Appendix 13
Structural Controls Monitoring Plan

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February 24, 2016

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Subject: Structural Controls Monitoring Plan

Dear Ms. Lowe:

This plan describes the monitoring, data management, and reporting efforts associated with the structural controls evaluation program. Data collected via monitoring efforts serves to supplement modelling for a complete effectiveness evaluation of the two selected structural controls. We anticipate two years of monitoring data will be required to conduct a complete effectiveness evaluation.

WinSLAMM (Source Loading and Management Model for Windows) has been selected to evaluate the biofiltration swale/drainage swales at Bogart and the seepage bed at Pen Crossing. The following provides an overview of the modelling approach including a description of the ways in which data collected through monitoring efforts complements the model parameters.

In this application, WinSLAMM uses land use data and estimated influent flow volumes to calculate an influent load in the structural control in the model. The parameters entered in the model representative of control features such as filter media type and level of compaction, dimensions, and capacity, then control the degree to which modeled influent loads are treated inside the structural control. The model produces an effluent load and a pounds/percent reduction value, which will be used to determine the overall effectiveness of each control.

Using Monitoring Data

Because of the variability in stormwater pollutant loading attributable to climate and drainage area characteristics and activities that influence runoff volumes and pollutant accumulation rates between events, it is important to perform a quality control check or "ground truth" influent pollutant concentrations as well as influent volumes associated with various storms.

WinSLAMM calculates influent concentrations and volumes by accounting for the various "sources" within the catchment area of the structural control. Each source area (i.e., roadways, rooftops, sidewalks, lawns, etc.) has a unique runoff coefficient and potential pollutant load. The runoff coefficients and loads are influenced by the length of periods of accumulation (dry) and wash-off (rain events). During dry periods, pollutants are assumed to be accumulating in the drainage area. Then, during rain events a certain amount of the accumulated pollutants are washed off of these source areas and discharged through the structural control. The pollutant load in wash-off is derived from the intensity (a function of depth and duration) of each event and the amount of accumulation (a function of land use type, duration of dry period, and season) prior to the event.

Model defaults assume a specific amount of runoff from each source area based on geography, degree of connectedness input by the user, slope, and soil type (infiltration capacity). Continuous flow monitoring allows the user to validate the flow volumes estimated in the model by comparing estimated flow volumes with measured flow volumes. The model-calculated flow volumes can then be calibrated by adjusting the model default values and evaluating connectivity assumptions from each source.

Once flow volumes are calibrated and sufficient water quality data is available from Pen Crossing, sample results can be used to evaluate confidence in modeled influent concentrations. If monitored event mean concentrations are outside of expected values when compared to model results for the same storms, the drainage area source loads can be evaluated on a source by source basis to identify discrepancies. Where appropriate, the WinSLAMM parameter files will be revised until the modeled results more closely match the monitored data. Any adjustments made to the model to more accurately depict source loading at Pen Crossing can be carried through to influent loading estimates for Bogart.

Model Runs and Effectiveness Evaluation

Once the model is set up for each of the structural controls and their respective drainage areas, the model can be run to provide results for various conditions for each site. Sensitivity analyses can be conducted to identify the degree of control various factors exert on modeled responses. Variations in design criteria (i.e., comparing multiple iterations of Ada County Highway District design guidelines to as-built conditions) and comparing responses such as wetting front depths and residence time under varying rainfall intensities and temperatures can aid in determining boundary conditions for effectiveness. This analysis also helps to determine which design parameters have a higher degree of control on treatment effectiveness. For each modeled condition, summary results can be reported by the month, season, year, or on an event-by-event basis. Each type of summary report provides a different level of resolution for identifying the reduction of loads between influent and effluent and further effectiveness evaluation.

Very truly yours,

Brown and Caldwell

Andy Weigel, Project Manager

Structural Controls Monitoring Plan

Prepared for
Ada County Highway District
Boise, Idaho
February 24, 2016

Structural Controls Monitoring Plan

Prepared for

Ada County Highway District Boise, Idaho

February 24, 2016

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List of Abbreviations

ACHD	Ada County Highway District
AV	area velocity
BC	Brown and Caldwell
BMP	best management practices
CFR	Code of Federal Regulations
COC	chain of custody
cfs	cubic feet per second
DQI	data quality indicator
DQO	data quality objective
EPA	Environmental Protection Agency
LDPE	low density polyethylene
mg/L	milligrams per liter
MDL	method detection limit
NH3	ammonia
NO2	nitrite
NO3	nitrate
NPDES	National Pollutant Discharge Elimination System
NWS	National Weather Service
PMEP	Project Monitoring and Evaluation Plan
PRDL	project required detection limit
QA/QC	quality assurance/quality control
QAPP	Quality Assurance Program Plan
RPD	relative percent difference
TKN	total Kjeldahl nitrogen
TM	technical memorandum
TSS	total suspended solids
WINSLAMM	Source Loading and Management Model for Windows
WQL	Boise City Water Quality Laboratory

Executive Summary

The National Pollutant Discharge Elimination System Phase I Permit No. IDS-027561 (Permit) was issued effective February 1, 2013, to Ada County Highway District (ACHD), Boise State University, City of Boise, City of Garden City, Drainage District #3, and the Idaho Transportation Department District #3, referred to as the "Permittees." Under this permit, the Permittees are required to update the existing storm water permit monitoring plan to be consistent with the monitoring and evaluation program objectives as described in Permit Part IV.A.2

The two permanent stormwater controls that ACHD has chosen to evaluate are a biofiltration swale and a seepage bed; both are listed under ACHD's approved best management practices, numbers 07 and 04, respectively in Section 8200 of the *ACHD Design and Policy Manual* (revised April 9, 2014). Prior to selecting sites for evaluation and developing this monitoring plan, Brown and Caldwell (BC) conducted a review of ACHD's design standards for biofiltration swales and seepage beds in order to identify and account for factors that may limit effectiveness of the control measure as designed. The information was compiled in a technical memorandum entitled *Structural Controls Context Review* (BC, 2014).

Major factors identified in the *Structural Controls Context Review* include infiltration rates of native soils, filtration media used in the structural controls, drawdown time, maintenance practices, sizing and anticipated runoff volumes into the control, and separation to groundwater. These factors were used to guide the selection of several potential sites for evaluation under this program. Candidate sites were then further evaluated to determine which two sites best fit the goals of the program, could be modeled and fitted with specific monitoring equipment, and provided the lowest potential for interference in the effectiveness evaluation process. Bogart was chosen for the biofiltration swale and Pen Crossing for the seepage bed.

A combination of monitoring and modeling efforts will be used to evaluate the effectiveness of the structural controls described in this plan. Monitoring will be used to collect information about precipitation for both sites. Influent stormwater runoff at the Pen Crossing seepage bed site will be monitored for water quality and runoff volume. Effluent data at both sites, and influent data at the Bogart biofiltration swale, will be modeled using WinSLAMM (Source Loading and Management Model for Windows).

This Structural Controls Monitoring Plan has been developed in line with guidance provided in the *Project Monitoring and Evaluation Plan* (ACHD, 2013) and the *Quality Assurance Program Plan for NPDES Storm Water Permit Monitoring* (ACHD, 2014).

Section 1

Introduction

The National Pollutant Discharge Elimination System (NPDES) Phase I Permit No. IDS-027561 (Permit) was issued effective February 1, 2013, to Ada County Highway District (ACHD), Boise State University, City of Boise, City of Garden City, Drainage District #3, and the Idaho Transportation Department District #3, referred to as the "Permittees." The Permit requires that the Structural Controls Monitoring Plan be consistent with the monitoring and evaluation program objectives and plan as described in Permit Part IV.A.2. These objectives are described in the *Project Monitoring and Evaluation Plan* (PMEP). Additional Permit requirements specific to structural controls monitoring include the following:

- Evaluate at least two different types of permanent structural stormwater management controls currently mandated by the Permittees at new development and redevelopment sites.
- For each selected control, the evaluation must determine whether the control is effectively treating or preventing the discharge of the pollutants of concern into waterbodies listed in Permit Table II.C, which includes segments of the Boise River, Fivemile Creek, and Tenmile Creek.
- Results of the evaluation must be submitted to the Environmental Protection Agency (EPA) in subsequent annual reports as the evaluation projects are implemented and completed.

The two permanent stormwater controls that ACHD has chosen to evaluate are a biofiltration swale and a seepage bed; both are listed under ACHD's approved best management practices (BMPs) numbers 07 and 04, respectively, in Section 8200 of the *ACHD Design and Policy Manual* (revised April 9, 2014). The data acquisition approach chosen for the seepage bed is a combination of influent flow and water quality monitoring and effluent modeling. Evaluation of the biofiltration swale will be a modeling effort for influent and effluent.

In addition to the basic specific permit requirements, ACHD is taking a more comprehensive approach to evaluating these facilities. The effectiveness evaluation will also consider the following additional permit requirements from Permit Part IV.A.2.a:

- Broadly estimate reductions in annual pollutant loads of sediment, bacteria, phosphorus, and temperature discharged to impaired receiving waters from the Municipal Separate Storm Sewer Systems.
- Assess the effectiveness and adequacy of permanent stormwater controls and low impact development techniques or controls selected for evaluation by the Permittees which are intended to reduce the total volume of stormwater discharging from impervious surfaces and/or improve overall pollutant reduction in stormwater discharges.
- Identify and prioritize those portions of the permit area where additional controls can be accomplished to further reduce the total volume of stormwater discharges and/or reduce pollutants in stormwater discharges to waters of the U.S.

1.1 Structural Controls Monitoring and Objectives

Under the guidance presented in the PMEP, the Structural Controls Monitoring Plan is designed to address the minimum permit requirements for evaluating effectiveness of structural controls as listed in Permit Part IV.A, as well as meet the level of service goals identified in the PMEP. This monitoring plan serves as guidance for data acquisition and management as well as reporting efforts undertaken by the Permittees.

This document outlines the approach to structural controls monitoring as well as modeling and includes specific *Quality Assurance Program Plan* (QAPP) elements recommended by the EPA. EPA-recommended QAPP elements are addressed as either program elements or monitoring plan elements.

Monitoring plan elements are described in full in this document, while program elements are addressed in the QAPP. Monitoring plan elements are those components that contain details specific to each monitoring plan. Plan organization, responsibilities, and objectives are derived from the PMEP, which serves as guidance to standardize stormwater management under this Permit as a whole, including the approach to quality assurance and monitoring plan implementation. Program elements consist of the standardized monitoring components that all individual monitoring plans developed under the Permit reference. A list of program and monitoring plan elements is included in Table 1-1.

Table 1-1. QAPP Element Document Reference

EPA Recommended QAPP Elements	QAPP Element	Structural Controls Monitoring Plan Element; Section
Group A: Project Management		
A1 – Title and Approval Sheet	X	
A2 – Table of Contents	X	
A3 – Distribution List	X	
A4a – Project Organization	X	
A4b – Task Organization		X; 1.3
A5 – Problem Definition/Background	X	
A6 – Project/Task Description		X; 1.2
A7a – Quality Objectives and Criteria for Measurement Data	X	
A7b – Method Dependent Criteria for Measurement Data		X; 6.2
A8 – Special Training Needs/Certification	X	
A9 – Documents and Records	X	
Group B: Data Generation and Acquisition		
B1 – Sampling Process and Design		X; 2
B2 – Sampling Methods		X; 3, 4, 5
B3 – Sample Handling and Custody		X; 4.6, 4.7
B4 – Analytical Methods		X; 4.2
B5a – Quality Control	X	
B5b – QA/QC Sampling Schedule		X; 6.1
B6 – Instrument/Equipment Testing, Inspection, and Maintenance		X; 3
B7 – Instrument/Equipment Calibration and Frequency		X; 3
B8 – Inspection/Acceptance of Supplies and Consumables	X	
B9 – Non-direct Measurements	X	
B10 – Data Management	X	

Table 1-1. QAPP Element Document Reference		
EPA Recommended QAPP Elements	QAPP Element	Structural Controls Monitoring Plan Element; Section
Group C: Assessment and Oversight		
C1 – Assessments and Response Actions	X	
C2 – Reports to Management	X	
Group D: Data Validation and Usability		
D1 – Data Review, Verification, and Validation	X	
D2 – Verification and Validation Methods	X	
D3 – Reconciliation and User Requirements	X	

1.2 Task Organization

ACHD is the lead agency for monitoring efforts under the Permit, and a consultant team is responsible for assisting with the monitoring program and modeling efforts. Key roles and job functions are described in the QAPP. The structural controls monitoring and evaluation program organization chart is presented in Figure 1-1.

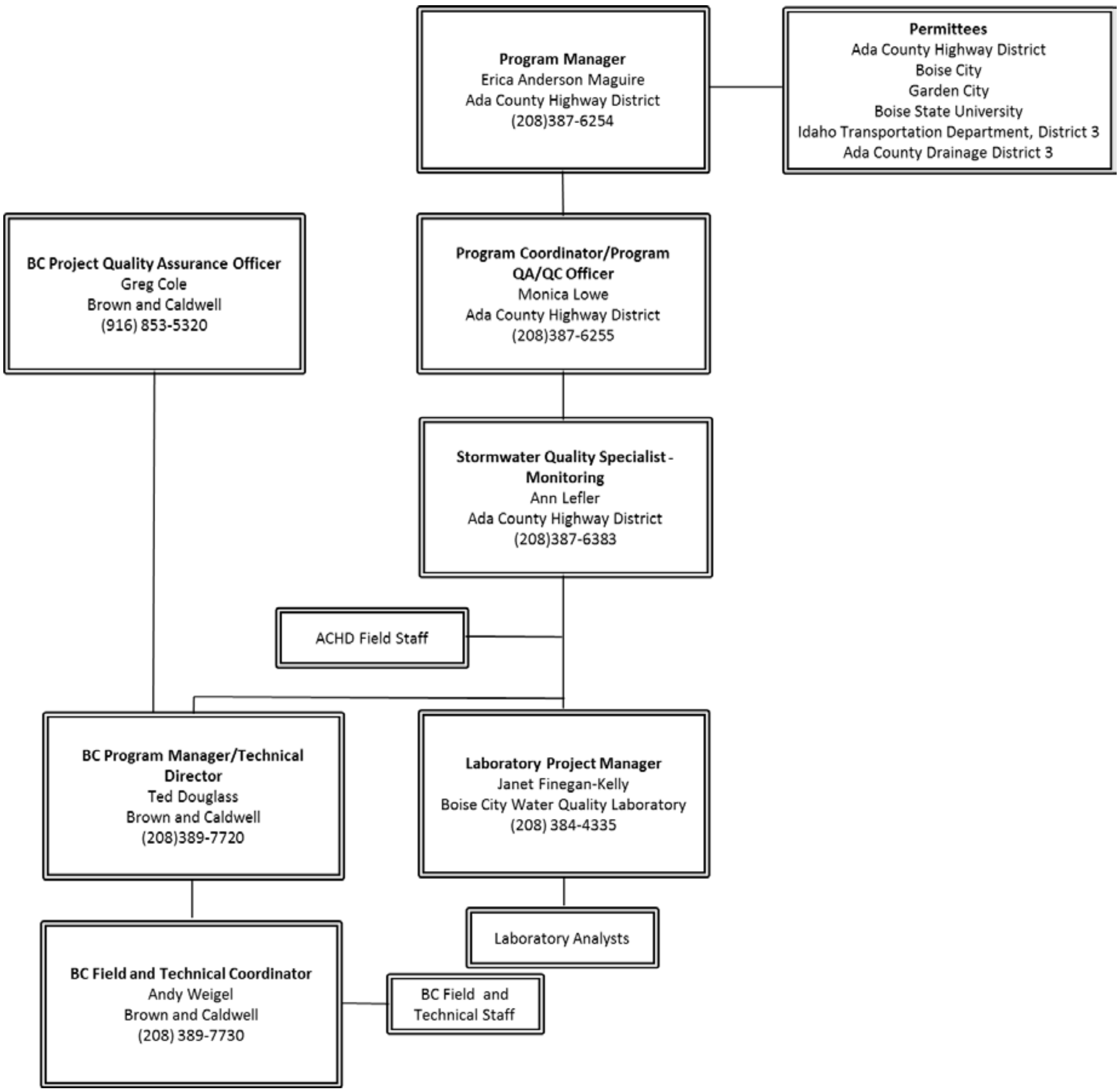

Figure 1-1. Structural controls monitoring organization chart

Section 2

Sampling Process Design

The sampling process design for this project consists of both monitoring and modeling efforts. Monitoring will be used to collect information about precipitation for both the Bogart Biofiltration Swale and Pen Crossing Seepage Bed sites. Influent stormwater runoff at the Pen Crossing site will be monitored for water quality and runoff volume. Effluent data at both sites and influent data at the Bogart site will be modeled using WinSLAMM (Source Loading and Management Model for Windows). Section 2.1 provides an overview of the methods used to obtain monitoring data as well as modeling inputs and outputs. Monitoring detail is provided in Sections 3 and 4. Appendix A includes a description of the modeling approach.

The process ACHD used for selecting monitoring sites is outlined in Section 2.2. Detailed site description information is included in Section 2.3. Section 2.4 describes the design and siting of each structural control.

2.1 Data Collection Overview

Monitoring data will be collected at the Pen Crossing site only and includes flow, rain, and water quality data. Additional data used as inputs for the modeling portion are based on construction details, soil conditions, and land cover for each site. The general approach to data collection and organization is described in Sections 2.1.1 and 2.1.2.

2.1.1 Pen Crossing Monitoring Data Collection Overview

Data collection at the Pen Crossing monitoring station will be facilitated by a combination of automated sampling, measurement equipment and manual observation, and characterization activities. Automated sampling equipment includes a flow module with an area velocity (AV) sensor installed in the inlet pipe to the sand and grease trap installed in front of the seepage bed. The flow module is attached to an interface module that serves as the primary device for monitoring. The flow module will continuously monitor and record all wet and dry weather discharges in addition to the targeted monitoring events.

The automatic sampler is triggered to collect a flow-weighted composite sample based on data recorded on the flow module. Throughout a sampling event, the sampler initiates pumping at a pre-programmed runoff volume interval (described in Section 4.4) in order to collect a representative composite sample of the stormwater discharge. The composite sample will be submitted to the City of Boise Water Quality Laboratory (WQL) where laboratory analysts will split the sample for analysis of individual constituent concentrations.

The Pen Crossing site is associated with a rain gauge installed near the monitoring station and connected to the interface module. The rain gauge collects precipitation data for use in conjunction with sampling and flow data for analysis and quality assurance. Additionally, forecasts, weather, and hourly precipitation data for the weather station located at the Boise Airport are available from the National Weather Service (NWS) at http://www.crh.noaa.gov/data/obhistory/KBOI.html.

Data recorded on the flow module, automatic sampler, and rain gauge can be retrieved through the interface module, which allows remote access to stored data through Isco's Flowlink software. Monitoring equipment operation and maintenance descriptions are included in Section 3. Information specific to water quality samples including analytical methods is included in Section 4.

2.1.2 Modeling Data Collection Overview

Modeling will be conducted for influent characteristics and effluent loads at both sites. Appendix A provides details of the inputs and modeling processes as they relate to each site. Basic inputs needed for modeling influent data include drainage area delineation, surface coverage, soil types, local precipitation data (from site specific rain gauges described in Section 3), and in the case of Pen Crossing, measured runoff volume and constituent concentrations from sampling events.

Basic inputs needed for effluent modeling include influent concentrations, design specifications for each structural control including dimensions, filter media, native soil infiltration rates, and in the case of the Bogart biofiltration swale, vegetation height. Structural controls design is discussed in further detail in Section 2.3.

2.2 Site Selection

In November 2014, Brown and Caldwell (BC) conducted a review of ACHD's design standards for swales and seepage beds in order to identify and account for factors that may limit effectiveness of the control measure as designed. The information was compiled in a technical memorandum (TM) entitled *Structural Controls Context Review* (BC, 2014), included as Appendix B. The TM was developed to provide a better understanding of the context of the factors that may impact evaluated removal efficiencies, infiltration rates, and the overall effectiveness of each structural control. This review included a comparison of design criteria, site suitability, and maintenance requirements and considerations outlined in ACHD's Policy Manual Sections 8000 and 8200 (ACHD, 2011) with regional and national standards for these two structural controls. This TM serves as a framework to evaluate and identify specific performance metrics for each structural control.

Major factors identified included infiltration rates of native soils, filtration media used in the structural controls, drawdown time, maintenance practices, sizing and anticipated runoff volumes into the control, and separation to groundwater. These factors were used to guide selection of several potential sites for evaluation under this program. Candidate sites were then further evaluated to determine which two sites best fit the goals of the program, could be modeled and fitted with specific monitoring equipment, and provide the lowest potential for interference in the effectiveness evaluation process as described above.

BC developed a controls selection matrix to aid ACHD in organizing available site options and comparing site conditions side-by-side. The evaluation criteria included in the matrix was based on the considerations identified in the Structural Controls Context Review TM and the critical components needed to meet permit requirements and objectives outlined in Section 1. The completed site selection matrix is shown in Appendix C.

2.3 Structural Control Design

All infiltration BMPs are required to be installed with at least a 3-foot separation from groundwater. If this separation is not achievable, an impervious liner sloping to an outfall is required, or a variance can be requested, which initiates further review by ACHD (ACHD, 2011). The two types of infiltration BMPs selected are designed with infiltration time targets (seepage beds) or residence time targets (biofiltration swales) to efficiently collect and treat stormwater runoff from up to a 100-year design storm of 1-hour duration. This design provides water quality benefit through filtration, diverting stormwater runoff through the structural control to groundwater as opposed to discharging directly to surface water. Design drawings and specifications are included in Appendix D.

Seepage Beds

Seepage beds are designed to infiltrate stormwater through a trench backfilled with ¾- to 2-inch drain rock. Stormwater enters the trench through a perforated pipe. Void volumes between 30 and 40 percent are required in the drain rock depending on the material type. A layer of filter sand 1.5 feet thick is required underneath the drain rock. Seepage beds are designed to infiltrate 90 percent of the 100-year design storm within 24 hours. They are required to include a pretreatment forebay to settle out some of the larger particles transported by the runoff prior to entry into the perforated pipe. Sand and grease traps are the most common pretreatment used by ACHD.

Pen Crossing Seepage Bed

The seepage bed installed at Pen Crossing was designed in November 2012 but closely follows the specifications of ACHD's BMP 04 from the *ACHD Design and Policy Manual*, Section 8202.14, (Revised April 9, 2014). Seepage bed design was modified slightly in the most recent revisions to the *Design and Policy Manual* adopted on October 14, 2015. Actual installed conditions as well as changes to the design can be represented in the model by adjusting the structural control input parameters. Additional model runs may be conducted to evaluate effectiveness under the new design requirements.

Biofiltration Swales

Typical biofiltration swales are designed to accommodate infiltration of stormwater and uptake by plants, and consist of a vegetated open channel with a longitudinal slope of no more than 1 percent. An outlet is optional under ACHD's design standards. ACHD's swale design consists of a swale bottom constructed with a filter media of 50 percent coarse sand, 20 percent sandy loam, 30 percent compost, and less than 10 percent fines passing a #200 sieve. Swale capacity design focuses on residence time of water flowing through the swale, with a target residence time of 9 minutes. Design drawings and specifications are included in Appendix D.

Bogart Biofiltration Swale

The design in 2005 of the biofiltration swale installed at Bogart includes elements of ACHD design guidance adopted in 2004 for roadside infiltration swales as well as specifications of ACHD's BMP 07 Biofiltration Swale from the *ACHD Design and Policy Manual*, Section 8202.17 (revised April 9, 2014). The October 14, 2015, revision to the *Design and Policy Manual* does not include biofiltration swales, and instead lists a bioretention swale and a treatment and conveyance swale. Of the two new options, the installation at Bogart more closely resembles the design of the conveyance/treatment swale. As with the seepage beds, actual installed conditions as well as changes to the design can be represented in the model by adjusting the structural control input parameters. Additional model runs may be conducted to evaluate effectiveness under the new design requirements.

2.4 Site Descriptions

Both of the selected structural controls sites are located in residential subdivisions constructed in 2006 (Bogart) and 2014 (Pen Crossing). The seepage bed selected for the structural controls monitoring program is located in southeast Boise in the River Heights subdivision. The seepage bed is installed below grade in the right-of-way on Pen Crossing Street. Additional site-specific information is included in Table 2-1. Figure 1 is a vicinity map showing the locations of the sites. Figures 2 and 3 provide a detailed map of the drainage area for the Pen Crossing site and the Bogart site, respectively and include an overlay of the ground surface types in each drainage area that will be used to support modeling efforts. Figure 4 includes pictures of Pen Crossing and Figure 5 shows Bogart.

Table 2-1. Site Information		
Site Information	Pen Crossing (Site ID: 17)	Bogart (Site ID: NA)
Location	south side of East Pen Crossing Street (Southeast Boise)	east side of North Bogart Lane just north of West Utahna Street (northwest Boise)
Construction Date	2014	2006
Subwatershed area	2.46 acre	1.03 acre
Total impervious area	1.26 acre	0.63 acre
Effective impervious area (approximate)	0.68 acre[1]	0.36 acre[2]
Receiving water	infiltration to groundwater	infiltration to groundwater and overflow to Eagle Drain
Rain gauge location	Pen Crossing 5 feet southeast of inlet pipe	Edgewood, Cynthia Mann
Rain gauge distance from station	10 feet	Edgewood: 2.1 miles west/northwest
Inlet construction	12 inch PVC	Modified curb cut inlet

[1] *Runoff from rooftops and sidewalks in the drainage area is directed into French drains installed underneath driveways or in landscaped/lawn areas.*

[2] *The majority of runoff from rooftops in the drainage area is directed to landscaped/lawn areas.*

Section 3

Monitoring Equipment

Monitoring equipment in use at the Pen Crossing site includes a modem module, flow module, sampler, and rain gauge. The flow module, modem, and automatic sampler are installed in a secured and locked traffic enclosure near the inlet pipe to the seepage bed. Section 3 provides a detailed description of each piece of equipment installed at the Pen Crossing monitoring station along with a discussion of the rain gauges that will be used for reference for the Bogart Site. Figure 6 provides a schematic of the monitoring equipment setup at Pen Crossing.

3.1 Interface Module

An Isco 2105ci interface module is installed in a stack connection with the flow module and linked to the sampler and rain gauge by a communication cable. The interface module serves as the primary device for monitoring. The interface module includes a built-in cell phone modem, which facilitates a remote connection to the site using Isco's Flowlink software. The Flowlink software is used to program and download data from the Isco equipment and can also receive pushed data at a preprogrammed interval frequency. Programming and data retrieval can be accomplished via modem connection or direct cable connection to each individual piece of monitoring equipment or through the interface module.

3.2 Flow Module

The Isco 2150 Area Velocity Flow Module measures liquid level and average stream velocity and calculates the flow rate and total flow. The water level and velocity measurements are read from an AV sensor that is situated in the inlet pipe to the sand and grease trap. The sensor is attached to the flow module via a cable and is secured in the inlet pipe on a spring ring. Flow rate and total flow calculations are performed by the flow module using the measured parameters from the AV sensor. These flow calculations are used to trigger sampler pacing during composite sample collection activities.

The AV sensor measures level using a pressure transducer inside the sensor. Velocity is measured using ultrasonic waves produced by transducers within the sensor to measure wave reflections off of particles and air bubbles suspended in the flow. Additionally the flow calculation software on the flow module constantly recalibrates its interpretation of the signals received by the AV sensor to obtain more accurate readings. To compensate for low-flow conditions, the flow module uses velocity data collected when the water level is greater than 1 inch to interpolate velocities when the water level drops below 1 inch. This interpolation is also constantly adjusted by the flow module.

3.3 Automatic Sampler

Composite sample collection is accomplished using an Isco 6712 Portable Sampler. Sample aliquots are pumped by a peristaltic pump from the inlet pipe to a 15-liter low density polyethylene (LDPE) carboy contained in the base of the sampler. For each sampling event, the automatic sampler will be programmed to collect samples based upon flow-paced signals recorded by the flow module and relayed through the interface module via a control cable. The sampler collects one sample for each signal from the flowmeter. Sample aliquot volumes are programmed and calibrated to produce a flow-weighted composite sample of the storm event discharge consisting of a targeted 16 subsamples. A record of the sampler's operations (e.g., execution data and sample times) is stored on the hard drive of both the sampler and the flow module and may be accessed and downloaded through the interface module or direct connection to the sampler or flow module at any time.

3.4 Rain Gauges

Rain gauges are installed to collect continuous precipitation data throughout the year. The program uses tipping-bucket style rain gauges that measure rainfall depths in 0.01-inch increments. The Pen Crossing site is equipped with an Isco 674 Rain Gauge that is mounted on a pole next to the equipment enclosure and is connected via a cable connection to the interface module. An existing Global Water rain gauge equipped with dual Hobo loggers at ACHD’s Edgewood NPDES Phase II monitoring sites will serve as the reference gauge for the Bogart Site. This rain gauge is located approximately two miles west-northwest of the Bogart Site.

3.5 Equipment Maintenance

Equipment maintenance will be conducted once each spring and fall. Maintenance activities conducted during the spring and fall include cleaning the AV sensor and sampler intake strainer, checking all connections and desiccants, and synchronizing clocks on all instrument modules. Rain gauges will also be checked and cleaned as needed during maintenance events. Sampler intake and pump tubing will be changed during fall maintenance each year. Equipment blank and rinsate blank samples will be collected during maintenance as described in Section 6.1. An example maintenance checklist is included in Appendix E.

Section 4

Sampling Procedures

4.1 Analytical Sample Collection Frequency

The Permit does not specify a minimum frequency for sampling events. However, a minimum of six data points are recommended for inclusion of monitoring results in the modeling analysis. Therefore, a minimum of six successful events will be targeted over the next two years to meet data sufficiency goals for the effectiveness evaluation. Attempts will be made to separate sampling events by a minimum of 30 days in order to represent seasonal variability.

4.2 Stormwater Parameter Analysis

The constituents and analytical methods planned for use in this monitoring program are presented in Table 4-1 below. The constituents to be monitored are those included in the stormwater outfall monitoring program that are treated by the structural controls being evaluated in this program. The NPDES Permit requires that "sample collection, preservation, and analysis must be conducted according to sufficiently sensitive methods/test procedures approved under 40 Code of Federal Regulations [CFR] Part 136, unless otherwise approved by EPA. Where an approved 40 CFR Part 136 method does not exist, and other test procedures have not been specified, any available method may be used after approval from EPA." As such, the methods identified below are the selected and preferred options. However, sample, laboratory, or instrument conditions may require the substitution of an alternate Part 136 method.

Table 4-1. Analytical Methods for Stormwater Constituents

Constituent	Analytical Method
Total Phosphorus[1]	EPA 200.7
Dissolved orthophosphate	EPA 365.1
Total suspended solids (TSS)[1]	SM 2540 D
Ammonia (NH3)	SM 4500 NH3-D
Total Kjeldahl nitrogen (TKN)	Perstorp PAI-DK01
Nitrite plus nitrate (NO2+NO3)	EPA 353.2
Arsenic – total	EPA 200.7
Cadmium – total and dissolved	EPA 200.7
Copper – dissolved	EPA 200.7
Lead – total and dissolved	EPA 200.7
Mercury – total	EPA 245.2
Zinc – dissolved	EPA 200.7
Flow/discharge volume	Non Specific
Precipitation	Non Specific

[1] *Permit-listed pollutant of concern.*

4.3 Weather Forecast and Storm Selection

When possible, monitoring under this program will be conducted concurrently with monitoring under the stormwater outfall monitoring programs. The forecasting and storm selection procedures will follow those outlined under the stormwater outfall monitoring program as closely as possible. The stormwater specialist (or designee) will obtain up-to-date information on a storm's anticipated physical characteristics from the NWS. Information obtained for each forecast will include the probability of precipitation, the expected amount of precipitation, and the expected arrival time of the storm. Weather forecasts and information will ordinarily be obtained via the Internet and supplemented as needed by telephone conversations with the NWS meteorologist on duty. The stormwater specialist will review weather forecasts on a daily basis and compare them with the established storm selection criteria to determine the likelihood of initiating stormwater sampling.

ACHD will use the following criteria to assist in decision making for selecting forecasted storms to target under typical conditions:

- 70 percent or greater probability of precipitation forecasted
- Quantitative precipitation forecast predicted precipitation of greater than 0.10 inch in a 12-hour period
- Event separated by a minimum of 72 hours of dry weather from the previous measurable storm event (rainfall greater than 0.10 inch)
- At least 30 day separation from the previous sampling event

Criteria for snow conditions include the following:

- Forecasted precipitation in the form of snowfall will be evaluated in the context of the greater weather forecast to determine the likelihood of runoff occurring at the outfall.
- Though snowmelt is considered stormwater runoff, sampling events will not be initiated for collection of runoff from snowmelt alone when criteria for a representative storm are not forecasted to be met.

These criteria represent the general approach to storm event targeting used for this program. Ultimately, the stormwater specialist will use these criteria in conjunction with additional forecast information, sampling program and staffing requirements, and other factors to make the decision to target any particular storm.

The ACHD Stormwater Quality Division will communicate the sampling status to the consultant field coordinator on a daily basis by means of the Sampling Event Communication Form (included in Appendix E). The Sampling Event Communication Form will also be sent to laboratory project personnel and ACHD field sampling staff.

If storm selection criteria appear to be met, the stormwater specialist will confer with the program coordinator and consultant field coordinator. If both parties agree, the consultant field coordinator will initiate storm event preparation as described in Section 4.4.

Since there are no specific monitoring requirements identified in the permit for structural controls monitoring, ACHD has the flexibility to adjust the monitoring requirements as needed to collect samples for this program. ACHD and its monitoring consultant will confer when these requirements are adjusted for this program.

4.4 Monitoring Station Set-up

The consultant field coordinator will generally be responsible for preparing the flowmeter and automatic sampler at the Pen Crossing monitoring station prior to a sampling event. Setup procedures are outlined on Form 2A (Appendix E). Because of the timing of the storm events (often after sunset and before sunrise), setup can occur outside of business hours and on the weekends. In these instances setup will be conducted by two trained staff in order to support health and safety objectives.

The stormwater specialist or designee will ensure that adequate supplies are available for sampling and notify the laboratory of the possible sampling event.

Monitoring station set-up activities include the following:

- flushing the sampler intake line with a dilute hydrochloric acid solution
- replacing the silicone discharge tubing
- checking the condition of the sampler and modules
- inspecting electrical and tubing connections for tightness
- installing recharged batteries
- freeing sampler tubing of twists, pinches, or cracks and replacing if needed
- loading bottles and ice for the automatic sampler
- programming the sampler and flowmeter
- initiating the sampling program
- recording setup information on field data sheets

Runoff Coefficient and Trigger Volume

In order to collect a flow-weighted composite sample throughout a storm, an estimate will be calculated for the runoff volume expected from the storm event. The expected runoff volume will be divided by the planned number of sample aliquots, and the resulting value will be used as the trigger volume for programming the flowmeter. The trigger volume is the amount of flow that will be measured before the automatic sampler is triggered to collect a subsample. Therefore, the number of samples collected over the course of a storm is a result of the runoff volume expected for the total storm as forecasted at the time of station setup.

Calculating the total estimated runoff is a function of the weighted rainfall amount expected and the site-specific runoff coefficient. Precipitation amounts are weighted by multiplying the predicted rainfall amount by the probability of precipitation as forecasted by the NWS. The site-specific runoff coefficient is derived from the percentage of impervious ground cover in the subwatershed and will be refined by empirical values from observed storm data.

The variability in the size, duration, and intensity of a storm, along with variability within the drainage area including soil moisture, temperature, snow cover, and a multitude of other smaller variables, all contribute to the actual volume of runoff discharged. Actual runoff volumes recorded during storms will be used to refine the runoff coefficient between events and over the course of the program to more accurately predict runoff and produce trigger volumes that will more consistently result in composite samples of adequate volume and that are representative of the storm.

4.5 Sample Collection

During a targeted storm, consultant and field staff can monitor progress of composite sample collection progress remotely via the modem connection or mobilize to the monitoring station and connect directly to the monitoring equipment. During station setup, the sampler will be programmed for an event-specific trigger volume. When the flow module records the trigger volume amount, the integrated peristaltic pump on the automatic sampler engages and draws a sample through the tubing installed in the invert of the pipe discharging into the first chamber of the sand and grease trap. The sample aliquot is pumped into the composite sample bottle secured in the sampler base. If automatic compositing of samples is not possible because of issues with equipment or other difficulties, manual composites may be collected. Procedures for manual composite sample collection are listed in Appendix F.

The sampler program will end automatically after the last programmed subsample has been collected (typical target of 24 subsamples). Collection date, time, and sample identification will be recorded on sample containers immediately following collection of the sample container. Collection date, time, and other observations will be recorded on a Setup/Shutdown Checklist and Composite/Large Volume Sample Information form (Appendix E – Forms 2A and 2B).

Variability between expected runoff amounts and measured runoff amounts are common. In order to increase the probability of collecting a representative sample, a conservative approach to setting up the composite sampler is used. The minimum volume required by the WQL to run the analyses identified in Table 4.1 is 8 liters. In order to collect a representative composite sample, the sampler is programmed to collect 24 aliquots at 625 milliliters per aliquot. This will provide a minimum of 16 subsamples with a conservative estimate of forecasted rainfall. This will also provide additional capacity to collect up to 8 more aliquots in the event the intensity and duration of the storm is more than expected.

4.6 Sample Handling Procedures

When collected and analyzed individually, the targeted constituents have varying holding time requirements. However, as a composite sample collected in an LDPE carboy has a holding time of 48 hours. Preservation techniques in the field are limited to cooling samples to a target sample temperature of less than 6°C but above freezing. Five to ten pounds of food-grade ice will be placed in the base of the automatic sampler during station setup. Sufficient ice will also be placed in coolers used for sample transport to maintain the samples at a maximum temperature of 6°C.

No chemical preservation measures are required in the sample collection process. WQL will add chemical preservatives after the composite samples are split as necessary for analysis, e.g., metals analysis. Current regulations under the EPA Method Rule Update issued on May 18, 2012, require that samples collected for the analysis of dissolved metals including dissolved orthophosphate be filtered within 15 minutes of collecting a grab sample or the last subsample of a composite sample.

WQL has committed to splitting the composite and filtering the dissolved metals samples at the time of submission to the laboratory when they are submitted during normal business hours and within 24 hours when samples are submitted after hours. Samples filtered within the 24 hour timeframe will not be qualified as estimates in the context of the program-established data quality objectives discussed in Section 5.2. In the event that filtration is not accomplished within 24 hours of collection, results will be rejected.

4.7 Chain of Custody (COC) Procedures

A standard COC form, shown in Appendix E, will be completed prior to submitting samples to the laboratory. Information recorded on the COC includes the following:

- sample collection team member names
- sample identification
- sample type (composite)
- analyses requested
- start and stop times
- sample start and end date

A sample is considered to be “in custody” if authorized personnel have it in actual physical possession or in a secured area that is restricted to authorized personnel. Such areas include laboratory refrigerators, the monitoring shed at ACHD, ACHD and consultant office space, and ACHD and consultant vehicles. Automatic sampling equipment at Pen Crossing is installed in a locking enclosure. All transfers of custody will be recorded by signature, date, and time by both the individual relinquishing custody and the one receiving custody. This information is placed in the designated area on the bottom of standard COC forms.

Samples may be stored overnight (in coolers with ice) at the ACHD monitoring shed or offices while awaiting quantitative analysis. The COC forms must be reviewed and signed by at least one of the persons who collected the samples listed on the COC form. The COC forms will be delivered to the laboratory with the samples.

If samples are submitted to the laboratory during business hours, samples are relinquished to laboratory personnel in person for immediate receipt with signature, date, and time. ACHD has after-hour access to the laboratory to accommodate sample submittal. When sample delivery occurs after hours, the samples are stored in coolers and packed with ice. The team delivering the samples will notify a laboratory representative that the samples have been dropped off and the time the samples were collected. A signed COC form will be left in the locked laboratory for morning receipt by laboratory personnel.

Analytical samples will be named according to the three level naming convention used throughout the monitoring program. The naming convention includes the date of station setup, the monitoring station number, and the sample type in the form “YYMMDD”-“monitoring station number”-“sample type.” The example sample ID 150324-17-WC would represent a wet weather composite sample collected at the Pen Crossing monitoring station on March 24, 2015.

The sample types anticipated for use in this monitoring program include the following:

- WC – wet weather composite
- 102 – composite sample field duplicate
- 002 – composite sample field blank
- 003 – equipment blank
- 004 – rinsate blank

Sample collection times for quality control (QC) samples will be recorded as 12:00 on the COC form to maintain duplicates as laboratory blind samples. The actual collection time will be recorded on the field form. The QAPP includes a detailed approach to data validation as it pertains to holding times and laboratory qualifiers for QC samples.

4.8 Monitoring Station Shut Down

Post-sampling activities include downloading data from the automatic sampler, flow module, and rain gauge according to the applicable procedures listed in Appendix F, replacing batteries as necessary, and reviewing the overall condition of the equipment. Equipment shutdown will be conducted by ACHD personnel and may occur as late as two weeks after sample collection, in order to accommodate hydrologic data collection.

The WQL will analyze the samples for the constituents identified in Table 4-1. Quality assessment activities, to be performed by the program quality assurance/quality control (QA/QC) officer, will include reviewing field notes and COC documents as well as validating data packages received from the laboratory. QA/QC procedures are discussed in further detail in Section 5.

Section 5

QA/QC

QA/QC measures included in this monitoring program follow the guidance developed in the QAPP.

5.1 QC Sampling Schedule

The QC sampling schedule developed for this monitoring program consists of a combination of field QC samples and laboratory QC samples. Field QC sample types are described in the QAPP and include: composite duplicate, field blank, rinsate blank, and equipment blank. Field QC sampling will be incorporated into the rotation of QC samples used in the ACHD Stormwater Outfall Monitoring Plan to meet Data Quality Objectives. Laboratory QC sample results are included in each analytical report.

Duplicate sample collection is contingent upon sample volume. Field blanks may be collected during any storm not targeted for composite sampling. The field blank may be collected after all planned samples have been collected. Rinsate and equipment blanks are collected during the fall maintenance events.

ACHD may choose to conduct additional QA/QC to address data discrepancies, potential sample contamination, or other QA/QC issues. These events will be handled on an as-needed basis, depending on the particular issue(s) involved.

5.2 Data Quality Objectives (DQO)

The DQO for ACHD stormwater monitoring can be summarized by the following statement:

Monitoring efforts will provide data of sufficient quality and quantity in accordance with permit requirements to accurately estimate pollutant concentrations and loading trends, evaluate effectiveness of permanent stormwater controls and green infrastructure/low impact development projects, and support watershed and land use management initiatives.

5.2.1 Data Quality Indicators (DQIs)

DQIs have been established to set measurable qualitative and quantitative goals for data acceptance that meet the program DQOs described above. Each DQI is described below. DQIs are the basis for addressing field and laboratory analytical instrument performance, as well as sample collection and handling procedures. QA/QC samples provide input for several of the DQIs. QA/QC sample collection procedures are included in Section 2.1 of the QAPP.

DQIs are described fully in Section 1.8.1 of the QAPP. A brief description of each DQI is included in the list below.

- **Project Required Detection Limit (PRDL):** Achieving appropriate reported constituent concentration results at values that allow for comparison to baseline data and water quality standards.
- **Accuracy:** The accuracy of the data is a measure of the extent to which a measured value represents the true value.
- **Precision:** Precision is a measurement of the reproducibility of the analytical data.
- **Bias:** Bias is minimized by using standard data collection and analytical methods and protocols, as well as standard sample preservation, transport, and storage procedures.

- **Representativeness:** Representativeness is a measure of the degree to which data accurately and precisely indicate environmental conditions.
- **Comparability:** The comparability of a data set is the extent to which data accurately and precisely indicate environmental conditions.
- **Completeness:** Completeness is a comparison between the amount of usable data collected versus the total amount of data collected.
- **Sufficiency:** Data set sufficiency is the amount of data required to perform the level or type of analysis necessary for each monitoring element.

Analysis-specific data quality indicators include PRDLs and precision evaluated as relative percent difference (RPD). The target values for these indicators are listed in Table 5-1 below.

Table 5-1. Data Quality Indicator Targets

Constituent	Analytical Method	PRDL[1,2]	Units	Precision[3,4] (RPD)
Total phosphorus	EPA 200.7	0.04	mg/L	20%
Dissolved orthophosphate	EPA 365.1 or SM 4500-P E	0.084	mg/L	20%
Total suspended solids (TSS)	SM 2540 D	1.0	mg/L	20%
Ammonia (NH3)	SM 4500 NH3-N	0.045	mg/L	20%
Total Kjeldahl nitrogen (TKN)	Perstorp PAI-DK01	0.3	mg/L	20%
Nitrite plus nitrate (NO2+NO3)	EPA 353.2	0.04	mg/L	20%
Arsenic – total	EPA 200.7	0.05	mg/L	20%
Cadmium – total	EPA 200.7	0.02	mg/L	20%
Cadmium – dissolved	EPA 200.7	0.2	mg/L	20%
Copper – dissolved	EPA 200.7	0.2	mg/L	20%
Lead – total	EPA 200.7	0.02	mg/L	20%
Lead – dissolved	EPA 200.7	0.2	mg/L	20%
Mercury – total	EPA 245.2	0.02	mg/L	20%
Zinc – dissolved	EPA 200.7	0.2	mg/L	20%
Flow/discharge volume	Non Specific	0.001	cfs	NA
Precipitation	Non Specific	0.01	in	NA

[1] Field instrument resolution values are listed in lieu of a PRDL for field parameter measurements.

[2] PRDL is defined as the effective method detection limit (MDL) as reported by the analytical laboratory.

[3] Precision calculations based on field duplicate samples.

[4] In cases where one value is reported at the MDL and the other value is less than five times the MDL, the samples will be considered within acceptable precision limits.

mg/L = milligrams per liter.

cfs = cubic feet per second.

Anticipated issues with optimal performance for DQIs include the possibility of not meeting the method-required filtration window for dissolved orthophosphate in composite samples. These issues will be monitored closely from the outset of the structural controls monitoring program to track and understand the impact the deviation may have on DQIs.

5.2.2 Storm Event Acceptance Criteria

Acceptance criteria for a representative storm include the following:

- 48 hour antecedent dry period
- sufficient volume to produce measurable runoff in sufficient quantity to collect a flow-weighted composite sample

Storm data used to evaluate acceptance criteria will be measured based on data records at the site rain gauge and flowmeter.

Ideally, upon completion of the sampler program, a flow-weighted composite sample is collected that represents the entire duration of the storm. Acknowledging that this is not always achievable, additional acceptance criteria for composite samples have been developed based on the portion of the storm represented by the composite sample. Composite samples will be considered to be representative of the storm if either of the following minimum conditions are met.

- 75 percent of the total storm runoff volume is represented in the composite sample, or
- continuous composite sample collection covers the first flush and the peak of the hydrograph.

If the composite sample is not representative of at least 75 percent of the measured flow associated with the sampled storm and does not cover the minimum portion of the storm hydrograph as described above, the sample will be qualified and data will be considered an estimate based on the DQOs outlined earlier in this section. Another storm may be targeted to replace it if possible.

On a limited number of historic occasions, an automatic sampler has triggered before the beginning of storm event runoff. In the event of this occurrence, the extraneous aliquots will be considered not to have compromised the entire composite sample if they represent less than 10 percent of the total composite sample volume (typically one to two subsamples). In the event of this occurrence, the composite sample will be qualified based on the DQIs outlined earlier in this section. If the composite sample is determined to be comprised of 10 percent or more non-stormwater sample, the entire composite sample will be rejected.

Section 6

Data Management and Reporting

All data collected as part of the structural controls monitoring program will be stored in electronic format for secure storage and timely and accurate retrieval for data analysis and reporting. Data collected as part of the sampling program will include rainfall data, runoff volumes, runoff coefficients, laboratory analytical data, QA/QC results, and modeling results. All data will be formatted according to preset standards in order to interface with the developed database storage and parameter evaluation procedures. Specific reporting procedures are provided below.

6.1 Data Acquisition Requirements (Non-Direct Measurements)

Weather forecasts and hourly precipitation totals will typically be obtained from the NWS Boise airport station website at http://forecast.weather.gov/MapClick.php?CityName=Boise&state=ID&site=BOI&lat=43.6461&lon=-116.267. Additional forecasts or weather reports may be obtained from local media, community, or commercial weather services. When obtaining weather forecasts for storm events, the stormwater specialist will typically call the NWS Boise airport station for additional details if it appears that an approaching storm may meet the sampling criteria. Pertinent details of these conversations will be recorded on the Sampling Event Communication Form (Appendix E).

6.2 Data Management System

ACHD has acquired DataSight database software for managing data collected from stormwater monitoring programs. The intent of using this program to manage and store data is to provide ACHD a safe and secure platform for storing, validating, viewing, and analyzing data. Program data will be imported into the database according to established procedures listed in Appendix F for flow and rain data and in the database guidance document discussed below.

The DataSight database is configured in four tiers or “levels” under which data is stored and related. The database structure and level dependencies for the stormwater outfall monitoring program are illustrated in Figure 6-1 below.

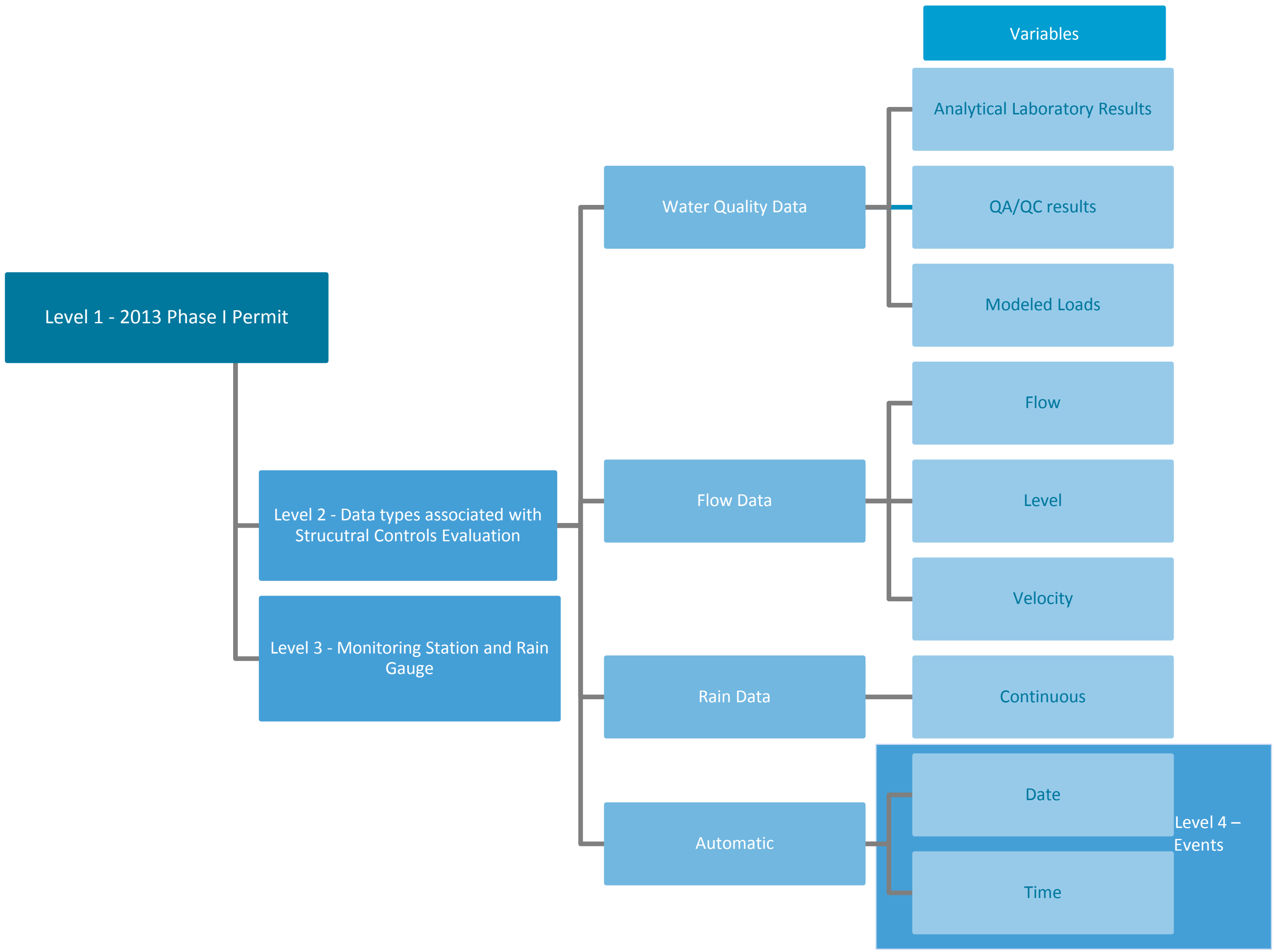

Figure 6-1: Database levels setup

After DataSight was installed and set up BC prepared a database guidance document (BC, 2014) to provide an overview of the organization of the database. This guidance document further describes data and program relationships as well as the approach ACHD will take to use the various functions and capabilities available within the DataSight software. Specific features discussed in the guidance document include the following:

- Organization of data within the levels of the database
- Organization and grouping of variables into data types
- Conversions and calculations ACHD will carry out in the database
- Approach to tying information to individual sites and specific events
- The use of control documents and site properties menus for storing program documents and other important records
- Data import functions to be used
- Data analysis, reporting, and export functions that will be used for retrieving data for subsequent use

- QA/QC measures and validation
- Data security including information about the ACHD secure servers, access restrictions, and automatic audit logs

6.3 Data Reporting

In addition to annual reporting requirements, data reporting will be accomplished throughout the year between storm events to maintain DQOs and provide direction to improve the sampling program throughout each year. These reports will provide the basis for annual reporting to the EPA.

6.3.1 Event Reporting

Following each sampling event, a storm event report will be prepared by the consultant that summarizes the events and results of data collection efforts during the storm. The report will also provide a specific summary of the storm characteristics and monitoring activities and will include the following Level 2 data and control documents:

- Storm Event Information
  - date and time span of the storm
  - antecedent dry period based on the local rain gauge
  - total rainfall
  - a qualitative description of the forecast and storm
  - composite sample volume
  - trigger volume used
- Water Quality Data
  - laboratory analytical data
  - QC sample results
  - notes and observations impacting analytical data
- Flow Data
  - storm event flow total
  - total flow sampled
- Rain Data
  - storm event precipitation total
- Program Documents
  - laboratory analytical report
  - data validation checklist

Additionally, each storm event report will include the following report elements:

- Project status summary table
- Discussion of QA/QC analysis
  - storm event acceptance criteria
  - results of the data validation review for the event
- Narrative summary of notes from the current event and recommendations for the next event
- Event hydrograph for the Pen Crossing monitoring station

6.3.2 Annual Reporting

At the end of each monitoring year (October 1 through September 30) of the program, an annual stormwater monitoring report will be prepared which summarizes results and progress of the program. The report will include information from the storm event reports and a comprehensive evaluation of all of the data collected. If data have been qualified as part of the QA/QC program, this will be noted in the appropriate table. The data evaluation will also include a discussion and analysis of sampling analytical performance against DQOs including discussion of any planned changes to the current plan based on QA/QC issues, site conditions, or program conditions.

Model results, including effluent values, loading reductions, and the results of any sensitivity analyses will be summarized in each annual report. A review of the year’s modeling efforts and data used will also be included and will be used to identify evaluation objectives and recommendations for the following year. A full effectiveness evaluation for each control will be provided in the final annual report after all monitoring has been completed.

Section 7

References

Ada County Highway District (ACHD), Project Monitoring and Evaluation Plan, 2013.

ACHD, Quality Assurance Program Plan for NPDES Storm Water Permit Monitoring Boise and Garden City, Idaho, 2014.

ACHD, Policy Manual, 8000, “Drainage and Stormwater Management,” 2011.

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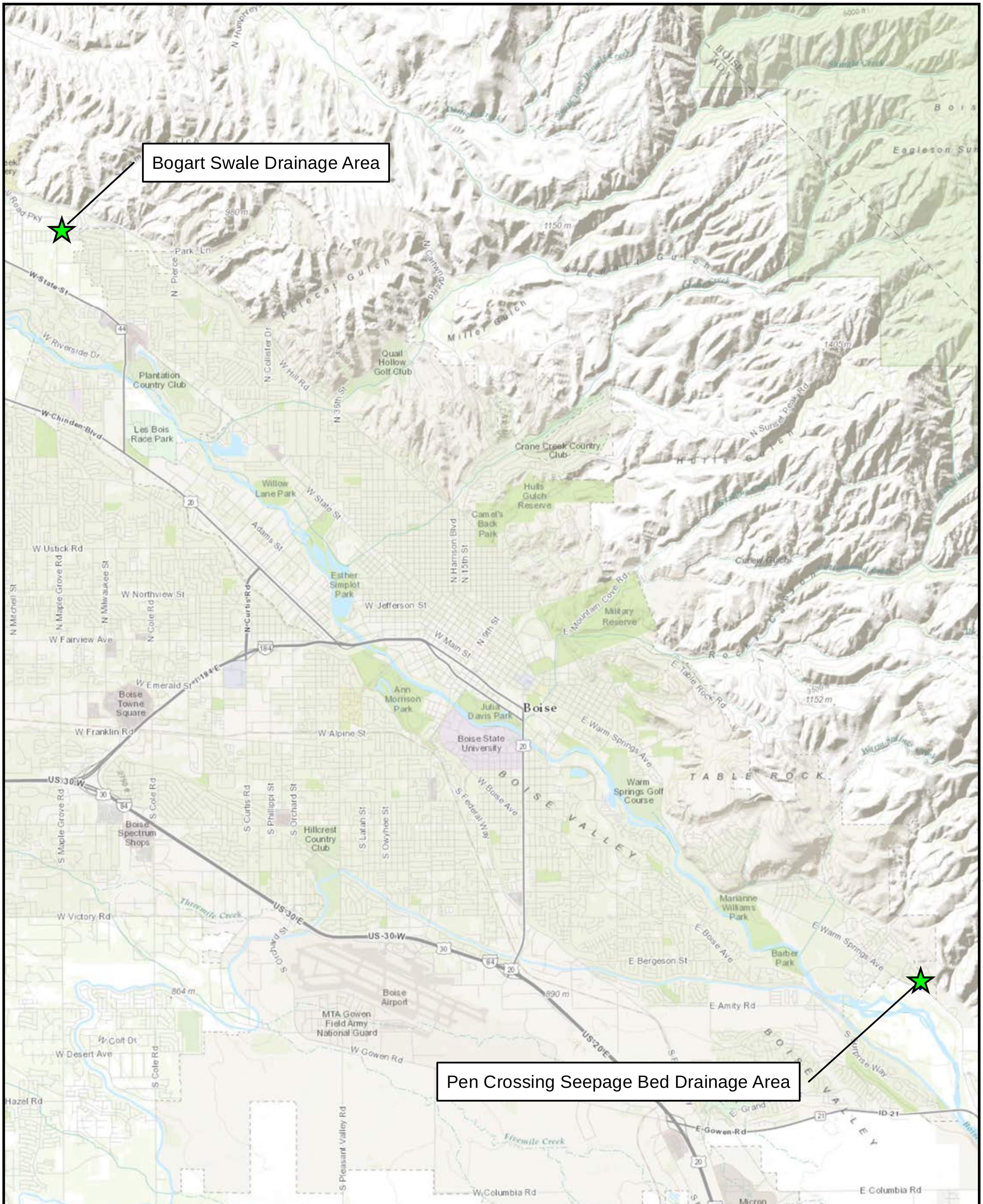
Perstorp Analytical Company. *Nitrogen, Total Kjeldahl, Method PAI-DK01 (Block Digestion, Steam Distillation, Titrimetric Detection)*. Wilsonville, OR: Perstorp Analytical Company, 1995.

Pitt, R. and J. Voorhees. “SLAMM, the Source Loading and Management Model.” In: Wet-Weather Flow in the Urban Watershed (Edited by Richard Field and Daniel Sullivan). CRC Press, Boca Raton. pp 103–139. 2002.

Figures

1. Vicinity Map
2. Pen Crossing Seepage Bed Drainage Area
3. Bogart Biofiltration Swale Drainage Area
4. Pen Crossing Site Photos
5. Bogart Site Photos
6. Pen Crossing Conceptual Monitoring Station Configuration



Brown AND Caldwell	Date: 7/29/2015 Project No: 146826 Client: ACHD	Basemap: World Topographic Map 0 3,750 7,500 Feet 1 inch = 7,500 feet	N	**Figure 1** **Vicinity Map** **Connectivity Evaluation**

Path: Bcboi02\G:\PROJECTS\ACHD\Maps\Connectivity_Eval_Field_Maps\Drainage_Areas\Figure_1_Vicinity_8x11P.mxd

Brown AND Caldwell

Date: 2/15/2016

Project No: 146826

Client: ACHD

Basemap: Google 2015

Feet 0 37.5 75

1 inch = 75 feet

N

Figure 2
Pen Crossing Seepage Bed Drainage Area
ACHD MS4 Phase I
Connectivity Evaluation

Path: Bcboi02\G:\PROJECTS\ACHD\Maps\Connectivity_Eval_Field_Maps\Drainage_Areas\Figure_2_Pen_Crossing_Drainage_8x11L.mxd

Brown AND Caldwell

Date: 2/15/2016
Project No: 146826
Client: ACHD

Basemap: Google 2015

Feet
0 20 40
1 inch = 36 feet

N

Figure 3
Bogart Swale Drainage Area
ACHD MS4 Phase I
Connectivity Evaluation

Path: Bcboi02\G:\PROJECTS\ACHD\Maps\Connectivity_Eval_Field_Maps\Drainage_Areas\Figure_3_Bogart_Drainage_8x11L.mxd

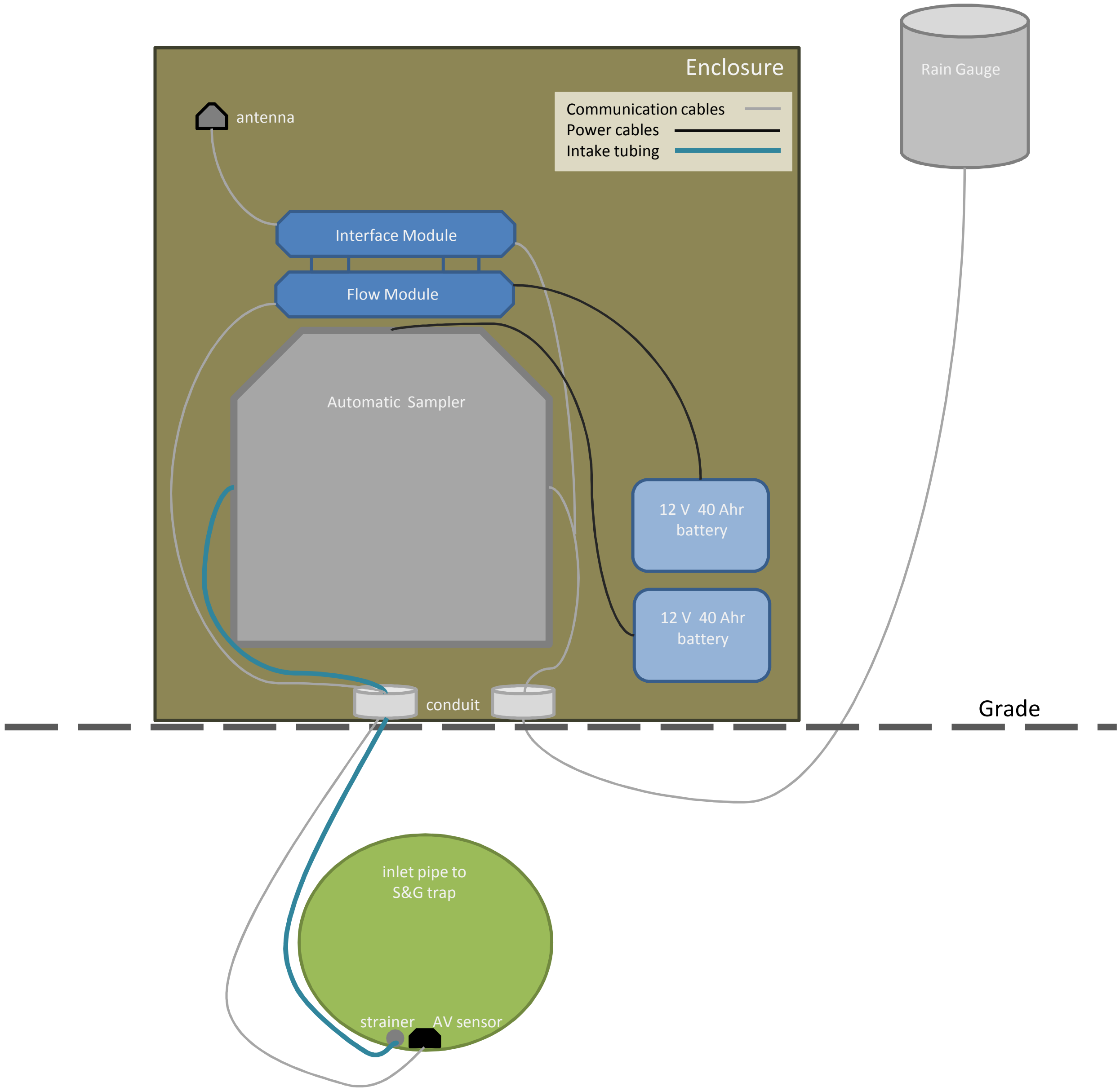
Figure 4a. Pen Crossing Seepage Bed Monitoring Station

Figure 4b. Equipment Enclosure

Figure 4c. AV sensor and strainer installed in sand and grease trap inlet

Figure 5a. Bogart Biofiltration Swale

Figure 5b. Modified curb cut inlet to swale



Pen Crossing conceptual monitoring station configuration

Appendix A: Model Inputs

Appendix A. Model Inputs

Site information for each drainage area is required to calculate influent loading into the structural controls. Design specifications for each control are then used to determine the degree of treatment achieved. Model inputs required to calculate influent and effluent loads are described in the tables below. Additional information describing influent load calculation is included in the cover letter to the Structural Controls Monitoring Plan.

<table>
<tr><th colspan="4">Table A-1. Drainage Area Inputs</th></tr>
<tr><th rowspan="2">Category</th><th rowspan="2">Input</th><th colspan="2">Value</th></tr>
<tr><th>Pen Crossing</th><th>Bogart</th></tr>
<tr><td rowspan="5">Source areas (acres)</td><td>rooftop</td><td>0.59</td><td>0.28</td></tr>
<tr><td>roadway</td><td>0.38</td><td>0.21</td></tr>
<tr><td>driveway</td><td>0.21</td><td>0.10</td></tr>
<tr><td>landscaping/lawn</td><td>1.20</td><td>0.42</td></tr>
<tr><td>sidewalks</td><td>0.08</td><td>0.04</td></tr>
<tr><td rowspan="5">Runoff</td><td>rain start date</td><td rowspan="5">To be determined for each event over the course of a full water year using data from the Pen Crossing rain gauge</td><td rowspan="5">To be determined for each event over the course of a full water year using data from the Edgewood rain gauge</td></tr>
<tr><td>rain start time</td></tr>
<tr><td>rain stop date</td></tr>
<tr><td>rain stop time</td></tr>
<tr><td>total depth</td></tr>
<tr><td>Near surface soils</td><td>soil type; infiltration rate</td><td>sandy clay; 0.025 in./hr.</td><td>sandy loam; 0.5 in./hr.</td></tr>
</table>

Pollutant removal is calculated in WinSLAMM according to the design of each structural control and the influent loads. Model parameters for each of the selected controls are described in Table A-2.

Table A-2. Structural Controls Model Parameters		
Site	Specification	Value
Pen Crossing seepage bed	top area	828 sq. ft
	bottom area	828 sq. ft
	total depth – from bottom of engineered soil/device to top of infiltration pipe	10 ft
	native soil infiltration rate	8 in/hr.
	engineered media type	¾- to 2-inch angular rock
	engineered media filled depth	10 ft
	engineered media porosity	40%
	sand and grease trap volume	1,500 gal
Bogart biofiltration swale[1]	total swale length	75 ft
	bottom width	2 ft
	swale side slope	4:1
	typical longitudinal slope	1%
	typical grass height	3.5 in.
	soil depth	1 ft
	soil composition	50% coarse sand by volume 20% sandy loam 30% < 10% passing #200 sieve no clay
	engineered media type	Filter sand
	engineered media filled depth	2 ft
	native soil infiltration rate	13 in./hr.
	Swale retardance factor	to be determined[1]
	Evapotranspiration coefficient	to be determined[1]

[1] *Swale retardance factor and evapotranspiration rates are chosen from a table in WinSLAMM once the other parameters have been entered.*

Appendix B: Structural Controls Context Review TM

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Technical Memorandum

Prepared for: Ada County Highway District (ACHD)

Project Title: Water Year 2014 Phase I Outfall Monitoring

Project No.: 145053

Technical Memorandum

Subject: Structural Controls Context Review

Date: November 14, 2014

To: Monica Lowe

From: Ted Douglass, Project Manager

Prepared by: Marie E Binford

Marie Binford, Engineer II, E.I.T

Reviewed by: ______________________

Ted Douglass, Project Manager

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Section 1: Introduction

In response to the National Pollutant Discharge Elimination System (NPDES) Municipal Separate Storm Sewer System Permit requirement to monitor permanent stormwater controls as outlined in Permit Part IV.A.9, the permittees must monitor two different types of permanent stormwater controls at new development and redevelopment sites. The two permanent stormwater controls that ACHD has chosen to evaluate are a vegetated swale and a seepage bed; both are listed under Ada County Highway District's (ACHD) approved best management practices (BMPs), number BMP 07 and BMP 04, respectively.

This technical memorandum (TM) is written to assist in evaluating the identified structural controls by providing additional context for monitoring these types of facilities. The evaluation of structural controls attempts to account for factors that may limit effectiveness of the control measure as designed. The information in this TM has been developed to provide a better understanding of the context of the factors that may impact evaluated removal efficiencies, infiltration rates, and the overall effectiveness of each structural control.

A benchmark comparison is presented to aid in the process of understanding best practices that are commonly used in similar environments. The benchmarking evaluation compares ACHD's design, installation, and maintenance practices with those of other entities with similar environmental conditions. In addition, the National Stormwater BMP Database provides design recommendations for BMPs that were reviewed to provide national context.

The benchmarking effort identifies limiting factors that can be used to better develop criteria for decision making regarding BMP effectiveness evaluation. This process will inform the selection of potential monitoring sites in an attempt to mitigate any issues that would skew or hide the results necessary to properly evaluate the effectiveness of these controls as designed and installed according to the ACHD Policy Manual.

The TM identifies key steps in selecting permanent stormwater controls for monitoring:

- Section 2 of this TM provides a review of ACHD's policy and design guidelines for siting and designing permanent stormwater structural controls.
- Section 3 provides a comparison of ACHD's structural control planning and design requirements to regional and national standards.
- Section 4 outlines the significant differences between ACHD and the regional and national standards.
- Section 5 provides a summary of considerations for structural control monitoring and a site selection matrix.

Section 2: Review of ACHD Policy and Design Manual for Swales and Infiltration Basins

Current ACHD stormwater guidance is outlined in the ACHD Stormwater Policy and Design Manual. The ACHD Stormwater Policy (2013 ACHD Policy Manual, Drainage and Stormwater Management, Section 8000) defines the management of stormwater in Ada County and outlines the standards and procedures to mitigate the impacts of urban stormwater runoff. The Design Manual (2013 ACHD Policy Manual, Stormwater Design Manual, Section 8200) provides tools and guidance for stormwater systems within Ada County and is supplemental to the Stormwater Policy. The Stormwater Policy states that ACHD holds the NPDES permit which requires implementation of a stormwater management program designed to limit the discharge of pollutants to the maximum extent possible. The Policy and Design Manual aid in addressing compliance with permit requirements by stormwater system design measures that improve water quality and adequately address pollutants of concern such as sediment, phosphorus, and bacteria. Additionally, the Stormwater Policy outlines that infiltration is the preferred method of stormwater management and treatment for public streets in Ada County.

2.1 Baseline Criteria Selection

A review was performed on ACHD's Stormwater Policy and Guidance Manual. The review was conducted to establish a baseline BMP selection criteria process for what would identify the most appropriate, effective, and feasible stormwater facility to meet the goals and treatment requirements of the development site. The Policy Manual and Design Manual outline many factors that must be considered when selecting a BMP for new or redevelopment projects. Three main selection criteria areas were chosen for the process of selecting and designing permanent stormwater BMPs. The three criteria areas include site suitability, design criteria, and maintenance requirements and considerations. These three main criteria were chosen to help focus the review and provide ACHD guidance to evaluate the effectiveness of these controls as designed and installed for monitoring.

2.2 Swales

The three selection criteria areas and sub-requirements for selection of swales are identified in Table 1.

Table 1. Swale Comparison

Selection Criteria Category	Comparison Criteria
Site Suitability	Drainage Area
	Soil and Vegetation
	Groundwater
	Space Limitations
	Utilities
	Constructability
Design Parameters	Hydraulic Retention Time
	Water Velocity
	Depth to Flow
	Side Slope
	General Length
	General Width
	Sizing
	Channel Cross Section
	Channel Slope
	Vegetation
	Curb/Gutter Requirements
	Drainage Area
	Soil Type
	Infiltration Rate
Maintenance Requirements and Considerations	Sediment Removal
	Visual Inspection Schedule
	Vegetation
	Curb Cuts and Outlets
	Litter Control
	Fertilizers/Insecticides
	Responsible Party

2.3 Seepage Beds

The three criteria and sub-requirements for selection of seepage beds are identified in Table 2.

Table 2. Seepage Bed Comparison

Selection Criteria Category	Comparison Criteria
Site Suitability	Drainage Area
	Soil and Vegetation
	Groundwater
	Space Limitations
	Utilities
	Constructability
Design Parameters	Design Storm
	Runoff Area
	Drawdown Time
	Backfill Material
	Void Ratio
	Perforated Pipe
	Observation Well
	Pretreatment Facility
	Infiltration Rate
	Bed Width
	Bed Length
	Bed Depth
	Freeboard
	Bottom Slope
	Filter Sand
	Depth to Groundwater
	Geotextile Fabric
	Land Use
Maintenance Requirements and Considerations	Pre-Treatment Maintenance
	Observation Wells
	Sediment Removal
	General Maintenance
	Pre-Treatment Maintenance

Section 3: Comparison with Regional and National Standards and Criteria

Guidance from regional stormwater programs implemented in similar climates as well as nationally accepted practices has been reviewed for comparison to ACHD's policies. While factors such as climate and geology change with location, most considerations for BMP effectiveness do not change.

Climate and terrain conditions can vary widely across the state and the northwest region of the United States. During the selection of other entities to perform the benchmark comparison, similar regional factors were considered such as climate, hydrology, geology, terrain, and rainfall-runoff relationships. In addition, qualifying factors such as a semi-arid climate and four distinct seasons with substantial variations in temperature and precipitation were highly considered. Therefore, the *Stormwater Management Manual for Eastern Washington* (Ecology, 2004), was selected for comparison of standards and design criteria.

Lastly, nationally accepted guidance based on one of the six minimum control measures, post-construction stormwater management in new development and re-development, was reviewed. An approach that integrates the control of successful national stormwater control measures was included form the Environmental Protection Agency (EPA). Therefore, the *National Menu of Stormwater BMPs* (EPA, 2014) and associated *Stormwater BMP Fact Sheets* were included in the benchmark comparison. The BMP fact sheets are frequently updated to include new practices and technologies.

3.1 Eastern Washington

The Washington State Department of Ecology developed the *Stormwater Management Manual for Eastern Washington* to provide guidance in stormwater design and management for Eastern Washington. The manual was developed to provide a commonly accepted set of technical standards as well as present new design information and new approaches in stormwater management. While this guidance document has been developed for a much larger region than Ada County, Eastern Washington is similar in that special considerations are made for the semi-arid climate and freezing weather. Average annual rainfall ranges from 8 to 28 inches per year within the Eastern Washington region, and Ada County with an average annual rainfall of 11.5 inches per year falls into this applicable range. It should be noted that this manual is not a regulation; rather, it is a guidance document to provide local governments, state and federal agencies, developers, and project proponents with a set of stormwater management practices. The State of Washington also adheres to a process for evaluating and approving emerging stormwater treatment BMPs called Technology Assessment Protocol-Ecology. The process provides structure for reviewing and approving new treatment BMPs.

3.2 EPA

The EPA released the National Menu of Best Management Practices for Stormwater Phase II in October 2000. With the acknowledgement that stormwater is an emerging and evolving field, the EPA indicates that its specifications change with developments in research. The EPA's specifications describe the minimum standards for BMPs given recent information and research. Thus, the EPA database is a valuable comparison source in that minimum national standards are established. The EPA is limited in regional applicability standards and should not be as heavily relied upon in comparing site suitability criteria.

Section 4: Identified Gaps in Standards and Criteria

During the benchmark comparison of stormwater BMP design guidance processes, the three main factors, Site Suitability, Design Criteria, and Maintenance Requirements and Considerations, were examined. Key BMP performance factors and parameters relevant to design performance considerations were reviewed. Selecting an inappropriate BMP for a site could lead to adverse resource impacts; inadequate treatment functions or stormwater control success; wasted time, ACHD resources, and funding. Therefore, appropriate BMP selection is critical to project success.

Comparison of the ACHD Policy Manual with regional and national guidance identified some differences in the siting, design, and maintenance considerations that may be significant in terms of functionality, effectiveness, and lifespan of the swales and seepage beds installed under the guidance of the ACHD Policy Manual. ACHD's Design Guidance Manual, BMP 07, Biofiltration Swale and BMP 04 Seepage Beds are provided in Appendix A and B, respectively.

The following sections review swales and seepage beds and provide a comparison of identified gaps and discrepancies between the benchmark studies.

4.1 Swales

A comparison of ACHD's Policy Manual/ Design Guidance Manual to regional/ national entities for bioswales is presented in Appendix C. ACHD's BMP 07 Biofiltration Swale (used for pretreatment, primary treatment, and storage) was used in the benchmark comparison (ACHD Design Guidance Manual, Section 8200). BMP T5.40, *Biofiltration Swales*, from Eastern Washington's Stormwater Manual was used in the Design Criteria comparison. *Stormwater Technology Fact Sheet: Vegetated Swales* and *Grassed Swales* from the EPA's National Menu of BMPs were used in the design criteria comparison. In addition, *EPA's Fact Sheet: Infiltration Basin* was review for infiltration rates.

This section discusses potential weaknesses and identifies gaps of the Biofiltration Swale BMP selection and design process and how BMP performance can potentially be affected.

4.1.1 Site Suitability

Comparison Finding#1: Two siting criteria areas, Soils and Vegetation Considerations and Groundwater Considerations, under the site suitability criterion display some inconsistencies. A large discrepancy is in relation to the required infiltration rate; ACHD does not make a distinction in depth of infiltration required for the provided soil types. As an example, ACHD allows an infiltration rate of 0.5–8 inches per hour (in/hr) Eastern Washington specifies an infiltration rate of 0.5–2.4 in/ hr to a depth of 2.4 times the maximum flooded depth.

It should also be noted that biofiltration swales provide treatment by several processes: vegetation uptake, filtering through the subsoil matrix, and infiltration into the underlying soils. The EPA recommends (*Fact Sheet: Infiltration Basins)* an infiltration rate between 0.5–3 in/hr and cautions that soils that infiltrate too rapidly may not provide sufficient treatment creating the potential for groundwater contamination. Furthermore, the EPA recommends that soils should have no greater than 20 percent clay content and less than 40 percent silt/clay content. Therefore, ACHD may allow infiltration rates that are too high to adequately treat the water quality volume stipulated if the incorrect soil type is used in the BMP facility.

Comparison Finding#2: The degree to which explicit or centralized constructability language is outlined in the ACHD Guidance Manual may have an impact on activities during construction that may impact the effectiveness of the BMP. While the ACHD Policy and Design Manual clearly outline requirements for protection of permanent and temporary BMPs during construction, additional considerations such as site layout during construction, testing requirements before final sign-off, constriction staging and traffic patterns, and processes to restore damaged areas are not centrally defined.

4.1.2 Design Criteria

Comparison Finding#1: A discrepancy has been noted between the ACHD Design Guidance Manual BMP 07 specifications page and the standard drawing regarding the depth of flow for a biofiltration swale. The specification page outlines a maximum depth of flow of 3 inches, while the standard drawing requires a depth less than 6 inches. The depth of flow within a biofiltration swale is often shallow which allows increased soil and grass contact with the stormwater and increased infiltration. Additionally, a common method for sizing swales is such that the water quality volume flows at a depth approximately equal to the grass height. Both Eastern Washington and the EPA National Menu of BMPs outline for a maximum height of 4 inches or not to exceed the height of vegetation, respectively.

Comparison Finding#2: Another important sizing characteristic to consider is swale channel longitudinal slope. The longitudinal swale slope is noted on the ACHD Design Guidance specification page and standard drawing page for BMP 07, Biofiltration Swale; the standard drawing page indicates that a longitudinal slope of 1 percent maximum is required. Biofiltration swales are flow-through vegetated channels similar to storm drain channels but often much wider and shallower to maximize flow residence time and promote pollutant removal via vegetation uptake. As such, a maximum channel slope of 1 percent may not allow the flow to distribute evenly across the channel bottom or could allow for increased occurrence of ponding. The common practices noted in the Eastern Washington manual and the EPA menu recommend a slope of 1–2 percent and in some cases no more than 4 percent.

Comparison Finding#3: Sizing of the stormwater BMP is a critical piece in the design and implementation process of stormwater BMP monitoring. ACHD requires a BMP to be designed to a 100-year storm event that shall drain 90 percent of the design volume in 24 hours. During the benchmarking review, it was noted that Eastern Washington designates sizing based on a treatment capacity or conveyance capacity. Eastern Washington stipulates a treatment facility should be designed for a 6-month storm, where a conveyance BMP should be designed for a 25-year storm. Oversizing or undersizing a stormwater BMP may have significant impacts to the water quality effectiveness including increased or decreased infiltration rates. Most likely, due to swale sizing for 100-year storm events, the BMP is receiving volume reduction capacity credit rather than required treatment volume credit.

4.1.3 Maintenance Requirements and Considerations

Comparison Finding#1: Periodic sediment removal can aid in swale efficiency and allow the swale to remove targeted pollutants. In addition, periodically clearing out curb cuts and inlets may lessen the amount of debris and sediment that enters the swale. The ACHD policy requires tilling or raking of sand infiltration basins; however, the policy does not explicitly require sand removal. The EPA recommends periodically removing accumulated sediment. Over time, as sediment enters the swale, vegetation growth could be inhibited, thus lowering the BMP's effectiveness.

Comparison Finding#2: ACHD clearly outlines vegetation maintenance requirements such as mowing and aerating grass. However, a designated vegetation height (maximum or minimum) has not been established. If vegetation or grasses grow past the design depth-of-flow, stormwater may not be able to successfully infiltrate. Eastern Washington stipulates a vegetation height of no more than 1 inch above design treatment depth.

Comparison Finding#3: While ACHD outlines owner and ACHD maintenance responsibilities (light versus heavy maintenance), simple troubleshooting procedures may be effective in identifying corrective measures for the identified BMP defect or problem. The Eastern Washington manual provides a troubleshooting procedure in which various potential problems are outlined, the condition when maintenance is needed, and the recommended maintenance to correct the problem. This troubleshooting procedure may help the owner/developer to better develop the Stormwater BMP Operation and Maintenance Plan per ACHD Design Guidance, Section 8200, Appendix C.

4.2 Seepage Beds

A comparison of ACHD's Policy Manual and Design Guidance Manual to regional/national entities for Seepage Beds is presented in Appendix D. ACHD's BMP 04 *Seepage Bed with Optional Stormwater Chambers* (used for pretreatment, primary treatment, and storage) was used in the benchmark comparison (ACHD Design Guidance Manual, Section 8200). BMP F6.22, *Infiltration Trenches*, from Eastern Washington's Stormwater Manual and the EPA's *Stormwater Technology Fact Sheet: Infiltration Trench* from the National Menu of BMPs were used in the design criteria comparison. Additionally, since ACHD directly refers to the Idaho Department of Environmental Quality (IDEQ) for additional detail design considerations (stated in ACHD BMP 04), IDEQ's BMP #8 *Cover for Material and Equipment* was also used in the comparison analysis for seepage beds.

In addition to the evaluation of the existing ACHD design manual, the following internal policy changes have been identified.

- The depth of filter sand changed from 3 feet to 1.5 feet in 2010.
- 30-inch perforated pipe was required between 2010 and 2014. 18-inch perforated pipe was required before 2010 and after 2014.
- The 2010 policy identified the requirement to retain the 100-year design storm with no infiltration during the first hour resulting in a sedimentation factor of 25 percent (15 percent before 2010).
- The 2014 policy identified a design infiltration rate of 8 in/hr would result in a 0 percent sediment factor and <8 in/hr infiltration rate resulted in a 15 percent sediment factor.

These policy changes should be considered when selecting a site but are not evaluated in the comparisons identified below.

This section discusses potential weaknesses and gaps of the seepage bed BMP selection and design process and how BMP performance can be affected.

4.2.1 Site Suitability

Comparison Finding#1: Additional considerations may need to be evaluated regarding the design specifications for sub-surface infiltration facilities. ACHD outlines a requirement for a minimum of a 3-foot groundwater separation distance (from bottom of drain rock) in observation wells for monitoring and verification. Eastern Washington and the EPA outline slightly stricter requirements for depth to groundwater. Eastern Washington requires 5 feet of separation distance from base of stormwater control device to groundwater, while the EPA outlines 2 to 5 feet of separation from the bottom of the infiltration trench to seasonally high groundwater. Eastern Washington guidance accounts for treatment capacity of the soil. It specifies that, generally, a greater depth to groundwater is required if the treatment capacity of the soil is lower. Land use is directly related to pollutant loading and needs to be considered when determining if the underground facility is appropriate.

4.2.2 Design Criteria

Comparison Finding#1: Sustainability of a selected BMP is based on a variety of functions, and selecting the design storm size is a critical piece. Again, in the review of seepage beds it was noted that ACHD specifies a 100-year, 1-hour design storm. ACHD additionally requires seepage beds to be designed with volumes increased by 25 percent to account for sediment. Eastern Washington specifies a 25-year storm with overflow for higher events or to infiltrate 100 percent of storm runoff volume. The EPA specifies that seepage beds should only be used for small storms (only for water quality “off-line” practices). Seepage beds may have the potential to be over-sized and not provide for adequate treatment of targeted pollutants; therefore, if the seepage beds are oversized, they may be less effective.

Comparison Finding#2: Drawdown time may be a constraining factor in the design and implementation of seepage beds. Drawdown time requirements for ACHD seepage beds specifies that 90 percent of the flow must be infiltrated in 24 hours. The Eastern Washington manual specifies that stormwater must infiltrate within 72 hours. The EPA suggests that stormwater must also infiltrate within 72 hours or before the next storm event, with a minimum retention of 6 hours. The seepage bed performance may be hindered due to the rapid drawdown time by not allowing the system to fully provide adequate treatment since ACHD’s required time is nearly tripled as compared to Eastern Washington or national recommendations.

Comparison Finding#3: Sizing of the perforated pipe is an important consideration. ACHD requires an 18-inch perforated pipe to be used in the underdrain system. Eastern Washington requires a minimum of an 8-inch perforated pipe, while the EPA has not outlined specific pipe sizing requirements. Most likely, ACHD requires a large pipe due to the 100-year design storm requirement. If the design storm were reduced, the pipe diameter size could be reduced and, therefore, additional depth would be available for the sand filter treatment system. In addition to increased depth for the sand filter, the system would have increased separation distance from groundwater to the bottom of the treatment facility.

Comparison Finding#4: Generally, all reviewed benchmark entities specify pretreatment facilities prior to seepage beds. Both Eastern Washington and the EPA advocate pretreatment facilities such as vegetated filter strips or grassed swales as the preferred pretreatment method. Stormwater runoff filters through practices such as a grass filter strip prior to the trench. While this design component may not adversely affect the treatment capacity of stormwater BMPs, it was noted as a common design consideration.

4.2.3 Maintenance Requirements and Considerations

Comparison Finding#1: ACHD, Eastern Washington, and the EPA's baseline maintenance procedures were similar and require many of the same maintenance practices. A general maintenance practice that ACHD does not explicitly state is trash and debris removal. While trash and debris may not severely affect the design and function of seepage beds (seepage beds have a native top soil cover), added language on general maintenance for trash and debris removal may aid in overall BMP effectiveness.

Section 5: Considerations for Selection of Controls for Monitoring

BMP selection for water quality monitoring may be one of the most important factors in monitoring permanent stormwater controls. It is critical to recognize that for BMPs to function effectively they must take into account site-specific conditions, they must be installed and maintained correctly and meet performance expectations.

Based on the review and comparison of the benchmark studies, the following considerations are suggested for selection of structural controls that may be suitable as monitoring sites that are most likely to lead to conclusive results for evaluation of the effectiveness of swales and seepage beds constructed according to ACHD's standard policies.

5.1 Swales

The following are considerations for site selection of swales for structural control monitoring.

- Infiltration rates between 0.5–3 inches/hour are nationally recognized to provide adequate treatment for USDA SCS Hydrologic Soil Groups B and C.
- Review the stormwater BMP facility for evidence of proper installation (no damaged structures, etc.).
- Depth of flow should not exceed 3 inches.
- Swale channel longitudinal slope should be between 1–2 percent.
- Swales that may have been sized for smaller, more frequent storms (such as a 25-year, 6-month, or 24-hour storm event).
- Swales that have documented operation and maintenance (or as required); swale should show evidence of sediment and debris removal.
- Vegetation height no more than 1 inch above design treatment depth, so no more than 4-inches of vegetation if using a design depth of 3 inches.

A selection matrix has been developed to aid in identifying a stormwater structural control (Appendix E). The matrix allows all existing ACHD structural control identification numbers to be entered into the matrix. Each control can be analyzed by site suitability, design criteria, operation and maintenance, and monitoring evaluation questions.

5.2 Seepage Beds

The following are considerations for site selection of seepage beds for structural control monitoring.

- Minimum of a 3-foot separation distance from the bottom of the facility to groundwater.
- Seepage beds that may have been sized for smaller, more frequent storms (such as a 25-year storm).
- Slower drawdown time (such as 72 hours) to allow for adequate treatment.
- Seepage beds with a vegetated filter strip or grassed swales for pretreatment (instead of sand and grease trap as currently suggested).
- Evidence of proper maintenance; documentation of O&M is preferable.

A selection matrix has been developed to aid in identifying a stormwater structural control (Appendix F). The matrix allows all existing ACHD structural control identification numbers to be entered into the matrix. Each control can be analyzed by site suitability, design criteria, operation and maintenance, and monitoring evaluation questions.

5.3 Monitoring Approach

The following monitoring recommendations are based on the permit requirements, design information provided above, and the consideration that ACHD may want to evaluate the impacts of the treatment systems to groundwater quality. There are basic monitoring approaches provided below. Option 1 provides a recommendation that meets the minimum permit requirements, and Option 2 provides an approach to include groundwater impacts in the evaluation. The monitoring approaches also assume that ACHD will target the four pollutants of concern identified in the permit (temperature, phosphorus, *E. coli*, and total suspended solids). It is assumed that since the sizing criteria for BMPs retain a 100-year storm event that limited flow will be measured at the effluent end of the treatment system.

5.3.1 Option 1

The influent load should be measured between the pretreatment BMP and the influent pipe. At this location a flow meter and an automated sampler will be installed. The automated sampler would be set up to collect flow weighted samples to determine an influent event mean concentration. At the outflow of the system (or in the seepage bed overflow bypass) an additional flow meter should be installed to quantify any flow that passes through the entire system. If flow is measured at the effluent end of the system, a grab sample should be taken. Based on site selection and the assumed sizing criteria, effluent water quality sampling will be difficult. In this scenario, removal efficiency would be calculated based on the retained volume of flow.

5.3.2 Option 2

The influent load and effluent loads should be measured the same as in Option 1. This option targets evaluation of the removal efficiency of the infiltration system. Three piezometers screened below the bottom of the infiltration system but above the high groundwater level will be installed along the length of the BMP. Each piezometer will be capped and will require purging before and after each event. Nalgene ball valve samplers should be installed in a sump in each piezometer to collect infiltration as it leaves the BMP. It is also possible to track the influence of the infiltration treatment on temperature by using temperature loggers in the wells. In addition to monitoring infiltration during (or soon after) storm events, groundwater samples should be taken from the adjoining observation wells twice during the monitoring year. In this scenario the load reductions will be presented the same as above. However, an evaluation of the infiltration removal efficiency will be evaluated by comparing water quality concentrations between the influent load and the effluent load collected in the sump of each monitoring well. In addition, the water quality of existing ground-water conditions should be evaluated.

References

Ada County Highway District, *Policy Manual*, 8000, "Drainage and Stormwater Management," 2011.

Ada County Highway District, *Policy Manual*, 8200, "Stormwater Design Manual," 2011.

Idaho Department of Environmental (IDEQ), *Catalog of Stormwater Best Management Practices for Idaho Cities and Counties*; IDEQ Water Quality Division, 2004.

United States Environmental Protection Agency, "Grassed Swales," *Water: Best Management Practices*, http://water.epa.gov/polwaste/npdes/swbmp/Grassed-Swales.cfm.

United States Environmental Protection Agency, "Infiltration Basins," *Water: Best Management Practices*, http://water.epa.gov/polwaste/npdes/swbmp/Infiltration-Basin.cfm

United States Environmental Protection Agency, *Storm Water Technology Fact Sheet: Vegetated Swales*, Office of Water, 1999.

Washington State Department of Ecology, Stormwater Management Manual for Eastern Washington, "Chapter 5: Runoff Treatment Facility Design," 2004.

Appendix A: ACHD BMP No 07 Biofiltration Swale Specification

8202.17 BMP 07 Biofiltration Swale (Pretreatment, Primary Treatment & Storage)

Description

This BMP is approved for pretreatment or primary treatment and storage.

Concentrated flows from a pipe network shall be pretreated by another approved pretreatment BMP like a Forebay or Sand/Grease Trap.

Biofiltration swales treat and infiltrate stormwater runoff. They may be used for infiltration or conveyance to storage facility.

Design

For conveyance swales, a hydraulic residence time of 9-minutes is required. Water velocity, as determined by Manning's "n", should not exceed 0.9 feet/second. The maximum depth of flow through a conveyance swale shall be 3-inches.

Swale side slopes shall be no steeper than 3:1.

For surface flow on streets with curb/gutter, flow shall enter the swale through a Shallow Inlet or Scupper Inlet per Details 10 and 11.

Provide for energy dissipation and flow spread using Flow Spreaders, per Detail 4.

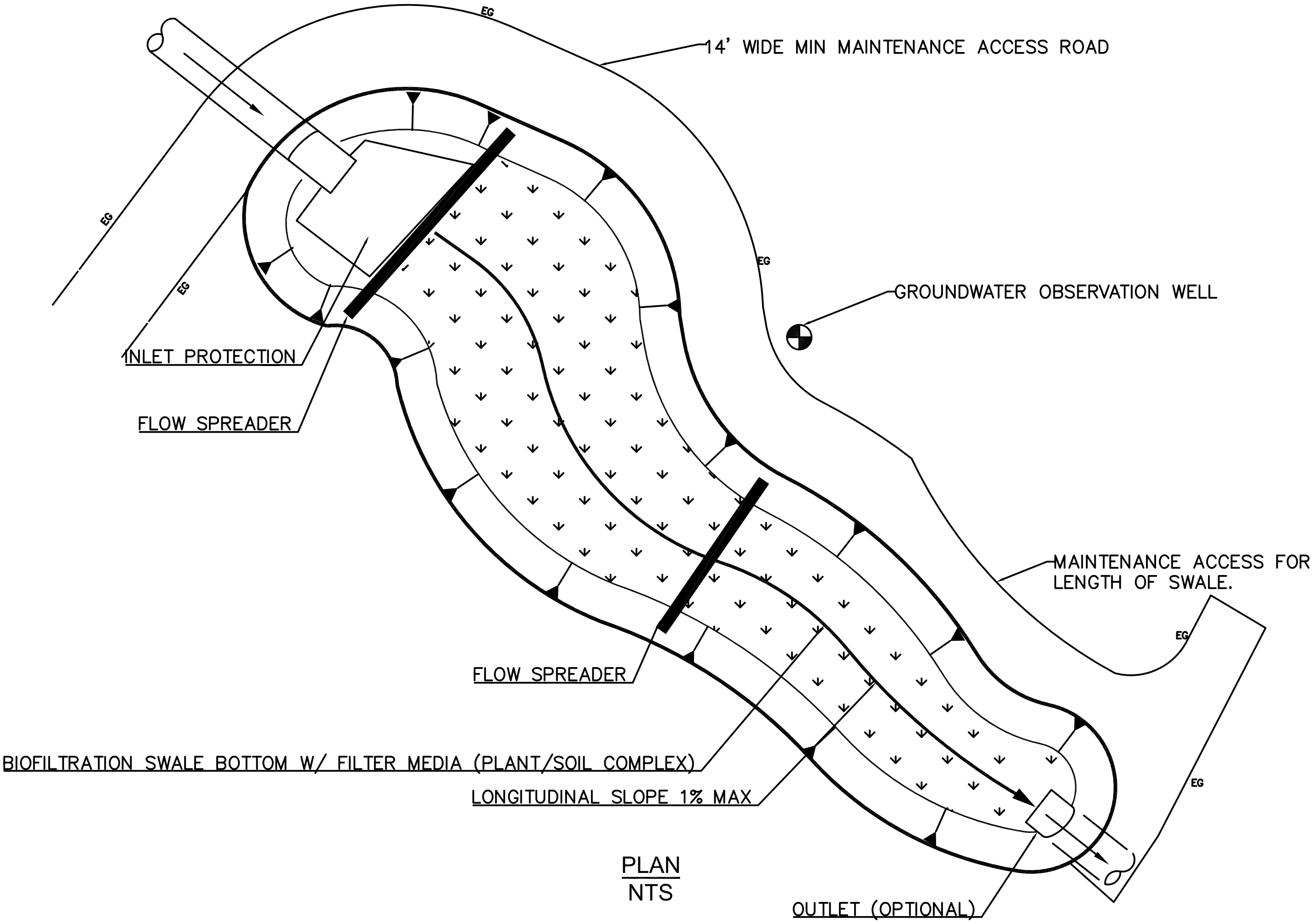
If there is not 3-foot minimum separation to groundwater the swale must be lined with an impervious liner and sloped at a minimum of 1% grade to an outfall.

The length of swale required for pretreatment:

Length = Q_{WQ}/A_{swale} x 540
Where 9 min residence time x 60 sec/min=540
A_{swale} = Cross sectional area of swale

Light maintenance of this BMP, when approved for use by the District, shall be performed by the developer or a homeowner's association unless it is an ACHD owned facility.

Adopted: Res 966
Revised: Res 2035 (4/9/14)



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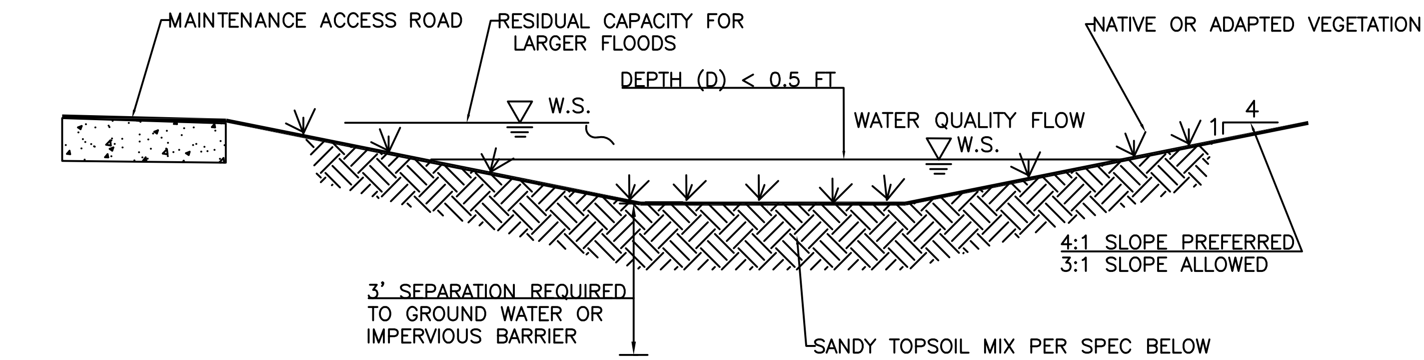

SECTION
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NOTES:

1. SWALE IS DESIGNED FOR INFILTRATION OF STORMWATER AND PLANT UPTAKE. STORMWATER CAN FLOW LONGITUDINALLY IN SWALE. SWALE LONGITUDINAL GRADE SHOULD BE A MAXIMUM OF 1%.
2. SANDY TOPSOIL SPECIFICATIONS:
   *50% COARSE SAND BY VOLUME
   *20% SANDY LOAM
   *30% COMPOST
   *FINES <10% PASSING #200 SIEVE
   *NO CLAY
3. DROUGHT PLANT SPECIES

2014

ACHD STORMWATER DESIGN GUIDELINES Adopted: Res 966 Revised: Res 2035 (4/9/14)	BIOFILTRATION SWALE	STANDARD DRAWING BMP 07

Appendix B: ACHD BMP No Seepage Bed Specification

8202.14 BMP 04 Seepage Bed With Optional Stormwater Chambers (Pretreatment, Primary Treatment & Storage)

Description

This is approved as a pretreatment BMP for primary treatment and storage if preceded by another approved pretreatment BMP.

A seepage bed stores stormwater runoff in a trench backfilled with uniformly sized drain rock and infiltrates the water into the ground. See Idaho DEQ BMP #8 for additional detail.

Flows shall be pretreated upstream using approved pretreatment BMPs like BMP 01.

The system may also include underground storage chambers for additional storage.

Design

Seepage beds and underground stormwater chambers shall be sized to store the entire 100-year design storm of one-hour duration assuming no infiltration. Facilities must infiltrate 90% of the design storm in 24-hours through the area of the sand filter. Volume shall be increased by 25% to account for sediment.

A stone aggregate of clean, washed drain rock, 1.5 to 2 inches in diameter should be used for storage. Crushed aggregates to interlock may be required for storage chambers. Follow Manufacturer's recommendations. Other materials may be used to create voids per the table below. Void volumes for the specific materials used must be lab verified and clean with less than 2 percent passing a 200 sieve.

Void Volume of Typical Materials	
Material	Void Volume %
2" Max Blasted Rock	30
(1-½" to 2") Uniform Size Gravel	40
¾" Uniform Size Crushed Chips	40
Crushed Glass	30

The Design Engineer may determine void volumes for other materials by laboratory analysis and submit them to the District for review.

The 18-inch perforated pipe shall be 3/8-inch perforations within the corrugation valleys per the schedule in this standard detail.

Following are the requirements for filter fabric and woven structural fabric.

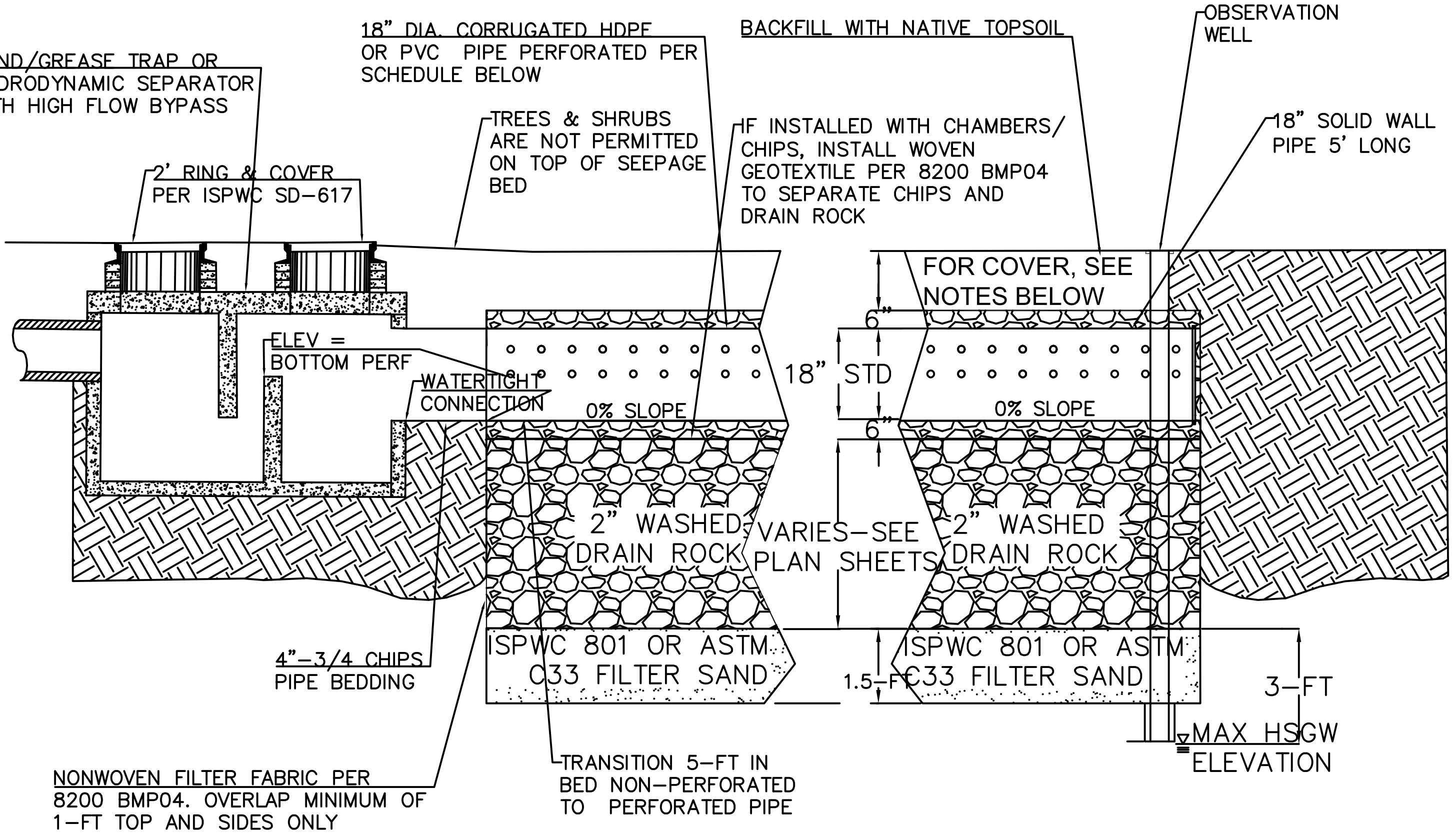
Non-Woven Filter Fabric

Property	Test Method	English
Tensile Strength (Grab)	ASTM D-4632	120 lbs
Elongation	ASTM D-4632	50%
Puncture	ASTM D-4833	65 lbs
Trapezoidal Tear Strength	ASTM D-4533	50 lbs
UV Resistance	ASTM D-4355	70%
Apparent Opening Size (AOS)	ASTM D-4751	70 US Std. Sieve
Permittivity	ASTM D-4491	1.50 sec-1
Water Flow Rate	ASTM D-4491	120 gpm/ft2

Woven Fabric

Property	Test Method	English
Tensile Strength (Grab)	ASTM D-4632	350 lbs
Elongation	ASTM D-4632	20 x 15%
Puncture	ASTM D-4833	150 lbs
Trapezoidal Tear Strength	ASTM D-4533	120 lbs
UV Resistance	ASTM D-4355	80%
Apparent Opening Size (AOS)	ASTM D-4751	35 US Std. Sieve
Permittivity	ASTM D-4491	0.27 sec-1
Water Flow Rate	ASTM D-4491	20 gpm/ft2

Adopted: Res 966
Revised: Res 2035 (4/9/14)



SECTION
NTS

GENERAL NOTES

1. CONTACT DESIGN ENGINEER FOR SEEPAGE BED REDESIGN IF GROUNDWATER IS ENCOUNTERED ABOVE MAX HSGW ELEVATION
2. ALL VAULTS, MANHOLES, & SAND AND GREASE TRAPS SHALL BE HS25 OR GREATER LOAD RATED
3. SEEPAGE BED SHALL BE SHOWN ON BOTH PLAN AND PROFILE VIEWS
4. OPTIONAL CHAMBERS PER MANUFACTURERS SPECIFICATIONS
5. ALL GEOTEXTILE SEAMS SHALL OVERLAP 1 FOOT MINIMUM
6. EL. IN >= EL. BOTTOM PERFORATIONS IN 18" PERF PIPE
7. MAXIMUM BED LENGTH IS 400-FT BETWEEN MANHOLES
8. BED WIDTH SHALL REMAIN CONSTANT
9. 1.5-FT FILTER SAND ALLOWED FOR THIS BMP AND BMP 10 ONLY. ALL OTHER BMPS REQUIRE 3-FT SAND
11. THE DESIGN ENGINEER IS SOLELY RESPONSIBLE FOR ASSESSING THE BEARING RESISTANCE OF THE SUBGRADE SOILS AND DETERMINING THE DEPTH OF FOUNDATION STONE
12. SEE BMP01 FOR SAND/GREASE TRAP DETAILS

FOR SEEPAGE BEDS BEDS IN PUBLIC RIGHT-OF-WAY

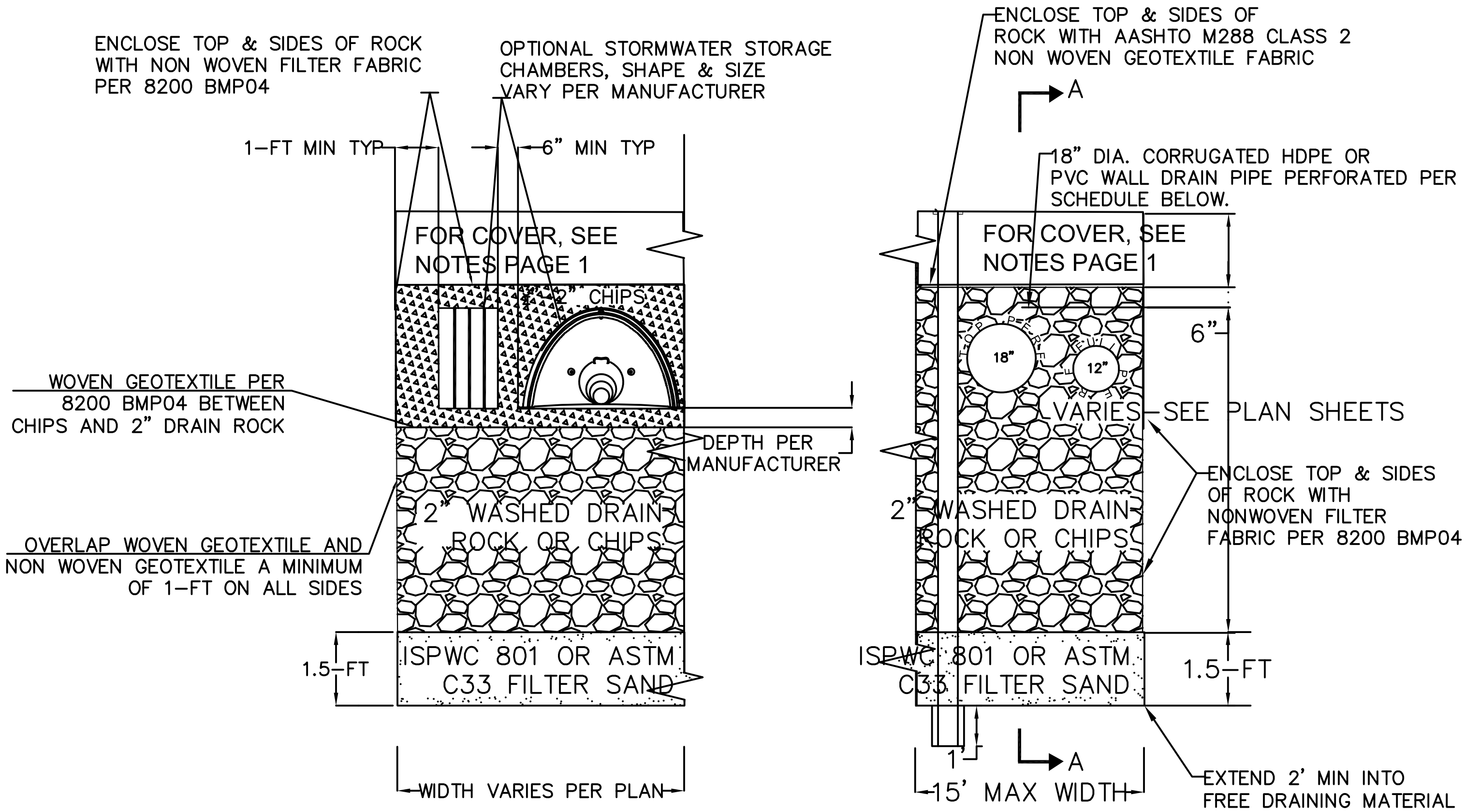
1. A MINIMUM 1-FT COVER FROM TOP OF BED TO ROAD SUBGRADE IS REQUIRED
   --BACKFILL OVER BED TO SUBGRADE WITH 6"-8" MINUS PITRUN
   --WOVEN GEOTEXTILE FABRIC REQUIRED OVER TOP OF BED
2. IF < 1-FT COVER FROM TOP OF BED TO SUBGRADE, ANGULAR $\frac{3}{4}$" TO 2" ROCK IS REQUIRED IN PLACE OF 2" DRAIN ROCK
3. FULL ROADWAY GRAVEL SECTION IS REQUIRED OVER SEEPAGE BEDS. SEEPAGE BEDS SHALL NOT EXTEND ABOVE SUBGRADE

FOR SEEPAGE BEDS BEDS OUTSIDE PUBLIC RIGHT-OF-WAY

1. A MINIMUM 1.5-FT COVER FROM TOP OF BED TO FINISH GRADE IS REQUIRED

2014

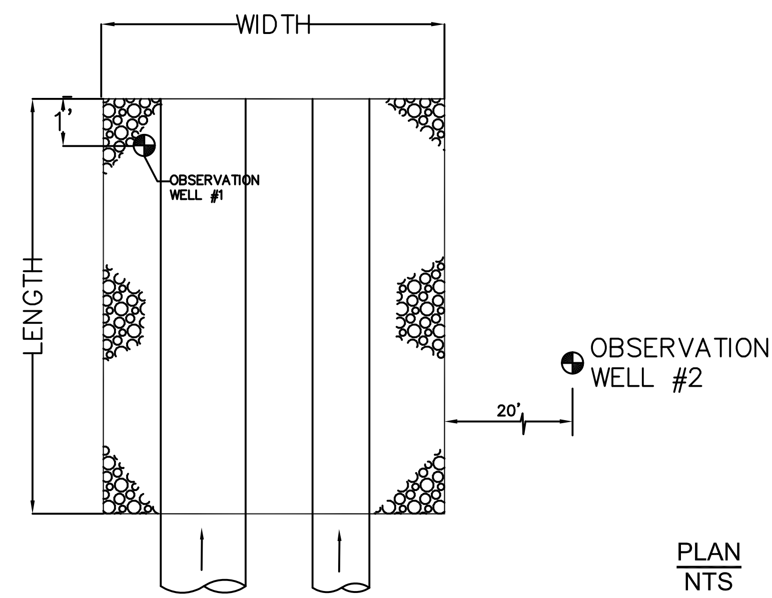
ACHD STORMWATER DESIGN GUIDELINES Adopted: Res 966 Revised: Res 2035 (4/9/14)	SEEPAGE BED WITH OPTIONAL CHAMBERS	STANDARD DRAWING BMP 04 SHT 1 OF 3



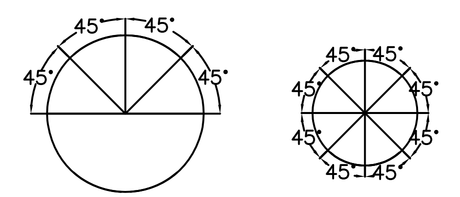
OPTIONAL CHAMBER

STANDARD

SECTION
NTS



PLAN
NTS



18" PERF PIPE WQ

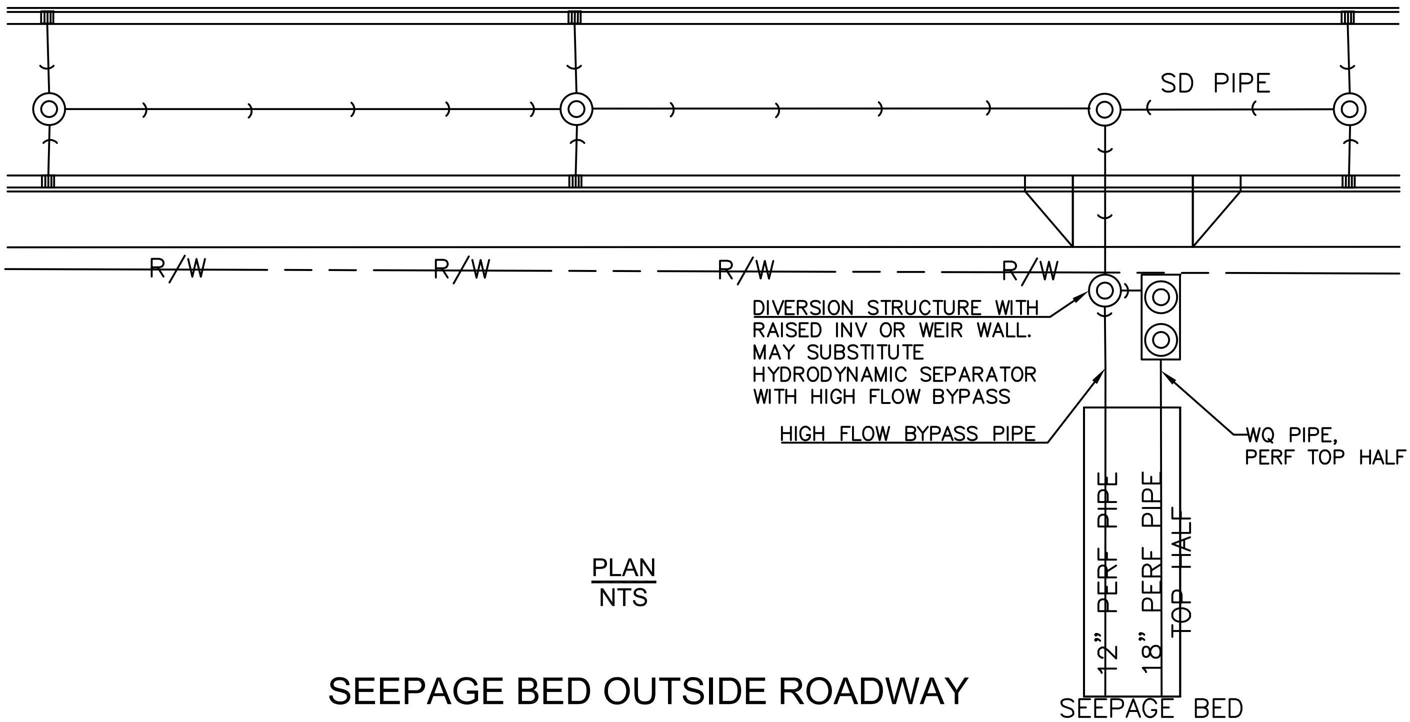
12" PERF PIPE BYPASS

PERFORATION SCHEDULE
3/8" PERFORATIONS IN VALLEYS OF CORRUGATED PIPE. 5 EA ON 18", 8 EA ON 12"

OBSERVATION WELLS: 2 REQUIRED PER BED

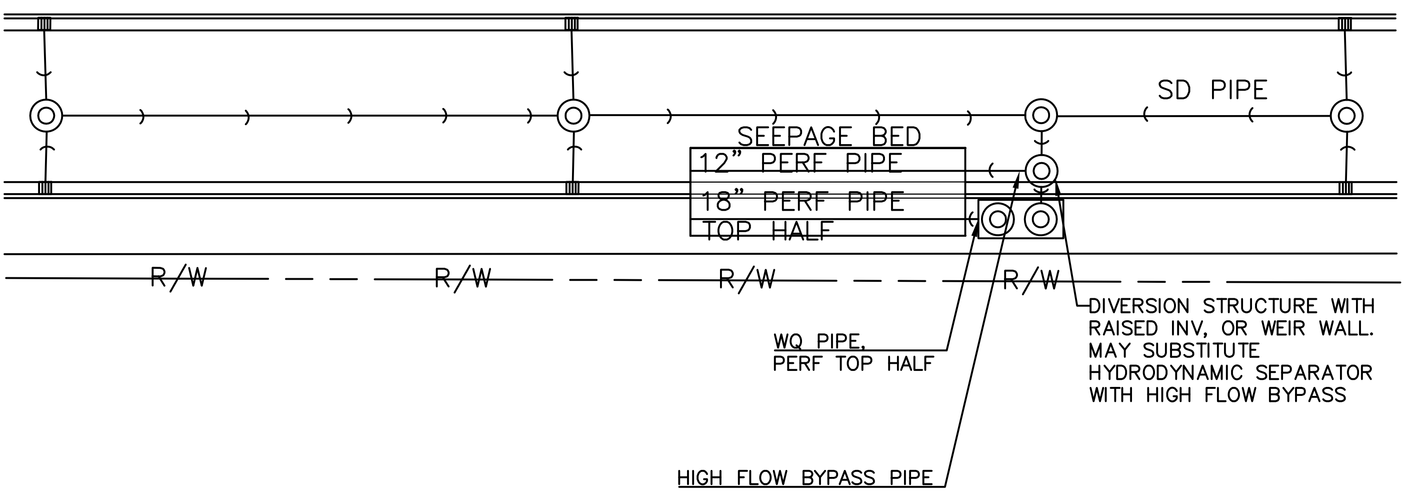
2014

ACHD STORMWATER DESIGN GUIDELINES Adopted: Res 966 Revised: Res 2035 (4/9/14)	SEEPAGE BED WITH OPTIONAL CHAMBERS	STANDARD DRAWING BMP 04 SHT 2 OF 3



PLAN
NTS

SEEPAGE BED OUTSIDE ROADWAY



PLAN
NTS

SEEPAGE BED IN RIGHT-OF-WAY

2014

ACHD STORMWATER DESIGN GUIDELINES Adopted: Res 966 Revised: Res 2035 (4/9/14)	ACHD SEEPAGE BED LAYOUT	STANDARD DRAWING BMP 04 SHT 3 OF 3

Appendix C: Biofiltration Swale Comparison Tables

Site Suitability Considerations for Infiltration BMPs							
Siting Criteria (Blocks from GSI Manual)	ACHD		Eastern Washington		EPA Standards		Gaps
	Siting Consideration	Details	Siting Consideration	Details	Siting Consideration	Details	
Drainage Areas					Drainage Area	• Treat runoff from small drainage area (less than 5 acres) • If treated area becomes too large, objectives of treatment and conveyance cannot both be met	
Soils and Vegetation Considerations	Soil Types and Infiltration Characteristics (8009.1, 8009.2)	• The infiltration system shall not be located in fill unless the fill is clean sand or gravel and the geotechnical report specifically addresses infiltration and slope stability. • Infiltration facilities are not permitted if the surface and underlying soil are SCS Hydrologic Group C or D or the saturated infiltration rate is less than 0.5 inches/hour. • The design infiltration rate shall not exceed 8 inches/hour.	Soil Infiltration Rate/Drawdown Time	• Long-term soil infiltration rate: minimum of 0.5 inches/hour, maximum of 2.4 inches/hour to a depth of 2.5 times the maximum design flooded depth. • Above infiltration requirements usually correspond to textures represented by Hydrologic Soil Groups B and C. • Infiltration control to empty the maximum water depth within 72 hours from completion of inflow to control in order to meet the following objectives: Restore hydraulic capacity, maintain infiltration rates, and keep vegetation healthy and functional.	Slope	• 1–2% grade recommended; 4% maximum (unless check dam is implemented).	No distinction in depth of infiltration required for varying soil types
					Soils/Topography	• Grassed swales can be used on most soils, with restrictions on the most impermeable soils. • A fine, close-growing, water resistant grass should be selected.	
	Slope and Geology of Site (8009.2)	• Infiltration basins should not be constructed in highly erodible soils, on slopes greater than 10%, or within fill soils unless these are specifically addressed in the geotechnical report and mitigated for in the design by the Engineer of Record.	Soil Physical and Chemical Suitability for Treatment	• Cation exchange capacity (CEC) of treatment soil must be > 5 milliequivalents CEC/100 g dry soil (characteristic of loamy sands). • Depth of soil = minimum of 18 inches except for designed, vegetated infiltration facilities with an active root zone (e.g., bio-infiltration swales). • Organic content of treatment soil. • Waste fill materials should not be used as infiltration soil media. • Engineered soils may be used, but field performance evaluations would be needed to determine feasibility and acceptability.			
Groundwater	Groundwater (8009.2, 8009.3, 8009.6)	• Bedrock, groundwater, or impervious soils must be greater than 3 feet below the bottom of the infiltration surface. • Observation wells are required at all stormwater facilities to monitor and verify that the 3 feet to groundwater requirement is met.	Groundwater Protection Areas	• Site not suitable if infiltrated stormwater will cause violation of Ecology's Groundwater Quality Standards. (Local jurisdictions to determine if site is located in aquifer sensitive area, sole source aquifer, or wellhead protection zone and determine necessary pretreatment procedures.)	Groundwater	Bottom of swale should be constructed at least 2 feet above the ground water table.	
			Depth to Bedrock, Water Table, or Impermeable Layer	• Base of control should be 5 feet or above the seasonal high water mark, bedrock, or other low permeable layer. • Minimum of 3 feet could be considered if groundwater mounding analysis, volumetric receptor capacity, and design of overflow and/or bypass structure are judged adequate by a professional engineer (P.E.)			

Site Suitability Considerations for Infiltration BMPs							
Siting Criteria (Blocks from GSI Manual)	ACHD		Eastern Washington		EPA Standards		Gaps
	Siting Consideration	Details	Siting Consideration	Details	Siting Consideration	Details	
Space Limitations	Setbacks (8010.1.2)	• 100 feet from public or private drinking water wells • 50 feet from perennial and irrigation surface waters • 25 feet from basements • 10 feet from home foundations (without basements)	Setback Criteria	• Greater than 100 feet from drinking water wells, septic tanks or drainfields, and springs for public drinking water supplies. • From building foundations: >20 feet downslope and 100 feet upslope • From Native Growth Protection Easement: > 20 feet • From the top of slopes > 15%: Setback distance 50 feet minimum or as determined by P.E. • *Additional setbacks are to be considered if roadway deicers or herbicides are likely in the influent.*	Location	Swales may be used effectively wherever the site provides adequate space.	
Utilities	Horizontal Separation Distances (8010.1.2)	• 10-foot horizontal separation from potable water mains (to prevent hydrocarbons in stormwater contacting PVC pipes) • Minimum vertical separation of 1.5 feet is required from potable mains and storm crossings if the storm line is constructed with a water class pipe	Seepage Analysis and Control	• Determine whether there would be any adverse effects caused by seepage zones on nearby building foundations, basements, roads, parking lots, or sloping sites. • Infiltration not recommended on or upgradient of contaminated sites where infiltration of even clean water can cause contaminants to mobilize.			
Constructability	Contained in several sections (General Requirements for infiltration facilities, Design and Construction Infiltration Rates, and Protection of Infiltration Facilities during Home Construction) (8009.1, 8010.1.5, 8010.2)	• After construction, the area selected for the infiltration system shall be secured to prevent heavy equipment from compacting the underlying soils. • Design infiltration rates shall be based on in-situ geotechnical tests. • During construction, an infiltration test is required at each facility once excavation is complete and prior to backfilling (ACHD inspector to observe testing). • Temporary construction BMPs (to protect swale): site design and source control measures, inlet protection, and capturing sediment with filter fabric prior to discharge to treatment and storage facilities.	Construction Monitoring	• P.E. should monitor the construction of the infiltration facility to ensure work is completed in compliance with designer's intent • Following construction, facility should be visually monitored quarterly over a two-year period to assess performance and design	Construction	• The subsurface of the swale should be carefully constructed to avoid compaction of soil (compact soils reduces infiltration and inhibits vegetation growth). • Damaged areas should be restored immediately to ensure desired level of treatment is maintained.	Consider reorganizing construction requirements for reader usability

Design Criteria for Biofiltration Swale				
Design Parameter	ACHD	Eastern Washington	National Standards	Gaps
HRT	> 9 minutes			
Water velocity	< 0.9 feet/sec	< 1 feet/sec	Velocity not given; maximum flow = 5 cubic feet per second	
Depth of flow	Maximum = 3 inches	Maximum = 4 inches	Depth of stormwater should not exceed height of vegetation	Contradictory design information on specs (depth < 3 inches) and drawing (depth < 5 inches)
Side slope	No steeper than 3:1	No steeper than 3:1	No steeper than 3:1	
General length*		200 feet		
General width*		10 feet		
Sizing	Design storm: 100-year event, infiltrate 90% of design storm volume within 24 hours	• As treatment facility: design for 6-month storm • As conveyance (if BMP is located "on-line"): 25-year storm	Design storm: 6- month frequency, 24-hour storm event	ACHD controls are sized too large – may be affecting the effectiveness of the facilities
Channel cross section		Trapezoidal	Parabolic or trapezoidal	
Channel slope	1%	1–5%	> 4% slope, 1–2% recommended; check dams can be applicable in areas with steeper slopes	Contradictory design info on specs (1% channel minimum grade) and drawing (1% maximum grade)
Vegetation	Drought plant species	• Required: consult National Resource Conservation service (NRCS) for vegetation selection recommendations (plants need to endure prolonged periods of wetting and sustained dry periods) • Divert runoff during period of vegetation establishment (other than necessary irrigation)		
Curb/gutter requirements	Flow enters swale from shallow inlet or scupper inlet	If flow diverted through curb cuts, place pavement slightly above biofilter elevation. Curb cuts should be a minimum of 12 inches wide (to prevent clogging).		
Drainage area			Generally less than 5 acres (if aiming to treat and not solely convey)	
Soil type	SCS Hydrologic Group A or B	SCS Hydrologic Group B or C	Can be used with most soil types, with some restrictions on most impermeable soils	
Infiltration Rate	0.5–8 inches per hour	0.5–2.4 inches per hour	> 0.5 inches per hour	Max infiltration rate may be too high for ACHD for treatment

Reference: 5.5.3 – BMP T5.40

*Notes: *actual dimensions for a specific site may vary.*

Maintenance Procedures for Biofiltration Swale				
Baseline Maintenance Procedures	ACHD	Eastern Washington	National Standards	Gaps
Sediment removal	• Tilling and raking sand infiltration areas • Sediment removal (heavy maintenance, ACHD responsibility)	Remove sediments during summer months when they build up to 4 inches in any spot, cover biofilter vegetation, or interfere with BMP performance. Reseed bare spots from removal equipment.	• Reseeding of bare areas • Clearing of debris and blockages. Accumulated sediment shall be manually removed as needed (remove sediment buildup once it has accumulated to 25% of original design volume).	Sediment removal responsibility can be more clearly defined
Visual inspection schedule	HOA shall maintain annual inspection records for stormwater facilities that shall be made available to ACHD upon request.	Inspect swales after periods of heavy runoff: remove sediment, fertilize, and reseed as necessary.	• Inspect grass alongside slopes for erosion and formation of rills or gullies and correct (annually). • Inspect pea gravel diaphragm for clogging and correct the problem (annually).	
Vegetation	• Mowing and aerating grass • Controlling irrigation flows (not overwatering)	Grass to be mowed to appropriate height (at or 1 inch above design treatment depth)	• Periodic mowing (never shorter than design flow depth). • Weed control. • Watering during drought conditions. • Cuttings should be removed and disposed of in local composting facility.	No minimum mow height designated (will affect treatment ability of BMP)
Curb cuts and outlets		Clean curb cuts when soil and vegetation buildup interferes with flow introduction.		No curb cut/inlet procedures
Litter control		Remove litter to keep biofilters free of external pollution.	Remove trash and debris accumulated in the inflow forebay (annually or as needed)	No litter control procedures
Other	Applying fertilizers, pesticides, and insecticides according to Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) standards		• Use of fertilizers and pesticides should be minimal. • Any standing water removed during O&M procedures must be disposed to a sanitary sewer at an approved discharge location.	Define maintenance “triggers”; create a simpler troubleshooting procedure
Reference	8013.15	BMP T5.40, Appendix 5A – No. 8		
Responsible party	• Developer or HOA responsible for light maintenance of stormwater facilities • ACHD maintains all catchment and conveyance facilities within public right of way	A local government, designated group such as HOA, or adjacent property owner should accept responsibility for structural control maintenance. A specific maintenance plan should be formulated outlining the schedule and scope of maintenance operations.		

Appendix D: Seepage Bed Comparison Tables

Site Suitability Considerations for Infiltration BMPs								
Siting Criteria (Blocks from GSI Manual)	ACHD			Eastern Washington		EPA Standards		Gaps
	Siting Consideration	Details: Policy Manual	Details: IDEQ BMP 8	Siting Consideration	Details (Sections 5.4.3 and 5.6)	Siting Consideration	Details	
Drainage Areas						Drainage Area	• Treat runoff from small drainage area (less than 5 acres). • Application to larger sites generally causes clogging, resulting in a high maintenance burden.	
Soils and Vegetation Considerations	Soil Types and Infiltration Characteristics (8009.1, 8009.2)	• The infiltration system shall not be located in fill unless the fill is clean sand or gravel and the geotechnical report specifically addresses infiltration and slope stability. • Infiltration facilities are not permitted if the surface and underlying soil are SCS Hydrologic Group C or D or the saturated infiltration rate is less than 0.5 inches/hour. • The design infiltration rate shall not exceed 8 inches/hour.	• Infiltration rates shall be 0.5 inches or greater. • SCS Type A and B should convey at this rate, but site-specific testing should be conducted to confirm. Soil conditions that do not support the use of infiltration trenches are soils with more than 40% clay content (subject to frost heave) and fill soils (unless specifically designed to accommodate facility).	Soil Infiltration Rate/Drawdown Time	• Long-term soil infiltration rate: minimum of 0.5 inches/hour, maximum of 2.4 inches/hour to a depth of 2.5 times the maximum design flooded depth. • Above infiltration requirements usually correspond to textures represented by Hydrologic Soil Groups B and C. • Infiltration control to empty the maximum water depth within 72 hours from completion of inflow to control in order to meet the following objectives: Restore hydraulic capacity, maintain infiltration rates, and keep vegetation healthy and functional.	Slope	• Infiltration trenches should be placed on flat ground, but the slopes of the site draining to the practice can be as steep as 15 percent.	
	Slope and Geology of Site (8009.2)	• Infiltration basins should not be constructed in highly erodible soils, on slopes greater than 10%, or within fill soils unless these are specifically addressed in the geotechnical report and mitigated for in the design by the Engineer of Record.	• Steep site slopes (greater than 25%) can contribute to slope failures.	Soil Physical and Chemical Suitability for Treatment	• Cation exchange capacity (CEC) of treatment soil must be > 5 milliequivalents CEC/100 g dry soil (characteristic of loamy sands). • Depth of soil = minimum of 18 inches except for designed, vegetated infiltration facilities with an active root zone (e.g., bio-infiltration swales). • Organic content of treatment soil. • Waste fill materials should not be used as infiltration soil media. • Engineered soils may be used, but field performance evaluations would be needed to determine feasibility and acceptability.	Soils/Topography	• Infiltration rate should range between 0.5–3 inches per hour. • Soils should not have greater than 20% clay content or less than 40% silt/clay content. • Infiltration rates and textural class of soil need to be confirmed in the field. • Infiltration trenches may not be used in regions of karst topography, due to potential for sinkhole formation or ground water contamination.	
Groundwater	Groundwater (8009.2, 8009.3, 8009.6)	• Bedrock, groundwater, or impervious soils must be greater than 3 feet below the bottom of the infiltration surface. • Observation wells are required at all stormwater facilities to monitor and verify that the 3 feet to groundwater requirement is met.	• Infiltration facilities are not suitable in many areas of Idaho where the groundwater table is shallow. Conditions should be observed at the site during winter and early spring when the water table is at its highest.	Groundwater Protection Areas	• Site not suitable if infiltrated stormwater will cause violation of Ecology's Groundwater Quality Standards. (Local jurisdictions to determine if site is located in aquifer sensitive area, sole source aquifer, or wellhead protection zone and determine necessary pretreatment procedures.)	Groundwater	• Designers always need to provide significant separation (2 to 5 feet) from the bottom of the infiltration trench and the seasonally high ground water table, to reduce the risk of contamination. In addition, infiltration practices should be separated from drinking water wells.	Additional considerations may need to be taken for sub-surface infiltration facilities
				Depth to Bedrock, Water Table, or Impermeable Layer	• Base of control should be 5 feet or above the seasonal high water mark, bedrock, or other low permeable layer. • Minimum of 3 feet could be considered if groundwater mounding analysis, volumetric receptor capacity, and design of overflow and/or bypass structure are judged adequate by a professional engineer (P.E.). • IF USING PERFORATED PIPE: Infiltration trench design becomes subject to additional underground injection control (UIC) constraints. Generally, a greater depth to groundwater is required if the treatment capacity of the soils is lower (Table 5.6.1). Additionally, land use is directly related to pollutant loading and needs to be considered when determining if a UIC is appropriate (Table 5.6.2, 5.6.3). For full tables and decision matrix, see Eastern Washington Manual.			

Site Suitability Considerations for Infiltration BMPs								
Siting Criteria (Blocks from GSI Manual)	ACHD			Eastern Washington		EPA Standards		Gaps
	Siting Consideration	Details: Policy Manual	Details: IDEQ BMP 8	Siting Consideration	Details (Sections 5.4.3 and 5.6)	Siting Consideration	Details	
Space Limitations	Setbacks (8010.1.2)	• 100 feet from public or private drinking water wells • 50 feet from perennial and irrigation surface waters • 25 feet from basements • 10 feet from home foundations (without basements)	• Trenches should be a minimum of 100 feet upslope and 20 feet downslope from any building foundation or water supply well.	Setback Criteria	• Greater than 100 feet from drinking water wells, septic tanks or drain fields, and springs for public drinking water supplies. • From building foundations: >20 feet downslope and 100 feet upslope. • From Native Growth Protection Easement: > 20 feet. • From the top of slopes > 15%: Setback distance 50 feet min or as determined by P.E. • Additional setbacks are to be considered if roadway deicers or herbicides are likely in the influent.	Location	• Trenches must be located at least 100 feet upgradient from water supply wells and 100 feet from building foundations.	
Utilities	Horizontal Separation Distances (8010.1.2)	• 10-foot horizontal separation from potable water mains (to prevent hydrocarbons in stormwater from contacting PVC pipes) • Minimum vertical separation of 1.5 feet is required from potable mains and storm crossings if the storm line is constructed with a water class pipe		Seepage Analysis and Control	• Determine whether there would be any adverse effects caused by seepage zones on nearby building foundations, basements, roads, parking lots, or sloping sites. • Infiltration not recommended on or upgradient of contaminated sites where infiltration of even clean water can cause contaminants to mobilize.			
Constructability	Contained in several sections (General Requirements for infiltration facilities, Design and Construction Infiltration Rates, and Protection of Infiltration Facilities during Home Construction) (8009.1, 8010.1.5, 8010.2)	• After construction, the area selected for the infiltration system shall be secured to prevent heavy equipment from compacting the underlying soils. • Design infiltration rates shall be based on in-situ geotechnical tests. • During construction, an infiltration test is required at each facility once excavation is complete and prior to backfilling (ACHD inspector to observe testing).	• See IDEQ Construction Guidelines	Construction Monitoring	• P.E. should monitor the construction of the infiltration facility to ensure work is completed in compliance with designer's intent. • Following construction, facility should be visually monitored quarterly over a two-year period to assess performance and design.	Construction	• The subsurface of the trench should be carefully constructed to avoid compaction of soil (compact soils reduce infiltration). • Damaged areas should be restored immediately to ensure desired level of treatment is maintained.	
				All from 5.4.3				

Design Parameters Specifications for Infiltration Trench				
Design Parameter	ACHD	Eastern Washington	National Standards	Gaps
Design storm	Retains 100 year, 1 hour duration	25-year storm with overflow for higher events or infiltrate 100% of storm runoff volume	Designed for small storms (only for water quality, "off-line" practices)	Design storm may be too large
Runoff area			10 acres max; after 5 acres, pretreatment becomes more necessary	
Drawdown time	90% of flow must be infiltrated in 24 hours	Infiltrate within 72 hours	72 hours (or before next storm event), minimum retention of 6 hours	Drawdown time may be too quick (especially if trying to achieve treatment abilities)
Backfill material	Stone aggregate, 1.5 to 2 inches in diameter, clean and washed	Clean aggregate with max diameter of 3 inches and minimum diameter of 1.5 inches	Stone aggregate, 1–3 inches diameter	
Void ratio	30–40%	30–40%; assume void space maximum of 30% for design calculations	40%	
Perforated pipe	18-inch pipe, 3/8-inch perforations, 5 feet in length	Minimum of 8-inch perforated pipe		Design pipe much larger than Eastern Washington's—may be attributed to larger design storm event. May be able to reduce size.
Observation well	Required	Yes; installed at lower end of trench to monitor water levels, drawdown time, sediment accumulation, and water quality monitoring.	Yes	
Pretreatment facility	Yes; generally sand and grease trap	Yes; generally a vegetated filter strip. Facilities are generally above grade rather than sub-grade	Yes; practices such as grassed swales, vegetated filter strips, detention, or a plunge pool in series	Subgrade facilities are generally not the first choice; infiltration trench with vegetated filter strip as pretreatment BMP more regularly seen. Sand and grease trap is appropriate pretreatment BMP for subgrade infiltration facilities
Infiltration rate	0.5–3 inches per hour	0.5–2.4 inches per hour	0.5–3 inches per hour	
Bed width	Constant: 3 feet typically	Minimum of 24 inches		
Bed length	Maximum of 400 feet between manholes			
Bed depth	3–12 feet	3–8 feet	3–12 feet	
Freeboard		Minimum of 1 foot above 25-year surface water elevation		
Bottom slope		< 3%	Flat ground, but slopes draining to the practice can be as steep as 15%	
Filter sand	Minimum of 1.5 feet	6–12 inches of filter sand or permeable filter cloth		
Depth to groundwater	Minimum of 3 feet to maximum water table depth	• Minimum of 5 feet above the seasonal high water mark, bedrock, or other low-permeability layer (at grade trench) • Subgrade trench: 10–50 feet to water table depending on soil treatment capacity	2–5 feet	
Geotextile fabric	Yes; overlap minimum of 1 foot top and sides only	Yes; aggregate fill material shall be encased in engineering geotextile fabric (except in exposed aggregate surface, where fabric encases aggregate) except for top 1 foot.	Yes; aggregate shall be encased except for top 1 foot	
Land use				

Maintenance Procedures for Seepage Bed (Infiltration Trench)				
Baseline Maintenance Procedures	ACHD	Eastern Washington	National Standards	Gaps
Pre-treatment maintenance	BMPs for pretreatment shall be inspected regularly. Sediment deposits shall be removed and grassy swales or filter strips should be mowed. Repair any erosion in pretreatment swales or filter strips that might concentrate runoff flow and cause erosion prior to the infiltration trench.	Pre-treatment BMPs shall be monitored and maintained on schedules and criteria dictated by the chosen BMP.	• Remove sediment and oil/grease from pretreatment devices or overflow structures. • When vegetated filter strip is used, it should be inspected for erosion and other damage after major storm events; vegetated strips should have healthy grass that is regularly mowed.	
Observation wells	• For first year after construction, well should be monitored after every large storm (greater than 1 inch in 24 hours) or monthly during the winter (October 15–April 15) and quarterly during the summer (April 16–October 14). • Once performance has been verified, can move to annual inspection schedule.	Sediment accumulation should be monitored on the same schedule as the observation well.	Check observation wells following 3 days of dry weather. Failure to percolate within this time period indicates clogging.	
Sediment removal	• Sediment buildup shall be observed on same schedule as observation wells. • Sediment deposits shall not be allowed to build up to the point where the rate of infiltration into the trench is reduced.	Remove sediment from trench if: • 2 inches or more of sediment is visibly present. OR • Facility is failing to infiltrate 90% of design capacity in 72 hours. • If trench has top layer of pea gravel, replace gravel if little or no water flows through the filter during heavy rainstorms.	Annual inspection: if inspection indicates that trench is clogged or partially clogged, then it should be restored to design condition (i.e., replace aggregate)	
General maintenance		• Remove trash and debris (during scheduled maintenance or upon observation) • Trees that interfere with maintenance activities or trench performance should be removed • If topsoil is used at the top of the trench, hydroseed to prevent erosion and improve surface infiltration opportunities	Trees and other large vegetation adjacent to the trench should also be removed to prevent damage to the trench.	May want to include language on general maintenance (removing trash and debris, landscaping, etc.)

Appendix E: Swale Selection Matrix

Application Assessment
1 - No or unlikely
2 - in part or unsure
3 - yes or very likely

Biofiltration Swale	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
Structural Controls	N05-063	07-077	06-077	06-120	07-058	05-036	05-097	05-132	06-043	06-032	06-115	06-069	06-105	07-001	10-014	12-009	06-104	04-125	04-100	06-048	07-017
Structural Controls Monitoring Plan: Controls Selection Matrix	Alexas	Altaview	Bellingham Park 1	Bellingham Park 2	Bellingham Park 3	Bridgetower Crossing 10	Bridgetower Crossing 11	Bridgetower Crossing 12	Claymont	Coast to Coast	Colt Place	Crossfield 1	Crossfield 2	Crossfield 3	Crossfield 32	Crossfield 4	Estancia	Fenix Ranchette	Havencrest 1	Havencrest 2	Kathleen Estates
Site Suitability Selection																					
Is the control expected to reduce sediment/TSS effetively?																					
Is the control expected to reduce bacteria effetively?																					
Is the control expected to reduce phosphorous effetively?																					
Is the control expected to reduce nitrogen effetively?																					
Is the control expected to reduce temperature effetively?																					
Does it Characterize stormwater quality discharges from the MS4?																					
Is the groundwater table below the 3-ft depth requirement?																					
Does the BMP match the selection of an appropriate BMP for targeted pollutants?																					
Is the control likely to be installed and used effectively within the Permit area?																					
Are conditions of the control stable temporally? (i.e. no extreme changes in land use or cover from season to season)																					
Does the control have low risk of influence from complicating inconsistencies (i.e. no sewer line cross contamination, irrigation return, etc)																					
Is the control in use in reasonable travel time?																					
Does the control occur frequently within the MS4?																					
Design Criteria																					
Can we estimate reductions in pollutant load?																					
Can we assess effectiveness of stormwater controls?																					
Does the control have high BMP efficiency expectations as designed by ACHD?																					
Does the control have high BMP efficiency expectations as defined by the national BMP database?																					
Will the option considered fit with current and historical data?																					
Would selecting this option help to provide the conditions necessary to meet the overall program goals and permit requirements.																					
Is this control in use in the Five Year Work Program area of impact?																					
Will this control be representative of controls in use within the Permit area?																					
Can we delineate land use?																					
Is receiving water a TMDL or impaired waterway?																					
Can we access the design package?																					
Was this BMP installed according to the design package and ACHD secifications?																					
Operation and Maintenance of BMP Facility																					
Is there an O&M manual for the structural control?																					
Can we identify locations of additional controls?																					
Does ACHD have records/ schedules for heavy maintenance?																					
Can ACHD track owner maintenance efforts?																					
Does the facility visually appear to be maintained?																					
Monitoring Evaluation																					
Can controls be accessed safely for monitoring?																					
Would monitoring the control result in minimal increase in O&M effort?																					
Can the control be monitored within National BMP monitoring guidance requirements?																					
Is the control a long term solution to the monitoring and evaluation needs of the program?																					
Would monitoring the control maintain O&M compliance?																					
Are life cycle costs for monitoring the control within acceptable budget range?																					
Will this station provide data to help evaluate overall effectiveness of selected storm water management practices?																					
Will this station provide data to help characterize the quality of storm water discharges from the MS4?																					
Applicability Score	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LOS																					
Regulatory compliance																					
Health and Safety																					
Funding/Financial																					
System Performance																					
Sustainability																					
Social and Economic Impacts																					
LOS Score	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Score	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Comments:																					

Do discharges from the MS4 cause or have a reasonable potential to cause or contribute to an excursion above the Idaho water quality standards?
How does implementation of the SWMP prevent adverse impacts on water quality?
How will stormwater discharges be characterized?
How will the effectiveness of stromwater controls be evaluated?
How will reductions in pollutant loading be evaluated?
Will data collected be comparable across the program?
What are the ongoing practicies for gathering, tracking, maintaining, and using informaiton to set priorities and evaluate the SWMP and permit compliance?
How will data consistency be evaluated?
What guidance will be referenced or established for outfall monitoring, in-stream monitoring, stormwater control evaluation, LID evaluation, and dry weather montioring?

Appendix F: Seepage Bed Selection Matrix

Seepage Beds	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
Application Assessment 1 - No or unlikely 2 - in part or unsure 3 - yes or very likely	**Structural Controls**																				
Structural Controls Monitoring Plan: Controls Selection Matrix	Column1	Column2	Column3	Column4	Column5	Column6	Column7	Column8	Column9	Column10	Column11	Column12	Column13	Column14	Column15	Column16	Column17	Column18	Column19	Column20	Column21
Site Suitability Selection																					
Is the control expected to reduce sediment/TSS effetively?																					
Is the control expected to reduce bacteria effetively?																					
Is the control expected to reduce phosphorous effetively?																					
Is the control expected to reduce nitrogen effetively?																					
Is the control expected to reduce temperature effetively?																					
Does it Characterize stormwater quality discharges from the MS4?																					
Is the groundwater table below the 3-ft depth requirement?																					
Does the BMP match the selection of an appropriate BMP for targeted pollutants?																					
Is the control likely to be installed and used effectively within the Permit area?																					
Are conditions of the control stable temporally? (i.e. no extreme changes in land use or cover from season to season)																					
Does the control have low risk of influence from complicating inconsistencies (i.e. no sewer line cross contamination, irrigation return, etc)																					
Is the control in use in reasonable travel time?																					
Does the control occur frequently within the MS4?																					
Design Criteria																					
Can we estimate reductions in pollutant load?																					
Can we assess effectiveness of stormwater controls?																					
Does the control have high BMP efficiency expectations as designed by ACHD?																					
Does the control have high BMP efficiency expectations as defined by the national BMP database?																					
Will the option considered fit with current and historical data?																					
Would selecting this option help to provide the conditions necessary to meet the overall program goals and permit requirements.																					
Is this control in use in the Five Year Work Program area of impact?																					
Will this control be representative of controls in use within the Permit area?																					
Can we delineate land use?																					
Is receiving water a TMDL or impaired waterway?																					
Can we access the design package?																					
Was this BMP installed according to the design package and ACHD secifications?																					
Operation and Maintenance of BMP Facility																					
Is there an O&M manual for the structural control?																					
Can we identify locations of additional controls?																					
Does ACHD have records/ schedules for heavy maintenance?																					
Can ACHD track owner maintenance efforts?																					
Does the facility visually appear to be maintained?																					
Monitoring Evaluation																					
Can controls be accessed safely for monitoring?																					
Would monitoring the control result in minimal increase in O&M effort?																					
Can the control be monitored within National BMP monitoring guidance requirements?																					
Is the control a long term solution to the monitoring and evaluation needs of the program?																					
Would monitoring the control maintain O&M compliance?																					
Are life cycle costs for monitoring the control within acceptable budget range?																					
Will this station provide data to help evaluate overall effectiveness of selected storm water management practices?																					
Will this station provide data to help characterize the quality of storm water discharges from the MS4?																					
Applicability Score	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LOS																					
Regulatory compliance																					
Health and Safety																					
Funding/Financial																					
System Performance																					
Sustainability																					
Social and Economic Impacts																					
LOS Score	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Score	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Comments:																					

Do discharges from the MS4 cause or have a reasonable potential to cause or contribute to an excursion above the Idaho water quality standards?
How does implementation of the SWMP prevent adverse impacts on water quality?
How will stormwater discharges be characterized?
How will the effectiveness of stromwater controls be evaluated?
How will reductions in pollutant loading be evaluated?
Will data collected be comparable across the program?
What are the ongoing practicies for gathering, tracking, maintaining, and using informaiton to set priorities and evaluate the SWMP and permit compliance?
How will data consistency be evaluated?
What guidance will be referenced or established for outfall monitoring, in-stream monitoring, stormwater control evaluation, LID evaluation, and dry weather montioring?

Appendix C: Site Selection Matrix

Seepage Beds	1	2
Application Assessment 1 - No or unlikely 2 - in part or unsure 3 - yes or very likely	Structural Controls	
Structural Controls Monitoring Plan: Controls Selection Matrix	Riverheights5	Pinetree Village Sub No. 6
Site Suitability Selection		
Is the control expected to reduce sediment/TSS effectively?	3	3
Is the control expected to reduce bacteria effectively?	2	2
Is the control expected to reduce phosphorus effectively?	2	2
Is the control expected to reduce nitrogen effectively?	2	2
Is the control expected to reduce temperature effectively?	2	2
Does it Characterize stormwater quality discharges from the MS4?	3	3
Is the groundwater table below the 3-ft depth requirement?	3	3
Does the BMP match the selection of an appropriate BMP for targeted pollutants?	3	3
Is the control likely to be installed and used effectively within the Permit area?	3	3
Are conditions of the control stable temporally? (i.e. no extreme changes in land use or cover from season to season)	2	2
Does the control have low risk of influence from complicating inconsistencies (i.e. no sewer line cross contamination, irrigation return, etc)	2	2
Is the control in use in reasonable travel time?	2	2
Does the control occur frequently within the MS4?	3	3
Design Criteria		
Can we estimate reductions in pollutant load?	2	2
Can we assess effectiveness of stormwater controls?	2	2
Does the control have high BMP efficiency expectations as designed by ACHD?	2	2
Does the control have high BMP efficiency expectations as defined by the national BMP database?	2	2
Will the option considered fit with current and historical data?	2	2
Would selecting this option help to provide the conditions necessary to meet the overall program goals and permit requirements.	3	3
Is this control in use in the Five Year Work Program area of impact?	2	2
Will this control be representative of controls in use within the Permit area?	2	2
Can we delineate land use?	3	3
Is receiving water a TMDL or impaired waterway?	1	1
Can we access the design package?	3	2
Was this BMP installed according to the design package and ACHD specifications?	2	2
Operation and Maintenance of BMP Facility		
Is there an O&M manual for the structural control?	1	1
Can we identify locations of additional controls?	1	1
Does ACHD have records/ schedules for heavy maintenance?	1	1
Can ACHD track owner maintenance efforts?	2	2
Does the facility visually appear to be maintained?	2	2
Monitoring Evaluation		
Can controls be accessed safely for monitoring?	3	1
Would monitoring the control result in minimal increase in O&M effort?	2	1
Can the control be monitored within National BMP monitoring guidance requirements?	2	2
Is the control a long term solution to the monitoring and evaluation needs of the program?	2	2
Would monitoring the control maintain O&M compliance?	2	2
Are life cycle costs for monitoring the control within acceptable budget range?		
Will this station provide data to help evaluate overall effectiveness of selected storm water management practices?	2	2
Will this station provide data to help characterize the quality of storm water discharges from the MS4?	2	2
Applicability Score	**80**	**76**
LOS		
Regulatory compliance		
Health and Safety		
Funding/Financial		
System Performance		
Sustainability		
Social and Economic Impacts		
LOS Score	**0**	**0**
Total Score	**80**	**76**
Comments:		

Do discharges from the MS4 cause or have a reasonable potential to cause or contribute to an excursion above the Idaho water quality standards?
How does implementation of the SWMP prevent adverse impacts on water quality?
How will stormwater discharges be characterized?
How will the effectiveness of stormwater controls be evaluated?
How will reductions in pollutant loading be evaluated?
Will data collected be comparable across the program?
What are the ongoing practices for gathering, tracking, maintaining, and using information to set priorities and evaluate the SWMP and permit compliance?
How will data consistency be evaluated?
What guidance will be referenced or established for outfall monitoring, in-stream monitoring, stormwater control evaluation, LID evaluation, and dry weather monitoring?

Biofiltration Swale	33
Application Assessment 1 - No or unlikely 2 - in part or unsure 3 - yes or very likely	Structural Controls 05-113
Structural Controls Monitoring Plan: Controls Selection Matrix	Pinebrook Place
Site Suitability Selection	
Is the control in the phase I permit area?	3
Is the control expected to reduce sediment/TSS effectively?	3
Is the control expected to reduce bacteria effectively?	2
Is the control expected to reduce phosphorous effectively?	2
Is the control expected to reduce nitrogen effectively?	2
Is the control expected to reduce temperature effectively?	2
Does it Characterize stormwater quality discharges from the MS4?	3
Is the groundwater table below the 3-ft depth requirement?	3
Does the BMP match the selection of an appropriate BMP for targeted pollutants?	3
Is the control likely to be installed and used effectively within the Permit area?	3
Are conditions of the control stable temporally? (i.e. no extreme changes in land use or cover from season to season)	3
Does the control have low risk of influence from complicating inconsistencies (i.e. no sewer line cross contamination, irrigation return, etc)	2
Is the control in use in reasonable travel time?	3
Does the control occur frequently within the MS4?	3
Design Criteria	
Can we estimate reductions in pollutant load?	2
Can we assess effectiveness of stormwater controls?	
Does the control have high BMP efficiency expectations as designed by ACHD?	2
Does the control have high BMP efficiency expectations as defined by the national BMP database?	2
Will the option considered fit with current and historical data?	2
Would selecting this option help to provide the conditions necessary to meet the overall program goals and permit requirements.	3
Is this control in use in the Five Year Work Program area of impact?	1
Will this control be representative of controls in use within the Permit area?	3
Can we delineate land use?	2
Is receiving water a TMDL or impaired waterway?	
Can we access the design package?	3
Was this BMP installed according to the design package and ACHD specifications?	3
Operation and Maintenance of BMP Facility	
Is there an O&M manual for the structural control?	2
Can we identify locations of additional controls?	3
Does ACHD have records/ schedules for heavy maintenance?	2
Can ACHD track owner maintenance efforts?	1
Does the facility visually appear to be maintained?	2
Monitoring Evaluation	
Can controls be accessed safely for monitoring?	3
Would monitoring the control result in minimal increase in O&M effort?	3
Can the control be monitored within National BMP monitoring guidance requirements?	2
Is the control a long term solution to the monitoring and evaluation needs of the program?	3
Would monitoring the control maintain O&M compliance?	
Are life cycle costs for monitoring the control within acceptable budget range?	1
Will this station provide data to help evaluate overall effectiveness of selected storm water management practices?	2
Will this station provide data to help characterize the quality of storm water discharges from the MS4?	2
Applicability Score	**86**
LOS	
Regulatory compliance	1
Health and Safety	0
Funding/Financial	0
System Performance	1
Sustainability	0
Social and Economic Impacts	0
LOS Score	**2**
Total Score	**88**
Comments:	

Do discharges from the MS4 cause or have a reasonable potential to cause or contribute to an excursion above the Idaho water quality standards?
How does implementation of the SWMP prevent adverse impacts on water quality?
How will stormwater discharges be characterized?
How will the effectiveness of storm water controls be evaluated?
How will reductions in pollutant loading be evaluated?
Will data collected be comparable across the program?
What are the ongoing practices for gathering, tracking, maintaining, and using information to set priorities and evaluate the SWMP and permit compliance?
How will data consistency be evaluated?
What guidance will be referenced or established for outfall monitoring, in-stream monitoring, storm water control evaluation, LID evaluation, and dry weather monitoring?

Appendix D: Structural Controls Design Drawings

8202.14 BMP 04 Seepage Bed With Optional Stormwater Chambers (Pretreatment, Primary Treatment & Storage)

Description

This is approved as a pretreatment BMP for primary treatment and storage if preceded by another approved pretreatment BMP.

A seepage bed stores stormwater runoff in a trench backfilled with uniformly sized drain rock and infiltrates the water into the ground. See Idaho DEQ BMP #8 for additional detail.

Flows shall be pretreated upstream using approved pretreatment BMPs like BMP 01.

The system may also include underground storage chambers for additional storage.

Design

Seepage beds and underground stormwater chambers shall be sized to store the entire 100-year design storm of one-hour duration assuming no infiltration. Facilities must infiltrate 90% of the design storm in 24-hours through the area of the sand filter. Volume shall be increased by 25% to account for sediment.

A stone aggregate of clean, washed drain rock, 1.5 to 2 inches in diameter should be used for storage. Crushed aggregates to interlock may be required for storage chambers. Follow Manufacturer's recommendations. Other materials may be used to create voids per the table below. Void volumes for the specific materials used must be lab verified and clean with less than 2 percent passing a 200 sieve.

Void Volume of Typical Materials	
Material	Void Volume %
2" Max Blasted Rock	30
(1-½" to 2") Uniform Size Gravel	40
¾" Uniform Size Crushed Chips	40
Crushed Glass	30

The Design Engineer may determine void volumes for other materials by laboratory analysis and submit them to the District for review.

The 18-inch perforated pipe shall be 3/8-inch perforations within the corrugation valleys per the schedule in this standard detail.

Following are the requirements for filter fabric and woven structural fabric.

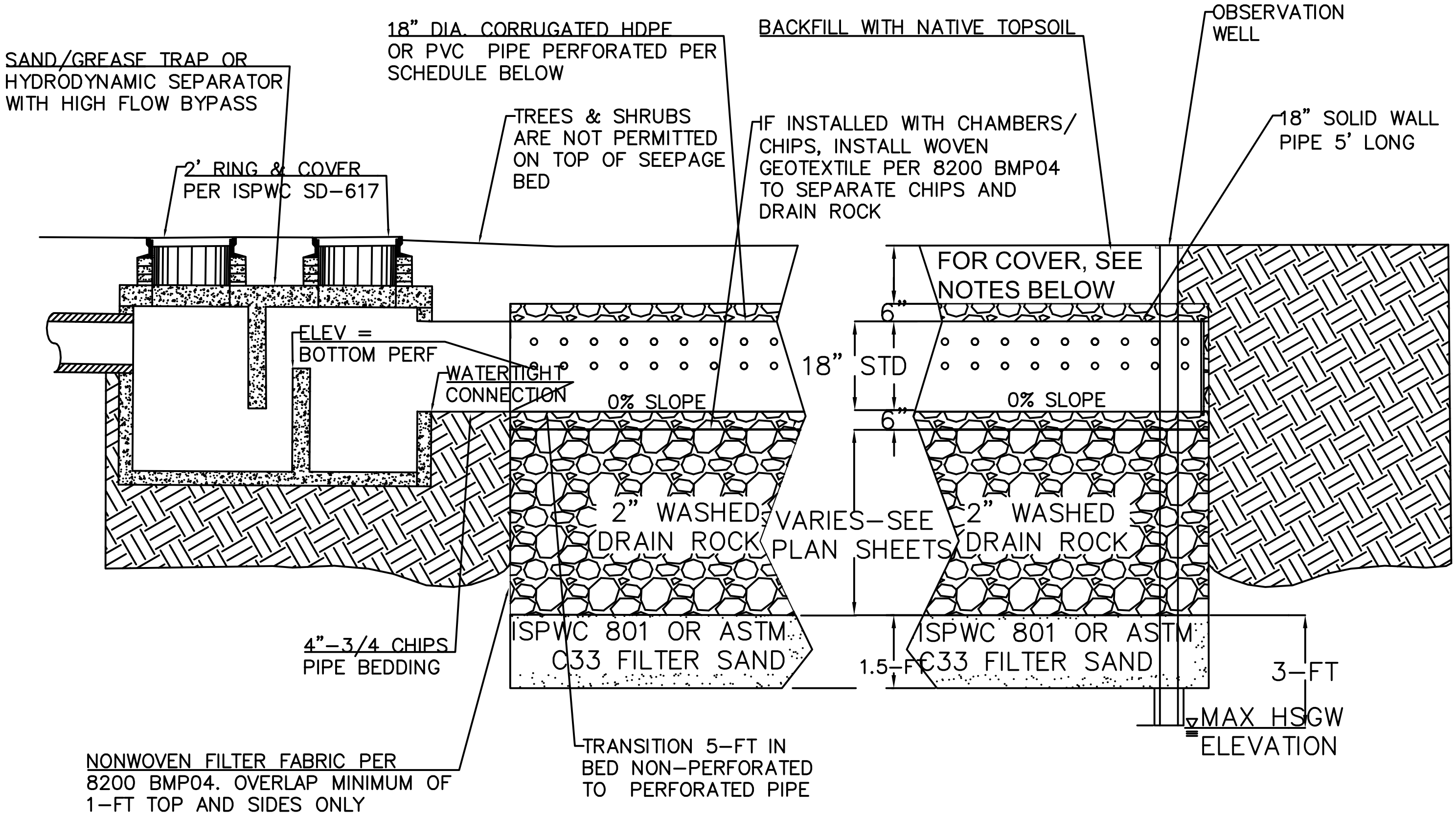
Non-Woven Filter Fabric

Property	Test Method	English
Tensile Strength (Grab)	ASTM D-4632	120 lbs
Elongation	ASTM D-4632	50%
Puncture	ASTM D-4833	65 lbs
Trapezoidal Tear Strength	ASTM D-4533	50 lbs
UV Resistance	ASTM D-4355	70%
Apparent Opening Size (AOS)	ASTM D-4751	70 US Std. Sieve
Permittivity	ASTM D-4491	1.50 sec-1
Water Flow Rate	ASTM D-4491	120 gpm/ft2

Woven Fabric

Property	Test Method	English
Tensile Strength (Grab)	ASTM D-4632	350 lbs
Elongation	ASTM D-4632	20 x 15%
Puncture	ASTM D-4833	150 lbs
Trapezoidal Tear Strength	ASTM D-4533	120 lbs
UV Resistance	ASTM D-4355	80%
Apparent Opening Size (AOS)	ASTM D-4751	35 US Std. Sieve
Permittivity	ASTM D-4491	0.27 sec-1
Water Flow Rate	ASTM D-4491	20 gpm/ft2

Adopted: Res 966
Revised: Res 2035 (4/9/14)



SECTION
NTS

GENERAL NOTES

1. CONTACT DESIGN ENGINEER FOR SEEPAGE BED REDESIGN IF GROUNDWATER IS ENCOUNTERED ABOVE MAX HSGW ELEVATION
2. ALL VAULTS, MANHOLES, & SAND AND GREASE TRAPS SHALL BE HS25 OR GREATER LOAD RATED
3. SEEPAGE BED SHALL BE SHOWN ON BOTH PLAN AND PROFILE VIEWS
4. OPTIONAL CHAMBERS PER MANUFACTURERS SPECIFICATIONS
5. ALL GEOTEXTILE SEAMS SHALL OVERLAP 1 FOOT MINIMUM
6. EL. IN >= EL. BOTTOM PERFORATIONS IN 18" PERF PIPE
7. MAXIMUM BED LENGTH IS 400-FT BETWEEN MANHOLES
8. BED WIDTH SHALL REMAIN CONSTANT
9. 1.5-FT FILTER SAND ALLOWED FOR THIS BMP AND BMP 10 ONLY. ALL OTHER BMPS REQUIRE 3-FT SAND
11. THE DESIGN ENGINEER IS SOLELY RESPONSIBLE FOR ASSESSING THE BEARING RESISTANCE OF THE SUBGRADE SOILS AND DETERMINING THE DEPTH OF FOUNDATION STONE
12. SEE BMP01 FOR SAND/GREASE TRAP DETAILS

FOR SEEPAGE BEDS BEDS IN PUBLIC RIGHT-OF-WAY

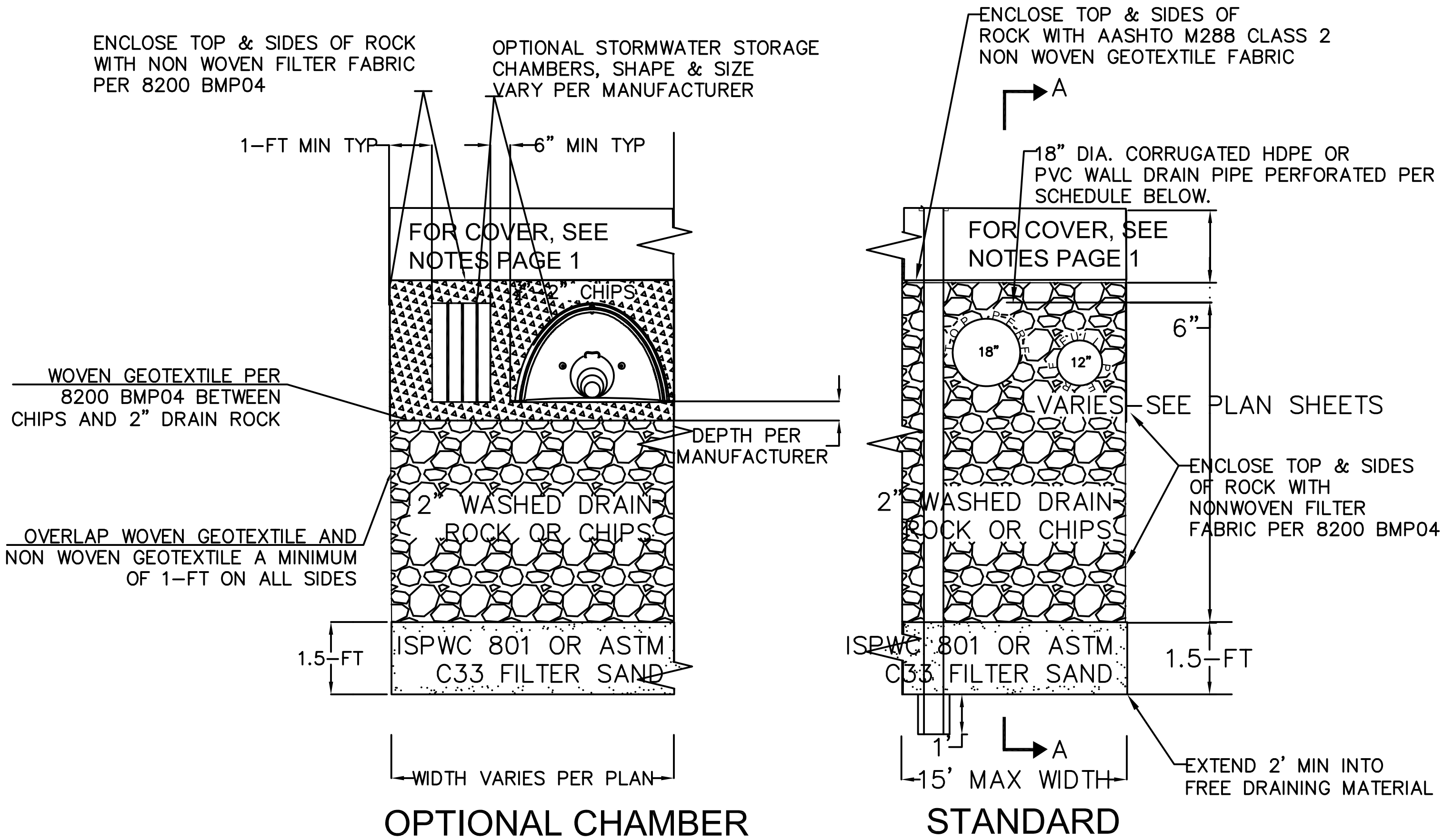
1. A MINIMUM 1-FT COVER FROM TOP OF BED TO ROAD SUBGRADE IS REQUIRED
   --BACKFILL OVER BED TO SUBGRADE WITH 6"-8" MINUS PITRUN
   --WOVEN GEOTEXTILE FABRIC REQUIRED OVER TOP OF BED
2. IF < 1-FT COVER FROM TOP OF BED TO SUBGRADE, ANGULAR $\frac{3}{4}$" TO 2" ROCK IS REQUIRED IN PLACE OF 2" DRAIN ROCK
3. FULL ROADWAY GRAVEL SECTION IS REQUIRED OVER SEEPAGE BEDS. SEEPAGE BEDS SHALL NOT EXTEND ABOVE SUBGRADE

FOR SEEPAGE BEDS BEDS OUTSIDE PUBLIC RIGHT-OF-WAY

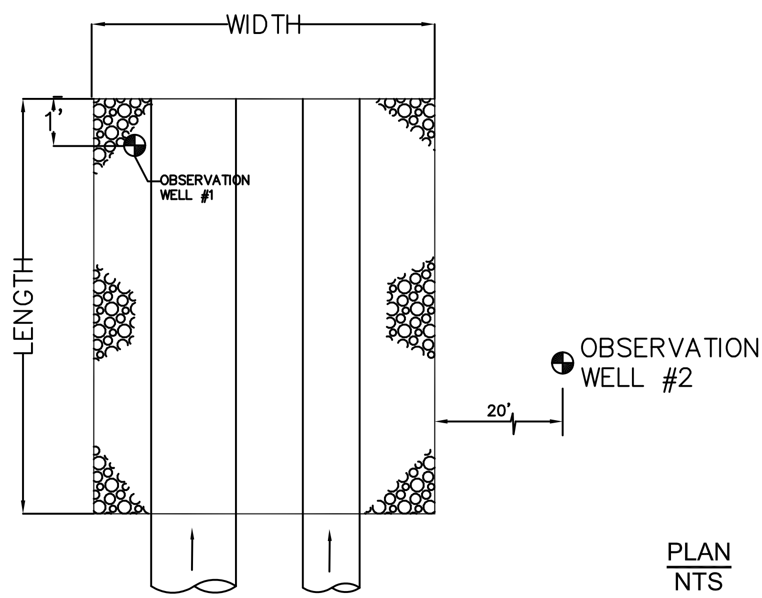
1. A MINIMUM 1.5-FT COVER FROM TOP OF BED TO FINISH GRADE IS REQUIRED

2014

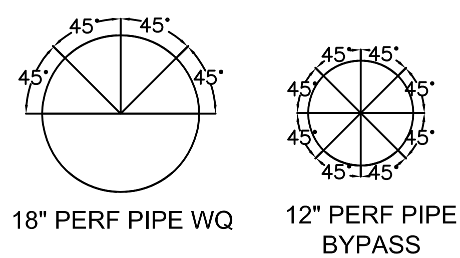
ACHD STORMWATER DESIGN GUIDELINES Adopted: Res 966 Revised: Res 2035 (4/9/14)	SEEPAGE BED WITH OPTIONAL CHAMBERS	STANDARD DRAWING BMP 04 SHT 1 OF 3



SECTION
NTS



PLAN
NTS

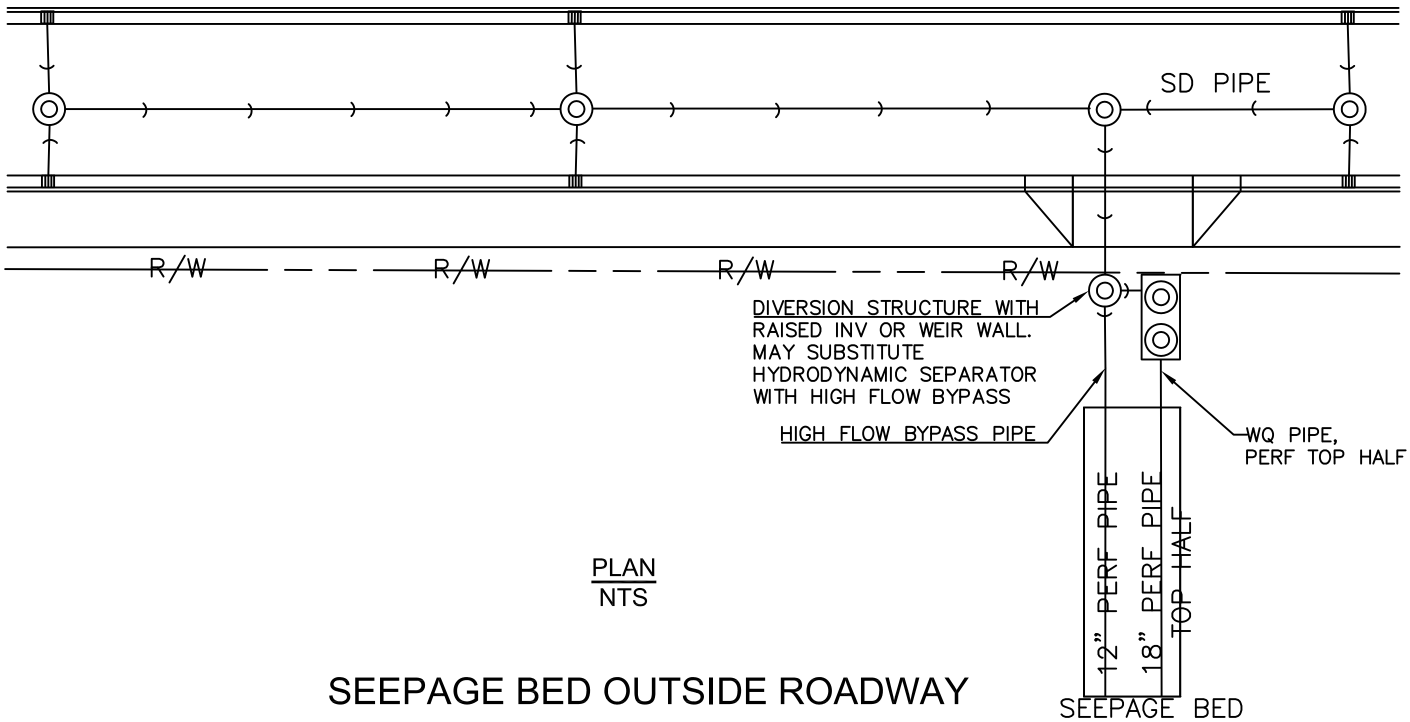


PERFORATION SCHEDULE
3/8" PERFORATIONS IN VALLEYS OF CORRUGATED PIPE. 5 EA ON 18", 8 EA ON 12"

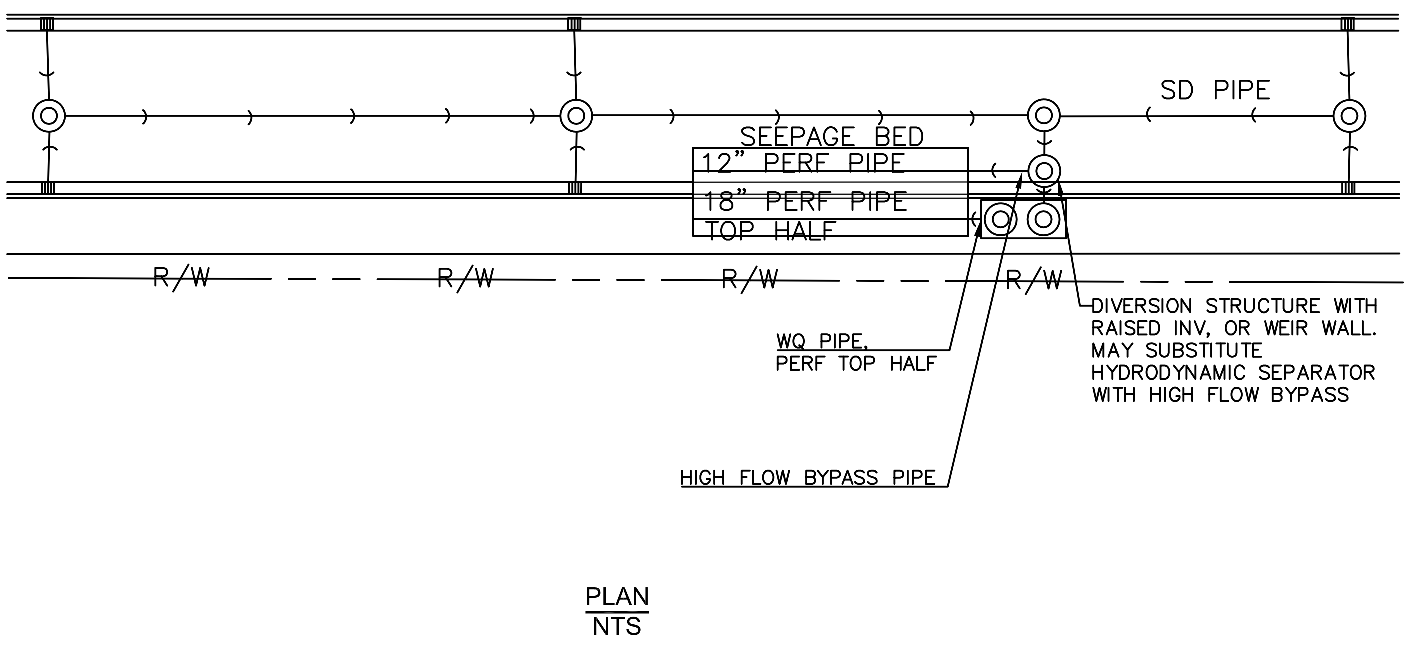
OBSERVATION WELLS: 2 REQUIRED PER BED

2014

ACHD STORMWATER DESIGN GUIDELINES Adopted: Res 966 Revised: Res 2035 (4/9/14)	SEEPAGE BED WITH OPTIONAL CHAMBERS	STANDARD DRAWING BMP 04 SHT 2 OF 3



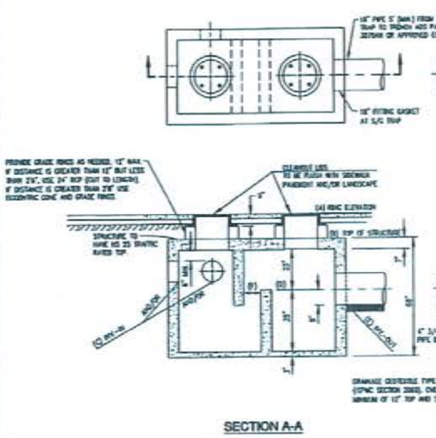
SEEPAGE BED OUTSIDE ROADWAY



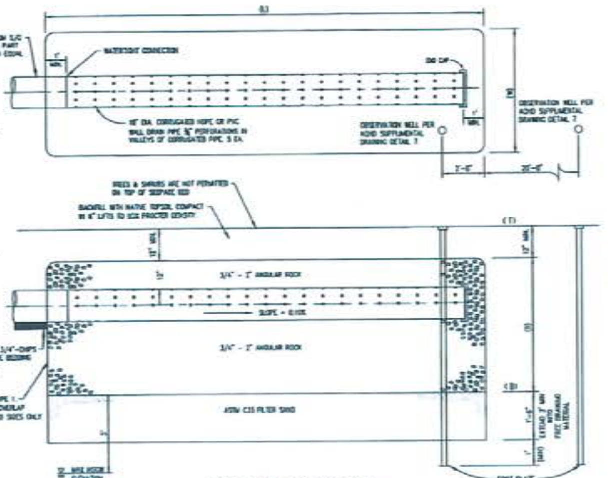
SEEPAGE BED IN RIGHT-OF-WAY

2014

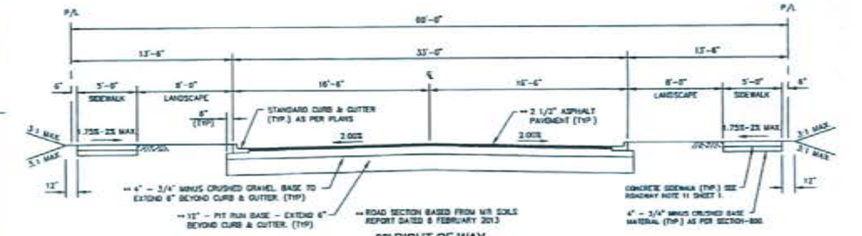
ACHD STORMWATER DESIGN GUIDELINES Adopted: Res 966 Revised: Res 2035 (4/9/14)	ACHD SEEPAGE BED LAYOUT	STANDARD DRAWING BMP 04 SHT 3 OF 3



TYPICAL GREASE/SAND TRAP
(PER ISPWC SD-624)
-NTS-

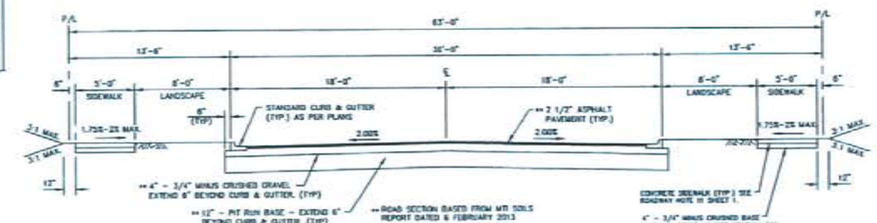


TYPICAL SEEPAGE TRENCH
-NTS-



1-91

60' RIGHT-OF-WAY
33' TYPICAL STREET SECTION
-NTS-



63' RIGHT-OF-WAY
36' TYPICAL STREET SECTION
-NTS-

GREASE/SAND TRAP TABLE:							
G/S TRAP #	GALLON	(A)	(B)	(C)	(D)	(E)	(F)
1	1000	2811.74	2810.26	2808.18	2807.76	2807.01	18"
2	1500	2816.42	2815.02	2812.94	2812.52	2811.77	18"
3	1000	2822.65	2821.17	2819.09	2818.67	2817.92	12"
4	1500	2829.69	2828.29	2826.21	2825.79	2825.04	18"
5	1500	2815.09	2813.12	2811.41	2810.64	2809.89	18"

—1500 gal

SEE STREET PLAN & PROFILES FOR LOCATIONS/SIZES AND TYPE OF PIPES COMING IN AND OUT OF GREASE/SAND TRAPS

* NOTE: BOUYANT WIDTH VARIES ACCORDING TO SPECIFIC LOCATION OF VAULT.

SEEPAGE TRENCH TABLE:							
TRENCH #	(L)	(W)	(D)	(T)	(B)	VOLUME (FT)³	PERC. RT.
1	69'	12'	11'	2811.74	2799.74	3,706	8
2	91'	12'	11'	2816.42	2804.42	4,861	8
3	33'	10'	11'	2822.65	2810.65	1,467	8
4	89'	12'	11'	2829.69	2817.69	4,769	8
5	102'	12'	11'	2815.09	2803.09	5,455	8

SEE STREET PLAN & PROFILE FOR LOCATION OF SEEPAGE TRENCH

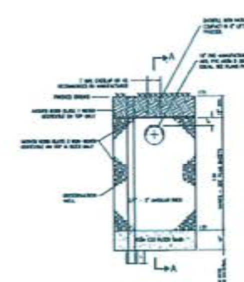
NOTES:

1. DRAINAGE CONTRACTOR SHALL INSTALL 4" SCH 80 WATER CLASS PIPE CONDUITS THROUGH THE SEEPAGE TRENCHES FOR UNDERGROUND POWER LINES, GAS LINES AND TELEPHONE LINES. SEWER SERVICES SHALL BE PLACED IN 4" C 900 PVC CONDUIT THROUGH SEEPAGE TRENCHES. WATER SERVICES SHALL BE PLACED IN 2" SCH 80 PVC CONDUIT THROUGH SEEPAGE TRENCHES. THE PRECISE LOCATION, DEPTH AND SIZE SHALL BE DETERMINED AT THE PRE-CONSTRUCTION CONFERENCE OR BY THE ENGINEER.
2. IF GROUNDWATER IS ENCOUNTERED, THE CONTRACTOR SHALL NOTIFY THE ENGINEER AS SOON AS POSSIBLE FOR REDESIGN OF SEEPAGE TRENCHES TO PROVIDE 3' MIN. CLEARANCE BETWEEN GROUNDWATER AND THE BOTTOM OF THE SEEPAGE TRENCH. UNTIMELY NOTIFICATION OF THE ENGINEER MAY RESULT IN ADDITIONAL COSTS TO THE CONTRACTOR.
3. WHEN ROCK IS ENCOUNTERED, CONTRACTOR SHALL HAVE PERCOLATION TEST PERFORMED BY SOILS ENGINEER AFTER SEEPAGE TRENCH IS FULLY EXCAVATED. IF THE PERCOLATION IS LESS THAN SPECIFIED BY THE SOILS REPORT AND ENGINEER, CONTRACTOR MAY NEED TO BLAST OR BORE TO CREATE CONDUIT FOR DRAINAGE TO OCCUR OR REDESIGN THE SYSTEM TO ACHIEVE THE REQUIRED INFILTRATION.
4. BOTTOM OF SAND LAYER ELEVATION IS THE MINIMUM EXCAVATION.
5. ALL VAULTS, MANHOLES, & SAND AND GREASE TRAPS MUST BE HS25 OR GREATER LOAD RATED.
6. ALL GEOTEXTILE SEAMS SHALL OVERLAP 1 FOOT MINIMUM, UNLESS OTHERWISE DIRECTED PER MANUFACTURE.

PER THE SOILS REPORT BY MATERIALS NATURAL RESOURCE SOLUTIONS, LLC DATED 6 FEBRUARY 2013, GROUNDWATER WAS NOT PRESENT AT DEPTHS BELOW 15.0 FEET (EVEL. 2798) IN ALL 12 TEST PITS. LOWEST NATURAL GROUND ELEVATION AT TEST TP-10 2812.5.

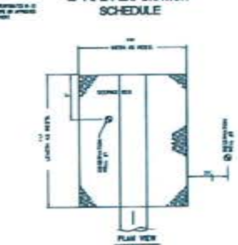
NOTES TO CONTRACTOR:

1) CONTRACTOR TO FIELD VERIFY ALL EXISTING CURB & GUTTER, STORM DRAIN, CHANNEL CROSSINGS, & OTHER ELEVATIONS OR INVERTS PRIOR TO CONSTRUCTION AND NOTIFY ENGINEER WHEN ELEVATIONS OR INVERTS DO NOT MATCH PLANS.
2) THE LOCATIONS OF EXISTING UNDERGROUND UTILITIES ARE SHOWN IN APPROXIMATE LOCATIONS. THE CONTRACTOR SHALL DETERMINE THE EXACT LOCATION OF ALL EXISTING UTILITIES BEFORE COMMENCING WORK. HE AGREES TO BE FULLY RESPONSIBLE FOR ANY AND ALL DAMAGES WHICH MIGHT OCCUR BY HIS FAILURE TO EXACTLY LOCATE AND PRESERVE ANY AND ALL UNDERGROUND UTILITIES.

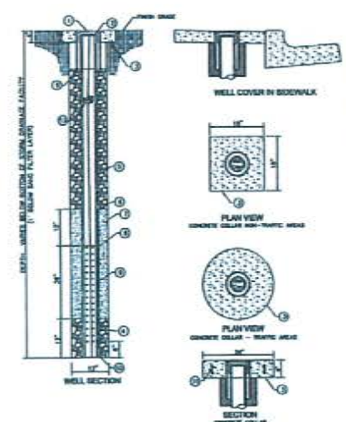


STANDARD

18" PIPE PERFORATION SCHEDULE



OBSERVATION WELL



GROUND WATER OBSERVATION WELL

LEGEND

1. WELL COVER, 8" DIAM. WATERTIGHT GALVANIZED STEEL COVER AND CANISTER.
2. PVC CAP, GASKETED (WATERTIGHT).
3. CONCRETE (COLLAR), CLASS 3000 (ISPWC SECTION 703).
4. 3/4" MINUS CRUSHED AGGREGATE FOR BASE (ISPWC SECTION 802) OR MATERIAL REQUIRED FOR STORM DRAINAGE FACILITY (I.E. 1.5" TO 3" DRAIN ROCK, FILTER SAND).
5. PVC PIPE, 4" DIAMETER ASTM D-3034 SDR 35 FOR DRILLED WELLS. PVC PIPE, 6" DIAMETER ASTM D-3034 SDR 35 FOR WELLS DUG & BACKFILLED (INSIDE SEEPAGE BEDS FOR EXAMPLE)
6. 2 - STAINLESS STEEL HOSE CLAMPS AT 3" SPACING. SECURE GEOTEXTILE IN PLACE.
7. FILTER SAND (ISPWC SECTION 801)
8. PERFORATED PVC PIPE, ASTM D-3034 SDR 35 WITH 4 - 3/8" DIA. HOLES AT 3" ON CENTER.
9. DRAINAGE GEOTEXTILE, TYPE I (ISPWC SECTION 2050).
10. PVC CAP, SOLVENT WELDED OR GASKETED (WATERTIGHT).
11. (3) #4 REBAR HOOPS WITH #4 VERTICALS.
12. NO. 12 AWG. GALVANIZED FINDER WIRE.
13. THREE 6" DIAMETER COILS.

NOTES:

A. WELLS ARE FOR OBSERVATION OF GROUNDWATER LEVEL NEAR STORM DRAINAGE FACILITIES.
B. LOCATION OF GROUNDWATER OBSERVATION WELLS SHALL BE APPROVED BY ENGINEER.

Plans Are Accepted For Public Street Construction

				DESIGNED BY: KAM	DATE: NOV '12
				DRAWN BY: KAM	DATE: NOV '12
				CHECKED BY:	DATE:
				APPROVED:	DATE:
				AS-BUILTS BY:	DATE:
NO.	REVISIONS	BY	DATE		

Engineering NorthWest, LLC BOISE, IDAHO (208)376-5000

RIVERHEIGHTS SUBDIVISION NO. 5

DRAINAGE DETAILS

JOB NO. 11-022

SHEET NO. 6.1

8202.17 BMP 07 Biofiltration Swale (Pretreatment, Primary Treatment & Storage)

Description

This BMP is approved for pretreatment or primary treatment and storage.

Concentrated flows from a pipe network shall be pretreated by another approved pretreatment BMP like a Forebay or Sand/Grease Trap.

Biofiltration swales treat and infiltrate stormwater runoff. They may be used for infiltration or conveyance to storage facility.

Design

For conveyance swales, a hydraulic residence time of 9-minutes is required. Water velocity, as determined by Manning's "n", should not exceed 0.9 feet/second. The maximum depth of flow through a conveyance swale shall be 3-inches.

Swale side slopes shall be no steeper than 3:1.

For surface flow on streets with curb/gutter, flow shall enter the swale through a Shallow Inlet or Scupper Inlet per Details 10 and 11.

Provide for energy dissipation and flow spread using Flow Spreaders, per Detail 4.

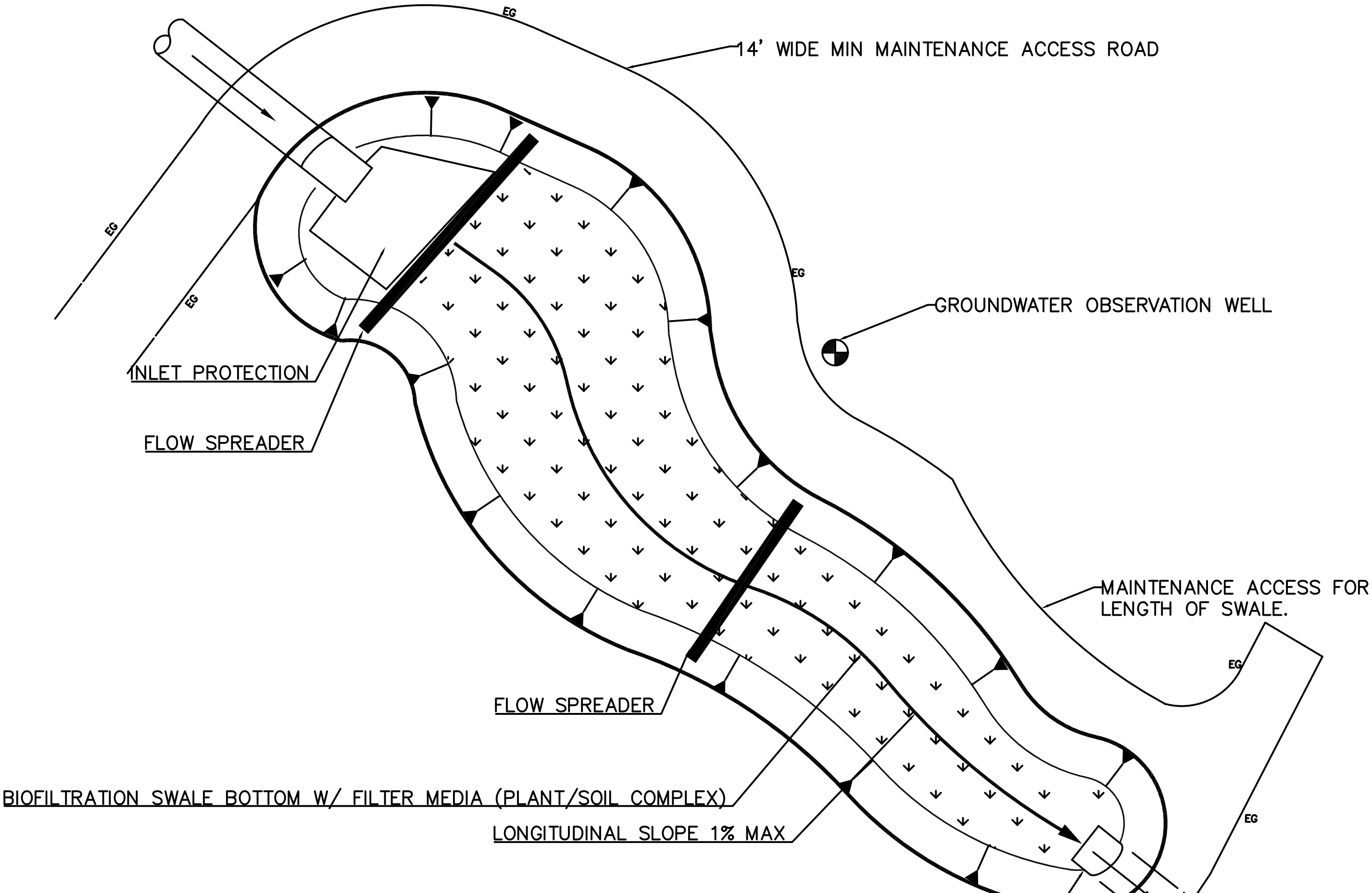
If there is not 3-foot minimum separation to groundwater the swale must be lined with an impervious liner and sloped at a minimum of 1% grade to an outfall.

The length of swale required for pretreatment:

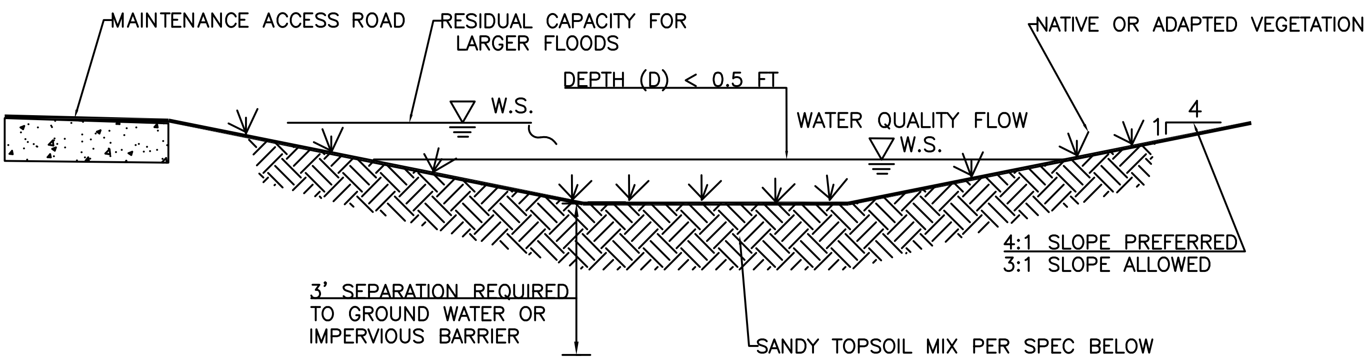
Length = Q_{WQ}/A_{swale} x 540
Where 9 min residence time x 60 sec/min=540
A_{swale} = Cross sectional area of swale

Light maintenance of this BMP, when approved for use by the District, shall be performed by the developer or a homeowner's association unless it is an ACHD owned facility.

Adopted: Res 966
Revised: Res 2035 (4/9/14)



PLAN
NTS



SECTION
NTS

NOTES:

1. SWALE IS DESIGNED FOR INFILTRATION OF STORMWATER AND PLANT UPTAKE. STORMWATER CAN FLOW LONGITUDINALLY IN SWALE. SWALE LONGITUDINAL GRADE SHOULD BE A MAXIMUM OF 1%.
2. SANDY TOPSOIL SPECIFICATIONS:
   *50% COARSE SAND BY VOLUME
   *20% SANDY LOAM
   *30% COMPOST
   *FINES <10% PASSING #200 SIEVE
   *NO CLAY
3. DROUGHT PLANT SPECIES

2014

ACHD STORMWATER DESIGN GUIDELINES Adopted: Res 966 Revised: Res 2035 (4/9/14)	BIOFILTRATION SWALE	STANDARD DRAWING BMP 07

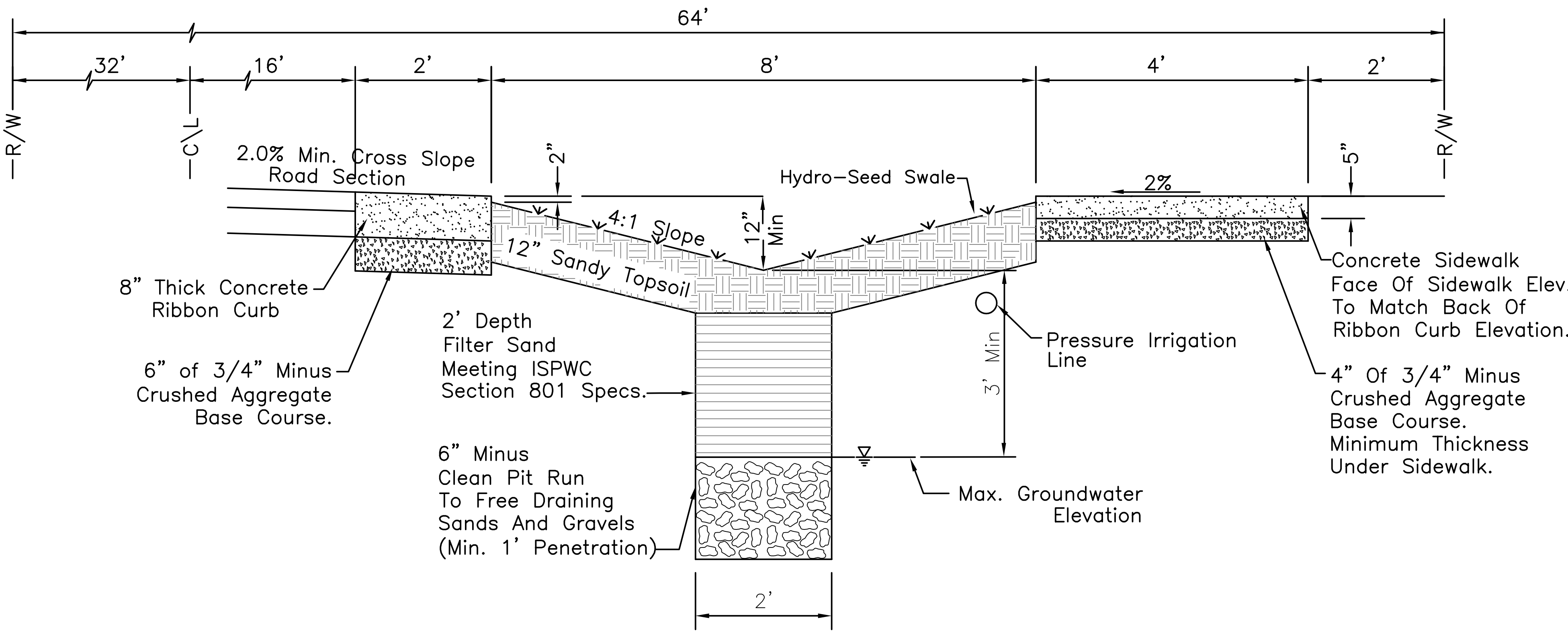
ACHD ROADSIDE INFILTRATION SWALE CRITERIA AND DESIGN DETAILS
Adopted by Commission Action February 25, 2004

Roadside Infiltration Swales shall be considered under the following conditions:

- Developments outside a city's area of impact; or,
- Infill developments within city limits in areas without existing urban street improvements; or,
- Developments meeting both of the following conditions:
  - High groundwater or shallow bedrock
    - conventional piped system to a retention or detention facility not feasible due to separation requirements; and
  - No available outlet
    - no discharge to existing waterway, drain or irrigation facility available.

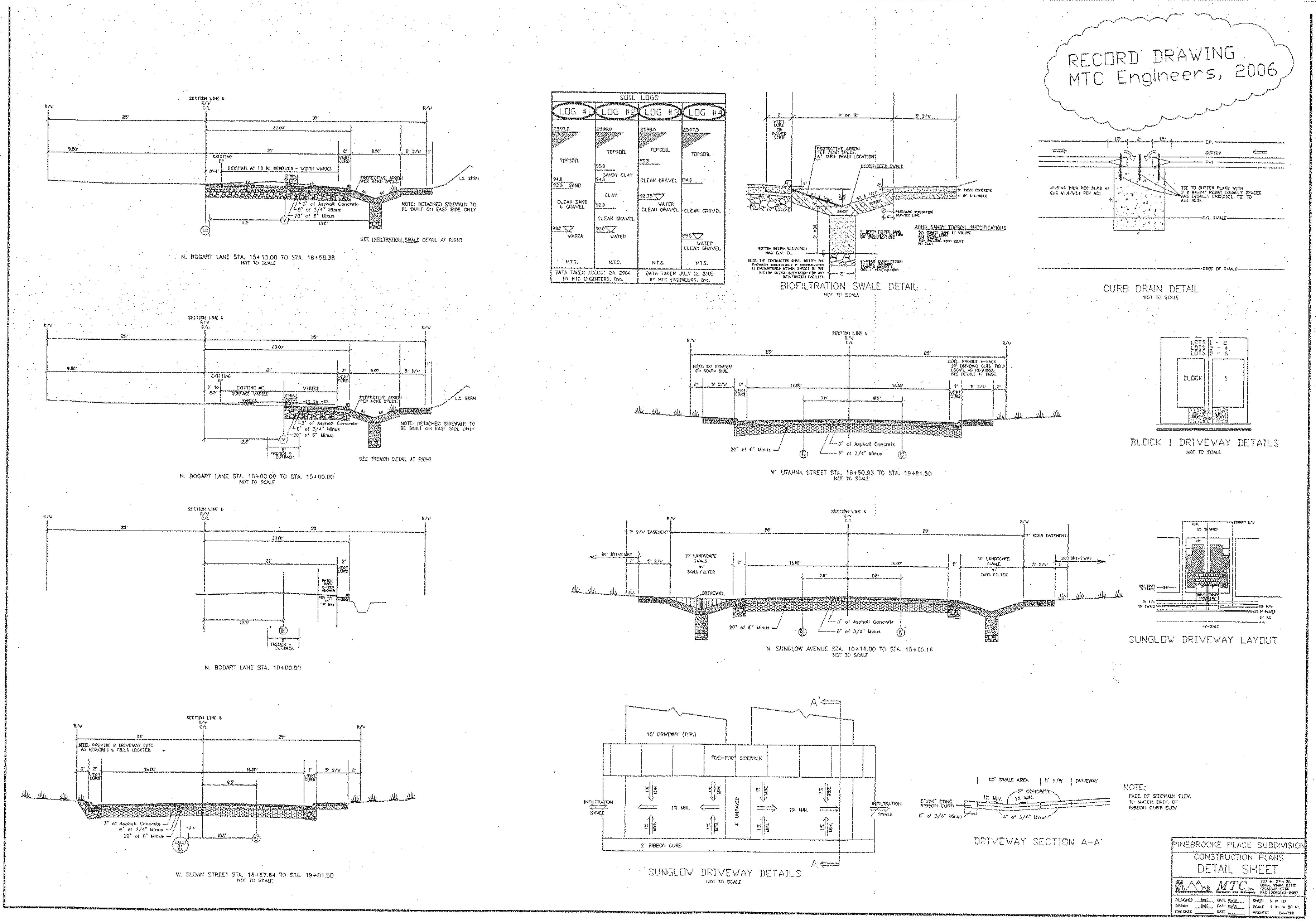
<u>DESIGN</u>

- Road section shall consist of a minimum 32-feet of pavement, 2-foot ribbon curb 8-inches thick on each side, a minimum 8-foot wide swale a minimum of 1-foot deep on each side, and a 4-foot wide 5-inches thick concrete sidewalk on each side.
  - Sidewalk required in developments with lot sizes less than 1-acre.
  - If no sidewalk is required, a 1-foot wide 8-inches thick ribbon curb is required at the top back of swale.
  - Minimum road cross slope 2%.
  - Maximum swale profile grade 1%.
- Swale shall be located within the public right-of-way, sidewalk may be placed in an easement. Minimum right-of-way width of 52-feet required for a 36-foot street section as measured from back-of-curb to back-of-curb.
- Swale shall be constructed with maximum 4:1 slopes, a minimum of 8-feet in width and a minimum of 1-foot in depth as measured from the top of slope.
  - Minimum 3-foot separation to groundwater or bedrock required from flow line of swale.
  - A continuous sand trench a minimum of 2-feet in depth and 2-feet in width required below swale.
    - Trench shall be excavated to free draining sands and gravels.
    - In areas of shallow bedrock design must demonstrate acceptable percolation rate and that adjoining properties will not be negatively impacted by storm water infiltration.
    - Trench shall be filled with filter sand meeting ISPWC Section 801 specifications.
  - 12 inches of sandy topsoil required full width of swale. Sandy topsoil shall meet the following specifications:
    - 50% coarse sand by volume,
    - 20% sandy loam,
    - 30% compost,
    - Less than 10% fines passing #200 sieve,
    - No clay.
  - A 2" reveal required from top finish grade of swale to top of concrete at ribbon curb and sidewalk.
- Vertical curb required at main entryways beyond radius a minimum of 50-feet or past entryway island taper, whichever is greater.
- Maximum 20' driveway width (across swale area) for lots 80' wide or less
- Maximum driveway width of 30% of lot frontage for lots > 80' wide.



ROADSIDE INFILTRATION SWALE CROSS SECTION

Sidewalk Required


RECORD DRAWING
MTC Engineers, 2006
N. BOGART LANE STA. 15+13.00 TO STA. 16+58.38
NOT TO SCALE
NOTE: DETACHED SIDEWALK TO BE BUILT ON EAST SIDE ONLY
SEE INFILTRATION SWALE DETAIL AT RIGHT
N. BOGART LANE STA. 10+00.00 TO STA. 15+00.00
NOT TO SCALE
SEE TRENCH DETAIL AT RIGHT
N. BOGART LANE STA. 10+00.00
W. SLOAN STREET STA. 18+57.64 TO STA. 19+81.50
NOT TO SCALE
3" of Asphalt Concrete
6" of 3/4" Minus
20" of 6" Minus
SOIL LOGS
LOG #1
2597.5
TOPSOIL
94.0
93.5 SAND
CLEAN SAND & GRAVEL
90.0 WATER
N.T.S.
LOG #2
2599.0
TOPSOIL
95.0
SANDY CLAY
94.0
CLAY
92.0
CLEAN GRAVEL
90.0 WATER
N.T.S.
LOG #3
2598.0
TOPSOIL
95.5
CLEAN GRAVEL
92.75 WATER
CLEAN GRAVEL
N.T.S.
LOG #4
2597.5
TOPSOIL
94.0
CLEAN GRAVEL
89.5 WATER
CLEAN GRAVEL
N.T.S.
DATA TAKEN AUGUST 24, 2004 BY MTC ENGINEERS, Inc.
DATA TAKEN JULY 11, 2005 BY MTC ENGINEERS, Inc.
BIOFILTRATION SWALE DETAIL
NOT TO SCALE
CURB DRAIN DETAIL
NOT TO SCALE
W. UTAHNA STREET STA. 16+50.03 TO STA. 19+81.50
NOT TO SCALE
BLOCK 1 DRIVEWAY DETAILS
NOT TO SCALE
N. SUNGLOW AVENUE STA. 10+16.00 TO STA. 15+10.16
NOT TO SCALE
SUNGLOW DRIVEWAY LAYOUT
16' DRIVEWAY (TYP.)
FIVE-FOOT SIDEWALK
INFILTRATION SWALE
2' RIBBON CURB
SUNGLOW DRIVEWAY DETAILS
NOT TO SCALE
DRIVEWAY SECTION A-A'
NOTE:
FACE OF SIDEWALK ELEV. TO MATCH BACK OF RIBBON CURB ELEV.
PINEBROOKE PLACE SUBDIVISION
CONSTRUCTION PLANS
DETAIL SHEET
MTC
SHEET 9 of 10

Appendix E: Communication and Field Data Forms

Sampling Event Communication Form

Form 2A-2B Setup/Shutdown Checklist

Chain-of-Custody Form

example ~ SAMPLING EVENT COMMUNICATION FORM ~ example

Date: 24 Jan 2014 **Time:** 8:26 **Initials:** ML

Sampling Event Determination

Is there a targeted sampling event expected during the next 36 hours?
(Or, if it is Friday, is a targeted event expected before 5:00 PM on Monday?)

○ Yes ○ Maybe ● No

If YES or MAYBE, then call BC. Include discussion of reasons for "Maybe" below.

☐ Date and Time of Expected Event
☐ Expected Amount of Precipitation
☐ Percent Chance of Precipitation

Targeted Stations & Samples

Americana	**Main**	**Lucky**	**Stilson**	**Whitewater**
☐ Grab	☐ Grab	☐ Grab	☐ Grab	☐ Grab
☐ Composite	☐ Composite	☐ Composite	☐ Composite	☐ Composite

Phase II

Chrisfield	**Edgewood**
☐ Grab	☐ Grab

Type of Forecasted Precipitation

☐ Light Rain ☐ Thunder Showers ☐ Other (Describe below)
☐ Rain ☐ Snow Melt
☐ Scattered Showers ☐ Rain on Snow

Reasons for Not Targeting a Forecasted Storm or Targeting Selected Stations/Samples

☐ Equipment Concerns (Describe below) ☐ Holiday ☐ Other (Describe below)

☐ Waiting on Antecedent Dry Period. Expires:

Comments

Issued by: National Weather Service Boise, ID
Last Update: 3:20 am MST Jan 24, 2014

Short Term Forecast

Today: A chance of flurries before 11am. Widespread haze after 11am. Patchy fog before 11am. Otherwise, cloudy, with a high near 31. Calm wind.
Tonight: Widespread haze before 11pm. Patchy fog after 11pm. Otherwise, cloudy, with a low around 24. Calm wind.
Saturday: Widespread haze after 11am. Patchy fog before 11am. Otherwise, cloudy, with a high near 31. Calm wind.
Saturday Night: Patchy fog. Otherwise, cloudy, with a low around 23. Calm wind.
Sunday: Widespread haze after 11am. Patchy fog before 11am. Otherwise, cloudy, with a high near 30. Calm wind.
Sunday Night: Patchy fog. Otherwise, cloudy, with a low around 24.
Monday: Widespread haze after 11am. Patchy fog before 11am. Otherwise, cloudy, with a high near 30.
Monday Night: Patchy fog. Otherwise, cloudy, with a low around 28.
Tuesday: Widespread haze after 11am. Patchy fog before 11am. Otherwise, cloudy, with a high near 32.
Tuesday Night: Patchy fog. Otherwise, cloudy, with a low around 29.
Wednesday: Widespread haze after 11am. Patchy fog before 11am. Otherwise, cloudy, with a high near 34.
Wednesday Night: Patchy fog. Otherwise, cloudy, with a low around 26.
Thursday: Widespread haze after 11am. Patchy fog before 11am. Otherwise, cloudy, with a high near 34.

NATIONAL WEATHER SERVICE BOISE ID
311 AM MST FRI JAN 24 2014

.SHORT TERM...**TODAY THROUGH SATURDAY**...**THE INVERSION WILL STRENGTHEN OVER THE NEXT COUPLE OF DAYS INCREASING HIGH TEMPERATURES ACROSS THE ID MTNS AND HIGHER TERRAIN OF SE OREGON THROUGH SATURDAY.** LOW CLOUDS WILL CONTINUE TO BREATHE BACK AND FORTH IN THE SNAKE RIVER VALLEY AND SE OREGON...EXPANDING AT NIGHT AND CONTRACTING DURING THE DAY. **TODAY WILL BE MUCH LIKE THURSDAY** AS A SOUTHEASTERLY NEAR-SURFACE WIND WILL ERODE THE LOW CLOUDS TO

Form 2A
SET-UP/SHUT-DOWN CHECKLIST – Phase I

Station : ___________________________ Bottle _____ of _____

SET-UP:

Date/Time On-site: _______________________MDT/MST*(circle one) Personnel: ________________

____ Record Flow Meter status (use chart); Replace battery if v<11.9

____ If background flow is present, decon. Sampler line (HCl), rinse, collect dry weather sample per flow chart ; Complete Form 1A,1B

____ Download Flow Meter to perform velocity cut-off calculations Downloaded to:________

Flow Meter Status & Velocity Cut-off Chart					
Time/Date					
Level					in.
Flow					cfs
Velocity					fps
Total					cf
Battery					V

72 Hour Velocity Mean___________ Velocity Cut-off (Mean + 2*StdDev)_______

Trigger Volume_______________

____ Repeat decon. cycle per flow chart (HCl, rinse)

____ Install battery on Sampler at Lucky, Stilson, Whitewater

____ Place 15L sample bottle in cooler; fill cooler with 1 bag ice

____ Open sample jar bag; Remove jar lid and place in a clean re-sealable plastic bag; place tubing in hole in cap of bottle; @ Lucky place sample jar lid under Sampler top cover

____ Verify all cable and tubing connections

____ Set Flow Meter and Sampler program parameters

____ Start Flow Meter program and Sampler program; Verify Running

____ If dry weather samples were collected, complete Chain of Custody (COC) form; arrange lab transport

Comments:

Date/Time Off-site:_________________

COMPOSITE SAMPLE COLLECTION

Date/Time On-site: ______________________________ Personnel: ________________________

____ Halt Sampler program

____ Put lid on sample bottle

____ Properly label sample bottle; Record Sample ID on back of sheet

____ Record liquid height/sample volume and visual observations on back of sheet

If Sampling is Complete:

____ Power off Samplers

____ Disable Flow Meter pacing

____ Resume Flow Meter program

____ Verify Flow Meter is running

If Continuing Sampling (sample bottle change out):

____ Download sampler. Downloaded to:__________

____ Keep Flow Meter running

____ Install new 15 L bottle, add ice

____ Restart program from beginning; Verify running

____ Add ice to sample transport container cooler

____ Complete Chain of Custody (COC) form; Arrange transport to lab

Comments:

Date/Time Off-site:____________________

SHUT-DOWN:

Date/Time On-site: ______________________________ Personnel: ________________________

____ Record Flow Meter status: Replace battery if v<11.9

____ Halt programs on Flow Meter & Sampler

____ Download data from Flow Meter & Sampler. Downloaded to:__________________________

____ Remove Sampler battery at Lucky

____ Change velocity cutoff to 0.02 fps if it was changed during sampling event

____ Restart Flow Meter program from beginning; Verify Running

Flow Meter Status		
Level		in.
Flow		cfs
Velocity		fps
Battery		V

Comments: Date/Time Off-site:______________________

Form 2B
COMPOSITE/LARGE VOLUME SAMPLE INFORMATION – Phase I

Sample ID: ______________________ Comp (fill in station name) Bottle _____ of _____

Sample Quantitative Results

Component	Value	Unit
Composite Sample Volume (Approx.)	____________________	mL
Trigger volume	____________________	ft^3

Liquid Height vs. Approximate Sample Volume Conversion Chart

Liquid Height	Sample Volume	Liquid Height	Sample Volume	Liquid Height	Sample Volume	Liquid Height	Sample Volume	Liquid Height	Sample Volume	Liquid Height	Sample Volume
0.5 “	400 mL	4.0 “	5000 mL	7.5 “	10250 mL	After 2”:					
1.0 “	800 mL	4.5 “	5750 mL	8.0 “	11000 mL	1” =	1500 mL				
1.5 “	1400 mL	5.0 “	6500 mL	8.5 “	11750 mL						
2.0 “	2000 mL	5.5”	7250 mL	9.0”	12500 mL						
2.5 “	2750 mL	6.0 “	8000 mL	9.5 “	13250 mL						
3.0 “	3500 mL	6.5 “	8750 mL	10.0 “	14000 mL						
3.5 “	4250 mL	7.0 “	9500 mL	10.5 “	14750 mL						

Sample Qualitative Results

Component	Description	Examples
Clarity	____________________	Clear, Cloudy, Silty
Color	____________________	Clear, Gray, Tan, Brown, Black

Subsample Information:

Trigger #	Date/Time MDT/MST (circle one)	Sampler Message / Subsample Result	Trigger #	Date/Time	Sampler Message / Subsample Result
1			21		
2			22		
3			23		
4			24		
5			25		
6			26		
7			27		
8			28		
9			29		
10			30		
11			31		
12			32		
13			33		
14			34		
15			35		
16			36		
17			37		
18			38		
19			39		
20			40		

Notes: The date/time for the first trigger is the “Start Date/Time”; The date/time for the final trigger is the “End Date/Time”

COMMENTS:

Sample ID: QC - ____________ (fill in appropriate sequential number) Sample Type: Laboratory Split

QA Sample? ☑ **QA SAMPLE TYPE:** Laboratory split duplicate

SUBSAMPLE INFORMATION:

Date/Time MDT/MST (circle one)	Container - Test (Subsample Result)
12:00	COC Sample Date & Time

Notes: Use the “Start Date/Time” and “End Date/Time” for the parent sample.

**MST is observed during fall and winter; MDT is observed in spring and summer.*

Ada County Highway District

Attn: Monica Lowe
3775 Adams Street
Garden City, Idaho 83714–6418
Tel. (208) 387–6255
Fax (208) 387–6391

Purchase Order: ______________________

Project: ______________________

Sampler(s): ______________________

____

____

						Matrix	Type																		
Lab#	**Begin Date**	**End Date**	**Begin Time**	**End Time**	**Sample Identification**	Water	Grab	Composite	BOD_5 - SM 5210 B	COD - Hach 8000	TSS - SM 2540 D	TDS - SM 2540 C	TKN - Perstorp PAI-DK01	TP - EPA 200.7	Orthophosphate - EPA 365.1	Total As, Cd, Pb - EPA 200.7	Diss. Cd Cu, Pb, Zn - EPA 200.7	Total Hg - EPA 245.2	E. Coli - IDEXX Colilert	Turbidity - EPA 180.1	Hardness - SM2340 B	NO_3+NO_2 - EPA 353.2	NH_3 - SM 4500 NH_3 - D		Total Containers

Relinquished by (sign)	**Date & Time Transferred**	**Received by (sign)**	**Comments/Special Instructions:**

Appendix F: Standard Operating Procedures and Procedure Guidance

Appendix 14
Permeable Paver Monitoring Plan

Permeable Paver Monitoring Plan

Prepared by

Ada County Highway Department

Garden City, ID

September 8, 2014

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Appendix E: Observation Forms **WW**

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Appendix G: Standard Test Method for Surface Infiltration

Rate of Permeable Unit Pavement System **BBB**

1. Introduction

1.1 Basis for Monitoring Plan

Ada County Highway District (ACHD) is installing a Green Stormwater Infrastructure (GSI) pilot project which involves the installation of permeable paver systems in two alleys located in downtown Boise, Idaho.

Alley 1 – located between Idaho St. and Main St., between 3rd St. and 4th St.
Alley 2 – located between Idaho St. and Main St., between 13th St. and 14th St.

This monitoring plan is designed to assess the effectiveness of permeable pavers as a GSI practice for alley retrofit projects. GSI practices have been developed to reduce onsite runoff from reaching the stormwater conveyance system and thereby reduce pollutant loads associated with runoff. The goal of GSI projects are to closely mimic a site's predevelopment hydrology by using techniques which infiltrate, filter, store or detain stormwater rather than convey it offsite to receiving water bodies, such as the Boise River. Permeable pavers are concrete block paver systems which allow stormwater to infiltrate into a gravel base. The gravel base creates a 'reservoir' in the void spaces to store stormwater and allow it to infiltrate into pervious soils below.

The National Pollutant Discharge Elimination System (NPDES) Phase I Permit No. IDS-027561 (Permit) was issued effective February 1, 2013, to Ada County Highway District (ACHD), Boise State University, City of Boise, City of Garden City, Drainage District #3, and the Idaho Transportation Department District #3, referred to as the "Permittees". The Permit requires that the Permittees identify and construct three Low Impact Development (LID) or Green Stormwater Infrastructure (GSI) pilot projects. The Permit outlines the following requirements for the performance evaluation of GSI techniques (II.B.2.C.ii):

The Permittees must monitor, calculate or model changes in runoff quantities for each pilot project site in the following manner:

1. *For retrofit projects, calculate changes in runoff quantities as a percentage of 100% pervious surface before and after implementation of the LID practice;*
2. *Measure the runoff flow rate and prepare runoff hydrographs to characterize peak runoff rates and volumes, discharge rates and volumes, and duration of discharge volumes;*

3. *Quantification and description of each type of land cover contributing to surface runoff for each pilot project, including area, slope, vegetation type and condition for pervious surfaces, and the nature of impervious surfaces;*
4. *Use runoff values to evaluate the overall effectiveness of various technique(s) or practice(s) that address appropriate use, design, type, size, soil type and operation and maintenance practices.*

Permit section II.B.2.C can be found in Appendix A.

In addition to the Permit requirements, this monitoring plan is based on level of service goals and outcome levels identified in the Program Monitoring and Evaluation Plan (PMEP, 2013). The PMEP provides guidance to tie together all monitoring requirements under the Permit (i.e. stormwater outfall monitoring, dry weather monitoring, structural control monitoring, and GSI monitoring).

This plan focuses on monitoring the performance of the permeable paver systems installed at the two identified alley locations in downtown Boise. The alley permeable paver project is considered one of the three required GSI pilot projects.

Precipitation volume and onsite conditions will be monitored at least until the project's final evaluation, due the 5th year of the Permit (December 2018). The performance monitoring approach described in this plan will provide the required information to complete the overall evaluation of this GSI technique. If the evaluation results are positive then an incentive strategy will be developed to encourage the increased use of permeable pavers as a GSI technique in both private and public sector development projects throughout the Permit area.

1.2 Plan Objectives

The paver systems will be monitored to (1) determine the effectiveness of the systems in reducing runoff and thereby reducing pollutants discharging off site, (2) to evaluate performance relative to design parameters and (3) to understand the maintenance requirements of these systems.

The PMEP provides guidance for the evaluation and assessment of GSI projects and designates that flow reduction can be viewed as a surrogate for pollutant load reduction due to the difficulties of directly monitoring pollutants in these systems (PMEP 4.4.2). The objectives of this plan are generally focused on understanding the hydrology of the sites before and after the installation of the permeable pavers. The monitoring objectives focus on quantifying the reductions in flow resulting from the paver systems. The information collected under this plan will assist in determining if this project meets the Outcome Levels and ultimately the Level of Service priorities outlined in the PMEP for this GSI solution.

This plan is designed to direct data collection efforts to assist in meeting the Permit requirements and in addressing the PMEP assessment and evaluation guidance. The Permeable Paver Monitoring Plan (PPMP) outlines specific modelling, data collection and analysis to meet the following plan objectives:

1. Estimate changes in runoff quantities and flow rates
2. Develop site hydrographs
3. Compare pre and post-construction site hydrological conditions
4. Assess performance and maintenance effectiveness
5. Collect physical data to validate modelled results and observational data

1.3 Organization

The Permit requirement for evaluation and assessment of (3) GSI pilot projects is a joint Permittee responsibility. ACHD is the lead agency for monitoring activities under the Permit. ACHD stormwater staff will be responsible for data collection, management and reporting as specified in this plan.

2. Project Details

Two alleyways in the downtown Boise, Idaho were reconstructed using permeable pavers. Both of the alleys were experiencing deterioration due to drainage problems and deferred maintenance. The reconstruction involved installing a permeable paver system with a shallow gravel filled reservoir as a base to capture and infiltrate stormwater during storm events.

2.1 Permeable Paver Drainage System Description

The installation of the permeable pavers involved removal of any existing paving and sub base, re-grading the site, installation of concrete surfaces surrounding the paver system, installation of the permeable pavers, installation of asphalt paving to tie into existing asphalt, and installation of observation wells. The permeable paver drainage system consists of a 6 foot 8 inch wide strip of permeable pavers located in the middle of each alleyway extending the entire length of the alley. The pavers have a 1.5 foot crushed rock retention bed. The retention bed allows stormwater runoff to infiltrate into the existing underlying soils. Terracon tested the underlying soils and found they infiltrate approximately 0.5 inches per hour. Any runoff that exceeds the infiltration rate and reservoir capacity of this system will sheet flow to the existing storm water conveyance system. Run-off from both of the alleys currently discharges to the Boise River.

The drainage system has been sized to store the 80th percentile storm event which is equal to a 1 hour event producing 0.34 in. The sizing was based on ensuring that the "first flush" of stormwater under most storm conditions would be retained on site. Water draining into the alleys includes direct rainfall and runoff from adjacent parking lots and roof drains, as explained in the Site Description section below. The GSI evaluation will be considering the appropriateness of the design sizing based on the hydrologic performance data collected according to this monitoring plan.

Appendix B includes the project plan set including the demolition plans, site plans and grading plans.

2.2 Site Descriptions

The following site descriptions and associated maps provide the required information outlined in Permit Section II.B.2.c.ii, including land cover, area, slope, pervious area description and impervious area descriptions, as well as geotechnical study results. Photographs of the project sites before and after construction, as well as detailed maps of the project location are included in Appendix C. A drainage and geotechnical report completed by The Land Group, Inc. and Terracon is included in Appendix D.

Alley 1 – located between Idaho St. and Main St., between 3rd St. and 4th St., Boise, Idaho

Land cover**:** asphalt road surface, roof tops, concrete, gravel and permeable pavers

Total drainage area**:** 23,433 sq. ft.

Rooftop drainage area: 10,897 sq. ft.

Alley/Parking Lot drainage area: 12,286 sq. ft.

Permeable Paver area: 2,001 sq. ft.

Area description**:** 89% impervious

Slope: The soil subgrade slope is generally level; the final paver design involves north/south slopes ranging from 1% to 4% directing flows to the center of the alley where the pavers are located; the centerline grading plan specified slopes from the center of the alley to the west ranging from 0.01% to 7.5% and slopes from the center to the east range from 0.2% to 3.75% directing excess flows out of the system to both 3rd Street and 4th Street.

Underlying soils**:** medium colored, silty sand with a trace of gravel

Percolation rate of underlying soil: 0.5 inches per hour

Alley 2 – located between Idaho St. and Main St., between 13th St. and 14th St., Boise, Idaho

Land cover: gravel road surface, roof tops

Total drainage area: 40,148 sq. ft.

Rooftop drainage area: 34,579 sq. ft.

Alley/Parking Lot drainage area: 5,569 sq. ft.

Permeable Paver area: 2,001 sq. ft.

Area description: 95.5% impervious

Slope: The soil subgrade slope is generally level on the eastern half of the alley and slopes to the south on the western half; the final paver design involves slopes on the western half of the alley sloping southward between 2% and 4% directing flow to the south side of the paver system, for the eastern half slopes range from 1% to 5% directing flows to the center of the alley; the centerline grading plan calls for slopes ranging from 0.07% to 4.5% directing flows primarily to the west (14th Street).

Underlying soils: medium colored, poorly graded, silty sand

Percolation rate of underlying soil: 0.5 inches per hour

2.3 Site Selection

The site selection process involved collaboration with Boise City Public Works, Boise City Downtown Business Association and Boise City Planning and Development Services, as well as ACHD Maintenance and Stormwater personnel. A prioritized list of alleys needing repairs was developed by Boise City which was reviewed by ACHD. There were various considerations in determining which alleys to focus on for the pilot project including parking, trash/oil pick-up, dumpster types, presence of utilities and pedestrian usage. The two alleys chosen were in need of repair and the least amount of inconvenience was anticipated and during the construction phase. Some unforeseen utility complications arose in both alleys and how they impact the design of paver performance will be discussed in the evaluation.

In accordance with guidance provide provided in the PMEP, Alley 2 was one of the preferred locations because it is within the Americana subwatershed. This subwatershed is one of the five subwatersheds that are part of the stormwater monitoring efforts outlined in Section IV of the Permit. This area is also one of the two subwatershed planning areas where plans are being developed in compliance with Section II.A.4 of the Permit. The information gained from monitoring this project will help to inform the pollution reduction strategies being developed for stormwater monitoring and subwatershed planning.

3. Monitoring and Data Collection

Data collection will involve compiling information from three sources: hydrological modeling, on-site observations, and physical data collection. Modelled results will be assessed against observations and actual physical site data as this information is collected over time. The data collected will be used for the overall evaluation of using permeable pavers as a GSI practice, to refine design specifications for future permeable paver projects and to assist in developing appropriate incentive strategies for promoting green infrastructure.

3.1 Hydrologic Modelling

Since inflow measurement is inherently difficult in urban environments because GSI designs seek to disperse flow rather than concentrate it, modeling flows is an acceptable alternative to measuring inflow to the GSI. At the permeable paver sites, the drainage areas are nearly 100% impervious. The hydrological modeling will involve running various storm scenarios using the Oregon State Porous Pavement Hydrologic Calculator, which will allow us to characterize the hydrologic characteristics of the sites. This calculator will calculate runoff quantities, runoff flow rates and allow for the development of hydrographs characterizing the hydrologic performance of the sites before and after the implementation of the GSI project.

The Oregon State University (OSU) Porous Pavement Hydrologic Calculator (OSU Calculator) uses the rational method to calculate peak flows. According to Oregon State University Stormwater Assessment and Management, "Generally, the rational method isn't recommended for volume sensitive calculations" (2014). However, since the Urban Hydrology for Small Watersheds TR-55 model isn't able to accurately calculate storms under 1 inch or small areas, the OSU Calculator is the best option to model the alley sites at this time. The OSU Calculator applies the rational method in 10 minute increments and uses the Santa Barbara Urban Hydrograph (SBUH) Type 1A rainfall distribution, which synthetically distributes 24-hour rainfall on a curve. The Type II rainfall distribution is typically used for the Boise area. The Type IA distribution has a longer duration of rainfall intensity whereas the Type II distribution has shorter duration but higher intensity rainfall. However, after running the model with several different sized storm events, the model appears to replicate rainfall intensity accurately for our area, compared to rainfall intensities measured at the nearest ACHD rain gauge, located on Front St. near 17th St.

The OSU Calculator was chosen because it is able to produce the data required by the permit, is applicable on a site-scale for small storm events and allows for pre and post development comparisons. Results from various rainfall scenarios will be analyzed to obtain an understanding of the expected hydrological performance of this system under various conditions.

3.2 On-site Observations

On-site observations will be made by ACHD stormwater staff to maintain a visual record of site conditions and to provide comparisons with the modelled results. Observations will occur prior to construction, during construction and post-construction. The types of observations will vary depending upon the differing activities occurring at the sites during the different project phases. Photo-documentation will occur during all phases providing visual records over time of the site conditions. The level and frequency of photo-documentation may be adjusted as data is gathered and comparisons with modelled results are made.

Stormwater staff will conduct field observations and photo documentation at pre-set locations in each alley during and after rain events greater than 0.20 inches to record pre-construction, construction and post- construction conditions. The locations where observations will be taken are shown on the observation forms in Appendix E. The frequency of observation will depend upon when the rain event occurs (i.e. timing of storm or staff constraints due to other monitoring projects during storm events). To the extent possible, observations will occur as soon as practicable after a rain event of 0.20 inches occurs and follow-up field observations will be conducted at 6 to 12 hour intervals-for up to 2 days post storm. Based on results from the OSU calculator, ponding is not expected to occur with events producing as little as 0.20 inches, however, as a conservative estimate, observations will be conducted until it can be visually verified that no ponding or runoff occur during such events. The observation schedule and storm conditions requiring observation may be adapted as data is collected.

Data collection sheets have been developed for each phase of the project. An Alley Observation Form, Form GSI-1 (Appendix E) will be completed during each visit to standardize the documentation of the site conditions. All observation forms will be scanned, saved and stored at ACHD. A table summarizing each field visit will be maintained by ACHD staff. (Appendix F). The observation form may be revised to include new information depending upon the phase of the project (i.e. pre-construction phase, construction phase, post-construction phase).

Pre-construction phase observations will include the presence of ponding water, run-off to the storm drain system, contaminants (e.g. sediment, oil sheen), flow from roof drain and any other notable occurrences. All observations will be recorded on Form GSI-1.

During the **construction phase** of the project all of the observations noted during the pre-construction phase will be recorded, as well as taking notes on subsurface conditions, construction installation, protection of infiltration surface and construction materials, tracking and run-on, and utility conflicts. All observations will be recorded on Form GSI-1.

Post-construction phase observations will include all of the observations noted during pre-construction phase, as well as the presence of any damaged or cracked pavers, overall condition of site, monitoring well levels, performance following snow events, and evidence of maintenance activities.

3.3 Physical Data

Physical data will include precipitation measurements in the general vicinity of the project, water level measurements in the observation wells and periodic measurement of infiltration rates compared to pre-construction infiltration rates. Physical data will be compared to observational data and modelled results. All collected data will be used to evaluate the maintenance requirements of the systems.

Precipitation data will be collected from the National Weather Service (NWS) Boise airport station website at http://www.nws.noaa.gov/climate/index.php?wfo=boi and from the ACHD rain gauge installed at Front St. and 17th St, Boise, Idaho. The ACHD rain gauge utilizes primary and backup HOBO data loggers that record events from a tipping-bucket style rain gauge that measures tips in 1/100" increments. The Front rain gauge is approximately 1,800 feet from Alley 2 and 5,425 feet from Alley 1.The rain gauge at Front St. will be downloaded periodically in accordance with Stormwater SOP 211a. Rain gauge data will be exported to an Excel spreadsheet where it will be compared with NWS data. Rain data will be analyzed over time to ensure that the rainfall distribution assumptions used in the OSU Calculator model are reasonable.

Water levels in the observation wells will be observed and measured post storms, during on-site observations. The data will be entered into an Excel spreadsheet and charts will be developed to analyze how long water resides in the system in comparison to the size of the rain event. This information will be used to compare the actual performance of the paver system to the modelled performance.

The standard test method for surface infiltration rate of permeable unit pavement systems (ASTM C1781/C1781M-13, 2013) will be used to measure post-construction infiltration rates if the paver system is not performing as expected, based on results from the OSU calculator. The measured infiltration rate will be compared to the infiltration rate measured at the time the pavers were installed to assess the performance of the system over time. The procedure for the Infiltrometer Test is outlined in Appendix G.

4. Quality Assurance/Quality Control

All data collected as part of this project will be reviewed by the Stormwater Program Coordinator for accuracy and completeness. The Quality Assurance Program Plan (QAPP) guides all monitoring activities required by the Permit, including this monitoring plan. The QAPP outlines the data quality objective (DQO) that has been developed for all monitoring plans. Section 1.8 of the QAPP summarizes the DQO for ACHD stormwater monitoring:

"Monitoring efforts will provide data of sufficient quality and quantity in accordance with permit requirements to accurately estimate pollutant concentrations and loading trends, evaluate effectiveness of permanent stormwater controls and GSI/LID projects, and support watershed and land use management initiatives."

The QAPP also describes data quality indicators (DQIs) which set measurable quantitative and qualitative goals for acceptable data to achieve the DQO described above. The following is an outline of the DQIs described in Section 8 of the QAPP: Project Required Detection Limits, Accuracy, Precision, Bias, Representativeness, Comparability, Completeness and Sufficiency. Modelling results will be compared to other simple models to ensure the DQIs are also followed.

5. Data management and reporting

All data collected as part of this plan will be stored in electronic format for secure storage and timely and accurate retrieval. The data, located on the S: drive in folder *STORMWATER>Phase 1 Monitoring>LID Monitoring* will be housed on an ACHD server which is backed-up nightly .

5.1 Data Collection Schedule

Data collection efforts began in February 2014 with the completion of the first Observation Forms for a storm event occurring on February 12, 2014. A summary of the data collected and a short project status will be included as an appendix in each annual report. Data will be collected at least through the completion of the final pilot project evaluation report due with the 5th Year Annual Report (December 2018). Depending upon the results of the evaluation report, additional data may be collected.

5.1.1 Hydrologic Model Data

Hydrologic modelling data will be collected on an on-going basis with model inputs being refined as more information is collected on actual site conditions. Each of the sites will be modelled using the following scenarios:

- pre-construction (existing) conditions
- post-construction conditions
- pre-development conditions (100% pervious)

The following outputs will be compared:

- runoff quantities
- runoff flow rates
- site hydrographs

Initial model results will be included in the 2nd Year Annual Report. Depending on actual observations of the permeable paver systems, these results may be updated in subsequent annual reports. Final model results will be included in the final pilot project evaluation.

5.1.2 Observational Data

As observational data is collected the results will be included in each annual report. This data will include all completed Observation Forms and the summary data table. All observational data will be included as part of the final pilot project evaluation.

5.1.3 Physical Data

Rainfall data, monitoring well level data and infiltration test data will be included in a summary table in each annual report. An analysis of this data will be included in the final pilot project evaluation.

5.2 Evaluation

The monitoring data gained from the PPMP will be used in the effectiveness evaluation required in the Permit in sections II.B.2.c.ii and IV.A.10, which are included in Appendix A. The evaluation will be guided by the PMEP and discuss Outcome Levels 4 and 5: Reducing Loads from Sources and Improving Runoff Quality, as described in the PMEP.

The evaluation will discuss several objectives of the GSI pilot projects including; how the monitoring data will be used to evaluate the effectiveness of the GSI, how pollutant load reductions will be estimated from runoff reductions, cost-benefit analysis, short-term versus long-term performance, maintenance considerations, design sizing, construction logistics, future recommendations, and the development of a GSI incentive strategy (Permit *Section II.B.2.c*).

References

Ada County Highway District (ACHD), Project Monitoring and Evaluation Plan (PMEP), 2013.

ACHD, Quality Assurance Program Plan for NPDES Storm Water Permit Monitoring Boise and Garden City, Idaho, 2014.

ASTM Standard C1781/C1781M. 2013."Standard Test Method for Surface Infiltration Rate of Permeable Unit Pavement Systems" ASTM International, West Conshohocken, PA, 2013, DOI 10.1520/C1781_C1781M.

National Weather Service (NWS). 2014. Daily Climate Report. <Accessed 9/8/2014> Available at http://www.nws.noaa.gov/climate/index.php?wfo=boi.

Oregon State University (OSU). 2014. Porous Pavement Hydrologic Calculator. <Accessed 8/1/2014> http://extension.oregonstate.edu/stormwater/porous-pavement-calculator.

United States Environmental Protection Agency (EPA). 2013. Boise/Garden City Area MS4 Permit #IDS-027561

Appendix A

Appendix A

Excerpts from Permit and PMEP

Boise/Garden City Area MS4, Permit No.: IDS-027561

Excerpt: Section II.B.2.c

c) **Green Infrastructure/Low Impact Development (LID) Incentive Strategy and Pilot Projects**. No later than September 30, 2015, the Permittees must develop a strategy to provide incentives for the increased use of LID techniques in private and public sector development projects within each Permittee's jurisdiction. Permittees must comply with applicable State and local public notice requirements when developing this Strategy. Pursuant to Part IV.A.2.a, the Strategy must reference methods of evaluating at least three (3) Green Infrastructure/LID pilot projects as described below. Permittees must implement the Green Infrastructure/LID Incentive Strategy, and complete an effectiveness evaluation of at least three pilot projects, prior to the expiration date of this Permit.

(i) As part of the 3rd Year Annual Report, the Permittees must submit the written Green Infrastructure /LID Incentive Strategy; the Strategy must include a description of at least three selected pilot projects, and a narrative report on the progress to evaluate the effectiveness of each selected LID technique or practice included in the pilot project. Each pilot project must include an evaluation of the effectiveness of LID technique(s) or practice(s) used for on-site control of water quality and/or quantity. Each Pilot Project must involve at least one or more of the following characteristics:

-The project manages runoff from at least 3,000 square feet of impervious surface;

-The project involves transportation related location(s) (including parking lots);

-The drainage area of the project is greater than five acres in size; and/or

-The project involves mitigation of existing storm water discharges to one or more of the water bodies listed in Table II.C.

(ii) Consistent with Part IV.A.10, the Permittees must evaluate the performance of LID technique(s) or practice(s) in each pilot project, and include a progress report on overall strategy implementation in the 4th Annual Report. Final pilot project evaluations must be submitted in the 5th Year Annual Report. The Permittees must monitor, calculate or model changes in runoff quantities for each of the pilot project sites in the following manner:

- For retrofit projects, changes in runoff quantities shall be calculated as a percentage of 100% pervious surface before and after implementation of the LID technique(s) or practice(s).
- For new construction projects, changes in runoff quantities shall be calculated for development scenarios both with LID technique(s) or practice(s) and without LID technique(s) or practice(s).

- The Permittees must measure runoff flow rate and subsequently prepare runoff hydrographs to characterize peak runoff rates and volumes, discharge rates and volumes, and duration of discharge volumes. The evaluation must include quantification and description of each type of land cover contributing to surface runoff for each pilot project, including area, slope, vegetation type and condition for pervious surfaces, and the nature of impervious surfaces.

- The Permittees must use these runoff values to evaluate the overall effectiveness of various LID technique(s) or practice(s) and to develop recommendations for future adoption of LID technique(s) or practice(s) that address appropriate use, design, type, size, soil type and operation and maintenance practices.

(iii) **Riparian Zone Management and Outfall Disconnection.** No later than September 30, 2015, the Permittees must identify and prioritize riparian areas appropriate for Permittee acquisition and protection. Prior to the expiration date of this Permit, the Permittees must undertake and complete at least one project designed to reduce the flow of untreated urban storm water discharging through the MS4 system through the use of vegetated swales, storm water treatment wetlands and/or other appropriate techniques. The Permittees must submit the list of prioritized riparian protection areas, and a status report on the planning and implementation of the outfall disconnection project, as part of the 3rd Year Annual Report. Documentation of the completed outfall disconnection project must be included in the 5th Year Annual Report.

(iv) **Repair of Public Streets, Roads and Parking Lots.** When public streets, roads or parking lots are repaired (as defined in Part VII), the Permittees performing these repairs must evaluate the feasibility of incorporating runoff reduction techniques into the repair by using canopy interception, bioretention, soil amendments, evaporation, rainfall harvesting, engineered infiltration, rain gardens, infiltration trenches, extended filtration and/or evapotranspiration and/or any combination of the aforementioned practices. Where such practices are found to be technically feasible, the Permittee performing the repair must use such practices in the design and repair. These requirements apply only to projects whose design process is started after the effective date of this Permit. As part of the 5th Year Annual Report, the Permittees must list the locations of street, road and parking lot repair work completed since the effective date of the Permit that have incorporated such runoff reduction practices, and the receiving water body(s) benefitting from such practices. This documentation must include a general description of the project design, estimated total cost, and estimates of total flow volume and pollutant reduction achieved compared to traditional design practices.

Excerpt: Section IV.A.10

10. Evaluate the Effectiveness of Green Infrastructure/Low Impact Development Pilot Projects. The Permittees must evaluate the performance and effectiveness of the three pilot projects required in Part II.B.2.c of this Permit, or contract with another entity to conduct such evaluations. An evaluation summary of the LID technique or control and any recommendations of improved treatment performance must be submitted in subsequent Annual Reports as the evaluation projects are implemented and completed.

Program Monitoring and Evaluation Plan
Excerpt Section 4.4

4.4 LID Evaluation and Assessment Monitoring

The Permittees are required to evaluate the effectiveness of Green Infrastructure/Low Impact Development (GI/LID) Pilot projects. LID solutions mimic natural hydrology to reduce pollutant loads. These solutions are localized and assist in the efforts of reducing flow conveyed through the MS4.

4.4.1 Permit Requirements

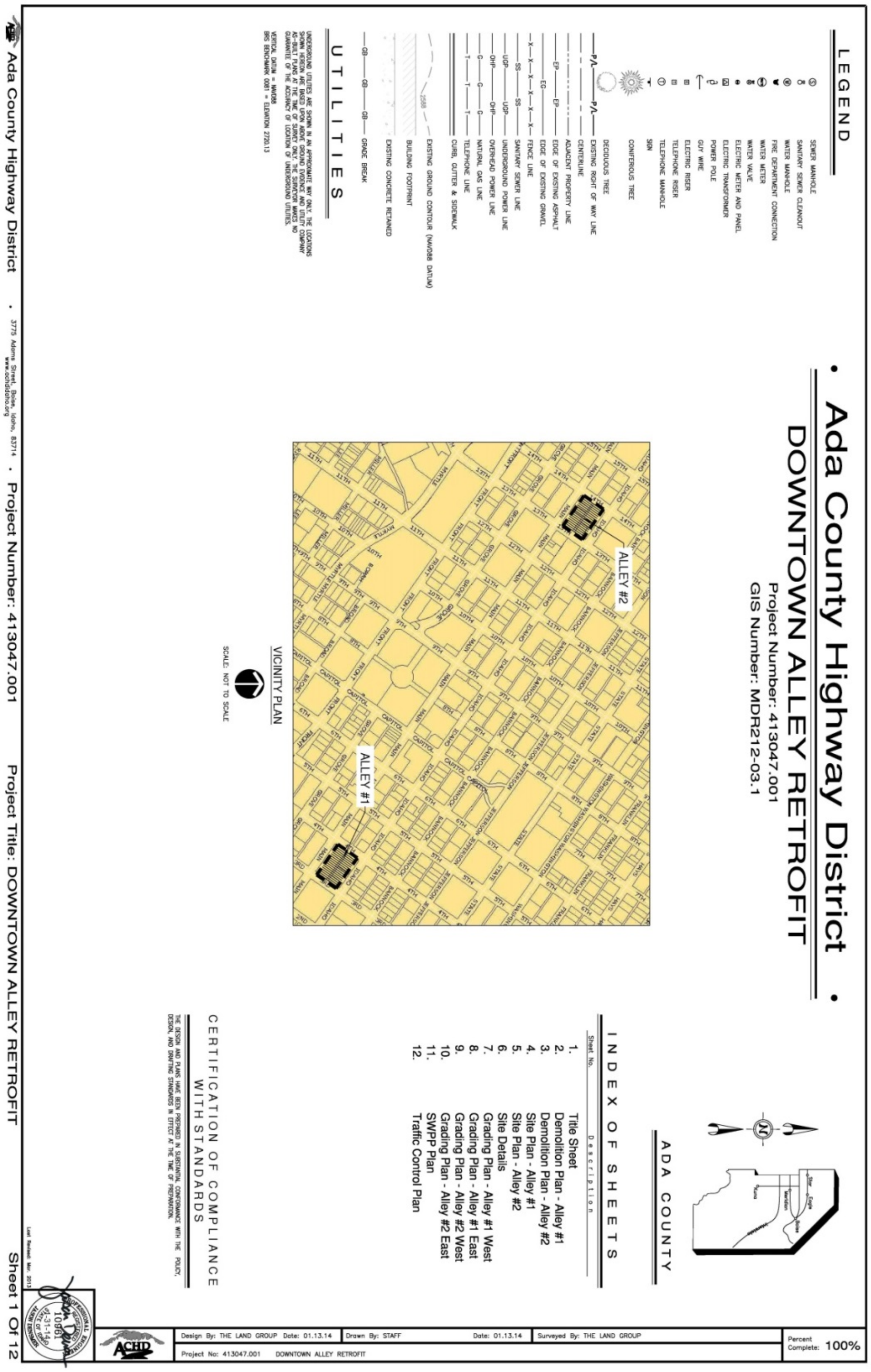
Under this Section (Section II.B.2.c) of the Permit the Permittees are required to establish a GI/LID incentive strategy.

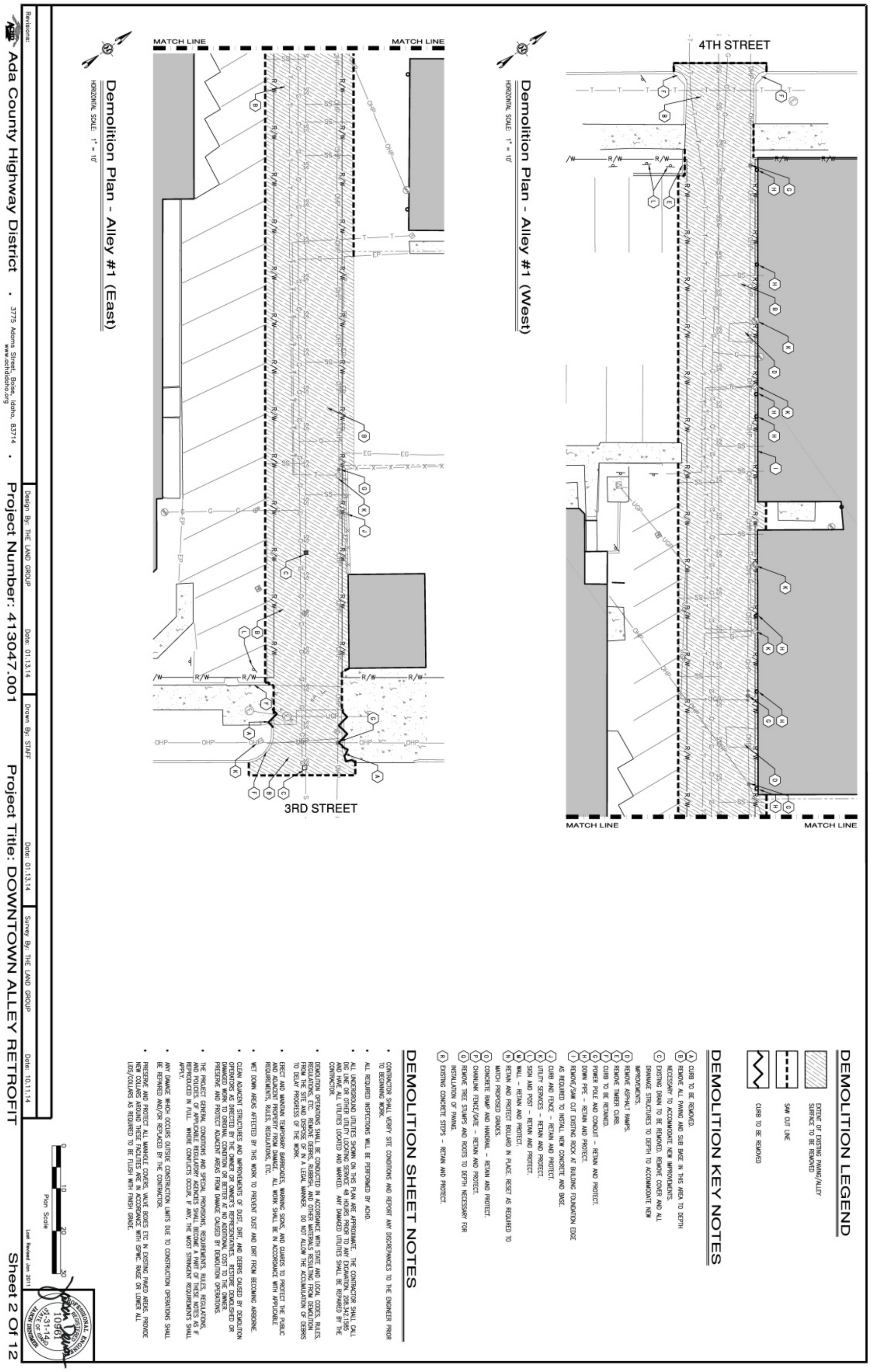
4.4.2 Evaluation and Assessment

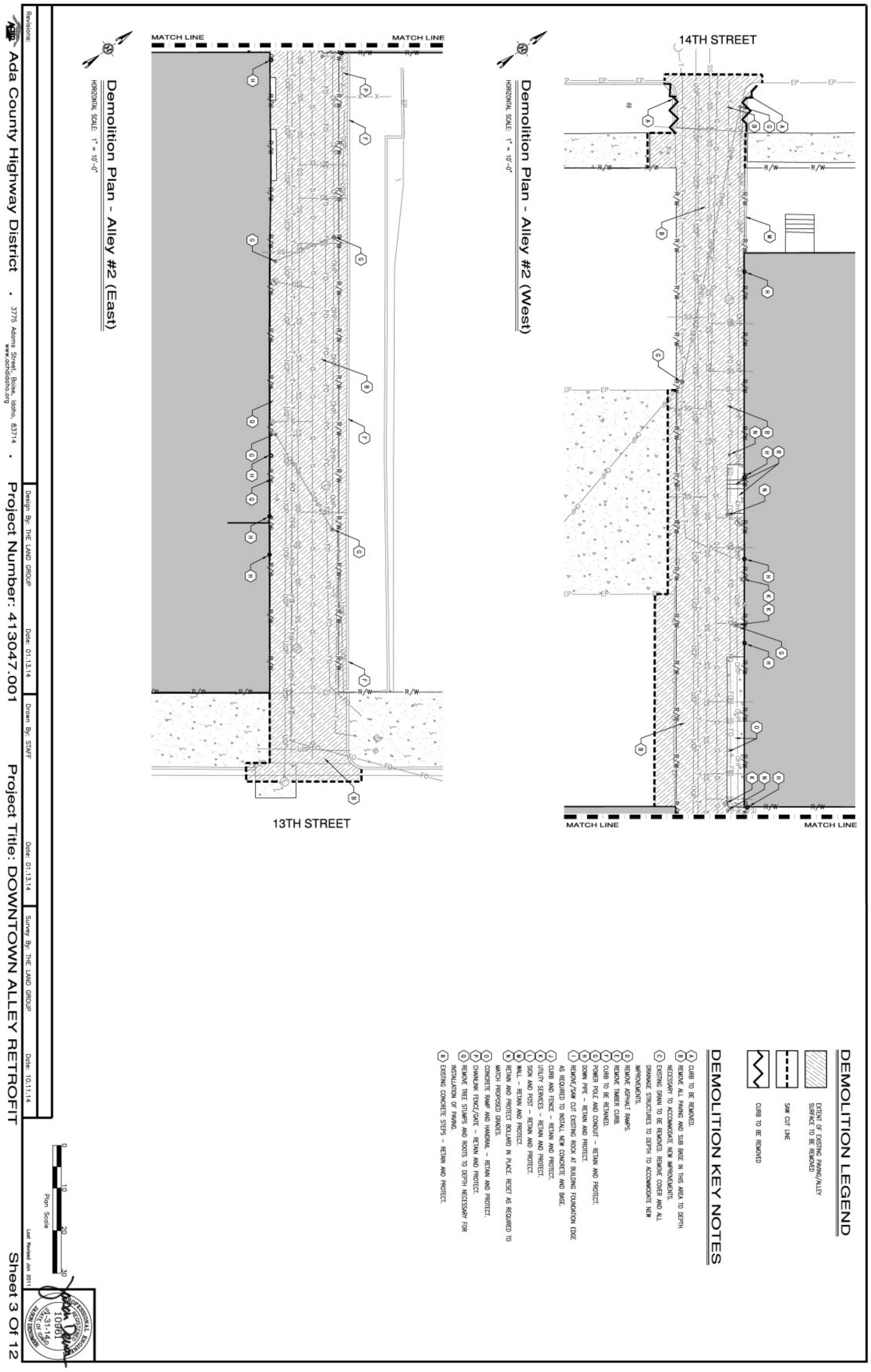
In order to relate the assessment and evaluation of GI/LID solutions pollutant load reductions must be characterized. Therefore, evaluation of this solution must measure or estimate both flow and concentration into and out of the stormwater control. Since LID relies heavily on infiltration to treat stormwater, outfall monitoring may be difficult. In these situations the evaluation can assume that flow reduction is a surrogate for pollutant load reduction. If at some point in the program enough data has been collected to normalize reduction expectations for these solutions a modeling approach can be used to assess the pollutant reduction capacity of GI/LID solutions.

Appendix B

Appendix B
Permeable Paver Plan Set




4TH STREET
3RD STREET
MATCH LINE
Demolition Plan - Alley #1 (West)
Demolition Plan - Alley #1 (East)
DEMOLITION LEGEND
DEMOLITION KEY NOTES
DEMOLITION SHEET NOTES
Ada County Highway District
Project Number: 413047.001
Project Title: DOWNTOWN ALLEY RETROFIT
Sheet 2 Of 12


14TH STREET
MATCH LINE
MATCH LINE
Demolition Plan - Alley #2 (West)
HORIZONTAL SCALE: 1" = 10'-0"
MATCH LINE
MATCH LINE
Demolition Plan - Alley #2 (East)
HORIZONTAL SCALE: 1" = 10'-0"
13TH STREET
DEMOLITION LEGEND
DEMOLITION KEY NOTES
Revisions:
Ada County Highway District · 3775 Adams Street, Boise, Idaho, 83714 · www.achdidaho.org
Design By: THE LAND GROUP
Date: 01.13.14
Drawn By: STAFF
Date: 01.13.14
Survey By: THE LAND GROUP
Date: 10.11.14
Project Number: 413047.001
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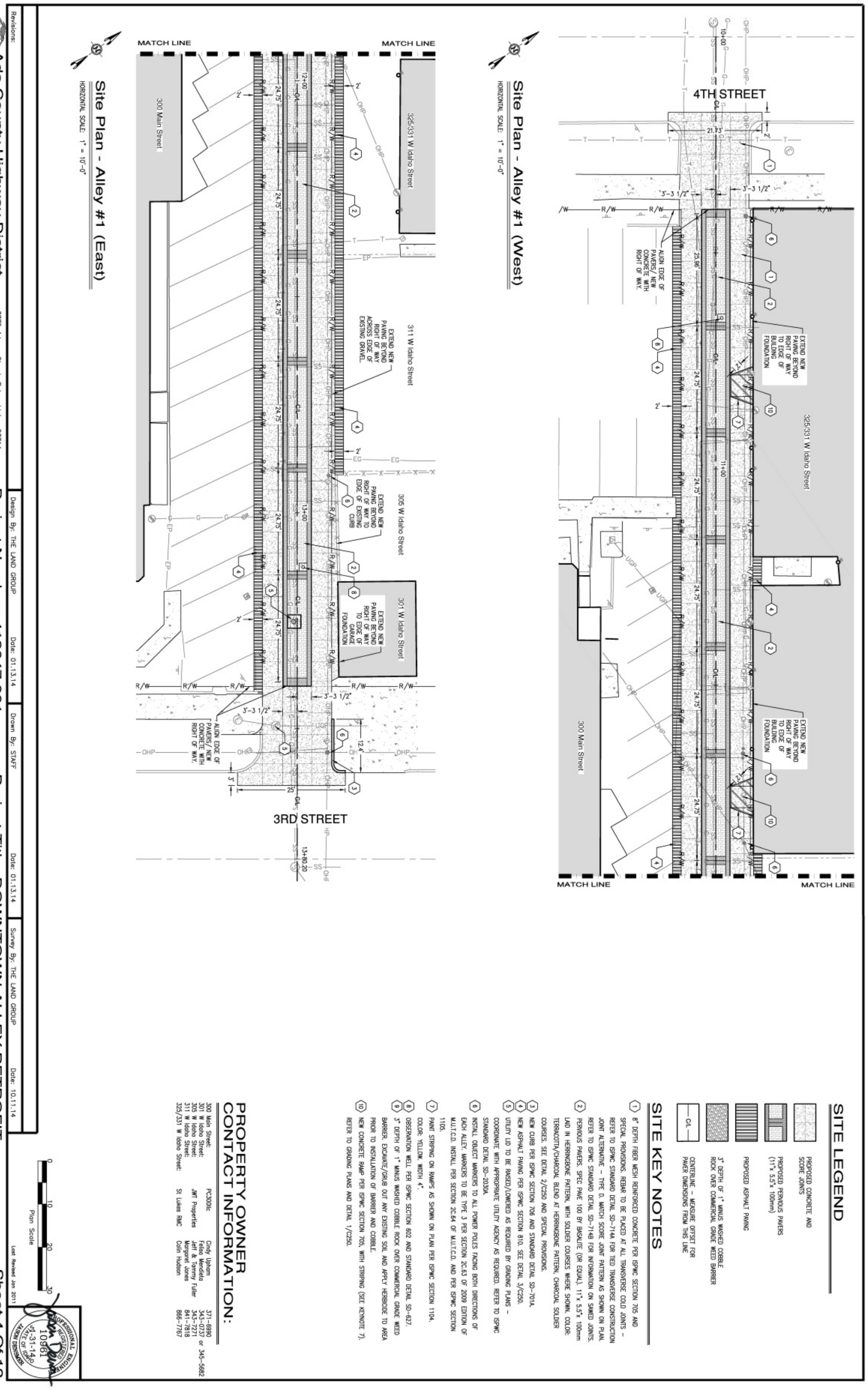
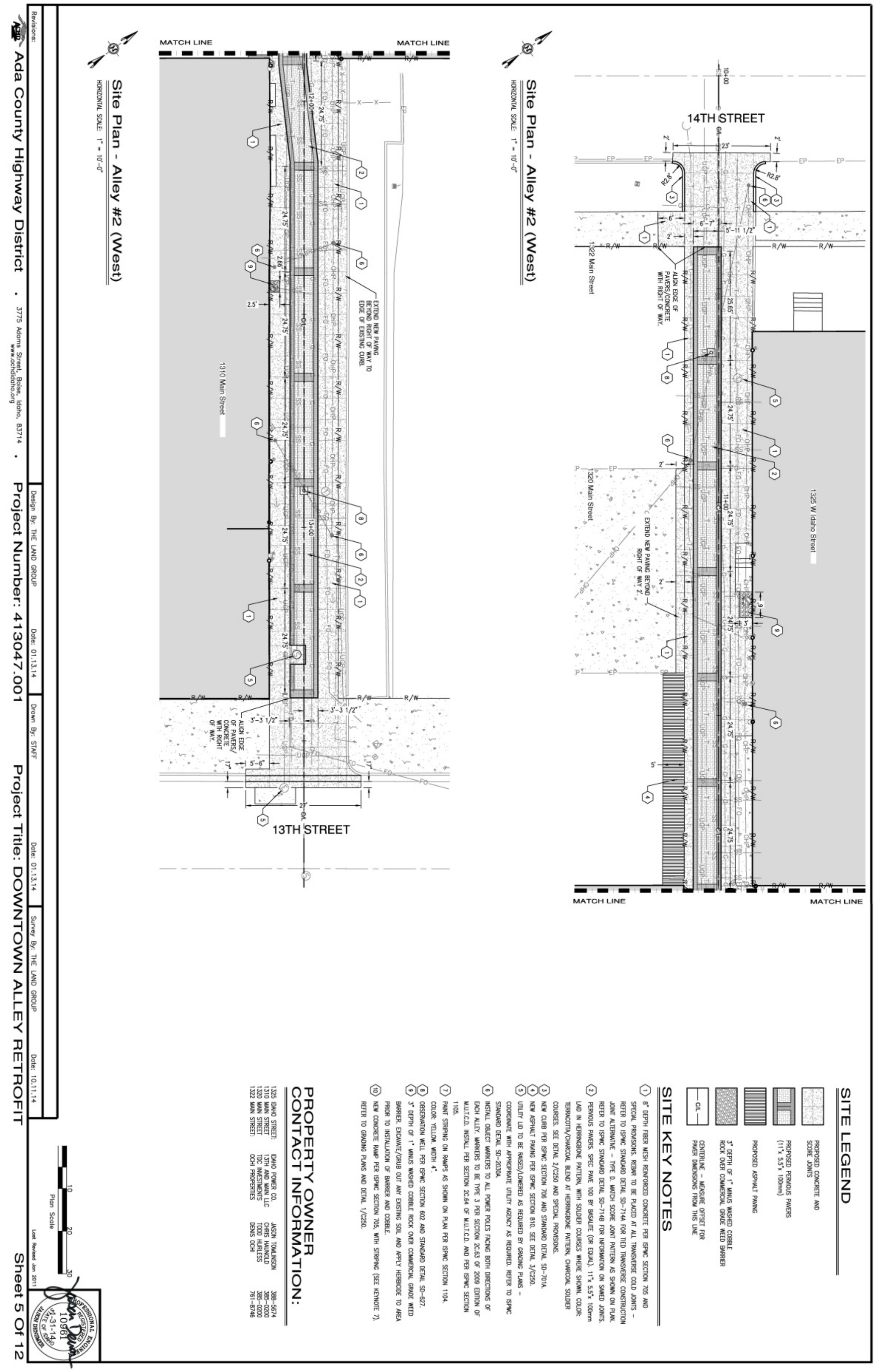
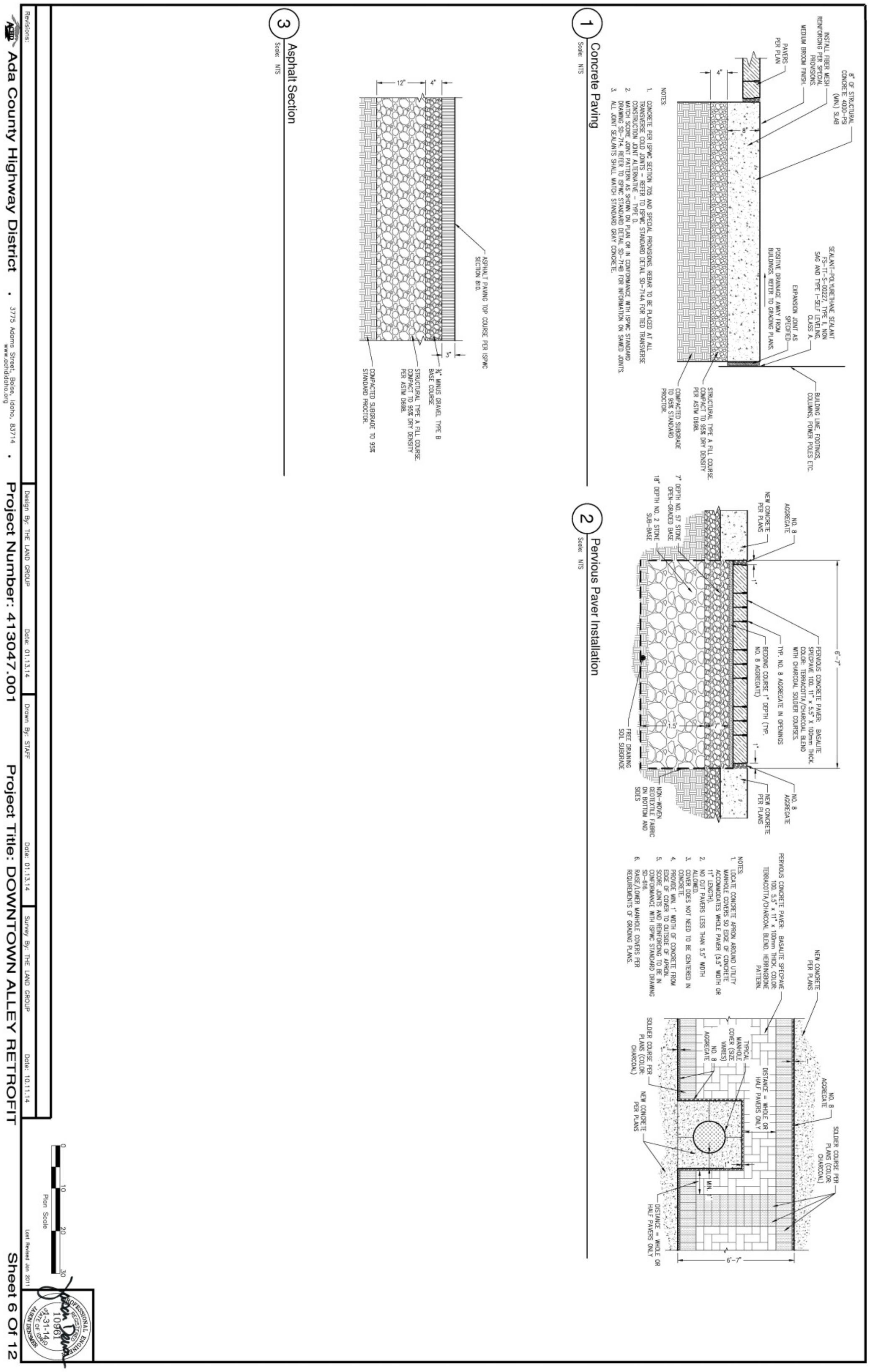
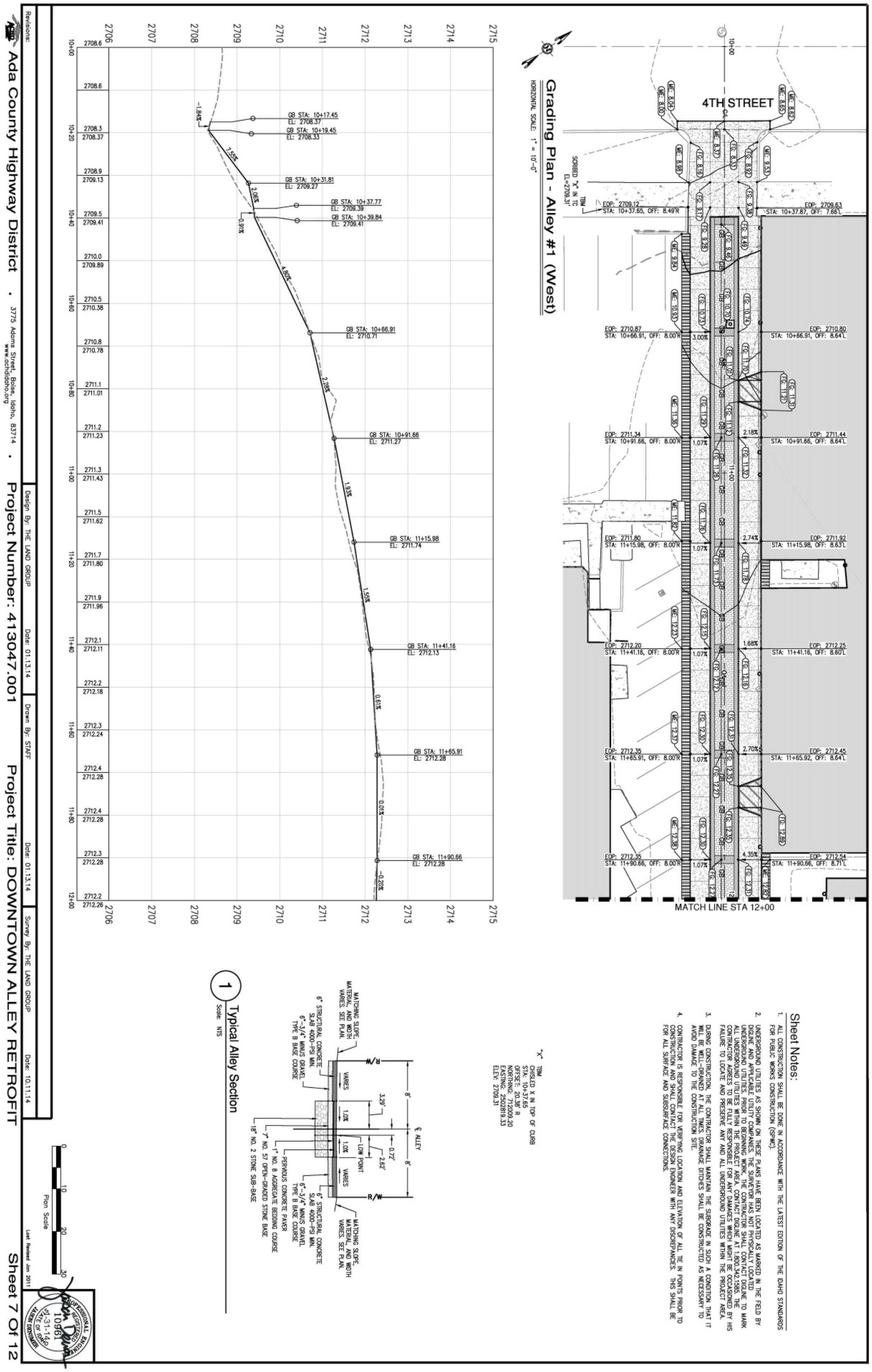
Plan Scale
Sheet 3 Of 12

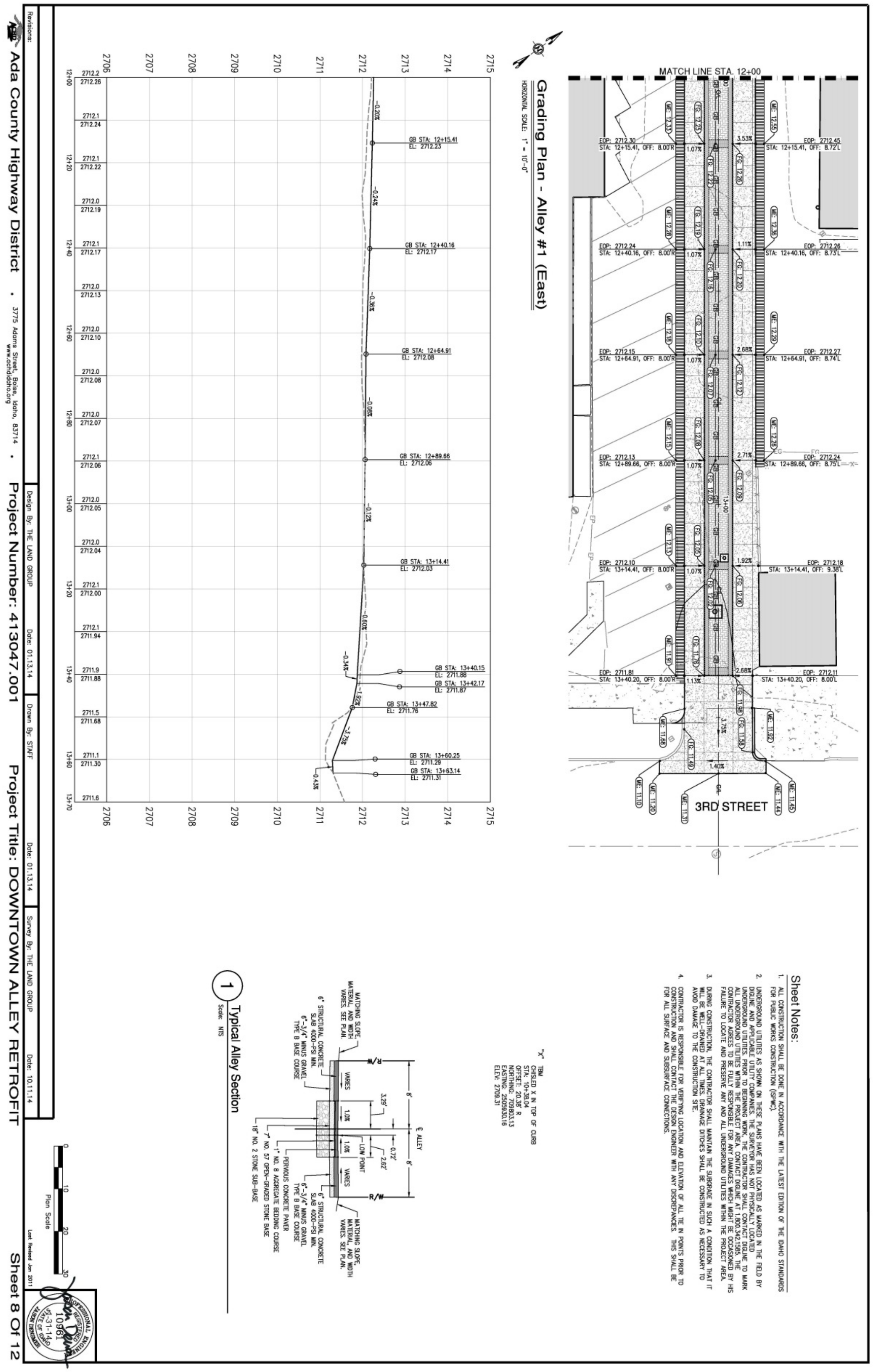


4TH STREET
3RD STREET
MATCH LINE
Site Plan - Alley #1 (West)
Site Plan - Alley #1 (East)
325/331 W Idaho Street
311 W Idaho Street
305 W Idaho Street
301 W Idaho Street
300 Main Street
SITE LEGEND
SITE KEY NOTES
PROPERTY OWNER CONTACT INFORMATION:
Ada County Highway District
Project Number: 413047.001
Project Title: DOWNTOWN ALLEY RETROFIT
Sheet 4 Of 12


Site Plan - Alley #2 (West)
14TH STREET
13TH STREET
MATCH LINE
1310 Main Street
1325 W Idaho Street
SITE LEGEND
SITE KEY NOTES
PROPERTY OWNER CONTACT INFORMATION:
Ada County Highway District
Project Number: 413047.001
Project Title: DOWNTOWN ALLEY RETROFIT
Sheet 5 Of 12


1 Concrete Paving
2 Pervious Paver Installation
3 Asphalt Section
Ada County Highway District
Project Number: 413047.001
Project Title: DOWNTOWN ALLEY RETROFIT
Sheet 6 Of 12


4TH STREET
Grading Plan - Alley #1 (West)
MATCH LINE STA 12+00
Sheet Notes:
Typical Alley Section
Ada County Highway District
Project Number: 413047.001
Project Title: DOWNTOWN ALLEY RETROFIT
Sheet 7 Of 12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Grading Plan - Alley #1 (East)
3RD STREET
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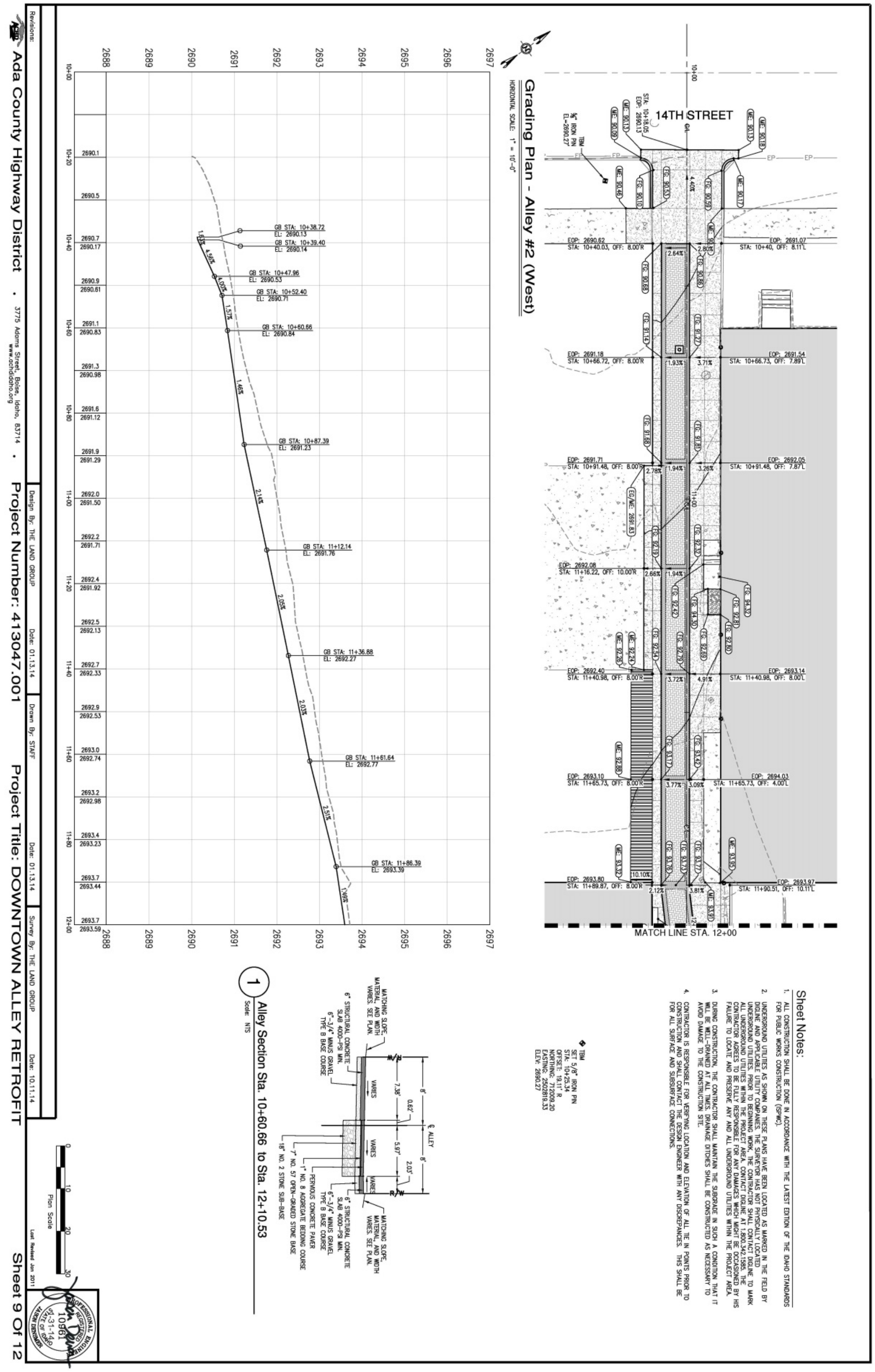
Typical Alley Section
Ada County Highway District
Project Number: 413047.001
Project Title: DOWNTOWN ALLEY RETROFIT
Sheet 8 Of 12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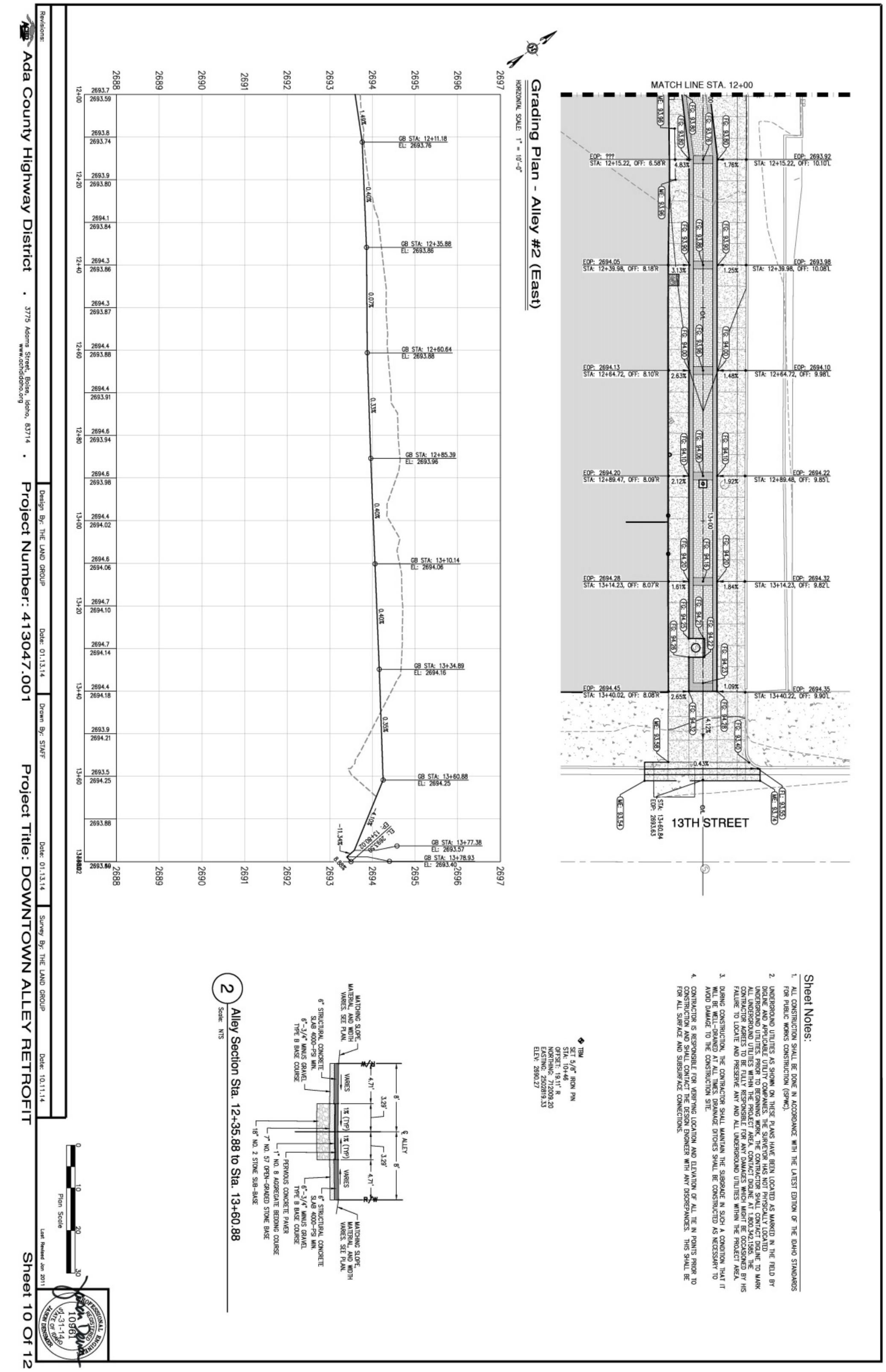
Grading Plan - Alley #2 (West)
Sheet Notes:
Alley Section Sta. 10+60.66 to Sta. 12+10.53
Ada County Highway District
Project Number: 413047.001
Project Title: DOWNTOWN ALLEY RETROFIT
Sheet 9 Of 12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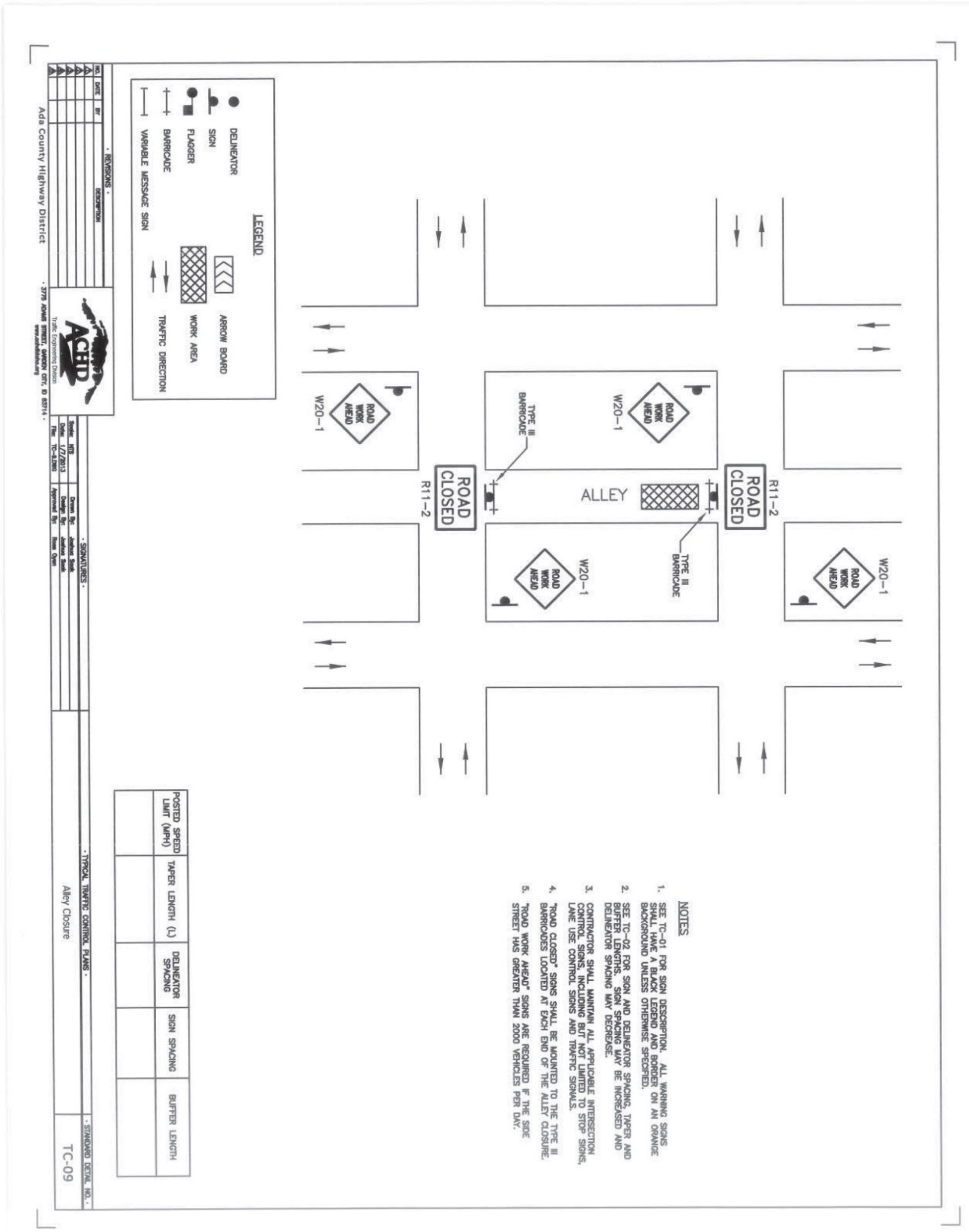
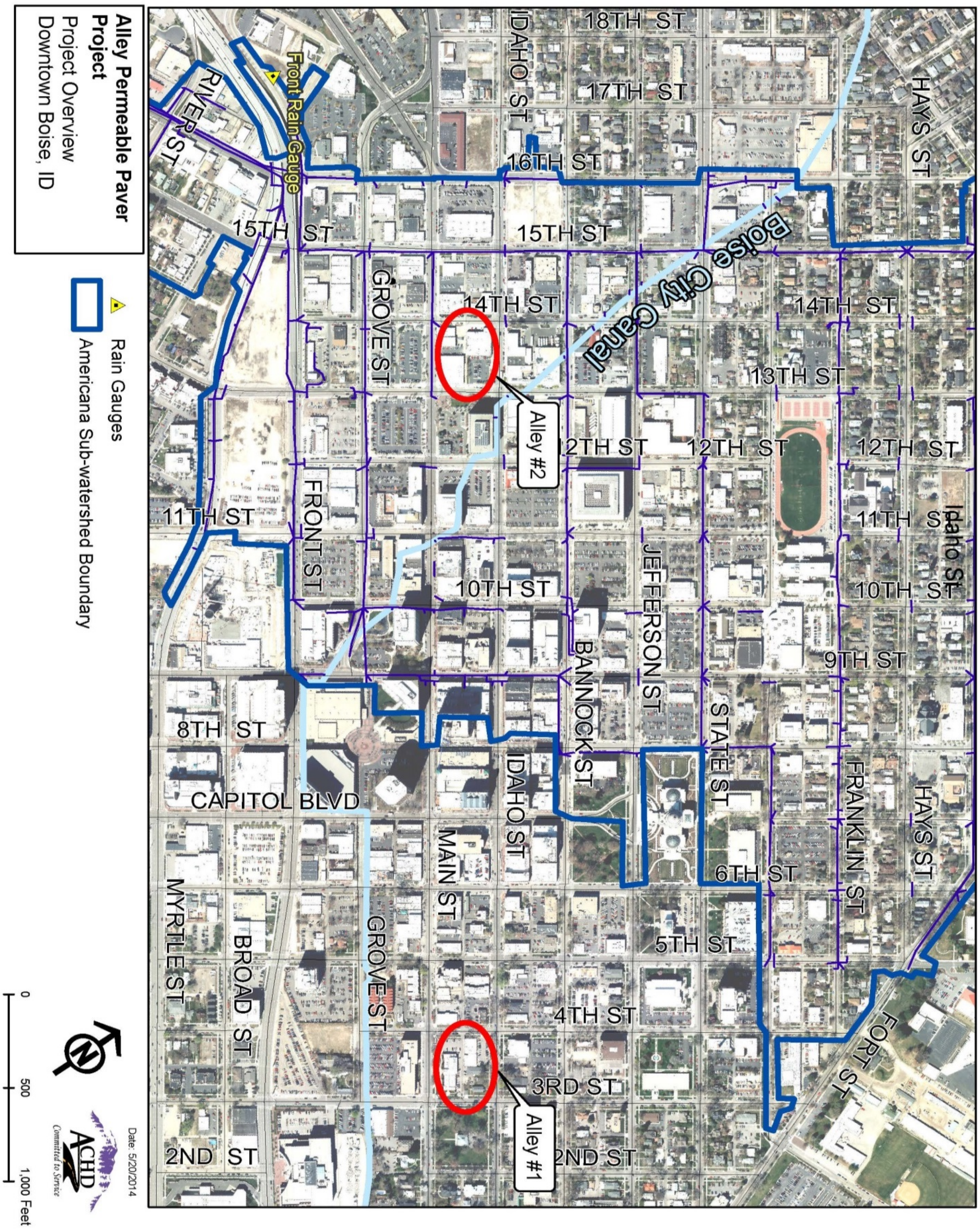
13TH STREET
Sheet Notes:
Alley Section Sta. 12+35.88 to Sta. 13+60.88
Ada County Highway District
Project Number: 413047.001
Project Title: DOWNTOWN ALLEY RETROFIT
Sheet 10 Of 12

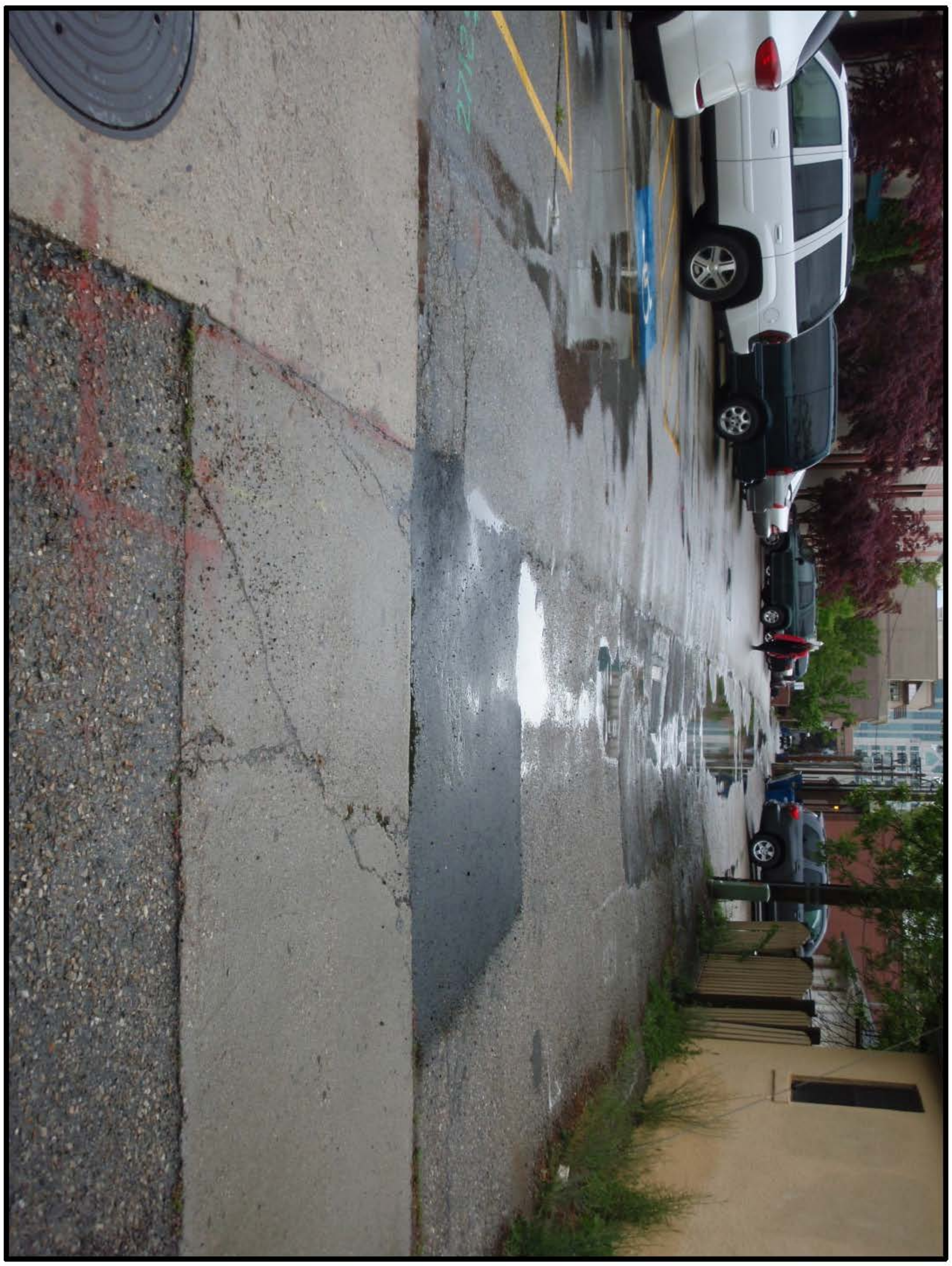

LEGEND
DELINEATOR
SIGN
FLAGGER
BARRICADE
VARIABLE MESSAGE SIGN
ARROW BOARD
WORK AREA
TRAFFIC DIRECTION
ROAD WORK AHEAD
W20-1
ROAD CLOSED
R11-2
TYPE III BARRICADE
ALLEY
NOTES
1. SEE TC-01 FOR SIGN DESCRIPTION. ALL WARNING SIGNS SHALL HAVE A BLACK LEGEND AND BORDER ON AN ORANGE BACKGROUND UNLESS OTHERWISE SPECIFIED.
2. SEE TC-02 FOR SIGN AND DELINEATOR SPACING, TAPER AND BUFFER LENGTHS. SIGN SPACING MAY BE INCREASED AND DELINEATOR SPACING MAY DECREASE.
3. CONTRACTOR SHALL MAINTAIN ALL APPLICABLE INTERSECTION CONTROL SIGNS, INCLUDING BUT NOT LIMITED TO STOP SIGNS, LANE USE CONTROL SIGNS AND TRAFFIC SIGNALS.
4. "ROAD CLOSED" SIGNS SHALL BE MOUNTED TO THE TYPE III BARRICADES LOCATED AT EACH END OF THE ALLEY CLOSURE.
5. "ROAD WORK AHEAD" SIGNS ARE REQUIRED IF THE SIDE STREET HAS GREATER THAN 2000 VEHICLES PER DAY.
POSTED SPEED LIMIT (MPH)
TAPER LENGTH (L)
DELINEATOR SPACING
SIGN SPACING
BUFFER LENGTH
Ada County Highway District
- TYPICAL TRAFFIC CONTROL PLANS -
Alley Closure
- STANDARD DETAIL NO. -
TC-09

Appendix C

Appendix C
Maps and Photos of Project Areas

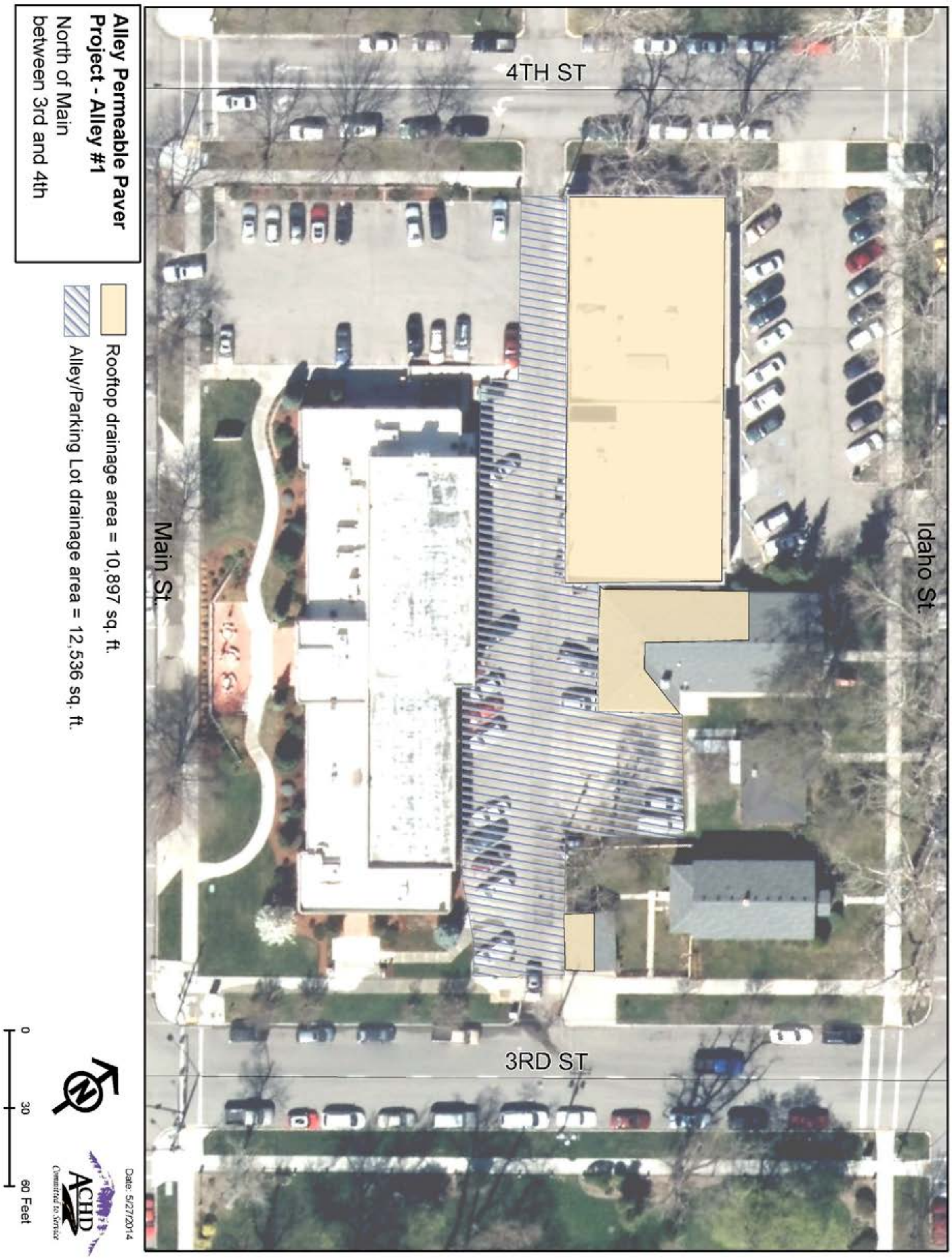



Alley Permeable Paver Project - Alley #1
North of Main between 3rd and 4th
Project area
4TH ST
3RD ST
Main St.
Idaho St.
Date: 5/20/2014
ACHD
Committed to Service
0
30
60 Feet



Permeable Paver Project Alley #1 – North of Main St. between 3rd and 4th

Observation Position # 4 – Pre-construction

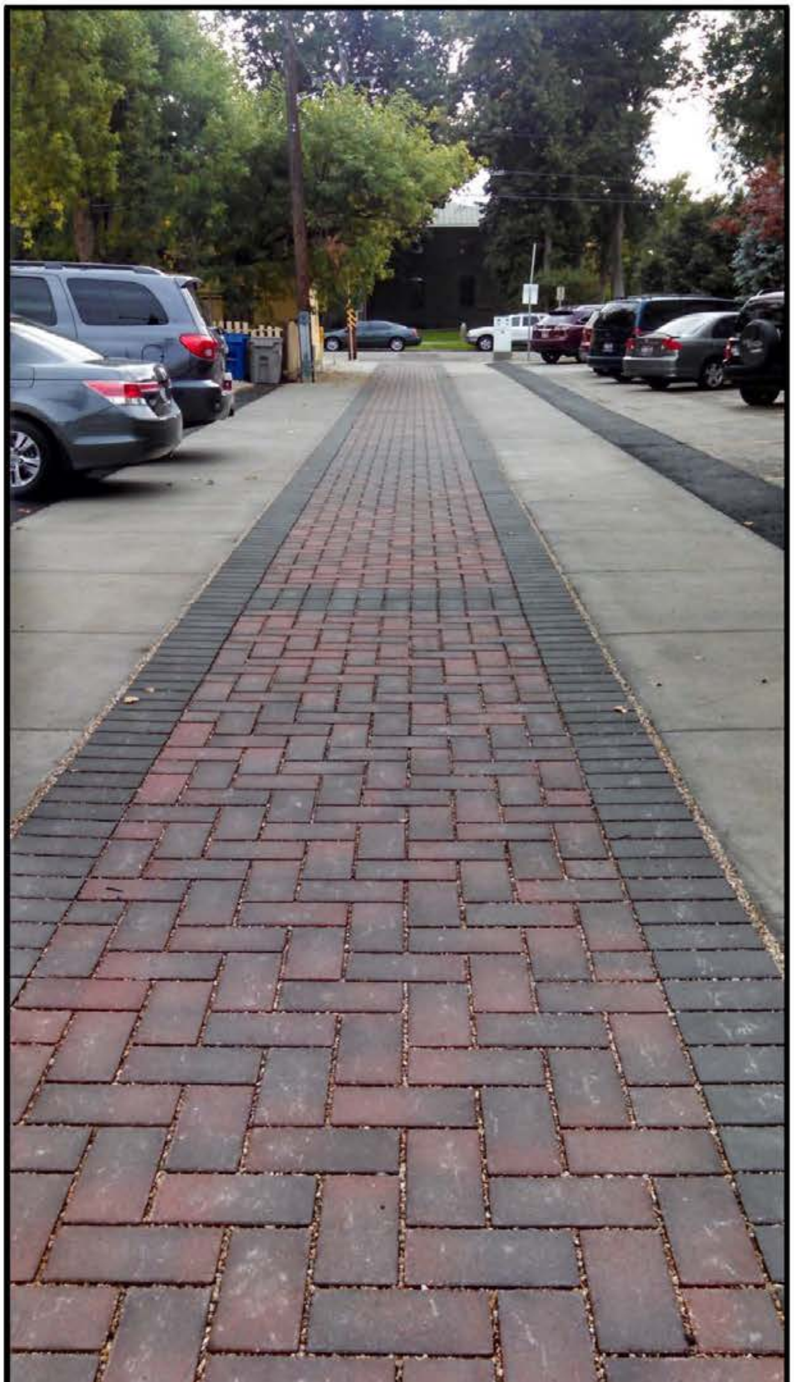

Alley Permeable Paver Project - Alley #1
North of Main between 3rd and 4th
Rooftop drainage area = 10,897 sq. ft.
Alley/Parking Lot drainage area = 12,536 sq. ft.
4TH ST
3RD ST
Main St.
Idaho St.
N
0
30
60 Feet
Date: 5/27/2014
ACHD
Committed to Service

Permeable Paver Project Alley #1 – North of Main St. between 3rd and 4th

Observation Position # 4 – Pre-construction

Permeable Paver Project Alley #1 – North of Main St. between 3rd and 4th
Observation Position # 3 – During Construction

Permeable Paver Project Alley #1 – North of Main St. between 3rd and 4th
Observation Position # 1 – During Construction



Permeable Paver Project Alley #1 – North of Main St. between 3rd and 4th Streets

Observation Position # 3 – Post Construction


Alley Permeable Paver
Project - Alley #2
North of Main
between 13th and 14th
Project area
14TH ST
13TH ST
MAIN ST
Idaho St.
Date: 5/20/2014
ACHD
Committed to Service
0
40
80 Feet


Alley Permeable Paver Project - Alley #2
North of Main between 13th and 14th
Rooftop drainage area = 34,579 sq. ft.
Alley/Parking Lot drainage area = 5,569 sq. ft.
14TH ST
13TH ST
MAIN ST
Idaho St.
Date: 5/27/2014
ACHD
Committed to Service
0
40
80 Feet
N

Permeable Paver Project Alley #2 – North of Main St. between 13th and 14th
Observation Position # 3 – Pre-construction

Permeable Paver Project # 2 – North of Main St. between 13th and 14th

Observation Point # 4 – During Construction

Permeable Paver Project Alley # 2 – North of Main St. between 13th and 14th

Observation Point # 3 – Post Construction

Appendix D

Appendix D
Engineering Drainage Report

THE LAND GROUP, INC.

Ada County Highway District

Downtown Alley Retrofit – Alleys 1, 2 and 3

Boise, Idaho

Storm Water Management - Engineering Drainage Report

Owner

Ada County Highway District
3775 Adams Street
Garden City, Idaho 83714

Engineer

The Land Group, Inc.
462 East Shore Drive, Ste. 100
Eagle, Idaho 83616
Contact: Jason Densmer, PE
Ph: 208.939.4041

PROFESSIONAL ENGINEER
REGISTERED
10961
01-31-14
STATE OF IDAHO
JASON DENSMER

January 31, 2014

Project No. 113146

Site Planning · Landscape Architecture · Civil Engineering · Golf Course Irrigation & Engineering · Graphic Design · Surveying
462 E. Shore Drive, Suite 100 · Eagle, Idaho 83616 · P 208.939.4041 · F 208.939.4445 · www.thelandgroupinc.com

Site Description

The project will re-construct three (3) alleyways in the downtown area of Boise, Idaho. The alleyways are currently paved, but are experiencing ongoing pavement deterioration due to poor drainage.

- **Alley 1** is located between Idaho St and Main St and between 3rd St and 4th St
- **Alley 2** is located between Idaho St and Main St and between 13th St and 14th St
- **Alley 3** is located between Bannock St and Idaho St and between 5th St and 6th St.

The re-construction of each alleyways will reduce or eliminate runoff pooling within the alleyway or draining to the adjacent street drainage system.

Standard seepage beds were determined to be an infeasible solution due to the large amount of utilities which exist within the alleyways. A permeable paver solution with a shallow storage system has been implemented as an appropriate solution to capture and infiltrate as much of the storm water as possible.

Assessment of Soils & Seasonal Ground Water

An infiltration study was performed at each alley site by Terracon Consultants, Inc. Test pits were advanced from 1.3 to 2.1 feet below existing ground surface to determine the soil type and to perform infiltration testing. The soil types at the depth of the tests ranged from clayey sand and gravel to silty sand. The summary report dated October 23, 2013 is included in Appendix C.

Terracon Consultants found that the percolation rate for Alley 1 and Alley 2 is approximately 0.5 inches per hour and 28 inches per hour for Alley 3. For design purposes a percolation value of 0.5 inches per hour was used.

Peak Run-Off Rate & System Sizing

Event Areas (See Drainage Area Exhibit)

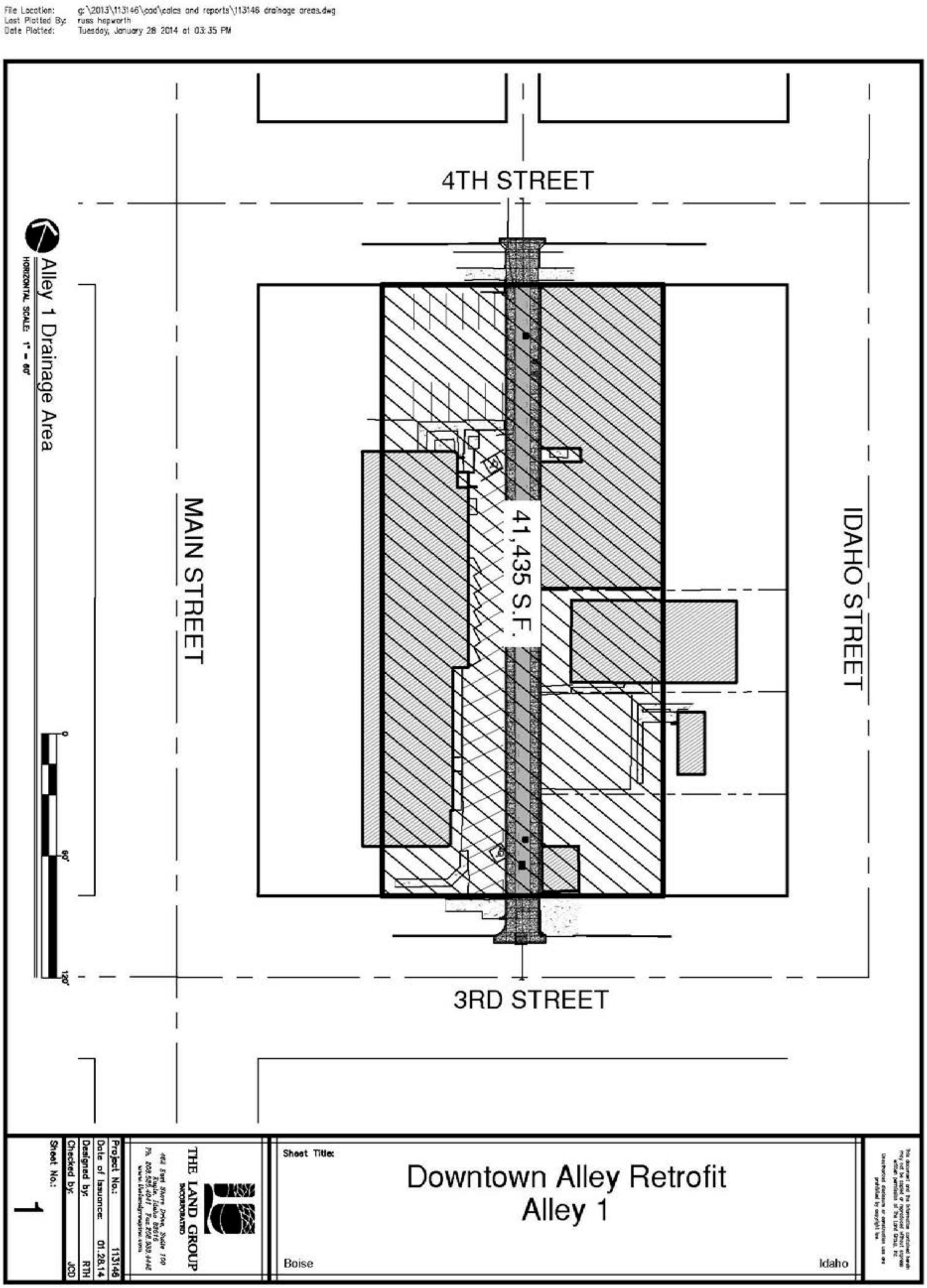
The permeable paver drainage system will consist a 6'-8" wide strip of permeable pavers generally located in middle of each alleyway and extend the entire length of the alley. The pavers will have a 1.5-foot deep crushed rock retention bed that will hold the volume of runoff generated from the 80^{th} percentile storm event for an area equal to half the block width on each side of the alleyway. The retention bed will allow the runoff to infiltrate into the existing underlying soils. Any runoff from a larger storm event that this system does not accept will sheet flow to the existing storm water facilities that currently exist.

The drainage system has been designed to store the 80th percentile storm event, a 1-hour event producing 0.34-in/hr with a 60-min time of concentration.

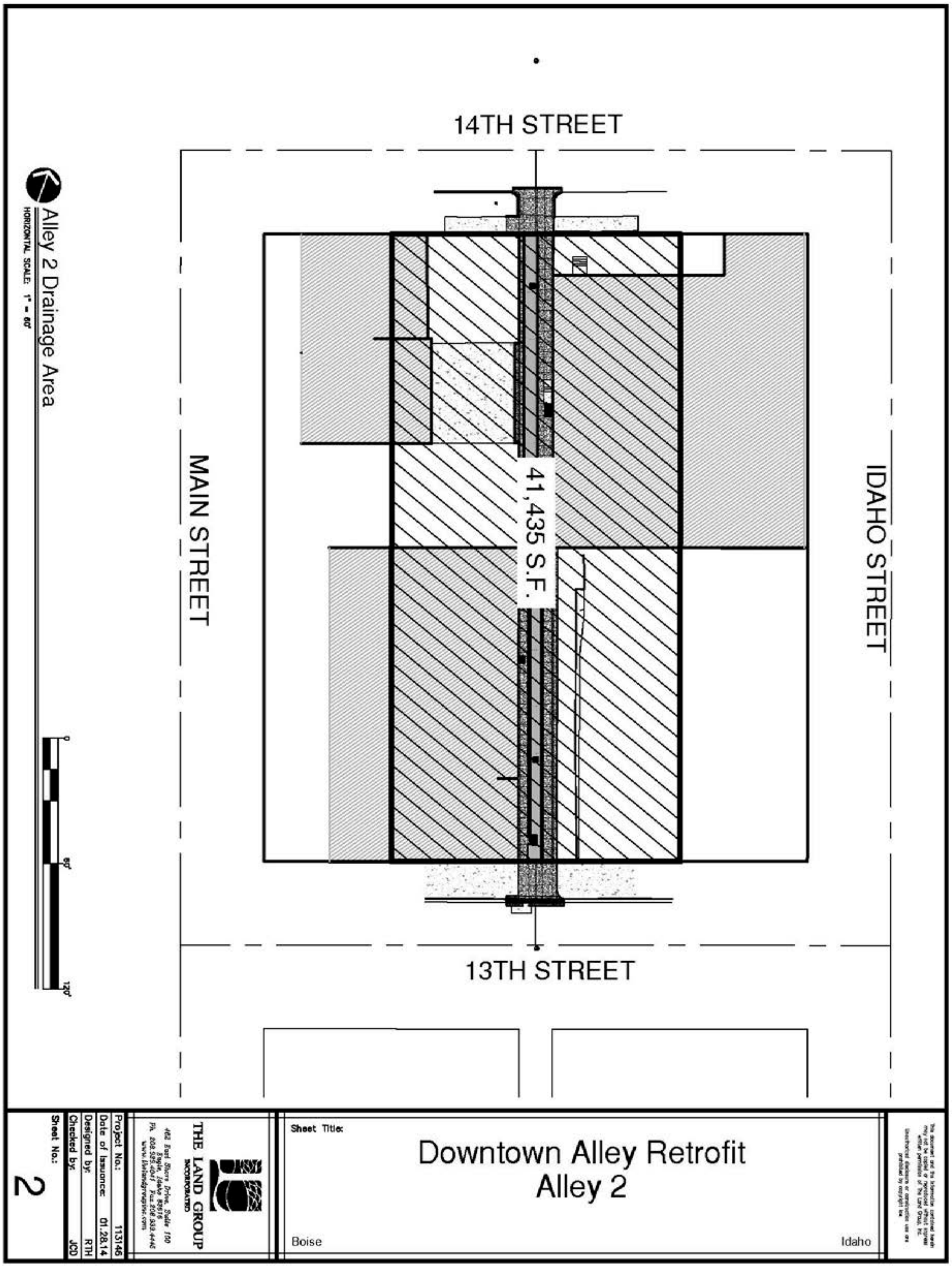
Drainage calculations are attached in Appendix B.

Appendix A

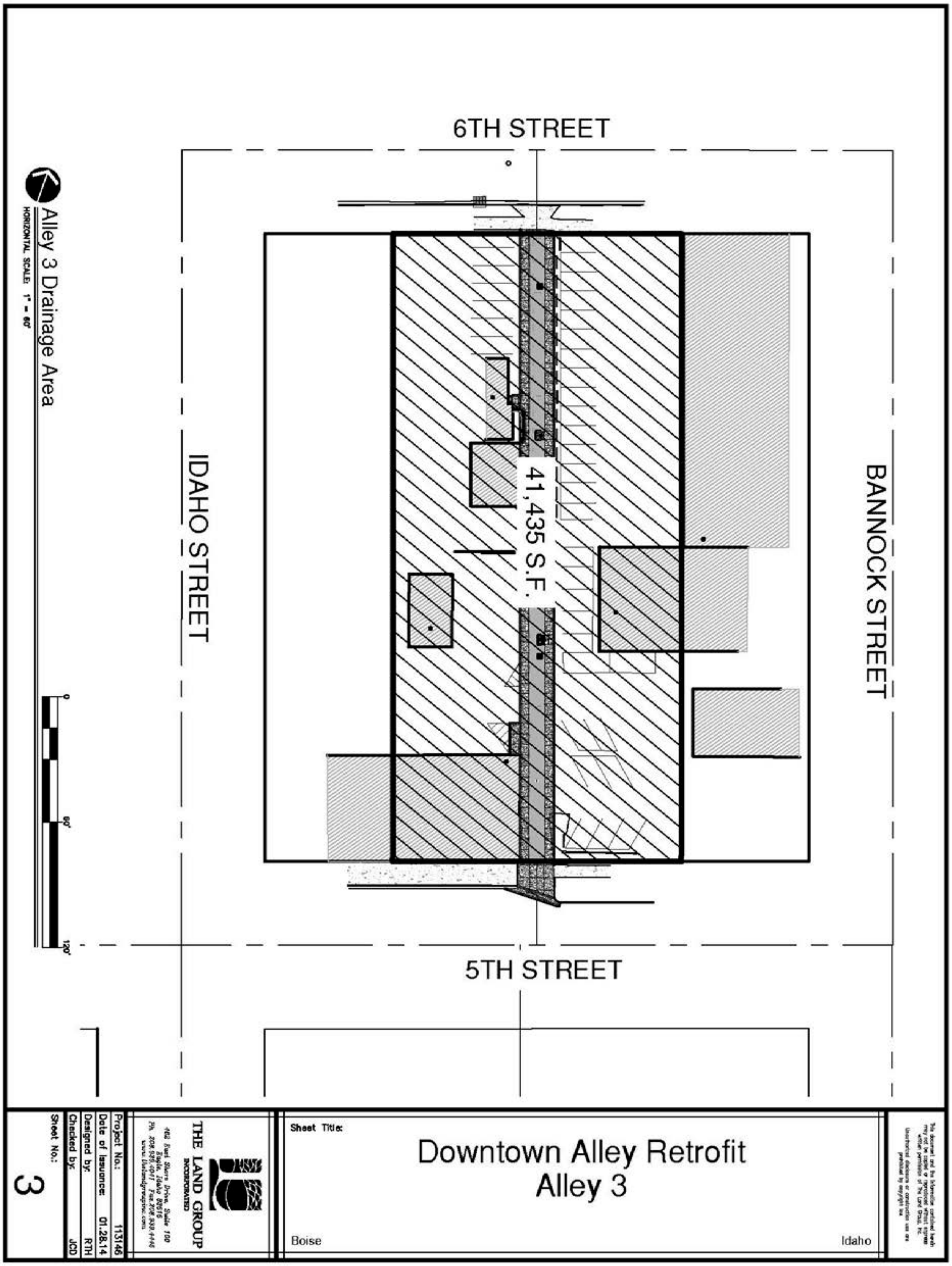
Site Drainage Areas


File Location: g:\2013\113146\cad\calcs and reports\113146 drainage areas.dwg
Last Plotted By: russ hepworth
Date Plotted: Tuesday, January 28 2014 at 03:35 PM
4TH STREET
3RD STREET
MAIN STREET
IDAHO STREET
41,435 S.F.
Alley 1 Drainage Area
HORIZONTAL SCALE: 1" = 60'
0
60'
120'
Sheet Title:
Downtown Alley Retrofit
Alley 1
Boise
Idaho
THE LAND GROUP
INCORPORATED
Project No.: 113146
Date of Issuance: 01.28.14
Designed by: RTH
Checked by: JCD
Sheet No.: 1

File Location: g:\2013\113146\cad\calcs and reports\113146 drainage areas.dwg
Last Plotted By: russ hepworth
Date Plotted: Tuesday, January 28 2014 at 03:36 PM



File Location: g:\2013\113146\cad\calcs and reports\113146 drainage areas.dwg
Last Plotted By: russ hepworth
Date Plotted: Tuesday, January 28 2014 at 03:39 PM



Appendix B

Drainage Calculations

THE LAND GROUP, INC.

Drainage (continued)

Retention System Summary

Vwq =	1,032	c.f.	← Required Storage Volume (Water Quality Capture Volume)***
Vsed =	103	c.f.	← 10% Sediment Storage
Vtot =	1,135	c.f.	← Total Storage Volume Required
VSp =	1,201	c.f.	← Total Volume Provided

Infiltration volume =	6.7	ft (wide) x	300.0	ft (long) x	1.50	ft (deep)

*** Required Storage Volume = Volume Developed - Volume Infiltrated

Seepage Bed Recovery Time:

Vs Max=	1,115	cf	←80th Percentile Runoff Developed
Q perc =	83	cf per hr	
Time Rec =	13.4	hours	

Site Planning · Landscape Architecture · Civil Engineering · Golf Course Irrigation & Engineering · Graphic Communication · Surveying
462 E. Shore Drive, Ste. 100, Eagle, Idaho 83616 · P 208.939.4041 F 208.939.4445 · www.thelandgroupinc.com

THE LAND GROUP, INC.

Downtown Alley Retrofit
Alleys 1, 2 and 3
Storm Water Management Report

Appendix C

Geotechnical Report (for reference)

Site Planning · Landscape Architecture · Civil Engineering · Golf Course Irrigation & Engineering · Graphic Design · Surveying
462 E. Shore Drive, Suite 100 · Eagle, Idaho 83616 · P 208.939.4041 · F 208.939.4445 · www.thelandgroupinc.com

October 23, 2013

The Land Group, Inc.
462 East Shore Drive, Suite 100
Eagle, ID 83616

Attn: Mr. David Koga
P: [208] 939 4041
E: david@thelandgroupinc.com

Re: Summary of Infiltration Testing Services
Various Alleys
Boise, Idaho
Terracon Project No. 62135042

Dear Mr. Koga:

This letter summarizes the results of Terracon's services consisting of performing infiltration testing at various alley locations in Boise, Idaho. This work was performed in general accordance with our revised proposal dated September 18, 2013.

Terracon understands the alleys listed below are experiencing issues with drainage and a deteriorating condition of the existing pavement sections.

- ½ block north of Main Street, between 13th and 14th Streets (Test Location 1).
- ½ block north of Main Street, between 3rd and 4th Streets (Test Location 2).
- ½ block north of Idaho Street, between 5th and 6th Streets (Test Location 3).

We further understand permeable pavement sections are being considered by others for these alleys. As requested by The Land Group, Terracon performed an infiltration test in each alley. The testing locations were selected by ACHD in conjunction with Terracon in areas clear of utility conflicts. The approximate infiltration testing locations are shown on the attached Infiltration Testing Location Plan.

Infiltration Tests

Terracon subcontracted the cutting of the existing asphalt and excavation of soils at the infiltration testing locations. Infiltration testing depths varied between approximately 1½ and 2 feet below ground surface (bgs). The excavations were advanced using a small track-mounted excavator. Disturbed soil samples were obtained from the excavations at various depths. A Terracon field technician recorded logs of the excavations. Descriptions of the materials encountered are presented on the logs, which are attached to this letter.

Summary of Infiltration Testing
Various Alley Ways ■ Boise, Idaho
October 23, 2013 ■ Terracon Project No. 62135042

A double-ring infiltration test was performed in general accordance with ASTM D3385-09 in test locations 1 and 2. The tests were performed with a head of water between 6 and 9 inches. Repeated attempts were made to perform a double-ring infiltrometer test at location 3. However, due to rapid infiltration, the test apparatus could not maintain a constant head during testing. As a result, Terracon performed several falling head permeability tests within the double rings at this test location. The falling head test was performed with an initial head of 15 inches, and the test was repeated for a total of four cycles. Details of the tests are summarized in the following table. Results of the constant head tests are attached to this document.

Infiltration Test Location	Approximate Depth[1] of Test	Soil Type at Depth of Test	Measured Infiltration Rate
1 (Between 13th and 14th)	1.3 feet	Fill: Clayey Sand with Gravel	See attached test report
2 (Between 3rd and 4th)	1.6 feet	Silty Sand to Sandy Silt	See attached test report
3 (Between 5th and 6th)	2.1 feet	Silty Sand, underlain by Sand	28 inches/hour

1. Depth below the existing ground surface

This field test results are not intended to be design rates. The results represent the measured rates at the depth and location indicated, as described above. The design rate should be determined by the designer by applying an appropriate factor of safety. With time, the bottoms of infiltration systems tend to plug with organics, sediments, and other debris. Long-term maintenance will likely be required to remove these deleterious materials to help reduce decreases in the actual infiltration rate. In addition, the infiltration rate may be affected by the following factors, which should be considered when selecting the factor of safety:

Test Procedures: The test results may include both vertical and lateral seepage, whereas seepage from storm water infiltration systems may primarily flow downward, depending on the geometry and details of the system.

Water Quality: The infiltration tests were performed with clear water, whereas storm water will likely not be clear, but may contain organics, fines, and grease/oil. The presence of these deleterious materials will tend to decrease the infiltration rate. Design of the storm water infiltration system should account for the presence of these materials and should incorporate structures/devices to remove these deleterious materials.

Soil Variability: Based on the soils encountered in our exploration, we expect the infiltration rates of the soils could be different than measured in the field due to variations in fines content and soil type. The design elevation and size of the proposed infiltration system should account for this expected variability in the infiltration rate.

Terracon

Closure

The information presented in this report is based upon the data obtained from the excavations advanced at the indicated locations and from other information discussed in this report. This report does not reflect variations that may occur between testing locations, across the site, or due to the modifying effects of construction or weather. The nature and extent of such variations may not become evident until during or after construction. If variations appear, we should be immediately notified so that further evaluation and supplemental recommendations can be provided.

The scope of services for this project does not include either specifically or by implication any environmental or biological (e.g., mold, fungi, bacteria) assessment of the site or identification or prevention of pollutants, hazardous materials or conditions. If the owner is concerned about the potential for such contamination or pollution, other studies should be undertaken.

This report has been prepared for the exclusive use of our client for specific application to the project discussed and has been prepared in accordance with generally accepted geotechnical engineering practices. No warranties, expressed or implied, are intended or made. Site safety, excavation support, and dewatering requirements are the responsibility of others. In the event that changes in the nature, design, or location of the project as outlined in this report are planned, the conclusions and recommendations contained in this report shall not be considered valid unless Terracon reviews the changes and either verifies or modifies the conclusions of this report in writing.

We appreciate the opportunity to work with you on this project. Please call our office if you have any questions regarding this letter.

Sincerely,
Terracon Consultants, Inc.

PROFESSIONAL ENGINEER
REGISTERED
10/23/13
12154
STATE OF IDAHO
RYAN J. OLSEN

Ryan J. Olsen, P.E.	Mathew B. Fielding, P.E.
Geotechnical Department Manager	Office Manager

Attachments
Copies To: Addressee (2 Original, 1 Electronic)


N
LEGEND:
Infiltration Testing Location
IMAGE PROVIDED BY GOOGLE EARTH PRO
DIAGRAM IS FOR GENERAL LOCATION ONLY, AND IS NOT INTENDED FOR CONSTRUCTION PURPOSES
Project Manager: RJO
Drawn By: JWB
Checked By: RJO
Approved By: RJO
Project No. 62135042
Scale: N.T.S.
File Name: 62135042BLP
Date: 10/18/2013
Terracon
Consulting Engineers & Scientists
INFILTRATION TESTING LOCATION PLAN
DOUBLE RING INFILTROMETER TESTING
VARIOUS BOISE ALLEYS
BOISE, IDAHO
Exhibit
A-1
N 14th St
N 13th St
Test 1
W Main Street
W Idaho Street
W Bannock Street
N 6th St
Test 3
N 5th St
N 4th St
Test 2
N 3rd St

TEST PIT LOG NO. 1

Page 1 of 1

PROJECT: Boise Alley Double RIng Infiltrometer

CLIENT: The Land Group, Inc.
Eagle, Idaho

SITE:
Boise, Idaho

GRAPHIC LOG	LOCATION N of W Main St between N 13th and N 14th St Latitude: 43.61931° Longitude: -116.20968° DEPTH	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	FIELD TEST RESULTS
	FILL - CLAYEY SAND, trace gravel, brown	1			
	1.3			I	
	Test Pit Terminated at 1.3 Feet Infiltration test performed at 1.3 ft				

Stratification lines are approximate. In-situ, the transition may be gradual.

Advancement Method:
Mini Excavator

Abandonment Method:
Loosely backfilled with soil upon completion.

Notes:

WATER LEVEL OBSERVATIONS
Not Encountered

Terracon
11849 W. Executive Dr., Suite G
Boise, Idaho

Test Pit Started: 10/9/2013	
Excavator:	Operator: Syman
Project No.: 62135042	

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GEO SMART LOG-NO WELL 62135042.GPJ TERRACON2012.GDT 10/23/13

TEST PIT LOG NO. 2

Page 1 of 1

PROJECT: Boise Alley Double RIng Infiltrometer

CLIENT: The Land Group, Inc.
Eagle, Idaho

SITE:
Boise, Idaho

LOCATION N of W Main St between N 3rd and N 4th St
Latitude: 43.61317° Longitude: -116.19775°

DEPTH	Description	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	FIELD TEST RESULTS
0.3	**ASPHALT CONCRETE**				
0.5	**FILL - SILTY GRAVEL WITH SAND**, light brown				
0.9	**FILL - SILTY SAND WITH GRAVEL**, dark brown				
1.5	**SILTY SAND (SM)**, trace gravel and cemented fragments, white to light brown	1		I	
1.6	**SILTY SAND to SANDY SILT (SM)**, dark brown			I	

Test Pit Terminated at 1.6 Feet

Infiltration test performed at 1.6 ft

Stratification lines are approximate. In-situ, the transition may be gradual.

Advancement Method:
Mini Excavator

Abandonment Method:
Loosely backfilled with soil upon completion.

Notes:

WATER LEVEL OBSERVATIONS
Not Encountered

Terracon
11849 W. Executive Dr., Suite G
Boise, Idaho

Test Pit Started: 10/10/2013	
Excavator:	Operator: Syman
Project No.: 62135042	

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GEO SMART LOG-NO WELL 62135042.GPJ TERRACON2012.GDT 10/23/13

TEST PIT LOG NO. 3

Page 1 of 1

PROJECT: Boise Alley Double RIng Infiltrometer

CLIENT: The Land Group, Inc.
Eagle, Idaho

SITE:
Boise, Idaho

LOCATION N of W Idaho St between N 5th and 6th St
Latitude: 43.61524° Longitude: -116.19936°

GRAPHIC LOG / DEPTH	Description	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	FIELD TEST RESULTS
0.2	**ASPHALT CONCRETE**				
0.6	**FILL - AGGREGATE BASE COURSE**				
1.1	**SANDY SILT (ML)**, dark brown	1			
1.9	**SILTY SAND (SM)**, light brown				
2.1	**SILTY SAND WITH GRAVEL (SM)**, dark brown	2		I	
2.3	**WELL GRADED SAND WITH SILT AND GRAVEL (SW-SM)**, yellowish-brown				

Test Pit Terminated at 2.3 Feet

Infiltration test performed at 2.1 ft

Stratification lines are approximate. In-situ, the transition may be gradual.

Advancement Method:
Mini Excavator

Abandonment Method:
Loosely backfilled with soil upon completion.

Notes:

WATER LEVEL OBSERVATIONS
Not Encountered

Terracon
11849 W. Executive Dr., Suite G
Boise, Idaho

Test Pit Started: 10/11/2013	
Excavator:	Operator: Syman
Project No.: 62135042	

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GEO SMART LOG-NO WELL 62135042.GPJ TERRACON2012.GDT 10/23/13

GENERAL NOTES

DESCRIPTION OF SYMBOLS AND ABBREVIATIONS

SAMPLING

Bulk | Shelby Tube | Split Spoon
Rock Core | Macro Core | Modified California Ring Sampler
Grab Sample | No Recovery | Modified Dames & Moore Ring Sampler

WATER LEVEL

Water Initially Encountered
Water Level After a Specified Period of Time
Water Level After a Specified Period of Time

Water levels indicated on the soil boring logs are the levels measured in the borehole at the times indicated. Groundwater level variations will occur over time. In low permeability soils, accurate determination of groundwater levels is not possible with short term water level observations.

FIELD TESTS

(HP)	Hand Penetrometer
(T)	Torvane
(b/f)	Standard Penetration Test (blows per foot)
N	N value
(PID)	Photo-Ionization Detector
(OVA)	Organic Vapor Analyzer

DESCRIPTIVE SOIL CLASSIFICATION

Soil classification is based on the Unified Soil Classification System. Coarse Grained Soils have more than 50% of their dry weight retained on a #200 sieve; their principal descriptors are: boulders, cobbles, gravel or sand. Fine Grained Soils have less than 50% of their dry weight retained on a #200 sieve; they are principally described as clays if they are plastic, and silts if they are slightly plastic or non-plastic. Major constituents may be added as modifiers and minor constituents may be added according to the relative proportions based on grain size. In addition to gradation, coarse-grained soils are defined on the basis of their in-place relative density and fine-grained soils on the basis of their consistency.

LOCATION AND ELEVATION NOTES

Unless otherwise noted, Latitude and Longitude are approximately determined using a hand-held GPS device. The accuracy of such devices is variable. Surface elevation data annotated with +/- indicates that no actual topographical survey was conducted to confirm the surface elevation. Instead, the surface elevation was approximately determined from topographic maps of the area.

STRENGTH TERMS

RELATIVE DENSITY OF COARSE-GRAINED SOILS (More than 50% retained on No. 200 sieve.) Density determined by Standard Penetration Resistance Includes gravels, sands and silts.			CONSISTENCY OF FINE-GRAINED SOILS (50% or more passing the No. 200 sieve.) Consistency determined by laboratory shear strength testing, field visual-manual procedures or standard penetration resistance			
Descriptive Term (Density)	**Standard Penetration or N-Value Blows/Ft.**	**Ring Sampler Blows/Ft.**	**Descriptive Term (Consistency)**	**Unconfined Compressive Strength, Qu, psf**	**Standard Penetration or N-Value Blows/Ft.**	**Ring Sampler Blows/Ft.**
Very Loose	0 - 3	0 - 6	Very Soft	less than 500	0 - 1	< 3
Loose	4 - 9	7 - 18	Soft	500 to 1,000	2 - 4	3 - 4
Medium Dense	10 - 29	19 - 58	Medium-Stiff	1,000 to 2,000	4 - 8	5 - 9
Dense	30 - 50	59 - 98	Stiff	2,000 to 4,000	8 - 15	10 - 18
Very Dense	> 50	≥ 99	Very Stiff	4,000 to 8,000	15 - 30	19 - 42
			Hard	> 8,000	> 30	> 42

RELATIVE PROPORTIONS OF SAND AND GRAVEL

Descriptive Term(s) of other constituents	Percent of Dry Weight
Trace	< 15
With	15 - 29
Modifier	> 30

GRAIN SIZE TERMINOLOGY

Major Component of Sample	Particle Size
Boulders	Over 12 in. (300 mm)
Cobbles	12 in. to 3 in. (300mm to 75mm)
Gravel	3 in. to #4 sieve (75mm to 4.75 mm)
Sand	#4 to #200 sieve (4.75mm to 0.075mm
Silt or Clay	Passing #200 sieve (0.075mm)

RELATIVE PROPORTIONS OF FINES

Descriptive Term(s) of other constituents	Percent of Dry Weight
Trace	< 5
With	5 - 12
Modifier	> 12

PLASTICITY DESCRIPTION

Term	Plasticity Index
Non-plastic	0
Low	1 - 10
Medium	11 - 30
High	> 30

Terracon

DOUBLE RING INFILTROMETER TESTING ASTM D3385

Project: Boise Alley Double Ring Infiltrometer Testing
Project No.: 62135042
Client: The Land Group
Service Date: 10/9/2013

Terracon
11849 West Executive Drive, Suite G
Boise, Idaho 83713
(208) 323-9520 FAX (208) 323-9592

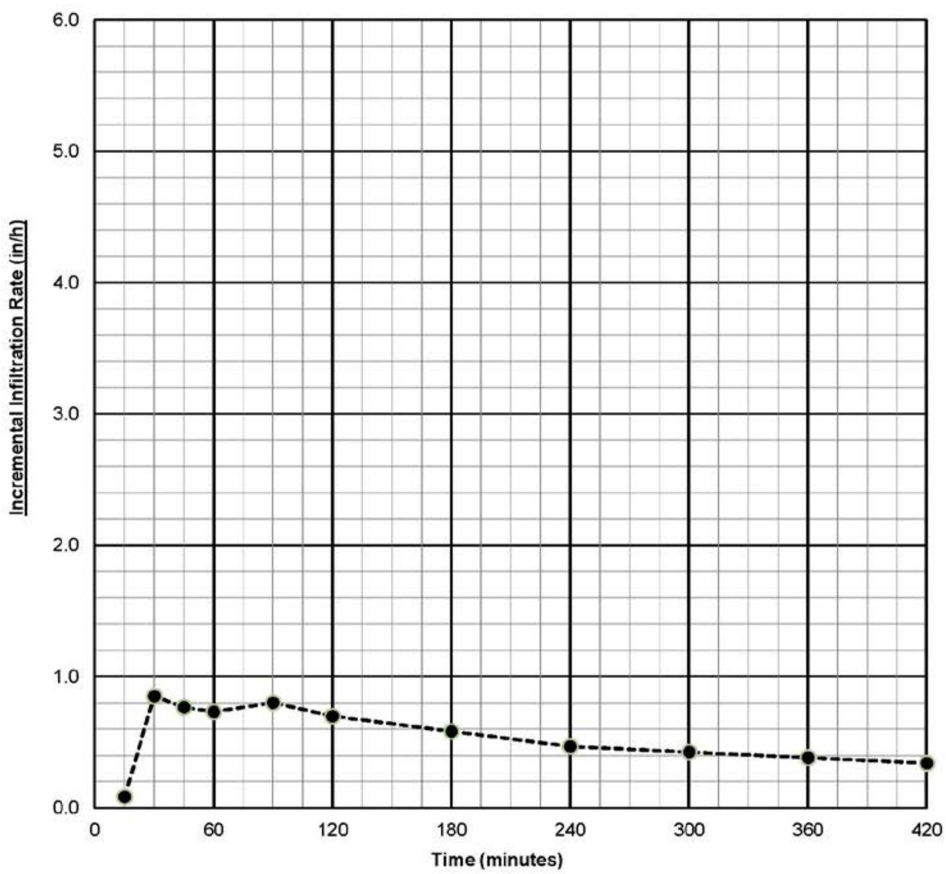
SITE DATA

Test Location: Alley 1/2 block North of Main between 13rd & 14th 43.619312, -116.20968
Elevation: 1.3' below grade
Depth to ground water: Unknown
Soil Classification: Fiil - Clayey Sand, trace gravel
Weather: Clear and Calm

TEST DATA

Technican: CFK
Ground Temperature (°F): 58.8
Water Temperature (°F): 56.1
Inner Ring Embedment (in): 4.4
Outer Ring Embedment (in): 4.4
Inner Ring Liquid Depth (in): 8.7
Annulus Area Liquid Depth (in): 8.7
Liquid Used: Water

Measured Infiltration Rate



DOUBLE RING INFILTROMETER TESTING ASTM D3385

Project: Boise Alley Double Ring Infiltrometer Testing
Project No.: 62135042
Client: Ada County Highway District
Service Date: 10/10/2013

Terracon
11849 West Executive Drive, Suite G
Boise, Idaho 83713
(208) 323-9520 FAX (208) 323-9592

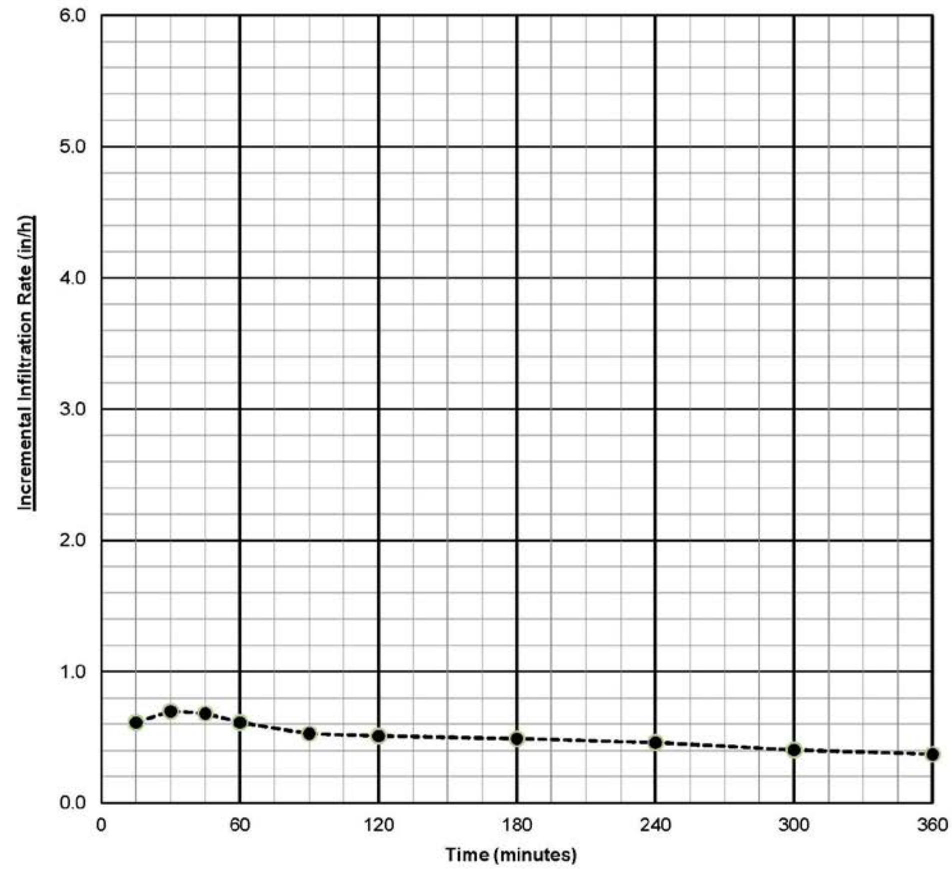
SITE DATA

Test Location: Alley 1/2 block North of Main between 3rd & 4th 43.61317 x -116.19775
Elevation: 15" below grade
Depth to ground water: Unknown
Soil Classification: Silty Sand to Sandy Silt
Weather: Overcast with moderate wind

TEST DATA

Technican: CFK
Ground Temperature (°F): 58.2
Water Temperature (°F): 53.8
Inner Ring Embedment (in): 6.6
Outer Ring Embedment (in): 6.6
Inner Ring Liquid Depth (in): 6.7
Annulus Area Liquid Depth (in): 6.6
Liquid Used: Water

Measured Infiltration Rate



Appendix E

Appendix E
Observation Forms

Permeable Paver Project Observation Form - Main btw. 3rd & 4th					
Date:		Time:		Personnel:	
Weather:				Last Rain:	
Instructions:					
1. Take photos oriented as indicated on map at each station (1-4) and record filename or time of each photo.					
2. Note the presence of ponding water, run-off, contaminants (oil sheen, sediments, etc).					
3. Note flow coming off roof drains (HF= heavy flow, MF=medium flow, LF= low flow, NF = no flow)					
4. Use the photo below to record observation types					
5. In constrution phase note sub-surface conditions, tracking, run-on, utility conflicts and any other construction concerns					
6. In post-construction phase note any damage to pavers, evidence of maintenance, snow event performance, well levels.					
Observation types: PW = ponding water, RU = run-off, CS = contaminants ,O= oil sheen, SS= sediments					
Observation Type	**Observation Notes**				
Monitoring Well #1 Level:		Monitoring Well #2 Level:			

Permeable Paver Project Observation Form - Main btw. 13th and 14th					
Date:		Time:		Personnel:	
Weather:				Last Rain:	
Phase:	Pre-Construction	Construction	Post-Construction		
Instructions:					
1. Take photos at each station (1-4) and record file or time of each photo.					
2. Note the presence of ponding water, run-off, contaminants (oil sheen, sediments, etc).					
3. Note flow coming off roof drains (HF= heavy flow, MF=medium flow, LF= low flow, NF = no flow)					
4. Use the photo below to record observation types					
5. In constrution phase note sub-surface conditions, tracking, run-on, utility conflicts and any other construction concerns					
6. In post-construction phase note any damage to pavers, evidence of maintenance, snow event performance, well levels.					
Observation types: PW = ponding water, RU = run-off, CS = contaminants ,O= oil sheen, SS= sediments					
Observation Type	**Observation Notes**				
Monitoring Well #1 Level:		Monitoring Well #2 Level:			

Appendix F

Appendix F
Observation Spreadsheet

Alley Observations

Date	Alley ID	Personnel	Rain Amt.	Rain Time Period (hrs)	Rain Source	Raining at Time of Visit	MW #1 Level	MW #2 Level	Photos	Summary Observations
2/12/2014	All 3	DMB, MIL	0.29	7	NWS	Yes			Yes	1st observation trip, photos are not at designated spots; observation form not yet created
3/27/2014	Main1314	DMB	0.14	13	NWS	Yes			Yes	ponding water, sediment flowing into 14th, some tracking into 14th, heavy flow from IMT roof drain scouring away gravel/dirt
3/27/2014	Main34	DMB	0.14	13	NWS	Yes			Yes	light run-off to 4th (clear), standing water, run-off to 3rd had oil sheen, light flow from NW bld. roof, DI ~8 inches from full
3/27/2014	Idaho56	DMB	0.14	13	NWS	Yes			Yes	lots of standing water; very little run-off from alley; some oil sheen in puddles, light flow from roofs on southside
4/2/2014	Main1314	DMB	0.54	24	NWS	No			Yes	ponding water in depressions; no water flowing off alley; roof drain from IMT building creating gulley/erosion; some erosion from Idaho Power roof drain near 14th
4/2/2014	Main34	DMB	0.54	24	NWS	No			Yes	very little flow coming off alley; little to no flow from roofs; DI at 3rd full and creating large puddle onto 3rd (pic)
4/2/2014	Idaho56	DMB	0.54	24	NWS	No			Yes	ponding water in depressions; more standing water on east side; little to no flow off of alley to street
5/9/2014	Main1314	LR				Yes (hail)			Yes	ponding water against IMT building; some ponding along rest of alley; run-off from many roof drains running mainly to the west
5/9/2014	Main34	LR				Yes (light rain)			Yes	ponding on east side mainly; runoff mostly headed toward west; oil and sediments in ponding water on east side
7/21/2014	Main1314	APL, JM	0	NA	NA	No			Yes	During Construction: Concrete and Base Installed, Contractor noted that fabric was being used to prevent sediment from construction entering and clogging the base and that construction practices were careful not to compact the soils below the base to maintain infiltration rates
7/21/2014	Main34	APL, JM	0	NA	NA	No			Yes	During Construction: Utility work done, waiting for paver construction to begin
7/29/2014		APL								Paver installation was delayed because of delay in paver product completion until week of 8/4/14
8/14/2014	Main34 & Main 1314	APL	0.04	9	Front	No			Yes	All runoff infiltrated into pavers

Appendix G

Appendix G

Designation: C1781/C1781M – 14

Standard Test Method for Surface Infiltration Rate of Permeable Unit Pavement Systems[1]

This standard is issued under the fixed designation C1781/C1781M; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (´) indicates an editorial change since the last revision or reapproval.

1. Scope*

1.1 This test method covers the determination of the field surface infiltration rate of in place permeable unit pavement systems surfaced with solid interlocking concrete paving units, concrete grid paving units, or clay paving brick.

1.2 The values stated in either SI units or inch-pound units are to be regarded separately as standard. The values stated in each system may not be exact equivalents; therefore, each system shall be used independently of the other. Combining values from the two systems may result in non-conformance with the standard.

1.3 The text of this test method references notes that provide explanatory material. These notes shall not be considered as requirements of the test method.

1.4 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

C902 Specification for Pedestrian and Light Traffic Paving Brick
C920 Specification for Elastomeric Joint Sealants
C936 Specification for Solid Concrete Interlocking Paving Units
C1232 Terminology of Masonry
C1272 Specification for Heavy Vehicular Paving Brick
C1319 Specification for Concrete Grid Paving Units
C1701 Test Method for Infiltration Rate of In Place Pervious Concrete

2.2 *Other Standards:*[3]

Federal Specification A-A-3110 (TT-P-1536A) Plumbing Fixture Setting Compound

3. Terminology

3.1 *Definitions*—The terms used in this test method are defined in Terminology C1232.

4. Summary of Test Method

4.1 An infiltration ring is temporarily sealed to the surface of a permeable unit pavement system. These pavements typically consist of solid concrete paving units conforming to Specification C936, concrete grid paving units conforming to Specification C1319, or clay paving brick conforming to Specification C902 or C1272. These pavements allow drainage through joints between the units or through voids formed by the intersection of two or more units or intentionally manufactured into the units. The results of this test method for unit pavement systems can be compared to that using Test Method C1701 for pervious concrete. After pre-wetting the test location, a given mass of water is introduced into the ring and the time for the water to infiltrate the pavement is recorded. The infiltration rate is calculated in accordance with 9.1.

5. Significance and Use

5.1 This test method can be used for acceptance of surface infiltration of new permeable unit pavement systems.

5.2 Tests performed at the same location across a span of years may be used to detect a reduction of infiltration rate of the permeable surface, thereby identifying the need for any remedial maintenance intended to increase the infiltration rates to predefined levels.

5.3 The infiltration rate obtained by this method is valid only for the localized area of the pavement where the test is conducted. To determine the surface infiltration rate of the entire permeable pavement, multiple locations must be tested and the results averaged.

[1] This test method is under the jurisdiction of ASTM Committee C15 on Manufactured Masonry Units and is the direct responsibility of Subcommittee C15.04 on Research.

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[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

5.4 The minimum acceptable infiltration rate is typically established by the design engineer of record or the municipality and can be a function of the design precipitation event.

6. Apparatus

6.1 *Infiltration Ring*—A cylindrical ring, open at both ends (See Fig. 1). The ring shall be watertight, sufficiently rigid to retain its form when filled with water, and shall have a diameter of 300 ± 10 mm [12.0 ± 0.5 in.] with a minimum height of 50 mm [2.0 in.]. The bottom edge of the ring shall be even. The inner surface of the ring shall be marked or scored with two lines at a distance of 10 and 15 mm [0.40 and 0.60 in.] from the bottom of the ring. Measure and record the inner diameter of the ring to the nearest 1 mm [0.05 in.].

NOTE 1—Ring materials that have been found to be suitable include steel, aluminum, rigid plastic, and PVC.

6.2 *Balance*—A balance or scale accurate to 10 g [0.02 lb].

6.3 *Container*—A cylindrical container typically made of plastic having a volume of at least 20 L [5 gal], and from which water may be easily poured at a controlled rate into the infiltration ring.

6.4 *Stop Watch*—Accurate to 0.1 s.

6.5 *Plumbers Putty (Non-Hardening)*—Meeting Specification C920 or Federal Specification A-A-3110.

6.6 *Water*—Potable water.

7. Test Locations

7.1 Perform tests at multiple locations at a site as requested by the purchaser of testing services. Unless otherwise specified, use the following to determine the number of tests to perform:

7.1.1 Three test locations for areas up to 2500 m^2 [25 000 ft^2].

7.1.2 Add one test location for each additional 1000 m^2 [10 000 ft^2] or fraction thereof.

7.2 Provide at least 1 m [3 ft] clear distance between test locations, unless at least 24 h have elapsed between tests.

7.3 Do not test if there is standing water on top of the permeable pavement. Do not test within 24 h of the last precipitation.

8. Procedure

8.1 *Infiltration Ring Installation*—Clean the pavement surface by only sweeping off trash, debris, and other non-seated material.

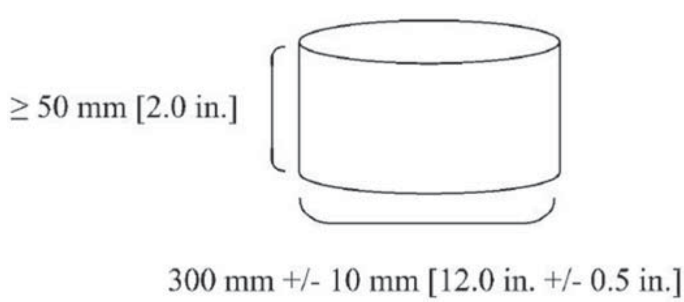

FIG. 1 Dimensions of Infiltration Ring

8.2 Take a photograph of the immediate area to be tested to document the pavement pattern and layout. Move the ring over the surface of the pavement until the pattern, drainage joints and drainage voids framed within the infiltration ring are representative of the entire paving pattern, drainage joints and drainage voids across the pavement surface. Set the ring on the pavement surface and mark its location by circumscribing it with chalk or other temporary marking. Take a photograph of the circumscribed chalk or temporary marking to document the placement of the ring relative to the pavement pattern and layout (see Note 2).

NOTE 2—The procedure in 8.2 for selecting and documenting the placement of the infiltration ring on a representative area of the pavement is sufficient in most cases for determining the infiltration rate of the pavement. The drainage area within the infiltration ring is typically within ±20 % of the average drainage area of the pavement as a whole. This accuracy is adequate for most situations. If a more accurate quantification of the infiltration rate is needed, the procedure detailed in Appendix X1 can be used to normalize the drainage area within the infiltration ring to the average drainage area of the pavement as a whole.

8.3 For solid interlocking concrete paving units and clay brick paving, remove aggregate to a depth of no greater than 10 mm [0.5 in.] in any joint or drainage void that will be directly below the test ring and fill these areas with plumbers putty so that a positive seal can be made to the test ring once it is placed on the surface. Take care not to extend the plumbers putty more than 10 mm [0.5 in.] inside the perimeter of the chalk line or other temporary marking. For concrete grid paving units, center as much of the ring as possible on the webs. For ring locations over openings, remove any vegetation, if present, directly below the test ring to a depth of no greater than 10 mm [0.5 in] and apply plumbers putty to the surface of the soil, or to the aggregate, if present, so that a positive seal can be made to the test ring once it is placed on the surface. Take care not to extend the plumbers putty more than 10 mm [0.5 in.] inside the perimeter of the chalk line or other temporary marking.

8.4 Apply plumbers putty around the bottom edge of the ring and place the ring onto the surface being tested. Press the putty into the surface and around the bottom edge of the ring to create a watertight seal making sure that the putty does not extend more than 10 mm [0.5 in] inside the perimeter of the ring. Place additional putty as needed to ensure a watertight seal.

NOTE 3—In a hot environment or when the surface temperature is over 38°C [100°F] plumbers putty may not adhere to the surface of the pavement easily. Therefore it is advisable to perform this test during a cooler temperature.

8.5 *Prewetting*—Pour water into the ring at a rate sufficient to maintain a head between the two marked lines. Take care to pour the water such that it falls directly on the surface of a paving unit and not onto the joints. This minimizes displacement of jointing aggregate and any accumulated sediment in the joints during the test (see Note 4). Use a total of 3.60 ± 0.05 kg [8.0 ± 0.1 lb] of water. Begin timing as soon as the water impacts the permeable pavement surface. Stop timing when free water is no longer present on the surface. Record the amount of elapsed time to the nearest 0.1 second.

NOTE 4—It is recommended that the pour height be limited to a maximum of 150 mm [6.0 in.] above the surface of the paving units to minimize disruption.

8.6 *Test*—The test shall be started within 2 min after the completion of the prewetting. If the elapsed time in the prewetting stage is less than 30 s, then use a total of 18.00 ± 0.05 kg [40.00 ± 0.1 lb] of water. If the elapsed time in the prewetting stage is greater than or equal to 30 s, then use a total of 3.60 ± 0.05 kg [8.0 ± 0.1 lb] of water. Record the weight of water to the nearest 10 g [0.02 lb]. Pour the water onto the ring at a rate sufficient to maintain a head between the two marked lines and until the measured amount of water has been used. Take care to pour the water such that it falls directly on the surface of a paving unit and not onto the joints. This minimizes displacement of jointing aggregate and any accumulated sediment in the joints during the test (see Note 5). Begin timing as soon as the water impacts the permeable pavement surface. Stop timing when free water is no longer present on the surface. Record the testing duration (t) to the nearest 0.1 second.

NOTE 5—If a sloped pavement is being measured, maintain head between the two marked lines at the lowest point of the slope.

8.7 If a test is repeated at the same location, the repeat test does not require pre-wetting if conducted within 5 min after completion of the first test. If more than one test is conducted at a location on a given day, the infiltration rate at that location on that day shall be calculated as the average of the two tests. Do not repeat this test more than twice at the same location on a given day.

8.8 When completed with testing, remove plumbers putty from the joints and surface, reinstate the removed aggregate jointing materials, and sweep test area clean.

9. Calculation

9.1 Calculate the infiltration rate (I) using consistent units as follows:

$$I = KM/(D^2 * t) \qquad (1)$$

where:

- I = Infiltration rate, mm/h [in./h],
- M = Mass of infiltrated water, kg [lb],
- D = Inside diameter of infiltration ring, mm [in.],
- t = time required for measured amount of water to infiltrate the surface, s, and
- K = 4 583 666 000 in SI units or 126 870 in [inch-pound] units.

NOTE 6—The factor K has units of $(mm^3 s)/(kg h)$ $[(in.^3 s)/(lb h)]$ and is needed to convert the recorded data (W, D, and t) to the infiltration rate I in mm/h [in./h].

10. Report

10.1 Report the following information:

10.1.1 Identification number,

10.1.2 Location,

10.1.3 Date of test,

10.1.4 Age, type and thickness of paving units (label Unknown if not known),

10.1.5 Include a photograph of the immediate area that was tested to document the pavement pattern and layout and a photograph of the circumscribed chalk or temporary marking to document the placement of the ring relative to the pavement pattern and layout,

10.1.6 Time elapsed during prewetting, s,

10.1.7 Amount of rain during last event, if known, mm [in.],

10.1.8 Weight of infiltrated water, kg [lb],

10.1.9 Inside diameter of infiltration ring, mm [in.],

10.1.10 Time elapsed during infiltration test, s,

10.1.11 Infiltration rate, mm/h [in./h], and

10.1.12 Number of tests performed at each location, if applicable.

11. Precision and Bias[4]

11.1 The following precision statements are based on duplicate measurements done at 74 locations on 37 different permeable unit pavement systems with average infiltration rates ranging from 30 to 1600 in./h by two separate operators:

11.1.1 The 95 % Confidence Limit (CL) for single-operator repeatability (r) averages 7.7 % with a median value of 5.9 %.

11.1.2 The 95 % CL for the multiple-operator reproducibility (R) averages 19.8% with a median value of 10.0%.

11.2 Based on the average results of four measurements at each of two locations on 37 different permeable unit pavement systems with average infiltration rates ranging from 30 to 1600 in./h, the difference between average results at the two locations averages 19.1 % with a median value of 12.2 %.

11.3 This test method has no bias because the infiltration rate of permeable unit pavement systems is defined only in terms of this test method.

12. Keywords

12.1 clay paving units; concrete grid paving units; concrete paving units; infiltration; permeable; unit pavement systems; water

[4] Supporting data have been filed at ASTM International Headquarters and may be obtained by requesting Research Report RR:C15-1000. Contact ASTM Customer Service at service@astm.org.

APPENDIX

(Nonmandatory Information)

X1. PROCEDURE FOR NORMALIZATION OF DRAINAGE AREA WITHIN THE INFILTRATION RING TO THE AVERAGE DRAINAGE AREA OF THE PAVEMENT AS A WHOLE

X1.1 Scope

X1.1.1 The procedure in 8.2 for selecting and documenting the placement of the infiltration ring on a representative area of the pavement is sufficient in most cases for determining the infiltration rate of the pavement. The drainage area within the infiltration ring is typically within ±20 % of the average drainage area of the pavement as a whole. This accuracy is adequate for most situations. If a more accurate quantification of the infiltration rate is needed use the procedure detailed in this appendix to normalize the drainage area within the infiltration ring to the average drainage area of the pavement as a whole.

X1.1.2 The provisions in this appendix cover two basic drainage methods: the first in which the system is designed to drain through the joints between units and the second in which the system is designed to drain through voids that are formed at the intersection of two or more units or that are intentionally manufactured into the units.

X1.1.3 For systems designed to drain through joints between the units, for the sake of simplicity, the drainage area is estimated by measuring the total linear drainage joint length. This assumes that the joint width is designed to be consistent across the field of the pavement. This removes the necessity of measuring the width of each individual joint.

X1.1.4 For systems designed to drain through voids that are formed at the intersection of two or more units or that are intentionally manufactured into the units, for the sake of simplicity, the drainage area is estimated by the counting the number of voids in a given area. This assumes that the voids are designed to be consistent in size across the field of the pavement. This removes the necessity of determining the area of each individual void.

X1.1.5 For systems designed to drain through a combination of joints and voids or in which the joints or voids are of different widths or sizes, the drainage area can be determined by calculating the area of each joint and void within a given area and summing the areas together. These areas could then be used in calculations analogous to the ones shown in this appendix to normalize the drainage area within the infiltration ring to the average drainage area of the pavement as a whole.

X1.2 Procedure

X1.2.1 Determine the amount of drainage area per surface area of pavement as follow:

X1.2.1.1 For systems designed to drain through joints between the units, mark off with chalk or other temporary marking an area of pavement that has minimum dimensions of 1.5 by 1.5 m [5 by 5 ft] (see Note X1.1). The edges of the marked area shall not coincide with a continuous drainage joint. Measure and record as L_a in cm [in.] the length of the marked off region. Measure and record as Wa in cm [in.] the width of the marked off region. Measure and record as L_d in cm [in.] the total linear drainage joint length in the marked off region. Calculate the amount of linear drainage joint length per area as follows:

$$LDPA = L_d / (L_a \times W_a) \tag{X1.1}$$

where:

$LDPA$ = linear drainage joint length per area of pavement, cm/m^2 [in./ft^2],
L_d = total linear drainage joint length in marked off region, cm [in.],
L_a = length of marked off area, m [ft], and
L_a = width of marked off area, m [ft].

X1.2.1.2 For systems designed to drain through voids that are formed at the intersection of two or more units or that are intentionally manufactured into the units, mark with chalk or other temporary marking an area of pavement that has minimum dimensions of 1.5 by 1.5 m [5 by 5 ft] (see Note X1.1). Minimize the number of drainage voids that coincide with the marked area edges. Measure and record as L_a in cm [in.] the length of the marked off region. Measure and record as W_a in cm [in.] the width of the marked off region. Measure and record as N_v the number of drainage voids in the marked off region. Calculate the number of drainage voids per area as follows:

$$DVPA = N_v / (L_a \times W_a) \tag{X1.2}$$

where:

$DVPA$ = number of drainage voids per area of pavement, #/m^2 [#/ft^2],
N_v = total number of drainage voids in marked off region,
L_a = length of marked off area, m [ft], and
W_a = width of marked off area, m [ft].

NOTE X1.1—The marked off area should be representative of the repeating pattern of the pavement units. For unit pavement systems with numerous different unit shapes, a larger area than the specified minimum may need to be marked off to ensure that a whole repeating pattern has been encompassed.

X1.2.2 Follow the procedure in 8.3 to place the infiltration ring and to document the immediate area to be tested, as well as the placement of the ring relative to the pavement pattern and layout. In addition, totally fill any void that is directly below the test ring so that only whole voids are exposed and counted during the testing. Also, photograph the marked off region from X1.2.1 to document the area used to calculated the drainage area per surface area of pavement.

X1.2.2.1 For pavements with drainage joints, measure and record the length of drainage joints within the infiltration ring as L_t in cm [in.]. Calculate the amount of linear drainage joint length per area in the infiltration ring as follows:

$$LDTA = 1{,}000{,}000L_t / (\pi D^2/4), \text{ for SI units or} \quad (X1.3)$$

$$LDTA = 144L_t / (\pi D^2/4), \text{for in.-lb units}$$

where:

$LDTA$ = linear drainage joint length per area of the infiltration ring, cm/m^2 [in./ft^2],
L_t = total linear drainage joint length in the infiltration ring, cm [in.], and
D = inside diameter of infiltration ring, mm [in.].

X1.2.2.2 For pavements with drainage voids, measure and record the number of drainage voids entirely within the infiltration ring as N_t. Calculate the number of drainage voids per area of the infiltration ring as follows:

$$DVTA = 1{,}000{,}000N_t / (\pi D^2/4), \text{ for SI units or} \quad (X1.4)$$

$$DVTA = 144N_t / (\pi D^2/4), \text{for in.-lb units}$$

where:

$DVTA$ = total number of drainage voids per area of the infiltration ring, #/m^2 [#/ft^2],
N_t = total number of drainage voids in the infiltration ring, and
D = inside diameter of infiltration ring, mm [in.].

X1.3 Calculation

X1.3.1 Calculate the infiltration rate (I) using consistent units as follows:

X1.3.1.1 For systems designed to drain through joints between the units:

$$I = KM/(D^2 * t) \times (LDPA/LDTA) \quad (X1.5)$$

where:

I = infiltration rate, mm/h [in./h],
M = mass of infiltrated water, kg [lb],
D = inside diameter of infiltration ring, mm [in.],
t = time required for measured amount of water to infiltrate the surface, s,
K = 4 583 666 000 in SI units or 126 870 in [inch-pound] units,
$LDPA$ = linear drainage joint length per area of pavement, cm/m^2 [in./ft^2] (see Eq X1.1), and
$LDTA$ = linear drainage joint length per area of the infiltration ring, cm/m^2 [in./ft^2] (see Eq X1.3).

X1.3.1.2 For systems designed to drain through voids that are formed at the intersection of two or more units or that are intentionally manufactured into the units:

$$I = KM/(D^2 * t) \times (DVPA/DVTA) \quad (X1.6)$$

where:

I = infiltration rate, mm/h [in./h],
M = mass of infiltrated water, kg [lb],
D = inside diameter of infiltration ring, mm [in.],
t = time required for measured amount of water to infiltrate the surface, s,
K = 4 583 666 000 in SI units or 126 870 in [inch-pound] units,
$DVPA$ = number of drainage voids per area of pavement, #/m^2 [#/ft^2] (see Eq X1.2), and
$DVTA$ = total number of drainage voids per area of the infiltration ring, #/m^2 [#/ft^2] (see Eq X1.4).

X1.4 Report

X1.4.1 In addition to the reporting requirements of Section 10, include a photograph of the marked off region from X1.2.2 to document the area used to calculated the drainage are per surface area of pavement

X1.4.2 For systems designed to drain through joints between units, include the following:

X1.4.2.1 Linear drainage joint length per area of pavement, cm/m^2 [in./ft^2] (see Eq X1.1 for LDPA).

X1.4.2.2 Linear drainage joint length per area of the infiltration ring, cm/m^2 [in./ft^2] (see Eq X1.3 for LDTA).

X1.4.3 For systems designed to drain through voids that are formed at the intersection of two or more units or that are intentionally manufactured into the units, include the following:

X1.4.3.1 Number of drainage voids per area of pavement, #/m^2 [#/ft^2] (see Eq X1.2 for DVPA).

X1.4.3.2 Total number of drainage voids per area of the infiltration ring, #/m^2 [#/ft^2] (see Eq X1.4 for DVTA).

SUMMARY OF CHANGES

Committee C15 has identified the location of selected changes to this standard since the last issue (C1781/C1781M – 13) that may impact the use of this standard. (July 1, 2014)

(1) Revised Section 11 to add additional precision statements.