RCBs on Top of Compaction Grouting
Open Channel on Top of Liner on Top of Gravel Layer on Top of Geogrid on Top of Vibro Piers™

Feet

0 160 320

PROJECT NO. 4029-7
BY AJ
CHECKED DBS
DRAWN AEM
DRAWING NAME DC_DrainageSystems
DRAWING DATE Nov. 30, 2015
REVISION DATE

CLIENT: EMSI Engineering Management Support, Inc.
FigURE NO. 6
Figure 8

SCALE IN FEET

0 50 100

GLOBEVILLE LANDING OUTFALL PROJECT

NOV. 19, 2015

DEPARTMENT OF PUBLIC WORKS

DENVER, CO

DEWATERING SYSTEM LAYOUT

DEWATER-DESIGN.DWG

NOT FOR CONSTRUCTION

PRELIMINARY

APPROVED BY:

DESIGNED BY:

DRAWN BY:

JGM

DEWATERING SYSTEM LAYOUT

201 WEST COLFAX AVENUE
DENVER, CO 80202
PHONE: (720) 913-4501
FAX: (720) 913-4544

DEPARTMENT OF PUBLIC WORKS

DENVER, CO

GLOBEVILLE LANDING OUTFALL PROJECT

NOV. 19, 2015

DEPARTMENT OF PUBLIC WORKS

DENVER, CO

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GLOBEVILLE LANDING OUTFALL PROJECT

NOV. 19, 2015

DEPARTMENT OF PUBLIC WORKS

DENVER, CO
**WELLS 1, 3 & 4 - DRAIN & MAIN LINE CONNECTIONS**

- **Drain Line Spacing**
- **Wet Well As Specified**
- **4" PVC Ell**
- **1/2 Drain Line Spacing**
- **4" PVC Double 1/4 Turn**
- **4" PVC Perforated Drain Pipe with Filter Sock (Typ)**

**NOTES:**
1. Main Line and Drain Construction Are The Same.
2. All Angle Fittings Will Be Sanitary Tees, 45° or 90° Long-Turn Els To Facilitate Cleanout.

**TYPICAL DRAIN SECTION**

- **ELEVATIONS**
  - **Final Grade**
  - **August 2015 Water Level**
- **Trench Bottom**
- **Drain Pipe**
- **Support Gravel As Specified**
- **Perforated PVC Drain Pipe with Filter Sock**

**NOTES:**
1. Trench Width Approximately 1 Ft. Or As Approved By Engineer.
2. Trench Bottom Elevation 6 Inches Below Drain Pipe Final Grade, As Specified For Each Zone.
3. Support Gravel As Specified. Place 3 Inch Thickness Below Centered Drain Pipe, Fill Trench To Final Grade With Gravel.

**TYPICAL DRAIN PIPE CLEANOUT**

- **Cleanout At 200 Ft Intervals**
- **Cleanout At Upstream End**
- **4" PVC Pipe**
- **Gravel Fill**
- **4" PVC Wye**
- **4" PVC 45° Ell**

**NOTES:**
1. In-Line And Upstream-End Cleanouts (Typ).
2. Cleanout Riser Caps Set Just Above Grade For Ease Of Access.
3. In-Line Cleanouts Spaced At 200 Ft Or Less Along Drain Pipe.

**WELL 2 - DRAIN & MAIN LINE CONNECTIONS**

- **4" PVC Long-Turn Ell**
- **4" PVC Double 1/4 Turn**
- **4" PVC Sanitary Tee**
- **4" PVC Perforated Drain Pipe with Filter Sock (Typ)**

**NOTES:**
1. Specifications For Wet Well And Pump Mounting In Progress.

**CONCEPT SKETCH OF WELL AND PUMP MOUNTING**

- **Steel Cable**
- **Discharge Hose**
- **Electrical Cable**
- **Pump With Level Control**
- **Pump Inlet**
- **Sediment Sump**
- **Pump Retrieval Winch & Support Structure**
- **Pump With Level Control**
- **Active Water Storage**
- **Depth Of Sediment Sump**
- **Depth, Ground To Inlet**
- **Depth, Inlet To Bottom**
- **Well Diameter Or Side**
- **Water Level Above Bottom**

**NOTES:**
1. Well Diameter Or Side
2. Depth, Ground To Inlet
3. Depth, Inlet To Bottom
4. Water Level Above Bottom
5. "Active" Water Storage
6. Depth Of Sediment Sump
### TABLE 1

**Summary of Dewatering Simulation Including Zone 4**

<table>
<thead>
<tr>
<th>Dewatering Zone</th>
<th>Existing Ground Surface Elevation (feet amsl)</th>
<th>Existing Water Table Elevation (feet amsl)</th>
<th>Target Elevation for Dewatering (feet amsl)</th>
<th>Depth Water Table is to be Lowered (feet)</th>
<th>Simulated Drain Elevation (feet amsl)</th>
<th>Approximate Drain Depth Below Existing Grade (feet)</th>
<th>Time to Dewater to Target Elevation (days)</th>
<th>Weekly Average Dewatering Flow Rates (gallons per minute)</th>
<th>Volume Removed to Dewater to Target (gallons)</th>
</tr>
</thead>
<tbody>
<tr>
<td>South Platte to Box Culvert Outlet</td>
<td>5142.0 - 5167.7</td>
<td>5140.9 - 5150.5</td>
<td>5138.5 - 5141.0</td>
<td>2.4 - 9.4 (Avg. 5.9)</td>
<td>5138.5 - 5141.0</td>
<td>4 - 27 (Avg. 19)</td>
<td>5</td>
<td>5.9</td>
<td>42,300</td>
</tr>
<tr>
<td>Box Culvert Outlet to Top of Vertical Pipe</td>
<td>5164.9 - 5174.0</td>
<td>5150.5 - 5155.4</td>
<td>5142.5 - 5145.5</td>
<td>7.6 - 10.1 (Avg. 8.9)</td>
<td>5142.5 - 5145.5</td>
<td>22 - 30 (Avg. 29)</td>
<td>7</td>
<td>5.8</td>
<td>57,900</td>
</tr>
<tr>
<td>Open Channel in Globeville Landing Park</td>
<td>5161.3 - 5179.8</td>
<td>5155.0 - 5156.6</td>
<td>5151.0 - 5152.0</td>
<td>3.0 - 5.6 (Avg. 4.5)</td>
<td>5148.0 - 5149.0</td>
<td>12 - 31 (Avg. 27)</td>
<td>68</td>
<td>14</td>
<td>489,500</td>
</tr>
<tr>
<td>Open Channel in Coliseum Parking Lot</td>
<td>5164.0 - 5169.3</td>
<td>5156.1 - 5156.2</td>
<td>5152.0 - 5153.0</td>
<td>3.1 - 4.2 (Avg. 3.5)</td>
<td>5149.0 - 5150.0</td>
<td>14 - 20 (Avg. 16)</td>
<td>23</td>
<td>16</td>
<td>329,400</td>
</tr>
<tr>
<td>RCB Conduit in Coliseum Parking Lot</td>
<td>5163.9 - 5187.0</td>
<td>5155.3 - 5159.5</td>
<td>5154.0 - 5155.5</td>
<td>0.3 - 4.0 (Avg. 2.5)</td>
<td>5151.0 - 5152.5</td>
<td>12 - 34 (Avg. 18)</td>
<td>50</td>
<td>6.4</td>
<td>192,800</td>
</tr>
</tbody>
</table>
TECHNICAL MEMORANDUM

TO: Timothy Shangraw, P.E. – Engineering Management Support, Inc. 4029-8

FROM: Dan Stone, Ph.D.
       Alan Jang, Ph.D., P.E.
       Dong Ding, P.G.

DATE: 25 January 2016

SUBJECT: Globeville Landing Outfall Project Construction Dewatering Study, Phase 3 – Groundwater Flow Modeling

INTRODUCTION

This technical memorandum describes the third phase of a construction dewatering study that is being performed by Itasca Denver, Inc. (Itasca) on behalf of Environmental Management Support, Inc. (EMSI) for the Globeville Landing Outfall Project (GLOP). Dewatering of a portion of the GLOP site is required prior to construction of a storm-water drainage system. The Phase 3 study tasks discussed herein consist of numerical groundwater flow model simulations that were designed to test possible ways to reduce the amount of groundwater that will be produced by dewatering and must be managed and chemically treated prior to its release to the South Platte River.

In Phases 1 and 2 of the dewatering study, Itasca developed and calibrated a numerical groundwater flow model of the GLOP site, and then used the model to estimate dewatering rates and quantities and to help design the proposed dewatering system (Itasca 2015a, 2015b). In this phase, additional model simulations were performed to evaluate the effects of using subsurface hydraulic flow barriers to reduce the groundwater management/treatment requirements. The flow barriers are focused on the central, open-channel portions of the surface-water drainage system (Dewatering Zones 3a and 3b; see Figure 1), because those areas are expected to generate a majority of the inflow to the dewatering system and because groundwater in those areas may require more extensive treatment than groundwater from other parts of the GLOP site. The use of flow barriers for Zone 4 is also considered in this evaluation, since it contributes a non-trivial amount to the total dewatering-system inflow. The effectiveness of the flow barriers—in terms of reducing dewatering rates and volumes and the time required to dewater the construction area—is evaluated herein by comparing the current
modeling results to those of the previous Phase 2 dewatering simulation, which was comprehensively built upon the Phase 1 modeling.

PHASE 3 MODEL SIMULATIONS

The Phase 3 groundwater model simulations were designed to test the effects of two different configurations of flow-barrier walls in limiting the amount of groundwater that will flow into the construction area. The modeled flow-barrier walls represent steel sheet piles extending vertically from above the water table down to the bedrock surface.

MODEL SETTINGS

The Phase 3 simulations were performed with the same transient model run and the same initial distribution of hydraulic heads (shown in Figure 1) as were previously used in the Phase 2 modeling (Itasca 2015b). This base model includes the boundary conditions and hydraulic properties of the calibrated model, along with modifications for the anticipated ground improvements in Zones 3b and 4 (Vibro Piers™ and compaction grouting, respectively) and with added drain boundary conditions to simulate the dewatering system (Figure 2). Subsurface flow-barrier walls are used in the base model to limit the groundwater inflows in Zone 2 and to constrain the surface-water inflow from the South Platte River at the downstream end of Zone 1 during the dewatering and construction periods.

For the present simulations, additional flow-barrier walls were assumed to be installed along the perimeter of Dewatering Zones 3a, 3b, and 4, as shown in Figure 2. Two modeling scenarios were considered:

- **Scenario A** assumes that flow-barrier walls are installed along the entire perimeter of Zones 3a, 3b, and 4, and that the planned dewatering system is installed within those walls and operated prior to construction, as described in Itasca (2015b);

- **Scenario B** assumes that a line of flow-barrier walls is installed along the upgradient (southeast) sides of Zones 3a and 3b, and also along the upgradient (southeast) side and surrounding the upper-most reach of Zone 4. It is further assumed that no dewatering system is installed in the construction area; instead, the downgradient sides of Zones 3a, 3b, and 4 are open and allowed to freely drain to the north and west (toward the South Platte River), while recharge from the south and east is being blocked by the barrier walls.

The flow-barrier walls were simulated in the model by using the Horizontal Flow Barrier (HFB) package for MODFLOW. The flow-barrier walls were assigned throughout all model layers at the locations indicated in Figure 2. The HFB conductance parameters were set to low values (less than or equivalent to a hydraulic conductivity of $1 \times 10^5$ foot per day for a 1-foot wide barrier) so that there was substantial resistance to the horizontal flow of water across those boundaries.
The flow-barrier walls were assumed to be installed and the groundwater system re-equilibrated prior to the start of dewatering.

For Scenario B, the drains that were used to simulate the dewatering system were turned off, because it was assumed that there would be no active removal of groundwater in that scenario.

RESULTS OF SCENARIO A SIMULATION

Figure 3 shows the modeled groundwater flow directions (velocity vectors) for Scenario A after 18 weeks of dewatering. The figure illustrates the effectiveness of the flow-barrier walls in limiting groundwater flow into the construction area and dewatering system. (Note the mounding of groundwater on the upgradient side of the barrier walls and the low water levels within those walls, shown in the cross sections, which indicate dewatered conditions.)

To ensure that the entire construction area is sufficiently dewatered, a dewatering target elevation was established for each model cell within the footprint of that area. The cells were tracked through time to determine when the groundwater table was lowered to the target elevations. Figure 2 identifies the cells that were tracked; hydrographs showing the water levels for Scenario A in each of the tracked cells are provided in Figure 4.1 Table 1 summarizes the times required to dewater each zone to the target elevations and indicates that Zone 3a is the slowest to dewater (65 days). Based upon the modeling results, the anticipated time to dewater all zones within the construction area is approximately nine weeks.

The modeled weekly-average dewatering rates for Scenario A are shown in Figure 5 together with the results from Phase 2, for comparison. The maximum weekly rate for Scenario A is 43 gallons per minute (gpm); in the Phase 2 simulation, the maximum weekly rate was 47 gpm. The dewatering rates in Zone 1 are similar for both the Scenario A and Phase 2 simulations; however, the rates in all other zones are less for Scenario A, due to the effectiveness of the flow-barrier walls in limiting recharge to the construction area. The total dewatering rates decrease quicker for Scenario A than in the Phase 2 simulation. In Scenario A, the total dewatering rate is less than 10 gpm by the fourth week of dewatering, whereas it required six weeks to reach that threshold in the Phase 2 simulation.

Figure 6 shows the cumulative volumes of groundwater produced from each zone, and in aggregate, for both the Scenario A and Phase 2 simulations. Table 1 summarizes the dewatering rates and cumulative volumes for all of the zones in both simulations. The table includes a summation of the volumes of water that would be drained from each zone in order to reach the targeted dewatering elevations, and also the total volumes that would be generated over an 18-week time period from the start of dewatering.

1 Note that in Figure 4, each dewatering zone has been further subdivided into a few distinct groups of hydrographs to avoid overcrowding the graphs and to facilitate the interpretation of the data. For example, the title "Zone 4-2" means that the set of hydrographs are within group 2 of Dewatering Zone 4.
The modeling results presented in Figure 6 and Table 1 indicate that, after 18 weeks of dewatering, a total volume of approximately 1,289,400 gallons would be produced under the assumptions of Scenario A, whereas for the Phase 2 simulation, a total volume of approximately 1,847,200 gallons was generated over that same time period. Thus, the inclusion of flow-barrier walls in the Scenario A simulation resulted in approximately 30 percent (%) less water being produced by the dewatering system over an 18-week time period, relative to the Phase 2 simulation without the additional barrier walls. The reduction in total produced groundwater comes primarily from lower inflows to Zones 3a and 3b (reductions of 30% and 50%, respectively) and secondarily from the reductions of inflows in Zones 4 and 2 (17% and 18%, respectively), as indicated in Table 1. A visual comparison of the slopes of the curves of total cumulative volumes from the two simulations, shown in Figure 6, indicates that the percentage reduction in produced water due to the barrier walls would be even greater over longer periods of time.

RESULTS OF SCENARIO B SIMULATION

Figure 7 shows the modeled groundwater flow directions (velocity vectors) for Scenario B at 18 weeks after the flow-barrier walls are installed on the upgradient sides of Zones 3a, 3b, and 4. The figure illustrates the effectiveness of the flow-barrier walls in limiting groundwater flow across the upgradient boundary of the construction area (note the mounding of groundwater on the upgradient side of the walls); however, it also shows that, in the construction area downgradient of the flow-barrier walls, dewatered conditions were not achieved after 18 weeks of passive groundwater flow following installation of the walls.

Hydrographs showing the water levels for Scenario B in each of the tracked cells are provided in Figure 8, and they clearly show that the groundwater table was not lowered to the target elevations in this case. Hence, the modeling results indicate that an upgradient barrier wall with no subsurface dewatering system would be ineffective in dewatering the construction area as needed, regardless of the amount of time that transpires.

CONCLUSIONS

Based on the results of the Phase 3 groundwater flow modeling described in this memorandum, Itasca concludes the following:

1. If flow-barrier walls are placed around the perimeter of Dewatering Zones 3a, 3b, and 4 and the dewatering system is installed and operated within those walls for a period of 18 weeks, then approximately 1,289,400 gallons of groundwater is expected to be produced. This amount is approximately 30% less than the volume of groundwater that would be generated if the dewatering system is operated without the barrier walls. The reduction in total produced groundwater comes primarily from lower inflows to Zones 3a and 3b and secondarily from the reductions of inflows in Zones 4 and 2.
2. The flow-barrier walls will result in a lower maximum weekly-total dewatering rate of approximately 43 gpm (instead of 47 gpm) and a quicker decrease in the weekly-total dewatering rates relative to the case without the flow-barrier walls in place prior to dewatering. The weekly-average dewatering rates in Zone 1 will not be appreciably affected if the assumed perimeter flow-barrier walls are used; however, in all other zones, the dewatering rates will be less if the flow-barrier walls are employed, due to their effectiveness in limiting recharge to the construction area.

3. A line of flow-barrier walls along the upgradient boundary of Zones 3a, 3b, and 4, by itself, is insufficient to block the ambient groundwater flow and produce the downgradient hydraulic heads that would lower water levels in the construction area to the target elevations. Hence, upgradient flow-barrier walls with no subsurface dewatering system would be ineffective in dewatering the construction area as needed, regardless of the amount of time that transpires.

REFERENCES


Attachments: Figure 1 – Construction Dewatering Zones and Modeled Groundwater Levels After Installing Vibro Piers™ and Compaction Grouting

Figure 2 – Simulated Locations of Drain Lines, Dewatering Targets, and Flow-Barrier Walls

Figure 3 – Modeled Groundwater Velocity Vectors in Plan and Cross Section Views at end of Simulation for Scenario A

Figure 4 – Hydrographs of Dewatering Targets for Scenario A

Figure 5 – Modeled Weekly-Average Dewatering Rates for Scenario A Compared with Rates from Phase 2 Simulation

Figure 6 – Modeled Cumulative Volumes from Dewatering System for Scenario A Compared with Volumes from Phase 2 Simulation

Figure 7 – Modeled Groundwater Velocity Vectors in Plan and Cross Section Views at end of Simulation for Scenario B
Figure 8 – Hydrographs of Dewatering Targets for Scenario B

Table 1 – Comparison of Phase 3 (Scenario A) and Phase 2 Simulations – Dewatering Times, Rates, and Volumes
Construction Dewatering Zones and Modeled Groundwater Levels After Installing Vibro Piers™ and Compaction Grouting

Legend
- Sanitary Sewer
- Simulated Water-Level Elevation (ft amsl)
- Dewatering Zone Limits of Fill Material
- Within the Coliseum Parking Lot
- Study Area Boundary

Scale: 0 200 400 Feet

Zone 1
Zone 2
Zone 3a
Zone 3b
Zone 4

Project: 4029
By: AJ
Checked: DBS
Drawn: AEM
Drawing Name: DCHSA_DWZones
Drawing Date: Jan. 21, 2016
Revision Date:

Client: EMSI Engineering Management Support, Inc.

Figure No. 1
Simulated Locations of Drain Lines, Dewatering Targets, and Flow-Barrier Walls

Legend
- Dewatering Targets
- Sanitary Sewer
- Flow-Barrier Walls
  - Scenario A
  - Scenario B
  - Phases 1 and 2
- Limits of Fill Material
- Within the Coliseum Parking Lot
- Study Area Boundary
- Model Grid Cells

Drain Cells
- Zone 1
- Zone 2
- Zone 3a
- Zone 3b
- Zone 4

Scale: 0, 200, 400 Feet
Modeled Groundwater Velocity Vectors in Plan and Cross Section Views at end of Simulation for Scenario A

Legend
- Upward Directed Velocity Vector
- Downward Directed Velocity Vector
- Simulated Water-Level Elevation (ft amsl)
- Flow Boundary Wall

Cross-Section Along Row 33
Cross-Section Along Column 36

Scale: 0 100 200 Feet

Client: EMSI
Engineering Management Support, Inc.

Project No.: 4029

_checked by AJ
 DRAWN by AEM

Drawing Name: DC_VelocityScA
Drawing Date: Jan. 21, 2016
Revision Date: 

G:\ARCGIS\DenverColiseum\DC_VelocityScA.mxd
Hydrographs of Dewatering Targets for Scenario A

Locations of Dewatering Targets:
R21C26 indicates the target at Row 21, Column 26.
Locations of Dewatering Targets:
R28C30 indicates the target at Row 28, Column 30.

Hydrographs of Dewatering Targets for Scenario A
Hydrographs of Dewatering Targets for Scenario A

Locations of Dewatering Targets:
R32C31 indicates the target at Row 32, Column 31.
Hydrographs of Dewatering Targets for Scenario A

Locations of Dewatering Targets:
R49C53 indicates the target at Row 49, Column 53.
Modeled Weekly-Average Dewatering Rates for Scenario A Compared with Rates from Phase 2 Simulation
Modeled Cumulative Volumes from Dewatering System for Scenario A Compared with Volumes from Phase 2 Simulation

**Phase 3 - Scenario A**

- **Volume (gallons)**
- **Time (Week)**

**Phase 2**

- **Volume (gallons)**
- **Time (Week)**

**Legend:**
- Zone 1
- Zone 2
- Zone 3a
- Zone 3b
- Zone 4
- Total
Modeled Groundwater Velocity Vectors in Plan and Cross Section Views at end of Simulation for Scenario B

Legend:
- Upward Directed Velocity Vector
- Downward Directed Velocity Vector
- Simulated Water-Level Elevation (ft amsl)
- Flow Boundary Wall

Cross-Section Along Row 33
Cross-Section Along Column 36

Legend:
- Simulated Water-Level Elevation (ft amsl)
- Flow Boundary Wall

0 100 200 Feet

Jan. 21, 2016
Hydrographs of Dewatering Targets for Scenario B

Locations of Dewatering Targets:
- R21C26 indicates the target at Row 21, Column 26.
Hydrographs of Dewatering Targets for Scenario B

Locations of Dewatering Targets:
R28C30 indicates the target at Row 28, Column 30.
Hydrographs of Dewatering Targets for Scenario B

Locations of Dewatering Targets:
R32C31 indicates the target at Row 32, Column 31.
Locations of Dewatering Targets:
R50C52 indicates the target at Row 50, Column 52.
### TABLE 1

Comparison of Phase 3 (Scenario A) and Phase 2 Simulations - Dewatering Times, Rates, and Volumes

<table>
<thead>
<tr>
<th>Dewatering Zone</th>
<th>Phase 3 (Scenario A)</th>
<th>Phase 2</th>
<th>Difference in Volume Removed After 18 Weeks (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Time to Dewater to Target Elevation (days)</td>
<td>Weekly Average Dewatering Flow Rates (gallons per minute)</td>
<td>Volume Removed to Dewater to Target Elevation (gallons)</td>
</tr>
<tr>
<td></td>
<td>Initial</td>
<td>Final</td>
<td>Median</td>
</tr>
<tr>
<td>1 South Platte to Box Culvert Outlet</td>
<td>5</td>
<td>5.8</td>
<td>5.8</td>
</tr>
<tr>
<td>2 Box Culvert Outlet to Top of Vertical Pipe</td>
<td>6</td>
<td>6.1</td>
<td>6.1</td>
</tr>
<tr>
<td>3a Open Channel in Globeville Landing Park</td>
<td>65</td>
<td>12.8</td>
<td>1.4</td>
</tr>
<tr>
<td>3b Open Channel in Coliseum Parking Lot</td>
<td>15</td>
<td>13.9</td>
<td>3.1</td>
</tr>
<tr>
<td>4 RCB Conduit in Coliseum Parking Lot</td>
<td>47</td>
<td>6.2</td>
<td>1.2</td>
</tr>
<tr>
<td>Totals</td>
<td>862,400</td>
<td>1,289,402</td>
<td>1,111,900</td>
</tr>
</tbody>
</table>
APPENDIX F
Remediation Discharge Permits
See Materials Management Plan, Appendix A-1
APPENDIX G
Drawings
Environmental Components for Globeville Landing Outfall Project

EC-1  Cover Sheet
EC-2  General Overview
EC-3  Removal Action Layout
EC-4  Subgrade Stabilization Pier Locations
EC-5  Subgrade Stabilization Pier Details
EC-6  Typical Channel Liner Section
EC-7  Liner Connection Details
EC-8  Conveyance System Plan and Profile
EC-9  Cross-Sections A and B
EC-10  Cross-Sections C and D
EC-11  Cross-Section E
EC-12   Dewatering System Layout
EC-13  Dewatering System Profiles
EC-14  Dewatering System Details and Typical Sections
EC-15  Water Treatment Process Flow Diagram

ENVIRONMENTAL COMPONENTS
(See Design Report for descriptions)

- Removal and off-site disposal of waste from Coliseum parking lot
- Removal and on-site beneficial use and/or off-site disposal of "soil and debris" from Globeville Landing Park.
- Stabilization of waste material in Coliseum parking lot using compacted grout columns beneath RCB conduit and Vibro-Stone columns beneath open channel.
- Impermeable boundary beneath open channel system in Coliseum parking lot and Globeville Landing Park.
- Dewatering throughout entire alignment and treatment of dewatered water and/or off-site disposal.
- Methane odor and dust control throughout construction.
- Construction of RCB conduit, open channel, vertical drop inlet structure, box culverts beneath existing sanitary sewers (see sheet EC-2), protection over existing sanitary sewers (sheet EC-2), open channel outlet to South Platte River, bike paths, landscaping, earthwork, and other park features are not environmental components.
Approximate Limits of Existing Waste Material. All Waste Material Excavated Within These Limits Shall Be Managed in Accordance With Materials Management Plan.

Globeville Landing Park

Open Channel Wing Wall (not part of Environmental Components)

Transition Details not part of Environmental Components

Buried Box Culvert (not part of Environmental Components)

Box Culvert Beneath Existing Sanitary Sewer (not part of Environmental Components)

Protection Over Sanitary Sewer (not part of Environmental Components)

Center Line of Open Channel from Existing Conduit Beneath Pepsi Property

Vertical Drop Inlet Structure See Sheet EC-8 (not part of Environmental Components)

Center Line of Open Channel from New Drainage System

Limits of Impermeable Barrier (See Sheet EC-1)

Limits of Open Channel (See Sheet EC-1)

Existing Sanitary Sewers

See Sheet EC-3 for Conveyance System Profile

Limits of Outlet Open Channel
- APPROXIMATE LOCATIONS OF VIBRO STONE COLUMNS (508± TOTAL) (SEE DETAIL ON SHEET EC-5 AND SPECIFICATIONS)

- APPROXIMATE LOCATIONS OF COMPACTION GROUT HOLES (838± TOTAL) (SEE DETAIL ON SHEET EC-5 AND SPECIFICATIONS)

* NOT PART OF ENVIRONMENTAL COMPONENT
COMPACTATION GROUTING NOTES (SEE SPECIFICATIONS):
1. Compaction grouting shall be done where the conditions are conducive of existing sand, the compaction grout column shall be extended to depths as shown in the specifications.
2. Installation shall be done in accordance with specifications. Adjustments may be made by the engineer in the field based on conditions encountered during drilling.

VIBRO STONE COLUMN NOTES (SEE SPECIFICATIONS):
1. The Vibro stone columns shall be installed dewatered open end Vibro concrete columns using a bottom feed auger. The stone column shall extend to the bottom.
2. The stone shall be aggregate No. 3T aggregate placed in order increments.

TYPICAL COMPACTATION GROUTING HOLE LAYOUT ALONG 3'-10" x 8' RCB CONDUIT

TYPICAL VIBRO STONE COLUMN LAYOUT BENEATH
PROPOSED CHANNEL LINER (LANDFILL AREA) - STA 5+80 TO STA 8+82.

SCALE: 1"=50'
IN COLISEUM PARKING LOT, TOP OF CONCRETE WALL AT 100-YR WATER SURFACE, MIN.

18 INCHES OF NO. 57 AGGREGATE

IMPERMEABLE BARRIER CONNECTED TO CONCRETE WALL

IN PARK, TOP OF CONCRETE WALL AT 2-YR WATER SURFACE, MIN.

TYPICAL CHANNEL IMPERMEABLE BARRIER SECTION (STA 5+80 TO STA 8+82)

VERTICAL SCALE: 1"=20'
HORIZONTAL SCALE: 1"=20'

12" THICK NO. 57 AGGREGATE

IMPERMEABLE BARRIER AND STRENGTHENING LAYER DETAIL

CHECK DAM (SEE SPECIFICATION FOR STRENGTHENING LAYER)
1. TO BE INSTALLED JUST DOWNSTREAM OF VIBRO STONE COLUMNS
2. PROVIDE COMPACTED CLAY

TYPICAL CHANNEL IMPERMEABLE BARRIER SECTION (STA 4+22 TO 5+80) AND RELOCATED CHANNEL

VERTICAL SCALE: 1"=20'
HORIZONTAL SCALE: 1"=20'

18" THICK NO. 57 AGGREGATE,
THICKNESS VARIES, SEE SECTIONS

GEONET COMPOSITE ABOVE GEOMEMBRANE

STRENGTHENING LAYER INCLUDES GEOGRID, AGGREGATE, AND CHECK DAM (SEE DETAIL THIS SHEET).

60 mil LLPDE TEXTURED GEOMEMBRANE

IMPERMEABLE BARRIER INCLUDES GEOTEXTILE, LLPDE GEOMEMBRANE, AND GEONET COMPOSITE.

16 oz./sy GEOTEXTILE BELOW GEOMEMBRANE

STRENGTHENING LAYER INCLUDES GEOGRID, AGGREGATE, AND CHECK DAM (SEE DETAIL THIS SHEET).

12" THICK NO. 57 AGGREGATE

CHECK DAM DETAIL

1. TO BE INSTALLED JUST DOWNSTREAM OF VIBRO STONE COLUMNS
2. PROVIDE COMPACTED CLAY

TYPICAL CHANNEL IMPERMEABLE BARRIER SECTION (STA 5+80 TO STA 8+82)

VERTICAL SCALE: 1"=20'
HORIZONTAL SCALE: 1"=20'

STRENGTHENING LAYER INCLUDES GEOGRID, AGGREGATE, AND CHECK DAM (SEE DETAIL THIS SHEET).

60 mil LLPDE TEXTURED GEOMEMBRANE

IMPERMEABLE BARRIER INCLUDES GEOTEXTILE, LLPDE GEOMEMBRANE, AND GEONET COMPOSITE.

16 oz./sy GEOTEXTILE BELOW GEOMEMBRANE

STRENGTHENING LAYER INCLUDES GEOGRID, AGGREGATE, AND CHECK DAM (SEE DETAIL THIS SHEET).

IMPERMEABLE BARRIER CONNECTED TO CONCRETE WALL

IMPERMEABLE BARRIER INCLUDES GEOTEXTILE, LLPDE GEOMEMBRANE, AND GEONET COMPOSITE.
Notes:
1. Anchor bolts shall be 3/8 inch X 4 1/2 inch (min) 316 Stainless Steel.
2. Nuts and washers shall be 316 Stainless Steel.
3. Batten Bar shall be 1/4 inch X 2 inch wide 316 Stainless Steel with elongated holes set for 6 inch O.C.
4. Sealing Strip (top, under batten bar) shall be 1/8 inch X 2 inch vulcanized rubber.
5. Sealing Tape (bottom, under geomembrane) shall be 1/8 inch X 2 inch Butyl preformed tape.
6. Sealant shall be Sikaflex 1A Polyurethane (or approved equal).
7. See specifications for geotextile, geomembrane liner, and geonet composite.
8. Concrete edge shall be chamfered and smooth.
9. Soil at edge of concrete shall be compacted to min 95% SPD.
10. Vulcanized rubber gasket specification to be submitted to Owner's Representative for approval.
GLOBEVILLE LANDING OUTFALL
PROJECT - PHASE I
201 WEST COLFAX AVENUE
DENVER, CO  80202
PHONE:  (720) 913-4501
FAX:  (720) 913-4544
DEPARTMENT OF
PUBLIC WORKS

SECTION A & B

1" = 20' HOR.
1" = 10' VER.

NOT FOR CONSTRUCTION
PRELIMINARY
OF
15 FEBRUARY 3, 2016

SERIES ARE LISTING CORRECTLY
NOTES:
1. Trench depth foundation to be installed from XA, 0.94 to 1.9 ft. above.
2. 1.5 ft of compacted permeable dry soil material to slope.
3. Trench wall to be constructed with compacted crushed drainable material 0.5 ft. deep above trench excavation and space 1st ballast.
4. Install 0.5 ft of permeable drainable compacted dry soil material below the maximum of 200 feet on center.

4" TYP. ACCESS HOLE DETAIL SEES SHEET 4. TYP. 10" DIA. CONDUIT DETAIL SEES SHEET 5.

D TYPICAL REINFORCED CONCRETE BOX CONDUIT TRENCH SECTION DETAIL

 sectional view of earth fill material see specification sheet 6.0.5

EXISTING/PROPOSED GRADE
NOTES:
1. Trench Width Approximately 1 Ft. or as Approved by Engineer.
2. Trench Bottom Elevation 6 inches Below Drain Pipe ≤ Elevation, As Specified For Each Zone.
3. Support Gravel as Specified. Place 3 inch Thickness Below Centered Drain Pipe, Fill Trench to final Grade With Gravel.

NOTES:
1. In-Line and Upstream-End Cleanouts (Typ).
2. Cleanout Riser Caps Set Just Above Grade for Ease of Access.
3. In-Line Cleanouts Spaced at 200 Ft or Less Along Drain Pipe.

NOTES:
1. Main Line and Drain Construction are the Same.
2. All Angle Fittings Shall Be Sanitary Tees, 45° or 90° Long-Turn Els to Facilitate Cleanout.
FOR ILLUSTRATIVE PURPOSES ONLY. CONTRACTOR SHALL DETERMINE TREATMENT PROCESSES NECESSARY TO COMPLY WITH SECTION 02900 - PERFORMANCE SPECIFICATIONS FOR TREATMENT OF DEWATERING WATER.
APPENDIX H
Specifications

- Compaction Grout
- Vibro-Stone columns
- Strengthening Layer
- LLDPE Geomembrane
- Protection Geotextiles
- Channel soils over the liner
- Dewatering System
- Water Treatment
PART 1 - GENERAL

1.01 INTRODUCTION

A. Compaction grouting involves the injection under high pressure of a low-slump, mortar-like grout to compact and displace the adjacent soils. The grout does not penetrate soil pores but displaces the subsurface soils by forming a homogeneous grout bulb near the grout pipe tip.

B. In situ soil types: Refer to the project specific geotechnical report for soil types.

C. Application: Loose fill stabilization; remediation of settling structures and utilities; soil densification for site improvement such as the GLOP; liquefaction mitigation.

D. Work will consist of intrusive excavation into waste material at a hazardous waste site. Consequently, workers will have the potential to be exposed to chemical or physical hazards, as detailed in the project Health and Safety Plan (Final Design Report, Appendix E). Contractor will be held responsible for operating in accordance with the applicable Occupational Safety and Health Administration (OSHA) rules and regulations, specifically provisions of 29 CFR 1910.120, 1910.134, 1910.1001-1101, 1910.1200, and 29 CFR 1926.

1.02 INTENT

The intent of the compaction grouting specified herein is to provide soil improvement within the limits indicated on Project Drawings EC-4 and EC-5 to achieve the required degree of improvement detailed in these specifications.

1.03 STANDARDS AND REFERENCES

A. The most recent version of the following testing methods or standards shall be employed:

1. ASTM D1586 Standard Penetration Testing (SPT) and Split-Barrel Sampling of Soils
2. ASTM C1019 Sampling and Testing Grout
3. ASTM C150/C150M Portland Cement
4. ASTM C143/C143M Slump of Hydraulic-Cement Concrete

B. Reference documents as provided to the Compaction Grouting Contractor shall include:

1. This specification.
2. Final Design Report, including
   a. Materials Management Plan (Appendix A)
   b. Health and Safety Plan (Final Design Report, Appendix E)
c. Construction Drawings (Final Design Report, Appendix G)
3. Project specific geotechnical report.
4. Bid Documents.

1.04 DEFINITIONS

A. **Compaction Grout**: A material blend of fine aggregate, fines and water to achieve a pumpable, thixotropic, viscous grout of a low slump to enable pumping at high pressure and remain intact after injection.

B. **Field Quality Control Representative (FQCR)**: The Contractor’s representative given specific inspection tasks identified in this specification.

C. **Treated Zone** – The area requiring subgrade stabilization (compaction grouting) as measured between bedrock (or depth of refusal) and the subgrade of the facility to be supported.

D. **Overburden/untreated zone** – The area as measured between the existing ground surface and the subgrade of the facility to be supported.

E. **Refusal** – This definition relies on information provided by the approved contractor and is required as a submittal. In general Refusal is the point at which pipe advancement has stopped, based upon the physical limitations of the machine being used to advance the pipe.

F. **Geotechnical Data Report (GDR)** – See Section 1.03B.3.

1.05 SCOPE OF WORK

A. The work shall consist of installation, monitoring and testing of compaction grouting within the limits indicated on the Drawings to meet the acceptance criteria presented in within these specifications.

B. In connection with the compaction grouting program, as shown on the Drawings, the Compaction Grouting Contractor shall provide all labor, materials and equipment as detailed in the contract documents and within the Measurement and Payment to accomplish the work

1.06 SUBMITTALS

A. The following shall be submitted to the Owner’s Representative by the Compaction Grouting Contractor a minimum of two (2) weeks prior to the start of the work:

1. A ground movement monitoring plan, as detailed in this specification, if structures are located within a horizontal distance equal to the depth of treatment.
2. A mix design for the project indicating sources and types of grout materials, with volumetric proportions, and field test data from previous projects indicating compressive strength and slump of 1 inch or less achieved. If the Compaction Grouting Contractor intends to deviate from the gradation provided in this
specification, the contractor shall submit evidence of satisfactory use of the proposed material from past projects with similar geotechnical conditions.

3. Work procedures and control criteria (including volumes and pressures for each stage).

4. A general Work Procedures Plan outlining the spacing as shown on the Drawings, location, depth and estimated quantity of grout to achieve the specified criteria detailed in this specification. Grout hole locations shall be dimensionally referenced to the facility foundation as shown on the Drawings.

5. A project Health and Safety Plan.

6. Written documentation verifying that personnel who will perform work at the site have completed appropriate health and safety training, in accordance with 29 CFR 1910.120, the Hazardous Waste Operations and Emergency Response (HAZWOPER) standard.

B. The following shall be submitted to the Owner’s Representative by the Compaction Grouting Contractor during construction:

1. Accurate daily records of all grout pipe installation, compaction grouting quantities, including stage data, volume, pressure and depth for each grout pipe location.
2. Any change in the predetermined grouting program necessitated by a change in the subsurface conditions.

Part 2 – EQUIPMENT AND MATERIALS

2.01 GROUTING EQUIPMENT

A. The Compaction Grouting Contractor shall supply equipment capable of advancing the grout pipe through overburden, soils and other obstructions to the specified depth or as required to meet the project objectives.

B. The Compaction Grouting Contractor shall supply all equipment required to operate a compaction grouting system capable of supplying the specified grout at variable flow rates and pressures, measured at the pump, up to 250 psi and at rates of 0.5 to 12 cubic feet per minute.

C. The grout mixer shall be a continuous auger type to ensure complete uniform mixing of the materials used and shall be of sufficient capacity to continuously provide the pumping unit with mixed grout at its normal pumping range. The mixer shall be capable of volumetrically proportioning the grout materials.

D. The Compaction Grouting Contractor shall provide gauges or other instrumentation (measuring devices) to measure:

1. Continuous grout pressure close to the top of the injection casing.
2. Flow rate of grout.
3. Volume of grout injected.

E. The Compaction Grouting Contractor shall supply and install structural monitoring
equipment in accordance with these specifications.

F. A communication system shall be maintained between the pumping and batching plant and the injection location. As an alternate, the Compaction Grouting Contractor shall furnish a remote control system to allow full control (start, stop, flow rate, reversing) of the pump directly by the contractor’s personnel from the injection point.

2.02 GROUT PIPES

A. Grout pipes and connections shall be steel casing of adequate strength to maintain the hole and to withstand the required jacking and pumping pressures. The pipes shall be at least 2.0 inches inside diameter in order to adequately handle the specified low slump material without plugging. All casing shall be flush joint threaded or a single piece tubing to provide a smooth inner wall and unobstructed inside diameter. It shall be the contractor’s responsibility to install casing that does not detrimentally impact the grouting procedure.

B. Pipes shall be installed such that grout material will not travel in the annular space between the pipe and adjacent ground and escape at the surface when pumped.

2.03 GROUT MATERIALS


B. Fine aggregate shall be sand with fines content (percent passing No. 200 sieve) of not less than 10 percent and not more than 30 percent. Natural fines may be supplemented with Fly ash, a minimal amount of bentonite, or aggregate washings.

C. Proportions of the mixture shall be as required to achieve a pumpable mix with not more than 1 inch slump.

D. Upon discharge into the pump hopper or holding tank, the grout shall be continuously agitated. Mixed grout shall not be held in the agitator for more than 1.5 hours unless a set retarder, approved by the Owner’s representative, is used.

Part 3 – EXECUTION

3.01 SITE EXAMINATION

A. If adjacent buildings are involved, a building survey shall be performed.

3.02 COMPACTION GROUTING

A. Compaction grouting shall be performed in accordance with the approved grout injection point layout scheme to achieve the following acceptance criteria in the in situ soil between the injection points:
1. Post-grouting average, corrected Standard Penetration values exceeding 15 in typical site soils. Locations of the tests shall be agreed upon between the Compaction Grouting Contractor, Owner’s Representative and FQCR and shall be spaced at no greater than 100 foot intervals. At each location, the Standard Penetration tests shall begin at the approximate bottom of the facility to be supported and shall be taken at 3 to 5-ft intervals in the treated zone.

B. Compaction grouting shall extend from bedrock up to the subgrade of the facility to be supported.

C. The grout shall be injected in stages until one of the following occurs:
   1. Grout flow ceases at a gauge pressure reading of 50 to 150 psi (250 psi maximum) or,
   2. Surface ground heave of 1 inch as measured via survey or,
   3. An injected grout volume equal to approximately 2 to 6 cubic feet per 1 vertical linear foot of the material being treated.

D. Compaction grouting shall be sequenced so that grouting does not take place within 4 feet of locations grouted within the previous 12 hours.

E. As compaction grouting is completed at each location, the Compaction Grouting Contractor shall completely fill the grout hole to the ground surface with an approved granular material.

F. Should the contractor reach refusal, at an elevation other than that which is expected, the FQCR shall notify the Construction Owner’s Representative immediately.

3.03 FIELD QUALITY CONTROL
The Compaction Grouting Contractor’s FQCR shall ensure that procedures and documentation conform to these specifications.

A. All compaction grouting shall be performed under the inspection of the FQCR.

B. Monitoring and logging of compaction grouting operations for both test areas and production work shall be done by the Compaction Grouting Contractor and the FQCR.

C. The FQCR shall perform slump tests of grout and take measurements of grout mix quantities to verify the Compaction Grouting Contractor’s grout mix, as follows:
   1. Slump tests shall be performed a minimum of twice during each grout shift.
   2. Grout mix proportions shall be checked a minimum of once daily.

D. The FQCR shall cast minimum size 2 inch by 4 inch grout test cylinders or 2 inch by 2 inch cube molds for strength testing (per ASTM C1019). One set of four cylinders...
or molds shall be cast during each slump test.

E. Layout of grout injection points shall be by the Compaction Grouting Contractor and checked by the FQCR and Owner’s Representative with survey control provided by the Compaction Grouting Contractor.

F. As detailed in this specification, daily records shall be maintained by the Compaction Grouting Contractor and submitted to the Compaction Grouting Contractor on a daily basis.

G. The Compaction Grouting Contractor shall monitor nearby structures as follows:
   1. A level control system shall be installed by the contractor for each structure within a horizontal distance equal to the depth of treatment of the grouting operations.
   2. Monitoring shall be carried out on a continuing basis whenever compaction grouting is occurring within a horizontal distance equal to the depth of treatment.
   3. After completion of the compaction grouting program, the monitoring system and grout pipes shall be removed and all holes shall be filled with an approved granular material and the surface shall be restored to match existing materials.

3.04 TESTING AND INSPECTION

A. The effectiveness of the proposed grouting layout scheme shall be verified as follows:
   1. The Contractor’s FQCR shall perform the in situ Standard Penetration testing as directed by the Owner’s Representative. Two test sections shall be performed before and during production work, as follows:
      a. Test section locations will be agreed upon by the FQCR, Owner’s Representative and Compaction Grouting Contractor within the treatment area. A test section shall consist of a single module comprised of at least three grout injection points for isolated footings and sixteen grout injection points for area applications (such as along the alignment of the facility being supported). Tests shall be performed at the center of the module prior to and after grouting. Standard Penetration tests shall begin at the approximate bottom of the facility being supported and shall be taken at 3 to 5-ft intervals in the treated zone below the facility being supported.
      b. All testing to determine specification compliance shall be provided by the FQCR. The same test method shall be utilized both before and after the soil improvement work in order to provide the most accurate assessment of the degree of improvement obtained.
      c. The method of installation of the test section shall comply with this specification and shall be performed using the same grout line sizes, grout mix drilling and grouting equipment and procedures as that to be used for production work.

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d. Prior to commencement of production grouting, two (2) test sections shall be performed. If the pre-production test sections indicate that the required ground improvement has not been achieved, the Compaction Grouting Contractor shall revise the Work Procedure Plan and re-test at two (2) test sections.

B. Monitoring and logging of compaction grouting operations in the test areas and for production work shall be done by the Compaction Grouting Contractor and submitted to the FQCR on a daily basis.

END OF SECTION
PART 1 - GENERAL

1.01 INTRODUCTION

A. Vibro-Stone Columns (VSC) are columns of compacted aggregate used to reinforce the ground to increase bearing capacity and reduce settlement of a structure. They also can serve to increase slope stability. Vibro-Stone Columns are constructed with a down-hole vibrator.

B. Suitable Soils: Vibro-Stone Columns are typically utilized in fine grained soils that require additional reinforcement to increase bearing capacity and reduce settlement. For soils and groundwater conditions in which the predrilled hole remains open and stable, the aggregate can be placed by a loader into the open hole and compacted in lifts using a down-hole vibrator. In unstable conditions, the hole stability shall be maintained with a bottom feed down-hole vibrator, or other suitable method.

C. Applications: Vibro-Stone Columns are used in many applications. Examples of structures previously constructed on Vibro-Stone Columns include: warehouses, multi-level condominiums, commercial retail or office space, wind turbine towers, roadway embankments, tanks, retaining structures, and parking structures.

D. Work will consist of intrusive excavation into waste material at a hazardous waste site. Consequently, workers will have the potential to be exposed to chemical or physical hazards, as detailed in the project Health and Safety Plan (Final Design Report, Appendix E). Contractor will be held responsible for operating in accordance with the applicable Occupational Safety and Health Administration (OSHA) rules and regulations, specifically provisions of 29 CFR 1910.120, 1910.134, 1910.1001-1101, 1910.1200, and 29 CFR 1926.

1.02 INTENT

The intent of the Vibro-Stone Columns specified herein is to provide soil reinforcement within the limits indicated on the project drawings to achieve the degree of improvement required to meet the performance criteria in Section 3.03 of these specifications.

1.03 STANDARDS AND REFERENCES

A. The most recent version of the following testing methods or standards shall be employed:
   1. ASTM D1586 Standard Penetration Testing (SPT)

B. Reference documents as provided to the Vibro Stone Column contractor shall include:
   1. This specification.
   2. Final Design Report, including
a. Materials Management Plan (Appendix A)
b. Health and Safety Plan (Final Design Report, Appendix E)
c. Construction Drawings (Final Design Report, Appendix G)
3. Project specific geotechnical report.
4. Bid Documents.

1.04 DEFINITIONS

A. Vibro-Stone Columns are columns of compacted aggregate used to reinforce the ground to increase bearing capacity and reduce settlement of a structure.

B. Down-Hole Vibrators are specially-designed, high-energy depth vibrators. The horizontal vibrations are created by a motor and eccentric weight located near the tip of the vibrator. Extension tubes are bolted to the vibrator to allow it to be lowered to the necessary treatment depth.

C. Bottom Feed Vibrators are down-hole vibrators which are equipped with a tremie pipe through which the aggregate is fed to the tip of the vibrator. This equipment is most often used in soil conditions which are too soft or cohesionless to remain open when pre-drilled.

D. Field Quality Control Representative (FQCR): The individual given specific inspection tasks identified in this specification.

1.05 SCOPE OF WORK

A. The work shall consist of installation, monitoring and testing of the Vibro-Stone columns within the limits indicated on Drawings EC-4 and EC-5 to meet the acceptance criteria presented in within Section 3.03 of these specifications.

B. In connection with the Vibro-Stone Column program, as shown on the drawings, the Vibro-Stone Column contractor shall provide all labor, materials, and equipment to accomplish the following items of work:

1. Pre-drilling of holes as necessary and stockpiling of all spoil as directed by the Owner’s Representative, and
2. Construction of the Vibro-Stone Columns to the lines and grades on the construction drawings.
3. It shall be the Vibro-Stone Column contractor’s responsibility to determine and implement the systems and criteria to ensure that the specified performance is achieved.

1.06 SUBMITTALS

A. The following shall be submitted to the Owner’s Representative by the Vibro-Stone Column contractor with the bid documents:

1. A list of at least five previously completed projects of similar scope and purpose for
approval by the Owner’s Representative. The list shall include a description of the project, relative size, and contact person with phone number.

B. The following shall be submitted to the Owner’s Representative by the Vibro-Stone Column contractor two weeks prior to the start of work:

1. Resumes of the management, supervisory, and key personnel.
2. A ground improvement design based on information contained in the project geotechnical report, prepared by an engineer licensed in the state of the work to be performed that demonstrates that the program achieves the specified performance criteria as specified in Section 3.03 of these specifications.
3. A ground improvement QA plan, as detailed in section 3.04 of these specifications.
4. Work procedures and control criteria.
5. A shop drawing for review, indicating the spacing, location, and depth of the Vibro-Stone Columns to achieve the criteria outlined in this specification.
6. A baseline report prepared by a Professional Engineer registered in Colorado that includes at least 20 borings regularly spaced in the work area. Standard penetration testing in accordance with ASTM 1586 shall be conducted at 2 foot depth intervals from the top to the bottom of the zone to be treated.
8. Written documentation verifying that personnel who will perform work at the site have completed appropriate health and safety training, in accordance with 29 CFR 1910.120, the Hazardous Waste Operations and Emergency Response (HAZWOPER) standard.

C. The following shall be submitted to the Owner’s Representative by the Vibro-Stone Column contractor during the work:

1. Accurate daily records that include the type and size of compaction equipment and predrill auger diameter used, and, for each Vibro-Stone Column, the identification number and depth of the pier tip.
2. Any change in the subsurface conditions observed during the work.

D. The following shall be submitted to the Owner’s Representative by the Vibro-Stone Column contractor after the work is completed:

1. A post-treatment report prepared by a Professional Engineer registered in Colorado that includes at least 30 borings regularly spaced in the work area. Standard penetration testing in accordance with ASTM 1586 shall be conducted at 2 foot depth intervals from the top to the bottom of the zone to be treated. The report shall include an analysis of the pre- and post-treatment test results.
2. A warranty document good for one year.
1.07 QUALIFIED CONTRACTORS

A. The Vibro-Stone Column contractor shall meet the requirements stated in section 1.08 of these specifications.

1.08 QUALITY ASSURANCE

A. The Vibro-Stone Column program shall be performed by a specialist Vibro-Stone Column contractor with at least five continuous years of documented experience in Vibro-Stone Columns.

B. The Vibro-Stone Column contractor shall provide experienced management, supervisory and key personnel to implement the Vibro-Stone Column program.

C. As detailed in Section 1.06, the Vibro-Stone Column contractor shall provide evidence of Vibro-Stone Column project experience.

D. The FQCR shall ensure that procedures and documentation conform to these specifications.

PART 2 – EQUIPMENT AND MATERIALS

2.01 EQUIPMENT

A. Down-Hole Vibrator: The down-hole vibrator shall be capable of providing at least 80 HP of rated energy and a centrifugal force of 15 tons. An appropriate metering device shall be provided at such a location that inspection of amperage increase may be verified during the operation of the equipment. The metering device may be an ammeter directly indicating the performance of the vibrator tip. Complete equipment specifications shall be submitted to the Owner’s Representative prior to commencement of the fieldwork.

2.02 BACKFILL MATERIALS

A. The backfill aggregate shall consist of hard, angular to sub-angular durable rock fragments, with the majority of particles in the range of 1/8th inch to 1-1/2 inches such as ASTM C33 size No. 57.

PART 3 – EXECUTION

3.01 SITE INSPECTION

A. If an adjacent building is within 15 ft of the Vibro-Stone Column work area, a relevant building examination shall be performed prior to initiating work to document pre-
existing cracks/damage. The building shall also be monitored for movement during any work within 15 ft of the structure. The work shall be stopped and the engineer notified if any building settlement is observed. If adjacent buildings are involved, a building survey shall be performed.

3.02 VIBRO-COLUMN CONSTRUCTION

The general procedures are as follows:

A. Stable Ground Conditions: The following general procedures shall be followed when the pre-drilled hole remains open during construction.

1. Pre-drilling to the design depth shall be performed with an auger diameter equal to the finished column diameter.
2. The quantity of aggregate initially added shall be such that the vibrator tip is able to penetrate to within 12 inches of the design depth. The vibrator shall be raised and lowered repeatedly, such that on each re-penetration, the tip of the vibrator advances to within 12 inches of the previous penetration depth.
3. The aggregate shall be removed and replaced with fresh aggregate if cave-ins occur during the aggregate placement such that the volume of caved-in soil is greater than 10 percent of the aggregate being compacted.

B. Unstable Ground Conditions: The following general procedures shall be followed when a pre-drilled hole will not remain open before or during Vibro-Stone Column construction.

If the hole will remain temporarily stable, the hole may be filled with aggregate to a level above the instability as long as the vibrator is still able to penetrate to within 1 foot of the pre-drilled depth. If the hole will not remain temporarily stable. A Bottom Feed Down-Hole vibrator may be used.

C. Obstructions: Vibro-Stone Columns shall be constructed within 6 inches of the design location. Obstructions encountered during excavation or drilling that will prevent installation of the Vibro-Stone Columns to design depth, or cause the Vibro-Stone Column to stray from its specified location during installation shall be removed. To the extent the obstructions are shown in the geotechnical report, removal of obstructions shall be performed at no additional cost to the Owner.

Obstructions include, but are not limited to, boulders, timbers, concrete, bricks, utility lines, etc., that prevent installing the Vibro-Stone Columns to the required depth, or cause the Vibro-Stone Column to drift from the required locations. Dense natural rock or weathered rock shall not be deemed obstructions, and piers may be terminated short of design lengths on such materials. The Vibro-Stone Column contractor will be notified within 24 hours to verify that the short piers are acceptable.
3.03 PERFORMANCE CRITERIA

The Vibro-Stone Column contractor’s FQCR shall ensure that procedures and documentation conform to these specifications.

A. For soils that have a pre-treatment Standard Penetration Test result (N-Value) of 10 or less the expected post-treatment average N-value is to be at least 50 percent higher. For existing soils with N-values between 10 and 15, the expected improvement is at least 35 percent.

3.04 FIELD QUALITY ASSURANCE

A. Inspections.

1. All Vibro-Stone Column operations shall be performed under the inspection of the FQCR.
2. Monitoring and logging of Vibro-Stone Column operations for both test and production work shall be done by the FQCR.
3. The FQCR shall provide site observation and documentation to ensure performance of the Vibro-Stone Column work. This inspection may include the following: recording of predrill hole depth, observance of the Vibro-Stone Column contractor’s procedures, and recording of compaction energy information.
4. A sample of the backfill material shall be submitted to the Engineer for a grain size distribution analysis to establish the suitability, the cost of which will be borne by the Owner. Certification of grain size distribution provided by the quarry may be submitted in lieu of a sample.

B. Standard Penetration Test

Testing to determine specification compliance shall be provided by the Vibro-Stone Column contractor, and shall consist of at least 30 regularly-spaced borings made no closer than 3 feet from any Vibro-Stone Column. Standard Penetration Tests (SPT) shall be conducted in each boring using a standard split spoon (2.0 inch diameter) driven 18 inches in accordance with ASTM D1586 procedures. SPT’s shall be taken at 2-foot depth intervals through the zone defined as average top to bottom of neighboring Vibro-Stone Column. The Owner’s Representative shall evaluate the data and approve the installation or require more treatment.

3.05 Rejection of Vibro-Stone Columns

A. If a Vibro-Stone Column is installed in an incorrect location or exceeds the specified tolerances, the Vibro-Stone Column contractor shall replace the pier. Pier replacement may be avoided if alternate remedial procedures are approved by the Owner’s Representative. Unless the rejection is caused by obstruction, refusal in rock or dense soil or errors in the project drawings, the cost of all labor and material required for the replacement shall not be the responsibility of the Owner.
3.06 EXCAVATION OF VIBRO-STONE COLUMN TOPS and UTILITIES

A. Excavations conducted after Vibro-Stone Column installation shall be performed such that the horizontal distance between the edge of any Vibro-Stone Column and the nearest edge of the excavation is such that the pier is not affected. If installed Vibro-Stone Columns are located within the zone of influence of any excavation, the Vibro-Stone Column contractor and Owner’s Representative shall collaborate to develop solutions to excavation or construction methods that will avoid detrimental impact to the installed Vibro-Stone Columns.

Potential solutions include:

2. Placing and compacting select aggregate in excavation zones that have disrupted the structural continuity of any Vibro-Stone Columns. Operations, materials, equipment, and testing shall adhere to the following requirements:

   a. Gradation of the aggregate shall meet specifications drafted by the Owner’s Representative.
   b. The impact compaction equipment shall be motorized and be capable of providing controlled placement of the aggregate.
   c. Compaction of the aggregate shall reach 70% of the Relative Density. The Relative Density shall be determined by ASTM D4253 and D4254.
   d. Placement and compaction shall be observed on-site by personnel from an independent testing firm. The independent testing firm shall also execute density testing on-site, and submit results of the density testing to the Vibro-Stone Column contractor and Owner’s Representative. Scheduling of excavation, placement, and compaction shall be determined by the Vibro-Stone Column contractor. The Vibro-Stone Column contractor shall provide the aforementioned schedule to the independent testing firm and make arrangements for observation of placement and compaction, and execution of density testing.

3.07 RESTRICTIONS

A. Vibro-stone Column construction is typically performed under the site grading permit. The Vibro-Stone Column contractor shall be responsible for obtaining any state and local permits (if required) and conforming to all state and local regulations.

B. The Owner’s Representative will be responsible for the precise delineation of all above and below ground utilities and obstructions.

END OF SECTION
PART 1 – GENERAL

1.01 INTRODUCTION

A. A Strengthening Layer is required beneath an impermeable barrier that will be constructed beneath the Open Channel segment of the Globeville Landing Outfall Project (GLOP). As shown on Project Drawing EC-1, the Open Channel segment is located in the western portion of the Coliseum Parking Lot and southeastern portion of the Globeville Landing Park. This Open Channel segment is upstream (east) of the sanitary sewer lines shown on Project Drawing EC-2.

B. The Strengthening Layer consists of a Geogrid, which forms the base of the Strengthening Layer, and 1.5 feet of stone aggregate placed over the Geogrid. The Strengthening Layer shall be placed with the long direction perpendicular to the center line of the Open Channel. An impermeable barrier, which is addressed in a separate specification, will be constructed over the Strengthening Layer by others.

C. The Strengthening Layer has the potential to create a preferential pathway for groundwater migration toward the South Platte River beneath the impermeable barrier. To mitigate this potential, a “check-dam” comprised of low-permeable clay soil shall be constructed within the Strengthening Layer across the full width of the Layer, at the western end of the Vibro-Stone columns. See Project Drawings EC-6 and EC-8 for details and location of the “check-dam”, respectively.

D. Work will consist of intrusive excavation into waste material at a hazardous waste site. Consequently, workers will have the potential to be exposed to chemical or physical hazards, as detailed in the project Health and Safety Plan (Final Design Report, Appendix E). SL Contractor will be held responsible for operating in accordance with the applicable Occupational Safety and Health Administration (OSHA) rules and regulations, specifically provisions of 29 CFR 1910.120, 1910.134, 1910.1001-1101, 1910.1200, and 29 CFR 1926.

1.02 INTENT

The intent of the Strengthening Layer over the Vibro-Stone Columns in the Coliseum Parking Lot is to minimize differential settlement between columns. The purpose for the Strengthening Layer in the Globeville Landing Park is to enhance the bearing strength of exposed, soft material to support heavy equipment during construction and to minimize differential settlement long-term. The Strengthening Layer shall be constructed within the limits of the impermeable barrier underlying the Open Channel segments of the GLOP as indicated on Project Drawings EC-3 and EC-4, and in accordance with the details illustrated on Project Drawings EC-6 and EC-8 as further defined in these specifications.

1.03 STANDARDS AND REFERENCES

A. Reference documents as provided to the Strengthening Layer (SL) Contractor shall
include:

1. This specification.
2. Final Design Report, including
   a. Materials Management Plan (Appendix A)
   b. Health and Safety Plan (Final Design Report, Appendix E)
   c. Construction Drawings (Final Design Report, Appendix G)
   d. Construction QA Plan (Final Design Report, Appendix I)

1.05 SCOPE OF WORK

A. The work shall consist of installation and testing of the Strengthening Layer as shown on the project Drawings and detailed in these specification.

1.06 SUBMITTALS

A. Pre-Certification Submittals: Prior to delivery of material to the site, the SL Contractor shall submit the following to the Owner’s Representative for approval:

1. Manufacturer’s written certification that the Geogrid material meets or exceeds the physical/mechanical properties as listed in the table under paragraph 2.01B.
2. Manufacturer’s samples and product literature for the proposed Geogrid material.
3. Manufacturer’s and Installer’s Qualifications.
4. Manufacturer’s QC Manual
5. Installer’s QC Manual including recommended installation procedures, standard details and CQC Plan with Proposed Data Sheets.
6. List of qualified Installer’s personnel that will be installing the Geogrid along with their resumes and experience in the installation of similar Geogrids.

B. Pre-Construction Submittals: Submit the following to the Owner’s Representative for review within 5 days of the date of shipment:

1. Written list of the specific lot numbers and rolls to be shipped.
2. Manufacturer’s Quality Control data for rolls to be shipped to the site indicating conformance with the material properties shown in the table under paragraph 2.01B.
3. Manufacturer’s Quality Control Certificates for each shifts production signed by a responsible party of the manufacturer and notarized.
4. Results of Manufacturer’s Quality Control tests indicating the resin quality used to manufacture Geogrid rolls assigned to this project and that the tests conform to the requirements of Part 2 of this section.
5. Gradation data for stone aggregate.
6. Clay soil geotechnical test data for check-dam, per section 2.03 of these specifications
8. Written documentation verifying that personnel who will perform work at the site have completed appropriate health and safety training, in accordance with 29 CFR 1910.120, the Hazardous Waste Operations and Emergency Response (HAZWOPER) standard.
C. **During Construction:** Submit accurate daily records that include the type and amount of line-item quantities identified in the bid documents.

D. **Construction Submittals:** Submit the following to the Owner’s Representative for review no later than 5 days following substantial completion:

1. Quality Control Installation documentation by Installer.
2. As-built draft geomembrane panel layout drawings indicating all field seams, repairs and destructive test cut-outs.
3. Conformance Test Results.

E. **Post-Construction Submittals:** Submit the following to the Owner’s Representative no later than 30 days following substantial completion:

1. Geogrid Installation Certification.
2. Geogrid Warranty for Manufacture and Installation.
3. Quality Control Test Results.
4. Recompaction certifications for Vibro-Stone Columns, as appropriate.

**PART 2 – EQUIPMENT AND MATERIALS**

**2.01 GEOGRID**

A. The Geogrid shall be manufactured from a punched polypropylene sheet, which is then oriented in three substantially equilateral directions so that the resulting ribs shall have a high degree of molecular orientation, which continues at least in part through the mass of the integral node.

B. The properties contributing to the performance of the mechanically stabilized layer include the following:

<table>
<thead>
<tr>
<th>Index Properties</th>
<th>Longitudinal</th>
<th>Diagonal</th>
<th>Transverse</th>
<th>General</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rib pitch, mm (in)</td>
<td>40 (1.60)</td>
<td>40 (1.60)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mid-rib depth mm (in)</td>
<td>2.0 (0.08)</td>
<td></td>
<td>1.6 (0.06)</td>
<td></td>
</tr>
<tr>
<td>Mid-rib width mm (in)</td>
<td>1.0 (0.04)</td>
<td>1.3 (0.05)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rib shape</td>
<td></td>
<td></td>
<td></td>
<td>Rectangular</td>
</tr>
<tr>
<td>Aperture shape</td>
<td></td>
<td></td>
<td></td>
<td>Triangular</td>
</tr>
</tbody>
</table>

C. **Manufacturing Quality Control:** Testing shall be performed at a laboratory accredited by GAI-LAP and A2LA for tests required for the Geogrid, as a frequency meeting or exceeding ASTM D4354.
D. Manufacturer’s certifications and testing of quality assurance samples obtained using Procedure B of ASTM D4354 shall be provided to the Owner’s Representative.

E. An acceptable Geogrid material is Tensar TriAx TX7.

### 2.02 STONE AGGREGATE

A. The stone aggregate shall meet the requirements of ASTM C33 for No. 57 Coarse Concrete Aggregate and have the following gradation:

<table>
<thead>
<tr>
<th>Class No. 57 Gradation</th>
<th>Nominal Size</th>
<th>Percent Passing by Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1 ½ inches 100</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1 inch       95-100</td>
<td></td>
</tr>
<tr>
<td></td>
<td>½ inch       25-60</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Sieve #4     0-10</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Sieve #8     0-5</td>
<td></td>
</tr>
</tbody>
</table>

### 2.03 CHECK-DAM

A. The Check-Dam material shall consist of clay soil meeting the following criteria:

<table>
<thead>
<tr>
<th>MATERIAL REQUIREMENT</th>
<th>Criteria</th>
<th>Standard Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>I. Gradation (% passing)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>a. 2-inch</td>
<td>100</td>
<td>ASTM D-422</td>
</tr>
<tr>
<td>b. 1-inch</td>
<td>90-100</td>
<td>ASTM D-422</td>
</tr>
<tr>
<td>a. No. 4</td>
<td>80-100</td>
<td>ASTM D-422</td>
</tr>
<tr>
<td>b. No. 200</td>
<td>≥ 65</td>
<td>ASTM D-422</td>
</tr>
<tr>
<td>II. Liquid Limit</td>
<td>≥ 35</td>
<td>ASTM D 4318</td>
</tr>
<tr>
<td>III. Plasticity Index</td>
<td>15-50</td>
<td>ASTM D 4318</td>
</tr>
<tr>
<td>IV. Field Moisture Content</td>
<td>OMC≤MC≤+4%OMC</td>
<td>ASTM D 2216</td>
</tr>
</tbody>
</table>

B. The City and County of Denver has located a potential source of clay material at the Denver Arapahoe Disposal Site (DADS), which may be suitable for clay barrier construction based upon limited laboratory testing to date. SL Contractor may use the clay material from DADS at his expense, or provide his own source of clay at his expense. Either way, the material shall meet the requirements listed above. If the SL Contractor elects to use the DADS material, he shall coordinate with DADS for loading of the clay material into the SL Contractor’s trucks for haul to the project site.
PART 3 – EXECUTION

3.01 SUBGRADE PREPARATION

A. Prior to placement of the Strengthening Layer, Vibro-Stone Column tops shall be excavated in a manner that will prevent the soil matrix surrounding the Vibro-Stone Column tops from softening, and achieve a direct and rigid connection between the Vibro-Stone Columns and Strengthening Layer.

B. Over-excavation below the design subgrade elevation that have disrupted the structural continuity of any Vibro-Stone Columns, or placement and compaction of aggregate in excavation zones that have disrupted the structural continuity of any Vibro-Stone Columns, shall follow the procedures described below:

1. Gradation of the aggregate shall meet specifications drafted by the Owner’s Representative.
2. The impact compaction equipment shall be motorized and be capable of providing controlled placement of the aggregate.
3. Compaction of the aggregate shall reach 70% of the Relative Density. The Relative Density shall be determined by ASTM D4253 and D4254.
4. Placement and compaction shall be observed on-site by personnel from an independent testing firm. The independent testing firm shall also execute density testing on-site, and submit results of the density testing to the SL Contractor and Owner’s Representative. Scheduling of excavation, placement, and compaction shall be determined by the SL Contractor. The SL Contractor shall provide the aforementioned schedule to the independent testing firm and make arrangements for observation of placement and compaction, and execution of density testing.

C. Vibro-Stone Column tops and liner bearing soils shall be compacted with a motorized smooth drum compactor. Tampers of the “sled” variety shall not be employed. The entire surface area shall be treated to ensure that any loose surface soil and/or loose surface aggregate is compacted.

D. Subgrade preparation in the Globefille Landing Park shall provide a surface that is free sharp or protruding objects that could compromise the integrity of the Geogrid. Any depressions in the subgrade shall be filled with select soil or soil cement, subject to the limitations of Section 3.01.B above, and roller compacted to final grade.

E. The following criteria shall apply, and be verified by the SL Contractor’s Field Quality Control Representative (FQCR) in a written report:

1. The excavation has been kept free of water since completion of excavation work. This will ensure that the unconfined matrix soil surrounding the Vibro-Stone Columns has not been softened.
2. All Vibro-Stone Columns installed have been fully exposed within the limits of the excavation.
3. That the following specified procedures required immediately prior to construction
of the Strengthening Layer have been followed:

a. Inspection of each Vibro-Stone Column top after exposure by the footing excavation.
b. Recompaction, as required, of Vibro-Stone Column tops and abandoned dewatering system components by mechanical impact compaction equipment.
c. Recompaction of Vibro-Stone Column tops that have or may have been disturbed by footing excavation or other actions, to the satisfaction of the FQCR.

F. Assurance that no excavation has been made within a distance that will affect any completed pier, without being approved in writing by the Vibro-Stone Column contractor and Owner’s Representative.

G. Geogrid and gravel shall be placed immediately following approval of the completed subgrade preparation work.

3.02 GEOGRID

A. Acceptance and Storage: Upon delivery of the Geogrid rolls to the site, the SL Contractor shall:

1. Inventory each Geogrid roll and inspect it for damage. Any rolls or portions of rolls that are damaged beyond repair shall be rejected and removed from the site. Rolls with minor damage that can be repaired shall be noted by the SL Contractor and repaired.
2. The wrapping (if any) shall not be removed until deployment.
3. Geogrid or wrapping damaged as a result of storage or handling shall be repaired or replaced;
4. Geogrid rolls shall not be stacked more than three rolls high;
5. Upon delivery of the geogrid rolls to the site and at the discretion of the Owner’s Representative, test samples shall be collected at the rate of one per lot or one per 100,000 sq.ft. of geogrid placed. Samples shall be forwarded to a certified testing laboratory to verify conformance with the Specifications.

B. Installation: The Geogrid shall be handled and placed as follows:

1. Deployment procedures and equipment used shall not damage the Geogrid.
2. Geogrid rolls damaged during placement shall be removed or repaired.
3. Only Geogrid rolls that can be joined together and ballasted or covered with aggregate in one day shall be deployed.
4. The Geogrid is properly ballasted with adequate ballast (e.g., sandbags) in the presence of excessive winds or for any period of time that the Geogrid is left exposed without aggregate cover materials.
5. Geogrid is laid smooth and free of folds or excessive wrinkles.
6. Geogrid is placed with the machine or roll direction parallel to line of maximum slope.
7. Geogrid field overlaps are oriented parallel to the line of maximum slope.
8. Vehicles are not operated directly on the geogrid.

C. Overlapping and connection shall be as follows:

1. All Geogrid is overlapped and mechanically tied in accordance with the Manufacturer’s recommendations.
2. Geogrid rolls are continuously overlapped a minimum of 3.0 ft and fastened together with nylon zip ties every 3.0 ft along the length.
3. Cross seams on slope areas shall be overlapped and fastened together with zip ties every 1.0 ft across the roll width.
4. Prior to joining with zip ties, the seam overlap is aligned and held in tension with minimum wrinkles.

D. Any holes, tears or imperfections in the Geogrid shall be repaired in accordance with the manufacturer’s recommendations.

3.03 STONE AGREGGATE

A. Installation of the stone aggregate shall be performed in manner that the earthmoving equipment does not travel on the Geogrid system. Aggregate shall be placed in a thick lift (12 to 18 inches) from the edge of the Geogrid area and pushed on to the Geogrid maintaining a thick lift. Leveling the completed gravel layer shall be accomplished by track blades or track loaders. Tracking across the completed stone layer shall be sufficient to consolidate the gravel material. During placement of the aggregate, SL Contractor shall:

1. Maintain Geogrid covered surface areas and overlaps to prevent aggregate intrusion between Geogrid and subgrade.
2. During placement of the aggregate material, maintain tension on the Geogrid to prevent/minimize wrinkles.
3. Assure that wrinkle formation is minimized and that in all cases wrinkles or waves do not develop during aggregate placement.
4. Aggregate shall be placed within 24 hrs after Geogrid placement.
5. Aggregate is placed from bottom to top of slope at a uniform thickness of 18 inches.

3.04 CHECK-DAM

A. Similar to the Stone Aggregate, installation of the clay soil shall be performed in manner that the earthmoving equipment does not travel on the Geogrid system. Clay soil shall be placed in loose lifts of no greater than 8-inches and shall be homogenized, moisture conditioned, and compacted to \( \geq 95\% \) of Standard Proctor density (ASTM D698).

B. The location and dimensions of the Check-Dam component shall be as shown on Design Drawings EC-6 and EC-8. The top elevation of the Check-dam shall be the top
of the adjacent stone aggregate layer.

3.05 FIELD QUALITY CONTROL

A. The FQCR shall ensure that procedures described above conform to the specifications and are documented.

END OF SECTION
PART 1   GENERAL

1.01   INTRODUCTION

A. This section includes the technical requirements for the furnishing and installation of the LLDPE Textured Geomembrane. The Geomembrane shall be textured on both sides to provide increased surface friction characteristics on the upper and lower surfaces in contact with protection geotextiles.

B. The geomembrane shall meet the requirements of this section as specified herein and all work shall be performed in accordance with the procedures provided herein, the manufacturer’s recommendations, and the contract drawings.

C. Work may consist of intrusive excavation into waste material at a hazardous waste site. Consequently, workers will have the potential to be exposed to chemical or physical hazards, as detailed in the project Health and Safety Plan (Final Design Report, Appendix E). Contractor will be held responsible for operating in accordance with the applicable Occupational Safety and Health Administration (OSHA) rules and regulations, specifically, provisions of 29 CFR 1910.120, 1910.134, 1910.1001-1101, 1910.1200, and 29 CFR 1926.

1.02   REFERENCES

A. GRI Standards - Geosynthetic Research Institute (GRI) Standards, most recent published standards and revisions.


1. ASTM D 792 - Standard Test Method for Determining Specific Gravity and Density of Plastics by Displacement

2. ASTM D 1004 - Standard Test Method for Determining the Initial Tear Resistance of Plastic Film and Sheeting

3. ASTM D 1238 - Standard Test Method for Determining Flow Rates of Thermoplastics by Extrusion Plastometer

4. ASTM D 1505 - Standard Test Method for Determining Density of
Plastics by the Density-Gradient Technique

5. ASTM D 1603 - Standard Test Method for Determining Carbon Black Content in Olefin Plastics

6. ASTM D 3895 - Standard Test Method for Determining Oxidative Induction Time (OIT) for Polyolefins

7. ASTM D 4437 - Standard Practice for Determining the Integrity of Field Seams Used in Joining Flexible Polymeric Sheet Geomembranes


12. ASTM D 5641 - Standard Practice for Geomembrane Seam Evaluation by Vacuum Chamber

13. ASTM D 5820 - Standard Practice for Pressurized Air Channel Evaluation of Dual Seamed Geomembranes

14. ASTM D 5994 - Standard Test Method for Determining the Core Thickness of Textured Geomembranes

15. ASTM D 6392 - Standard Test Method for Determining the Integrity of Nonreinforced Geomembrane Seams Produced Using Thermo-Fusion Methods


C. Design and Procurement documents, including:

1. This specification.

2. Final Design Report, including
   a. Materials Management Plan (Appendix A)
   b. Health and Safety Plan (Final Design Report, Appendix E)
c. Construction Drawings (Final Design Report, Appendix G)

d. Construction QA Plan (Final Design Report, Appendix I)


1.03 SUBMITTALS

A. Pre-Certification Submittals: Prior to delivery of material to the site, submit the following to the Owner’s Representative for approval:

1. Manufacturer’s written certification that the Geomembrane materials meet or exceed the physical/mechanical properties as listed in Table 1 of paragraph 2.1.

2. Manufacturer’s written certification that no reclaimed polymer is added to the LLDPE resin during the manufacture of the LLDPE sheet materials to be used on this project.

3. Manufacturer’s samples and product literature for Geomembrane materials that are proposed for use as the primary geomembrane.

4. Manufacturer’s and Installer’s Qualifications.

5. Manufacturer’s QC Manual

6. Installer’s QC Manual including recommended installation procedures, standard details and CQC Plan with Proposed Data Sheets.

7. List of qualified Installer’s personnel that will be performing the LLDPE geomembrane thermal welding along with their resumes and experience in the installation of similar geomembranes.

C. Pre-Construction Submittals: Submit the following to the Owner’s Representative for review within 5 days of the date of shipment:

1. Written list of the specific lot numbers and rolls to be shipped.

2. Manufacturer’s Quality Control data for rolls to be shipped to the site indicating conformance with the material properties shown in Table 1, Part 2.

3. Manufacturer’s Quality Control Certificates for each shift production signed by a responsible party of the manufacturer and notarized.

4. Manufacturer’s data for raw materials:

   a. Copies of Natural Resin Manufacturer’s Quality Control
Certificates and production dates of resin used in production of LLDPE sheet for this project.

b. Results of Manufacturer’s Quality Control tests indicating the resin quality used to manufacture geomembrane rolls assigned to this project and that the tests conform to the requirements of Part 2 of this section.

5. A project Health and Safety Plan.

6. Written documentation verifying that personnel who will perform work at the site have completed appropriate health and safety training, in accordance with 29 CFR 1910.120, the Hazardous Waste Operations and Emergency Response (HAZWOPER) standard.

D. Construction Submittals: Submit the following to the Owner’s Representative for review no later than 5 days following substantial completion:

1. Quality Control Installation documentation by Installer

2. As-built draft geomembrane panel layout drawings indicating all field seams, repairs and destructive test cut-outs

3. Conformance Test Results.

E. Post-Construction Submittals: Submit the following to the Owner’s Representative no later than 30 days following substantial completion:

1. Geomembrane Installation Certification.

2. Geomembrane Warranty for Manufacture and Installation.

3. Quality Control Test Results.

4. Electrical Leak Location Survey Reports

5. Final Panel Layout Drawings indicating all field seams, field seam test results, repairs, destructive test cut-outs and Electrical Leak Location Results/Identification for leak sites and repairs.

1.04 QUALIFICATIONS

A. The Manufacturer of the LLDPE Textured Geomembrane shall have a minimum of 5 continuous years experience in the manufacture of similar Geomembrane rolls. The Manufacturer must demonstrate, by submitting a list of previous projects, a minimum of 10 million square feet of manufactured LLDPE geomembrane.
B. The Installer of the LLDPE geomembrane shall have a minimum of 5 years continuous experience in the installation of LLDPE geomembranes or similar products. The Installer must demonstrate, by submitting a list of previous projects, a minimum of 5 million square feet of LLDPE geomembrane installed on at least 5 completed projects.

C. The Installer’s personnel performing seaming operations shall be qualified by experience or by successfully passing seaming tests. At least one Master Seamer shall have experience seaming a minimum of 2 million square feet of LLDPE geomembrane using the same type of seaming apparatus that is to be used on site. The Master Seamer shall provide direct supervision, as required, over less experienced seaming personnel. Substitution of the Master Seamer shall not be allowed unless prior approval is obtained from the Owner’s Representative by the submittal process.

1.05 CONSTRUCTION QUALITY CONTROL

A. Field Inspection and Testing will be performed under the provisions of this Specification, Manufacturers QC Manual and Installers QC Manual.

B. Quality Control Program:

1. Manufacturer/Installer shall agree to participate in and conform with all items and requirements of the Construction Quality Assurance Plan (CQAP) as outlined in these specifications.

2. Construction Quality Control (CQC) monitoring shall be the responsibility of the Contractor/Installer and shall be conducted in accordance with these Specifications and the Installers QC Manual.

3. Quality Control (QC) testing associated with filling, compaction and Geosynthetic installation operations shall be performed by the Contractor or Contractors CQC consultant in compliance with the Specifications and the Contractors CQA/CQC plan.

4. Quality Control (QC) testing completed by a third party laboratory shall be accomplished only at a GAI-LAP accredited laboratory approved by the Owner’s Representative.

C. Panel Layout (as constructed) Drawings for the Geomembrane shall:

1. Identify panel numbers, placement orientation and dimensions.

2. Identify field seams and types.

3. Identify defect repairs, pipe penetrations, connections and additional details which deviate from the original drawings.
4. Identify the locations of destructive and nondestructive tests and their results.

D. Conformance Testing

1. At the discretion of the Owner’s Representative, Geomembrane materials that are delivered to the site may be tested for conformance with properties listed in Part 2 of this section.

2. Samples shall be taken across the entire width of the Geomembrane roll and shall not include the first 3 ft or outer wrap of the roll. Samples shall be 3 ft. in length by the full roll width.

3. The Owner’s Representative may request additional conformance testing at any time during the Contract to confirm that the Geomembrane meets the specified properties listed in Part 2 of this section. The SL Contractor shall bear the costs of any failing tests.

4. In the event that a portion of the material fails the quality control criteria, the Installer shall remove non-conforming rolls from site. In the event the material failing the quality control criteria has been installed, the Installer shall remove and replace the entire area that failed quality control testing at no cost to the Owner.

1.06 WARRANTY

A. The Contractor shall provide a written 20 year material warranty and a 2 year installation warranty from the date of substantial completion of the geomembrane installation.

1.07 DELIVERY, STORAGE AND HANDLING

A. Packing and Shipping

1. The geomembrane shall be shipped in rolls and protected by appropriate methods to prevent damage to the material during shipping and to facilitate off-loading without damage.

2. Geomembrane rolls shall be marked or tagged with the following information:
   a. Product Identification including Manufacturer and type
   b. Lot number and roll number
   c. Roll thickness, width, length and weight
B. Storage and Protection:

1. Unloading, on-site handling and storage of Geomembrane rolls are the responsibility of the Installer and shall conform to the recommendations of the Geomembrane Manufacturer and this specification.

2. The Contractor shall provide on-site storage areas for the rolls.

3. Store and protect the Geomembrane rolls from dirt, water, traffic, vandalism and other sources of damage.

4. Place geomembrane rolls on a smooth, level, elevated surface that is easily accessible by transport and placement equipment.

5. Do not stack rolls more than 3 rolls in height.

6. Preserve the integrity and readability of geomembrane roll labels.

C. On-Site Handling

1. Unloading, on-site handling and storage of the geomembrane is the responsibility of the Installer.

2. Use appropriate handling equipment when unloading or moving the geomembrane rolls from one place to another. Manufacturer’s recommendations for procedures and equipment used in handling geomembrane rolls shall be followed to prevent damage to the rolls.

3. Geomembrane material damaged due to poor delivery, storage or handling methods shall be repaired or replaced, as determined by the Owner’s Representative, at no additional cost to the Owner.

PART 2 PRODUCTS

2.01 MATERIALS

A. The specifications require that the channel section be lined with nominal 60 mil thick LLDPE Textured Geomembrane. The Geomembrane shall be procured from an approved manufacturer that is in the business of manufacturing LLDPE sheet geomembrane materials. The approved manufacturer for this project is Agru America, Inc., Georgetown, SC, www.agruamerica.com.

B. Resin used in the manufacturing of the Geomembrane shall be new, first-quality polyethylene resin. The addition of recycled polymer (from the manufacturing process) to resin shall be permitted if it does not exceed 2% by weight. The addition of reclaimed polymer to resin shall not be allowed.
C. The finished sheet properties shall meet or exceed the values specified in Table 1 of this part of the specifications. Unless otherwise noted, specified values are minimum average values.

D. Finished sheet surface structure for the LLDPE sheet shall be an integral part of the sheet on both sides. The LLDPE geomembrane shall be Agru Microspike.

E. Resin used in extrusion welding shall be the same resin type as the parent Geomembrane material and shall have the same physical properties.

F. The LLDPE Geomembrane material shall meet or exceed the following physical/mechanical properties characteristics:

**TABLE 1 – LLDPE TEXTURED GEOMEMBRANE PROPERTIES**

<table>
<thead>
<tr>
<th>Property</th>
<th>Test Method</th>
<th>Test Value</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thickness</td>
<td>ASTM D 5994</td>
<td>0.57</td>
<td>mils</td>
</tr>
<tr>
<td>Density</td>
<td>ASTM D 792/1505</td>
<td>0.939</td>
<td>g/cc</td>
</tr>
<tr>
<td>Melt Flow Index (max)</td>
<td>ASTM D 1238</td>
<td>1.00</td>
<td>g/10 min</td>
</tr>
<tr>
<td>Tensile Properties</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Break Strength</td>
<td>ASTM D 6693</td>
<td>168</td>
<td>lb/in</td>
</tr>
<tr>
<td>Break Strain</td>
<td></td>
<td>400</td>
<td>%</td>
</tr>
<tr>
<td>Axi-Symmetric Break Resistance Strain</td>
<td>ASTM D 5617</td>
<td>30</td>
<td>%</td>
</tr>
<tr>
<td>Tear Resistance</td>
<td>ASTM D 1004</td>
<td>36</td>
<td>lb</td>
</tr>
<tr>
<td>Puncture Resistance</td>
<td>ASTM D 4833</td>
<td>70</td>
<td>lb</td>
</tr>
<tr>
<td>Carbon Black Content</td>
<td>ASTM D 1603</td>
<td>2.0</td>
<td>%</td>
</tr>
<tr>
<td>Carbon Black Dispersion</td>
<td>ASTM D 5596</td>
<td>1-2</td>
<td>cat 1</td>
</tr>
<tr>
<td>Oxidative Induction Time (Standard OIT)</td>
<td>ASTM D 3895</td>
<td>140</td>
<td>hrs</td>
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<tr>
<td>Asperity Height</td>
<td>ASTM D 7466</td>
<td>20</td>
<td>mil</td>
</tr>
<tr>
<td>Seam Strength Properties</td>
<td>ASTM D 6392</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Shear at Yield (1)</td>
<td></td>
<td>72</td>
<td>lb/in</td>
</tr>
<tr>
<td>Peel at Yield (1, 2)</td>
<td></td>
<td>60</td>
<td>lb/in</td>
</tr>
</tbody>
</table>

Notes: (1) - Seam strength values shall be in Film Tear Bond (FTB)
(2) – Peel incursion shall be less than 25% by area
PART 3 EXECUTION

3.01 SURFACE ACCEPTANCE

A. For each day of geomembrane installation, the Installer shall provide written acceptance of the surface or subgrade on which the geomembrane is to be installed.

B. After the surface is accepted by the Installer, it shall be the Installer’s responsibility to indicate to the Contractor any change in conditions that may require repair work prior to placement of the geomembrane.

C. The surface under the protection geotextile shall be firm, smooth (roller compacted) and free from loose aggregate larger than ½ inch, debris, sharp objects, etc.

D. The geomembrane shall not be placed over loose, soft, eroded or saturated subgrade conditions that may exist under the protection geotextile. Any areas that have become unacceptable since placement of the geotextile shall be reconditioned and/or re-compacted.

3.02 EQUIPMENT

A. Heavy equipment such as front-end loaders or fork lifts used for moving or deploying geomembranes shall not be operated over the geomembrane.

B. Geomembrane roll deployment shall utilize a spreader bar or equivalent to prevent damage to the roll edges during unrolling.

C. Equipment used shall not damage the Geomembrane by handling, trafficking, or other means. Defects in material resulting from the use of installation equipment shall be repaired at no cost to the Owner.

D. Geomembrane in traffic areas shall be protected from damage by using sacrificial geomembrane, geotextiles or other suitable materials.

3.03 PLACEMENT

A. General requirements:

1. Personnel working on the geomembrane shall not smoke, wear damaging shoes or engage in activities that could damage the geomembrane.

2. Methods used to unroll panels shall not cause scratches or crimps or in any way damage the geomembrane and shall not damage supporting soil or geotextiles.
3. Methods used to place panels shall minimize wrinkles (especially wrinkles between adjacent panels at the overlap).

4. Prevent uplift by wind by placing adequate ballast such as sand bags along edges of geomembrane panels and in the anchor trench. All exposed geomembrane must be ballasted to prevent wind uplift and damage. Any damage due to wind on areas that are determined by the Owner’s Representative to be inadequately ballasted will be the responsibility of the Installer. Subsequent replacement and repair of damaged panels will provided by the Installer at no additional cost to the Owner.

5. The geomembrane shall be covered within 14 calendar days of placement.

B. Panel Installation:

1. Follow Manufacturer’s instructions to ensure panels are unrolled in the proper direction for seaming.

2. Panel sizes shall be established by Installer’s Panel Layout Drawing showing dimensions, panel numbering and installation details.
   a. A field panel is a roll or portion of a roll cut in the field that is to be seamed in the field.
   b. When placed, designate each roll with panel number or code number consistent with the layout plan. Position panels on site as shown in the Panel Layout Drawing.

3. Place panels one at a time and seam each panel immediately after its placement. Seam all panels that are placed each day.

4. Place panels in direction of maximum slope (parallel to the slope length).

C. Weather Conditions:

1. Panels shall not be placed at ambient temperatures below or above the Manufacturer’s recommended ambient temperature range for installation.

2. Panels shall not be placed during precipitation, in the presence of excessive moisture (e.g., fog, dew, snow), in areas of ponded water or during excessive winds.

D. Damage:

1. Panels that become seriously damaged (torn or twisted beyond repair) shall be replaced at no cost to the Owner. Less serious damage may be repaired at the discretion of the Owner’s Representative.
2. Remove rejected panels or portions of panels from the project.

E. Materials in Contact with Geomembrane:

1. Materials in contact with the Geomembrane shall be carefully installed to minimize any damage potential. Geotextiles shall be used as temporary protection for the Geomembrane in areas of heavy traffic or mechanical attachment.

2. Fasteners such as preformed embed strips, batten strips, bolts, washers, nuts or other items shall have a life expectancy equal to or exceeding the geomembrane

F. Concrete Structure Attachment:

1. Install geomembrane to concrete structures as shown on the detail drawings using mechanical batten bar connections.

2. Final structure connections shall be made after geomembrane material is placed and seamed. Maintain sufficient overlap or excess material to ensure attachment of geomembrane can be accomplished as required.

3. Extreme care must be taken when seaming around structures as seam destructive or nondestructive testing may not be feasible.

4. Extreme care shall be taken while making connections to concrete structures to prevent any damage to the geomembrane.

5. Provide corner support under the geomembrane with compacted soil at the subgrade/concrete structure as shown on the drawings.

G. Anchor Trench

1. Anchor trenches shall be excavated to the dimensions shown on the drawings.

2. Anchor trench edge to be rounded for smooth transition of geomembrane into the trench (no sharp edge or rock allowed)

3. Bottom of trench shall be firm, free of standing water of soft soils and no loose soils shall be allowed prior to geosynthetics installation

4. Geosynthetics shall be installed down and across the bottom of the trench.

5. No loose or excess geosynthetics shall be allowed in the trench (cut and trim excess material and discard prior to backfilling.)
6. Backfill with select material or soil cement and compact in lifts without damaging the geosynthetics.

3.04 GEOMEMBRANE FIELD SEAMING

A. Seam Layout:
   1. In general, orient seams parallel to line of maximum slope.
   2. No horizontal seam shall be less than 5 ft from toe of slope.
   3. No horizontal or butt seams shall be allowed on the slopes.

B. Overlapping and Temporary Bonding:
   1. Overlap panels a minimum of 4 inches for fusion welding or 3 inches for extrusion welding.
   2. Spot hot air welding procedure used to temporarily bond adjacent panels together for extrusion welding shall not damage the geomembrane.
   3. Temporary adhesive bonding shall not be used unless approved by the Manufacturer and approved in writing by the Owner’s Representative.

C. Seam Preparation:
   1. Prior to seaming, the seam area shall be clean and free of moisture, dirt, debris of any kind and foreign material.
   2. If seam overlap grinding is required, the process shall be completed in accordance with the Manufacturer’s instructions and in a way that is not damaging to the Geomembrane.
   3. Align seam overlaps with minimal wrinkles or “fishmouths”.

D. Seaming Equipment and Products:
   1. General:
      a. Approved processes for field seaming are thermal fusion welding and extrusion welding. Daily production seaming shall be by thermal fusion methods only. Extrusion welding shall be restricted to repairs and welding applications not possible by fusion welding.
      b. Use only welding apparatus specifically approved by the geomembrane Manufacturer.
      c. Seam strengths shall meet or exceed specifications in Part 2
2. **Thermal Fusion Welding Process:**
   a. Use only automated thermal fusion welding apparatus equipped with applicable temperature, pressure and speed indicators.
   b. Seaming equipment shall not damage the geomembrane.
   c. If required, use a movable, protective layer directly below each overlap that is to be seamed to prevent moisture accumulation between the sheets.
   d. Protect the geomembrane from ancillary equipment such as generators by using a movable protection layer under the equipment or hot welding apparatus when not in use.

3. **Extrusion Welding Process:**
   a. Complete preparatory grinding in accordance with the Manufacturer’s instructions and no more than one hour prior to seaming.
   b. Exposed grind marks shall not extend more than 1/4 inch from the seam area.
   c. Use only clean, dry weld rod that is manufactured from the same resin as that used in the manufacture of the Geomembrane material approved for this project.
   d. Use only apparatus equipped with temperature sensors at the nozzle and digital indicators at the handle.
   e. Provide documentation certifying that the weld rod is comprised of the same resin as the Geomembrane.
   f. Purge extruder prior to beginning of seaming operation until all heat-degraded extrudate has been removed from barrel.
   g. Protect Geomembrane from ancillary equipment such as generators by using a movable protection layer under the equipment or hot welding apparatus when not in use.

E. **Weather Conditions for Seaming:**

1. No seaming shall be attempted below 32 degrees F or above 104 degrees F without approval of the Owner’s Representative. The Installer shall submit written procedures for cold weather or hot weather seaming.
procedures approved by the Manufacture for approval by the Owner’s Representative.

2. If seaming is required to be carried out below 32 degrees F or above 104 degrees F, the Installer must certify in writing that low temperature or high temperature seaming procedures will not cause any polymer modification to the Geomembrane that will generate any short or long-term deterioration of the Geomembrane properties.

3. Geomembrane shall be dry and protected from the wind.

F. General Seaming Requirements:

1. For Thermal Fusion welding, provide temporary sacrificial or protective layer of plastic directly below the overlap of the geomembrane to be seamed to prevent moisture accumulation between panel overlaps to be welded. This may not be required if conditions are dry and the underlying geotextile is dry.

2. Seaming shall extend to the outside edge of panels to be anchored to concrete or placed in an anchor trench.

3. If required, provide a firm substrate by using flat wood boards, conveyor belt or similar hard surface directly under the seam overlap to achieve proper support.

4. Wrinkles or “fish mouths” that occur at seam overlaps shall be cut along the ridge of the wrinkle and laid flat to form a flat overlap. Seam the cut wrinkle and patch any portion that is inadequate with an oval or round patch of the same geomembrane material which extends a minimum of 6 inches beyond the cut in all directions.

G. Trial Seams:

1. Trial seams of sufficient length shall be made on fragment pieces of geomembrane to confirm seaming equipment and conditions are acceptable for seaming. Trial seams shall be made at the beginning of each seaming period and at least once every five hours for each seaming apparatus used that day. Also, each seam technician shall make at least one trial seam each day. Additional trial seams may be required at the Owner’s Representative’s discretion.

2. Trial seam samples shall be cut at least 3 ft in length by 1 ft in width with the seam centered lengthwise. Six random test specimens, each 1 inch wide shall be cut from the seam sample. Test the six specimens in shear and peel using a field tensiometer. Specimens shall not fail in the seam. If the trial seam is unacceptable, a second trial seam shall be made and tested. If the second trial seam fails,
the seaming apparatus and/or seaming technician shall not be accepted and shall not be used for seaming until deficiencies are corrected and two consecutive passing trial seams are achieved.

H. Nondestructive (NDT) Seam Continuity Testing:

1. All field seams shall be nondestructively tested over their full length. Nondestructive continuity testing shall be done as the seaming work progresses and not at the completion of field seaming.

2. Nondestructive continuity testing shall be accomplished by one or all of the following methods:
   
a. Vacuum Chamber Testing - Testing shall be performed in accordance with ASTM D 5641 - Standard Practice for Geomembrane Seam Evaluation by Vacuum Chamber. (This method shall be restricted to testing of extrusion welded seams such as on patches, repairs or cap strips)

b. Dual Seam Air Channel Testing - Testing shall be performed in accordance with ASTM D 5820 - Standard Practice for Pressurized Air Channel Evaluation of Dual Seamed Geomembranes. (This method is to be used on all daily production seaming by dual track thermal fusion welders)

c. Electrical Spark Testing – Testing shall be performed in accordance with ASTM D 6365 – Standard Practice for Nondestructive Testing of Geomembrane Seams using the Spark Test. (This method is restricted to extrusion welded seams and areas that are not accessible or practical for testing by (a) and (b) above).

3. If a seam area cannot be tested prior to final installation, seaming and/or cap-stripping shall be observed by the Owner’s Representative for uniformity and completeness.

I. Destructive Seam Testing:

1. Location and Frequency:
   
a. Conduct a minimum of one test per 1000 ft of seam length or as directed by the Owner’s Representative.

b. Maximum frequency of test locations shall be agreed upon by the Installer and Owner’s Representative prior to commencement of the installation.
c. Test locations will be determined during seaming by the Owner’s Representative. Additional test locations may be required during seaming at the Owner’s Representatives discretion.

d. Frequency of test locations may be reduced at the discretion of the Owner’s Representative dependent on overall seam quality and trial weld frequency and acceptability.

e. Test locations shall not be located on the slope.

2. Sampling Procedure:

a. Cut samples as seaming progresses to obtain lab test results prior to completion of the geomembrane installation.

b. Properly identify each sample by a number/letter sequence and note location on the Panel Layout Drawing.

c. Sample holes shall be immediately repaired. Test the seam around repair according to NDT procedures (usually by Vacuum Box – ASTM D 5641).

3. Destructive Seam Sample Size:

a. Cut two 1 inch wide by 12 inch long samples with seam centered. Cut the two specimens a distance of 42 inches apart and test each of the strips for peel and shear.

b. If the two specimens pass the field test, remove the 12 inch wide by 42 inch long section between the two samples and cut it into three equal parts for distribution as follows:

   One 12 in. x 12 in. portion to Installer for lab testing
   One 12 in. x 12 in. portion to the Owner’s Representative for Archive
   One 12 in. x 18 in. portion to Independent laboratory for testing.

4. Submit Installer’s laboratory testing to the Owner’s Representative as soon as they become available.

5. Submit Independent laboratory test results to the Owner’s Representative no more than 24 hours after laboratory receives the samples. Test the sample for seam strength in “peel” and “shear” in accordance with ASTM D 6392. Minimal acceptable values are as indicated in Part 2 of this specification section. Test a minimum of 5 replicate specimens for both “peel” and “shear”. To be acceptable, four out of five replicates shall pass minimum requirements.
6. Procedures for Destructive Test Seam Failure:

   a. Reconstruct seam between any two passed test locations.

   or

   b. Retrace weld path to intermediate location, 10 ft minimum from location of failed test in each direction, and take samples for additional field tests. If additional samples pass, reconstruct seam between those locations on either side of the original failed sample location. If any sample fails, the process shall be repeated.

   c. In any case, acceptable seams shall be bounded by two passed destructive test locations.

J. Defects, Reconstruction and Repairs:

1. Repair Procedures:

   a. Patching - Use to repair holes, tears, un-dispersed raw materials and contamination by foreign matter.

   b. Spot Welding - Use to repair pinholes, minor localized flaws

   c. Cap Strips - Use to repair long lengths of failed seams.

   d. Topping or Extrudate Welding - Use to repair seams with an exposed edge or to weld the flap edge of a fusion weld.

   e. Surfaces of geomembrane to be repaired shall be dry and clean.

   f. Surfaces of geomembrane to be repaired by extrusion methods shall be abraded no more than 1 hour prior to repair.

   g. Seams used in repairs shall be approved extrusion or fusion welded seams and shall be subjected to the same nondestructive test procedures as outlined for other seams.

   h. Patches shall be of the same geomembrane material and shall be round or oval in shape. Patches shall extend a minimum of 6 inches beyond the edge of defects in all directions and shall be applied by approved seam methods only.

2. Reconstruction Procedure:

   a. Seam reconstruction shall be achieved by cutting out the existing seam and welding in a replacement strip or by welding in a top cover or cap strip that is a minimum of 12 inches in width and centered over the failed seam area. The cap strip shall be extrusion welded and vacuum tested.
3. Repair Verification
   a. Test each repair seam by one of the approved non-destructive methods.
   b. Repairs passing nondestructive testing shall be taken as an indication of an acceptable repair.
   c. Identify all repairs and note repair locations on the final panel layout plan.

3.05 GEOMEMBRANE ACCEPTANCE

A. Contractor/Installer shall retain ownership and responsibility for the geomembrane until final acceptance by the Owner. Geomembrane installation shall be accepted by the Owner when:

1. Geomembrane Installation is Complete.

2. Documentation of installation is complete, including all geomembrane test results.

3. Documentation of all field seaming and repairs is complete, including all associated nondestructive and destructive test results.

4. Documentation of Electrical Leak Location Survey is complete and submitted and all repairs to leak locations have been completed and tested.

END OF SECTION
PART 1   GENERAL

1.01 SUMMARY

A. This section includes the requirements for furnishing and installing the 16 oz/sq yard geotextile to be used as the underlying protection layer for the LLDPE textured geomembrane.

B. The geotextile used shall meet the requirements of this section as specified herein and all work shall be performed in accordance with the procedures provided herein, the manufacturer’s recommendations, and the Contract Drawings.

1.02 MEASUREMENT AND PAYMENT

A. Geotextile:
   1. Surface area required to be covered except no allowance will be made for seam overlap, repairs or waste
   2. Payment: Square yard price offered in the schedule.

1.03 REFERENCES

A. ASTM International (ASTM) – American Society for Testing and Materials, most recent published standards edition and revision

1. ASTM D 4355 - Standard Specifications for Deterioration of Geotextiles from Exposure to Ultraviolet Light and Water -Xenon-Arc Type Apparatus

2. ASTM D 4533 - Standard Test Method for Trapezoid Tearing Strength of Geotextiles


5. ASTM D 5199 - Standard Test Method for Measuring Nominal Thickness of Geotextiles and Geomembranes

6. ASTM D 5261 - Standard Test Method for Measuring Mass per Unit Area

02211 - 1
of Geotextiles

7. ASTM D 6241 – Standard Test Method for Static Puncture Strength of Geotextiles and Geotextile Related Products Using a 50-mm Probe

B AASHTO – American Association of State Highway and Transportation Officials, most recent edition.

1.04 SUBMITTALS

A. Pre-Certification Submittals: Submit the following to the Owner’s Representative for Approval:

1. Manufacturer’s written certification that the Geotextile meets the physical/mechanical properties listed in Table 1 of Paragraph 2.1.

2. Samples and product literature for proposed Geotextiles

3. Manufacturer’s and Installer’s Qualifications

4. Manufacturer’s and Installers QC Manual including recommended installation procedures.

B. Pre-Construction Submittals: Submit the following to the Owner’s Representative for review within 5 days of shipment:

1. Written list of the specific lot numbers and rolls to be shipped.

2. Manufacturer’s Quality Control data for rolls to be shipped to the site including the following:
   a. Roll numbers, lot or batch numbers, identification
   b. Results of all QC tests

3. Manufacturers Quality Control Certificates for each shifts production signed by a responsible party of the manufacturer.

C. Construction Submittals: Submit the following to the Owner’s Representative for review no later than 2 days following substantial completion:

1. Quality Control Installation Certification documentation by the Installer

2. Geotextile Warranty specific for this project
1.05 CONSTRUCTION QUALITY CONTROL

A. Field Inspection and Testing will be performed under the provisions of this Specification and Section on Quality Control.

B. Provide visual Inspection for delivery and installation damage and for conformance with this Specification.

C. Conformance Testing:

1. At the discretion of the Owner’s Representative, Geotextile material delivered to site may be tested for conformance with properties listed in Part 2 of this section.

2. Samples shall be taken across the full width of the Geotextile roll and shall not include the entire outer wrap. Samples shall be 3 ft. long by full roll width. Machine direction shall be marked on the sample.

3. The Owner’s Representative may request additional conformance testing at any time during the Contract to confirm that the Geotextile meets the specified properties listed in part 2 of this section. The Contractor shall bear the costs of any failing tests and retesting.

4. In the event that a portion of the material fails the quality control criteria, the Installer shall remove non-conforming rolls from site. In the event the material failing the quality control criteria has been installed, the Installer shall remove and replace the entire area that failed quality control testing at no cost to the owner.

1.06 QUALIFICATIONS

A. The Manufacturer of the Geotextile shall have a minimum of 5 continuous years experience in the manufacture of similar Geotextile products. The Manufacturer must demonstrate, by submitting a list of previous projects, a minimum of 15 million square feet of manufacturing experience of similar Geotextile product.

B. The Installer of the Geotextile shall have a minimum of 5 years continuous experience in the installation of similar geotextile products. The Installer must demonstrate, by submitting a list of previous projects, a minimum of 1 million square feet of similar Geotextile products installed in a least 5 facilities.

1.07 DELIVERY, STORAGE AND HANDLING

A. Packing and Shipping:

1. Geotextile shall be supplied in rolls individually wrapped with protective
plastic covers.

2. Geotextile rolls shall be marked and/or tagged with the following information in 3 locations - outer cover, roll and inside roll core:
   a. Product Identification including Manufacturer and Type
   b. Lot number and roll number.
   c. Roll length, width and weight.

B. Storage and Protection:

1. Unloading, on-site handling and storage of Geotextile rolls are the responsibility of the Installer and shall be in compliance with the Manufacturers written instructions and recommended methods for unloading, on-site handling and storage.

2. The Contractor shall provide secure, dry on-site storage areas for the rolls away from construction traffic.

3. Store and protect the Geotextile rolls from dirt, water, ultraviolet light, vandalism and other sources of damage.

4. Preserve integrity and readability of Geotextile roll labels.

1.08 COORDINATION OF WORK

A. Placement of Geotextiles shall be coordinated with other sections including Geomembrane and Earthwork.

B. Geotextiles must be installed and accepted by on-site QC and CQA prior to placement of overlying materials (geomembrane).

PART 2 PRODUCTS

2.01 MATERIALS

A. The final Geotextile product shall have minimum average roll values (MARV) for the physical/mechanical properties shown in Table 1.

B. The Geotextile shall be a 100% continuous or staple filament needle punched polyester or polypropylene consisting of a long chain polymer composed of at least 85 percent by weight polyester or polypropylene. The base polymer shall contain stabilizers or anti-oxidants to make the filaments resistant to UV deterioration and heat exposure. The geotextile shall be resistant to biological deterioration and shall be designed for a buried soil environment.
C. Geotextile shall conform to AASHTO M-288 Survivability Class 1

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PART 3 EXECUTION

3.01 SUBSURFACE ACCEPTANCE

A. Once the base layer (aggregate or geomembrane) has been prepared, the Installer shall inspect the surface and provide written acceptance for the placement of the non woven geotextile.

B. After the surface has been accepted by the Installer, it shall be the Installer’s responsibility to indicate to the Contractor any change in conditions that may require repair work.

3.02 EQUIPMENT

A. Methods used to unroll the geotextile shall not damage the underlying prepared surface.

B. Equipment used shall not damage the Geotextile by handling, trafficking, or other means. Defects in or damage to material during installation arising from the use of equipment shall be repaired or replaced at no cost to the owner.

3.03 INSTALLATION

A. Geotextile deployment shall comply with the following:

1. The Geotextile shall be placed in accordance with manufacturer’s recommendations, these specifications, and at locations shown on the Contract Drawings.
2. The Geotextile shall be placed with the long roll dimension parallel with the line of maximum slope and shall be laid smooth and free of wrinkles, tension, folds or creases. Butt seams shall not be allowed on the slopes.

3. Methods used to unroll and position the Geotextile shall not cause tears, punctures or abrasion to the Geotextile.

4. Methods used to place adjacent rolls of Geotextile shall maintain a minimum overlap of 4 inches and shall minimize wrinkles between adjacent rolls.

5. The Geotextile shall be protected at all times from accumulations of dirt, dust, debris, sand or mud that will alter the protection efficiency of the Geotextile. If excessive contaminant materials are noted on the Geotextile, the Geotextile shall be replaced as directed by the Owner’s Representative.

6. The Geotextile shall be protected at all times during construction to avoid damage caused by surface runoff or geomembrane placement. Any damage to the Geotextile during installation or during placement of overlying materials shall be repaired or replaced by the Contractor at no expense to the owner.

7. To prevent wind uplift and damage or movement down-slope, all exposed Geotextiles shall be ballasted with sand bags along leading edges and in the anchor trench top of slope. Sandbags shall remain in place until replaced with overlying geomembrane and/or anchor trench backfill.

B. Overlap Seaming

1. Geotextiles shall be overlapped a minimum of 4 inches prior to seaming.

2. All Geotextile overlaps shall be continuously thermally seamed by hot air/hot wedge methods. Seam width shall be a minimum of 1 inch.

3. Areas to be seamed shall be clean and free of foreign material.

4. Seamed area shall be flat with no loose edge on the overlying Geotextile.

C. Defects and Repairs

1. Repair all flaws or damaged areas by placing a round or oval patch of the same material extending a minimum of 1 ft in all directions beyond the damaged area.

2. Thermally seam the patch to the Geotextile by hot air or hot wedge
methods. Provide a minimum 1 inch seamed width around the entire patch perimeter with no loose edge.

3. Should any tear or cut exceed 10% of the roll width on slopes, that roll shall be removed and replaced (slope areas only)

3.04 PROTECTION OF COMPLETED WORK

A. Protect installed Geotextiles from damage by limiting traffic and access until overlying materials are placed.

B. Cover the Geotextile with the required Geomembrane or soil cover within 14 calendar days after placement.

END OF SECTION
SECTION 02212
GEONET COMPOSITE DRAINAGE LAYER

PART 1  GENERAL

1.01  SUMMARY

A. This section includes the requirements for furnishing and installing the Geonet Composite Drainage Layer, which is composed of geotextile/geonet/geotextile. The three layers are intended to provide a) protection over the LLDPE-T geomembrane liner, b) water transmission above the geomembrane liner, and c) water filtration above the geonet, respectively.

B. The geonet composite shall meet the requirements of this section as specified herein and all work shall be performed in accordance with the procedures provided herein, the manufacturer’s recommendations, and the Contract Drawings.

1.02  MEASUREMENT AND PAYMENT

A. Geonet Composite:

1. Measurement: surface area required to be covered including anchor trench (where required), except no allowance will be made for seam overlap, repair, or waste.

2. Payment: Square yard price offered in the schedule

1.03  REFERENCES

A. American Society for Testing and Materials (ASTM)


1.04 SUBMITTALS

A. Pre-Certification Submittals: Submit the following to the Owner’s Representative for Approval:

1. A copy of the Geonet Composite specification sheet listing all test methods and property values listed in Tables 1, 2 and 3.

2. One 8 in. x 10 in. sample of the Geonet Composite to be used on this project.

3. Manufacturer’s written certification that the Geotextile and Geonet Layers, and the Geocomposite meet the physical and hydraulic properties listed in Part 2 of this section.

4. Manufacturer’s and Installers Qualifications.
B. Pre-Construction Submittals: Submit the following to the Owner’s Representative within 5 days of the shipment date:

1. Written list of the specific rolls to be shipped to the project site.

2. Manufacturers Quality Control data for rolls shipped to the site including the following:
   a. Roll numbers, lot or batch numbers, identification.
   b. Results of all QC tests.

3. Manufacturers Quality Control Certificates for each shifts production signed by a responsible party of the manufacturer.

C. Post-Construction Submittals:

1. Geonet Composite Installation Certification.

2. Geonet Composite Warranty.

1.05 CONSTRUCTION QUALITY CONTROL

A. Field inspection and testing shall be performed under the provisions of this Specification.

B. Visual inspection for installation damage and conformance with the Specifications.

C. Conformance Testing:

1. At the discretion of the Owner’s Representative, a random conformance sample of the Geonet Composite shall be taken across the entire width of one of the rolls. The sample taken shall not include the outer wrap. Samples shall be taken at intervals of one sample every 50,000 square feet. The sample shall be tested for conformance with the properties presented in Table 2 & 3, Part 2 of this section.

2. If the sample does not comply with the properties specified in this section, the entire roll from which the sample was taken shall be rejected as well as all rolls associated with the same shifts production. The manufacturer shall remove and replace any rejected rolls at no cost to the owner.

3. Additional sample testing may be performed at the discretion of the Owner’s Representative to more closely identify any non-complying rolls and/or qualify individual rolls.
1.06 QUALIFICATIONS

A. The manufacturer of the Geonet and Geocomposite shall have a minimum of 5 years of continuous experience in the manufacture of Geocomposites or similar products and shall have manufactured a minimum of 5 million sq. ft. of products similar to those specified in this specification.

B. The installer of the Geonet Composite Drainage Layer shall have a minimum of 5 years of continuous experience in the installation of Geonet Composites or similar products. The installer must demonstrate, by submitting a list of previous projects, a minimum of 5 million sq. ft. of Geonet Composite installed in at least 5 facilities.

1.07 DELIVERY, STORAGE AND HANDLING

A. Packing and Shipping:

1. Geonet Composite shall be supplied in rolls wrapped individually in opaque plastic protective covers.

2. Geonet Composite shall be marked or tagged with Manufacturer’s name, brand, product code, lot number and roll number, roll length, width and weight in a minimum of three places including the outer wrapping, roll and inside roll core.

B. Storage and Protection:

1. Unloading, on-site handling, and storage of the Geonet Composite are the responsibility of the Installer.

2. The owner shall provide on-site storage area for Geonet Composite rolls from time of delivery until installation.

3. Store and protect Geonet Composite from mud, dirt, dust, water, exposure to ultraviolet light, heat, vandalism and other sources of damage.

PART 2 PRODUCTS

2.01 GEOTEXTILE

The geotextile layers on both sides of the Geonet shall be composed of a nonwoven, needle punched polyester or polypropylene product with minimum values as shown in Table 1.
TABLE 1
GEOTEXTILE PROPERTIES

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<td>Trap Tear Strength</td>
<td>lbs</td>
<td>80 min</td>
<td>ASTM D4533</td>
</tr>
<tr>
<td>Puncture Strength</td>
<td>lbs</td>
<td>500 min</td>
<td>ASTM D6241</td>
</tr>
<tr>
<td>Water Flow Rate</td>
<td>gal/min/ft</td>
<td>90 min</td>
<td>ASTM D4491</td>
</tr>
<tr>
<td>Apparent Opening Size</td>
<td>US Sieve No.</td>
<td>70-100</td>
<td>ASTM D4751</td>
</tr>
</tbody>
</table>

2.02 GEONET

A. Geonet portion of the Geonet Composite is to be comprised of high density polyethylene (HDPE). The geonet shall be manufactured by extruding two or three sets of strands to form a three dimensional structure to provide planar water flow. The geonet shall meet the minimum property values shown in Table 2.

TABLE 2
GEONET PROPERTIES

<table>
<thead>
<tr>
<th>Property</th>
<th>Units</th>
<th>Value</th>
<th>Test</th>
</tr>
</thead>
<tbody>
<tr>
<td>Density</td>
<td>g/cc</td>
<td>0.90 min</td>
<td>ASTM D792</td>
</tr>
<tr>
<td>Thickness</td>
<td>mils</td>
<td>250 min</td>
<td>ASTM D5199</td>
</tr>
<tr>
<td>Melt Flow Index</td>
<td>g/10 min</td>
<td>1.0 max</td>
<td>ASTM D1238</td>
</tr>
<tr>
<td>Carbon Black</td>
<td>%</td>
<td>2.0 min</td>
<td>ASTM D1603</td>
</tr>
</tbody>
</table>

2.03 GEONET COMPOSITE

A. Geonet Composite shall be supplied in rolls, free of defects, rips, holes, or flaws. The Geonet Composite shall be manufactured by heat bonding the geotextile layers to the geonet. Geotextile burn-through, glue, or adhesive shall not be permitted.
B. The Geonet Composite shall meet the following minimum values shown in Table 3

### TABLE 3
**GEONET COMPOSITE PROPERTIES**

<table>
<thead>
<tr>
<th>Property</th>
<th>Units</th>
<th>Value</th>
<th>Test</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flow Rate - MD</td>
<td>gal/min/ft</td>
<td>2.5 min</td>
<td>ASTM D4716</td>
</tr>
<tr>
<td>Ply Adhesion</td>
<td>lb/in</td>
<td>1.0 min</td>
<td>ASTM D7005</td>
</tr>
</tbody>
</table>

Notes: Geonet Composite flow rate to be measured by ASTM D4716 at a gradient of 0.1 and 250 psf normal load with the following boundary conditions from top to bottom: steel plate/geomembrane/geocomposite/steel plate. Flow rate shall be measured in the machine direction (MD).

### PART 3  EXECUTION

#### 3.01 DRAINAGE LAYER PLACEMENT AND HANDLING

A. Handle all Geonet Composite in such a manner as to ensure it is not damaged.

B. Do not drive vehicles directly on the Geonet Composite.

C. Geonet Composite shall not be dragged over the Geomembrane surface.

D. Geonet Composite shall be placed by unrolling downslope.

E. Geonet Composite shall be temporarily anchored so as to continually keep the material in tension. Sandbags shall be used at top of slope, roll edges and along the centerline as required.

F. Geonet Composite shall be completely covered within 14 days of removing protective wrapping from Geocomposite.

G. In the presence of wind, Geonet Composite shall be weighted with sandbags. Sandbags shall remain in place until placement of the cover soils.

H. During Geonet Composite placement, care shall be taken not to entrap stones, dirt, mud, debris or moisture.

#### 3.02 GEONET COMPOSITE OVERLAPS AND SEAMS

A. Adjacent edges of geonet shall be overlapped a minimum of 4 inches and joined
by colored plastic ties every 3.0 ft. along longitudinal seams and every 1.0 ft. along transverse seams.

B. Geonet butt seams shall be minimized on slopes > 3H:1V. All transverse (butt seams) or overlaps shall be tied by using plastic ties every 1.0 ft along the roll width. A 2.0 ft wide strip of nonwoven geotextile shall be thermally bonded to all butt seam overlaps. Overlaps shall be shingled downslope.

C. Excessively deformed roll ends of geonet shall not be allowed and shall be cut back and discarded.

D. The geotextile layer above and below the geonet shall be overlapped a minimum of 12 inches. The geotextile above the geonet shall be thermally welded continuously along the overlap so as to provide a flat seam surface. No exposed areas of geonet shall be allowed to come in contact with the geomembrane.

3.03 GEONET COMPOSITE REPAIR

A. Any holes or tears in the Geonet Composite shall be repaired as follows:

1. Overlap the geotextile below geonet a minimum of 6 inches. A patch made from geonet material shall be butted against undamaged geonet and tied in place.

2. Place a patch of the same geotextile on top of the geonet and 6 inches beyond the repair in all directions and thermally bond in place.

END OF SECTION
PART 1 - GENERAL

1.01 INTRODUCTION

A. Recognizing that the construction contractor will be responsible for the means and methods of dewatering to meet the intent stated below, this specification presents details of one dewatering alternative for consideration.

B. Dewatering could be accomplished with French drains that are connected to sumps (“wet wells”) at the down-gradient end of each dewatering segment. Each sump shall be equipped with a pump to remove the collected water and bring it to the surface for treatment. The method(s) of water transport between the sumps and treatment plant (such as piping, alignment, and tankage) are the responsibility of the water treatment contractor and are addressed separately. Dewatering drains, sumps, and pumping systems are addressed in this specification.

C. The drains and sumps are designed to be temporary features, which shall be abandoned following initial construction of: a) the outfall structure, wingwalls, box culvert, and vertical inlet structure in dewatering Zones 1 and 2; 2) the Strengthening Layer, wing wall footers, and concrete wall footers in dewatering Zones 3a and 3b; and 3) the base of the cast-in-place Reinforced Concrete Box conduit in dewatering Zone 4.

D. Locations and conceptual layouts for each dewatering zone are shown on Construction Drawing EC-12, drain profiles are shown on Drawing EC-13, and construction details are shown on Drawing EC-14.

E. Work will consist of intrusive excavation into waste material at a hazardous waste site. Consequently, workers will have the potential to be exposed to chemical or physical hazards, as detailed in the project Health and Safety Plan (Final Design Report, Appendix E). Contractor will be held responsible for operating in accordance with the applicable Occupational Safety and Health Administration (OSHA) rules and regulations, specifically provisions of 29 CFR 1910.120, 1910.134, 1910.1001-1101, 1910.1200, and 29 CFR 1926.

1.02 INTENT

The intent of the dewatering system is to depress the groundwater table sufficiently to create dry working conditions to construct the Globeville Landing Outfall Project stormwater drainage features that are shown on Drawing EC-12.

1.03 STANDARDS AND REFERENCES

A. Reference documents as provided to the Dewatering System contractor shall include:

1. This specification
2. Final Design Report, including
   a. Materials Management Plan (Appendix A)
   b. Health and Safety Plan (Final Design Report, Appendix E)
   c. Construction Drawings (Final Design Report, Appendix G)
3. Bid Documents

1.04 SUBMITTALS

A. The following shall be submitted to the Owner’s representative by the Dewatering Construction contractor with the bid documents:

1. A list of at least five previously completed projects of similar scope and purpose for approval by the Owner’s representative. The list shall include a description of the project, relative size, and contact person with phone number.

B. The following shall be submitted to the Owner’s representative by the Dewatering Construction contractor for review and approval two weeks prior to the start of work:

1. Resumes of the management, supervisory, and key personnel.
2. Designs for wet wells and appurtenances and pumping system.
3. Specifications for drainage pipe, drainage socks, pipe bedding and backfill material, and sump pumps.
5. Written documentation verifying that personnel who will perform work at the site have completed appropriate health and safety training, in accordance with 29 CFR 1910.120, the Hazardous Waste Operations and Emergency Response (HAZWOPER) standard.

C. The following shall be submitted to the Owner’s representative by the Dewatering Construction contractor during the work:

1. Accurate daily records that include the type and amount of line-item quantities identified in the bid documents.

1.05 QUALIFIED CONTRACTORS

A. The Dewatering Construction contractor shall meet the requirements stated in Section 1.06 of these specifications

1.06 QUALITY ASSURANCE

A. Construction of this dewatering system shall be performed by a contractor with at least
five continuous years of documented pipeline construction experience.

B. The Dewatering Construction contractor shall provide experienced management, supervisory and key personnel to install the dewatering system.

C. The Dewatering Construction contractor shall ensure that procedures and documentation conform to these specifications.

PART 2 – EQUIPMENT AND MATERIALS

2.01 TRENCHES

A. Trenches shall be excavated to depths and grades specified by the dewatering plans (see Sheets EC-12 and EC-13); they shall be of minimum 1-foot width or more as required by site conditions or as specified by the Owner’s Representative and shall have a flat bottom configuration with all excess loose soil material removed.

B. Trench alignment shall be as shown on Sheet EC-12, with the clarification that excavation through the area of soil stabilization (in Zone 4 from approximately station 9+00 to station 14+50, and in Zone 3B from approximately station 6+10 to station 8+75) shall require the alignment to curve around and avoid compaction-grout and Vibro-Stone columns.

C. Stabilization of trench walls shall be provided as necessary to keep the trench open and allow for construction of the dewatering system.

2.02 DRAIN PIPE

A. The drain pipe shall be rigid, perforated, nominal 4-inch I.D. SDR35 polyvinyl chloride (PVC) pipe in 20-foot lengths with solvent-weld bell end connections. Perforations shall be a minimum of two straight rows of ½-inch diameter holes placed along the pipe length parallel to the pipe axis. These two straight rows of holes shall be separated at the pipe circumference by approximately 120 degrees of angle. Changes to these drain-pipe specifications shall be subject to approval of the Owner’s Representative.

B. A ball valve and approximately 20 feet of non-perforated 4-inch PVC pipe shall be located at the downgradient end of each drain-line segment just prior to connection with the wet well in order to facilitate shutting off the flow from the drain line while the wet well is being installed and connected to the drain line. If possible, the ball valve shall remain accessible during dewatering operations.

2.03 DRAIN SOCK

A. Drain pipe filter sock (also known as drain sleeve filter) shall be commercially-available material of proper size to fit the specified drain pipe, constructed of suitable permeable material such as polyester fabric, and prevent entry of small particulates into
the drain pipe perforations. The drain sock shall be installed on the drain pipe prior to or during pipe installation, per the manufacturer’s recommended procedures.

2.04 DRAIN PIPE CLEANOUTS

A. Drain pipe cleanouts shall be constructed as shown in Sheet EC-14 and installed at approximately 200-foot intervals along each drain pipe, oriented to facilitate cleaning of the downstream pipe. Capped tops of the cleanouts shall protrude approximately four inches above ground surface elevation, or as directed by the Owner’s Representative. In all cases, a cleanout shall be located on each drain pipe within 100 feet of the wet well and directed towards the wet well connected to the drain pipe.

2.05 PIPE BEDDING AND BACKFILL

A. Gravel used for pipe bedding and backfill also serves as a partial filter. The gravel shall be washed rounded rock of ¾-inch minimum (100% retained) and approximately 3-inch maximum screen size, or as approved by the Owner’s Representative. The gravel shall be devoid of fine material and handled in a way to prevent the introduction of soil or other fines into the backfill.

2.06 WET WELLS

Wet well structures shall be site-fabricated or commercially-available units (see Sheet EC-14) incorporating the following features:

A. Wet well height shall be sufficient to extend from the drain pipe entry elevation to approximately one foot above surface grade or approximately one foot above the highest existing groundwater level along each drain line, whichever is greater. Wet well No. 1 (located at the downgradient end of Zone 1 by the river) shall require a different approach for water containment in the case of a pump failure; extending the well top to an elevation above the highest August 2015 groundwater level in Zones 1 and 2 shall require the well top to extend to a height above grade, as determined by the Owner’s representative. A shutoff valve on a blank (non-perforated) inlet pipe section in Zone 1 shall suffice, as described above in the “Drain Pipe” section.

B. Well depth shall extend sufficiently below the drain pipe entry elevation to provide a sump of adequate size to accommodate a sump pump and sufficient reservoir volume to prevent excessive pump cycling. Projected approximate maximum water inflows, pump capacities, sump volumes, and minimum cycle times for each zone are shown in the table below. Pump-cycle times will change as drainage rates decrease through time.
<table>
<thead>
<tr>
<th>Zone Number</th>
<th>Maximum Inflow Rate (gpm)</th>
<th>Required Pump Capacity (gpm)</th>
<th>Minimum Sump Volume (gallons)</th>
<th>Approximate Minimal Cycle Time (minutes)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 and 2</td>
<td>24</td>
<td>30</td>
<td>200</td>
<td>8</td>
</tr>
<tr>
<td>3a</td>
<td>28</td>
<td>30</td>
<td>200</td>
<td>7</td>
</tr>
<tr>
<td>3b</td>
<td>32</td>
<td>35</td>
<td>300</td>
<td>10</td>
</tr>
<tr>
<td>4</td>
<td>13</td>
<td>20</td>
<td>100</td>
<td>7</td>
</tr>
</tbody>
</table>

C. Wet well diameter shall be sufficient to provide a fluid-reservoir volume adequate to prevent excessive pump cycling during operations.

D. Wet well construction shall be adequate to resist earth pressures resulting from full or partial burial to required depths, and materials used shall resist chemical attack by contained fluids for the projected duration of the dewatering project. Wet well design shall allow placement of one or more pipe bulkhead fittings at drain pipe entry points. An oversized bottom flange or other suitable device shall be incorporated to act as an anchor to resist buoyant force and to prevent the installed wet well from moving from its designed installation depth.

E. Wet well covers shall be adequate to prevent fall hazards and the unwanted entry of animals and debris, as well as to provide personnel access and conduits for discharge pipe and electrical power cable.

### 2.07 PUMPING SYSTEM

The pumping system shall be installed in each wet well for the purpose of removing accumulated fluids from the wet wells. The pumping system shall be configured to operate automatically, with minimal personnel intervention, and shall incorporate the following feature (see Sheet EC-14):

A. Pumps shall be 120 volt, submersible (sump) type, sized for predicted maximum flow rates for each dewatering zone (see table above) at pumping heads of 30 to 40 feet of water column. Check valves shall not be incorporated into the pump or discharge piping so as to allow water to drain back into the well to prevent freezing between pumping cycles during cold weather conditions.

B. Pump motor and electrical controls shall be properly mounted either inside the well or nearby outside the well, shall be weatherproof, and shall comply with local electrical codes.

C. Electrical power supply will be provided to the well location by others.

D. Pump mounting and/or suspension and a retrieval system shall be provided to facilitate pump installation and removal for maintenance and to minimize or eliminate the need for personnel to enter the wet well.
E. Fluid level controls shall be provided to start and stop the pump at preset water levels within the well. The controls shall allow sufficient adjustment to fully utilize sump volume and maximize pump-cycle time.

F. Pump discharge pipe and fittings shall be 2-inch inside diameter. A full-opening ball or globe valve shall be installed in the discharge line outside the wet well and the pipe outlet shall be equipped with a quick-connect fitting as approved by the Owner’s Representative. The discharge pipe shall be securely anchored to the wet well or other structure outside the wet well to prevent the pipe from sliding in to the wet well and to facilitate connection to the dewatering water conveyance system (to be provided by others).

**PART 3 – EXECUTION**

The following procedures shall be followed during construction of the dewatering system, subject to Owner’s Representative approval.

**3.01 DRAIN LINES**

A. Buried utility lines and other potential hazards shall be located and marked prior to excavation and then avoided.

B. Trench excavation shall be with low ground-pressure equipment, as approved by the Owner’s representative. Excavated trench soils shall be transported to and placed in a staging area by the Contractor, as directed by the Owner’s representative.

C. Trench alignment and depth shall be as shown on Sheets EC-12 and EC-13, with the clarification that excavation through the area of soil stabilization (in Zone 4 from approximately station 9+00 to station 14+50, and in Zone 3B from approximately station 6+10 to station 8+75) shall require the trench alignment to curve around and avoid compaction-grout and Vibro-Stone columns.

D. Trench excavation shall be with low ground-pressure equipment, as approved by the Owner’s representative. Trench spoils shall be monitored and managed in accordance with the Materials Management Plan (EMSI, 2015).

E. Pipe bedding material shall be gravel, as specified elsewhere. A 3-inch minimum thickness of gravel shall be placed on the trench bottom. The top surface of the bedding gravel shall conform to the designed trench grade.

F. Drain pipe, filter sock, and pipe cleanouts shall be assembled and placed in the trench above bedding gravel and centered within the trench. Drain pipe perforations shall face downward (see Sheet EC-14).

G. Gravel backfill shall be placed around the sides of the drain pipe in a manner that
maintains the pipe in the center of the trench, does not damage the pipe or filter sock, and does not leave void spaces within the backfill. Gravel backfill shall extend to the top of the trench excavation or to a depth approved by the Owner’s Representative.

H. Drain pipe equipped with filter sock shall extend to within 20 feet of the wet well excavation. Non-perforated pipe shall be used for the final segment into the wet well excavation, and shall be equipped with a ball valve near the wet well location to facilitate pipe connection to the wet well. Wet well No. 1 may require a different inlet configuration, as described elsewhere.

3.02 WET WELLS

A. Contractor shall excavate an opening of sufficient dimension to accommodate the wet well and provide approximately one foot of open space around its sides. The excavation shall provide adequate access to connect the drain pipe to the well, shall extend to a depth sufficient to allow the drain pipe elevation to match the well inlet location, and shall allow for approximately one foot of bedding gravel to be placed below the well. The drain pipe inlet bulkhead fitting shall be installed at or before this time.

B. The well assembly shall be lowered into the excavation, assuring that the wet well maintains a vertical position following installation.

C. The non-perforated portion of the drain pipe shall be connected to the well well inlet bulkhead fitting.

D. Gravel backfill shall be placed around the well to ensure contact between the well walls, well-bottom flange, and excavation walls to resist buoyancy effects, but shall prevent collapse of the well.

E. Install pump equipment, pump retrieval equipment, power cable, discharge pipe, and fluid level control equipment.

F. Connect the well discharge pipe to the conveyance piping or tanks provided by others.

G. Connect electrical power (source provided by others), adjust fluid level controls, and test the system to ensure proper operation and assess pump-cycle times.

3.03 SYSTEM ABANDONMENT

As dewatering operations approach completion, each dewatering zone shall be abandoned in accordance with the following sequence and procedures:

A. Contractor shall abandon the drain lines starting at the upstream end of each dewatering zone. Drain lines shall remain in place, but cleanout risers shall be removed down to a
minimum of two feet below grade. The remaining portions of the cleanout riser pipes shall be capped and the resulting excavation shall be backfilled with gravel to grade.

B. Sufficient fill material from around the wet well shall be removed to allow for its removal.

C. The drain pipe extension between the wet well and buried shut-off valve shall be cut and the shut-off valve shall be closed.

D. Any remaining water in the wet well shall be pumped out, surface connections to/from the wet well shall be removed, and the wet well shall be extracted.

E. The wet well excavation shall be filled with gravel to grade.

F. Removed equipment shall be decontaminated in accordance with the Materials Management Plan, and either recycled or disposed in accordance with the Materials Management Plan.

END OF SECTION
SECTION 02900
PERFORMANCE SPECIFICATION FOR
TREATMENT OF DEWATERING WATER

PART 1     GENERAL

1.01 SUMMARY

A. A dewatering system will be used to depress the groundwater table during construction of the environmental components of the Globeville Landing Outfall Project (GLOP) in the Denver Coliseum Parking Lot and the Globeville Landing Park. Contractor shall install; operate, maintain, and monitor; and de-mobilize water treatment facilities to treat dewatering water and discharge treated dewatering water generated by the dewatering system.

B. A dewatering system will be used to dewater the entire area for construction of all of the environmental components of the GLOP in the Denver Coliseum Parking Lot and the Globeville Landing Park at one time, or portions of the dewatering system may be used to only dewater certain dewatering zones, as described in the Final Design Report - Environmental Components for Globeville Landing Outfall Project. The dewatering water treatment system shall be capable of treating the influent flow of dewatering water if the entire area is dewatered at one time, if only one of the zones is dewatered at one time, or if a combination of any of the zones is dewatered at one time.

C. The dewatering system is anticipated to have four sumps from which groundwater will be pumped. See Drawings EC-12 and EC-14 for preliminary sump locations and details, including pump capacities. The Contractor shall be responsible for connecting to the sumps, conveying dewatering water to an on-site dewatering water treatment plant from the sumps, treating the dewatering water, and discharging the treated dewatering water.

D. Contractor shall be responsible for compliance monitoring of the dewatering water treatment facility in accordance with the Colorado Department of Public Health and Environment (CDPHE) discharge permit Certification Number COG315386 under CDPS General Permit COG315000. Contractor shall also be responsible for collection of continuous monitoring parameters and effluent pH as required by the discharge permit, and reporting the results to the Owner’s Representative. Contractor shall allow Owner’s Representative access to the dewatering water treatment facility at any time.

D. Portions of the Denver Coliseum Parking Lot and the Globeville Landing Park are located within the Vasquez Boulevard/Interstate I-70 Superfund Site Operable Unit 2. Consequently, workers will have the potential to be exposed to chemical
or physical hazards, as detailed in the project Health and Safety Plan (Final Design Report, Appendix E). Contractor shall conduct work in accordance with the applicable Occupational Safety and Health Administration (OSHA) rules and regulations, including provisions of 29 CFR 1910.120, 1910.134, 1910.1001-1101, 1910.1200, and 29 CFR 1926.

E. Related Sections

1. 01300 – Submittals
2. 02300 – Dewatering System

1.02 REFERENCES

A. Final Design Report, including

1. Materials Management Plan (Appendix A)
2. Health and Safety Plan (Appendix B)
3. Construction Drawings (Appendix G)
4. Dewatering Specifications (Appendix H)
5. Treatability Test Results.

B. CDPHE, 2015, CDPS GENERAL PERMIT COG315000, REMEDIATION ACTIVITIES DISCHARGING TO SURFACE WATER, AUTHORIZATION TO DISCHARGE UNDER THE, COLORADO DISCHARGE PERMIT SYSTEM, May 20.

C. CDPHE, 2015, CERTIFICATION TO DISCHARGE UNDER CDPS GENERAL PERMIT COG315000, REMEDIATION ACTIVITIES DISCHARGING TO SURFACE WATERS, Certification Number COG315386, October 16.

D. CDPHE, 2015, Fact Sheet for Permit COG315386, VB I70 Operable Unit 2 Removal Action, October 16.

E. CDPHE, WATER AND WASTEWATER FACILITY OPERATORS CERTIFICATION REQUIREMENTS, REGULATION NO. 100, 5 CCR 1003-2.

1.03 SUBMITTALS

A. Pre-Construction Submittals: Submit the following to the Owner’s Representative within 10 days of award of bid:
1. Description and purpose of each unit treatment process and proposed layout/configuration of the treatment equipment within the area designated on Drawing EC-3.

2. Name of proposed dewatering water treatment system operator and operator’s Industrial Wastewater Treatment certification level under the CDPHE Water and Wastewater Facility Operators Certification Requirements. System operator shall have the certification requisite with the level of certification required for the treatment processes proposed for the dewatering water treatment system.

3. Certificate of Insurance providing evidence of the following coverages and limits and naming the City and County of Denver, its elected and appointed officials, employees, and volunteers, and Engineering Management Support, Inc. as additional insureds on the General Liability and Automobile Liability:
   
a. General Liability (Commercial General Liability and Contractors Pollution Liability [CPL]): $1,000,000 each occurrence/$2,000,000 general aggregate.
   
b. Automobile Liability for owned, hired, and non-owned autos: $1,000,000 combined single limit.
   
c. Workers Compensation: Statutory Limits. Employers’ Liability: $1,000,000 each accident; $1,000,000 disease each employee; $1,000,000 disease policy limit.
   
d. Professional Liability: $1,000,000 each claim/$2,000,000 aggregate.

4. Contractor’s Health and Safety Plan for operation, maintenance, and monitoring of the proposed dewatering water treatment system.

5. Material Safety Data Sheets for any and all chemicals and treatment media.

6. Operations and Monitoring Plan for the proposed dewatering water treatment system.

7. Guarantee per Section 1.04.

B. Submittals during Operation of Dewatering Water Treatment System: Submit the following to the Owner’s Representative no later than 5 days following submittal or receipt:
1. All monitoring results.

2. Discharge Monitoring Reports (DMRs).

3. Operating records.

4. Waste management and disposal records.

C. Post-Dewatering Water Treatment Submittals: Submit the following to the Owner’s Representative no later than 30 days following demobilization of treatment equipment:

1. Profiles and manifests associated with disposal of any residuals.

1.04 GUARANTEE

A. The Contractor shall provide a written guarantee that the dewatering water treatment system shall remove the constituents listed in Tables A-1 through A-7 of the Materials Management Plan such that limits for discharge to either Outfall Number 001A or Outfall Number 002A are met, as specified in CDPHE Discharge Permit Certification Number COG315386 under CDPS General Permit COG315000. Contractor shall pay any penalties associated with not meeting the discharge limitations.

PART 2 PRODUCTS

2.01 EQUIPMENT AND MATERIALS

A. Temporary conveyance piping and pipe supports from dewatering system wet well pump discharges (see Drawings EC-12 and EC-14) to the dewatering water treatment system location.

B. Dewatering water treatment system storage tanks, process vessels, and conveyance systems located within secondary containment facilities sized to treat an influent dewatering water flowrate of up to 100 gallons per minute (gpm). Instrumentation, controls, monitoring, and communications equipment and systems.

C. Power and fuel to operate the dewatering pumps (see Specification Section 02300 – Dewatering System).

D. Power and fuel to operate treatment system processes and appurtenances.

E. Treatment chemicals.
F. Maintenance materials, supplies, replacement parts, and tools.

G. Monitoring equipment and supplies.

H. Temporary 6 foot high galvanized steel chain link security fencing and gates constructed around dewatering water treatment system.

PART 3 EXECUTION

3.01 MOBILIZATION

A. Contractor shall mobilize and setup equipment and materials to convey dewatering water from the dewatering sumps to the dewatering water treatment system prior to any dewatering water being generated from dewatering operations.

3.02 DEWATERING WATER TREATMENT AND REPORTING

A. When dewatering water is being generated, Contractor shall operate, maintain, and monitor the dewatering water treatment system to remove constituents in the influent dewatering water such that discharge permit limitations are met prior to discharge of treated dewatering water to the outfall selected by the Owner’s Representative for discharge.

B. During and after operation of the dewatering water treatment system, Contractor shall prepare, execute, and transmit all data and reports required by CDPHE Discharge Permit Certification Number COG315386.

3.03 DEMOBILIZATION

A. After dewatering operations are completed, Contractor shall remove all equipment, temporary piping and supports, fencing, and materials from the site.

END OF SECTION
PART 1 – GENERAL

1.01 INTRODUCTION

A. A combination of Planting Soil materials must be placed above the geonet composite layer to facilitate plant establishment and growth within the Open Cannel segment of the Globeville Landing Outfall Project (GLOP). As shown on Project Drawing EC-1, the Open Channel segment is located in the western portion of the Coliseum Parking Lot and southeastern portion of the Globeville Landing Park. This Open Channel segment is upstream (east) of the sanitary sewer lines shown on Project Drawing EC-2.

B. The Planting Soil consists of an amended planting medium (Planting Soil Type A) and an unamended fill material (Planting Soil Type B). The geonet composite, which is addressed in a separate specification, shall be constructed below the Planting Soil by others. A meandering low-flow trickle channel shall be excavated within Planting Soil Type A and lined with Soil Riprap.

C. Work will consist of processing and amending stockpiled topsoil for use as Planting Soil Type A, processing stockpiled subsoil for use as Planting Soil Type B, placing and compacting Planting Soil Types A and B, excavating the low-flow trickle channel within Planting Soil Type A, and installing Soil Riprap in the low-flow trickle channel. If quantities of stockpiled topsoil and subsoil are insufficient to meet the quantities of Planting Soil Types A and B in accordance with these specifications and the Construction Drawings, work will also consist of importing, placing, and compacting a portion of, or the entire quantity of, required Planting Soil Types A and B.

1.02 INTENT

The intent of the Planting Soil is to provide a long-term, stable planting medium and subsoil for the establishment and sustained growth of plant materials. The Planting Soil shall be installed within the limits of the geonet composite and retaining walls, and in accordance with the Final Design Report, Bid Documents and these specifications.

1.03 STANDARDS AND REFERENCES

A. Reference documents as provided to the Planting Soil Contractor shall include:

1. This specification.
2. Final Design Report, including
   a. Materials Management Plan (Appendix A)
   b. Health and Safety Plan (Final Design Report, Appendix E)
   c. Construction Drawings (Final Design Report, Appendix G)
   d. Construction QA Plan (Final Design Report, Appendix I)
1.05 SCOPE OF WORK

A. The scope of work includes all labor, materials, tools, supplies, equipment, facilities, transportation and services necessary for, and incidental to performing all operations in connection with furnishing, delivery, and installation of Planting Soil and/or the modification of existing stockpiled soil for use as Planting Soil, and all labor, materials, tools, supplies, equipment, facilities, transportation and services necessary for, and incidental to performing all operations in connection with furnishing, delivery, and installation of Soil Riprap, complete as shown in the Construction Drawings and in these specifications.

B. The scope of work in this section includes, but is not limited to, the following:
   1. Locate, purchase and deliver Imported Planting Soil and soil amendments.
   2. Modify existing stockpiled site soil.
      a. Modify stockpiled site soil (topsoil) for use as Planting Soil Type A.
      b. Modify stockpiled site soil (subsoil) for use as Planting Soil Type B.
   3. Place and compact Planting Soil B.
   4. Place and compact Planting Soil A.
   5. Fine grade Planting Soil Type A.
   7. Clean up and disposal of all excess and surplus material.

1.06 SUBMITTALS

A. See the contract General Conditions for policy and procedures related to submittals.

B. Submit all product submittals four weeks prior to the start of the soil work.

C. Product data and certificates: For each type of manufactured product, submit data and certificates that the product meets the specification requirements, signed by the product manufacturer, and complying with the following:
   1. Submit manufacturers or supplier’s product data and literature certified analysis for standard products and bulk materials, complying with testing requirements and referenced standards and specific requested testing.
      a. For each Compost product submit the following analysis by a recognized laboratory:
         1.) pH
         2.) Salt concentration (electrical conductivity)
         3.) Moisture content %, wet weight basis
         4.) Particle size % passing a selected mesh size, dry weight basis
         5.) Stability carbon dioxide evolution rate mg CO2-C per g OM per day
         6.) Solvita maturity test
         7.) Physical contaminants (inerts) %, dry weight basis
8.) US EPA Class A standard, 40CFR § 503.13, Tables 1 and 3 levels
Chemical Contaminants mg/kg (ppm)

D. Samples: Submit samples of each product and material, where required by Part 2 of
the specification, to the Owner’s Representative for approval. Label samples to
indicate product, characteristics, and locations in the work. Samples will be
reviewed for appearance only.

1. Submit samples a minimum of 4 weeks prior to the anticipated date of the start of
soil installation.

2. Samples of all Topsoil, Coarse Sand, Compost, and Planting Soil shall be
submitted at the same time as the particle size and physical analysis of that
material.

E. Soil testing for Imported and Existing Topsoil, existing site soil to be modified as
Planting Soil and Planting Soil Mixes.

1. Topsoil, existing site soil and Planting Soil testing: Submit soil test analysis
report for each sample of Topsoil, existing site soil and Planting Soil from an
approved soil-testing laboratory and where indicated in Part 2 of the specification
as follows:
   a. Submit Stockpiled Soil, Compost, and Coarse Sand for testing at least 6
      weeks before scheduled installation of Planting Soil. Submit Planting Soil test
      no more than 2 weeks after the approval of the Stockpiled Soil, Compost and
      Coarse Sand. Do not submit to the testing laboratory Planting Soil for testing
      until all Stockpiled Soil, Compost and Coarse Sand have been approved.
   b. If tests fail to meet the specifications, obtain other sources of material, retest
      and resubmit until accepted by the Owner’s Representative.
   c. All soil testing will be at the expense of the Contractor.

2. Provide a particle size analysis (% dry weight) and USDA soil texture analysis.
   Soil testing of Planting Soil shall also include USDA gradation (percentage) of
   gravel, coarse sand, medium sand, and fine sand in addition to silt and clay.

3. Provide the following other soil properties:
   a. pH and buffer pH.
   b. Percent organic content by oven dried weight.
   c. Nutrient levels by parts per million including: phosphorus, potassium,
      magnesium, manganese, iron, zinc and calcium. Nutrient test shall include the
      testing laboratory recommendations for supplemental additions to the soil for
      optimum growth of the plantings specified.
   d. Soluble salt by electrical conductivity of a 1:2 soil water sample measured in
      Milliohm per cm.
   e. Cation Exchange Capacity (CEC).

PART 2 – EQUIPMENT AND MATERIALS

2.01 PLANTING SOIL TYPE A

   F. General definition: Planting Soil Type A shall be topsoil stripped and stockpiled in
   accordance with Stripping and Stockpiling specifications and modified to meet these
specifications. Modifications respond to the soil problems expected or encountered. The Owner’s Representative shall verify that the stockpiled soil is suitable for modification prior to beginning modification.

1. In the event that project construction has damaged the stockpiled soil to the point where the soil is no longer suitable to support the plants specified with the specified modification, the Owner’s Representative may require further modification of the damaged soil up to and including removal and replacement with soil of equal quality to the soil that would have resulted from the modification. Damage may include further compaction, contamination, grading, and creation of hard pan or drainage problems.

2. General requirements for all soil modifications:
   a. Take soil samples, test for chemical properties, and make appropriate adjustments.
   b. Remove all stones greater than 2 inches in diameter, bricks, concrete, and other debris.
   c. Unless otherwise instructed, remove all existing plants, root thatch, and non-soil debris from the soil using equipment that does not add to the compaction in the soil.
   d. All soil grading, tilling, modifying, mixing, and loosening must be completed at times when the soil moisture is below field capacity. Allow soil to drain for at least two days after any rain event more than 1 inch in 24 hours, or long enough so that the soil does not make the hand muddy when squeezed.

3. Planting Soil Type A shall meet the following physical and chemical criteria:
   a. Soil texture: USDA loam, sandy clay loam or sandy loam with clay content between 15 and 30%, sand content of no more than 55%, and a combined clay/silt content of no more than 55%.
   b. pH value shall be between 5.5 and 7.5.
   c. Percent organic matter (OM): 2.0-5.0%, by dry weight.
   d. Soluble salt level: Less than 4 mmhos/cm.
   e. Soil chemistry suitable for growing the plants specified.

2.02 PLANTING SOIL TYPE B

A. General definition: Planting Soil Type B shall be excavated and stockpiled subsoil removed during earthwork in accordance with the Stripping and Stockpiling specifications and after the topsoil has been stripped and stockpiled. Modifications respond to the soil problems expected or encountered. The Owner’s Representative shall verify that the soil in the designated areas is suitable for modification at the beginning of planting bed preparation work in that area.

1. The Owner’s Representative shall verify that the stockpiled subsoil is suitable for the specified modification at the beginning of planting bed preparation work in that area. In the event that the work of this project construction has damaged the existing soil in areas designated for modification to the point where the soil is no longer suitable to support the plants specified with the specified modification, the Owner’s Representative may require further modification of the damaged soil up to an including removal and replacement with soil of equal quality to the soil that
would have resulted from the modification. Damage may include further compaction, contamination, grading, and creation of hard pan or drainage problems.

2. General requirements for all soil modifications:
   a. Take soil samples, test for chemical properties, and make appropriate adjustments.
   b. Remove all stones greater than 2 inches in diameter, bricks, concrete, and other debris.
   c. Unless otherwise instructed, remove all existing plants, root thatch, and non-soil debris from the surface of the soil using equipment that does not add to the compaction in the soil.
   d. All soil grading, tilling and loosening must be completed at times when the soil moisture is below field capacity. Allow soil to drain for at least two days after any rain event more than 1 inch in 24 hours, or long enough so that the soil does not make the hand muddy when squeezed.

3. Planting Soil Type B shall meet the following physical and chemical criteria:
   a. Soil texture: USDA sandy clay, sandy clay loam, or clay loam with clay content of no more than 65%, sand content of no more than 35%, and a combined clay/silt content of no more than 80%.
   b. pH value shall be between 5.5 and 7.5.
   c. Percent organic matter (OM): no more than 1%, by dry weight.
   d. Soluble salt level: Less than 4 mmhos/cm.

2.03 IMPORTED TOPSOIL

A. Imported Topsoil definition: Fertile, friable soil containing less than 5% total volume of the combination of subsoil, refuse, roots larger than 1 inch diameter, heavy, sticky or stiff clay, stones larger than 2 inches in diameter, noxious seeds, sticks, brush, litter, or any substances deleterious to plant growth. The percent (%) of the above objects shall be controlled by source selection not by screening the soil. Topsoil shall be suitable for the germination of seeds and the support of vegetative growth. Imported Topsoil shall not contain weed seeds in quantities that cause noticeable weed infestations in the final planting beds. Imported Topsoil shall meet the following physical and chemical criteria:

1. Soil texture: USDA loam, sandy clay loam or sandy loam with clay content between 15 and 25%. And a combined clay/silt content of no more than 55%.
2. pH value shall be between 5.5 and 7.5.
4. Soluble salt level: Less than 4 mmhos/cm.
5. Soil chemistry suitable for growing the plants specified.

B. Provide a two gallon sample from each Imported Topsoil source with required soil testing results. The sample shall be a mixture of the random samples taken around the source stockpile or field.
2.04 SOIL RIPRAP

A. Soil Riprap shall be in accordance with current Urban Drainage and Flood Control District standard specifications.

PART 3 – EXECUTION

3.01 SITE EXAMINATION

A. SITE EXAMINATION

1. Prior to installation of Planting Soil, examine site to confirm that existing conditions are satisfactory for the work of this section to proceed.
   a. Confirm that the geonet composite installation has been approved by the Owner’s Representative.
   b. Confirm that areas to be filled with Planting Soil are free of construction debris, refuse, compressible or biodegradable materials, stones greater than 2 inches diameter, and/or standing water. Remove unsuitable material from the site.
   c. Confirm that no adverse drainage conditions are present.
   d. Confirm that no conditions are present which are detrimental to plant growth.
   e. If unsatisfactory conditions are encountered, notify the Owner’s Representative immediately to determine corrective action before proceeding.

B. COORDINATION WITH PROJECT WORK

1. The Contractor shall coordinate with all other work that may impact the completion of the work.

2. Prior to the start of work, prepare a detailed schedule of the work for coordination with other trades.

C. GRADE AND ELEVATION CONTROL

1. Provide grade and elevation control during installation of Planting Soil. Utilize surveying equipment and/or other means and methods to assure that grades and contours conform to the grades and soil depths indicated on the plans.

D. SITE PREPARATION

1. Remove all construction debris and material including any construction materials from the fill area.

2. Protect adjacent walls, walks and utilities from damage or staining by the soil. Use 1/2 inch plywood and or plastic sheeting as directed to cover existing concrete, metal and masonry work and other items as directed during the progress of the work.

3. Protect the geonet composite at all times throughout execution of Planting Soil placement, compaction, and grading.

4. At the end of each working day, clean up any soil or dirt spilled on any paved surface.

5. Any damage to the paving or site features, geonet composite, or work shall be
repaired at the Contractor’s expense.

E. SOIL MOISTURE

1. Volumetric soil moisture level in the Planting Soil, prior to, during and after planting shall be above permanent wilt point and below field capacity for each type of soil texture within the following ranges.

<table>
<thead>
<tr>
<th>Soil texture</th>
<th>Permanent wilting point</th>
<th>Field capacity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sand, Loamy sand, Sandy loam</td>
<td>5-8%</td>
<td>12-18%</td>
</tr>
<tr>
<td>Loam, Sandy clay, Sandy clay loam</td>
<td>14-25%</td>
<td>27-36%</td>
</tr>
<tr>
<td>Clay loam, Silt loam</td>
<td>11-22%</td>
<td>31-36%</td>
</tr>
<tr>
<td>Silty clay, Silty clay loam</td>
<td>22-27%</td>
<td>38-41%</td>
</tr>
</tbody>
</table>

2. The Contractor shall confirm the soil moisture levels with a moisture meter (Digital Soil Moisture Meter, DSMM500 by General Specialty Tools and Instruments, or approved equivalent). If moisture is found to be too low, the planting holes shall be filled with water and allowed to drain before starting any planting operations. If the moisture is too high, suspend planting operations until the soil moisture drains to below field capacity.

F. EXISTING SOIL MODIFICATION

1. Follow the requirements for modifying existing soil as indicated in Part 2 for the different types of soil modifications.

G. PLANTING SOIL INSTALLATION

1. Prior to installing any Planting Soil from stockpiles or off site sources, the Owner’s Representative shall approve the condition of the previously installed subgrade preparation, and geonet composite.

2. All equipment utilized to install or grade Planting Soils shall be wide track or balloon tire machines rated with a ground pressure of 4 psi or less. All grading and soil delivery equipment shall have buckets equipped with 6 inch long teeth to scarify any soil that becomes overly compacted.

3. Install Planting Soil Type B in 8 inch lifts to the required depths. Apply compacting forces to each lift as required to attain the required compaction. Scarify the top of each lift prior to adding more Planting Soil by dragging the teeth of a loader bucket or backhoe across the soil surface to roughen the surface.

4. Install Planting Soil Type A in 10 inch lifts to the required depths. Apply compacting forces to each lift as required to attain the required compaction. Scarify the top of each lift prior to adding more Planting Soil by dragging the
teeth of a loader bucket or backhoe across the soil surface to roughen the surface.

5. Phase work such that equipment to deliver or grade Planting Soil does not have to operate over previously installed Planting Soil Type A. Work in rows of lifts the width of the extension of the bucket on the loader. Install all lifts in one row before proceeding to the next.

6. Installing soil with soil or mulch blowers or soil slingers shall not be permitted due to the over mixing and soil ped breakdown cause by this type of equipment.

7. Where travel over installed Planting Soil Type A is unavoidable, limit paths of traffic to reduce the impact of compaction. Each time equipment passes over the installed soil it shall reverse out of the area along the same path with the teeth of the bucket dropped to scarify the soil. Comply with the paragraph “Compaction Reduction” in the event that soil becomes over compacted.

H. COMPACATION REQUIREMENTS FOR INSTALLED PLANTING SOIL

1. Compact installed Planting Soil to the compaction rates indicated and using the methods approved. Compact each soil lift as the soil is installed.

2. Installed Planting Soil Type B shall be compacted to 90-95% of maximum dry density standard proctor.

3. Installed Planting Soil Type A shall be compacted to 75-80% of maximum dry density standard proctor.

4. Planting Soil compaction shall be tested at each lift using a penetrometer calibrated to the soil and its moisture level.

5. Maintain moisture conditions within the Planting Soil during installation or modification to allow for satisfactory compaction. Suspend operations if the Planting Soil becomes wet. Apply water if the soil is overly dry.

6. Provide adequate equipment to achieve consistent and uniform compaction of the Planting Soils. Use the smallest equipment that can reasonably perform the task of spreading and compaction.

7. Do not pass motorized equipment over previously installed and compacted Planting Soil Type A except as authorized below.
   a. Light weight equipment such as trenching machines or motorized wheel barrows is permitted to pass over finished soil work.
   b. If work after the installation and compaction of soil compacts the soil to levels greater than the above requirements, follow the requirements of the paragraph "Over Compaction Reduction" below.

I. OVER COMPACATION REDUCTION

1. Any soil that becomes compacted to a density greater than the specified density shall be dug up and reinstalled. This requirement includes compaction caused by other sub-contractors after the Planting Soil is installed and approved.

2. Surface roto tilling shall not be considered adequate to reduce over compaction at levels 6 inches or greater below finished grade.
J. INSTALLATION OF CHEMICAL ADDITIVES

1. Following the installation of each soil and prior to fine grading and installation of the Compost till layer, apply chemical additives as recommended by the soil test, and appropriate to the soil and specific plants to be installed.

2. Types, application rates and methods of application shall be approved by the Owner’s Representative prior to any applications.

K. FINE GRADING AND LOW-FLOW TRICKLE CHANNEL INSTALLATION

1. The Owner’s Representative shall approve all rough grading prior to the installation of Compost, fine grading, planting, and mulching.

2. Grade the finish surface of all planted areas to meet the lines and grades shown on the drawings.

3. Utilize hand equipment, small garden tractors with rakes, or small garden tractors with buckets with teeth for fine grading to keep surface rough without further compaction. Do not use the flat bottom of a loader bucket to fine grade, as it will cause the finished grade to become overly smooth and or slightly compressed.

4. Excavate Planting Soil Type A and install Soil Riprap in the low-flow trickle channel in accordance with the Drawings, these specifications, and as directed in the field by the Owner’s Representative.

5. Provide for positive longitudinal low-flow trickle channel and overall channel drainage from all areas toward the existing drainage structures in accordance with the Drawings. Adjust grades as directed to reflect actual constructed field conditions of wall, inlet, and outlet invert elevations. Notify the Owner’s Representative in the event that conditions make it impossible to achieve designed drainage.

6. Provide smooth, rounded transitions between slopes of different gradients and direction.

L. CLEAN-UP

1. During installation, keep the site free of trash, pavements reasonably clean and work area in an orderly condition at the end of each day. Remove trash and debris in containers from the site no less than once a week.
   a. Immediately clean up any spilled or tracked soil, fuel, oil, trash or debris deposited by the Contractor from all surfaces within the project or on public right of ways and neighboring property.

2. Once installation is complete, wash all soil from pavements and other structures. Ensure that all tags and flagging tape are removed from the site.
   a. Make all repairs to grades, ruts, and damage to the work or other work at the site.
   b. Remove and dispose of all excess Planting Soil, subsoil, mulch, plants, packaging, and other material brought to the site by the Contractor.

M. PLANTING SOIL PROTECTION

1. The Contractor shall protect installed and/or modified Planting Soil from damage
including contamination and over compaction due to other soil installation, planting operations, and operations by other Contractors or trespassers. Maintain protection during installation until final acceptance. Utilize fencing and matting as required or directed to protect the finished soil work. Treat, repair or replace damaged Planting Soil immediately.

2. Loosen compacted Planting Soil and replace Planting Soil that has become contaminated as determined by the Owner’s Representative. Planting Soil shall be loosened or replaced at no expense to the Owner.
   a. Till and restore grades to all soil that has been driven over or overly compacted during the installation of plants.
   b. Where Planting Soil has become contaminated and needs to be replaced, provide imported soil that is of similar composition, depth and density as the soil that was removed.

N. PROTECTION DURING CONSTRUCTION

1. The Contractor shall protect the geonet composite layer, retaining walls, culverts, concrete work, planting and related work, and other site work from damage due to Planting Soil operations, operations by other Contractors, or trespassers.
   a. Maintain protection during installation until the date of plant acceptance (see specifications section – Planting). Treat, repair or replace damaged work immediately.
   b. Provide temporary erosion control as needed to stop soil erosion until the site is stabilized with mulch or plantings.

2. Damage done by the Contractor, or any of their sub-contractors to geonet composite layer, existing or installed plants, or any other parts of the work or existing features to remain, including large existing trees, soil, paving, utilities, lighting, irrigation, other finished work and surfaces including those on adjacent property, shall be cleaned, repaired or replaced by the Contractor at no expense to the Owner. The Owner’s Representative shall determine when such cleaning, replacement or repair is satisfactory. Damage to existing trees shall be assessed by a certified arborist.

O. Substantial Completion Acceptance

1. Upon written notice from the Contractor, the Owners Representative shall review the work and make a determination if the work is substantially complete.

2. The date of substantial completion of the planting soil shall be the date when the Owner’s Representative accepts that all work in Planting, Planting Soil, and Irrigation installation sections is complete.

P. FINAL ACCEPTANCE / SOIL SETTLEMENT

1. At the end of the plant warranty and maintenance period, (Planting Specification not included in work scope of “Environmental Components”) the Owner’s Representative shall observe the soil installation work and establish that all provisions of the contract are complete and the work is satisfactory.
   a. Restore any soil settlement and or erosion areas to the grades shown on the drawings. When restoring soil grades remove plants and mulch and add soil before restoring the planting. Do not add soil over the root balls of plants or
on top of mulch.

2. Failure to pass acceptance: If the work fails to pass final acceptance, any subsequent observations must be rescheduled as per above. The cost to the Owner for additional observations will be charged to the Contractor at the prevailing hourly rate of the Owner’s Representative.

END OF SECTION
APPENDIX I
Construction QA Plan for Geosynthetics Liner System
CONSTRUCTION QUALITY ASSURANCE PLAN
GEOSYNTHETICS LINING SYSTEM
VB/I70 CHANNEL LINING

Prepared for:
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January 2016

Prepared by:
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# TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>SECTION</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>SECTION 1 GENERAL</strong></td>
<td>1</td>
</tr>
<tr>
<td>1.1 PURPOSE AND SCOPE</td>
<td>1</td>
</tr>
<tr>
<td>1.2 CONSTRUCTION SCHEDULE</td>
<td>2</td>
</tr>
<tr>
<td>1.3 CQA PLAN DEFINITIONS</td>
<td>2</td>
</tr>
<tr>
<td>1.4 PROJECT COORDINATION MEETINGS</td>
<td>2</td>
</tr>
<tr>
<td>1.4.1 Resolution Meeting</td>
<td>2</td>
</tr>
<tr>
<td>1.4.2 Pre-Construction Meeting</td>
<td>3</td>
</tr>
<tr>
<td>1.4.3 Progress Meetings</td>
<td>4</td>
</tr>
<tr>
<td>1.4.4 Problem or Work Deficiency Meetings</td>
<td>4</td>
</tr>
<tr>
<td>1.4.5 Project Visitation Meetings</td>
<td>4</td>
</tr>
<tr>
<td>1.4.6 Manufacturing Plant Visits and Meetings</td>
<td>4</td>
</tr>
<tr>
<td><strong>SECTION 2 PROJECT ORGANIZATION AND RESPONSIBILITIES</strong></td>
<td>5</td>
</tr>
<tr>
<td>2.1 CONSTRUCTION SITE MANAGER</td>
<td>5</td>
</tr>
<tr>
<td>2.2 CONSTRUCTION QUALITY ASSURANCE MANAGER (CQAM)</td>
<td>5</td>
</tr>
<tr>
<td>2.3 CONSTRUCTION QUALITY ASSURANCE INSPECTOR(S)</td>
<td>6</td>
</tr>
<tr>
<td>2.4 GEOSYNTHETICS CQA CONSULTANT</td>
<td>7</td>
</tr>
<tr>
<td>2.5 CQA LABORATORY</td>
<td>7</td>
</tr>
<tr>
<td>2.6 GEOSYNTHETIC MANUFACTURER</td>
<td>8</td>
</tr>
<tr>
<td>2.7 GEOSYNTHETIC INSTALLER</td>
<td>8</td>
</tr>
<tr>
<td>2.8 ELECTRICAL LEAK LOCATION CQA CONTRACTOR</td>
<td>9</td>
</tr>
<tr>
<td><strong>SECTION 3 REPORTING REQUIREMENTS</strong></td>
<td>10</td>
</tr>
<tr>
<td>3.1 APPLICABLE FORMS FOR INSPECTION</td>
<td>10</td>
</tr>
<tr>
<td>3.2 PROBLEM IDENTIFICATION AND PLAN MODIFICATIONS</td>
<td>10</td>
</tr>
<tr>
<td>3.3 PHOTOGRAPHIC DOCUMENTATION</td>
<td>10</td>
</tr>
<tr>
<td>3.4 FINAL CONSTRUCTION DOCUMENTATION REPORT</td>
<td>11</td>
</tr>
<tr>
<td><strong>SECTION 4 GEOTEXTILES CONSTRUCTION QA</strong></td>
<td>12</td>
</tr>
<tr>
<td>4.1 CQA PERSONNEL</td>
<td>12</td>
</tr>
<tr>
<td>4.2 GEOTEXTILE MANUFACTURE AND DELIVERY</td>
<td>12</td>
</tr>
<tr>
<td>4.2.1 Labeling</td>
<td>12</td>
</tr>
<tr>
<td>4.2.2 Shipment and Storage</td>
<td>13</td>
</tr>
<tr>
<td>4.2.3 Quality Assurance Conformance Testing</td>
<td>13</td>
</tr>
<tr>
<td>4.3 GEOTEXTILE INSTALLATION</td>
<td>14</td>
</tr>
<tr>
<td>4.3.1 Handling and Placement</td>
<td>14</td>
</tr>
<tr>
<td>4.3.2 Overlap and Thermal Seaming</td>
<td>14</td>
</tr>
<tr>
<td>4.3.3 Repair</td>
<td>15</td>
</tr>
<tr>
<td>4.3.4 Cover Material Placement</td>
<td>15</td>
</tr>
<tr>
<td><strong>SECTION 5 LLDPE-T GEOMEMBRANE CONSTRUCTION QA</strong></td>
<td>17</td>
</tr>
<tr>
<td>5.1 CQA PERSONNEL</td>
<td>17</td>
</tr>
<tr>
<td>5.2 GEOMEMBRANE MANUFACTURE AND DELIVERY</td>
<td>17</td>
</tr>
<tr>
<td>5.2.1 Resin Certifications</td>
<td>17</td>
</tr>
<tr>
<td>5.2.2 Resin Quality Control Test Result Verifications</td>
<td>17</td>
</tr>
<tr>
<td>5.2.3 Roll Quality Control Test Result Verifications</td>
<td>17</td>
</tr>
</tbody>
</table>
SECTION 7

7.3 GEOMEMBRANE INSTALLATION .................................................. 19
7.3.1 Earthwork – Surface Preparation ............................................ 19
7.3.2 Earthwork – Anchor Trenches .................................................. 20
7.3.3 Geomembrane Deployment ...................................................... 20
7.3.4 Field Seaming ........................................................................ 21
7.4 NON-DESTRUCTIVE TEST SEAM QC CONTINUITY TESTING ......... 23
7.5 DESTRUCTIVE SEAM QUALITY CONTROL TESTING .................. 23
7.5.1 Location and Frequency .......................................................... 23
7.5.2 Sampling Procedure ............................................................... 23
7.5.3 Quality Control Field Testing .................................................. 23
7.5.4 Quality Control Laboratory Testing ......................................... 24
7.6 DEFECTS AND REPAIRS ............................................................ 24
7.6.1 Identification ........................................................................ 24
7.6.2 Quality Control Evaluation ...................................................... 24
7.6.3 Cover Material Placement and Large Wrinkles or Waves ............ 24
7.6.4 Repair Procedures Verification ................................................ 25
7.6.5 Testing of Repairs ................................................................. 25
7.7 APPURTEANCES AND CONCRETE ATTACHMENT ................. 25
7.8 LLDPE GEOMEMBRANE SYSTEM ACCEPTANCE .................. 25

SECTION 6 GEOGRID CONSTRUCTION QA ..................................... 27
6.1 CQA PERSONNEL .................................................................... 27
6.2 GEOGRID MANUFACTURE AND DELIVERY ............................. 27
6.2.1 Labeling .............................................................................. 27
6.2.2 Shipment and Storage ............................................................ 28
6.2.3 Quality Assurance Conformance Testing ................................. 28
6.3 GEOGRID INSTALLATION .......................................................... 29
6.3.1 Handling and Placement ......................................................... 29
6.3.2 Overlap and Connection ......................................................... 29
6.3.3 Repair ................................................................................. 29
6.3.4 Aggregate Cover Material Placement ..................................... 30

SECTION 7 GEONET COMPOSITE CONSTRUCTION QA .............. 31
7.1 CQA PERSONNEL .................................................................... 31
7.2 GEONET COMPOSITE MANUFACTURE AND DELIVERY ........ 31
7.2.1 Labeling .............................................................................. 32
7.2.2 Shipment and Storage ............................................................ 32
7.2.3 Quality Assurance Conformance Testing ................................. 32
7.3 GEONET COMPOSITE INSTALLATION ..................................... 33
7.3.1 Handling and Placement ......................................................... 33
7.3.2 Overlap and Seaming ............................................................. 34
7.3.3 Repair ............................................................................... 34
7.3.4 Cover Material Placement .................................................... 35
SECTION 8  ELECTRICAL LEAK LOCATION SURVEY ........................................ 36
8.1  CQA PERSONNEL .................................................................................. 36
8.2  ELECTRICAL LEAK LOCATION SURVEY ........................................... 36
8.3  ELECTRICAL LEAK LOCATION SURVEY PREPARATION................. 37
8.4  PERFORMANCE TESTING ...................................................................... 37
8.5  LEAK SURVEY ....................................................................................... 38
8.6  LEAK SURVEY REPORTING .................................................................. 39
SECTION 9  FINAL REPORT DOCUMENTATION .............................................. 40
9.0  FINAL CQA REPORT GEOSYNTHETICS ................................................. 40
SECTION 1
GENERAL

The VB/I70 Channel Lining will encompass approximately 140,000 sq. ft. of lined area located in the Denver Colosseum parking lot and Globeville Landing Park. A synthetic geomembrane lining system with protection geotextiles will be installed under the channel areas to prevent excessive seepage loss of water through the bottom and side slopes of the channel as well as to prevent below grade contaminated water from infiltrating the channel section. This Construction Quality Assurance Plan (CQAP) addresses the Construction Quality Assurance (CQA) procedures for acceptance and installation of the geomembrane lining system.

1.1 PURPOSE AND SCOPE

This CQAP describes the CQA procedures for the acceptance and installation of the geosynthetics components of the lining system for the VB/I70 Channel Lining. The term Quality Assurance (QA) is used in the broadest sense and is based upon the concept of Quality Control (QC). This plan addresses the geosynthetic components and associated soil components of the lining system and is to be used as the basis of the overall CQA program.

The overall goals of this CQA program are to ensure that proper construction techniques and procedures are used and to verify that the materials and installation methods used meet the project design requirements. After completion of construction, the program will culminate in preparation of a report which documents that the lining system was constructed in accordance with the design plans and specifications.

The CQA Manager shall be responsible for all QA inspection activities associated with construction of the lining system and related features for the VB/I70 Channel Lining. This CQAP addresses construction quality assurance relative to construction of the lining system including all geosynthetics materials, adjacent soils as required and related features. This CQAP is divided into the following sections:

Section 1    General
Section 2    Project Organization and Responsibilities
Section 3    Reporting Requirements
Section 4    Geotextiles CQA
Section 5    LLDPE-T Geomembrane CQA
Section 6    Geogrid CQA
Section 7    Geonet Composite CQA
Section 8    Electrical Leak Location Survey
Section 9    Final Report Documentation
1.2 CONSTRUCTION SCHEDULE

The Contractor will provide a construction work schedule, to be inserted in Appendix A.

1.3 CQA PLAN DEFINITIONS

- **Quality Assurance (QA)** - An integrated system of management activities involving planning, implementation, assessment, reporting, and quality improvement to ensure that a process, item or service is of the type and quality required by the contract documents.

- **Construction Quality Assurance (CQA)** - The planned and systematic means and actions designed to assure adequate confidence that materials and/or services meet requirements. CQA includes confirmatory inspections, independent testing, audits and evaluations of materials and workmanship to assure conformity with this CQAP, the Construction Drawings and Technical Specifications.

- **Construction Quality Control (CQC)** - Those actions which provide a means to measure and regulate the characteristics of an item or service in relation to contractual requirements. CQC refers to those actions taken by the Contractor, Subcontractors, Manufacturers, and Installers to directly control the quality of materials and workmanship to meet requirements of the Construction Drawings and Technical Specifications.

- **Design Engineer** - The Design Engineer provides Construction Drawings and Technical Specifications consistent with accepted practices for lining systems and in compliance with applicable laws and regulatory requirements. During construction, the design engineer may be requested to change some aspect of the design if unexpected conditions are encountered (e.g., change in site conditions, logistical problems, or unavailable acceptable materials). In certain cases the design engineer may interface with the CQA and QC programs if corrective action or clarification is required.

- **Geosynthetics** - Geosynthetics is the generic term for all synthetic materials used in geotechnical engineering applications and includes geotextiles, geogrids, geonets, geomembranes, geocomposites and geosynthetic clay liners. There are three types of geosynthetics addressed in this CQAP which are included in the VB/I70 Channel lining system. These geosynthetics include the: (1) Geogrid used to support Strengthening Layer; (2) Linear Low Density Polyethylene-Textured (LLDPE-T) geomembrane used as the seepage barrier in the lining system; and (2) Nonwoven geotextiles used as geomembrane protection in the lining system.

1.4 PROJECT COORDINATION MEETINGS

To help ensure a high degree of quality during construction, clear, open channels of communication are essential. To that end, meetings are critical to performance.

1.4.1 Resolution Meeting

Following the completion of the design, plans, and specifications for the project, a
Resolution Meeting shall be held. This meeting shall include the Geosynthetics CQA Consultant, Construction Quality Assurance Manager (CQAM), CQA Inspectors, Design Engineer, and the Construction Site Manager.

The purpose of this meeting is to begin planning for coordination of tasks, anticipate any problems which might cause difficulties and delays in construction, and present the CQA to all parties involved. This meeting should include but not limited to the following activities:

- Review the CQA;
- Communicate relevant documents to all parties;
- Review critical design details of the project;
- Review proposed panel and seam layout drawings;
- Make appropriate modifications to the CQA;
- Reach a consensus on the CQA and quality control procedures;
- Review responsibilities of each party;
- Review methods for documenting and reporting
- Confirm lines of authority
- Review CQA inspector training on site

1.4.2 Pre-Construction Meeting

A Pre-Construction Meeting shall be held at the site. As a minimum the meeting shall be attended by the Contractor, Installer Subcontractors, Geosynthetics CQA Consultant, CQAM, CQA Inspectors, Design Engineer and Construction Site Manager. Specific topics that can be considered for this meeting include the following:

- Modifications to the CQA;
- Review responsibilities of each party;
- Review lines of authority and communication;
- Review methods of documenting and reporting;
- Establish protocol for testing;
- Establish protocol for handling deficiencies, repairs and retesting;
- Establish protocol for writing on the geomembrane – who, what, what color;
- Review panel layout and numbering systems for panels and seams;
- Finalize field destructive cutout sample size, distribution of sample sections and archive;
- Review seam testing procedures;
- Review repair procedures;
- Conduct a site visit to verify current schedule and earthwork as well as storage locations for geosynthetics;

Document the above meeting minutes and specific changes to the CQA for inclusion in the CQA, Appendix B.
1.4.3 Progress Meetings

Weekly progress meetings shall be held on site between the CQAM, Installer Superintendent, Construction Site Manager and any other concerned parties. This meeting should discuss current progress, planned activities for the following week, schedule changes or revisions to the project. The CQAM shall log any problems, decisions, or questions arising at this meeting in their daily reports.

1.4.4 Problem or Work Deficiency Meetings

A special meeting will be held on site when and if a problem or deficiency has or is likely to occur. If the problem requires a design modification, the Design Engineer should also be present. The purpose of the meeting is to define and resolve work problems or communication problems and review alternative solutions. The meeting shall be documented in the CQAM daily reports.

1.4.5 Project Visitation Meetings

Periodically, the construction site will be visited by the principal Design Engineer, Engineering Staff, Project Personnel and the Geosynthetic CQA Consultant. These visits may or may not be coordinated and will result in site meetings with the CQAM and Construction Site Manager.

1.4.6 Manufacturing Plant Visits and Meetings

Geosynthetics manufacturing plant visits will be carried out by and at the discretion of the design engineer, representatives of the City and County of Denver or other designated parties. These visits are optional and will be independent of and in addition to any requirements for manufacturing quality assurance for the geomembrane or geotextiles.
SECTION 2
PROJECT ORGANIZATION AND RESPONSIBILITIES

Daily construction activities at the VB/I70 channel lining installation will be managed by the Construction Site Manager through direct interaction of several parties including but not limited to the Design Engineer, Prime Contractor, Subcontractors, CQAM and Geosynthetic and Earthwork Quality Control Programs. Independent commercial testing laboratories will be used for the specified QA conformance testing specified herein. Permanent staff will be assigned to the CQAM to monitor and record all QA activities required to assure a completed project as set forth in the specifications and contract drawings.

2.1 CONSTRUCTION SITE MANAGER

The Construction Site Manager is responsible for all site operations and overall management of construction. This includes cost, schedule, safety, quality, procurement, and environmental compliance. In this capacity, the Construction Site Manager integrates, directs, and manages the resources assigned to the work including contractors and subcontractors. In this CQA P, the term Construction Site Manager refers specifically to an authorized representative of the City and County of Denver. The CQAM will coordinate operationally with the Construction Site Manager.

2.2 CONSTRUCTION QUALITY ASSURANCE MANAGER (CQAM)

The Construction Quality Assurance Manager (CQAM) is designated by the City and County of Denver and reports to the Project Coordinator, and coordinates with the Construction Site Manager. The CQAM ensures that the lining system is constructed in accordance with the construction drawings and technical specifications. The CQAM will prepare a final Certification Report which includes narrative description of the construction, deviations from specifications or design, as-built (record) drawings, conformance laboratory test results, field test results, site photos, and a professional engineer certification that construction was completed in conformance with the original design and design amendments.

In addition, the CQAM is responsible for reviewing the CQAP, construction drawings and technical specifications. Other responsibilities include evaluations to ensure that proper procedures are followed, reporting deficiencies or problems, documenting corrective actions and ensuring the Construction Site Manager that contractor and subcontractor QC plans are being followed in accordance with the specifications. Specific duties associated with the CQAM are as follows:

- Attendance at all project coordination meetings, QC, Subcontractor coordination and safety meetings;
- Review of design criteria, plans and specifications for clarity and completeness so that the CQAP can be implemented;
- Training of CQA Inspection Personnel on CQA requirements and procedures;
- Directing and supporting the CQA Inspection Personnel in performing duties and tests;
- Reporting results of observations and tests as the work progresses and interacting with the Subcontractor(s) to provide assistance in confirming that materials and work comply with the specifications;
- Preparing CQA documentation required by the CQAP including Daily Reports, Contractor personnel logs, Weekly Field Reports, Geosynthetics CQA Records, Certifications, Photographic Documentation, Specification Changes and Final Reports;
- Performing on-site CQA inspection of the geosynthetics and associated earth work in progress to verify conformance with the CQAP, construction drawings, and technical specifications by:
  1. reviewing all equipment calibration and certification records for equipment used in the installation of geosynthetics;
  2. reviewing certifications and documentation from the Subcontractor(s) and the Geosynthetics Manufacturer and Installer and making appropriate recommendations;
  3. reviewing Geosynthetics Manufacturer’s QC documentation;
  4. reviewing Geosynthetics Installers QC documentation;
  5. monitoring off-loading, site handling and storage of geosynthetics;
  6. monitoring geosynthetic material deployment and installation;
  7. monitoring geosynthetic repair operations;
  8. monitoring cover soils placement operations.
- Review of Electrical Leak Location QA results as required herein;
- Collecting QA samples and requesting QA conformance testing as required herein;
- Reviewing QA conformance test results and verifying material conformance to Technical Specifications and Contract Drawings;
- Reviewing and evaluating as-built documentation;
- Reporting to the Construction Site Manager the results of all inspections including work that is not of acceptable quality or that fails to meet the specified design;
- Assisting with the preparation of the Final Report.

2.3 CONSTRUCTION QUALITY ASSURANCE INSPECTOR(S)

The CQA inspector will monitor and document the construction/installation of all geosynthetics and associated structures and/or earthwork which will be in direct contact with the geosynthetics. The CQA inspector(s) will document the activities of the Subcontractor(s) in sufficient detail and with sufficient continuity to provide a high level of confidence that the work complies with the plans and specifications. The CQA inspector(s) will report directly to the CQAM. As a minimum, the duties of the CQA inspector will include:

- Monitoring geosynthetic delivery, handling, storage and movement to site installation location for any damage or deterioration;
- Monitoring geosynthetic placement and seaming of geomembranes;
- Monitoring geosynthetic surface for damage after placement;
- Monitoring geomembrane destructive and non-destructive testing by installation subcontractor QC;
- Preparing daily field reports on appropriate report forms (see Appendix C);
- Recording CQA activities on appropriate report forms (see Appendix C);
- Collecting QA conformance samples for testing as required;
- Marking QA conformance samples for testing as required;
- Collecting QA destructive seam coupons for independent testing;
- Monitoring placement and condition of all underlying soils or base course aggregate prior to geotextile and geomembrane placement;
- Monitoring placement of all cover soil immediately above the geosynthetic lining system;
- Reporting any potential damage of geosynthetics due to cover soil placement immediately to the CQAM;
- Monitoring activities of the Electrical Leak Location Survey Subcontractor;
- Reporting any deviations from the CQA Plan, Technical Specifications and Construction Drawings to the CQAM.

2.4 GEOSYNTHETICS CQA CONSULTANT

The Geosynthetics CQA Consultant shall be an engineer experienced with geosynthetics, including but not limited to polyethylene geomembranes, geonet composites, geotextiles and geomembrane composites. The Geosynthetics CQA Consultant shall be experienced in quality assurance including installation quality assurance of all geosynthetics. The Geosynthetics CQA Consultant shall be experienced in the preparation of CQA documentation including CQA forms, reports, certifications and final reports.

The Geosynthetics CQA Consultant shall hold a BS, MS or Ph.D geotechnical or civil engineering degree, be registered as a Professional Engineer and have a minimum of 10 years of experience in the design, manufacture and installation of geosynthetics.

The Geosynthetics CQA Consultant shall be responsible for the CQA Plan development, oversight, QA personnel training and assist in the preparation of the final CQA report.

2.5 CQA LABORATORY

The QA Laboratory is an independent laboratory responsible for QA conformance testing in accordance with standards referenced in the Technical Specifications and Construction Drawings and this CQA Plan. Test results generated by the QA Laboratory will be used by the CQAM to verify compliance of geosynthetic materials and workmanship.

The QA Laboratory will hold a current accreditation by the Geosynthetic Accreditation Institute (GAI) in the test methods specified under the Technical Specifications and shall have extensive experience in testing geosynthetics similar to those proposed for use during construction of the lining system. The QA Laboratory will be capable of providing destructive test results for geomembrane field seams within 24 hours of receipt of samples and will maintain that capability throughout the duration of the project. Prior
to construction, the QA Laboratory will submit their qualifications to the CQAM for review and approval. The qualifications presented by the QA Laboratory shall, as a minimum include:

- Corporate literature, background and statement of qualifications;
- Listing of test capabilities with reference to ASTM, ISO or other standards;
- A laboratory QA Manual which meets the requirements of ANSI/ASQC E-4;
- Current GAI accreditation certificate and list of accredited tests;
- Information on staff size and experience; and
- Anticipated test turnaround time for tests required on this project.

2.6 GEOSYNTHETIC MANUFACTURER

Geosynthetic Manufacturers are the firms or corporations responsible for production of the geosynthetic materials to be used in construction of the VB/I70 Channel Lining System. Each Geosynthetics Manufacturer is responsible for the production and quality control of its respective geosynthetic product. In addition, each Geosynthetic Manufacturer is responsible for the condition of the geosynthetic until the material is accepted by the Subcontractor Installer. Each Geosynthetics Manufacturer shall produce a consistent high quality product which shall meet all the requirements of the Technical Specifications. Each Geosynthetics Manufacturer shall submit quality control documentation to the CQAM as required by the Technical Specifications.

2.7 GEOSYNTHETIC INSTALLER

The Geosynthetics Installer will be experienced and qualified to install the geosynthetic materials of the type specified for this project. The Geosynthetics Installer will be approved and/or licensed by the Geosynthetics Manufacturer. A copy of the approval letter or license will be submitted by the Subcontractor to the Construction Site Manager as required by the Contract Documents.

The Geosynthetic Installer’s supervisor will be responsible for handling installation of the geosynthetics specified for this project and for providing supervision and guidance to the installation crew(s). As a minimum, the Geosynthetics Installer’s supervisor shall:

- Coordinate installation activities with the CQAM and Construction Site Manager;
- Document installation activities including material inventories, on-site personnel, daily production figures, field test results, installation deficiencies and resolution of construction problems;
- Coordinate QC testing including destructive and non-destructive methods;
- Document QC testing activities and test results;
- Prepare geomembrane panel as-built (record) drawings as work progresses and coordinate drawing with the CQAM.
- Prepare installation warranty as required in the Contract Documents.
2.8 ELECTRICAL LEAK LOCATION CQA CONTRACTOR

As part of this CQA P, a geomembrane leak location survey will be conducted immediately after placement of the cover soils material. The leak location survey will be conducted using a very sensitive electrical method to accurately locate leaks in the geomembrane after installation and seaming of the geomembrane and after placement of the soil cover material.

The electrical leak location method detects electrical paths through the liner caused by water or moisture in the leaks. A voltage is connected to one electrode in the soil material covering the geomembrane and to a remote electrode connected to earth ground. Electrical current flowing through the leaks in the liner produces localized anomalous areas of high current density near any leaks. These areas are located by making electrical potential measurement scans on the soil in a fixed survey controlled grid pattern.

The electrical leak location survey shall be performed by a Electrical Leak Location Contractor whose business is specific to this type of work. The Electrical Leak Location Contractor shall have proven experience in large scale leak location surveys for geomembranes covered with soil including surveys within the previous three years totaling a minimum of 20,000,000 square feet, including one survey of more than 1,000,000 square feet. The Electrical Leak Location Contractor will be contracted by the Prime Contractor and report to and coordinate all work with the CQAM and the Construction Site Manager.

The electrical leak location survey shall be performed in accordance with Section 8 of this CQA P and will become a part of the final CQA report.
SECTION 3
REPORTING REQUIREMENTS

This section outlines the minimum requirements for the CQA Inspector in reporting construction activities associated with the installation of the geosynthetics lining system. The CQA Inspector will issue a daily report to the CQAM of construction activities observed. This report will include, as a minimum, the following information:

- Identifying sheet or form number for cross-reference and document control;
- Date, project name, location and other identification;
- Weather conditions;
- Problems and delays encountered and resolutions;
- Descriptions and locations of ongoing construction and CQC activities;
- Equipment and personnel in each work area;
- Description and locations of specific CQC tests observed and documented (identified by coordinate and/or seam/panel numbers);
- Locations where samples are taken (identified by coordinate and/or seam/panel numbers);
- Summary of test results, failures, retests;
- Calibration of test equipment and actions taken as a result of calibration;
- Observations of soils placement over geomembrane system.

3.1 APPLICABLE FORMS FOR INSPECTION

Blank forms and formats for use by CQA inspection are included in Appendix C. These forms can be modified as required and/or dictated by specific construction activities.

3.2 PROBLEM IDENTIFICATION AND PLAN MODIFICATIONS

The CQA Inspector is required to inform the CQAM and Construction Site Manager in a timely manner, of any difference between interpretation of the Technical Specifications and Contract Drawings by the Contractor and interpretation by the CQA Inspector. Any actual or suspected work deficiencies will be brought to the attention of the Construction Site Manager and Design Engineer. Design changes will be made only with written approval or modifications by the Design Engineer. If a problem or deficiency is identified, a special meeting will be held to resolve the problem or deficiency.

3.3 PHOTOGRAPHIC DOCUMENTATION

Photographs taken to document observations, problems, deficiencies, or work in progress will include, without exception, identification of the date, location, direction, and time taken. Photographs will be filed in chronological order in a permanent protected file by the CQAM. The permanent file will also contain a comprehensive index of each photo selected to include the following information:
• Date and time;
• Location including information regarding orientation (ie, direction);
• Subject matter description;
• Unique ID number

Construction photographs will document, as a minimum, the following work items:

• Base layer aggregate condition prior to geotextile and geomembrane placement;
• Deployment and seaming of the geomembrane;
• Deployment and seaming of the geotextile;
• Non-destructive seam QC testing of the geomembrane;
• Destructive test cut-out sampling and field QC tensiometer testing;
• Trial weld fabrication and tensiometer testing;
• Connections to concrete structures and retaining walls;
• Placement and backfill in anchor trenches if required;
• Placement of all overburden materials:
• Placement of cover soils over geomembrane system;
• Depth verification of cover soils material;
• Electrical Leak Location Survey work;
• Noted construction/installation deficiencies;
• Repairs and repair verifications.

3.4 FINAL CONSTRUCTION DOCUMENTATION REPORT

At the completion of all work associated with the construction of the geosynthetics lining system, the CQAM will prepare a final documentation report. This report will summarize the construction of the lining system and will certify that the work has been constructed in substantial compliance with the approved Technical Specifications and Contract Drawings. Any deviations from original design will be noted in the final report. Minimum requirements for the final construction CQA report are outlined in Section 9 of this CQAP.
SECTION 4
GEOTEXTILES CONSTRUCTION QA

This section addresses CQA requirements for manufacturing and installation of the protection geotextiles used in association with the primary geomembrane in the VB/I70 Channel Lining System, and outlines required CQA responsibilities to be performed by the CQAM and/or authorized representatives. The CQAM shall verify and document in the daily reports that the Subcontractor Installation QC personnel are performing all inspections and testing to assure quality control of the project. In addition to documenting deviations and corrective measures in the daily report, the CQAM shall also report any deviations directly to the Construction Site Manager.

4.1 CQA PERSONNEL

A minimum of one CQAM or Authorized Representative shall be on site at all times during installation of the geotextiles. All CQA personnel representing the CQAM and assigned responsibilities for QA work required by this section shall be familiar with installation of geotextiles and shall also be familiar with test methods required in project specifications and in this CQA P.

4.2 GEOTEXTILE MANUFACTURE AND DELIVERY

The CQAM shall review the following information from the Geotextile Manufacturer and Installer:

- The Manufacturing Quality Control certificates of compliance stating that the geotextile meets the requirements of the General Specifications and copies of quality control test results. The certificates of compliance will be attested to by a person having legal authority to bind the geotextile manufacturing company;
- Geotextile connection and penetration details;
- Geotextile Quality Control manual including instructions for storage, handling, installation, seaming and repair;

The CQAM shall examine all geotextile certifications to verify that the property values listed on the certifications meet or exceed those specified and that proper and complete documentation has been provided by the geotextile manufacturer for all geotextile used on site. The CQAM shall also review all details, qualifications statements and QC manuals to assure compliance with the Geotextile Specification.

4.2.1 Labeling

The CQAM shall visually inspect and verify the geotextile Manufacturer has labeled all rolls of geotextile with the manufacturer’s name, geotextile type, lot number, roll number and roll dimensions (length, width, gross weight) as specified in the Geotextile Specification. The CQAM shall record the roll numbers and date each roll was delivered to the site.
4.2.2 Shipment and Storage

Upon delivery of the geotextile to the site, the CQAM and Installer Subcontractor shall verify the following:

- Each roll is wrapped in an opaque and waterproof layer of plastic for shipment and storage;
- The plastic wrapping is not removed until deployment;
- Geotextile or plastic wrapping damaged as a result of storage or handling has been repaired or replaced;
- Geotextile rolls are not stacked more than three rolls high;
- Damaged rolls are repaired or replaced by the Installation Subcontractor.

The CQA Engineer will inventory the delivered geotextile and shall report to the Contractor and Construction Site Manager about any rolls or portions of rolls that should be rejected and removed from site, and any rolls with minor damage that are repairable.

4.2.3 Quality Assurance Conformance Testing

Upon delivery of the geotextile rolls to the site and at the discretion of the Engineer and Construction Site Manager, the CQAM may collect samples at the rate of one per lot or one per 100,000 sf of geotextile placed. The CQAM shall forward samples to the QA laboratory to verify conformance with the Geotextile Specifications.

QA conformance samples shall be taken across the entire roll width of the roll and will not include the outer wrap of the geotextile roll. Samples will be 3.0 ft. long by the full roll width with the machine direction clearly marked on the sample by the CQAM. The CQAM shall also write on the sample and affix a label to the sample with the following information:

- Sample number;
- Lot/batch and roll number;
- Date sampled;
- Project identification;
- Manufacturer;
- CQA Inspectors name.

CQA conformance testing will consist of the methods and frequency shown in Table 4-1.

The CQAM shall examine all results of QA Laboratory conformance testing and verify test results are in compliance with the Geotextile Specification and shall report any nonconformance to the Construction Site Manager.

In the event of a failing QA test, the Manufacturer may have the sample retested at two different CQAM approved geosynthetic laboratories. If both laboratories produce passing results, the material shall be accepted. If one or both of the laboratories do not
produce passing results, results from the original geosynthetic test laboratory will be accepted.

If a test is not in conformance, all material from the lot represented by the failing test will be considered out-of-specification and rejected. Additional conformance samples may be taken to bracket the portion of the lot which is in nonconformance. To isolate the nonconformance material, additional samples must be taken from rolls that have roll numbers immediately adjacent to the roll that was sampled and failed. If both additional tests pass, only the roll that initially failed will be rejected. If one or both of the additional tests fail, then the entire lot will be rejected or the procedure repeated with two additional tests that bracket a greater number of rolls within the lot.

4.3 GEOTEXTILE INSTALLATION

4.3.1 Handling and Placement

The CQAM and/or CQA Inspector shall observe the installation and verify conformance with the following:

- Any rolls with obvious flaws or significant damage are removed from site;
- Deployment procedures and equipment used do not damage the geotextile or underlying geomembrane;
- Geotextiles damaged during placement are removed or repaired;
- Only geotextile rolls that can be seamed together and ballasted in one day shall be deployed;
- The geotextile is properly ballasted with adequate ballast (e.g., sandbags) in the presence of excessive winds or for any period of time that the geotextile is left exposed without cover materials;
- Geotextile is laid smooth and free of tensile stress, folds or excessive wrinkles.
- Geotextile is placed with the machine or roll direction parallel to line of maximum slope;
- Geotextile field seams are oriented parallel to the line of maximum slope;
- Cross seams on slope areas are not allowed;
- Geotextile is cut using appropriate methods such as hook blades or scissors;
- Vehicles are not operated directly on the geotextile;

4.3.2 Overlap and Thermal Seaming

The CQAM or CQA Inspector shall inspect, measure where applicable, and verify the following:

- All geotextile seams are oriented, overlapped and thermally seamed in accordance with the Geotextile Specification;
- Geotextile rolls or panels are continuously overlapped a minimum of 4 inches and thermally welded by hot wedge or hot air fusion methods;
• Cross seams on slope areas shall not be allowed (roll end seams excepted);
• Prior to seaming, the seam area is clean and free of dirt, debris and any foreign material;
• Prior to seaming, the seam overlap is aligned with minimum wrinkles;
• Thermal fusion welds are a minimum of 1 inch in width;
• Thermal fusion welds are seamed flat to the geotextile and cannot be readily peeled apart by hand;

4.3.3 Repair

The CQAM or CQA Inspector shall visually inspect and verify that any holes, tears or imperfections in the geotextile are repaired in accordance with the requirements of the Geotextile Specification and as follows:

• Holes and tears are repaired with an oval or round patch or patch with rounded corners with minimum overlap of 12 inches in all directions from hole or tear;
• Geotextile rolls placed on a slope with a tear exceeding 10% of the roll width are removed and replaced;
• Patch is made from the same geotextile material that is being repaired;
• Patch is seamed to the geotextile by thermal seaming methods only and outside edge of patch is thermally seamed flat to the geotextile;
• Verify that the patch cannot be peeled from the geotextile surface by hand

4.3.4 Cover Material Placement

During placement of the overlying geomembrane, the CQAM shall closely observe placement methods and equipment travel for conformance with the Specifications. Any suspected area damage shall be marked and immediately reported to the Construction Site Manager and Contractor. In particular, the CQAM shall observe and verify the following:

• Geotextile surface area and seams shall be continuous with no open areas (i.e., seam area) that could allow underlying rock intrusion between the geotextile and geomembrane.;
• During placement of the overlying geomembrane, wrinkle development will be minimized and no tensile stress will be allowed to be mobilized in the geotextile;
• Wrinkle formation is minimized and that in all cases wrinkles or waves do not develop in the geotextile as geomembrane is placed; and
• Geomembrane is placed within 14 days after geotextile placement and seaming.
<table>
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<tr>
<th>Property</th>
<th>Test Method</th>
<th>Test Frequency</th>
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<td>Mass per Unit Area</td>
<td>ASTM D 5261</td>
<td>1 per 100,000 sq ft</td>
</tr>
<tr>
<td>Grab Tensile/Elongation</td>
<td>ASTM D 4632</td>
<td>1 per 100,000 sq ft</td>
</tr>
<tr>
<td>Puncture Resistance</td>
<td>ASTM D 6241</td>
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</tr>
<tr>
<td>Trapezoidal Tear</td>
<td>ASTM D 4533</td>
<td>1 per 100,000 sq ft</td>
</tr>
</tbody>
</table>
SECTION 5
LLDPE-T GEOMEMBRANE CONSTRUCTION QA

This section addresses CQA requirements for manufacturing and installation of the 60 mil (1.5 mm) thick Linear Low Density Polyethylene Textured (LLDPE-T) geomembrane used as the primary lining in the VB/I70 Channel Lining, and outlines required CQA responsibilities to be performed by the CQAM and/or authorized representatives. The CQAM shall verify and document in the daily reports that the Subcontractor Installation QC personnel are performing all inspections and testing to assure quality control of the project. The CQAM shall also perform supplemental CQA conformance testing and inspections for the purpose of quality assurance. In addition to documenting deviations and corrective measures in the daily report, the CQA Engineer shall also report any deviations directly to the Construction Site Manager.

5.1 CQA PERSONNEL

A minimum of one CQAM or Authorized Representative shall be on site at all times during installation of the Geomembrane. All CQA personnel representing the CQAM and having assigned responsibilities for QA work required by this section shall be familiar with geomembrane installation and shall also be familiar with testing methods required in the project specifications and in this CQA P.

5.2 GEOMEMBRANE MANUFACTURE AND DELIVERY

5.2.1 Resin Certifications

Prior to Installation of the geomembrane, the CQAM shall review a copy of the quality control certificates issued by the resin supplier that includes:

- Origin;
- Identification;
- Production date; and
- Test results.

5.2.2 Resin Quality Control Test Result Verifications

The CQAM shall obtain the resin source lot numbers from the manufacturer and compare them with the manufacturer’s roll listing to verify the proposed resin was used to manufacture the rolls delivered to the site.

5.2.3 Roll Quality Control Test Result Verifications

The CQAM shall obtain the roll numbers from the manufacturer and compare them with the manufacturer’s quality control certificates of laboratory test results to verify that the proposed geomembrane rolls to be delivered to the site meet the project specifications.

Prior to installation of the geomembrane materials, the CQAM shall review a copy of the quality control certificates issued by the geomembrane Manufacturer that includes the following:
• Laboratory test results and certification stating that the geomembrane meets the project specifications and
• Statement certifying that no post consumer reclaimed materials are added to the resin

5.2.4 Submittals

Prior to installation of the geomembrane, the CQAM shall review the following:

• Manufacturer’s certifications and quality control test results for resin, roll goods and extrusion weld rods or beads;
• Geomembrane panel layout and detail drawings;
• Manufacturer’s QC manual;
• Installer’s QC manual;
• Manufacturer, Installer, and QC laboratory qualification statements; and
• Resumes of key personnel involved in the project.

The CQAM shall review the above information and verify that:

• The above submittals are in compliance with the contract documents;
• Certified property values by the Manufacturer meet all specified values; and
• QC certificates have been provided at the specified frequency for the geomembrane rolls, and each certificate identifies the rolls, lot or batch number related to that certificate.

5.2.5 Labeling

The CQAM shall examine all geomembrane rolls upon delivery to the site and verify that the labels include manufacturer name, product type, thickness, roll number, and manufacture dates.

5.2.6 Delivery, Handling and Storage

Upon delivery of the geomembrane to the site, the CQAM shall verify the following:

• Geomembrane is handled and stored in accordance with the specifications and Manufacturers recommended procedures;
• Geomembrane rolls are not stacked more than three rolls in height;
• Temporary storage is away from standing water and construction traffic; and
• Damaged geomembrane rolls have been removed from site.

The CQAM will inventory the delivered geomembrane and shall report to the Construction Site Manager and Contractor any rolls or portions of rolls that should be rejected and removed from the site.
5.2.7 Quality Assurance Conformance Testing

Upon delivery of the geomembrane rolls to the site and at the discretion of the Engineer and Construction Site Manager, the CQAM may collect samples at the rate of one sample per 100,000 square feet of geomembrane to be installed. The CQAM shall forward all samples to the QA Laboratory for testing to verify conformance with the specifications. Alternatively, the conformance sampling can be accomplished at the point of Manufacture.

QA conformance samples shall be taken across the entire roll width and shall not include the outer wrap of the roll. Samples will be 3.0 feet long by the full roll width with the machine direction marked on the sample by the CQAM. The CQAM shall also write on the sample and affix a label to the sample with the following information:

- Sample number;
- Lot, batch and roll number;
- Date sampled;
- Project identification;
- Manufacturer;
- CQA Inspectors name.

QA conformance testing will consist of the properties and frequencies shown on Table 5-1. The CQAM shall examine all QA Laboratory conformance testing and verify that the test results are in compliance with the specifications. Any nonconformance will be reported to the Construction Site Manager and Contractor.

5.2.8 Manufacturing Plant Visitation

At the discretion of the City and County of Denver, a designated technical representative may make at least one visitation to the manufacturer’s plant during production of the LLDPE geomembrane roll goods designated for this project. The designated representatives will visually observe production methods, manufacturing QC procedures, laboratory QC testing, handling and shipping methods.

5.3 GEOMEMBRANE INSTALLATION

The CQAM shall visually inspect and verify the following procedures are performed by the Contractor, Subcontractors and Installer.

5.3.1 Earthwork – Surface Preparation

The CQAM and Geomembrane Installer shall certify in writing that the geotextile or soils surface on which the geomembrane will be installed is acceptable and shall ensure that the stabilized aggregate base is prepared as specified for geomembrane placement. The CQAM shall visually inspect on a daily basis and verify that the subgrade surface does not contain rocks larger than ½ inch or any other debris which could damage the geomembrane. Verify those materials are removed from the surfaces to be covered with the geomembrane. The CQAM shall verify that construction equipment tire or track deformation does not cause ruts greater than 1.0 inch in depth prior to geomembrane placement.
placement. The CQAM shall ensure that any subgrade abnormalities or damage is repaired by the Contractor prior to geomembrane placement.

5.3.2 Earthwork – Anchor Trenches

The CQAM shall visually inspect and verify the following for anchor trenches if required:

- Anchor trench dimensions, setback (runout) and locations conform to the specification requirements and project drawing details;
- Only the amount of anchor trench required for the geomembrane to be anchored in one day shall be excavated and prepared;
- Inside trench edge shall be rounded to avoid sharp geomembrane transition into the trench;
- All loose rocks, debris shall be removed from the upper, inside trench surfaces;
- Backfill in the anchor trench is properly placed and compacted in accordance with the specifications section on earthwork; and
- Construction equipment used in backfill and compaction does not damage the geomembrane.

5.3.3 Geomembrane Deployment

5.3.3.1 Field Panel Placement

The CQAM shall visually inspect and verify that field panels are installed at the locations and positions indicated in the approved layout drawings. The CQAM shall record the identification code, location, and date of installation for each panel. During geomembrane panel or roll placement, the CQAM shall verify the following:

- Any rolls containing flaws or damage are noted, rejected and removed from the site;
- Any rolls which require minor repair are repaired;
- Geomembrane is placed with a minimum of handling;
- Deployment procedures and equipment used do not damage the geomembrane, underlying aggregate base or geosynthetics;
- Geomembrane damaged during installation is removed or repaired;
- Only geomembrane rolls that can be seamed together in one day and anchored shall be deployed;
- Adequate ballast is placed on the geomembrane to prevent wind uplift;
- No equipment is allowed directly on the geomembrane;
- Geomembrane panels or rolls are placed in the direction from top of slope down;
- Geomembrane field seams are oriented parallel to line of maximum slope;
- Horizontal geomembrane field seams are a minimum of 5 feet from toe of slope;
- Horizontal geomembrane field seams are not allowed on slopes; and
- Geomembrane waves or large wrinkles are minimized and that no waves or wrinkles are allowed to fold over during cover materials placement.
5.3.3.2 Thickness Measurement

The CQAM shall take a minimum of one thickness measurement per roll deployed as a continuous check on thickness of the smooth edge of the textured geomembrane in addition to the requirement in Table 5-1 for QA sampling per 100,000 square feet. The CQAM shall verify that rolls or panels whose thickness falls below specification requirements are rejected and replaced by conforming rolls. All thickness recordings and actions taken due to inadequate thickness shall be included in the daily QA report.

5.3.3.3 Weather Conditions

The CQAM shall visually inspect and verify that the underlying aggregate base and geotextile has not been damaged by weather conditions and that rolls or panels will be deployed and field seamed only when the geomembrane is dry and winds gusts in excess of 15 mph are not occurring. The CQAM shall verify that seaming is not performed at ambient temperatures below 32 degrees F or above 104 degrees F.

5.3.3.4 Damage

The CQAM shall visually observe each panel after placement and prior to seaming for damage and mark the location of damage on the panels. The CQAM shall document, in the daily QA report, the location of the damaged panels or portions of damaged panels, repairs and repair testing results.

5.3.4 Field Seaming

5.3.4.1 Seam Layout

The CQAM shall verify that seam layout shown on layout drawings is consistent with the geomembrane specification. In addition, seams not specifically shown on layout drawings may not be made without the CQAM prior approval.

The CQAM shall verify that a seam numbering system compatible with the panel numbering system agreed upon by the Installation Subcontractor and the Design Engineer is being used by the Subcontractor.

5.3.4.2 Seaming Equipment

The CQAM shall verify the following by visual inspection and review of submittal and contract requirements:

- Equipment used is in accordance with the geomembrane manufacturer’s recommendations and is maintained in optimal working condition;
- LLDPE geomembrane production seams are by dual track thermal fusion methods only;
- LLDPE geomembrane detail seams (patching, sealing around pipes, destructive sample locations, etc.) are restricted to extrusion welding;
- Only seaming apparatus that has been inspected and approved by the CQAM should be used;
• Extrusion welding apparatus is equipped with readout gauges indicating the temperature of the extrudate and nozzle.
• Fusion welding apparatus is equipped with readout gauges for speed, seam temperatures; and
• Surface temperature pyrometer and ambient temperature measuring equipment is available and calibrated.

The CQAM shall verify approved equipment and qualified personnel perform all production and detail welding. In addition, all welding shall be performed under suitable conditions, using specified overlaps, properly aligned seams and detail techniques (grinding, extrudate placement, etc for extrusion welds) as specified in the LLDPE geomembrane specification. The CQAM shall record the following:

• Seam number, length and type;
• Seam location;
• Name and ID of seamer;
• Extrusion apparatus temperatures of extrudate and nozzle;
• Fusion apparatus temperatures and speed;
• Ambient and/or surface temperatures of sheet

5.3.4.3 Seam Preparation

The CQAM shall visually inspect and verify that:

• Prior to seaming, the seam area is clean and free of moisture, dirt, debris and any foreign material.
• Prior to seaming, the seam overlap is properly aligned with minimum wrinkles and maintained in accordance with geomembrane specifications.
• If seam overlap grinding is required, grinding marks are to be oriented perpendicular to the seam direction and no marks extend beyond the extrudate after placement. The depth of grind marks shall be no greater than 10% of the sheet thickness. Extrusion welding must commence within 10 minutes of grinding. Extrusion welds that must be rewelded or overlapped shall be prepared by grinding prior to applying new extrudate.

5.3.4.4 Weather Conditions

The CQAM shall verify that weather conditions are within the limits of the geomembrane specifications.

5.3.4.5 Trial Welds

The CQAM shall verify that the Installation Subcontractor makes trial welds on test strips of excess geomembrane material under actual field conditions to verify seaming technique and conditions are adequate. Trial welds shall be repeated at the beginning of each shift, every 5 hours or at any time the welders are shut down (ie. mid day, end of day, etc.)
The CQAM shall observe all trial weld procedures and verify that the QC Inspector assigns a number to and marks the trial weld accordingly and that the QC Inspector logs the date, hour, temperatures, seaming apparatus ID number, name of seamer and pass/fail description. The CQA engineer shall include the trial seam log information in the daily report.

5.4 NON-DESTRUCTIVE TEST SEAM QC CONTINUITY TESTING

As required by the geomembrane specifications, the Installer Subcontractor QC shall nondestructively test all field seams on a daily basis as production and detail seaming progresses and in accordance with Table 5-2 requirements. The CQAM shall verify that seams which fail are reported and repaired in accordance with the geomembrane specifications. The CQAM shall observe continuity testing and perform the following:

- Record seam number, location, date, test unit ID, tester ID, and outcome of all testing;
- Mark on the geomembrane passed seam number, date, tester ID;
- Mark on the geomembrane that repair of failed seams has been made and retested;
- Document all results.

5.5 DESTRUCTIVE SEAM QUALITY CONTROL TESTING

The CQAM shall verify that the Installer Subcontractor obtains destructive QC samples of production field seams and performs quality control testing in accordance with the geomembrane specifications. Seam strength (peel and shear tensile) destructive testing shall be accomplished as seaming work progresses, not at completion of all seaming.

5.5.1 Location and Frequency

The CQAM shall select locations where seam samples will be cut out for QC site and laboratory testing. The Installer Subcontractor shall not be informed in advance of locations where seam samples will be taken. Frequency will be established in accordance with the geomembrane specifications, preconstruction meeting written amendments or results of future seam quality. Destructive locations will be minimized if at all practical and restricted to non critical areas (trial welds, anchor trench, flat bench or terrace, etc.). No destructive samples shall be taken on slope areas.

5.5.2 Sampling Procedure

The CQAM shall verify that the Installer Subcontractor obtains, numbers and tests seam samples and logs results in accordance with the geomembrane specifications.

5.5.3 Quality Control Field Testing

The CQAM shall be present during all QC field testing and verify that the Installer Subcontractor and QC Inspector cut and test QC samples in accordance with the geomembrane specifications and Table 5-3 of this QA plan.
5.5.4 Quality Control Laboratory Testing

The CQAM shall verify that the Installer Subcontractor QC obtains the appropriate QC seam samples and has them tested as specified in the geomembrane specifications. The Subcontractor Installer QC laboratory shall be certified by the Geosynthetic Accreditation Institute (GAI) and be approved by the CQAM.

The QC Inspector will provide test results to the CQAM in a timely manner. The CQAM will review seam strength test results as soon as they become available, and inform the Contractor of the results, any discrepancies and course of action if required.

The CQAM will take appropriate samples from destructive cutouts for third party conformance testing as required. Results will meet or exceed Table 5-3 requirements.

5.6 DEFECTS AND REPAIRS

5.6.1 Identification

The CQAM shall visually inspect all seams and non-seam areas of the geomembrane for evidence of defects, holes, blisters and any sign of contamination by foreign matter. The CQAM may request the membrane surface be washed by the Contractor if the amount of dust and debris inhibits inspection.

5.6.2 Quality Control Evaluation

CQAM shall visually inspect and verify that each suspect location both in seam and non-seam areas is non-destructively tested using methods described for Quality Control testing in the geomembrane specifications and that each location which fails NDT is marked by the QC inspector and repaired by the Installation Subcontractor. Materials should not be placed over the geomembrane locations that have been repaired until the CQAM has approved the repair.

5.6.3 Cover Material Placement and Large Wrinkles or Waves

During placement of the cover soils material, the CQAM shall closely observe placement methods and equipment travel. Any suspected area damage shall be marked and immediately reported to the Construction Site Manager and Contractor.

Prior to placing any overlying materials, the CQAM shall visually inspect the geomembrane for wrinkles and will indicate to the Installer which wrinkles or waves shall be cut and reseamed. Any reseamed wrinkles shall be considered a seam and shall be tested and approved like any other field seam.

During placement of overlying cover soils material, wrinkle development will be minimized. The CQAM shall observe all cover material placement to ensure wrinkle formation is minimized and that in all cases, the geomembrane is not allowed to fold over on itself just prior to cover soils placement.
5.6.4 Repair Procedures Verification

The CQAM shall verify that any portion of the geomembrane exhibiting a flaw, or failing a destructive or nondestructive test is repaired by the Installation Subcontractor in accordance with the appropriate methods specified in the geomembrane specification.

5.6.5 Testing of Repairs

The CQAM shall verify seams that fail destructive and non destructive seam testing are repaired in accordance with the geomembrane specifications and retested by NDT methods as described in the geomembrane specifications.

5.7 APPURTENANCES AND CONCRETE ATTACHMENT

The CQAM shall verify the following:

- Installation of the geomembrane around, and connection of the geomembrane to appurtenances and concrete retaining walls has been made in accordance with standard industry practice and in accordance with the geomembrane specifications and drawing details;
- Methods used in attachment will not damage or stress the geomembrane sheet material;
- Extreme care is taken while seaming around appurtenances and that the seam is visually inspected during placement or attachment;
- The seam or connection is tested by non destructive methods in so far as practical;
- The geomembrane has not been visibly damaged while being connected to the appurtenances or concrete structures and will not be damaged during placement of cover materials.

5.8 LLDPE GEOMEMBRANE SYSTEM ACCEPTANCE

The geomembrane lining system will be considered acceptable when:

- The installation is complete;
- All seams, repairs and associated testing is complete and verified by the CQAM;
- All documentation associated with the geomembrane installation is complete;
- The CQAM has certified that the geomembrane installation has been completed in general accordance with this QA plan, project specifications and drawings.
### TABLE 5-1 LLDPE GEOMEMBRANE CQA CONFORMANCE TESTING

<table>
<thead>
<tr>
<th>Property</th>
<th>Test Method</th>
<th>Test Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thickness</td>
<td>ASTM D 5994/5199</td>
<td>1 per 100,000 sq ft</td>
</tr>
<tr>
<td>Density</td>
<td>ASTM D 792/1505</td>
<td>1 per 100,000 sq ft</td>
</tr>
<tr>
<td>Melt Flow Index (max)</td>
<td>ASTM D 1238</td>
<td>1 per 100,000 sq ft</td>
</tr>
<tr>
<td>Tensile Properties</td>
<td>ASTM D 6693</td>
<td>1 per 100,000 sq ft</td>
</tr>
<tr>
<td>Axi-Symmetric Strain</td>
<td>ASTM D 5617</td>
<td>1 per 100,000 sq ft</td>
</tr>
<tr>
<td>Tear Resistance</td>
<td>ASTM D 1004</td>
<td>1 per 100,000 sq ft</td>
</tr>
<tr>
<td>Puncture Resistance</td>
<td>ASTM D 4833</td>
<td>1 per 100,000 sq ft</td>
</tr>
<tr>
<td>Carbon Black Content</td>
<td>ASTM D 1603</td>
<td>as required</td>
</tr>
<tr>
<td>Carbon Black Dispersion</td>
<td>ASTM D 5596</td>
<td>as required</td>
</tr>
<tr>
<td>Oxidative Induction Time</td>
<td>ASTM D 3895</td>
<td>as required</td>
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</table>

### TABLE 5-2 LLDPE GEOMEMBRANE NDT CQA SEAM TESTING REQUIREMENTS

<table>
<thead>
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<th>Test Method</th>
<th>Frequency</th>
<th>Specified</th>
<th>Documented</th>
</tr>
</thead>
<tbody>
<tr>
<td>ASTM D 5641</td>
<td>100% Extrusion</td>
<td>Pass</td>
<td>Pass/Fail</td>
</tr>
<tr>
<td>Vacuum Box</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ASTM D 5820</td>
<td>100% Dual Fusion</td>
<td>Pass</td>
<td>Pass/Fail</td>
</tr>
<tr>
<td>Air Channel</td>
<td></td>
<td></td>
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</table>

### TABLE 5-3 LLDPE GEOMEMBRANE DESTRUCTIVE SEAM TESTING CQA REQUIREMENTS

<table>
<thead>
<tr>
<th>Test Method</th>
<th>Frequency</th>
<th>Specified</th>
<th>Documented</th>
</tr>
</thead>
<tbody>
<tr>
<td>ASTM D 6392</td>
<td>As Required</td>
<td>72 lb/in FTB</td>
<td>Pass/Fail</td>
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<tr>
<td>Seam Shear Strength</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>ASTM D 6392</td>
<td>As Required</td>
<td>60 lb/in FTB</td>
<td>Pass/Fail</td>
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<tr>
<td>Seam Peel Strength</td>
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<td></td>
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</tr>
</tbody>
</table>

Note: Peel incursion shall be less than 25% by area

Page 26
SECTION 6
GEOGRID CONSTRUCTION QA

This section addresses CQA requirements for manufacturing and installation of the Tensar Triax TX7 Geogrid used in association with the stabilization layer below the primary geomembrane in the VB/I70 Channel Lining System, and outlines required CQA responsibilities to be performed by the CQAM and/or authorized representatives. The CQAM shall verify and document in the daily reports that the Subcontractor Installation QC personnel are performing all inspections and testing to assure quality control of the project. In addition to documenting deviations and corrective measures in the daily report, the CQAM shall also report any deviations directly to the Construction Site Manager.

6.1 CQA PERSONNEL

A minimum of one CQAM or Authorized Representative shall be on site at all times during installation of the geogrid. All CQA personnel representing the CQAM and assigned responsibilities for QA work required by this section shall be familiar with installation of geogrids and shall also be familiar with test methods required in project specifications and in this CQA P.

6.2 GEOGRID MANUFACTURE AND DELIVERY

The Geogrid shall be Tensar Triax TX7 as manufactured by Tensar Corporation, Alpharetta, GA. The CQAM shall review the following information from the Manufacturer and Installer:

- The Manufacturing Quality Control certificates of compliance stating that the Tensar Triax TX7 geogrid meets the requirements of the General Specifications and copies of quality control test results. The certificates of compliance will be attested to by a person having legal authority to bind the manufacturing company;
- Geogrid overlap and connection details;
- Geogrid Quality Control manual including instructions for storage, handling, installation, joining and repair;

The CQAM shall examine all certifications to verify that the property values listed on the certifications meet or exceed those specified and that proper and complete documentation has been provided by the manufacturer for all geogrid used on site. The CQAM shall also review all details, qualifications statements and QC manuals to assure compliance with the Specifications.

6.2.1 Labeling

The CQAM shall visually inspect and verify the geogrid Manufacturer has labeled all rolls of geogrid with the manufacturer’s name, geogrid type, lot number, roll number and roll dimensions (length, width, gross weight). The CQAM shall record the roll numbers and date each roll was delivered to the site.
6.2.2 Shipment and Storage

Upon delivery of the geogrid rolls to the site, the CQAM and Installer Subcontractor shall verify the following:

- Each roll is protected for shipment and storage;
- The wrapping (if any) is not removed until deployment;
- Geogrid or wrapping damaged as a result of storage or handling has been repaired or replaced;
- Geogrid rolls are not stacked more than three rolls high;
- Damaged rolls are repaired or replaced by the Installation Subcontractor.

The CQA Engineer will inventory the delivered geogrid and shall report to the Contractor and Construction Site Manager about any rolls or portions of rolls that should be rejected and removed from site, and any rolls with minor damage that are repairable.

6.2.3 Quality Assurance Conformance Testing

Upon delivery of the geogrid rolls to the site and at the discretion of the Engineer and Construction Site Manager, the CQAM may collect samples at the rate of one per lot or one per 100,000 sq.ft. of geogrid placed. The CQAM shall forward samples to the QA laboratory to verify conformance with the Specifications.

QA conformance samples shall be taken across the entire roll width of the roll and will not include the outer wrap. Samples will be 3.0 ft. long by the full roll width with the machine direction clearly marked on the sample by the CQAM. The CQAM shall also affix a label to the sample with the following information:

- Sample number;
- Lot/batch and roll number;
- Date sampled;
- Project identification;
- Manufacturer;
- CQA Inspectors name.

CQA conformance testing will consist of the methods and frequency shown in Table 6-1.

CQA conformance testing can also be accomplished at the Manufacturer Plant (recommended)

The CQAM shall examine all results of QA Laboratory conformance testing and verify test results are in compliance with the Specification and shall report any nonconformance to the Construction Site Manager.

In the event of a failing QA test, the Manufacturer may have the sample retested at two different CQAM approved geosynthetic laboratories. If both laboratories produce passing results, the material shall be accepted. If one or both of the laboratories do not produce passing results, results from the original geosynthetic test laboratory will be accepted.
If a test is not in conformance, all material from the lot represented by the failing test will be considered out-of-specification and rejected. Additional conformance samples may be taken to bracket the portion of the lot which is in nonconformance. To isolate the nonconformance material, additional samples must be taken from rolls that have roll numbers immediately adjacent to the roll that was sampled and failed. If both additional tests pass, only the roll that initially failed will be rejected. If one or both of the additional tests fail, then the entire lot will be rejected or the procedure repeated with two additional tests that bracket a greater number of rolls within the lot.

6.3 GEOGRID INSTALLATION

6.3.1 Handling and Placement

The CQAM and/or CQA Inspector shall observe the installation and verify conformance with the following:

- Any rolls with obvious flaws or significant damage are removed from site;
- Deployment procedures and equipment used do not damage the geogrid.
- Geogrid rolls damaged during placement are removed or repaired;
- Only geogrid rolls that can be joined together and ballasted or covered with aggregate in one day shall be deployed;
- The geogrid is properly ballasted with adequate ballast (e.g., sandbags) in the presence of excessive winds or for any period of time that the geogrid is left exposed without aggregate cover materials;
- Geogrid is laid smooth and free of folds or excessive wrinkles.
- Geogrid is placed with the machine or roll direction parallel to line of maximum slope;
- Geogrid field overlaps are oriented parallel to the line of maximum slope;
- Vehicles are not operated directly on the geogrid;

6.3.2 Overlap and Connection

The CQAM or CQA Inspector shall inspect, measure where applicable, and verify the following:

- All geogrid is overlapped and mechanically tied in accordance with the Manufacturers recommendations;
- Geogrid rolls are continuously overlapped a minimum of 3.0 ft and fastened together with nylon zip ties every 3.0 ft along the length;
- Cross seams on slope areas shall be overlapped and fastened together with zip ties every 1.0 ft across the roll width;
- Prior to joining with zip ties, the seam overlap is aligned and held in tension with minimum wrinkles;

6.3.3 Repair

The CQAM or CQA Inspector shall visually inspect and verify that any holes, tears or imperfections in the geogrid are repaired in accordance with the manufacturers recommendations.
6.3.4 Aggregate Cover Material Placement

During placement of the overlying aggregate cover material, the CQAM shall closely observe placement methods and equipment travel for conformance with the Specifications. Any suspected area damage shall be marked and immediately reported to the Construction Site Manager and Contractor. In particular, the CQAM shall observe and verify the following:

- Geogrid surface area and overlaps shall be continuous with no open areas that could allow aggregate intrusion between the geogrid and base soil;
- During placement of the overlying aggregate material, wrinkle development will be minimized and the geogrid will be kept in tension to prevent wrinkles;
- Wrinkle formation is minimized and that in all cases wrinkles or waves do not develop during cover material placement;
- Aggregate cover material is placed within 24 hrs after geogrid placement; and
- Aggregate cover material is placed from bottom to top of slope in one 18 inch lift.

<table>
<thead>
<tr>
<th>Property</th>
<th>Test Method</th>
<th>Test Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mass per Unit Area</td>
<td>ASTM D 5261</td>
<td>1 per 100,000 sq ft</td>
</tr>
<tr>
<td>Wide Width Tensile</td>
<td>ASTM D 6037</td>
<td>1 per 100,000 sq ft</td>
</tr>
</tbody>
</table>
SECTION 7  GEONET COMPOSITE
CONSTRUCTION QA

This section addresses CQA requirements for manufacturing and installation of the geonet composite drainage layer used in association with the primary lining system in the VB/I70 Channel Lining, and outlines required CQA responsibilities to be performed by the CQAM and/or authorized representatives. The CQAM shall verify and document in the daily reports that the Installation Subcontractor QC personnel are performing all inspections and testing to assure quality control of the project. In addition to documenting deviations and corrective measures in the daily report, the CQAM shall also report any deviations directly to the Construction Site Manager. Subcontractor requirements of specification section 02212 titled: Geonet Composite, are reflected in this CQA P.

7.1  CQA PERSONNEL

A minimum of one CQAM or Authorized Representative shall be on site at all times during installation of the geonet composite. All CQA personnel representing the CQAM and assigned responsibilities for QA work required by this section shall be familiar with installation of geonet composites and shall also be familiar with test methods required in project specifications and in this CQA P.

7.2  GEONET COMPOSITE MANUFACTURE AND DELIVERY

The geonet composite consists of a geonet core and nonwoven geotextile bonded to both sides of the geonet to form the composite drainage layer. The CQAM shall review the following information from the Geonet Composite Manufacturer:

- The Manufacturing Quality Control certificates of compliance stating that the geotextile, geonet and composite meets the requirements of the General Specifications and copies of quality control test results. The certificates of compliance will be attested to by a person having legal authority to bind the manufacturing company;
- Geonet/geotextile certified test results for ply bond adhesion;
- Geonet composite planar water flow rate certified test results;
- Manufacturer’s Quality Control manual including instructions for storage, handling, installation, seaming and repair;

The CQAM shall examine all geonet composite certifications to verify that the property values listed on the certifications meet or exceed those specified and that proper and complete documentation has been provided by the manufacturer for all geonet composite used on site. The CQA Engineer shall also review all details, qualifications statements and QC manuals to assure compliance with the Geonet Composite Specification.
7.2.1 Labeling

The CQA Engineer shall visually inspect and verify that the geonet composite Manufacturer has labeled all rolls with the manufacturer’s name, geonet composite type, lot number, roll number and roll dimensions (length, width, gross weight) as specified in the Geonet Composite Specification. The CQA Engineer shall record the roll numbers and date each roll was delivered to the site.

7.2.2 Shipment and Storage

Upon delivery of the geonet composite to the site, the CQA Engineer and Installer Subcontractor shall verify the following:

- Each roll is wrapped in an opaque and waterproof layer of plastic for shipment and storage;
- The plastic wrapping is not removed until deployment;
- Geonet composite damaged as a result of handling has been repaired or replaced;
- Geonet composite rolls are not stacked more than three rolls high;

The CQA Engineer will inventory the delivered geonet composite and shall report to the Contractor and Construction Site Manager about any rolls or portions of rolls that should be rejected and removed from site, and any rolls with minor damage that are repairable.

7.2.3 Quality Assurance Conformance Testing

Upon delivery of the geonet rolls to the site, and at the discretion of the CQAM, roll samples may be collected at the rate of one per lot or one per 100,000 sq.ft. of geonet composite placed. The CQAM shall forward samples to the QA laboratory to verify conformance with the Geonet Composite Specifications.

QA conformance samples shall be taken across the entire roll width of the roll and will not include the outer wrap of the roll. Samples will be 3.0 ft. long by the full roll width with the machine direction clearly marked on the sample by the CQAM. The CQAM shall also write on the sample and affix a label to the sample with the following information:

- Sample number;
- Lot/batch and roll number;
- Date sampled;
- Project identification;
- Manufacturer;
- CQA Inspectors name.

CQA conformance testing will consist of the methods and frequency in Table 7-1.
The CQAM shall examine all results of QA Laboratory conformance testing and verify test results are in compliance with the Geonet Composite Specification and shall report any nonconformance to the Construction Site Manager.

In the event of a failing QA test, the Manufacturer may have the sample retested at two different CQAM approved geosynthetic laboratories. If both laboratories produce passing results, the material shall be accepted. If one or both of the laboratories do not produce passing results, results from the original geosynthetic test laboratory will be accepted.

If a test is not in conformance, all material from the lot represented by the failing test will be considered out-of-specification and rejected. Additional conformance samples may be taken to bracket the portion of the lot which is in nonconformance. To isolate the nonconformance material, additional samples must be taken from rolls that have roll numbers immediately adjacent to the roll that was sampled and failed. If both additional tests pass, only the roll that initially failed will be rejected. If one or both of the additional tests fail, then the entire lot will be rejected or the procedure repeated with two additional tests that bracket a greater number of rolls within the lot.

7.3 GEONET COMPOSITE INSTALLATION

7.3.1 Handling and Placement

The CQAM and/or CQA Inspector shall observe the installation and verify conformance with the following:

- The surface underlying the geonet composite is clean, and free of excessive dirt, debris, stones, or other obstructions that could potentially damage the geomembrane system;
- The geonet composite is free of dirt or excessive dust just prior to installation;
- Any rolls with obvious flaws or significant damage are removed from site;
- Deployment procedures and equipment used do not damage the geonet composite or underlying geomembrane;
- Geonet composite damaged during placement are removed or repaired;
- Geonet composite is not dragged across textured geomembrane during placement and that a thin plastic slip sheet is used during positioning;
- Only rolls that can be seamed together and ballasted in one day shall be deployed;
- The geonet composite is properly ballasted with adequate ballast (e.g., sandbags) in the presence of excessive winds or for any period of time that the geonet composite is left exposed without cover materials;
- Geonet composite is unrolled downslope keeping the roll in slight tension to minimize wrinkles and folds;
- Geonet composite is placed with the machine or roll direction parallel to line of maximum slope;
- Geonet composite field seams are oriented parallel to the line of maximum slope;
• Cross seams on slope areas are not allowed;
• Geonet composite is cut using appropriate methods such as hook blades or scissors that will not damage underlying geomembrane;
• Vehicles are not operated directly on the geonet composite; and
• Excessively deformed end of roll material is cut off and discarded.

7.3.2 Overlap and Seaming

The CQAM or CQA Inspector shall inspect, measure where applicable, and verify the following:

• Adjacent geonet composite rolls are overlapped so that the geonet core is overlapped a minimum of 4 inches and the geotextile overlaps a minimum of 12 inches;
• Geonet overlaps are tied with plastic, non metallic fasteners that are white or yellow in color for inspection purposes;
• Geonet overlaps are tied at 3 ft intervals along longitudinal seams;
• Geonet butt or end seams are not allowed on slopes;
• Geonet butt or end seams are overlapped a minimum of 12 inches and joined with plastic ties every 12 inches;
• Top geotextile layer is overlapped and thermally seamed continuously along the overlap to provide a flat surface.

7.3.3 Repair

The CQAM or CQA Inspector shall visually inspect and verify that any holes, tears or imperfections in the geotextile or geonet are repaired in accordance with the requirements of the Geonet Composite Specification and as follows:

• Geotextile only holes and tears are repaired with an oval or round patch or patch with rounded corners with minimum overlap of 6 inches in all directions from hole or tear;
• Geonet composite rolls placed on a slope with a tear exceeding 10% of the roll width are removed and replaced;
• Geonet only patch is made from the same geonet material that is being repaired;
• Geotextile top surface patch is seamed to the geotextile by thermal seaming methods only and outside edge of patch is thermally seamed flat to the geotextile;
• Verify that the patch cannot be peeled from the geotextile surface by hand;
• Geonet damage must be removed and a section of the same geonet core material cut to replace the removed section. The geonet patch shall be butt fitted and shall be tied to the existing geonet using white or yellow plastic ties spaced 6 inches apart along edge. A geotextile patch shall be placed as above.

The final decision as to the appropriate repair shall be agreed upon between the CQAM and the Installer Subcontractor. Prior to final acceptance of the geonet composite, the
Installer Subcontractor shall locate and repair all damaged areas as directed by the CQAM. The CQAM shall observe all repairs and report any noncompliance to the Construction Site Manager.

7.3.4 Cover Material Placement

During placement of the first overlying lift of select soil cover material, the CQAM shall closely observe placement methods and equipment travel for conformance with the Specifications. Any suspected area damage shall be marked and immediately reported to the Construction Site Manager and Contractor. In particular, the CQAM shall observe and verify the following:

- Geotextile surface area and seams shall be continuous with no open areas (i.e., seam area) that could allow soil intrusion into the geonet. If soil intrusion occurs, area must be cleaned, geotextile repaired and cover material replaced;
- During placement of the overlying soil material, wrinkle development will be minimized and no tensile stress will be allowed to be mobilized in the geonet composite;
- Top edge of Geonet Composite adjacent to retaining walls is securely held in place with sand bags during soil cover placement – remove ballast as soil is compacted in place at the retaining walls.
- Wrinkle formation is minimized and that in all cases wrinkles or waves do not develop in the geomembrane during cover material placement;
- Cover material is placed within 14 days after geonet composite placement and seaming, and;
- Cover material is placed from bottom to top of slope and drop height is restricted to 3.0 ft.

<table>
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<tr>
<th>Property</th>
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<th>Test Frequency</th>
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<td>Geonet Thickness</td>
<td>ASTM D 5199</td>
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<tr>
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<td>GRI GC 7</td>
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SECTION 8
ELECTRICAL LEAK LOCATION SURVEY

This section addresses CQA requirements for the Electrical Leak Location Survey to be conducted as part of the overall CQA plan for the primary geomembrane system. This section outlines the specification requirements for Electrical Leak Location and outlines required CQA responsibilities to be performed by the CQAM and/or authorized representatives. The CQAM shall verify and document in the daily reports that the third party Electrical Leak Location personnel are performing all inspections and testing as outlined herein to assure a quality installation. In addition to documenting daily Electrical Leak Location Survey work, results and observations in the daily report, the CQAM shall also report any deviations directly to the Construction Site Manager. Third party contractor requirements for Electrical Leak Location are reflected in this CQA plan.

8.1 CQA PERSONNEL

A minimum of one CQAM or Authorized Representative shall be on site at all times during the Electrical Leak Location Survey. All CQA personnel representing the CQAM and assigned responsibilities for QA work required by this section shall be familiar with the Electrical Leak Location method being used and shall also be familiar with test interpretation and repair requirements as outlined in this CQA plan.

8.2 ELECTRICAL LEAK LOCATION SURVEY

A geomembrane leak location survey using an electrical method shall be conducted over 100 percent of the primary lining system after installation of the geomembrane lining system and placement of the overlying soil cover material. The electrical leak location survey will be conducted in general accordance with ASTM D 7007 – “Standard Practice for Locating Leaks in Geomembranes Covered with Water or Earth Materials”.

The Electrical Leak Location Survey shall be performed by a geomembrane leak location contractor whose primary business is that of leak location by electrical methods. The Electrical Leak Location Contractor shall demonstrate having requisite experience in successful large scale leak location surveys for geomembranes covered with soil. In particular, the Electrical Leak Location Contractor shall have completed a minimum of 10 projects totaling 20,000,000 sq ft of surveys over geomembranes covered with soil within the previous three years and at least one survey of more than 1,000,000 sq ft. These projects shall be documented by submitting the project names, locations, size, dates completed and contacts for referral by the CQAM.

The CQAM shall review and verify the following information submitted by the Electrical Leak Location Contractor:

- Electrical Leak Location Contractor literature, web site and case histories;
- Electrical Leak Location Contractor submittals for required experience and references;
• Resumes of Electrical Leak Location Contractor principals and personnel that will be assigned this work including experience levels; and
• Proposed Leak Location Survey site layout, site requirements and schedule for completion;
• Quality Control and field calibration procedures.

8.3 ELECTRICAL LEAK LOCATION SURVEY PREPARATION

The CQAM shall coordinate and verify that the entire of completed and soil covered surface is available for the survey work. The area that is to be surveyed should be left exposed on the edges or at the mechanical batten strips to prevent measurement interference from electrical current flowing off the edges of the geomembrane. Mechanical connection can be coated with an approved sealant to isolate the connection from electrical current.

Leaks must have moisture in them during the survey. This is usually accomplished by natural soil moisture, soil moisture after rainfall or by uniformly saturating the soil.

The CQAM shall observe and verify the following:

• Sufficient area is available to the Electrical Leak Location Contractor on a daily basis;
• Geomembrane is electrically isolated at mechanical connections;
• Sufficient supplemental water is available on an as-needed basis for soil moisture.
• Groundwater has saturated the underlying aggregate base and geotextile.

The CQAM shall coordinate the above with the prime contractor and installation subcontractor on a daily basis to ensure completion of the leak location survey in a timely manner.

8.4 PERFORMANCE TESTING

Prior to the start of the Electrical Leak Location Survey, a large scale performance test will be carried out on a section of the completed liner system or on a test pad with geomembrane and cover material in place. This performance test will help determine the accuracy of the leak survey when run over the geomembrane and soil cover material to be installed at the site. In particular, the preparations, operation of the system, and survey parameters shall be verified by performing tests over a known hole placed in the geomembrane. The test parameters and procedures shall be as follows:

• A hole or series of holes of diameter 0.25 inch shall be made in the geomembrane with a drill at locations that are well documented by survey;
• If electrodes are installed under a geomembrane test pad the hole or holes shall be placed the farthest away for worse case position, but at least 50 ft from the edge of the geomembrane;
• The soil cover layer shall be placed in accordance with the general project specifications;
• Leak location measurements shall be made and recorded along closely spaced parallel lines in the vicinity of the test hole or holes. This data is the leak signal plus noise signal. The lines shall be located in an area of at least 40 by 40 ft and centered on the test hole;
• Leak location data shall be recorded and adjusted for noise and sensitivity by the Leak Location Contractor until the measured signals have the characteristics of a leak.
• Based on the data recorded, a leak detection distance shall be verified for the 0.25 inch hole;
• Based on the leak detection distance, the theoretical leak detection sensitivity (hole size) distance shall be calculated for a leak with a diameter of 0.01 inch or maximum leak detection sensitivity (measurements on a 3 x 5 ft nominal grid pattern) and at least 2,500 recorded measurements per acre.

The CQAM shall observe the performance test procedures, method and results and verify the following:

• The performance test and sensitivity of leak detection is satisfactory for the purposes of detecting damage to the geomembrane caused by soil cover layer placement.

8.5 LEAK SURVEY

The leak location data shall be taken on survey lines spaced no farther apart than twice the leak detection distance determined for a 0.01 inch leak as determined in the performance test requirements of paragraph 6.4. The measurement electrode spacing shall be no less than that used for the performance test. The spacing between measurements shall be no more than that used for the performance test.

The Electrical Leak Location Contractor shall record, plot and analyze data for leak signals. The positions of these leak signals shall be located and the leak location excavated. The leaks shall be marked on the geomembrane surface and repaired by the Installation Subcontractor in accordance with the geomembrane repair procedures in Specification Section 02210.

The Electrical Leak Location Contractor shall repeat the survey on the two closest survey lines for a distance extending 25 feet before and beyond the detected leak location. If another signal is detected, this process shall be repeated until no additional leaks are detected.

The CQAM shall observe the leak location survey and verify the following:

• Leak location area is properly identified and marked;
• Leak location area is carefully excavated by hand;
• Leak is visually identified, marked and repaired in accordance with specification requirements;
• Leak is repaired within 24 hours of detection;
• Leak location and repair is noted on the as-built (record drawings);
• Cover soil material is carefully replaced over the excavated leak area.

8.6 LEAK SURVEY REPORTING

The Electrical Leak Location Contractor shall communicate the results of all survey work in the form of a daily summary report to the CQAM. A final report documenting the electrical leak location surveys shall be submitted within 14 days of the completion of the leak survey. The report shall document the methodology used, the locations and descriptions of leaks detected, and a record drawing of the lining system showing the approximate leak locations detected.

The CQAM shall verify the following:

• Daily reports are complete and descriptive as to leaks detected;
• Final report is complete and provided in a timely manner.
SECTION 9
FINAL REPORT DOCUMENTATION

9.0 FINAL CQA REPORT GEOSYNTHETICS

A Final CQA Report will be issued upon completion of the project. The CQAM will be responsible for writing a final report on the CQA activities performed at the site. The final report shall be completed and submitted to the Construction Site Manager no more than 28 days after completion of construction and shall include as a minimum the following information:

- Brief description of the project including facility type, name, location, Owner, Design Engineer, Contractor, Subcontractor Installers, and any other parties involved in the project;
- Detailed description of the VB/I70 Channel Lining Design, surface area, slopes, sections, concrete mechanical connections, geosynthetic materials, base aggregate materials;
- Reference to the CQA P;
- Geosynthetic Manufacturer’s QC documentation;
- Geosynthetic Installer’s QC documentation;
- General record of CQA activities, operations, QA Inspectors, Installers Personnel, etc.;
- Photographic documentation including photographs of the site during phases of construction, construction details and QA operations;
- Copy of all forms, logs and daily reports filled out by CQA Inspection personnel;
- Copy of all field and laboratory test results;
- Discussion of special project problems and solutions;
- Copies of surface acceptance certificates;
- Summaries of construction activities;
- Discussion of any changes from design and material specifications;
- CQA as-built (record) drawings of geomembrane panel layout and seam locations including repair locations; and
- CQA as-built (record) drawings of the Electrical Leak Location Survey.

The CQA final report shall contain a summary statement documenting that CQA was conducted as provided in the CQAP and based on visual observations and data generated in accordance with the CQAP, the VB/I70 Specifications and related features shown on the construction drawings and that the lining system was constructed in accordance with the Technical Specifications, Construction Drawings and the CQAP, except as properly authorized and documented in the CQA final report. The CQA final report shall be signed and sealed by a Professional Engineer registered in Colorado.
APPENDIX A

CONSTRUCTION SCHEDULE
APPENDIX C

CQA FORMS