MOA and ADOT&PF
2013 Low Impact Development
Project Performance Monitoring Report

Prepared for:

The Municipality of Anchorage

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1. Introduction and Project Description

AWR Engineering, LLC and HDR Alaska are assisting the Municipality of Anchorage (MOA) with monitoring and reporting requirements for four Low Impact Development (LID) pilot projects. The pilot project construction, monitoring, and reporting are required per the current MOA and Alaska Department of Transportation and Public Facilities (ADOT&PF) Alaska Pollutant Discharge Elimination System (APDES) permit. Two of the pilot projects are owned by the MOA and two are owned by ADOT&PF. ADOT&PF is currently constructing a third pilot project, but project construction was delayed, and monitoring could not be completed at the time of this report.

1.1. APDES Reporting Requirements

The current APDES permit requires that the performance of each LID pilot project be monitored. The permit requires that changes in runoff quantities be calculated or modeled for each of the pilot projects and, for new construction projects, compared to a theoretical case of the project constructed without LID practices. The analysis requirements include preparing 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 nature of impervious surfaces (see page 15 of the APDES permit in Appendix A for additional information).

This report presents the required monitoring results for the LID pilot projects.

1.2. General Description of Pilot Projects

1.2.1. ADOT&PF Projects

ADOT&PF constructed the West Dowling Road Extension and Muldoon Road Pedestrian Improvements projects as LID projects for monitoring. West Dowling Road incorporates bioretention swales (bioswales) in lieu of traditional storm drains in several areas to provide treatment and infiltration of runoff before it enters nearby Campbell Creek. The Muldoon Road Pedestrian Improvements project focused on reducing impervious cover by replacing traditional impervious pedestrian facilities with vegetated planters and associated pervious landscaping.

1.2.2. MOA Projects

The MOA constructed the Taku Lake Rain Garden and Russian Jack Springs Park Parking Lot projects as LID projects for monitoring. Both of these projects were also parking lot retrofit projects, as required per the APDES permit, page 16, paragraph vi. (See Appendix A). Per page 15 of the permit, parking lot retrofits may be used as pilot projects. The Taku Lake Rain Garden project also meets the requirements for one of the two required rain gardens projects per page 16, paragraph iii of the permit. The second rain garden is addressed in a separate memorandum titled *Analysis for the Commercial Fishing and Agriculture Bank Rain Garden*. That memorandum is appended to this report.

The Taku Lake Rain Garden consists of a large bioretention area (rain garden) that accepts water from the adjacent Taku Lake parking lot, providing infiltration of small rainfall events and treatment and detention of larger events. The Russian Jack Springs Park Parking Lot includes both porous asphalt and a connected subsurface infiltration gallery that, together, accept all runoff from the parking lot.

This report presents information regarding the LID features, the monitoring process, and monitoring results for each project as required by the APDES permit. A map of project locations in the Anchorage area is included as Figure1, in Appendix B.

1.3. Quality Assurance Plan

In October of 2012, HDR prepared a Monitoring, Evaluation, and Quality Assurance Plan (QAP) for monitoring and reporting of LID projects for the MOA. Appendix E of this plan provides a process for both physical monitoring and hydrologic modeling of LID Projects. The monitoring, modeling, and reporting methods used for the analyses discussed in this report are similar to the processes described in the QAP. The QAP processes were modified as needed to reflect the unique characteristics of each site and the desired data output accuracy. These modifications are expected to improve overall results for each site. For example, the QAP initially suggested a 5-minute time step for hydrologic modeling, and a 1-minute time step for hydraulic modeling. These analyses used a time step of 30 seconds for both hydrologic and hydraulic modeling in order to provide better agreement between written and graphical output in the modeling software. Generally, the QAP processes were followed as much as possible.

2. West Dowling Road (ADOT&PF)

West Dowling Road is located in Anchorage, north of Dimond Boulevard, between C Street and the Old Seward Highway. The West Dowling Road project, constructed in 2012, expanded the existing roadway corridor from a two-lane road to a four-lane road with a center median and new pedestrian facilities. The project lies in the Campbell Creek Watershed and crosses Campbell Creek via a bridge between Potter Drive and the Old Seward Highway.

West Dowling Road is surrounded by residential and industrial areas to the north and south. The project’s hydrologic designers defined five drainage basins for the project area. This LID monitoring and reporting effort focuses on what the West Dowling designers refer to as Basin 4. Basin 4 has an area of 17.4 acres and is the largest basin in the project area that contributes stormwater runoff along the project corridor and toward Campbell Creek (see Figure 2 in Appendix B). Basin 4 is comprised of a residential area north of West Dowling Road and west of Campbell Creek. Based on information obtained from the project’s Hydrologic and Hydraulic (H&H) report, the topography in Basin 4 is fairly flat with an average slope of approximately 1.3 percent. The original design concept for stormwater runoff from Basin 4 included a piped storm drain system that would collect runoff from Basin 4 and discharge it directly to Campbell Creek, which is an impaired water body. Based on the need for LID pilot projects and on concerns for the health of Campbell Creek, project designers saw an opportunity to incorporate LID techniques into the project at this location. A portion of the proposed Basin 4 storm drain system was replaced with a bioswale that would treat stormwater prior to discharge into Campbell Creek. The project also incorporated LID techniques at other locations that were not analyzed as part of this study.

2.1. Bioretention Swale Details

The project's Basin 4 bioswale is located on the north side of West Dowling Road, east of Potter Drive and west of Campbell Creek. Based on review of the project's design drawing and on observations from site visits, the functional area of the swale is estimated to be 2,800 square feet with a gentle slope of less than one percent. The swale was constructed of local material which is primarily sands and gravels according to the project geotechnical report.

The primary purpose of the bioswale is to provide water quality treatment for stormwater before it enters Campbell Creek. The swale was intended to remove sediments, fecal coliform, and hydrocarbons that may be present in the residential runoff. Water quality monitoring is not required per the APDES permit, and the MOA did not have the resources to provide this type of monitoring at the time of this report. Therefore, the water quality benefit of the stormwater swale is addressed based on analysis of runoff volume. The second purpose of the bioswale is to provide infiltration of stormwater, thereby reducing peak flows and total stormwater runoff volume to the receiving water.

2.2. Monitoring and Reporting Plan

In order to demonstrate the bioswale's performance and benefit to the local watershed, inflow and outflow hydrographs were developed for two cases.

1. As required for new construction per the APDES permit, Case 1 is the hypothetical case of the project constructed without a LID. In this case, runoff from Basin 4 is routed directly to Campbell Creek via a traditional storm drain system as planned in the original design. The storm drain for Case 1 was assumed to be a standard 24-inch pipe with a Manning's roughness coefficient of 0.013, which is typical of concrete or plastic pipe.
2. Case 2 is the LID case that was constructed, with a large bioswale intercepting runoff from Basin 4 before it reaches Campbell Creek.

In addition to a hydrograph comparison of the two cases, the project was also visually monitored occasionally during construction and after project completion.

2.2.1.Hydrograph Development

Discharge hydrographs were developed using the EPA's Storm Water Management Model (SWMM) Version 5.0. SWMM produces hydrographs using the non-linear reservoir method based on user-defined rainfall parameters, soil conditions, and basin features. Infiltration in pervious areas of the basin was computed using Horton's method within SWMM. Basin characteristics and other notable model input parameters are presented in Table 1 and Table 2. These parameters apply to both cases evaluated.

Table 1: West Dowling Basin 4 Characteristics

Basin Characteristics (Both Cases)	
Basin Size (acres)	17.4
Percent Impervious	63.4
Runoff Routed to	Outlet
Infiltration Method	Horton
Routing Method	Dynamic Wave

Table 2: West Dowling Basin 4 Horton Parameters

Horton Parameters for Runoff	
Maximum Infiltration Rate (in/hr)	0.75
Minimum Infiltration Rate (in/hr)	0.05
Decay Constant (1/hr)	4

The basin characteristics listed in Table 1 were obtained from the project H&H report. In this report, residential areas were assumed to be 60 percent impervious.

The infiltration parameters for use with Horton's method were selected based on local soil information from the project's geotechnical report, recommended values from the SWMM user's manual, and the EPA's *Technical Guidance on Implementing the Stormwater Runoff Requirements for Federal Projects under Section 438 of the Energy Independence and Security Act*. The values used for this analysis are expected to be conservative for the local soil types. However, because the same parameters were used for both cases, the impact to the comparative analysis results is generally negligible.

The performance of the bioswale was modeled using the LID modeling options within SWMM. The bioswale modeling option in SWMM allows the user to define the swale parameters based on local conditions and then calculates infiltration in the swale using the Green-Ampt infiltration method. The selected bioswale parameters are summarized in Table 3Table 3. The project geotechnical report shows that the upper six feet of soil in the basin area is comprised of sand with some silt and gravel present. Groundwater is present at approximately six feet below the existing ground surface. Percolation testing was performed to the east of this bioswale with resulting infiltration rates of 45 inches per hour. Based on review of the geotechnical borings, it is estimated that the location of this test likely had more gravel present than the location of this bioswale. Therefore, a more conservative value of five inches per hour was selected for the swale's infiltration rate based on the geotechnical borings and on the United States Department of Agriculture's Soil Survey data for the project area. The Green-Ampt values were selected based on the recommendations in the SWMM user's manual for sand. The physical parameters of the swale were obtained from the project design drawings and from individual conversations with the project designer. The project geotechnical report, results of percolation testing, and the USDA soil survey data are included in Appendix C.

Table 3: West Dowling Bioswale Parameters

LID Bioswale Parameters	
Area (square feet)	2800
Storage Depth (in)	3
Vegetation Volume Fraction	0.5
Thickness (in)	36
Porosity (volume fraction)	0.4
Field Capacity (volume fraction)	0.105
Wilting Point (volume fraction)	0.047
Conductivity (in/hr)	5
Conductivity Slope	5
Suction Head (in)	2.4
Void Ratio	0.2

The swale's performance was evaluated for four rainfall events.

1. Event 1a: The first event was approximately the 90th percentile rainfall event as described in the MOA's current APDES permit. This event was 0.52 inch of rain in a 24-hour period. For Event 1, the rainfall was assumed to be evenly distributed in order to produce a hydrograph.
2. Event 1b: Because the distribution of the 90th percentile event tends to vary greatly by storm event, the second event modeled also represented the 90th percentile storm event. In this case, the 90th percentile event was distributed based on hourly rainfall data from Anchorage International Airport (AIA). According to this hourly data, a rainfall event nearly identical to the 90th percentile event occurred on July 21, 2012. This event produced 0.53 inch of rainfall in a 24-hour period, and modeling this distribution provided a comparison for the even distribution in Event 1a.
3. Event 2: This event occurred on August 1, 2012 and resulted in 0.19 inch of precipitation in 24 hours. This event was selected because it represented a small, frequent rainfall event and associated distribution for Anchorage. LID techniques are typically intended to capture these types of events.

4. Event 3: The fourth event modeled was the theoretical 10-year, 24-hour rainfall event for Anchorage, as defined in the MOA's Design Criteria Manual. This rainfall event was 1.77 inches distributed over 24 hours using a National Resource Conservation Service (NRCS) Type 1 rainfall distribution. This event was selected to evaluate the swale's performance during large rainfall events.

Rainfall Hyetographs for the non-synthetic events (Event 1b and Event 2) are provided in Figure 1Figure 1 and Figure 2,respectively.

Figure 1: July 21, 2012 Rainfall Hyetograph

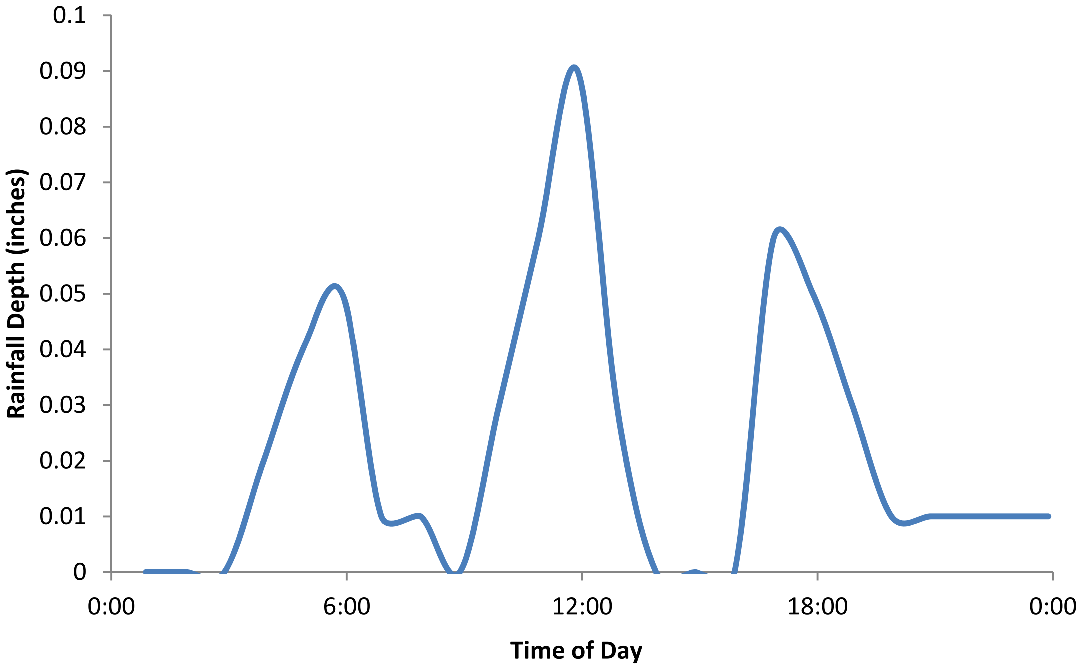
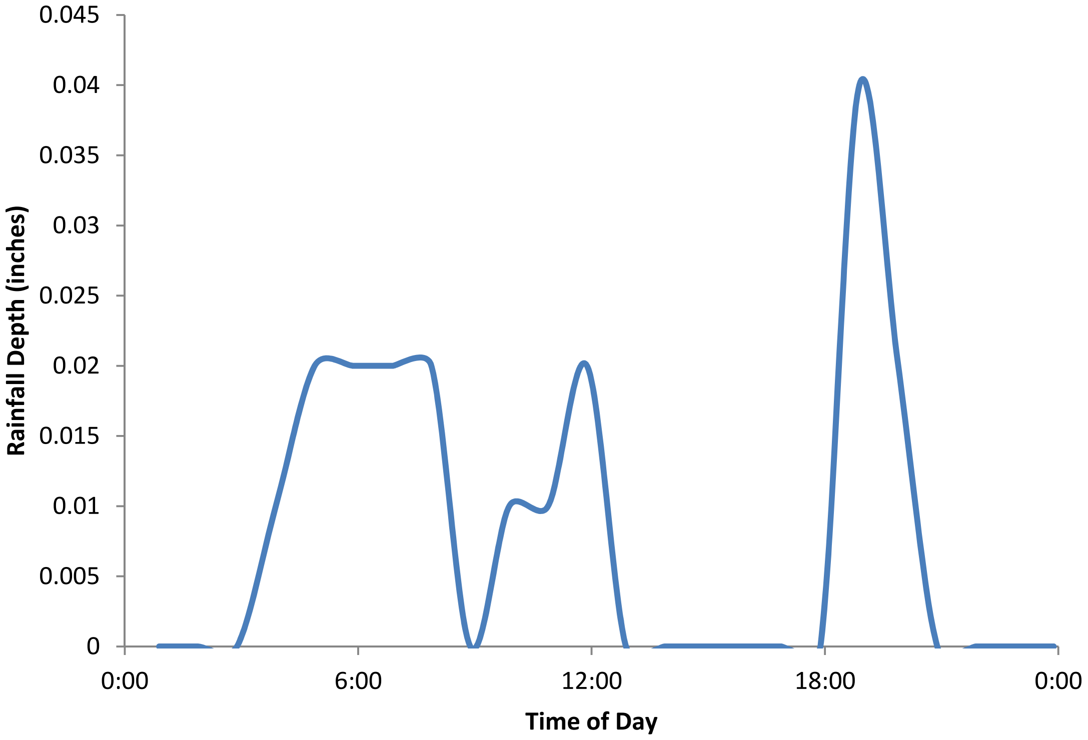


Figure 2: August 1, 2012 Rainfall Hyetograph



2.3. Results

2.3.1.Hydrograph Results

Table 4 shows the peak flow and total volume of runoff for each case. Full modeling output reports are included in Appendix D.

Table 4: West Dowling Bioswale Runoff Results Summary

Case	Event 1a: 90th Percentile Rainfall, Evenly Distributed		Event 1b: 90th Percentile Rainfall, Distributed as seen on 7-21-12		Event 2: Common Event as seen on 8-1-12		Event 3: 10-year, 24-hour Rainfall	
	Peak Flow (cfs)	Runoff Vol (cf)	Peak Flow (cfs)	Runoff Vol (cf)	Peak Flow (cfs)	Runoff Vol (cf)	Peak Flow (cfs)	Runoff Vol (cf)
Case 1 - No LID	0.24	17,378	0.96	18,426	0.29	5,576	11.87	593,375
Case 2 - Bioswale	0	0	0.64	4,617	0	0	11.56	405,033

The resulting hydrographs are shown in Figure 3 through Figure 6. These hydrographs represent the discharge point into Campbell Creek.

Figure 3: Event 1a - West Dowling Bioswale

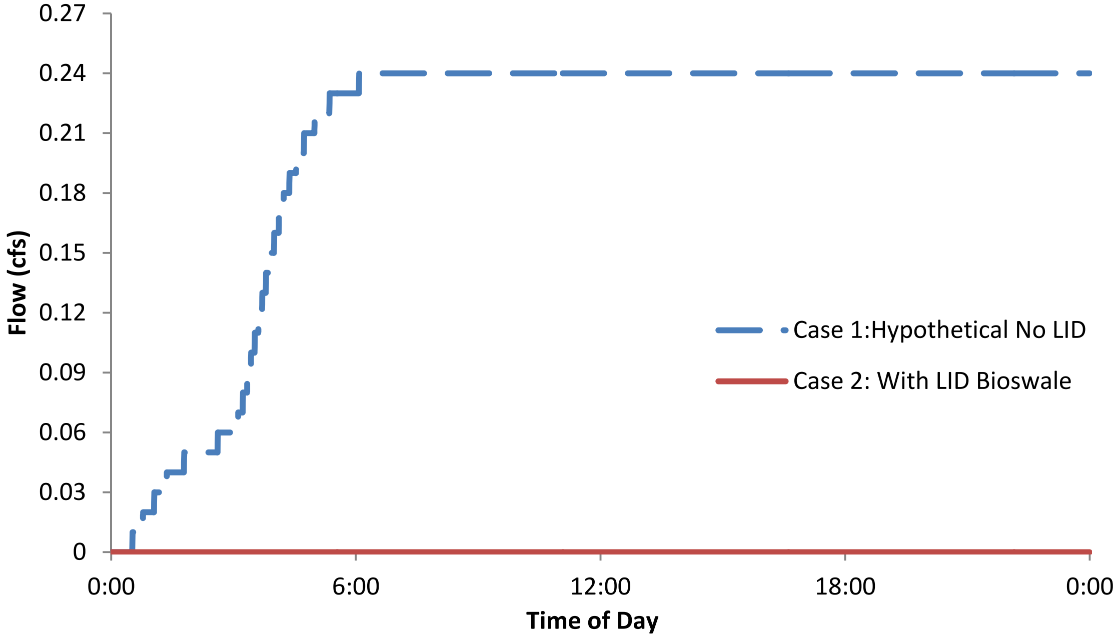


Figure 4: Event 1b - West Dowling Bioswale

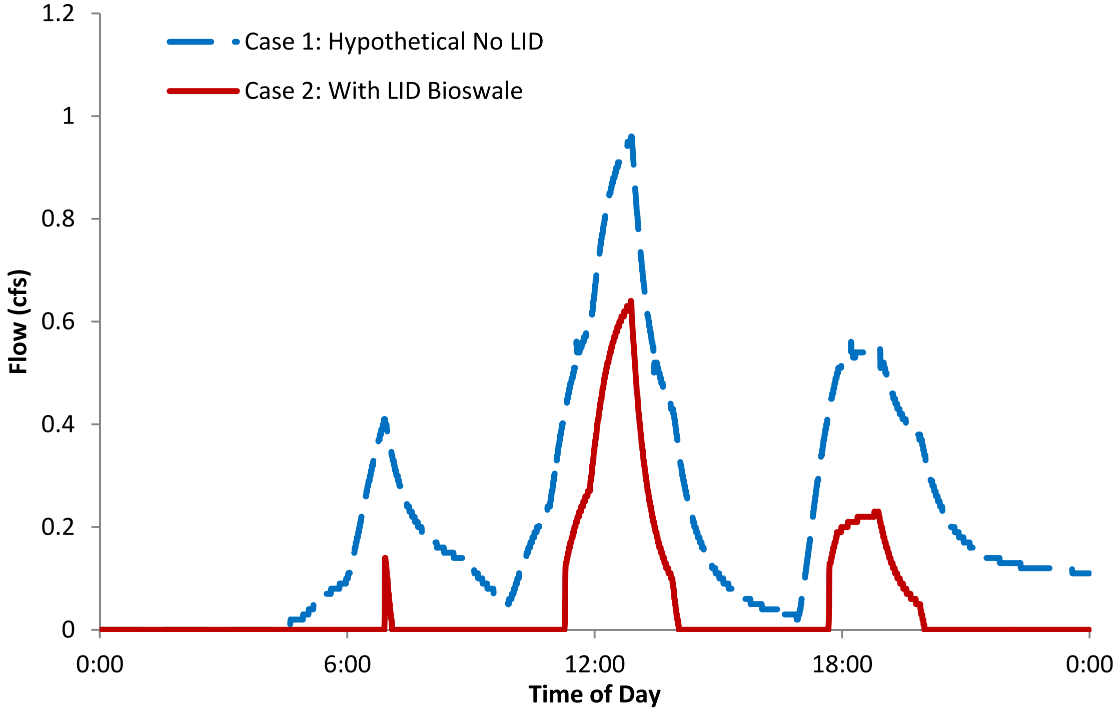


Figure 5: Event 2 - West Dowling Bioswale

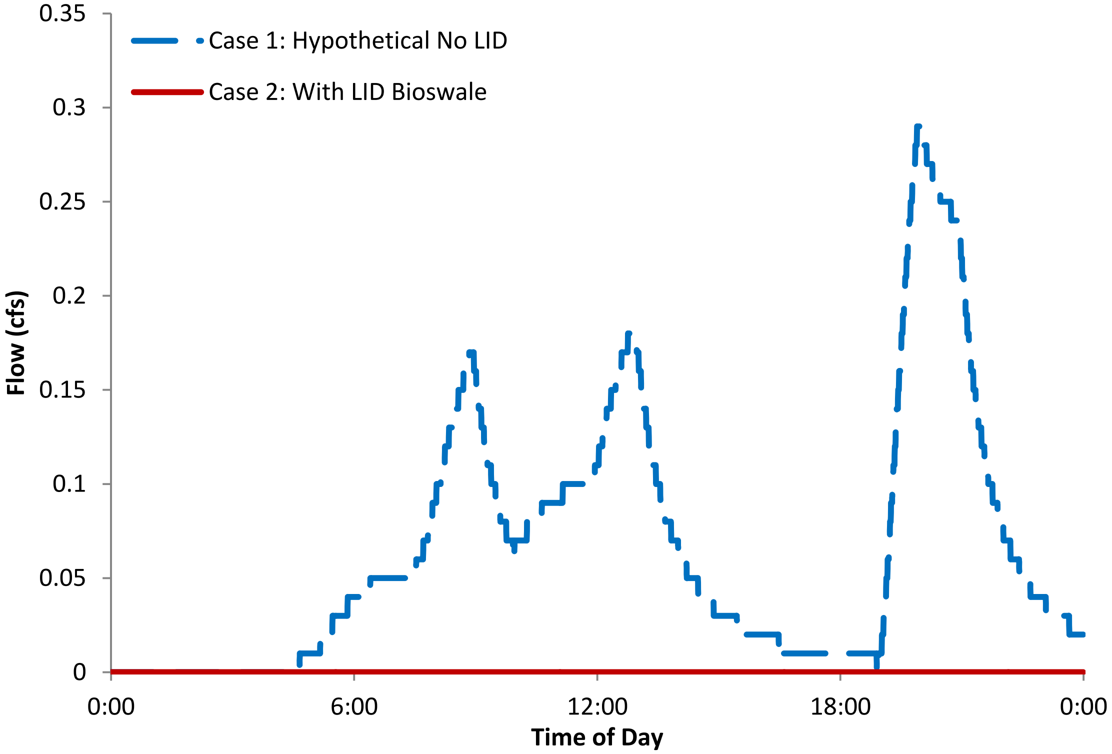
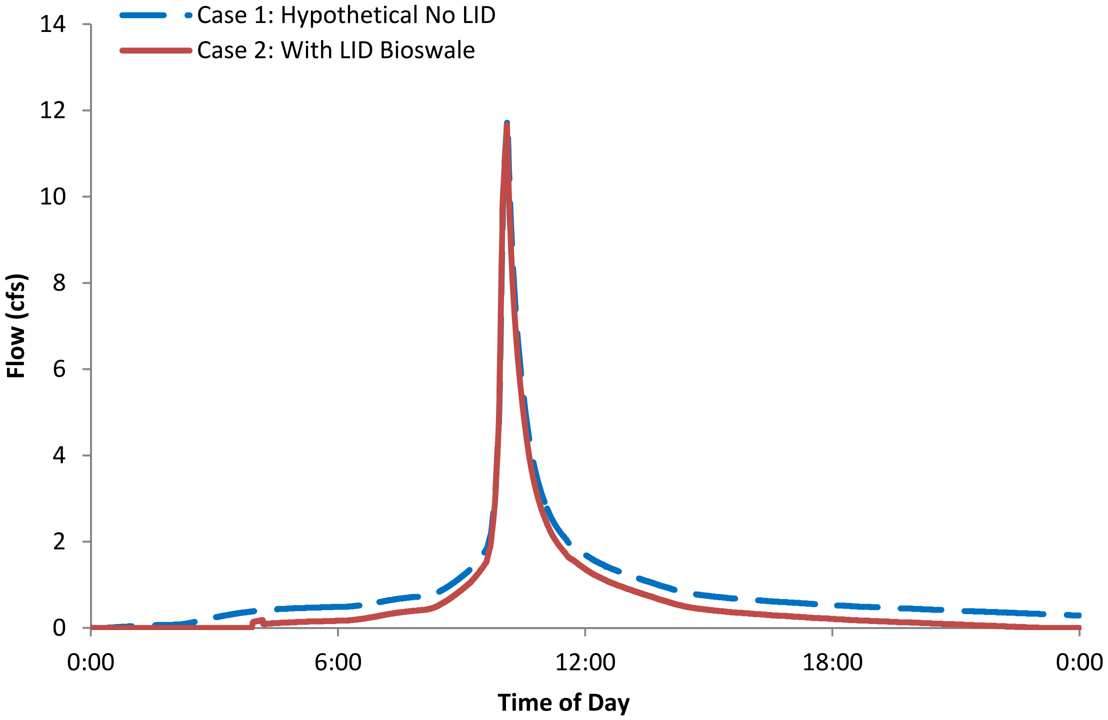


Figure 6: Event 3 - West Dowling Bioswale



For the evenly distributed 90th percentile event, the modeling results show that the swale was able to infiltrate all of the runoff and nothing was discharged to Campbell Creek. However, when the 90th percentile event was distributed as shown in Case 1b, not all of the runoff was infiltrated. The swale did reduce both the peak flow and the runoff volume for this case.

For Event 2, modeling results show that the swale was able to infiltrate all of the runoff.

For Event 3, the 10-year, 24-hour event, the modeling results show that although the swale did not have a significant impact on the peak runoff, it did result in a notable impact on the total runoff volume from the site. The modeling results show that a significant portion of the water entering the swale was infiltrated.

2.3.2. Visual Monitoring Results

In addition to the hydrograph development, this project was also visually monitored both during and after construction. The roadway was under construction during the fall of 2012 when Anchorage experienced significant rainfall and localized flooding. Rainfall records at AIA reported 1.41 inches on September 19, 2012 and 1.31 inches on September 20, 2012. During these significant events, project designers and construction personnel were concerned about erosion and impacts to downstream Campbell Creek because the bioswale vegetation was not yet established. However, construction personnel reported that the bioswale was able to absorb and infiltrate all of the water that entered, and no surface runoff was discharged to Campbell Creek.

The swale performance was also visually inspected following several days of rain on September 7, 2013. Rain occurred each day for six days preceding the site visit. Rainfall records from AIA report a total of 1.67 inches from September 1 through September 7. The bioswale had small amounts of ponded water in the bottom at approximately three inches deep. Water was flowing in small quantities into the bioswale from its inlet points, and water inside the bioswale was flowing slowly toward the outlet. A small rock berm separated the swale from its outlet to Campbell Creek, and water was not flowing over this berm. No water was observed to be entering Campbell Creek.

*West Dowling Bioswale,
looking east*

*West Dowling Bioswale, looking west from
Campbell Creek Bridge*

2.4. Conclusions and Recommendations for Future Projects

Although this project was originally intended to primarily provide water quality treatment without impacts to runoff volume, the bioswale provided an added, and perhaps more effective, benefit of reducing runoff volumes and peak flow. By infiltrating small, frequent rainfall events, the bioswale is capturing the “first flush” of runoff which is typically the most polluted. Those pollutants are treated through natural processes instead of entering Campbell Creek.

Bioswales are highly versatile LID tools, making them a recommended LID practice for use with long, linear applications like roadways. The presence of groundwater at six feet below the existing ground surface may have been a deterrent to some designers when considering infiltration tools. However, six feet is actually greater than the EPA-recommended separation distance between bioretention facilities and groundwater surface. Additionally, although infiltration was not the primary goal of the LID feature, the soils in this area were well-draining and caused the bioswale to exceed design expectations for volume reduction, despite the groundwater presence. This shows that perceived roadblocks to LID implementation can often be addressed with the right LID application for the site.

3. Muldoon Road Pedestrian and Landscaping Improvements (ADOT&PF)

The Muldoon Road Pedestrian and Landscaping Improvements project was designed to provide safer pedestrian facilities and install landscape features along Muldoon Road from just north of Debarr Road to just south of the Glenn Highway interchange in Anchorage. The project was constructed in three phases, and the final phase was completed in 2012. See Figure 3 in Appendix B for an overview of the project area.

The project corridor is surrounded primarily by commercial and industrial areas that are largely impervious. The project’s LID technique was to reduce impervious cover in the project corridor through the use of landscape features. Before the project was constructed, all runoff from the project corridor flowed directly to the local storm drain system and was then discharged to nearby Chester Creek, which is an impaired water body. The project’s LID goal was to reduce peak flows and total volume of runoff to the receiving water body by reducing impervious cover.

The landscape features are not specifically designed to accept stormwater runoff from adjacent impervious areas. The project does include a few locations where the landscaping is located at a lower elevation than the surrounding impervious areas, and it is expected that stormwater runoff from the surrounding areas will flow into the landscape beds. However, because this was not the design intent and because there was not data available regarding the size or topography of the surrounding areas, this benefit was not able to be quantified in this report.

3.1. Landscape Feature Details

The landscape features installed for this project were designed to fit into available space between the roadway’s drivable surface and the edge of the right-of-way (ROW). Based on information obtained from the project’s design documents, the landscape planting beds used a variety of trees, shrubs, and flowers planted in free-draining top soil. The surrounding surface was topped with wood-chip based mulch. The landscape features also included decorative walls of various sizes.

3.2. Monitoring and Reporting Plan

To demonstrate the impact of the landscape areas on flow reduction to the receiving system, inflow and outflow hydrographs were developed for two cases.

1. Case 1 is the hypothetical case of the project constructed without a LID. In this case, runoff from the project corridor is routed directly offsite where it would eventually flow into Chester Creek.
2. Case 2 is the LID case that was constructed with pervious landscape features throughout the project corridor.

3.2.1.Hydrograph Development

Similar to the West Dowling Road project, discharge hydrographs were developed using SWMM. Basin characteristics and other notable input parameters for both cases are presented in Table 5.

Table 5: Muldoon Basin Characteristics

Basin Characteristic	Case 1: No LID	Case 2: Pervious Landscape Areas
Basin Size (acres)	3.3	3.3
Percent Impervious	100%	82%
Runoff Routed to	Outlet	Outlet
Infiltration Method	Horton	Horton
Routing Method	Dynamic Wave	Dynamic Wave

The project area was defined as the area from the existing curb line to the edge of the ROW. The size of this area was obtained from the project design drawings. The project also included several temporary construction easements outside of the ROW, but because these areas were only temporarily disturbed and did not include permanent features, they were not included in the total project area.

For Case 1, the project area was assumed to be completely impervious with all runoff flowing directly to the receiving system. This represents the case of the project constructed with no LID.

For Case 2, the project area includes the new pervious landscape areas. Infiltration into the landscape areas was computed using Horton’s method within SWMM (see Table 6). The Horton’s method parameters were selected based on the topsoil and mulch properties from the design documents and on recommended values from the EPA’s *Technical Guidance on Implementing the Stormwater Runoff Requirements for Federal Projects under Section 438 of the Energy Independence and Security Act*. The project’s design and construction records did not provide details regarding the infiltrative properties of the native soil below the engineered landscaping. For this reason, accurate estimation of infiltration capacity is limited. The values selected are expected to be conservative for topsoil.

Table 6: Muldoon Horton Parameters for Runoff

Horton Parameters for Runoff	
Maximum Infiltration Rate (in/hr)	5
Minimum Infiltration Rate (in/hr)	0. 5
Decay Constant (1/hr)	4

The project's impact on peak flow and total runoff volume was evaluated for three rainfall events.

1. Event 1: The first event was the 90th percentile rainfall event as described in the MOA's current APDES permit. This event was 0.52 inch of rain in a 24-hour period. For Event 1, the rainfall was assumed to be evenly distributed in order to produce a hydrograph. In reality, the 90th percentile event has a distribution that varies for each storm event. However, the evenly distributed case would represent the most gentle distribution. Based on the results of this storm event, other possible distributions were not modeled.
2. Event 2: This event occurred on August 1, 2012 and resulted in 0.19 inch of precipitation in 24 hours. This event was selected because it represented a small, frequent rainfall event that is common for Anchorage. LID techniques are typically intended to capture these types of events.
3. Event 3: This event was the theoretical 10-year, 24-hour rainfall event for Anchorage, as defined in the MOA's DCM. This rainfall event was 1.77 inches distributed over 24 hours using the NRCS Type 1 rainfall distribution.

In addition to the hydrograph development, the project was also visually inspected in August of 2012.

3.3. Results

3.3.1. Hydrograph Results

The resulting hydrographs for both cases and the three storm events are shown in Figure 7, Figure 8, and Figure 9 below.

Figure 7: Event 1 - Muldoon Landscaping

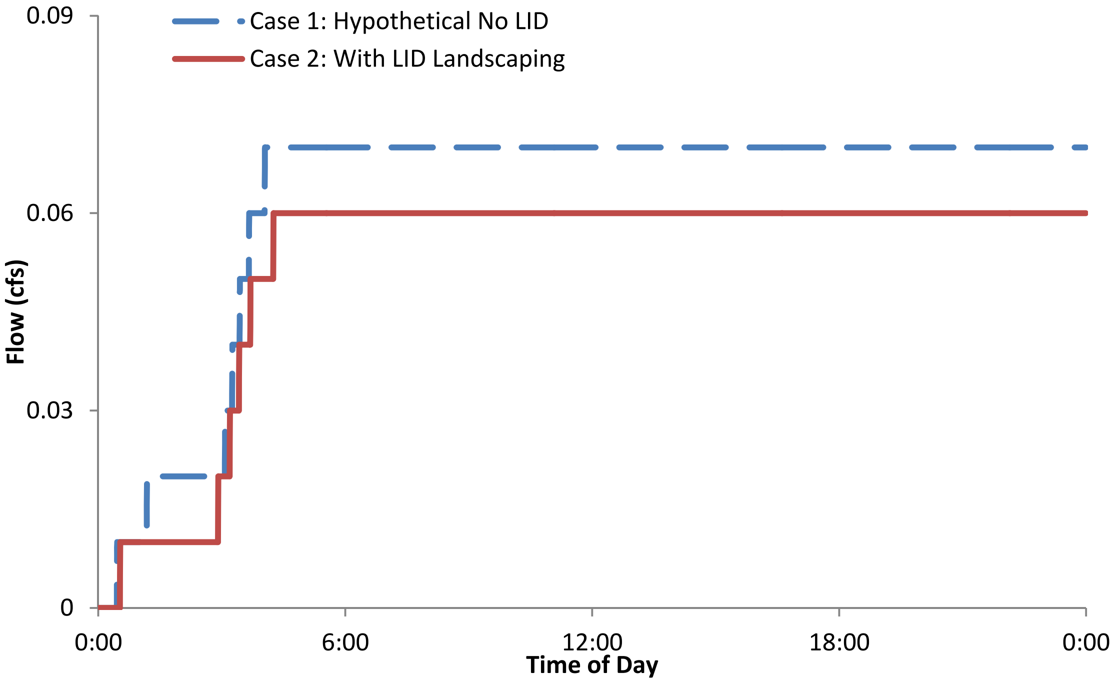


Figure 8: Event 2 - Muldoon Landscaping

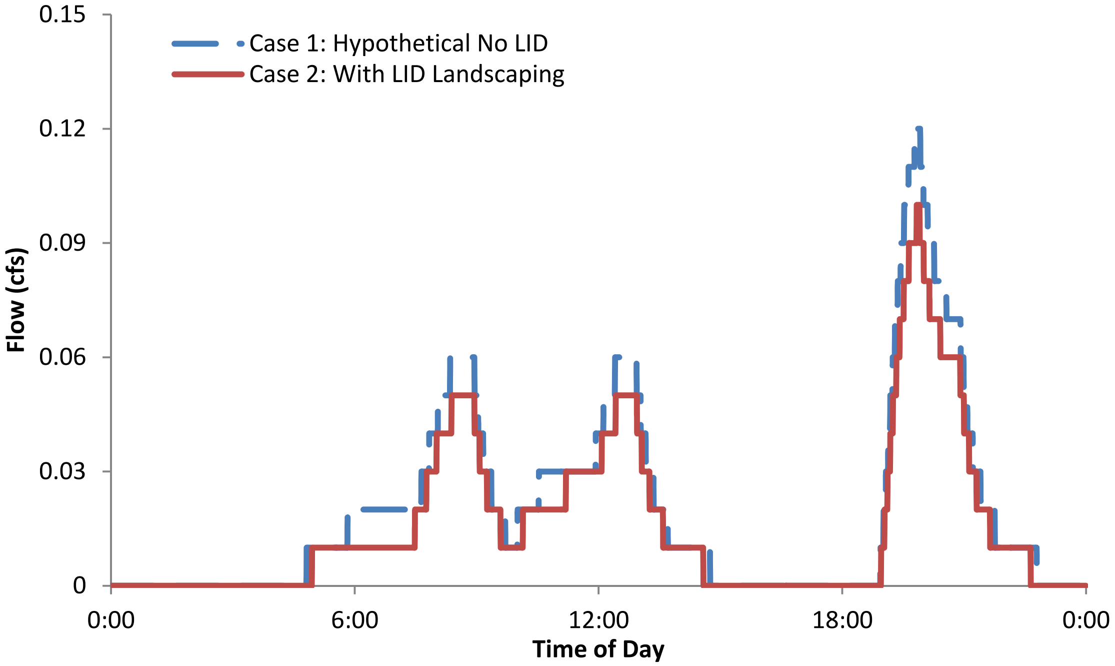


Figure 9: Event 3 - Muldoon Landscaping

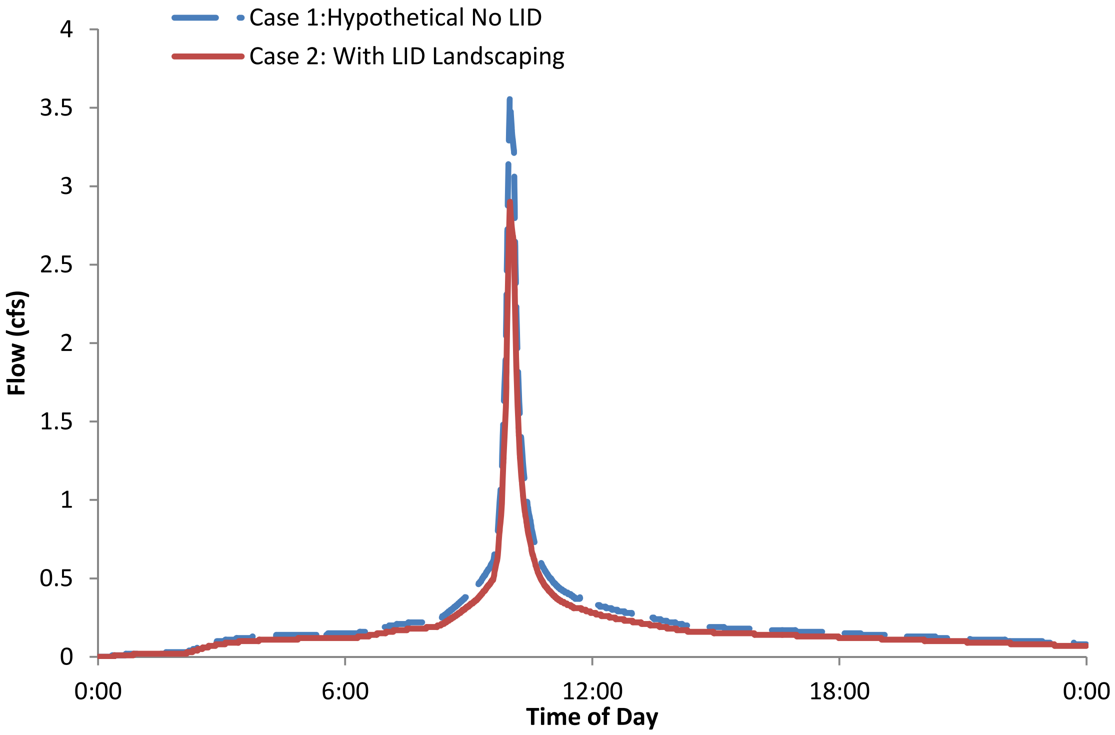


Table 7 shows the peak flow and total volume of runoff for each case. Full modeling output reports are included in Appendix E.

Table 7: Muldoon Bioswale Runoff Results Summary

Case	Event 1: 90th Percentile Event, Evenly Distributed		Event 2: Common Event as seen on 8-1-12		Event 3: 10-year, 24-hour Event	
	Peak Flow (cfs)	Runoff Vol (cf)	Peak Flow (cfs)	Runoff Vol (cf)	Peak Flow (cfs)	Total Runoff Volume (cf)
Case 1 - Hypothetical No LID	0.07	5,489	0.12	1,699	3.59	20,473
Case 2 - Pervious Landscape Areas	0.06	4,487	0.1	1,394	2.9	16,771

The modeling results show that for all three rainfall events, the landscape features result in a noticeable reduction of both the total volume and the peak discharge from the site. However, not all of the runoff from the 90th percentile event or the August 1, 2012 event is captured.

3.3.2.Visual Monitoring Results

The visual monitoring of this project resulted in a few concerns about the longevity of the landscape features. During an August 1, 2013 site visit, it was noted that most of the landscape beds had collected sand from roadway maintenance on top of the mulch and topsoil. Over time, if the sand loading is not controlled or if the mulch and topsoil are not regularly replaced, the sand is likely to reduce the infiltrative capacities of the landscape beds and thereby reduce their overall performance.

During the same site visit, it was also noted that in some cases, the decorative landscape walls were placed in locations that will inhibit the infiltrative performance of the landscaping. For example, in at least one location, a parking lot immediately adjacent to a landscape bed is sloped toward the landscaping, but the landscaping includes a decorative wall near the upstream edge, which limits the amount of stormwater runoff from the adjacent property that can enter the pervious area. In addition to reducing infiltration, this design is anticipated to be problematic for drainage and the stability of the landscape wall during spring breakup conditions.

It was also noted that the surface of the landscape beds are, in most cases, flush with the surrounding sidewalk. During large rainfall events or high wind events, it is expected that some of the mulch and topsoil from the landscaping may wash away. This would reduce the landscape’s stormwater performance and add additional sediment to the receiving system.

3.4. Conclusions and Recommendations for Future Projects

Although this project does result in a measurable decrease in peak flow and runoff volume to the receiving system, the project performance could likely be enhanced with a few design changes. The following list summarizes the recommended changes for future projects that incorporate landscaping as a stormwater LID technique.

1. Design the landscape features to accept stormwater runoff from the surrounding areas. If the project has limited amounts of space, this could be achieved through installation of a subdrain pipe that connects to the storm drain system. This would allow the landscaping to accept water from a larger area, achieving maximum retention benefits while also providing detention and stormwater cleaning prior to discharge.
2. Include a freeboard depth and an overflow mechanism that would prevent erosion of the topsoil and mulch during large flow events. Provide more thorough vegetative cover that would stabilize the soil and help prevent erosion. This would also improve the infiltrative capacity of the soil.
3. Omit the landscape walls since they can actually impede drainage and add a small amount of impervious surface.
4. Require regular maintenance of the top soil and mulch to ensure that it does not clog due to winter sanding.

Muldoon landscape area and decorative wall

Muldoon landscape area and decorative wall

4. Russian Jack Springs Park Improvements (MOA)

The Russian Jack Spring Park (RJSP) project was a joint effort between the MOA Parks and Recreation Department (Parks) and the MOA Project Management and Engineering (PM&E) Watershed Management Services (WMS) division. The project is located at 821 Pine Street in Anchorage, which is south of 6th Avenue, and north of Debarr Road (see Figure 4, Appendix B). The purpose of the project was to provide improved parking and safer pedestrian facilities for park users. The RJSP parking lot is used in the summer months for access to the softball fields located north and south of the parking lot. It is also used year-round for access to the park's popular trail system. The project improvements included: demolition of the park's existing, deteriorated tennis courts; replacing existing, deteriorated gravel parking with paved parking; providing safe pedestrian access around the parking area; and visually enhancing the parking area with new landscape features. WMS worked with Parks to incorporate LID techniques into the parking lot design instead of connecting the new parking lot to the municipal storm drain system that runs along Pine Street. The project construction was completed in the early summer of 2013.

The project's LID features include porous asphalt and an underground infiltration gallery. These features were selected for the site based on site conditions and maintenance constraints. The site's soil conditions were found to vary significantly with depth. At a depth of four to six feet from the surface, the native soils are very silty with a slow percolation rate (approximately 0.12 inch per hour). At a depth of eight feet and deeper, the soils change to a gravely sand with a percolation rate of six inches per hour and greater (see soil information in Appendix F). The combination of porous asphalt in the more slowly-draining, shallow soil and an infiltration gallery in the well-draining, deeper soil was used to accept stormwater runoff from the parking lot up to the 100-year, 24-hour event without discharge to the municipal storm drain system. These features also worked well with the maintenance plans for the site, as discussed further below.

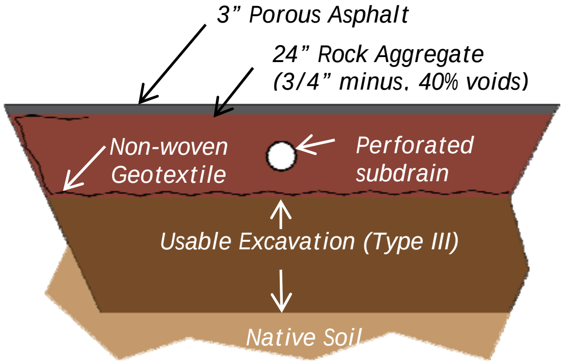
4.1. LID Feature Details

4.1.1. Porous Asphalt

The new parking lot and surrounding sidewalks are approximately 44,400 square feet. The parking lot is a combination of traditional asphalt pavement and porous asphalt pavement. There are three sections of porous asphalt totaling 14,288 square feet or approximately 32 percent of the parking lot area (see Figure 3 in Appendix B). The project designers worked with Parks maintenance personnel to determine the ideal placement of the porous asphalt for improved long-term performance of the asphalt. If porous asphalt is regularly snow plowed and then sanded for traction, it requires vacuum sweeping to prevent the fine sand particles from clogging the voids in the asphalt (the plowing itself is not expected to be problematic for porous asphalt, but plowing and sanding is usually performed in conjunction.) Parks' ability to maintain the asphalt is limited to their existing maintenance equipment, and the porous asphalt is not able to be vacuum swept. For this reason, project designers located the asphalt in portions of the parking lot that will not be opened for winter use, and therefore will not be sanded.

A typical section for the RJSP porous asphalt is provided in Figure 10.

Figure 10: Typical Porous Asphalt Section



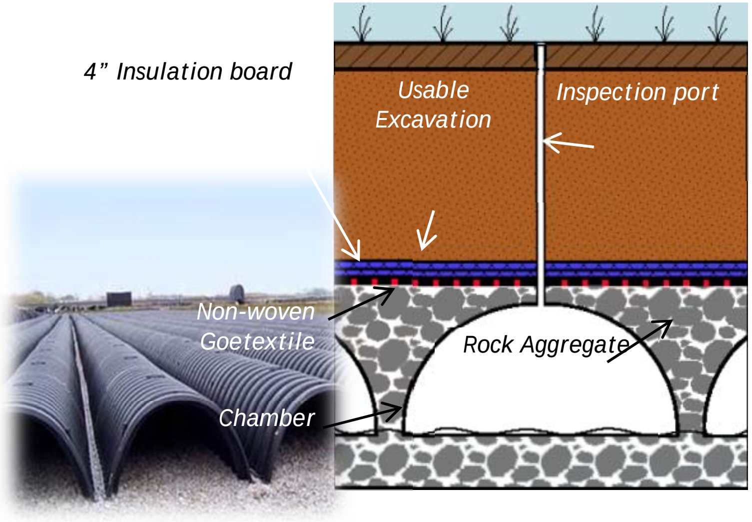
Two of the three porous asphalt sections were installed with a perforated subdrain near the top of the asphalt's structural section. One section was installed without the subdrain in order to compare the performance of the two types. The porous asphalt was designed to store and infiltrate up to the 10-year, 24-hour rainfall event without contributing flow to the infiltration gallery. In the event that the asphalt's structural section should become filled with water in excess of this amount, water would be collected in the subdrain pipe and directed away from the asphalt. The subdrain pipes are routed to the subsurface infiltration gallery (see details below) via an on-site storm drain system.

A shallow monitoring well is installed in each section of porous asphalt in order to monitor the water levels in the asphalt structural section.

4.1.2.Subsurface Infiltration Gallery

Runoff from the non-porous asphalt and any excess water from the perforated subdrain under the porous asphalt is directed to the subsurface infiltration gallery. The gallery is a Contech Chambermaxx system made up of five individual storage chambers. These chambers are designed to store and infiltrate water as soil capacity becomes available. A typical section and associated photo of the subsurface infiltration gallery are provided in Figure 11.

Figure 11: Typical Infiltration Gallery Section



The gallery was installed with inspection ports (see Figure 11) to monitor the water levels in each individual chamber. The chamber system does not have a secondary outlet. Combined with the porous asphalt storage area, it was designed to accept rain events up to the 100-year, 24-hour event.

4.2. Monitoring and Reporting Plan

In order to monitor the performance of the RJSP LID features, HDR installed monitoring equipment to record data from July 10 through October 11 of 2013. The recording period included all of September 2013, which was reported by the National Climatic Data Center (NCDC) to be the second wettest September on record for Anchorage with 5.56 inches of rain that month. The monitoring equipment included a v-notch weir and a system of pressure transducers as well as a tipping bucket rain gauge. The rain gauge was installed to provide an accurate record of inflow to the parking lot. Due to concerns of local vandalism, the rain gauge was installed on the roof top of nearby Wonder Park Elementary School, which is approximately 0.4 mile from the parking lot. This location also helped ensure that rainfall data was not influenced by trees or other buildings. Rainfall data is included in Appendix F.

To monitor the flow leaving the parking lot, the v-notch weir and two pressure transducers were installed in a manhole upstream of the infiltration gallery and its associated oil and grit separator. The weir was installed in the outflow pipe of the manhole so that all water leaving the parking lot and heading into the infiltration gallery was measured. By recording the amount of inflow and outflow from the parking lot, the impact of the porous asphalt can be measured and compared to a theoretical case of the parking lot constructed with all traditional, impervious asphalt. In the case of a completely impervious parking lot, it was assumed that rainfall inflow would be the same as parking lot outflow, as the parking lot would provide no infiltration and very little depression storage. Outflow data is also included in Appendix F.

In addition to the instrumentation, the porous asphalt monitoring wells were manually checked periodically during the same period. The performance of the infiltration gallery was monitored during this period by periodic inspection of the water levels through the inspection ports.

4.2.1. Hydrograph Development

In order to obtain information on the parking lot performance for various rainfall events, inflow and outflow hydrographs were developed for three storm events, as recorded by the project rain gauge at Wonder Park Elementary School. Events 1 and 2 represent the two largest, 24-hour rainfall events that occurred during the recording period. Event 3 represents the longest period of consecutive days (nine) of rainfall during the recording period and demonstrates the parking lot performance with numerous small, frequent rainfall events that are common in Anchorage during the rainy season.

1. Event 1 occurred on September 4 and resulted in 1.33 inches of rainfall in a 24-hour period.
2. Event 2 occurred on September 25 and resulted in 0.99 inch of rainfall in a 24-hour period.
3. Event 3 occurred from August 16 to August 24 and resulted in a total of 2.31 inches of rain. The maximum daily rainfall during this period was 0.48 inch and the minimum was 0.03 inch.

Rainfall Hyetographs and Inflow Hydrographs

Rainfall hyetographs were developed based on the recorded rain gauge data. The gauge provided a depth and time reading each time 0.01 inch of rainfall entered the tipping bucket. In order to produce a meaningful and "smooth" hyetograph, these readings were summed into thirty-minute time intervals for Events 1 and 2. A thirty-minute time interval was selected in order to minimize oscillation of the hyetograph because of very short bursts of intense rain and periods of little or no rain. This time interval also provides a meaningful visual representation of rainfall intensity. Rainfall intensity is most commonly reported and understood in inches per hour. Thus, a very intense burst of rain that lasted only a few minutes was found to cause visually misleading peaks in the rainfall graphs if a smaller time interval was selected. For Event 3, this time interval was increased to one hour for the same reasons and for manageability of the data. Figure 12, Figure 13, and Figure 14 show the rainfall hyetographs for Events 1, 2 and 3 respectively.

Figure 12: Russian Jack Rainfall Hyetographs

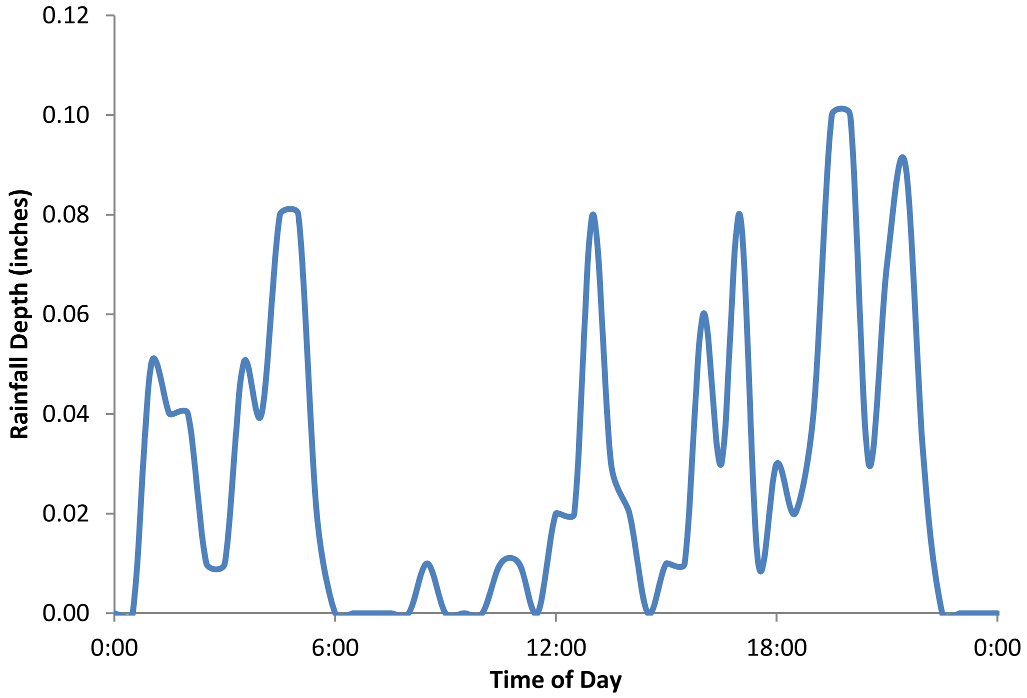


Figure 13: Russian Jack Rainfall Hyetographs

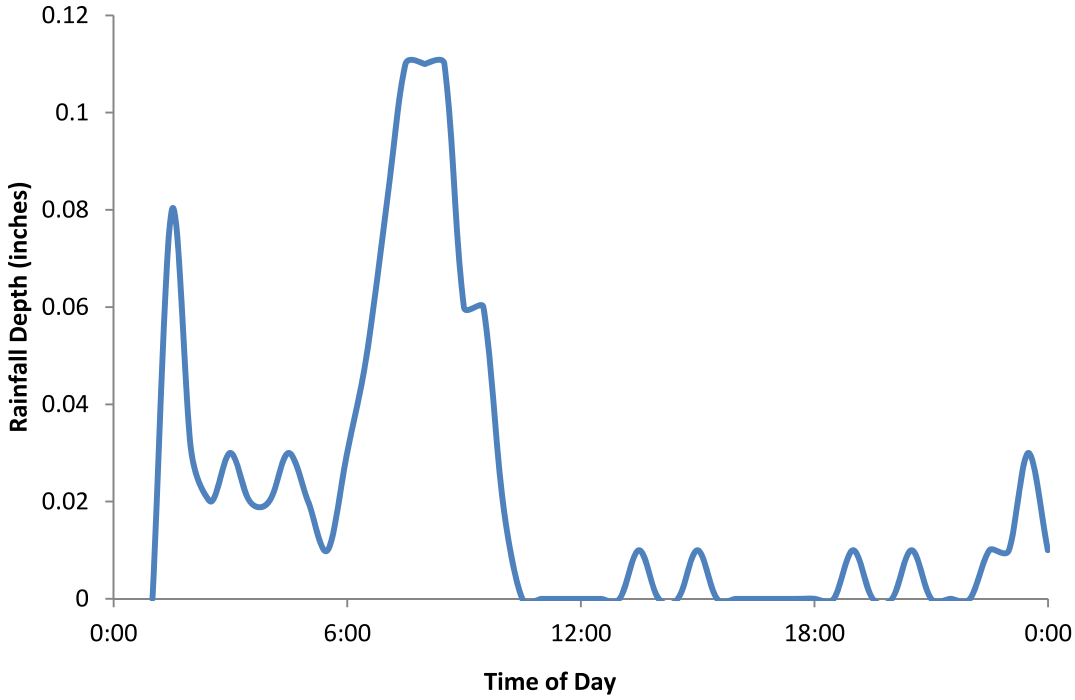
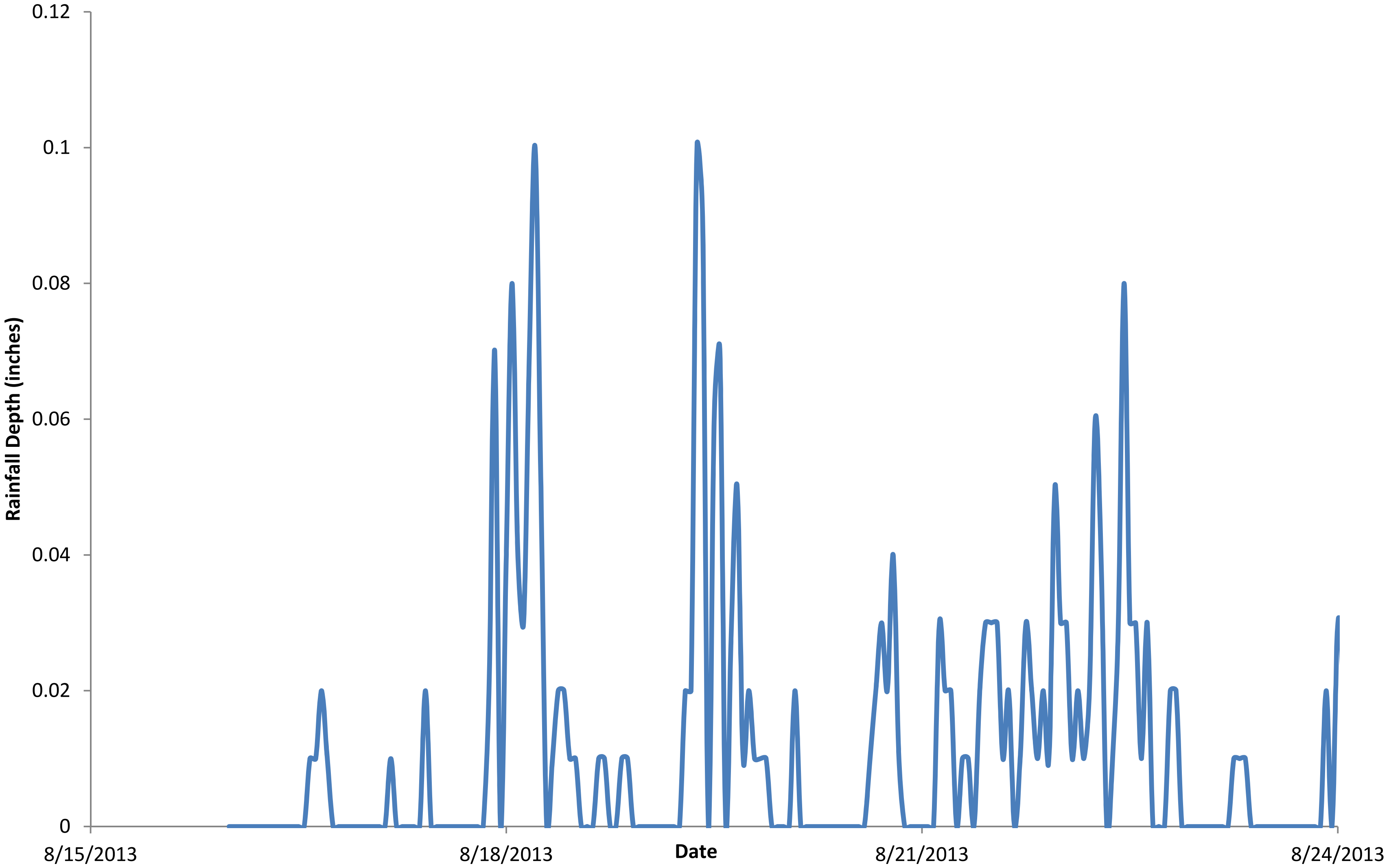


Figure 14: Russian Jack Rainfall Hyetographs



The rainfall hyetographs were converted to parking lot inflow hydrographs by multiplying the rainfall depth by the parking lot contributing area. The inflow hydrographs were assumed to represent the case of the project constructed with all traditional, non-porous asphalt. In reality, rainfall on an impervious parking lot would not directly correlate to runoff due to factors such as depression storage and associated evaporation from the asphalt surface. The exact rainfall reduction as a result of these factors varies from site to site but typically ranges from five to 10 percent of the rainfall amount. Newer asphalt typically produces more runoff than older asphalt. For the purposes of this analysis, depression storage and evaporation from a theoretical parking lot constructed of traditional asphalt was not accounted for, as it is expected to be insignificant.

It should be noted that the parking lot contributing area was selected based on the design topography of the site. However, it was noted during site visits that the grassy area east of the parking lot, which was designed to flow away from the parking lot, was contributing runoff into the parking lot. Because soil information and as-built topography of the area was not available, this additional contributing runoff could not be accurately quantified. If runoff from this area were accounted for, it would result in an increase of the inflow hydrographs. The rainfall inflow hydrographs are shown with the outflow hydrographs in Section 4.3 below.

Outflow Hydrographs

Measured outflow hydrographs were developed based on the readings from the pressure transducers. The pressure transducers recorded the depth of water over the v-notch weir, which was then converted to a flow rate using the following standard equation for a 90-degree, v-notch weir.

$$Q = 2.49\ h^{2.48}$$

Where:

Q = discharge over weir in cubic feet per second
h = head on the weir in feet

Recordings were taken every five minutes for the first part of the monitoring period, and the frequency was increased to every one minute on August 15. In order to provide a smooth outflow hydrograph comparable to the inflow hydrograph, these readings were averaged over 30-minute intervals for Events 1 and 2 and over a 60-minute interval for Event 3. The outflow hydrographs are shown with the inflow hydrographs in Section 4.3 below.

4.3. Results

4.3.1. Porous Asphalt Performance

The performance of the porous asphalt is shown in the following hydrographs (see Figure 15, Figure 16, and Figure 17). These hydrographs illustrate both the rainfall inflow to the parking lot and the measured parking lot outflow for each of the three storm events.

Figure 15: Event 1 Russian Jack Inflow and Outflow Hydrographs

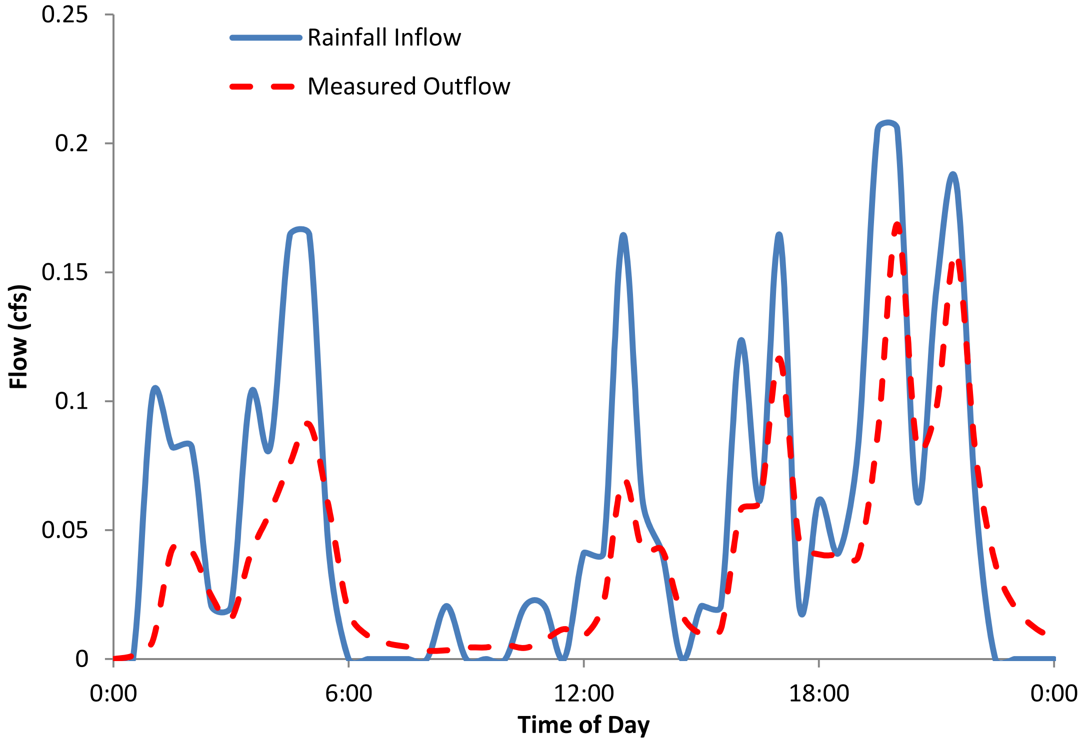


Figure 16: Event 2 Russian Jack Inflow and Outflow Hydrographs

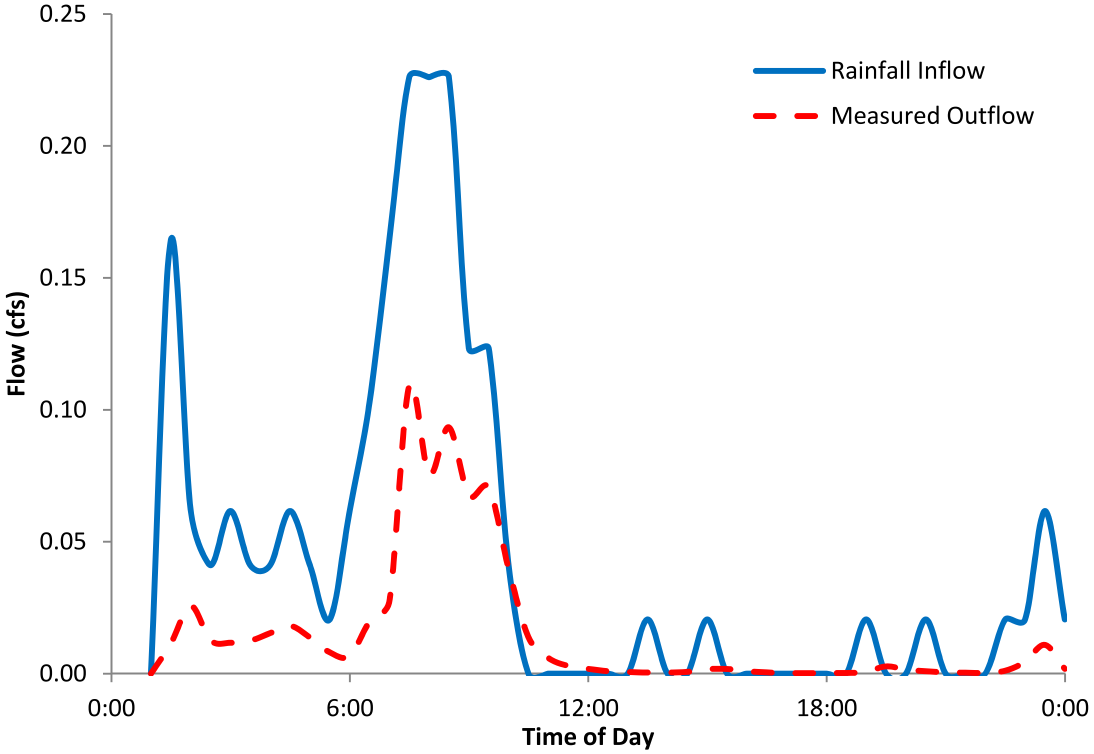
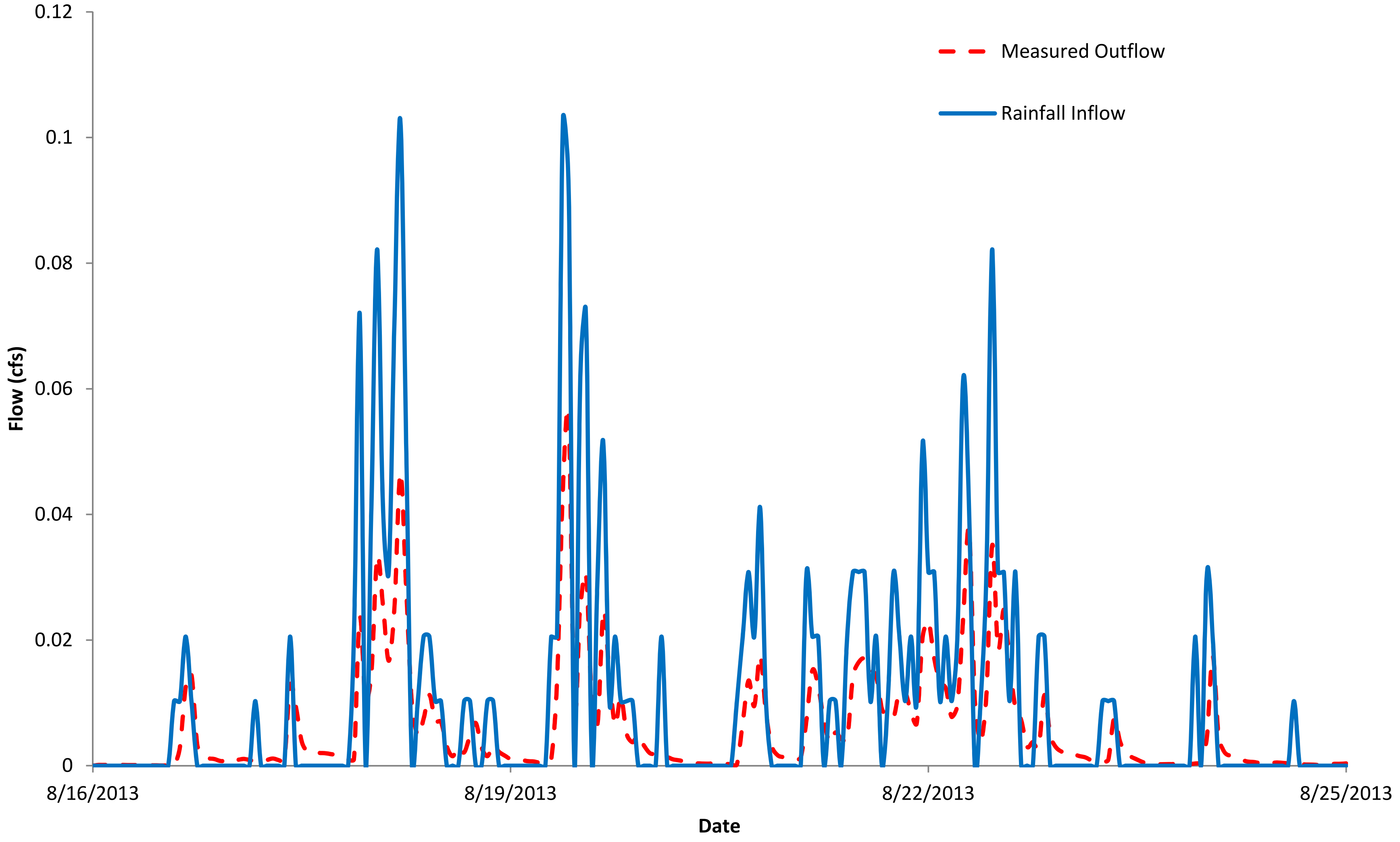


Figure 17: Event 2 Russian Jack Inflow and Outflow Hydrographs



As shown in the above hydrographs, the porous asphalt significantly reduced both the peak flow and the total volume of stormwater runoff from the parking lot in all three rainfall events evaluated. As noted above, this reduction would be even more significant if the additional contributing area east of the parking lot were accounted for.

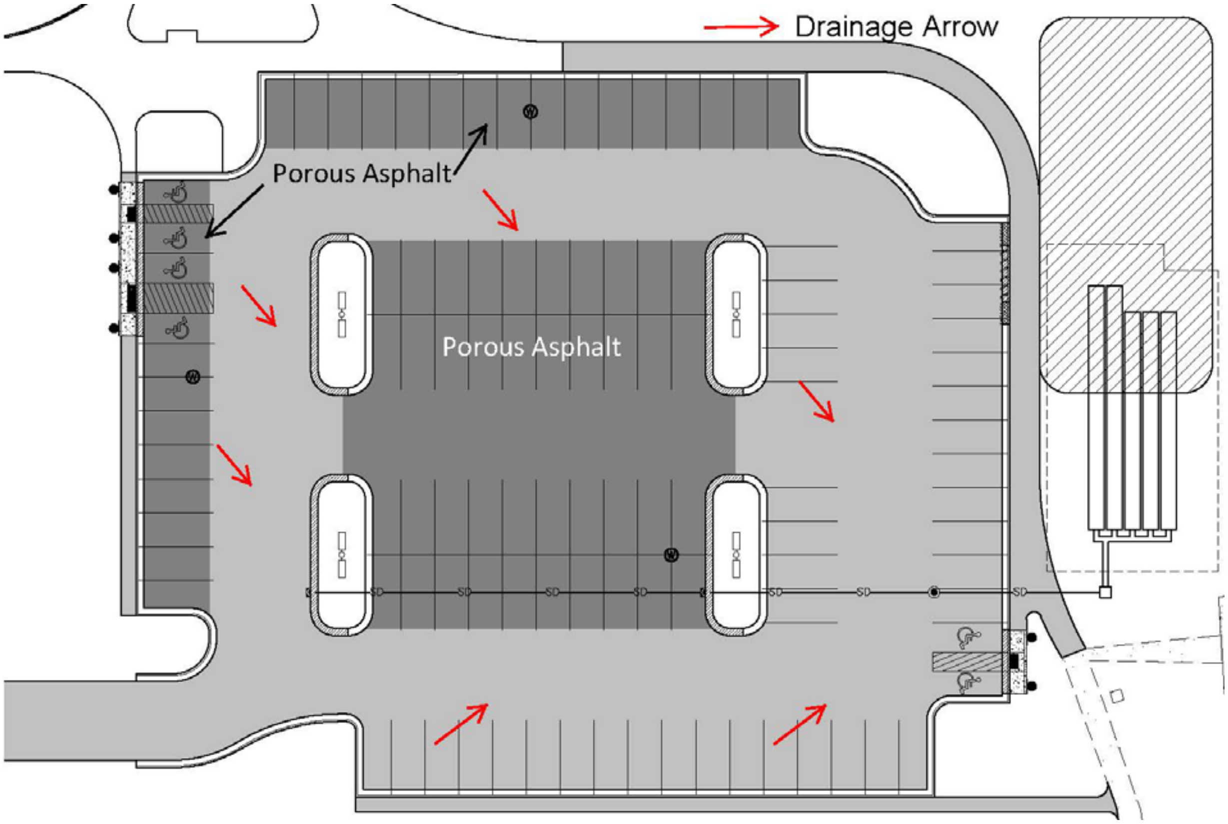
A comparison of inflow and outflow peak flow and total volume is provided in Table 8.

Table 8: Russian Jack Runoff Results Summary

Storm Event	Runoff Volume			Peak Flow		
	Inflow Volume (cf)	Outflow Volume (cf)	Percent Decrease	Inflow Peak (cfs)	Outflow Peak (cf)	Percent Decrease
Event 1, September 4	4,919	3,443	30%	0.21	0.17	19%
Event 2, September 25	3,662	1,270	65%	0.23	0.11	52%
Event 3, August 16 to August 24	8,544	4,853	43%	0.10	0.06	40%

Note that the RJSP parking lot is graded such that some runoff from the non-porous asphalt flows onto the porous asphalt. Therefore, the percent decrease in runoff is not a direct correlation to the percent of porous asphalt in the parking lot. A general drainage schematic is provided in Figure 18, and a site figure is provided in Appendix B.

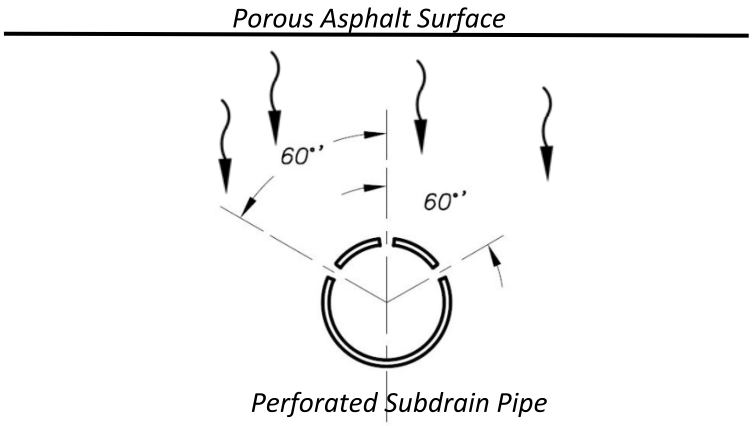
Figure 18: Russian Jack Drainage Schematic



The variation in percent decrease of peak flow and volume is expected to be a result of the rainfall intensity and the unaccounted for grassy area east of the parking lot. Under slower rainfalls with lower intensity, water has more time to naturally percolate into the ground. However, under heavy rains or in very saturated conditions, the grassy area will produce more runoff, which flows onto the parking lot. This runoff would then flow into the manhole that was measuring parking lot outflow and into the infiltration gallery. Thus, the extra runoff would be accounted for in the outflow volume, but not the inflow volume.

It is also expected that under higher rainfall intensity, more water enters the perforated subdrain through the pipe perforations, which are oriented approximately 65 degrees from the top of the pipe on both sides (see Figure 19). The monitoring wells in the porous asphalt section were measured on August 20, August 29, September 25, and October 10. Each time, the water surface elevation was below the design elevation of the perforated subdrain pipe. During a site visit on September 25, small amounts of water were observed to be entering the on-site storm drain system from the subdrain network, but the flow was not significant enough to indicate that the perforated pipe was submerged. It is reasonable to assume that the observed flow was from water entering the pipes through the perforations.

Figure 19: Perforated Subdrain Schematic



4.3.2.Subsurface Infiltration Gallery

The water levels in the infiltration gallery were measured on the following dates during the recording period: August 20, August 22, August 29, September 25, and October 10. In each case, no standing water was observed in the five chambers of the gallery. This shows that the infiltration gallery was able to accept and infiltrate all of the water coming into it in a relatively short amount of time. The volume of water entering the gallery for each of the three storm events is equivalent to the outflow volume in Table 8 above. This performance exceeds design expectations.

4.4. Conclusions and Recommendations for Future Projects

The RJSP project is the first porous asphalt project completed in Anchorage. The monitoring results show that it is performing well, but consideration of the following factors is recommended prior to selecting porous asphalt as a stormwater management technique:

1. **Cold Climate Performance**. The design and construction community have strong reservations about the porous asphalt's long-term performance in Anchorage's cold climate. The RJSP parking lot was observed during the winter of 2012 and spring breakup of 2013 and was found to perform very well under these circumstances. Because the parking lot was not fully completed at this time, it was not opened to the public and was not snow-plowed. On the traditional, impervious asphalt, snowmelt caused significant glaciation and icing. But on the porous asphalt, snowmelt was able to flow immediately through the asphalt and no glaciation occurred. As a result, the porous asphalt sections of the parking lot melted faster than the traditional asphalt sections and were safer for pedestrians. The porous asphalt also reduced spring snow-melt flows and associated pollutant loading. However, the 2013 breakup was the first breakup after parking lot construction. The parking lot performance during breakup should continue to be monitored into the future to obtain information related to the asphalt longevity.

2. **Maintenance.** The long term performance of the RJSP parking lot will depend heavily on how the parking lot is maintained. Due to the inability to vacuum sweep the parking lot, it is critical that the porous asphalt areas are not regularly sanded. Additionally, debris from surrounding trees and on-site landscape features should be swept off the parking lot at least twice per year. This will help keep particulate matter out of the asphalt pores as well and help minimize clogging of the infiltration gallery. Future projects should ensure that the facility's owner is capable of properly maintaining the porous asphalt in accordance with its intended use.

3. **Applicability**. The RJSP parking lot is unique in that only a portion of it is plowed and sanded for wintertime use. This is not the case with most parking lots in Anchorage, and, as discussed above, sanding porous asphalt requires vacuum sweeping to maintain the integrity of the porous asphalt. If vacuum sweeping becomes an available maintenance option for Anchorage, the use of porous asphalt could be a very effective stormwater management technique, particularly for areas that have more slowly draining soils. Until that time, porous asphalt is still a good alternative for areas that do not require regular sanding such as overflow parking areas, paved playgrounds, tennis courts, etc.

4. **Design Considerations**. Porous asphalt requires careful design by a knowledgeable geotechnical engineer. As shown in this project, it can perform well in the right situations, but careful consideration must be given to the characteristics of the native soil, the asphalt subgrade, and the asphalt's interface with other materials and subgrades. These and other factors should be considered by a geotechnical engineer in the asphalt mix and structural section design process.

5. **Construction Coordination**. During the design and construction process, WMS and the project design team gained valuable knowledge regarding the construction and maintenance challenges that similar future projects might face. It is recommended that careful consideration be given to construction sequencing to ensure that construction practices do not compromise the site conditions for which the LID techniques were designed. Additionally, it is critical to have on-site inspectors that are familiar with both LID concepts and the overall project design intent.

Russian Jack Springs Parking Lot, 9/25/13

Russian Jack Springs Parking Lot, 9/11/13

5. Taku Lake Rain Garden (MOA)

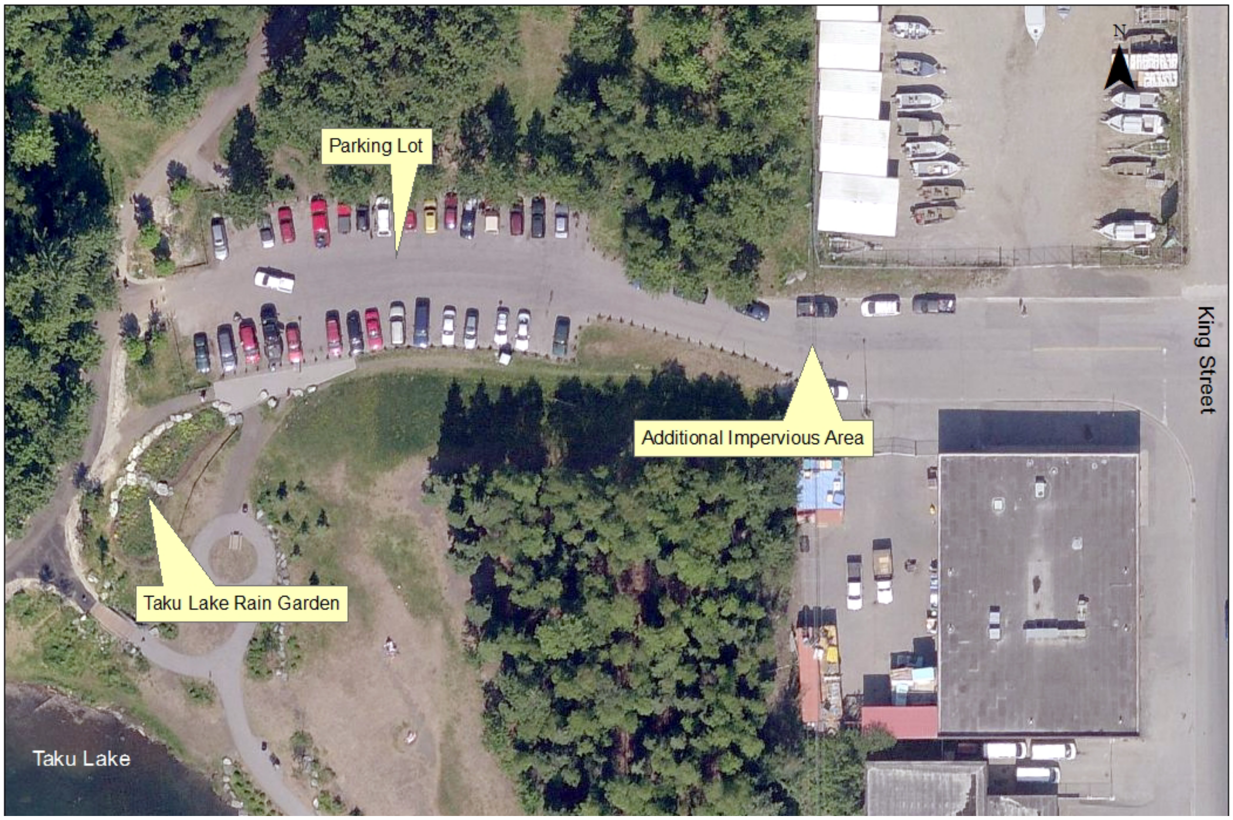
The Taku Lake Rain Garden project was completed by the MOA as part of an effort to improve a localized drainage and flooding problem at the Taku Lake parking lot. Taku Lake is located in Anchorage, north of Dimond Boulevard and west of King Street. The Campbell Creek trail is adjacent to the lake, and the area is popular year-round for recreational activities including walking, running, skiing, biking, and motorized miniature boats. The paved parking lot is approximately 12,150 square feet, and runoff from the parking lot and surrounding area originally flowed directly into Taku Lake via overland flow. The west portion of the parking lot was experiencing localized flooding and seasonal glaciation due to poor grading and drainage. The MOA needed to repair this deficiency and saw an opportunity to concurrently improve the runoff quality and decrease runoff quantity into Taku Lake by incorporating LID into the repair. The MOA designed and constructed a large rain garden on the southwest side of the parking lot to intercept overland flow before it discharges to Taku Lake. The general project area is shown in Figure 5 in Appendix B.

5.1. Rain Garden Details

The Taku Lake Rain Garden is approximately 1,400 square feet, and is located approximately 60 feet from the normal edge of water of Taku Lake. The local average groundwater table is approximately five feet below the surface at the rain garden location. The rain garden consists of approximately 1.3 feet of amended topsoil on top of 2.3 feet of large drain rock. The drain rock is surrounded by geotextile separation fabric. A four-inch diameter perforated drain pipe was installed one foot from the bottom of the rain garden to collect excess water that is not infiltrated into the native subgrade. The perforated drain pipe discharges at the west end of the rain garden near the edge of Taku Lake. The MOA planted a variety of native vegetation in the rain garden including wildflowers, ferns, and grasses. The perimeter of the rain garden is lined with large rock boulders. The rain garden has approximately one foot of surface freeboard.

The rain garden was designed to accept runoff from smaller, more frequent rainfall events. Water beyond the design capacity is either collected in the subdrain or is allowed to overflow from the rain garden and flow into the lake via overland flow. Figure 20 below shows the rain garden and its contributing area.

Figure 20: Taku Lake Rain Garden Site



5.2. Monitoring and Reporting Plan

To monitor the performance of the Taku Lake Rain Garden, on-site instrumentation was installed and data was collected from July 19 to October 17 of 2012. The instrumentation and data collection was performed by Hattenburg Dilley & Linnell, LLC. The instrumentation included a tipping-bucket rain gauge installed near the rain garden outlet and a pressure transducer installed inside the outlet pipe, just upstream of where it discharges to the lake.

The rain gauge was intended to provide a record of the rainfall patterns at the project site. However, the project rain gauge data was compared to data from other Anchorage rain gauges through data available from the NCDC. According to NCDC, the month of September in 2012 was the wettest September on record for Anchorage. The gauges at Merrill Field airport, AIA, and Rabbit Creek No. 2 reported 6.04 inches, 6.49 inches, and 8.64 inches of rain for the month, respectively. The project rain gauge at Taku Lake only reported 2.6 inches. This rain gauge was located in a publically accessible location, and it is suspected that the gauge was tampered with during the recording period. The rain gauge data was considered not reliable and was not used for this project. Instead, hourly rainfall data for July, August, and September of 2012 for AIA from the NCDC was used in this analysis. These data are included in Appendix G.

The pressure transducer was intended to detect water levels inside the pipe which could then be converted to flow rates. The pressure transducer recorded absolute pressure every 20 minutes for the recording period, but did not accurately account for changes in pressure due to variations in local barometric pressure. In order to correct for fluctuations in barometric pressure, the transducer data was averaged for each hour and the average hourly pressure was then correlated to hourly barometric pressure data obtained from the NCDC for AIA. To ensure that barometric pressure was not likely to vary significantly from the project site to AIA, the AIA barometric pressure readings were compared to the Merrill Field barometric pressure readings and were found to be nearly identical. Both the original pressure transducer data and the corrected pressure readings are included in Appendix G

In addition to the instrumentation, the project was visually monitored during the instrumentation period and during the late summer and fall of 2013.

For comparison to a theoretical event of no LID, it was assumed that all of the runoff in the project area would flow directly to Taku Lake. This represents the scenario before the rain garden was constructed.

5.2.1.Hydrograph Development

In order to obtain information on the rain garden performance for different rainfall events, inflow and outflow hydrographs were developed for two storm events.

1. Event 1 occurred on July 21, 2012 and resulted in 0.53 inch of rainfall in a 24-hour period (this is the same rain event that was used for West Dowling Road, Event 1b).
2. Event 2 occurred on September 19, 2012 and resulted 1.41 inches of rainfall in a 24-hour period.

Event 1 is nearly identical to the 90th percentile event for Anchorage, which is required for onsite retention per the current APDES permit. Event 2 represents the largest rain event that occurred during the recording period and is only 0.36 inch less than Anchorage's 10-year, 24-hour event.

Rainfall Hyetographs and Inflow Hydrographs

Rainfall hyetographs were developed based on the AIA hourly rainfall data. The hyetographs are shown in below in Figure and Figure 21.

Figure 21: Event 1 - Taku Lake Rainfall Hyetographs

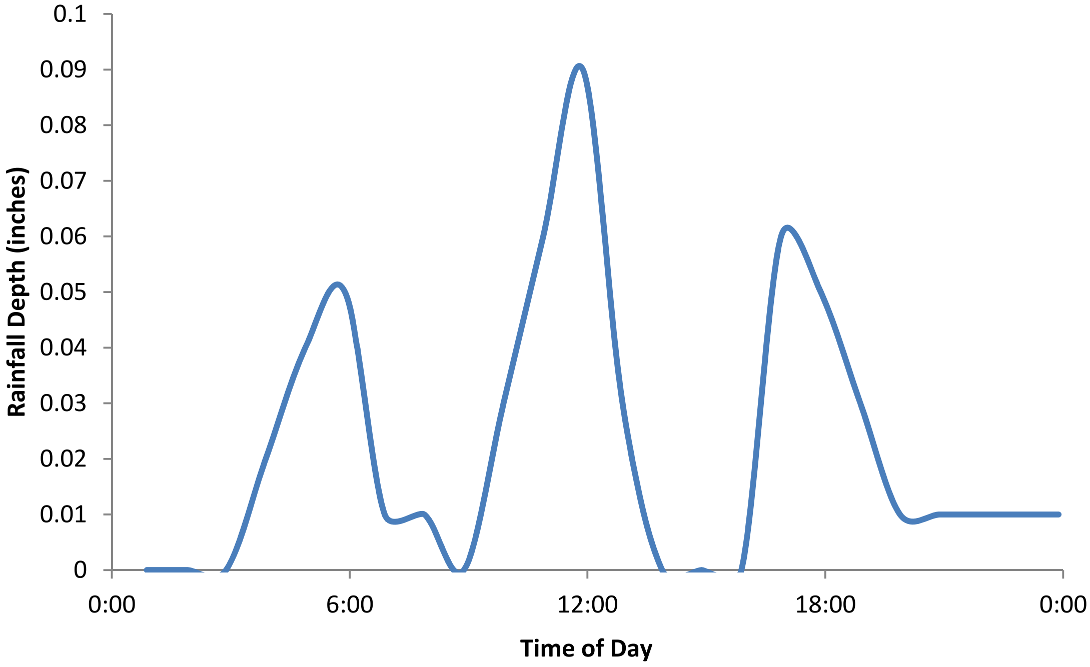
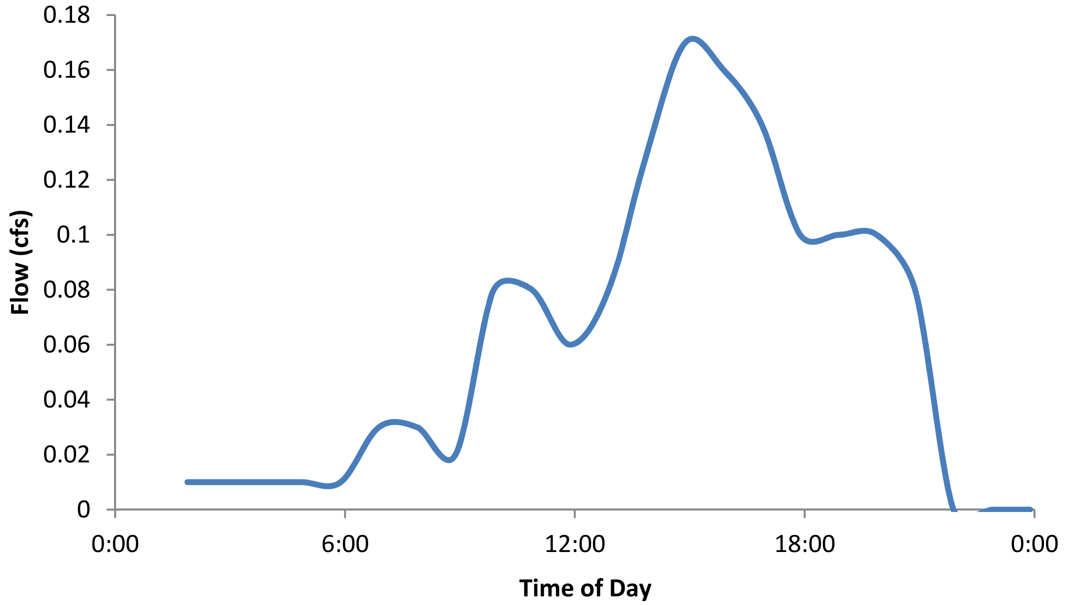


Figure 21: Event 2 - Taku Lake Rainfall Hyetographs



The rainfall hyetographs were converted to inflow hydrographs by multiplying the estimated, effective hourly rainfall depth by the contributing area. The contributing area includes the entire Taku Lake parking lot (12,150 square feet) and a portion of the parking lot access drive (approximately 8,800 square feet). A portion of the inflow from the access drive is being collected in a municipal storm drain system, but much of the flow is bypassing the storm drain inlet and flowing into the parking lot and then to the rain garden. It was roughly estimated, based on observations from site visits, that 75 percent of the flow from the access drive is bypassing the storm drain inlet. The contributing area also includes a small portion of pervious area south of the rain garden on a significant hill. This area is mostly grassy, with a small portion that is treed. For this analysis, it was assumed that 30 percent of the rainfall in the pervious area would become runoff and enter the rain garden. As discussed in Section 4.2.1, potential depression storage on the existing asphalt was not included in the analysis.

Because the contributing area is fairly small, it was assumed that rainfall would contribute flow to the rain garden with a very short time of concentration. Thus, any lag time between the rainfall and the inflow hydrograph was considered negligible. The contributing area was delineated based on the MOA's four-foot contour data, MOA 2009 aerial imagery, and observations from project site visits.

Outflow Hydrographs. Outflow from the rain garden was based on the pressure transducer readings after they were corrected for barometric pressure. The water depth readings from the transducer were converted to discharge flow rates using Manning's equation. A Manning's "n" value of 0.013 was selected for the perforated, plastic discharge pipe, and a pipe slope of 0.5 percent was used based on the MOA design drawings for the rain garden. These computations are included in Appendix G.

The rainfall inflow and outflow hydrographs are shown in the Section 5.3 below.

5.3. Results

5.3.1. Hydrograph Results

The resulting inflow and outflow hydrographs for both rain events are shown in Figure 22 and Figure 23 below.

Figure 22: Event 1 - Rain Garden Inflow and Outflow Hydrographs

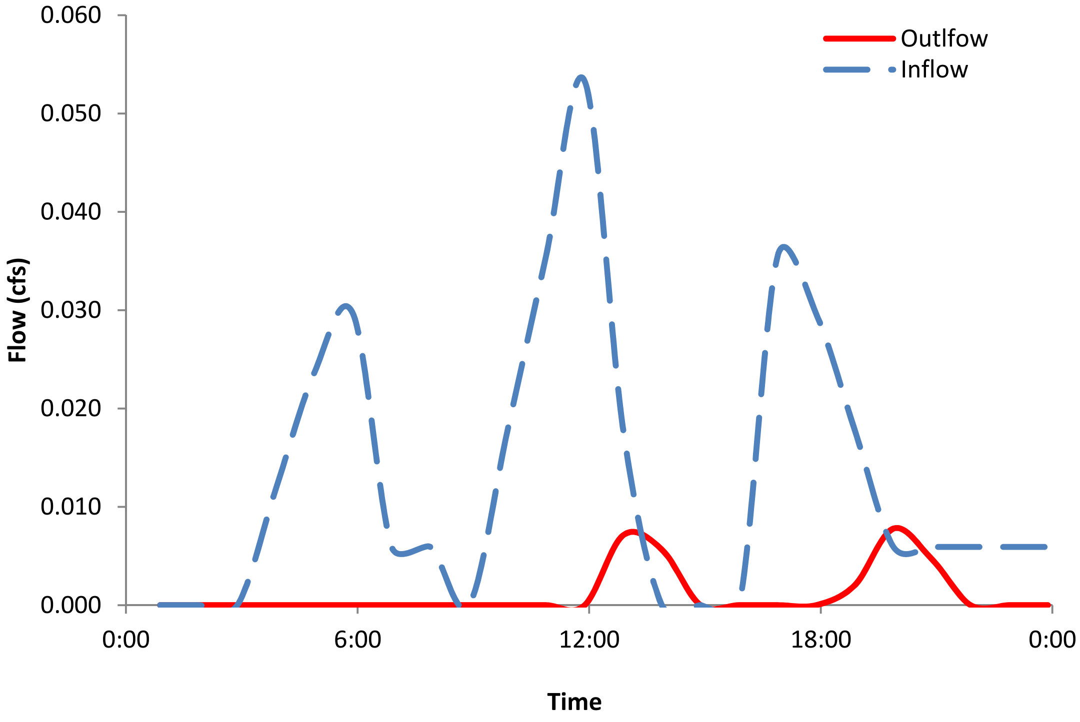
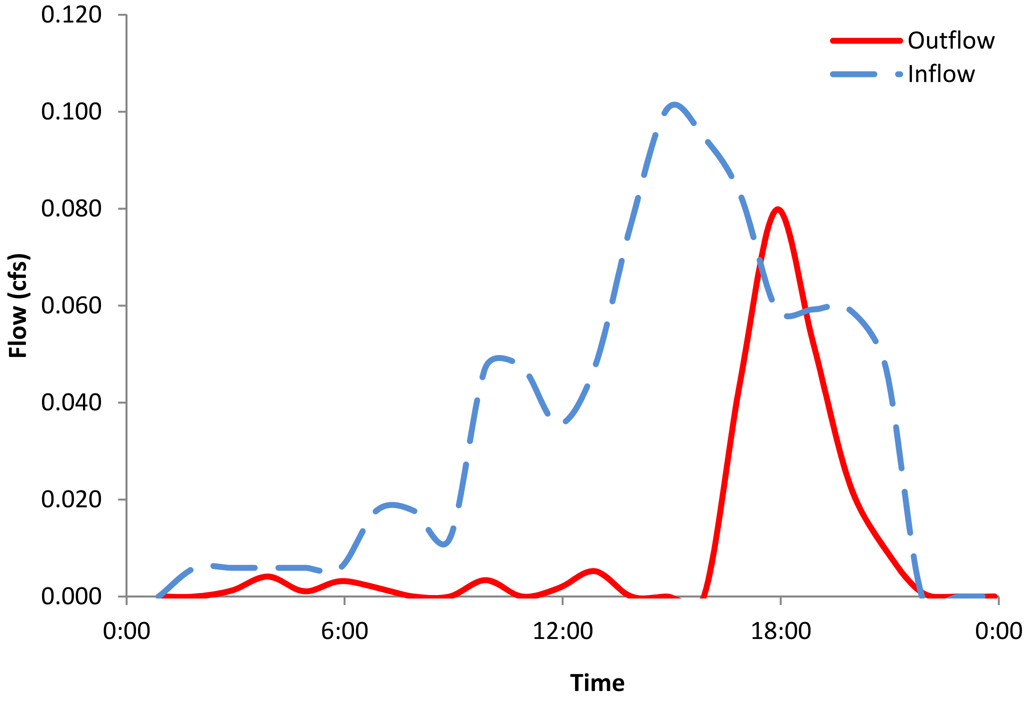


Figure 23: Event 2 - Rain Garden Inflow and Outflow Hydrographs



As shown in the above hydrographs, the rain garden significantly reduced both the peak flow and the total volume of stormwater runoff from the parking lot in both storm events. Although both of these events are fairly significant, the first portion of both hydrographs also shows that the rain garden would produce little to no discharge for smaller rain events that are common in Anchorage.

A comparison of peak flow and inflow and outflow volume for both events is provided in Table 9.

Table 9: Taku Lake Runoff Results Summary

Storm Event	Runoff Volume			Peak Flow		
	Inflow Volume (cf)	Outflow Volume (cf)	Percent Decrease	Inflow Peak (cfs)	Outflow Peak (cf)	Percent Decrease
Event 1, 7/21/12	1,130	98	91%	0.05	0.01	84%
Event 2, 9/19/12	3,006	1,589	47%	0.10	0.08	20%

There are several factors influencing the accuracy of the outflow hydrographs that should be noted.

1. The AIA barometric pressure is reported to have fluctuated approximately 1.7 feet over the recording period for this project. The rain garden outlet pipe is only a four-inch pipe, so variation of a single inch makes a significant difference in computed outflow. Without barometric pressure data from the same location and time as the pressure transducer readings, the pressure transducer readings cannot be considered exact.

2. The pressure transducer used to collect data in the outlet pipe was a Level Troll 700, made by In-Situ. In-Situ literature states that this instrument can be considered accurate to within 0.1 percent of the full scale measurement being taken. In the case of Taku Lake, the instrument was reading an absolute pressure of approximately 33 to 34 feet of head, which correlates to an allowable error of approximately 0.4 inch. Without exact barometric pressure readings, it is difficult to determine if some of the reported pressure fluctuations were due to atmospheric changes or if the fluctuations are the result of instrument error. For example, pressure transducer readings were frequently slightly negative. This is assumed to be due to instrument error or slight differences in the barometric pressure readings as described in the first paragraph of the list.

3. The rain garden outlet discharges to an area of tall, unmowed grass. Water from the outlet pipe then infiltrates into the ground or flows to Taku Lake. The grassy discharge area does not provide a free outlet for the discharge. During site visits when it was raining significantly, small amounts of ponded water were observed in the grass at the end of the outlet pipe. If the ponded water caused flow resistance, or back-up into the outlet pipe, the pressure transducer readings would not accurately reflect actual discharge flow rates.

4. At the beginning of the 2012 monitoring period, the groundwater elevation at the project site was determined to be approximately five feet from the ground surface. According to design drawings provided by the MOA, the perforated subdrain outlet pipe is located approximately 3.3 to 3.6 feet from the surface.

The bottom of the rain garden's drain rock layer is located 4.3 to 4.6 feet below the surface. Local groundwater levels are expected to have risen during the recording period, as seasonal peaks typically occur in the late spring and late fall in Anchorage. The magnitude of the groundwater fluctuations vary based on the summer's rainfall and the melting mountain snow pack, but is commonly two to ten feet. If the groundwater table at Taku Lake fluctuated two to ten feet, it would have risen above the perforated subdrain and caused additional outlet discharge.

5.3.2. Visual Monitoring Results

The Taku Lake Rain Garden was also visually monitored during the late summer and fall of 2013. September of 2013 is reported to be the second wettest September on record in Anchorage with 5.56 inches of rain reported at AIA. Taku Lake was visually inspected on August 15, September 4, September 11, and September 25. Small amounts of water were observed to be discharging from the outlet pipe during the September 11 and September 25 site visits. Rainfall records show that these rainfall events resulted in 1 inch and 1.14 inches of precipitation, respectively. Instrumentation was not in place during these rain events, so this outflow could not be quantified. It is also unclear if the flow observed in the discharge pipe was the result of surface water percolation through the rain garden or if the pipe may have intercepted groundwater during this very rainy month, as discussed above.

5.4. Conclusions and Recommendations for Future Projects

Based on all observations, the Taku Lake Rain Garden is performing well and exceeding design expectations. The project implemented a LID as part of a drainage design solution, despite several site constraints including a high groundwater table. The rain garden appears to be able to successfully infiltrate most water from rain events up to 0.53 inch and is significantly decreasing the quantity of surface water flow into Taku Lake. During larger rain events, the rain garden is still providing a significant reduction of total volume and runoff of peak flow. Water that discharges to Taku Lake is also cleaner than it would otherwise be since it has been filtered by the rain garden's plants and top soil, removing contaminants that is has picked up from the parking lot and access drive.

Based on observations of this facility's performance, the following recommendations have been developed for similar future projects:

1. Consider thorough documentation of the types of vegetation planted in the rain garden and how often the vegetation requires replacement or maintenance. This will provide better long-term information for bioretention facilities in Anchorage.
2. Minimize the use of costly features such as the large rock boulders. Many projects cannot afford the expense of these types of items, and if they are seen as required, they may be a deterrent to a LID.
3. If the project's performance will be monitored over time, provide a downstream access point for monitoring outflow, such as a storm drain structure.
4. Monitor groundwater levels to determine if the groundwater is impacting the rain garden performance.

Taku Lake Rain Garden

Appendix A: APDES Permit Excerpt

c) **Green Infrastructure/Low Impact Development (LID) Strategy and Pilot Projects.** Within one year of the effective date of this permit, the permittees must develop a strategy to provide incentives for the increased use of LID techniques in private and public sector development projects within both the MOA and ADOT&PF jurisdictions. The strategy must outline the methods of evaluating the Green Infrastructure/LID pilot projects described below. Permittees must begin implementation of the Green Infrastructure/LID Strategy and pilot projects within two years of the effective date of this permit.

(i) Beginning with the 4th Year Annual Report, the permittees must report on and evaluate the status of five pilot projects that use LID concepts for on-site control of water quality. Projects must involve managing runoff from at least 10,000 square feet of impervious surface. At least three of the five LID pilot projects must be ADOT&PF-owned locations. Parking lot retrofits as required in Part II.B.2.c.vi may be used as pilot projects. At least two of the pilot sites must address drainage areas greater than five acres in size. At least one pilot project must be located in the Chester Creek, Fish Creek, Campbell Creek, or Little Campbell Creek watersheds.

(ii) The permittees must monitor the performance of each pilot project and report the results beginning with the 4th Year Annual Report. The permittees must 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 practices.

- For new construction projects, changes in runoff quantities shall be calculated for development scenarios both with LID practices and without LID practices.

- 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 nature of impervious surfaces.

- The permittees must use these runoff values to evaluate the overall effectiveness of various LID practices and to develop recommendations for future LID practices addressing appropriate use, design, type, size, soil type and operation and maintenance practices. The permittees must use the recommendations to update their final LID criteria, as necessary, and utilize the information obtained through the LID pilot studies to revise the Storm Water Design Criteria Manual(s) no later than five years from the effective date of this permit.

(iii) **Rain Gardens.** Within four years of the effective date of this permit, the permittees must evaluate the effectiveness of rain gardens located in one neighborhood and one public-private community partnership. If feasible, pilot projects should be located within a TMDL watershed listed in Table II.C. The permittees must quantitatively evaluate the effectiveness of the rain gardens as outlined in Part II.B.2.c.ii above.

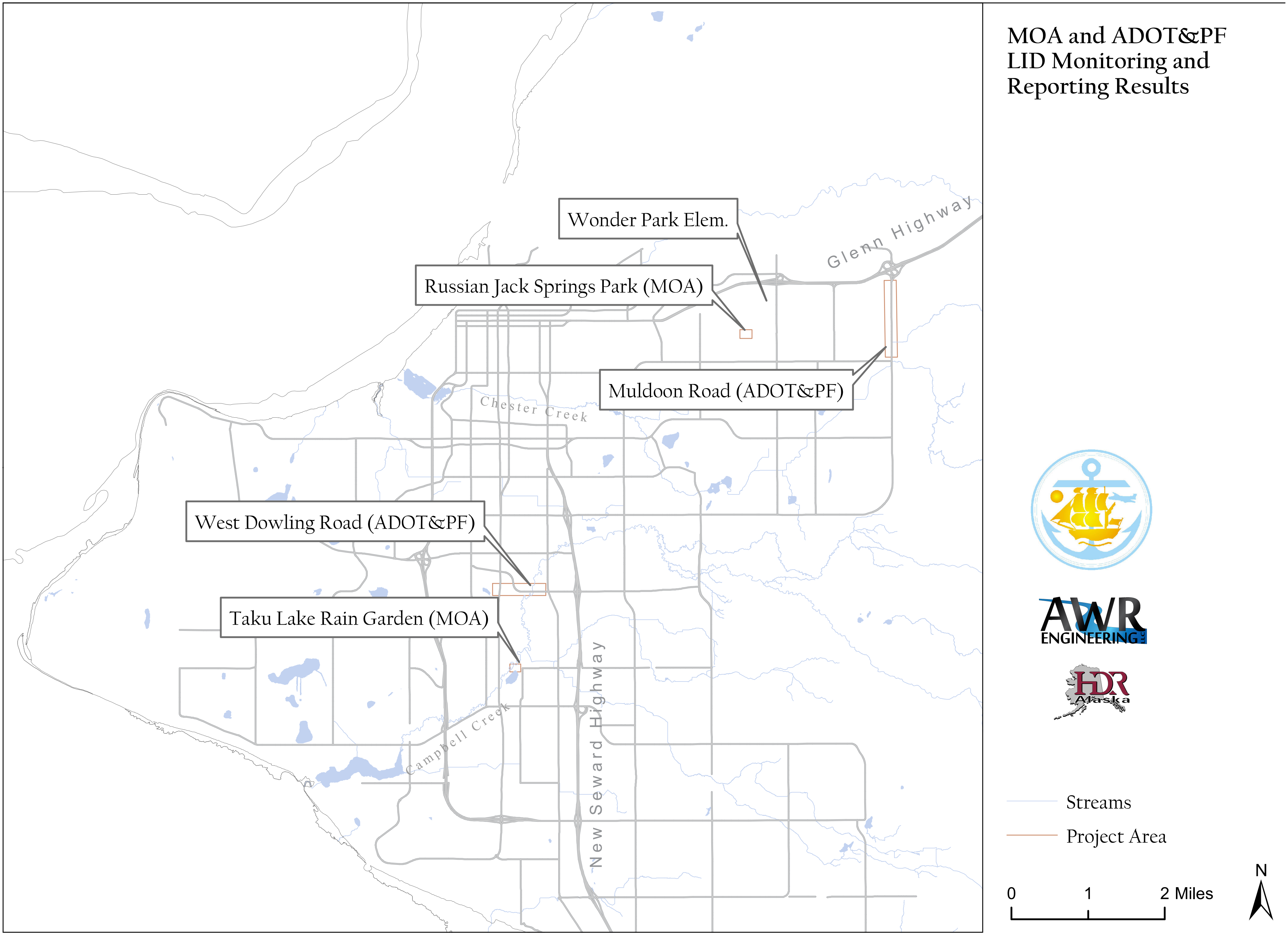
(iv) **Riparian Zone Management.** Within five years from the effective date of this permit, the permittees must identify and prioritize riparian areas appropriate for permittee acquisition and protection. Prior to the expiration date of this permit, the permittees must examine the feasibility of reconstructing MS4 outfalls, and must disconnect at least one major MS4 outfall from discharging from receiving waters using vegetated swales or other appropriate techniques.

(v) **Repair of Public Streets, Roads or Parking Lots.** When public streets, roads or parking lots are repaired as defined in Part VII, the permittees must evaluate the feasibility of incorporating runoff reduction techniques into the repair using canopy interception, 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 feasible, the permittees must consider the use of such practices in the design and repair. These requirements apply only to projects whose design is started after the effective date of this permit. Beginning in the 4th Year Annual Report, the permittees must document and list the locations of street, road and parking lot repair work completed within the last 12 month period that has incorporated such runoff reduction practices.

(vi) **Parking Lot Retrofits.** Prior to the expiration date of this permit, each permittee must retrofit at least two public facility parking lots with infiltration, evapotranspiration or reuse techniques designed to retain 100% of the parking lot runoff from the 90th percentile, 24 hour rainfall event. Each retrofit site must be located in a watershed draining to an impaired receiving water listed in Table II.C. The permittees must quantitatively measure the effectiveness of

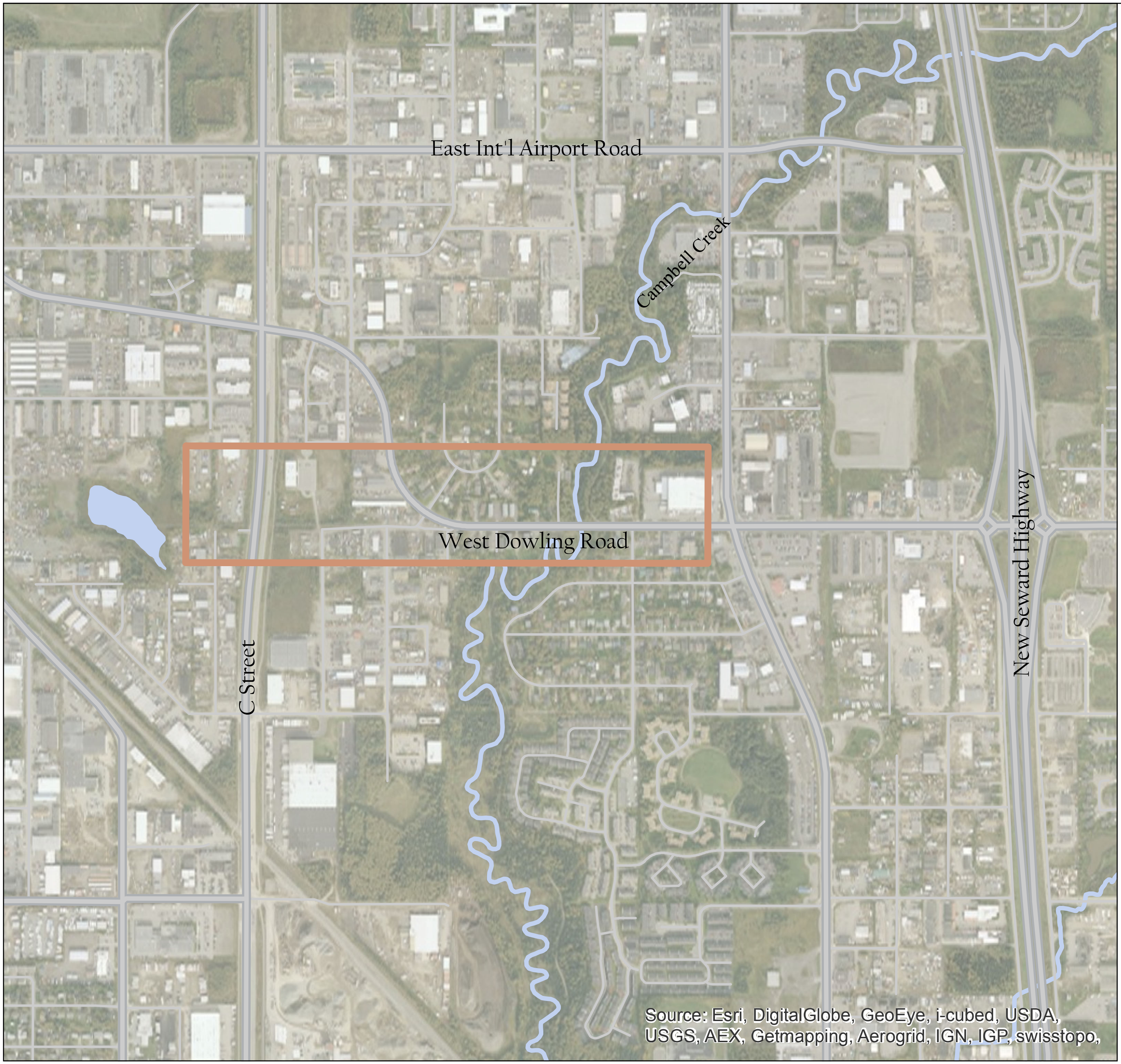
Appendix B: Figures

Figure 1: Project Overview Map



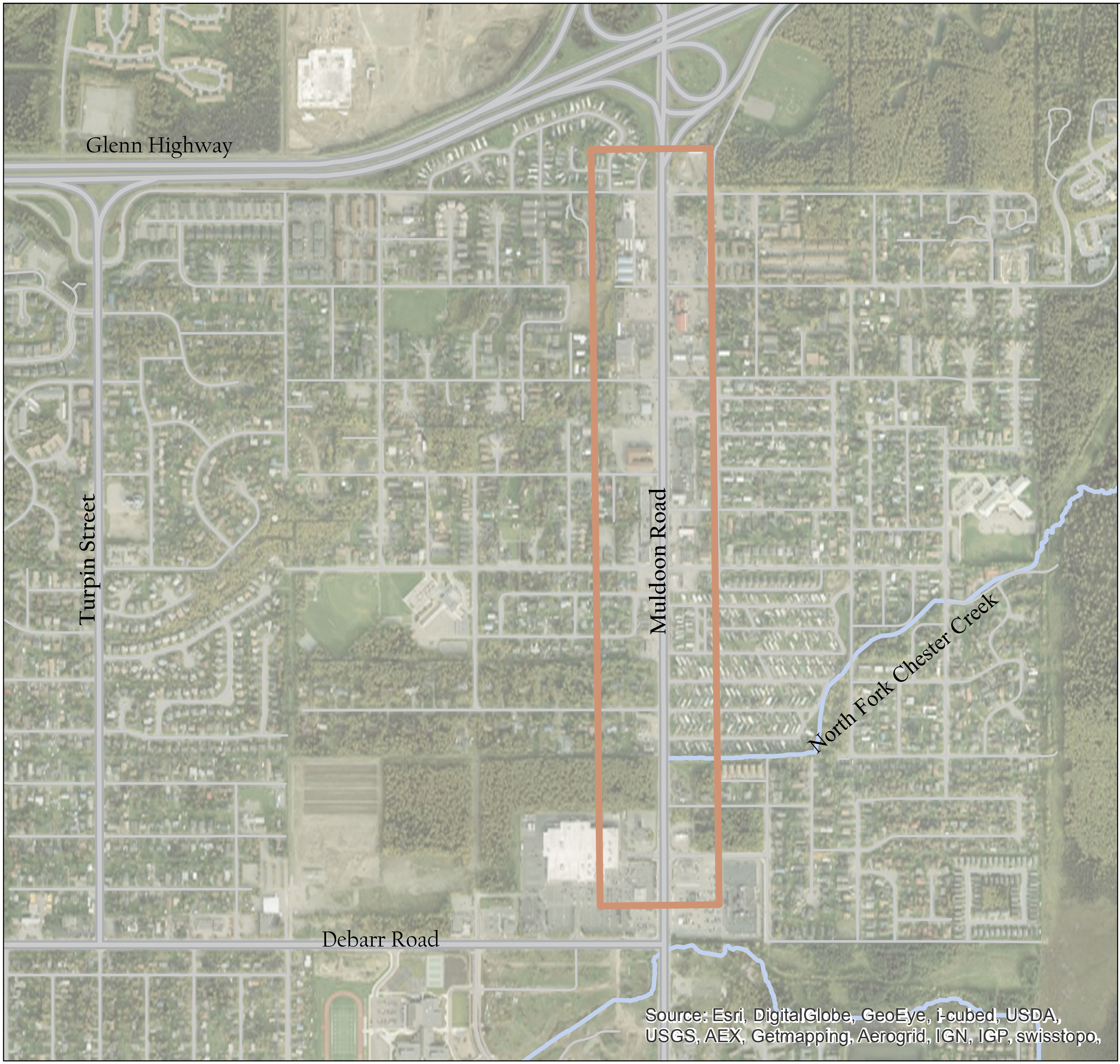
MOA and ADOT&PF
LID Monitoring and
Reporting Results

Figure 2: West Dowling Road (ADOT&PF)



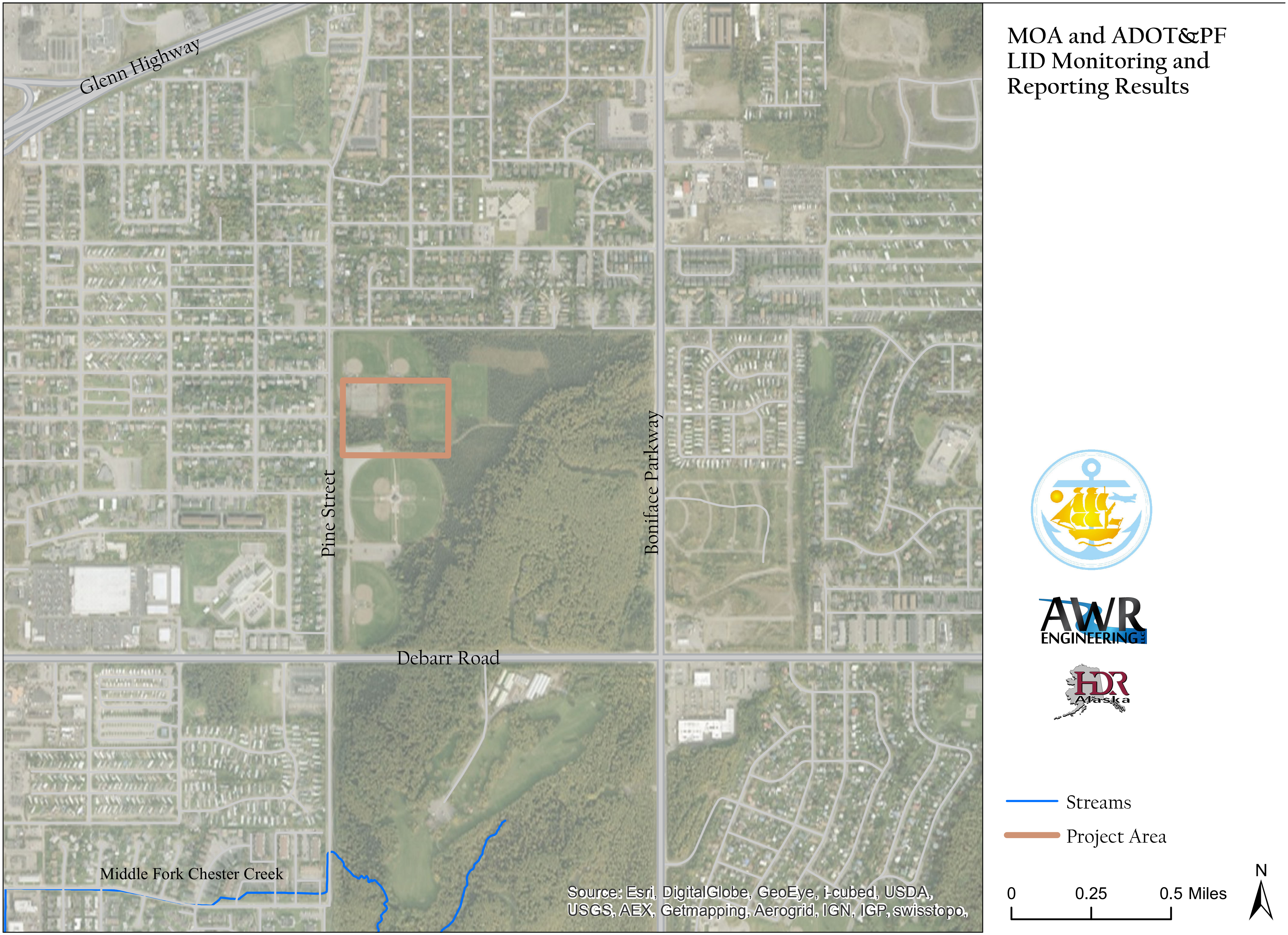
MOA and ADOT&PF LID Monitoring and Reporting Results

Figure 3: Muldoon Road Pedestrian and Landscaping Improvements (ADOT&PF)



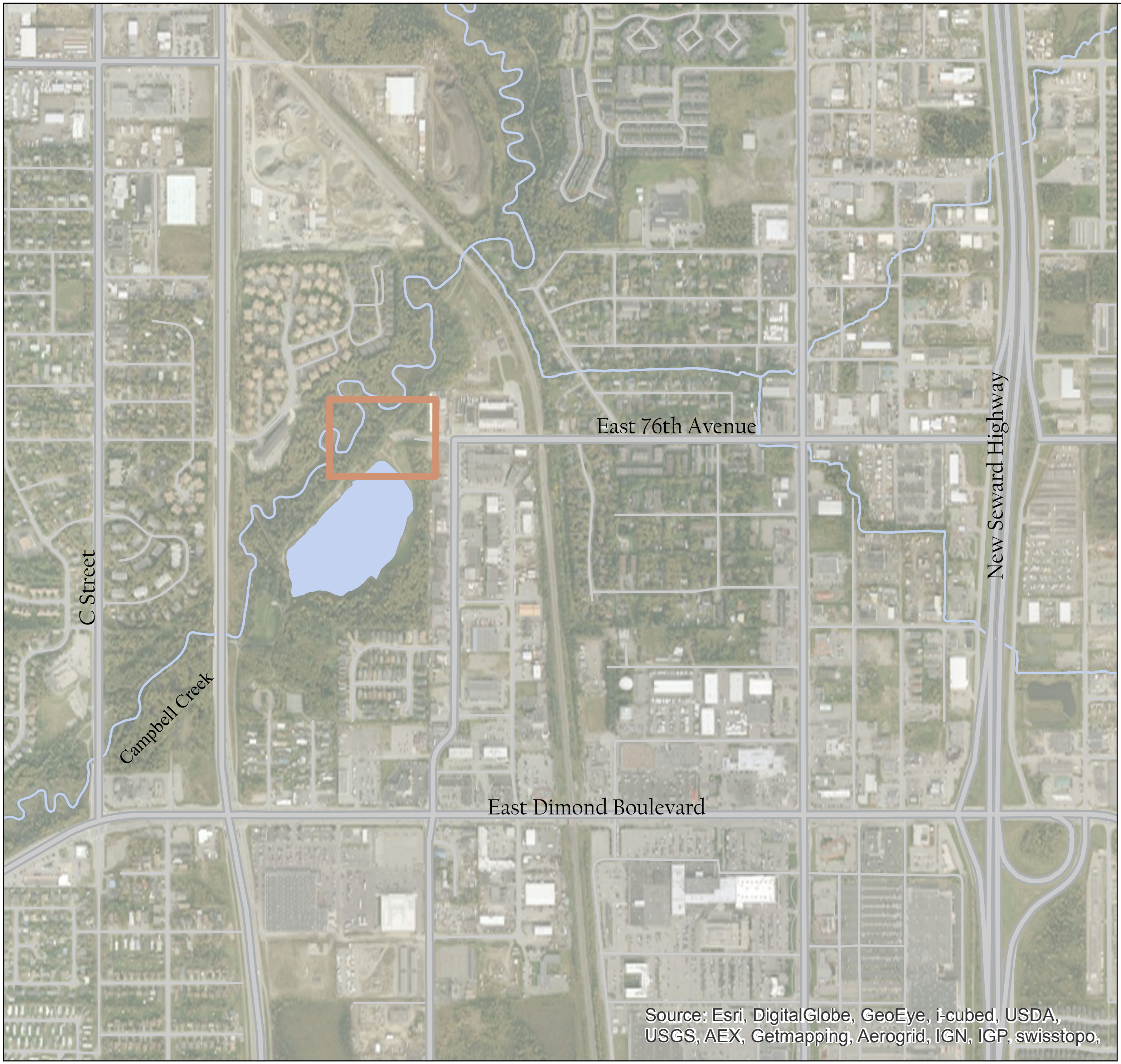
MOA and ADOT&PF LID Monitoring and Reporting Results

Figure 4: Russian Jack Springs Park Improvements (MOA)



MOA and ADOT&PF LID Monitoring and Reporting Results

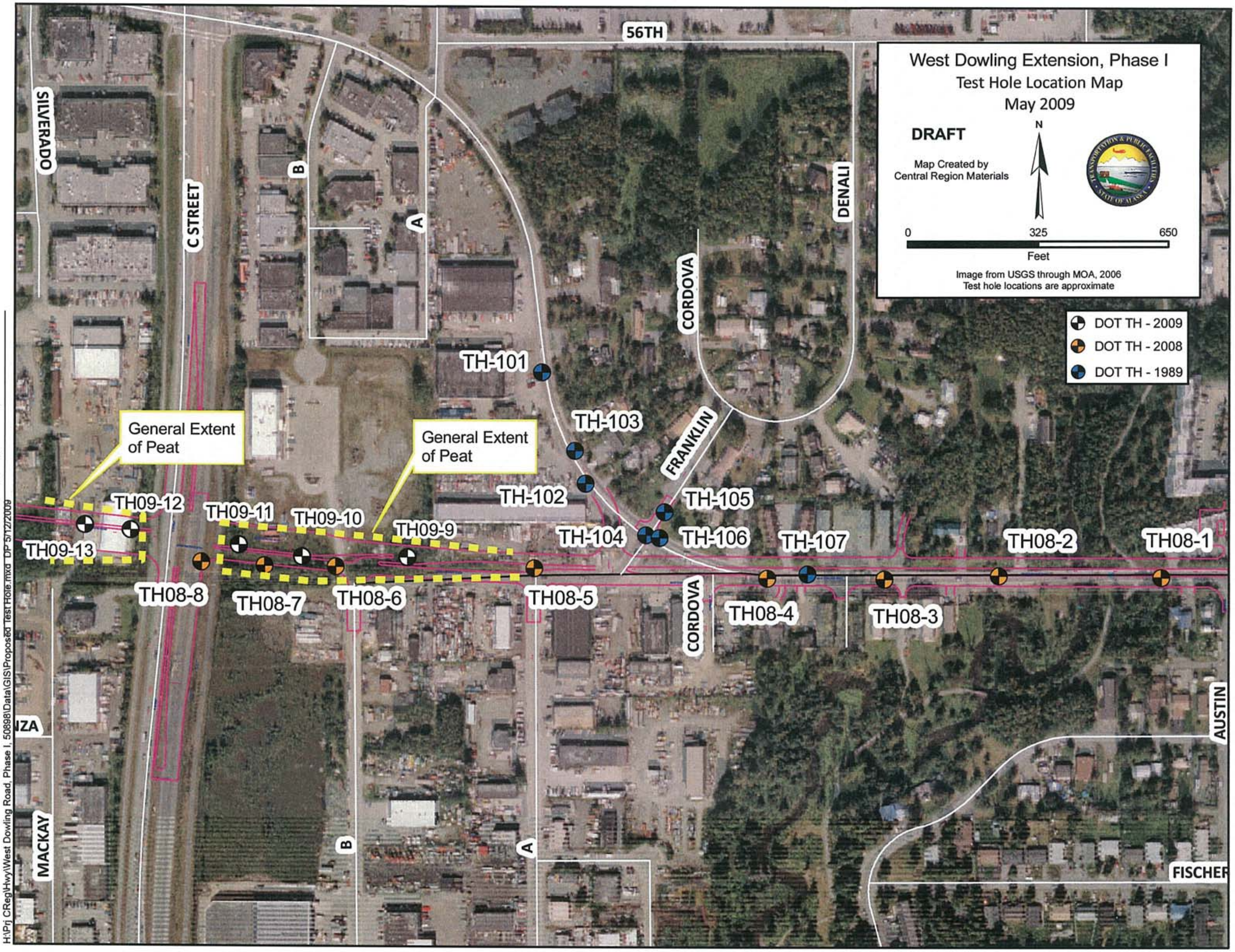
Figure 5: Taku Lake Rain Garden (MOA)



MOA and ADOT&PF LID Monitoring and Reporting Results

Appendix C: West Dowling Soil Data

1. Soil Borings from DOWL HKM H&H Report, June 2009
2. Percolation Test Results, DOWL HKM, June 2013
3. USDA Soil Data, July 2013



West Dowling Extension, Phase I
Test Hole Location Map
May 2009

DRAFT

Map Created by
Central Region Materials

Image from USGS through MOA, 2006
Test hole locations are approximate

H:\Prj CReg\Hwy\West Dowling Road, Phase I, 50898\Data\GIS\Proposed Test Hole.mxd DP 5/12/2009

LOG OF TEST HOLE

HOLE # TH08-01

STATE OF ALASKA DOT&PF
Central Region Materials
Geology Section

PROJECT NUMBER : *50898*
PROJECT : *West Dowling Road, Phase I*

Station / Location: *See Test Hole Location Map*
Offset:
Elevation:

Equipment_Type: *CME 75 Truck*
Drilling Method: *3.75" ID x 8" OD Hollow Auger*
Field Crew: *J. Love, R. Ruth*

Total Depth: *27.0 feet*
Date: *10/10/2008 - 10/10/2008*
Geologist: *C. Boeckman*

Ground Water Data		
Depth in (ft.)	7	
Time		
Date	10/10/08	
Symbol	▼	

Depth (Feet)	Sample Type	Number	Blow Count	Sample	Recovery	N-Value	USCS Classification	Frozen Zone	Soil Graphic
1	GRAB	FS19					GP-GM		
3	SPT	FS20	6 12 19 15			31			
6	SPT	FS21	10 11 13 14				ML		
7 ▼									
8	SPT	FS22	4 6 4 5			10	SM		
11	SPT	FS23	5 5 7 6			12			
16	SPT	FS24	5 6 6 8			12			
20	SPT	FS25	3 3 6 12			9	CL		
26	SPT	FS26	5 6 6 7			12			
27									BOH 27

SUBSURFACE MATERIAL	
1.5-inches asphalt. 1.5-inches tack coat	0.0
GRAVEL with Silt and Sand (GP-GM) Brown/Gry, moist, medium dense, Fill FS19 p200=5.7%, Sa=41%, Gr=53%, Moisture=2%	0.1
fabric (estimated contact - not observed in split spoon but in auger cuttings).	5.0
SANDY SILT (ML) Gray, moist, stiff, No recovery so grabbed a sample from the auger FS21 p200=56.8%, Sa=39%, Gr=4%, Moisture=18.3%, Org=2.8%, PI=NP, LL=20	5.1
SILTY SAND (SM) Brown, moist to wet, stiff FS22 Silty Sand (SM), p200=37.2%, Sa=60%, Gr=3%, Moisture=17.3%, Org=1.8%, PI=NP, LL=15	7.0
SILT with Gravel no to low plasticity, Gray, moist, stiff, contains gravel FS23 Moisture=14.4% FS24 Moisture=14.3%	9.5
CLAY (CL) medium plasticity, Gray, moist, stiff, very moist at 20 ft. Thin (1/4-inch) sand layers. FS25 Lean Clay (CL), p200=98.8%, Sa=1%, Gr=0%, Moisture=33.6%, Org=2.3%, PI=12, LL=36 FS26 Moisture=26.6%	18.0
	27.0

☒ CME Auto Hammer ☐ Cathead Rope Method ☒ 140 lb. hammer with 30 in. drop ☐ 340 lb. hammer with 30 in. drop

STATE OF ALASKA DOT&PF
Central Region Materials
Geology Section

LOG OF TEST HOLE

HOLE # TH08-02

PROJECT NUMBER : *50898*
PROJECT : *West Dowling Road, Phase I*

Station / Location: *See Test Hole Location Map*
Offset:
Elevation:

Equipment_Type: *CME 45*
Drilling Method: *3.75" ID x 8" OD Hollow Auger*
Field Crew: *J. Love, E. Carman*

Total Depth: *21.0 feet*
Date: *10/9/2008 - 10/9/2008*
Geologist: *C. Boeckman*

Ground Water Data

Depth in (ft.)	12	
Time		
Date	10/9/08	
Symbol	▼	

Sample Data

Depth (Feet)	Sample Type	Number	Blow Count	Sample Recovery	N-Value
0.5–2	GRAB	FS12		■	
2.5–4.5	SPT	FS13	14 12 11 10	☒ ■	
5–7	SPT	FS14	4 6 6 5	☒ ■	12
7.5–9.5	SPT	FS15	5 4 5 9	☒ ■	9
10–12	SPT	FS16	8 10 15 17	☒ ■	25
15–17	SPT	FS17	7 11 14 18	☒ ■	25
19.5–21	SPT	FS18	15 28 26	☒ ■	54

Ground water ▼ at 12 ft.

USCS Classification	Frozen Zone	SUBSURFACE MATERIAL	Depth
		2-inches sphalt, 1-inch tack coat	0.0 0.2
SP-SM		**SAND with Silt and Gravel** (SP-SM) Brown, moist, medium dense FS12 p200=12.3%, Sa=48%, Gr=40%, Moisture=3.1%	3.0
ML		**SILT with Sand** (ML) no to low plasticity, Brown, moist, stiff, Contains gravel. Some silty sand layers. FS14 p200=75.9%, Sa=19%, Gr=5%, Moisture=20.2%, Org=1.5%, PI=4, LL=21 FS15 Moisture=26.3% FS16 Moisture=20%	13.5
SM		**SILTY SAND** (SM) Gray, moist to wet, medium dense FS17 p200=24.9%, Sa=72%, Gr=3%	18.0
SP-SM		**SAND with Silt and Gravel** (SP-SM) Gray, wet, very dense FS18 p200=10.6%, Sa=50%, Gr=39%	21.0

BOH
21

A USCS LOG OF TEST HOLE W DOWLING OLD SEWARD TO C ST.GPJ 2006DATATEMPLATE.GDT 5/5/09

☒ CME Auto Hammer ☐ Cathead Rope Method ☒ 140 lb. hammer with 30 in. drop ☐ 340 lb. hammer with 30 in. drop

STATE OF ALASKA DOT&PF
Central Region Materials
Geology Section

LOG OF TEST HOLE

PROJECT NUMBER : *50898*
PROJECT : *West Dowling Road, Phase I*

HOLE # TH08-03

Station / Location: *See Test Hole Location Map*
Offset:
Elevation:

Equipment_Type: *CME 45*
Drilling Method: *3.75" ID x 8" OD Hollow Auger*
Field Crew: *J. Love, E. Carman*

Total Depth: *17.0 feet*
Date: *10/9/2008 - 10/9/2008*
Geologist: *C. Boeckman*

Ground Water Data

Depth in (ft.)	6	
Time		
Date	10/9/08	
Symbol	▼	

Sample Data

Depth (Feet)	Sample Type	Number	Blow Count	N-Value	USCS Classification
0.5–2	GRAB	FS6			SP-SM
3–4.5	SPT	FS7	12 10 9 6	19	
5–7 (▼ 6)	SPT	FS8	8 8 8 10	16	SM
7.5–9.5	SPT	FS9	3 4 4 6	8	ML
10–12	SPT	FS10	3 6 11 20		SM
15–17	SPT	FS11	7 12 15 14	27	ML

SUBSURFACE MATERIAL

0.0 – 3-inches asphalt. 0.5-inches tack coat

0.3 – **SAND with Silt and Gravel** (SP-SM) Brown, moist
FS6 p200=7.2%, Sa=51%, Gr=42%, Moisture=2.6%

FS7 p200=6.9%, Sa=65%, Gr=28%, Moisture=4.3%

5.0 – **SILTY SAND with Gravel** (SM) Gray, moist to wet FS8 p200=28.4%, Sa=58%, Gr=14%, Moisture=10.3%, Org=1.5%, PI=NP, LL=NV

7.0 – **SANDY SILT** (ML) no to low plasticity, Gray, moist to wet
FS9 p200=76.5%, Sa=23%, Gr=0%, Moisture=15%, PI=NP, LL=18

FS10 Moisture=7.3%

11.0 – **SILTY SAND with Gravel** (SM) Gray, moist

13.5 – **SILT with Gravel** (ML) no to low plasticity, Gray, moist

FS11 p200=64.3%, Sa=18%, Gr=18%, Moisture=13.1%, PI=NP, LL=19

17.0 – BOH 17

☒ CME Auto Hammer ☐ Cathead Rope Method ☒ 140 lb. hammer with 30 in. drop ☐ 340 lb. hammer with 30 in. drop

LOG OF TEST HOLE

HOLE # TH08-04

STATE OF ALASKA DOT&PF
Central Region Materials
Geology Section

PROJECT NUMBER : *50898*
PROJECT : *West Dowling Road, Phase I*

Station / Location: *See Test Hole Location Map*
Offset:
Elevation:

Equipment_Type: *CME 45*
Drilling Method: *3.75" ID x 8" OD Hollow Auger*
Field Crew: *J. Love, E. Carman*

Total Depth: *17.0 feet*
Date: *10/9/2008 - 10/9/2008*
Geologist: *C. Boeckman*

Ground Water Data

Depth in (ft.)	6.5	
Time		
Date	10/9/08	
Symbol	▼	

Depth (Feet)	Sample Data: Sample Type	Number	Blow Count	Sample	Recovery	N-Value	USCS Classification	Frozen Zone	Soil Graphic	SUBSURFACE MATERIAL	
0										2-inches asphalt. 1-inch tack coat.	0.0
1	GRAB	FS1					SP-SM			**SAND with Silt and Gravel** (SP-SM) Brown, moist, medium dense, Fill FS1 p200=11.3%, Sa=62%, Gr=27%, Moisture=4.1%	0.2
3	SPT	FS2	16 13 9 9								
4							OL			**ORGANIC SILT** (OL) Black, moist, stiff, some sand and gravel	4.0
5							SP-SM			**SAND with Silt and Gravel** (SP-SM) Brown, wet, loose FS3 p200=13.3%, Sa=72%, Gr=15%, Moisture=12.6%, Org=1.5%, PI=NP, LL=NV	5.0
6	SPT	FS3	3 5 5 4			10					
10							SM			**SILTY SAND** (SM) Gray, wet, medium dense FS4 p200=17.2%, Sa=83%, Gr=0%, Moisture=18.9%	9.5
11	SPT	FS4	10 13 16 14			29					
16	SPT	NA	10 10 11 14			21					
17									BOH 17		17.0

☒ CME Auto Hammer ☐ Cathead Rope Method ☒ 140 lb. hammer with 30 in. drop ☐ 340 lb. hammer with 30 in. drop

LOG OF TEST HOLE

HOLE # TH08-05

STATE OF ALASKA DOT&PF
Central Region Materials
Geology Section

PROJECT NUMBER : *50898*
PROJECT : *West Dowling Road, Phase I*

Station / Location: *See Test Hole Location Map*
Offset:
Elevation:

Equipment_Type: *CME 75 Truck*
Drilling Method: *3.75" ID x 8" OD Hollow Auger*
Field Crew: *J. Love, R. Ruth*

Total Depth: *17.0 feet*
Date: *10/10/2008 - 10/10/2008*
Geologist: *C. Boeckman*

Ground Water Data

Depth in (ft.)	7	
Time		
Date	10/10/08	
Symbol	▼	

Sample Data

Depth (Feet)	Sample Type	Number	Blow Count	Sample	Recovery	N-Value	USCS Classification	Frozen Zone
0 – 1.5	GRAB	FS30		▨	■		SP-SM	
2.5 – 4.5	SPT	FS31	3 5 3 4	☒	■	8		
5 – 7	SPT	FS32	3 3 2 3	☒	■	5	SM	
7.5 – 9.5	SPT	FS33/FS34	2 2 2 2	☒	■		SP	
10 – 12	SPT	FS35	2 3 6 8	☒	■	9	ML	
15 – 17	SPT	FS36	7 10 12 10	☒	■	22		

BOH 17

SUBSURFACE MATERIAL

0.0 — **SAND with Silt and Gravel** (SP-SM) Brown, loose, contains cobbles FS30 p200=12%, Sa=51%, Gr=37%, Moisture=5.4%

FS31 p200=13.5%, Sa=67%, Gr=19%, Moisture=8.7%

5.0 — **SILTY SAND** (SM) Gray, moist to wet, firm, some gravel. FS32 PID = 0 ppm, p200=34.8%, Sa=57%, Gr=8%, Moisture=16.1%, Org=1.7%, PI=NP, LL=17

FS33/FS34 PID = 131 ppm.

9.0 — **SAND** (SP) Black, loose, wet, loose

10.0 — **SILT** (ML) Gray, medium dense, very moist FS35 PID = 2.1 ppm

FS36 PID = 0.8 ppm

17.0

Notes:
PID used was a Mini-Rae 2000. Calibrated with 100 ppm Isobutylene span gas.
PID had a moisture trap.
Collected samples in zip lock bags. Allowed to heat slightly, then collected a reading.

On 3-11-09 installed a 3/4 inch diameter by 1.5 ft long stainless steel well point to 10 ft bgs. Used 3/4-inch galvanized pipe riser to surface. Used a 6-inch diamter flush mount vault box at surface. Installed by augering to 5 ft. Assembled the well point and drove to 10 ft. No seal (bentonite) placed in bore hole from 0 to 5 ft upon completion.

☒ CME Auto Hammer ☐ Cathead Rope Method ☒ 140 lb. hammer with 30 in. drop ☐ 340 lb. hammer with 30 in. drop

STATE OF ALASKA DOT&PF
Central Region Materials
Geology Section

LOG OF TEST HOLE

HOLE # TH08-06

PROJECT NUMBER : *50898*
PROJECT : *West Dowling Road, Phase I*

Station / Location: *See Test Hole Location Map*
Offset:
Elevation:

Equipment_Type: *CME 850*
Drilling Method: *3.75" ID x 8" OD Hollow Auger*
Field Crew: *J. Love, R. Ruth*

Total Depth: *21.0 feet*
Date: *10/13/2008 - 10/13/2008*
Geologist: *C. Boeckman*

Ground Water Data

Depth in (ft.)	4	
Time		
Date	10/13/08	
Symbol	▼	

Depth (Feet)	Sample Type	Number	Blow Count	Sample	Recovery	N-Value	USCS Classification	Frozen Zone	SUBSURFACE MATERIAL	
0							OL		**ORGANIC SILT** (OL) Brown, moist, soft, veg mat	0.0
2							SM		**SILTY SAND** (SM) Brown, moist to wet, medium dense	2.0
3–4 ▼	SPT	FS37	3 6 7 6	☒	■	13			FS37 PID = 1.3 ppm, p200=24.7%, Sa=74%, Gr=1%, Moisture=20.9%, Org=1.4%	
5	SPT	FS38	3 1 2 1	☒	■		PT		**Peat** (PT) Brown, moist to wet, soft, Contains sand and silt FS38 p200=10.8%, Sa=88%, Gr=1%, Moisture=262.1%, Org=52.3%, PI=NP, LL=NV	5.0
8.5							ML		**SILT** (ML) Gray, moist to wet, stiff	8.5
9–10	SPT	FS39	4 5 5 7	☒	■	10			FS39 PID = 5.1 ppm, p200=89.3%, Sa=11%, Gr=0%, Moisture=18.6%, Org=1.4%, PI=NP, LL=19	
10.5								■	Frozen? Thermistor readings did not indicate as frozen.	10.5
13							SP-SM		**SAND with Silt** (SP-SM) Gray, wet, medium dense	13.0
14–15		FS40	4 7 9 13		■				FS40 PID = 6.2 ppm, p200=4%, Sa=93%, Gr=3%, Moisture=18.7%	
15.5							ML		**SILT** (ML) Gray, moist to wet, stiff	15.5
19–20	SPT	FS41	3 4 7 8	☒	■	11			FS41 PID = 12.7 ppm, p200=90.8%, Sa=9%, Gr=0%, Moisture=27.2%, PI=NP, LL=26	
21							BOH 21			21.0

Notes:
PID used was a Mini-Rae 2000.
Calibrated with 100 ppm Isobutylene span gas. Using a moisture trap.
Collected samples in zip lock bags. Allowed to heat slightly, then collected a reading.

Installed 1-inch PVC for thermistor readings.

☒ CME Auto Hammer ☐ Cathead Rope Method ☒ 140 lb. hammer with 30 in. drop ☐ 340 lb. hammer with 30 in. drop

STATE OF ALASKA DOT&PF
Central Region Materials
Geology Section

LOG OF TEST HOLE

HOLE # TH08-07

PROJECT NUMBER : *50898*
PROJECT : *West Dowling Road, Phase I*

Station / Location: *See Test Hole Location Map*
Offset:
Elevation:

Equipment_Type: *CME 850*
Drilling Method: *3.75" ID x 8" OD Hollow Auger*
Field Crew: *J. Love, R. Ruth*

Total Depth: *21.0 feet*
Date: *10/13/2008 - 10/13/2008*
Geologist: *C. Boeckman*

Ground Water Data		
Depth in (ft.)	8	
Time		
Date	10/13/08	
Symbol	▼	

Sample Data

Sample Type	Number	Blow Count	Sample	Recovery	N-Value	Frozen Zone
SPT	FS42	3 2 3 3	☒	■		
SPT	FS42	2 2 2 3	☒	■	4	
SPT	FS43	0 1 3 3	☒	■		
SPT	FS44/FS45	2 2 2 4	☒	■		■
SPT	FS46	4 7 8 10	☒	■	15	■
SPT	FS47	3 6 6 5	☒	■	12	

USCS Classification	SUBSURFACE MATERIAL	Depth (Feet)
OL	**ORGANIC SILT** (OL) Brown, wet, soft, veg mat	0.0
PT	**Peat** (PT) Brown, moist to wet, soft, fibrous peat at 8-11.5 ft	2.0
OL/SM	**ORGANIC SILTY SAND** (OL/SM) Brown, moist to wet, loose FS42 p200=35.9%, Sa=60%, Gr=4%, Moisture=78.7%, Org=21.4%, PI=NP, LL=NV	4.0
PT	**Peat** (PT) Brown, moist to wet, soft, Frozen from 10-11.5 ft?? Nbn. Thermistor readings did not indicate frozen soil. FS43 Moisture=131.4%	8.0
OL	**ORGANIC SILT** (OL) Brown, moist to wet	11.5
ML	**SILT** (ML) low plasticity, Gray, moist to wet, stiff	12.5
	FS46 PID = 1.2 ppm, Moisture=24.9%, Org=1.6% Frozen at 15-16 ft?? Nbn. Thermistor readings did not indicate frozen soil.	15.0
	FS47 PID = 0.5 ppm, p200=98.8%, Sa=1%, Gr=0%, Moisture=28.5%, Org=1.8%, PI=NP, LL=28	
BOH 21		21.0

Notes:
PID used was a Mini-Rae 2000. Calibrated with 100 ppm Isobutylene span gas. Using a moisture trap.
Collected samples in zip lock bags. Allowed to heat slightly, then collected a reading.

Installed 1-inch PVC for thermistor readings.

☒ CME Auto Hammer ☐ Cathead Rope Method ☒ 140 lb. hammer with 30 in. drop ☐ 340 lb. hammer with 30 in. drop

Sheet Number 1 of 1

A USCS LOG OF TEST HOLE W DOWLING OLD SEWARD TO C ST.GPJ 2006DATATEMPLATE.GDT 5/5/09

STATE OF ALASKA DOT&PF
Central Region Materials
Geology Section

LOG OF TEST HOLE

PROJECT NUMBER : *50898*
PROJECT : *West Dowling Road, Phase I*

HOLE # TH08-08

Station / Location: *See Test Hole Location Map*
Offset:
Elevation:

Equipment_Type: *CME 75 Truck*
Drilling Method: *3.75" ID x 8" OD Hollow Auger*
Field Crew: *J. Love, R. Ruth*

Total Depth: *17.0 feet*
Date: *10/10/2008 - 10/10/2008*
Geologist: *C. Boeckman*

Ground Water Data

Depth in (ft.)	9	
Time		
Date	10/10/08	
Symbol	▼	

Depth (Feet)	Sample Type	Number	Blow Count	Sample	Recovery	N-Value	USCS Classification	Frozen Zone	Soil Graphic	SUBSURFACE MATERIAL	
0							OL			**ORGANIC** (OL) veg mat	0.0
0.5							GP-GM			**GRAVEL with Silt and Sand** (GP-GM) Gray/Brown, moist, medium dense	0.5
6	SPT	FS27	7 10 12 14	☒	■	22				FS27 p200=7.5%, Sa=42%, Gr=50%, Moisture=5.8%	
9 ▼											
9.5							PT			**Peat** (PT) Dark brown, wet, stiff	9.5
10	SPT	FS28	3 3 6 11	☒	■						
10.5							ML			**SILT** (ML) no to low plasticity, Gray, moist to wet, very stiff, Contains gravel.	10.5
16	SPT	FS29	10 12 18 12	☒	■	30				FS29 p200=88.3%, Sa=1%, Gr=11%, Moisture=21.8%, PI=NP, LL=27	
17									BOH 17		17.0

☒ CME Auto Hammer ☐ Cathead Rope Method ☒ 140 lb. hammer with 30 in. drop ☐ 340 lb. hammer with 30 in. drop

STATE OF ALASKA DOT&PF
Central Region Materials
Geology Section

LOG OF TEST HOLE

HOLE # TH09-09

PROJECT NUMBER : 50898
PROJECT : West Dowling Road, Phase I

Station / Location: *See Test Hole Location Map*
Offset:
Elevation:

Equipment_Type: *CME 850*
Drilling Method: *3.75" ID x 8" OD Hollow Auger*
Field Crew: *Wagster/Carman*

Total Depth: *16.0 feet*
Date: *3/10/2009 - 3/10/2009*
Geologist: *C. Boeckman*

Ground Water Data

Depth in (ft.)	10	
Time		
Date	3/10/09	
Symbol	▼	

Depth (Feet)	Sample Type	Number	Blow Count	Sample	Recovery	N-Value	USCS Classification	Frozen Zone	Soil Graphic	SUBSURFACE MATERIAL	
0							PT			**Peat** (PT) Dark brown, moist to wet, soft, Nbn, Berm (fill?). PID = 0.5 ppm	0.0
4–5	SPT	FS1	4 2 2 2	☒		4				FS1 Moisture=110.3%	
8							SM			**SILTY SAND** (SM) Brown, wet, medium dense, PID = 30 ppm FS2 p200=45.1%, Sa=54%, Gr=1%	8.0
9–10 ▼	SPT	FS2	8 11 11 11	☒		22					
14							ML			**SILT** (ML) Gray, moist to wet, stiff, PID = 2.3 ppm	14.0
15	SPT		5 7 7 7	☒		14					
16									BOH 16	Notes: Located on a berm adjacent to the property line fence.	16.0

☒ CME Auto Hammer ☐ Cathead Rope Method ☒ 140 lb. hammer with 30 in. drop ☐ 340 lb. hammer with 30 in. drop

Sheet Number 1 of 1

LOG OF TEST HOLE

HOLE # TH09-10

STATE OF ALASKA DOT&PF
Central Region Materials
Geology Section

PROJECT NUMBER : *50898*
PROJECT : *West Dowling Road, Phase I*

Station / Location: *See Test Hole Location Map*
Offset:
Elevation:

Equipment_Type: *CME 850*
Drilling Method: *3.75" ID x 8" OD Hollow Auger*
Field Crew: *Wagster/Carman*

Total Depth: *21.0 feet*
Date: *3/10/2009 - 3/10/2009*
Geologist: *C. Boeckman*

Ground Water Data

Depth in (ft.)	10	
Time		
Date	3/10/09	
Symbol	▼	

Depth (Feet)	Sample Type	Number	Blow Count	Sample	Recovery	N-Value	USCS Classification	Frozen Zone	Soil Graphic	SUBSURFACE MATERIAL	
0							OL	■		**Vegetative Mat** (OL) Dark brown, Nbn	0.0
1							ML	■		**SILT** (ML) Gray, moist, stiff, Berm. Fill? Contains gravel and sand.	1.0
2	GRAB	FS3		▨	■		SM	■		**SILTY SAND with Gravel** (SM) Brown, wet, medium dense FS3 Combined with FS4	2.0
5	SPT	FS4	3 5 8 7	☒	■	13				FS4 PID = 0. Temp gun = 34 deg F, p200=32.4%, Sa=43%, Gr=25%, Moisture=20.9%, Org=5.8%, PI=NP, LL=39	
10 ▼	SPT	FS5	5 4 2 3	☒	■		ML			FS5 PID = 10 ppm, p200=15.2%, Sa=64%, Gr=21%, Moisture=22.0%, Org=2.6%, PI=NP, LL=NV **SILT with Sand** (ML) Gray, wet, firm, Some gravel	10.0
15	SPT	FS6	6 11	☒	■					FS6 p200=71.3%, Sa=23%, Gr=6%, Moisture=22.1%, PI=NP, LL=25	
16	SPT	FS7	13 13	☒	■		SP			**SAND with Silt** (SP) Gray, wet, medium dense, Some gravel FS7 p200=7%, Sa=93%, Gr=0%	15.5
19	SPT	FS8	3 10 10 11	☒	■	20	ML			**SILT with Sand** (ML) Gray, wet, very stiff FS8 p200=80.8%, Sa=19%, Gr=0%, Moisture=25.0%, Org=1.3%, PI=4, LL=21	19.0
21									BOH 21	Notes: Located on a berm adjacent to the property line fence.	21.0

☒ CME Auto Hammer ☐ Cathead Rope Method ☒ 140 lb. hammer with 30 in. drop ☐ 340 lb. hammer with 30 in. drop

LOG OF TEST HOLE

HOLE # TH09-11

STATE OF ALASKA DOT&PF
Central Region Materials
Geology Section

PROJECT NUMBER : *50898*
PROJECT : *West Dowling Road, Phase I*

Station / Location: *See Test Hole Location Map*
Offset:
Elevation:

Equipment_Type: *CME 850*
Drilling Method: *3.75" ID x 8" OD Hollow Auger*
Field Crew: *Wagster/Carman*

Total Depth: *14.5 feet*
Date: *3/11/2009 - 3/11/2009*
Geologist: *S Evans*

Ground Water Data

Depth in (ft.)	12.5	
Time		
Date	3/11/09	
Symbol	▼	

Depth (Feet)	Sample Type	Number	Blow Count	N-Value	USCS Classification	SUBSURFACE MATERIAL	
0					PT	**Peat** (PT) Dark brown, moist to wet, soft, Nbn, fibric/hemic	0.0
3 – 5	SPT VANE	FS9	3 1 2 2	3		FS9 Temp gun = 31 deg F Initial shear = 42 ft/lbs, Remoulded = 10 ft/lbs	
8 – 10	SPT	FS10	1 6 9 10	15	SM	**SILTY SAND** (SM) Gray, moist to wet, loose, Organic FS10 PID = 44 ppm	8.0
12					ML	**SILT** (ML) Brown Gray, wet, medium dense FS11 Temp gun = 40 deg F, p200=99.4%, Sa=1%, Moisture=25.5%, PI=NP, LL=29	12.0
12.5 – 14.5	SPT	FS11	4 7 11 9	18			
14.5					BOH 14.5	Notes: Located on a berm adjacent to the property line fence.	14.5

☒ CME Auto Hammer ☐ Cathead Rope Method ☒ 140 lb. hammer with 30 in. drop ☐ 340 lb. hammer with 30 in. drop

LOG OF TEST HOLE

HOLE # TH09-12

STATE OF ALASKA DOT&PF
Central Region Materials
Geology Section

PROJECT NUMBER : *50898*
PROJECT : *West Dowling Road, Phase I*

Station / Location: *See Test Hole Location Map*
Offset:
Elevation:

Equipment_Type: *CME 850*
Drilling Method: *3.75" ID x 8" OD Hollow Auger*
Field Crew: *Wagster/Carman*

Total Depth: *21.0 feet*
Date: *3/12/2009 - 3/12/2009*
Geologist: *S Evans*

Ground Water Data

Depth in (ft.)	10	
Time		
Date	3/12/09	
Symbol	▼	

Sample Data

Depth (Feet)	Sample Type	Number	Blow Count	Sample	Recovery	N-Value	USCS Classification	Frozen Zone
1	GRAB	FS12		▨	■		SP-SM	■
5	SPT	FS13	3 1 1 2	☒	■	2	PT	
10 ▼	SPT		0 0 0 1	☒	■	0		
13							OL	
15	SPT	FS14	0 1 4 5	☒	■		ML	
20	SPT		3 5 5 9	☒	■	10		

SUBSURFACE MATERIAL

SAND with Silt and Gravel (SP-SM) Gray, moist, Nbn FS12 p200=13.4%, Sa=49%, Gr=38%	0.0
Peat (PT) Dark brown, moist, very soft, Fibric. Contains wood fragments. Wet at 10 ft. FS13 Moisture=401.5%	4.0
ORGANIC SILT (OL)	13.0
SILT (ML) Gray, wet, firm FS14 p200=98%, Sa=2%, Moisture=24.7%, Org=1.8%, PI=5, LL=29	14.5
BOH 21	21.0

☒ CME Auto Hammer ☐ Cathead Rope Method ☒ 140 lb. hammer with 30 in. drop ☐ 340 lb. hammer with 30 in. drop

STATE OF ALASKA DOT&PF
Central Region Materials
Geology Section

LOG OF TEST HOLE

PROJECT NUMBER : 50898
PROJECT : West Dowling Road, Phase I

HOLE # TH09-13

Station / Location: See Test Hole Location Map
Offset:
Elevation:

Equipment_Type: CME 850
Drilling Method: 3.75" ID x 8" OD Hollow Auger
Field Crew: Wagster/Carman

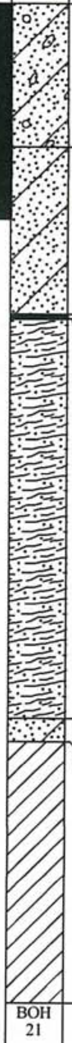
Total Depth: 21.0 feet
Date: 3/12/2009 - 3/12/2009
Geologist: S Evans

Ground Water Data

Depth in (ft.)	15	
Time		
Date	3/12/09	
Symbol	▼	

Sample Data

Depth (Feet)	Sample Type	Number	Blow Count	N-Value	USCS Classification
1	GRAB	FS15			SM
4	SPT	FS16	19 37 50	87	SM
7					PT
9.5	SPT		5 1 1 2	2	
11	VANE				
12.5	VANE				
14	SPT	FS17	0 1 1	2	
15.5					SM ML
20	SPT	FS18	4 5 7 10	12	



SUBSURFACE MATERIAL

0.0 **SILTY SAND with Gravel** (SM) Gray, Nbn FS15 p200=17.7%, Sa=59%, Gr=23%

3.0 **SILTY SAND** (SM) Gray, Organic (wood pieces in auger cuttings). Some gravel. Wet at 4 ft.
FS16 Temp gun = 31 Deg F., p200=39.7%, Sa=46%, Gr=14%, Moisture=15.4%, Org=1.2%

6.5 Fabric

6.6 **Peat** (PT) Dark brown, moist to wet, very soft

Initial = 120 ft/lbs. Remoulded = NA. Binding up.

Initial = 42 ft/lbs. Remoulded = 17 ft/lbs.
FS17 Moisture=255.9%

15.0 **SILTY SAND** (SM) Gray, wet, Some organic

15.5 **SILT** (ML) Gray, moist to wet, stiff

FS18 p200=99.0%, Sa=1%, Gr=0%, Moisture=28.6%, Org=1.5%, PI=NP, LL=29

21.0

☒ CME Auto Hammer ☐ Cathead Rope Method ☒ 140 lb. hammer with 30 in. drop ☐ 340 lb. hammer with 30 in. drop

Sheet Number 1 of 1

DOWL HKM

☒ 4041 B Street ■ Anchorage, Alaska 99503
907-562-2000 ■ 907-563-3953 (fax)
☐ 5368 Commercial Boulevard ■ Juneau, Alaska 99801
907-780-3533 ■ 907-780-3535 (fax)
☐ 1225 Tongass Avenue, Suite 4A ■ Ketchikan, AK 99901
907-220-0682
☐ 104 Center Avenue, Suite 206 ■ Kodiak, Alaska 99615
907-512-0519
☐ 809 S. Chugach Street, Unit 4 ■ Palmer, Alaska 99645
907-746-7600 ■ 907-746-6705 (fax)
☐ 406 North Church Avenue ■ Tucson, Arizona 85701
520-882-8696 ■ 520-624-0384 (fax)
☐ 430 W Warner Road, Suite B101 ■ Tempe, Arizona 85284
480-753-0800 ■ 480-753-0803 (fax)
☐ 222 N. 32nd Street, Suite 700 ■ Billings, Montana 59101
406-656-6399 ■ 406-656-6398 (fax)
☐ 130 North Main Street, Suite 100 ■ Butte, Montana 59701-2839
406-723-8213 ■ 406-723-8328 (fax)
☐ 2090 Stadium Drive ■ Bozeman, Montana 59715
406-586-8834 ■ 406-586-1730 (fax)
☐ 106 1st Avenue South, Suite A ■ Great Falls, Montana 59401
406-453-4085 ■ 406-453-4288 (fax)
☐ 104 East Broadway, Suite G-1 ■ Helena, Montana 59601
406-442-0370 ■ 406-442-0377 (fax)
☐ 713 Pleasant ■ Miles City, Montana 59301
406-234-6666 ■ 406-234-7065 (fax)
☐ 41 East Broadway ■ Dickinson, North Dakota 58601
701-300-7014 ■ 701-300-7015 (fax)
☐ 8420 154th Avenue NE ■ Redmond, Washington 98052
425-869-2670 ■ 425-869-2679 (fax)
☐ 1901 Energy Court, Suite 170 ■ Gillette, Wyoming 82718
307-686-4181 ■ 307-686-4858 (fax)
☐ 945 Lincoln Street ■ Lander, Wyoming 82520
307-332-3285 ■ 307-332-5795 (fax)
☐ 1575 N. 4th Street, Suite 105 ■ Laramie, Wyoming 82072
307-742-3816 ■ 307-742-9741 (fax)
☐ 16 W. 8th Street ■ Sheridan, Wyoming 82801
307-672-9006 ■ 307-672-5214 (fax)

MEMORANDUM

To:	Mike Gault, AK DOT/PF
From:	Osca Lage
Date:	06-17-13
Project No.:	1122.60047.11
Subject:	West Dowling Road Infiltration Test

In support to the rain garden for West Dowling Road, we conducted an infiltration test on 06-07-13. Prior to performing the test, we excavated a 6 foot deep test pit to collect information about the soils at the site. Based on the test pit, the soils consist of Silty Sand (SM) with 16% fines. Attached are the results of a particle size distribution test performed on a sample collected from the test pit.

The infiltration test was conducted on undisturbed soil at 2 foot of depth. The infiltration rate observed was 45 inches per hour.

Regards,
Oscar Lage

DOWL HKM

Client: ADOT & PF
Project: WDR Construction Support (Dowling)
Work Order: D60047

Particle Size Distribution

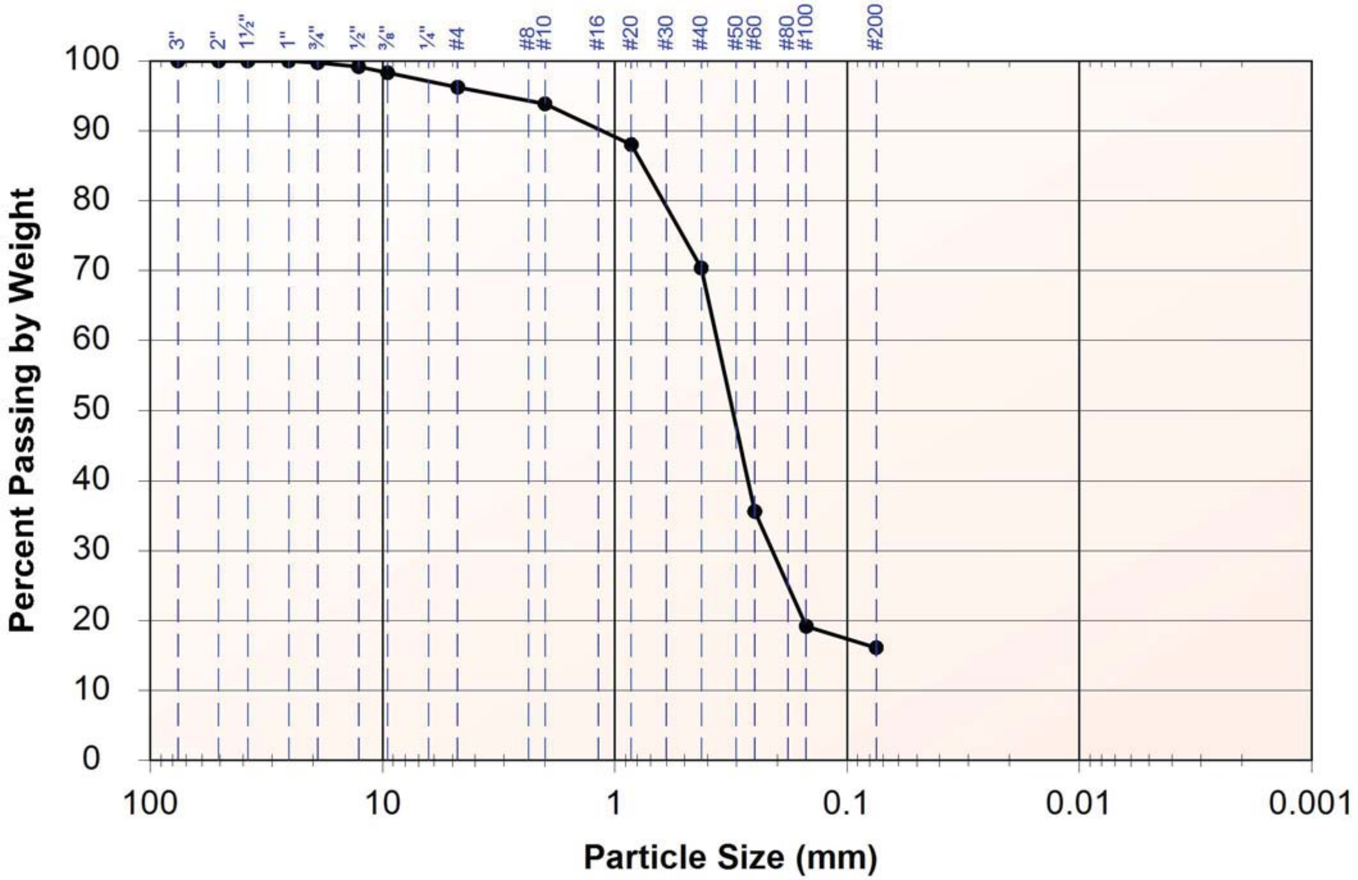
ASTM D422

Lab Number	2013-698
Received	6/7/2013
Reported	6/11/2013

Location: TP-1 0-6 Dowling

Engineering Classification: Silty Sand, SM

Frost Classification: Not Measured



Size	Passing	Specification
3"	100%	
2"	100%	
1½"	100%	
1"	100%	
¾"	100%	
½"	99%	
⅜"	98%	
#4	96%	
Total Weight of Sample 2790.6g		
#10	94%	
#20	88%	
#40	70%	
#60	36%	
#100	19%	
#200	16.1%	
Total Weight of Fine Fraction 389.7g		

Physical Soil Properties

This table shows estimates of some physical characteristics and features that affect soil behavior. These estimates are given for the layers of each soil in the survey area. The estimates are based on field observations and on test data for these and similar soils.

Depth to the upper and lower boundaries of each layer is indicated.

Particle size is the effective diameter of a soil particle as measured by sedimentation, sieving, or micrometric methods. Particle sizes are expressed as classes with specific effective diameter class limits. The broad classes are sand, silt, and clay, ranging from the larger to the smaller.

Sand as a soil separate consists of mineral soil particles that are 0.05 millimeter to 2 millimeters in diameter. In this table, the estimated sand content of each soil layer is given as a percentage, by weight, of the soil material that is less than 2 millimeters in diameter.

Silt as a soil separate consists of mineral soil particles that are 0.002 to 0.05 millimeter in diameter. In this table, the estimated silt content of each soil layer is given as a percentage, by weight, of the soil material that is less than 2 millimeters in diameter.

Clay as a soil separate consists of mineral soil particles that are less than 0.002 millimeter in diameter. In this table, the estimated clay content of each soil layer is given as a percentage, by weight, of the soil material that is less than 2 millimeters in diameter.

The content of sand, silt, and clay affects the physical behavior of a soil. Particle size is important for engineering and agronomic interpretations, for determination of soil hydrologic qualities, and for soil classification.

The amount and kind of clay affect the fertility and physical condition of the soil and the ability of the soil to adsorb cations and to retain moisture. They influence shrink-swell potential, saturated hydraulic conductivity (Ksat), plasticity, the ease of soil dispersion, and other soil properties. The amount and kind of clay in a soil also affect tillage and earthmoving operations.

Moist bulk density is the weight of soil (ovendry) per unit volume. Volume is measured when the soil is at field moisture capacity, that is, the moisture content at 1/3- or 1/10-bar (33kPa or 10kPa) moisture tension. Weight is determined after the soil is dried at 105 degrees C. In the table, the estimated moist bulk density of each soil horizon is expressed in grams per cubic centimeter of soil material that is less than 2 millimeters in diameter. Bulk density data are used to compute linear extensibility, shrink-swell potential, available water capacity, total pore space, and other soil properties. The moist bulk density of a soil indicates the pore space available for water and roots. Depending on soil texture, a bulk density of more than 1.4 can restrict water storage and root penetration. Moist bulk density is influenced by texture, kind of clay, content of organic matter, and soil structure.

Saturated hydraulic conductivity (Ksat) refers to the ease with which pores in a saturated soil transmit water. The estimates in the table are expressed in terms of micrometers per second. They are based on soil characteristics observed in the field, particularly structure, porosity, and texture. Saturated hydraulic conductivity (Ksat) is considered in the design of soil drainage systems and septic tank absorption fields.

Available water capacity refers to the quantity of water that the soil is capable of storing for use by plants. The capacity for water storage is given in inches of water per inch of soil for each soil layer. The capacity varies, depending on soil properties that affect retention of water. The most important properties are the content of organic matter, soil texture, bulk density, and soil structure. Available water capacity is an important factor in the choice of plants or crops to be grown and in the design and management of irrigation systems. Available water capacity is not an estimate of the quantity of water actually available to plants at any given time.

Linear extensibility refers to the change in length of an unconfined clod as moisture content is decreased from a moist to a dry state. It is an expression of the volume change between the water content of the clod at 1/3- or 1/10-bar tension (33kPa or 10kPa tension) and oven dryness. The volume change is reported in the table as percent change for the whole soil. The amount and type of clay minerals in the soil influence volume change.

Linear extensibility is used to determine the shrink-swell potential of soils. The shrink-swell potential is low if the soil has a linear extensibility of less than 3 percent; moderate if 3 to 6 percent; high if 6 to 9 percent; and very high if more than 9 percent. If the linear extensibility is more than 3, shrinking and swelling can cause damage to buildings, roads, and other structures and to plant roots. Special design commonly is needed.

Organic matter is the plant and animal residue in the soil at various stages of decomposition. In this table, the estimated content of organic matter is expressed as a percentage, by weight, of the soil material that is less than 2 millimeters in diameter. The content of organic matter in a soil can be maintained by returning crop residue to the soil.

Organic matter has a positive effect on available water capacity, water infiltration, soil organism activity, and tilth. It is a source of nitrogen and other nutrients for crops and soil organisms.

Erosion factors are shown in the table as the K factor (Kw and Kf) and the T factor. Erosion factor K indicates the susceptibility of a soil to sheet and rill erosion by water. Factor K is one of six factors used in the Universal Soil Loss Equation (USLE) and the Revised Universal Soil Loss Equation (RUSLE) to predict the average annual rate of soil loss by sheet and rill erosion in tons per acre per year. The estimates are based primarily on percentage of silt, sand, and organic matter and on soil structure and Ksat. Values of K range from 0.02 to 0.69. Other factors being equal, the higher the value, the more susceptible the soil is to sheet and rill erosion by water.

Erosion factor Kw indicates the erodibility of the whole soil. The estimates are modified by the presence of rock fragments.

Erosion factor Kf indicates the erodibility of the fine-earth fraction, or the material less than 2 millimeters in size.

Erosion factor T is an estimate of the maximum average annual rate of soil erosion by wind and/or water that can occur without affecting crop productivity over a sustained period. The rate is in tons per acre per year.

Wind erodibility groups are made up of soils that have similar properties affecting their susceptibility to wind erosion in cultivated areas. The soils assigned to group 1 are the most susceptible to wind erosion, and those assigned to group 8 are the least susceptible. The groups are described in the "National Soil Survey Handbook."

Wind erodibility index is a numerical value indicating the susceptibility of soil to wind erosion, or the tons per acre per year that can be expected to be lost to wind erosion. There is a close correlation between wind erosion and the texture of the surface layer, the size and durability of surface clods, rock fragments, organic matter, and a calcareous reaction. Soil moisture and frozen soil layers also influence wind erosion.

Reference:
United States Department of Agriculture, Natural Resources Conservation Service. National soil survey handbook, title 430-VI. (http://soils.usda.gov)

Report—Physical Soil Properties

Physical Soil Properties–Anchorage Area, Alaska

Map symbol and soil name	Depth	Sand	Silt	Clay	Moist bulk density	Saturated hydraulic conductivity	Available water capacity	Linear extensibility	Organic matter	Erosion factors			Wind erodibility group	Wind erodibility index
										Kw	Kf	T		
	In	*Pct*	*Pct*	*Pct*	*g/cc*	*micro m/sec*	*In/In*	*Pct*	*Pct*					
406—Cryorthents and Urban land, 0 to 5 percent slopes														
Cryorthents, skeletal	0-60	40-65- 90	10-30- 35	0- 5- 10	1.40-1.80	4.00-42.34	0.05-0.10	0.0-2.9	0.5-1.5	.10	.32	5	3	86
Urban land	—	—	—	—	—	—	—	—	—					
436—Matsu silt loam, 3 to 7 percent slopes														
Matsu	0-3	—	—	—	0.07-0.18	14.00-42.00	0.32-0.35	—	60.0-80.0			5	1	160
	3-6	20-32- 75	25-60- 70	5- 8- 15	0.65-0.90	4.00-14.00	0.31-0.37	0.0-2.9	2.0-8.0	.37	.37			
	6-11	20-30- 75	25-60- 70	5-10- 15	0.65-0.90	14.00-42.00	0.31-0.37	0.0-2.9	6.0-12.0	.37	.37			
	11-15	20-32- 75	25-50- 70	5-18- 22	0.90-1.30	14.00-42.00	0.15-0.22	0.0-2.9	5.0-20.0	.37	.37			
	15-31	10-20- 75	25-62- 80	5-18- 22	0.90-1.30	4.00-14.00	0.13-0.22	0.0-2.9	1.0-2.0	.37	.37			
	31-60	10-20- 75	25-62- 80	5-18- 22	0.90-1.30	4.00-14.00	0.13-0.22	0.0-2.9	0.5-2.0	.32	.37			

Physical Soil Properties–Anchorage Area, Alaska														
Map symbol and soil name	**Depth**	**Sand**	**Silt**	**Clay**	**Moist bulk density**	**Saturated hydraulic conductivity**	**Available water capacity**	**Linear extensibility**	**Organic matter**	**Erosion factors**			**Wind erodibility group**	**Wind erodibility index**
										Kw	**Kf**	**T**		
	In	*Pct*	*Pct*	*Pct*	*g/cc*	*micro m/sec*	*In/In*	*Pct*	*Pct*					
438—Moose River-Niklason complex, occasionally flooded, 0 to 3 percent slopes														
Moose river	0-5	—	—	—	0.07-0.18	14.00-42.00	0.32-0.35	—	60.0-80.0			3	8	0
	5-10	10-20- 75	25-75- 90	0- 5- 10	0.85-0.95	4.00-14.00	0.15-0.22	0.0-2.9	4.0-8.0	.37	.37			
	10-50	10-90- 95	5- 5- 90	0- 5- 10	0.85-1.00	4.00-14.00	0.15-0.22	0.0-2.9	1.0-5.0	.37	.37			
	50-60	80-90-100	0- 8- 15	0- 3- 5	1.40-1.50	14.00-141.00	0.04-0.07	0.0-2.9	1.0-5.0	.15	.32			
Niklason	0-1	—	—	—	0.07-0.18	14.00-42.00	0.32-0.35	—	60.0-80.0			2	2	134
	1-4	20-45- 50	40-50- 70	0- 5- 10	0.80-1.00	4.00-14.00	0.19-0.25	0.0-2.9	10.0-20.0	.32	.37			
	4-28	25-55- 80	20-40- 65	0- 5- 10	0.80-1.00	4.00-14.00	0.19-0.25	0.0-2.9	3.0-9.0	.32	.37			
	28-60	80-90-100	0- 8- 15	0- 2- 5	1.50-1.60	42.00-141.00	0.02-0.04	0.0-2.9	0.5-2.0	.02	.05			

Data Source Information

Soil Survey Area: Anchorage Area, Alaska
Survey Area Data: Version 8, Mar 27, 2007

Appendix D: West Dowling SWMM Modeling Output

Case 1: No LID - Event 1a, 90th Percentile Evenly Distributed

```
EPA STORM WATER MANAGEMENT MODEL - VERSION 5.0 (Build 5.0.022)
--------------------------------------------------------------


*********************************************************
NOTE: The summary statistics displayed in this report are
based on results found at every computational time step,
not just on results from each reporting time step.
*********************************************************

****************
Analysis Options
****************
Flow Units ............... CFS
Process Models:
  Rainfall/Runoff ........ YES
  Snowmelt ............... NO
  Groundwater ............ NO
  Flow Routing ........... YES
  Ponding Allowed ........ NO
  Water Quality .......... NO
Infiltration Method ...... HORTON
Flow Routing Method ...... KINWAVE
Starting Date ............ JUL-10-2013 00:00:00
Ending Date .............. JUL-11-2013 00:00:00
Antecedent Dry Days ...... 0.0
Report Time Step ......... 00:15:00
Wet Time Step ............ 00:05:00
Dry Time Step ............ 01:00:00
Routing Time Step ........ 30.00 sec


**************************        Volume         Depth
Runoff Quantity Continuity     acre-feet        inches
**************************     ---------       -------
Total Precipitation ......         0.753         0.520
Evaporation Loss .........         0.000         0.000
Infiltration Loss ........         0.276         0.190
Surface Runoff ...........         0.413         0.285
Final Surface Storage ....         0.066         0.045
Continuity Error (%) .....        -0.095


**************************        Volume        Volume
Flow Routing Continuity        acre-feet      10^6 gal
**************************     ---------     ---------
Dry Weather Inflow .......         0.000         0.000
Wet Weather Inflow .......         0.411         0.134
Groundwater Inflow .......         0.000         0.000
RDII Inflow ..............         0.000         0.000
External Inflow ..........         0.000         0.000
External Outflow .........         0.410         0.133
Internal Outflow .........         0.000         0.000
Storage Losses ...........         0.000         0.000
Initial Stored Volume ....         0.000         0.000
Final Stored Volume ......         0.001         0.000
Continuity Error (%) .....         0.000


********************************
Highest Flow Instability Indexes
********************************
All links are stable.


*************************
Routing Time Step Summary
*************************
Minimum Time Step           :    30.00 sec
Average Time Step           :    30.00 sec
```

```
Maximum Time Step           :    30.00 sec
Percent in Steady State     :     0.00
Average Iterations per Step :     1.00


***************************
Subcatchment Runoff Summary
***************************

---------------------------------------------------------------------------------------------------------
                          Total      Total      Total      Total      Total       Total     Peak  Runoff
                         Precip      Runon       Evap      Infil     Runoff      Runoff   Runoff   Coeff
Subcatchment                 in         in         in         in         in    10^6 gal      CFS
---------------------------------------------------------------------------------------------------------
Basin4                     0.52       0.00       0.00       0.19       0.28        0.13     0.24   0.548


******************
Node Depth Summary
******************

---------------------------------------------------------------------
                                 Average  Maximum  Maximum  Time of Max
                                   Depth    Depth      HGL   Occurrence
Node                 Type           Feet     Feet     Feet  days hr:min
---------------------------------------------------------------------
2                    JUNCTION       0.14     0.15     4.15     1  00:00
CampbellCreek        OUTFALL        0.14     0.15     0.15     1  00:00


*******************
Node Inflow Summary
*******************

-------------------------------------------------------------------------------------
                                  Maximum  Maximum                  Lateral       Total
                                  Lateral    Total  Time of Max      Inflow      Inflow
                                   Inflow   Inflow   Occurrence      Volume      Volume
Node                 Type             CFS      CFS  days hr:min    10^6 gal    10^6 gal
-------------------------------------------------------------------------------------
2                    JUNCTION        0.24     0.24     1  00:00       0.134       0.134
CampbellCreek        OUTFALL         0.00     0.24     1  00:00       0.000       0.133


**********************
Node Surcharge Summary
**********************

No nodes were surcharged.


*********************
Node Flooding Summary
*********************

No nodes were flooded.


***********************
Outfall Loading Summary
***********************

-----------------------------------------------------------
                      Flow       Avg.       Max.       Total
                      Freq.      Flow       Flow      Volume
Outfall Node          Pcnt.       CFS        CFS    10^6 gal
-----------------------------------------------------------
CampbellCreek         98.47      0.21       0.24       0.133
-----------------------------------------------------------
System                98.47      0.21       0.24       0.133
```

```
********************
Link Flow Summary
********************

-----------------------------------------------------------------------------
                               Maximum  Time of Max   Maximum    Max/    Max/
                                |Flow|   Occurrence   |Veloc|    Full    Full
Link                 Type          CFS  days hr:min    ft/sec    Flow   Depth
-----------------------------------------------------------------------------
2                    CONDUIT      0.24     1  00:00      2.22    0.01    0.08


*************************
Conduit Surcharge Summary
*************************

No conduits were surcharged.


Analysis begun on:  Fri Oct 25 17:20:58 2013
Analysis ended on:  Fri Oct 25 17:20:58 2013
Total elapsed time: < 1 sec
```

Case 2: With LID Bioswale - Event 1a, 90th Percentile Evenly Distributed

```
EPA STORM WATER MANAGEMENT MODEL - VERSION 5.0 (Build 5.0.022)
--------------------------------------------------------------


*********************************************************
NOTE: The summary statistics displayed in this report are
based on results found at every computational time step,
not just on results from each reporting time step.
*********************************************************

****************
Analysis Options
****************
Flow Units ............... CFS
Process Models:
  Rainfall/Runoff ........ YES
  Snowmelt ............... NO
  Groundwater ............ NO
  Flow Routing ........... YES
  Ponding Allowed ........ NO
  Water Quality .......... NO
Infiltration Method ...... HORTON
Flow Routing Method ...... DYNWAVE
Starting Date ............ JUL-10-2013 00:00:00
Ending Date .............. JUL-11-2013 00:00:00
Antecedent Dry Days ...... 0.0
Report Time Step ......... 00:00:30
Wet Time Step ............ 00:01:00
Dry Time Step ............ 01:00:00
Routing Time Step ........ 1.00 sec


**************************        Volume         Depth
Runoff Quantity Continuity     acre-feet        inches
**************************     ---------       -------
Total Precipitation ......         0.751         0.518
Evaporation Loss .........         0.000         0.000
Infiltration Loss ........         0.630         0.434
Surface Runoff ...........        -0.000        -0.000
Final Surface Storage ....         0.122         0.084
Continuity Error (%) .....        -0.022


**************************        Volume        Volume
Flow Routing Continuity        acre-feet      10^6 gal
**************************     ---------     ---------
Dry Weather Inflow .......         0.000         0.000
Wet Weather Inflow .......        -0.000        -0.000
Groundwater Inflow .......         0.000         0.000
RDII Inflow ..............         0.000         0.000
External Inflow ..........         0.000         0.000
External Outflow .........         0.000         0.000
Internal Outflow .........         0.000         0.000
Storage Losses ...........         0.000         0.000
Initial Stored Volume ....         0.000         0.000
Final Stored Volume ......         0.000         0.000
Continuity Error (%) .....         0.000


***************************
Time-Step Critical Elements
***************************
None


********************************
Highest Flow Instability Indexes
********************************
All links are stable.


*************************
Routing Time Step Summary
*************************
Minimum Time Step           :     1.00 sec
Average Time Step           :     1.00 sec
Maximum Time Step           :     1.00 sec
Percent in Steady State     :     0.00
Average Iterations per Step :     2.00
```

```
***************************
Subcatchment Runoff Summary
***************************

--------------------------------------------------------------------------------------------------------
                          Total      Total      Total      Total      Total       Total     Peak  Runoff
                         Precip      Runon       Evap      Infil     Runoff      Runoff   Runoff   Coeff
Subcatchment                 in         in         in         in         in    10^6 gal      CFS
--------------------------------------------------------------------------------------------------------
Basin4                     0.52       0.00       0.00       0.43      -0.00       -0.00     0.00  -0.000


***********************
LID Performance Summary
***********************

------------------------------------------------------------------------------------------------------------------
                                       Total      Evap     Infil   Surface     Drain     Init.     Final     Pcnt.
                                      Inflow      Loss      Loss   Outflow   Outflow   Storage   Storage     Error
Subcatchment      LID Control             in        in        in        in        in        in        in
------------------------------------------------------------------------------------------------------------------
Basin4            Swale                76.98      0.00     66.39      0.00      0.00      0.00     10.59      0.00

******************
Node Depth Summary
******************

---------------------------------------------------------------------
                                 Average  Maximum  Maximum  Time of Max
                                   Depth    Depth      HGL   Occurrence
Node                 Type           Feet     Feet     Feet  days hr:min
---------------------------------------------------------------------
BasinOutlet          JUNCTION       0.00     0.00     4.00     0  14:25
CampbellCreek        OUTFALL        0.00     0.00     0.00     0  00:00


*******************
Node Inflow Summary
*******************

-------------------------------------------------------------------------------------
                                Maximum  Maximum                  Lateral       Total
                                Lateral    Total  Time of Max      Inflow      Inflow
                                 Inflow   Inflow   Occurrence      Volume      Volume
Node                 Type           CFS      CFS  days hr:min    10^6 gal    10^6 gal
-------------------------------------------------------------------------------------
BasinOutlet          JUNCTION      0.00     0.00     0  11:21      -0.000      -0.000
CampbellCreek        OUTFALL       0.00     0.00     0  00:00       0.000       0.000


**********************
Node Surcharge Summary
**********************

No nodes were surcharged.


*********************
Node Flooding Summary
*********************

No nodes were flooded.


***********************
Outfall Loading Summary
***********************

-----------------------------------------------------------
                       Flow       Avg.       Max.       Total
                      Freq.       Flow       Flow      Volume
Outfall Node          Pcnt.        CFS        CFS    10^6 gal
-----------------------------------------------------------
CampbellCreek          0.00       0.00       0.00       0.000
-----------------------------------------------------------
System                 0.00       0.00       0.00       0.000


********************
Link Flow Summary
********************
```

```
  -----------------------------------------------------------------------------
                              Maximum  Time of Max   Maximum    Max/    Max/
                               |Flow|   Occurrence   |Veloc|    Full    Full
  Link                 Type       CFS  days hr:min    ft/sec    Flow   Depth
  -----------------------------------------------------------------------------
  2                    CONDUIT      0.00     0  00:00      0.00    0.00    0.00


  ***************************
  Flow Classification Summary
  ***************************

  -----------------------------------------------------------------------------------------
                      Adjusted    --- Fraction of Time in Flow Class ----   Avg.     Avg.
                       /Actual         Up    Down  Sub   Sup   Up    Down   Froude   Flow
  Conduit               Length    Dry  Dry   Dry   Crit  Crit  Crit  Crit   Number   Change
  -----------------------------------------------------------------------------------------
  2                       1.00   1.00  0.00  0.00  0.00  0.00  0.00  0.00     0.00   0.0000


  *************************
  Conduit Surcharge Summary
  *************************

  No conduits were surcharged.


  Analysis begun on:  Fri Oct 25 17:19:03 2013
  Analysis ended on:  Fri Oct 25 17:19:03 2013
  Total elapsed time: < 1 sec
```

Case 1: No LID - Event 1b, 90th Percentile distributed as seen on 7-21-12

```
EPA STORM WATER MANAGEMENT MODEL - VERSION 5.0 (Build 5.0.022)
--------------------------------------------------------------


*********************************************************
NOTE: The summary statistics displayed in this report are
based on results found at every computational time step,
not just on results from each reporting time step.
*********************************************************

****************
Analysis Options
****************
Flow Units ............... CFS
Process Models:
  Rainfall/Runoff ........ YES
  Snowmelt ............... NO
  Groundwater ............ NO
  Flow Routing ........... YES
  Ponding Allowed ........ NO
  Water Quality .......... NO
Infiltration Method ...... HORTON
Flow Routing Method ...... KINWAVE
Starting Date ............ JUL-10-2013 00:00:00
Ending Date .............. JUL-11-2013 00:00:00
Antecedent Dry Days ...... 0.0
Report Time Step ......... 00:00:30
Wet Time Step ............ 00:01:00
Dry Time Step ............ 01:00:00
Routing Time Step ........ 1.00 sec


**************************        Volume         Depth
Runoff Quantity Continuity     acre-feet        inches
**************************     ---------       -------
Total Precipitation ......         0.756         0.521
Evaporation Loss .........         0.000         0.000
Infiltration Loss ........         0.277         0.191
Surface Runoff ...........         0.423         0.291
Final Surface Storage ....         0.057         0.039
Continuity Error (%) .....        -0.011


**************************        Volume        Volume
Flow Routing Continuity        acre-feet      10^6 gal
**************************     ---------     ---------
Dry Weather Inflow .......         0.000         0.000
Wet Weather Inflow .......         0.422         0.138
Groundwater Inflow .......         0.000         0.000
RDII Inflow ..............         0.000         0.000
External Inflow ..........         0.000         0.000
External Outflow .........         0.422         0.137
Internal Outflow .........         0.000         0.000
Storage Losses ...........         0.000         0.000
Initial Stored Volume ....         0.000         0.000
Final Stored Volume ......         0.001         0.000
Continuity Error (%) .....         0.000


********************************
Highest Flow Instability Indexes
********************************
All links are stable.


*************************
Routing Time Step Summary
*************************
Minimum Time Step           :     1.00 sec
Average Time Step           :     1.00 sec
Maximum Time Step           :     1.00 sec
Percent in Steady State     :     0.00
Average Iterations per Step :     1.00


***************************
Subcatchment Runoff Summary
***************************

---------------------------------------------------------------------------------------------------------
                          Total      Total      Total      Total      Total        Total     Peak  Runoff
```

```
                         Precip      Runon       Evap      Infil     Runoff      Runoff   Runoff   Coeff
Subcatchment                 in         in         in         in         in    10^6 gal      CFS
--------------------------------------------------------------------------------------------------------
Basin4                     0.52       0.00       0.00       0.19       0.29        0.14     0.96    0.559


******************
Node Depth Summary
******************

---------------------------------------------------------------------
                               Average  Maximum  Maximum  Time of Max
                                 Depth    Depth      HGL   Occurrence
Node                 Type         Feet     Feet     Feet  days hr:min
---------------------------------------------------------------------
2                    JUNCTION     0.12     0.29     4.29     0  12:53
CampbellCreek        OUTFALL      0.12     0.29     0.29     0  12:53


*******************
Node Inflow Summary
*******************

-------------------------------------------------------------------------------------
                                Maximum  Maximum                  Lateral       Total
                                Lateral    Total  Time of Max      Inflow      Inflow
                                 Inflow   Inflow   Occurrence      Volume      Volume
Node                 Type           CFS      CFS  days hr:min    10^6 gal    10^6 gal
-------------------------------------------------------------------------------------
2                    JUNCTION      0.96     0.96     0  12:53       0.138       0.138
CampbellCreek        OUTFALL       0.00     0.96     0  12:53       0.000       0.137


**********************
Node Surcharge Summary
**********************

No nodes were surcharged.


*********************
Node Flooding Summary
*********************

No nodes were flooded.


***********************
Outfall Loading Summary
***********************

-----------------------------------------------------------
                      Flow       Avg.      Max.       Total
                      Freq.      Flow      Flow      Volume
Outfall Node          Pcnt.       CFS       CFS    10^6 gal
-----------------------------------------------------------
CampbellCreek         82.61      0.26      0.96       0.137
-----------------------------------------------------------
System                82.61      0.26      0.96       0.137


********************
Link Flow Summary
********************

-----------------------------------------------------------------------------
                               Maximum  Time of Max   Maximum    Max/    Max/
                                |Flow|   Occurrence   |Veloc|    Full    Full
Link                 Type          CFS  days hr:min    ft/sec    Flow   Depth
-----------------------------------------------------------------------------
2                    CONDUIT      0.96     0  12:53      3.41    0.05    0.15


*************************
Conduit Surcharge Summary
*************************

No conduits were surcharged.


Analysis begun on:  Tue Dec 17 20:18:18 2013
Analysis ended on:  Tue Dec 17 20:18:18 2013
```

```
  Total elapsed time: < 1 sec
```

Case 2: With LID Bioswale - Event 1b, 90th Percentile distributed as seen on 7-21-12

```
EPA STORM WATER MANAGEMENT MODEL - VERSION 5.0 (Build 5.0.022)
--------------------------------------------------------------


*********************************************************
NOTE: The summary statistics displayed in this report are
based on results found at every computational time step,
not just on results from each reporting time step.
*********************************************************

****************
Analysis Options
****************
Flow Units ............... CFS
Process Models:
  Rainfall/Runoff ........ YES
  Snowmelt ............... NO
  Groundwater ............ NO
  Flow Routing ........... YES
  Ponding Allowed ........ NO
  Water Quality .......... NO
Infiltration Method ...... HORTON
Flow Routing Method ...... DYNWAVE
Starting Date ............ JUL-10-2013 00:00:00
Ending Date .............. JUL-11-2013 00:00:00
Antecedent Dry Days ...... 0.0
Report Time Step ......... 00:00:30
Wet Time Step ............ 00:00:30
Dry Time Step ............ 00:00:30
Routing Time Step ........ 1.00 sec


**************************        Volume         Depth
Runoff Quantity Continuity     acre-feet        inches
**************************     ---------       -------
Total Precipitation ......         0.756         0.521
Evaporation Loss .........         0.000         0.000
Infiltration Loss ........         0.553         0.381
Surface Runoff ...........         0.106         0.073
Final Surface Storage ....         0.098         0.067
Continuity Error (%) .....        -0.034


**************************        Volume        Volume
Flow Routing Continuity        acre-feet      10^6 gal
**************************     ---------     ---------
Dry Weather Inflow .......         0.000         0.000
Wet Weather Inflow .......         0.106         0.034
Groundwater Inflow .......         0.000         0.000
RDII Inflow ..............         0.000         0.000
External Inflow ..........         0.000         0.000
External Outflow .........         0.107         0.035
Internal Outflow .........         0.000         0.000
Storage Losses ...........         0.000         0.000
Initial Stored Volume ....         0.000         0.000
Final Stored Volume ......         0.000         0.000
Continuity Error (%) .....        -0.623


***************************
Time-Step Critical Elements
***************************
None


********************************
Highest Flow Instability Indexes
********************************
All links are stable.


*************************
Routing Time Step Summary
*************************
Minimum Time Step           :     1.00 sec
Average Time Step           :     1.00 sec
Maximum Time Step           :     1.00 sec
Percent in Steady State     :     0.00
Average Iterations per Step :     2.00
```

```
***************************
Subcatchment Runoff Summary
***************************

--------------------------------------------------------------------------------------------------------
                           Total      Total      Total      Total      Total       Total     Peak  Runoff
                          Precip      Runon       Evap      Infil     Runoff      Runoff   Runoff   Coeff
Subcatchment                  in         in         in         in         in    10^6 gal      CFS
--------------------------------------------------------------------------------------------------------
Basin4                      0.52       0.00       0.00       0.38       0.07        0.03     0.64   0.140


***********************
LID Performance Summary
***********************

------------------------------------------------------------------------------------------------------------------
                                       Total      Evap     Infil   Surface     Drain     Init.     Final     Pcnt.
                                      Inflow      Loss      Loss   Outflow   Outflow   Storage   Storage     Error
Subcatchment      LID Control             in        in        in        in        in        in        in
------------------------------------------------------------------------------------------------------------------
Basin4            Swale                79.11      0.00     51.73     19.76      0.00      0.00      7.66     -0.05

******************
Node Depth Summary
******************

---------------------------------------------------------------------
                               Average  Maximum  Maximum  Time of Max
                                 Depth    Depth      HGL   Occurrence
Node                 Type         Feet     Feet     Feet  days hr:min
---------------------------------------------------------------------
BasinOutlet          JUNCTION     0.00     0.02     4.02     0  12:52
CampbellCreek        OUTFALL      0.00     0.02     0.02     0  12:52


*******************
Node Inflow Summary
*******************

-------------------------------------------------------------------------------------
                                Maximum  Maximum                  Lateral       Total
                                Lateral    Total  Time of Max      Inflow      Inflow
                                 Inflow   Inflow   Occurrence      Volume      Volume
Node                 Type           CFS      CFS  days hr:min    10^6 gal    10^6 gal
-------------------------------------------------------------------------------------
BasinOutlet          JUNCTION      0.64     0.64     0  12:52       0.034       0.034
CampbellCreek        OUTFALL       0.00     0.64     0  12:52       0.000       0.035


**********************
Node Surcharge Summary
**********************

No nodes were surcharged.


*********************
Node Flooding Summary
*********************

No nodes were flooded.


***********************
Outfall Loading Summary
***********************

-----------------------------------------------------------
                      Flow       Avg.      Max.       Total
                      Freq.      Flow      Flow      Volume
Outfall Node          Pcnt.       CFS       CFS    10^6 gal
-----------------------------------------------------------
CampbellCreek         21.65      0.25      0.64       0.035
-----------------------------------------------------------
System                21.65      0.25      0.64       0.035


********************
Link Flow Summary
********************
```

```
-----------------------------------------------------------------------------
                               Maximum  Time of Max   Maximum    Max/    Max/
                                |Flow|   Occurrence   |Veloc|    Full    Full
Link                 Type          CFS  days hr:min    ft/sec    Flow   Depth
-----------------------------------------------------------------------------
2                    CONDUIT      0.64     0  12:52      3.96    0.00    0.00


***************************
Flow Classification Summary
***************************

-----------------------------------------------------------------------------------------
                    Adjusted    --- Fraction of Time in Flow Class ----   Avg.     Avg.
                     /Actual         Up    Down  Sub   Sup   Up    Down   Froude   Flow
Conduit               Length    Dry  Dry   Dry   Crit  Crit  Crit  Crit   Number   Change
-----------------------------------------------------------------------------------------
2                       1.00   0.78  0.00  0.00  0.00  0.21  0.00  0.00     0.94   0.0000


*************************
Conduit Surcharge Summary
*************************

No conduits were surcharged.


Analysis begun on:  Tue Dec 17 19:33:30 2013
Analysis ended on:  Tue Dec 17 19:33:30 2013
Total elapsed time: < 1 sec
```

Case 1: No LID - Event 2, 8-1-12

```
EPA STORM WATER MANAGEMENT MODEL - VERSION 5.0 (Build 5.0.022)
--------------------------------------------------------------


*********************************************************
NOTE: The summary statistics displayed in this report are
based on results found at every computational time step,
not just on results from each reporting time step.
*********************************************************

****************
Analysis Options
****************
Flow Units ............... CFS
Process Models:
  Rainfall/Runoff ........ YES
  Snowmelt ............... NO
  Groundwater ............ NO
  Flow Routing ........... YES
  Ponding Allowed ........ NO
  Water Quality .......... NO
Infiltration Method ...... HORTON
Flow Routing Method ...... KINWAVE
Starting Date ............ JUL-10-2013 00:00:00
Ending Date .............. JUL-11-2013 00:00:00
Antecedent Dry Days ...... 0.0
Report Time Step ......... 00:00:30
Wet Time Step ............ 00:01:00
Dry Time Step ............ 01:00:00
Routing Time Step ........ 1.00 sec


**************************        Volume         Depth
Runoff Quantity Continuity     acre-feet        inches
**************************     ---------       -------
Total Precipitation ......         0.276         0.190
Evaporation Loss .........         0.000         0.000
Infiltration Loss ........         0.101         0.070
Surface Runoff ...........         0.128         0.088
Final Surface Storage ....         0.047         0.032
Continuity Error (%) .....         0.000


**************************        Volume        Volume
Flow Routing Continuity        acre-feet      10^6 gal
**************************     ---------     ---------
Dry Weather Inflow .......         0.000         0.000
Wet Weather Inflow .......         0.128         0.042
Groundwater Inflow .......         0.000         0.000
RDII Inflow ..............         0.000         0.000
External Inflow ..........         0.000         0.000
External Outflow .........         0.128         0.042
Internal Outflow .........         0.000         0.000
Storage Losses ...........         0.000         0.000
Initial Stored Volume ....         0.000         0.000
Final Stored Volume ......         0.000         0.000
Continuity Error (%) .....         0.000


********************************
Highest Flow Instability Indexes
********************************
All links are stable.


*************************
Routing Time Step Summary
*************************
Minimum Time Step           :     1.00 sec
Average Time Step           :     1.00 sec
Maximum Time Step           :     1.00 sec
Percent in Steady State     :     0.00
Average Iterations per Step :     1.00


***************************
Subcatchment Runoff Summary
***************************

----------------------------------------------------------------------------------------------------------
                          Total      Total      Total      Total      Total        Total     Peak  Runoff
```

```
                         Precip      Runon       Evap      Infil     Runoff      Runoff   Runoff   Coeff
Subcatchment                 in         in         in         in         in    10^6 gal      CFS
--------------------------------------------------------------------------------------------------------
Basin4                     0.19       0.00       0.00       0.07       0.09        0.04     0.29   0.464


******************
Node Depth Summary
******************

---------------------------------------------------------------------
                               Average  Maximum  Maximum  Time of Max
                                 Depth    Depth      HGL   Occurrence
Node                 Type         Feet     Feet     Feet  days hr:min
---------------------------------------------------------------------
2                    JUNCTION     0.07     0.17     4.17     0  19:53
CampbellCreek        OUTFALL      0.07     0.17     0.17     0  19:55


*******************
Node Inflow Summary
*******************

-------------------------------------------------------------------------------------
                                Maximum  Maximum                  Lateral       Total
                                Lateral    Total  Time of Max      Inflow      Inflow
                                 Inflow   Inflow   Occurrence      Volume      Volume
Node                 Type           CFS      CFS  days hr:min    10^6 gal    10^6 gal
-------------------------------------------------------------------------------------
2                    JUNCTION      0.29     0.29     0  19:53       0.042       0.042
CampbellCreek        OUTFALL       0.00     0.29     0  19:55       0.000       0.042


**********************
Node Surcharge Summary
**********************

No nodes were surcharged.


*********************
Node Flooding Summary
*********************

No nodes were flooded.


***********************
Outfall Loading Summary
***********************

-----------------------------------------------------------
                      Flow       Avg.      Max.       Total
                      Freq.      Flow      Flow      Volume
Outfall Node          Pcnt.       CFS       CFS    10^6 gal
-----------------------------------------------------------
CampbellCreek         82.00      0.08      0.29       0.042
-----------------------------------------------------------
System                82.00      0.08      0.29       0.042


********************
Link Flow Summary
********************

-----------------------------------------------------------------------------
                               Maximum  Time of Max   Maximum     Max/    Max/
                                |Flow|   Occurrence   |Veloc|     Full    Full
Link                 Type          CFS  days hr:min    ft/sec     Flow   Depth
-----------------------------------------------------------------------------
2                    CONDUIT      0.29     0  19:55      2.36     0.01    0.08


*************************
Conduit Surcharge Summary
*************************

No conduits were surcharged.


Analysis begun on:  Tue Dec 17 20:19:06 2013
Analysis ended on:  Tue Dec 17 20:19:06 2013
```

```
  Total elapsed time: < 1 sec
```

Case 2: With LID Bioswale - Event 2, 8-1-12

```
EPA STORM WATER MANAGEMENT MODEL - VERSION 5.0 (Build 5.0.022)
--------------------------------------------------------------


*********************************************************
NOTE: The summary statistics displayed in this report are
based on results found at every computational time step,
not just on results from each reporting time step.
*********************************************************

****************
Analysis Options
****************
Flow Units ............... CFS
Process Models:
  Rainfall/Runoff ........ YES
  Snowmelt ............... NO
  Groundwater ............ NO
  Flow Routing ........... YES
  Ponding Allowed ........ NO
  Water Quality .......... NO
Infiltration Method ...... HORTON
Flow Routing Method ...... DYNWAVE
Starting Date ............ JUL-10-2013 00:00:00
Ending Date .............. JUL-11-2013 00:00:00
Antecedent Dry Days ...... 0.0
Report Time Step ......... 00:00:30
Wet Time Step ............ 00:00:30
Dry Time Step ............ 00:00:30
Routing Time Step ........ 1.00 sec


**************************        Volume         Depth
Runoff Quantity Continuity     acre-feet        inches
**************************     ---------       -------
Total Precipitation ......         0.276         0.190
Evaporation Loss .........         0.000         0.000
Infiltration Loss ........         0.209         0.144
Surface Runoff ...........        -0.000        -0.000
Final Surface Storage ....         0.066         0.046
Continuity Error (%) .....        -0.030


**************************        Volume        Volume
Flow Routing Continuity        acre-feet      10^6 gal
**************************     ---------     ---------
Dry Weather Inflow .......         0.000         0.000
Wet Weather Inflow .......        -0.000        -0.000
Groundwater Inflow .......         0.000         0.000
RDII Inflow ..............         0.000         0.000
External Inflow ..........         0.000         0.000
External Outflow .........         0.000         0.000
Internal Outflow .........         0.000         0.000
Storage Losses ...........         0.000         0.000
Initial Stored Volume ....         0.000         0.000
Final Stored Volume ......         0.000         0.000
Continuity Error (%) .....         0.000


***************************
Time-Step Critical Elements
***************************
None


********************************
Highest Flow Instability Indexes
********************************
All links are stable.


*************************
Routing Time Step Summary
*************************
Minimum Time Step           :     1.00 sec
Average Time Step           :     1.00 sec
Maximum Time Step           :     1.00 sec
Percent in Steady State     :     0.00
Average Iterations per Step :     2.00
```

```
***************************
Subcatchment Runoff Summary
***************************

--------------------------------------------------------------------------------------------------------
                          Total      Total      Total      Total      Total       Total     Peak  Runoff
                         Precip      Runon       Evap      Infil     Runoff      Runoff   Runoff   Coeff
Subcatchment                 in         in         in         in         in    10^6 gal      CFS
--------------------------------------------------------------------------------------------------------
Basin4                     0.19       0.00       0.00       0.14      -0.00       -0.00     0.00  -0.000


***********************
LID Performance Summary
***********************

------------------------------------------------------------------------------------------------------------------
                                       Total      Evap     Infil   Surface     Drain     Init.     Final     Pcnt.
                                      Inflow      Loss      Loss   Outflow   Outflow   Storage   Storage     Error
Subcatchment      LID Control             in        in        in        in        in        in        in
------------------------------------------------------------------------------------------------------------------
Basin4            Swale                23.99      0.00     20.34      0.00      0.00      0.00      3.66     -0.06

******************
Node Depth Summary
******************

---------------------------------------------------------------------
                               Average  Maximum  Maximum  Time of Max
                                 Depth    Depth      HGL   Occurrence
Node                 Type         Feet     Feet     Feet  days hr:min
---------------------------------------------------------------------
BasinOutlet          JUNCTION     0.00     0.00     4.00     0  20:09
CampbellCreek        OUTFALL      0.00     0.00     0.00     0  00:00


*******************
Node Inflow Summary
*******************

-------------------------------------------------------------------------------------
                                Maximum  Maximum                  Lateral       Total
                                Lateral    Total  Time of Max      Inflow      Inflow
                                 Inflow   Inflow   Occurrence      Volume      Volume
Node                 Type           CFS      CFS  days hr:min    10^6 gal    10^6 gal
-------------------------------------------------------------------------------------
BasinOutlet          JUNCTION      0.00     0.00     0  20:00      -0.000      -0.000
CampbellCreek        OUTFALL       0.00     0.00     0  00:00       0.000       0.000


**********************
Node Surcharge Summary
**********************

No nodes were surcharged.


*********************
Node Flooding Summary
*********************

No nodes were flooded.


***********************
Outfall Loading Summary
***********************

-----------------------------------------------------------
                      Flow       Avg.      Max.       Total
                      Freq.      Flow      Flow      Volume
Outfall Node          Pcnt.       CFS       CFS    10^6 gal
-----------------------------------------------------------
CampbellCreek          0.00      0.00      0.00       0.000
-----------------------------------------------------------
System                 0.00      0.00      0.00       0.000


********************
Link Flow Summary
********************
```

```
-----------------------------------------------------------------------------
                               Maximum  Time of Max   Maximum    Max/    Max/
                                |Flow|   Occurrence   |Veloc|    Full    Full
Link                 Type          CFS  days hr:min    ft/sec    Flow   Depth
-----------------------------------------------------------------------------
2                    CONDUIT      0.00     0  00:00      0.00    0.00    0.00


***************************
Flow Classification Summary
***************************

-----------------------------------------------------------------------------------------
                    Adjusted    --- Fraction of Time in Flow Class ----   Avg.     Avg.  
                    /Actual         Up    Down  Sub   Sup   Up    Down    Froude   Flow  
Conduit               Length    Dry  Dry   Dry   Crit  Crit  Crit  Crit   Number   Change
-----------------------------------------------------------------------------------------
2                       1.00   1.00  0.00  0.00  0.00  0.00  0.00  0.00     0.00   0.0000


*************************
Conduit Surcharge Summary
*************************

No conduits were surcharged.


Analysis begun on:  Tue Dec 17 20:17:36 2013
Analysis ended on:  Tue Dec 17 20:17:36 2013
Total elapsed time: < 1 sec
```

Case 1: No LID - Event 3, 10yr-24hr

```
EPA STORM WATER MANAGEMENT MODEL - VERSION 5.0 (Build 5.0.022)
--------------------------------------------------------------


*********************************************************
NOTE: The summary statistics displayed in this report are
based on results found at every computational time step,  
not just on results from each reporting time step.
*********************************************************

****************
Analysis Options
****************
Flow Units ............... CFS
Process Models:
  Rainfall/Runoff ........ YES
  Snowmelt ............... NO
  Groundwater ............ NO
  Flow Routing ........... YES
  Ponding Allowed ........ NO
  Water Quality .......... NO
Infiltration Method ...... HORTON
Flow Routing Method ...... KINWAVE
Starting Date ............ JUL-10-2013 00:00:00
Ending Date .............. JUL-11-2013 00:00:00
Antecedent Dry Days ...... 0.0
Report Time Step ......... 00:15:00
Wet Time Step ............ 00:05:00
Dry Time Step ............ 01:00:00
Routing Time Step ........ 30.00 sec


**************************        Volume         Depth
Runoff Quantity Continuity     acre-feet        inches
**************************     ---------       -------
Total Precipitation ......         2.566         1.770
Evaporation Loss .........         0.000         0.000
Infiltration Loss ........         0.595         0.410
Surface Runoff ...........         1.821         1.256
Final Surface Storage ....         0.152         0.105
Continuity Error (%) .....        -0.075


**************************        Volume        Volume
Flow Routing Continuity        acre-feet      10^6 gal
**************************     ---------     ---------
Dry Weather Inflow .......         0.000         0.000
Wet Weather Inflow .......         1.819         0.593
Groundwater Inflow .......         0.000         0.000
RDII Inflow ..............         0.000         0.000
External Inflow ..........         0.000         0.000
External Outflow .........         1.816         0.592
Internal Outflow .........         0.000         0.000
Storage Losses ...........         0.000         0.000
Initial Stored Volume ....         0.000         0.000
Final Stored Volume ......         0.001         0.000
Continuity Error (%) .....         0.057


********************************
Highest Flow Instability Indexes
********************************
All links are stable.


*************************
Routing Time Step Summary
*************************
Minimum Time Step           :    30.00 sec
Average Time Step           :    30.00 sec
Maximum Time Step           :    30.00 sec
Percent in Steady State     :     0.00
Average Iterations per Step :     1.22


***************************
Subcatchment Runoff Summary
***************************

--------------------------------------------------------------------------------------------------------
                          Total      Total      Total      Total      Total       Total     Peak  Runoff
```

```
                         Precip      Runon       Evap      Infil     Runoff      Runoff   Runoff   Coeff
Subcatchment                 in         in         in         in         in    10^6 gal      CFS
--------------------------------------------------------------------------------------------------------
Basin4                     1.77       0.00       0.00       0.41       1.26        0.59    11.87   0.710


******************
Node Depth Summary
******************

---------------------------------------------------------------------
                               Average  Maximum  Maximum  Time of Max
                                 Depth    Depth      HGL   Occurrence
Node                 Type         Feet     Feet     Feet  days hr:min
---------------------------------------------------------------------
2                    JUNCTION     0.25     1.08     5.08     0  10:06
CampbellCreek        OUTFALL      0.25     1.08     1.08     0  10:06


*******************
Node Inflow Summary
*******************

-------------------------------------------------------------------------------------
                                Maximum  Maximum                  Lateral       Total
                                Lateral    Total  Time of Max      Inflow      Inflow
                                 Inflow   Inflow   Occurrence      Volume      Volume
Node                 Type           CFS      CFS  days hr:min    10^6 gal    10^6 gal
-------------------------------------------------------------------------------------
2                    JUNCTION     11.87    11.87     0  10:06       0.593       0.593
CampbellCreek        OUTFALL       0.00    11.78     0  10:06       0.000       0.592


**********************
Node Surcharge Summary
**********************

No nodes were surcharged.


*********************
Node Flooding Summary
*********************

No nodes were flooded.


***********************
Outfall Loading Summary
***********************

-----------------------------------------------------------
                      Flow       Avg.      Max.       Total
                      Freq.      Flow      Flow      Volume
Outfall Node          Pcnt.       CFS       CFS    10^6 gal
-----------------------------------------------------------
CampbellCreek         98.65      0.93     11.78       0.592
-----------------------------------------------------------
System                98.65      0.93     11.78       0.592


********************
Link Flow Summary
********************

-----------------------------------------------------------------------------
                               Maximum  Time of Max   Maximum    Max/    Max/
                                |Flow|   Occurrence   |Veloc|    Full    Full
Link                 Type          CFS  days hr:min    ft/sec    Flow   Depth
-----------------------------------------------------------------------------
2                    CONDUIT     11.78     0  10:06      6.88    0.57    0.54


*************************
Conduit Surcharge Summary
*************************

No conduits were surcharged.


Analysis begun on:  Fri Oct 25 17:25:08 2013
Analysis ended on:  Fri Oct 25 17:25:08 2013
```

```
  Total elapsed time: < 1 sec
```

Case 2: With LID Bioswale - Event 3, 10yr-24hr

```
EPA STORM WATER MANAGEMENT MODEL - VERSION 5.0 (Build 5.0.022)
--------------------------------------------------------------


*********************************************************
NOTE: The summary statistics displayed in this report are
based on results found at every computational time step,
not just on results from each reporting time step.
*********************************************************

****************
Analysis Options
****************
Flow Units ............... CFS
Process Models:
  Rainfall/Runoff ........ YES
  Snowmelt ............... NO
  Groundwater ............ NO
  Flow Routing ........... YES
  Ponding Allowed ........ NO
  Water Quality .......... NO
Infiltration Method ...... HORTON
Flow Routing Method ...... DYNWAVE
Starting Date ............ JUL-10-2013 00:00:00
Ending Date .............. JUL-11-2013 00:00:00
Antecedent Dry Days ...... 0.0
Report Time Step ......... 00:00:30
Wet Time Step ............ 00:01:00
Dry Time Step ............ 01:00:00
Routing Time Step ........ 1.00 sec


**************************        Volume         Depth
Runoff Quantity Continuity     acre-feet        inches
**************************     ---------       -------
Total Precipitation ......         2.564         1.768
Evaporation Loss .........         0.000         0.000
Infiltration Loss ........         1.100         0.759
Surface Runoff ...........         1.243         0.857
Final Surface Storage ....         0.220         0.152
Continuity Error (%) .....        -0.014


**************************        Volume        Volume
Flow Routing Continuity        acre-feet      10^6 gal
**************************     ---------     ---------
Dry Weather Inflow .......         0.000         0.000
Wet Weather Inflow .......         1.243         0.405
Groundwater Inflow .......         0.000         0.000
RDII Inflow ..............         0.000         0.000
External Inflow ..........         0.000         0.000
External Outflow .........         1.245         0.406
Internal Outflow .........         0.000         0.000
Storage Losses ...........         0.000         0.000
Initial Stored Volume ....         0.000         0.000
Final Stored Volume ......         0.000         0.000
Continuity Error (%) .....        -0.121


***************************
Time-Step Critical Elements
***************************
None


********************************
Highest Flow Instability Indexes
********************************
All links are stable.


*************************
Routing Time Step Summary
*************************
Minimum Time Step           :     1.00 sec
Average Time Step           :     1.00 sec
Maximum Time Step           :     1.00 sec
Percent in Steady State     :     0.00
Average Iterations per Step :     2.01
```

```
***************************
Subcatchment Runoff Summary
***************************

--------------------------------------------------------------------------------------------------------
                          Total      Total      Total      Total      Total       Total     Peak  Runoff
                         Precip      Runon       Evap      Infil     Runoff      Runoff   Runoff   Coeff
Subcatchment                 in         in         in         in         in    10^6 gal      CFS
--------------------------------------------------------------------------------------------------------
Basin4                     1.77       0.00       0.00       0.76       0.86        0.41    11.56   0.485


***********************
LID Performance Summary
***********************

------------------------------------------------------------------------------------------------------------------
                                       Total      Evap     Infil   Surface     Drain     Init.     Final     Pcnt.
                                      Inflow      Loss      Loss   Outflow   Outflow   Storage   Storage     Error
Subcatchment      LID Control             in        in        in        in        in        in        in
------------------------------------------------------------------------------------------------------------------
Basin4            Swale               291.49      0.00     95.13    183.73      0.00      0.00     12.64     -0.00

******************
Node Depth Summary
******************

---------------------------------------------------------------------
                               Average  Maximum  Maximum  Time of Max
                                 Depth    Depth      HGL   Occurrence
Node                 Type         Feet     Feet     Feet  days hr:min
---------------------------------------------------------------------
BasinOutlet          JUNCTION     0.02     0.12     4.12     0  10:05
CampbellCreek        OUTFALL      0.01     0.11     0.11     0  10:05


*******************
Node Inflow Summary
*******************

-------------------------------------------------------------------------------------
                                Maximum  Maximum                  Lateral       Total
                                Lateral    Total  Time of Max      Inflow      Inflow
                                 Inflow   Inflow   Occurrence      Volume      Volume
Node                 Type           CFS      CFS  days hr:min    10^6 gal    10^6 gal
-------------------------------------------------------------------------------------
BasinOutlet          JUNCTION     11.55    11.55     0  10:05       0.405       0.405
CampbellCreek        OUTFALL       0.00    12.10     0  10:05       0.000       0.406


**********************
Node Surcharge Summary
**********************

No nodes were surcharged.


*********************
Node Flooding Summary
*********************

No nodes were flooded.


***********************
Outfall Loading Summary
***********************

-----------------------------------------------------------
                      Flow       Avg.      Max.       Total
                      Freq.      Flow      Flow      Volume
Outfall Node          Pcnt.       CFS       CFS    10^6 gal
-----------------------------------------------------------
CampbellCreek         79.37      0.79     12.10       0.406
-----------------------------------------------------------
System                79.37      0.79     12.10       0.406


********************
Link Flow Summary
********************
```

```
  -----------------------------------------------------------------------------
                               Maximum  Time of Max   Maximum    Max/    Max/
                                |Flow|   Occurrence   |Veloc|    Full    Full
  Link                 Type        CFS  days hr:min    ft/sec    Flow   Depth
  -----------------------------------------------------------------------------
  2                    CONDUIT     12.10     0  10:05     12.43    0.00    0.03


  ***************************
  Flow Classification Summary
  ***************************

  -----------------------------------------------------------------------------------------
                      Adjusted    --- Fraction of Time in Flow Class ----   Avg.     Avg.
                       /Actual         Up    Down  Sub   Sup   Up    Down   Froude   Flow
  Conduit               Length    Dry  Dry   Dry   Crit  Crit  Crit  Crit   Number   Change
  -----------------------------------------------------------------------------------------
  2                       1.00   0.20  0.01  0.00  0.01  0.79  0.00  0.00     3.69   0.0000


  *************************
  Conduit Surcharge Summary
  *************************

  No conduits were surcharged.


  Analysis begun on:  Fri Oct 25 15:21:29 2013
  Analysis ended on:  Fri Oct 25 15:21:29 2013
  Total elapsed time: < 1 sec
```

Appendix E: Muldoon Road SWMM Modeling Output

Case 1: No LID -- Event 1, 90th Percentile Event Evenly Distributed

```
EPA STORM WATER MANAGEMENT MODEL - VERSION 5.0 (Build 5.0.022)
--------------------------------------------------------------


*********************************************************
NOTE: The summary statistics displayed in this report are
based on results found at every computational time step,
not just on results from each reporting time step.
*********************************************************

****************
Analysis Options
****************
Flow Units ............... CFS
Process Models:
  Rainfall/Runoff ........ YES
  Snowmelt ............... NO
  Groundwater ............ NO
  Flow Routing ........... YES
  Ponding Allowed ........ YES
  Water Quality .......... NO
Infiltration Method ...... HORTON
Flow Routing Method ...... DYNWAVE
Starting Date ............ AUG-12-2001 00:00:00
Ending Date .............. AUG-13-2001 00:00:00
Antecedent Dry Days ...... 0.0
Report Time Step ......... 00:00:01
Wet Time Step ............ 00:00:30
Dry Time Step ............ 01:00:00
Routing Time Step ........ 1.00 sec


WARNING 08: elevation drop exceeds length for Conduit 1

**************************        Volume         Depth
Runoff Quantity Continuity     acre-feet        inches
**************************     ---------       -------
Total Precipitation ......         0.142         0.518
Evaporation Loss .........         0.000         0.000
Infiltration Loss ........         0.000         0.000
Surface Runoff ...........         0.126         0.459
Final Surface Storage ....         0.016         0.059
Continuity Error (%) .....        -0.017


**************************        Volume        Volume
Flow Routing Continuity        acre-feet      10^6 gal
**************************     ---------     ---------
Dry Weather Inflow .......         0.000         0.000
Wet Weather Inflow .......         0.126         0.041
Groundwater Inflow .......         0.000         0.000
RDII Inflow ..............         0.000         0.000
External Inflow ..........         0.000         0.000
External Outflow .........         0.126         0.041
Internal Outflow .........         0.000         0.000
Storage Losses ...........         0.000         0.000
Initial Stored Volume ....         0.000         0.000
Final Stored Volume ......         0.000         0.000
Continuity Error (%) .....         0.000


***************************
Time-Step Critical Elements
***************************
None


********************************
Highest Flow Instability Indexes
********************************
```

```
All links are stable.


*************************
Routing Time Step Summary
*************************
Minimum Time Step           :     1.00 sec
Average Time Step           :     1.00 sec
Maximum Time Step           :     1.00 sec
Percent in Steady State     :     0.00
Average Iterations per Step :     2.00


***************************
Subcatchment Runoff Summary
***************************

--------------------------------------------------------------------------------------------------------
                          Total      Total      Total      Total      Total       Total     Peak  Runoff
                         Precip      Runon       Evap      Infil     Runoff      Runoff   Runoff   Coeff
Subcatchment                 in         in         in         in         in    10^6 gal      CFS
--------------------------------------------------------------------------------------------------------
MuldoonCorridor            0.52       0.00       0.00       0.00       0.46        0.04     0.07   0.885


******************
Node Depth Summary
******************

---------------------------------------------------------------------
                               Average  Maximum  Maximum  Time of Max
                                 Depth    Depth      HGL   Occurrence
Node                 Type         Feet     Feet     Feet  days hr:min
---------------------------------------------------------------------
junction             JUNCTION     0.03     0.03     1.03     0  15:42
outfall              OUTFALL      0.03     0.03     0.03     0  15:40


*******************
Node Inflow Summary
*******************

-------------------------------------------------------------------------------------
                                Maximum  Maximum                  Lateral       Total
                                Lateral    Total  Time of Max      Inflow      Inflow
                                 Inflow   Inflow   Occurrence      Volume      Volume
Node                 Type           CFS      CFS  days hr:min    10^6 gal    10^6 gal
-------------------------------------------------------------------------------------
junction             JUNCTION      0.07     0.07     0  15:42       0.041       0.041
outfall              OUTFALL       0.00     0.07     0  15:40       0.000       0.041


**********************
Node Surcharge Summary
**********************

No nodes were surcharged.


*********************
Node Flooding Summary
*********************

No nodes were flooded.


***********************
Outfall Loading Summary
***********************

-----------------------------------------------------------
```

```
                      Flow       Avg.      Max.       Total
                      Freq.      Flow      Flow      Volume
Outfall Node          Pcnt.       CFS       CFS    10^6 gal
-----------------------------------------------------------
outfall               99.06      0.06      0.07       0.041
-----------------------------------------------------------
System                99.06      0.06      0.07       0.041


********************
Link Flow Summary
********************

-----------------------------------------------------------------------------
                               Maximum  Time of Max   Maximum    Max/    Max/
                                |Flow|   Occurrence   |Veloc|    Full    Full
Link                 Type          CFS  days hr:min    ft/sec    Flow   Depth
-----------------------------------------------------------------------------
1                    CONDUIT      0.07     0  15:40     10.73    0.00    0.03


***************************
Flow Classification Summary
***************************

-----------------------------------------------------------------------------------------
                    Adjusted    --- Fraction of Time in Flow Class ----   Avg.     Avg.
                     /Actual         Up    Down  Sub   Sup   Up    Down   Froude   Flow
Conduit               Length    Dry  Dry   Dry   Crit  Crit  Crit  Crit   Number   Change
-----------------------------------------------------------------------------------------
1                       1.00   0.00  0.00  0.00  0.00  0.99  0.00  0.00    12.98   0.0000


*************************
Conduit Surcharge Summary
*************************

No conduits were surcharged.


Analysis begun on:  Wed Aug 14 12:31:54 2013
Analysis ended on:  Wed Aug 14 12:31:55 2013
Total elapsed time: 00:00:01
```

Case 2: With LID Landscaping

Event 1, 90th Percentile Event Evenly Distributed

```
EPA STORM WATER MANAGEMENT MODEL - VERSION 5.0 (Build 5.0.022)
--------------------------------------------------------------


*********************************************************
NOTE: The summary statistics displayed in this report are
based on results found at every computational time step,
not just on results from each reporting time step.
*********************************************************

****************
Analysis Options
****************
Flow Units ............... CFS
Process Models:
  Rainfall/Runoff ........ YES
  Snowmelt ............... NO
  Groundwater ............ NO
  Flow Routing ........... YES
  Ponding Allowed ........ YES
  Water Quality .......... NO
Infiltration Method ...... HORTON
Flow Routing Method ...... DYNWAVE
Starting Date ............ AUG-12-2001 00:00:00
Ending Date .............. AUG-13-2001 00:00:00
Antecedent Dry Days ...... 0.0
Report Time Step ......... 00:00:01
Wet Time Step ............ 00:00:30
Dry Time Step ............ 01:00:00
Routing Time Step ........ 1.00 sec


WARNING 08: elevation drop exceeds length for Conduit 1

**************************        Volume         Depth
Runoff Quantity Continuity     acre-feet        inches
**************************     ---------       -------
Total Precipitation ......         0.142         0.518
Evaporation Loss .........         0.000         0.000
Infiltration Loss ........         0.026         0.093
Surface Runoff ...........         0.103         0.376
Final Surface Storage ....         0.014         0.049
Continuity Error (%) .....         0.000


**************************        Volume        Volume
Flow Routing Continuity        acre-feet      10^6 gal
**************************     ---------     ---------
Dry Weather Inflow .......         0.000         0.000
Wet Weather Inflow .......         0.103         0.034
Groundwater Inflow .......         0.000         0.000
RDII Inflow ..............         0.000         0.000
External Inflow ..........         0.000         0.000
External Outflow .........         0.103         0.034
Internal Outflow .........         0.000         0.000
Storage Losses ...........         0.000         0.000
Initial Stored Volume ....         0.000         0.000
Final Stored Volume ......         0.000         0.000
Continuity Error (%) .....         0.000


***************************
Time-Step Critical Elements
***************************
None


********************************
Highest Flow Instability Indexes
********************************
```

```
All links are stable.


*************************
Routing Time Step Summary
*************************
Minimum Time Step           :     1.00 sec
Average Time Step           :     1.00 sec
Maximum Time Step           :     1.00 sec
Percent in Steady State     :     0.00
Average Iterations per Step :     2.00


***************************
Subcatchment Runoff Summary
***************************

--------------------------------------------------------------------------------------------------------
                          Total      Total      Total      Total      Total       Total     Peak  Runoff
                         Precip      Runon       Evap      Infil     Runoff      Runoff   Runoff   Coeff
Subcatchment                 in         in         in         in         in    10^6 gal      CFS
--------------------------------------------------------------------------------------------------------
MuldoonCorridor            0.52       0.00       0.00       0.09       0.38        0.03     0.06   0.725


******************
Node Depth Summary
******************

---------------------------------------------------------------------
                               Average  Maximum  Maximum  Time of Max
                                 Depth    Depth      HGL   Occurrence
Node                 Type         Feet     Feet     Feet  days hr:min
---------------------------------------------------------------------
junction             JUNCTION     0.02     0.03     1.03     0  16:11
outfall              OUTFALL      0.02     0.03     0.03     0  16:13


*******************
Node Inflow Summary
*******************

-------------------------------------------------------------------------------------
                                Maximum  Maximum                  Lateral       Total
                                Lateral    Total  Time of Max      Inflow      Inflow
                                 Inflow   Inflow   Occurrence      Volume      Volume
Node                 Type           CFS      CFS  days hr:min    10^6 gal    10^6 gal
-------------------------------------------------------------------------------------
junction             JUNCTION      0.06     0.06     0  16:13       0.034       0.034
outfall              OUTFALL       0.00     0.06     0  16:13       0.000       0.034


**********************
Node Surcharge Summary
**********************

No nodes were surcharged.


*********************
Node Flooding Summary
*********************

No nodes were flooded.


***********************
Outfall Loading Summary
***********************

-----------------------------------------------------------
```

```
                      Flow       Avg.      Max.       Total
                      Freq.      Flow      Flow      Volume
Outfall Node          Pcnt.       CFS       CFS    10^6 gal
-----------------------------------------------------------
outfall               98.97      0.05      0.06       0.034
-----------------------------------------------------------
System                98.97      0.05      0.06       0.034


********************
Link Flow Summary
********************

-----------------------------------------------------------------------------
                               Maximum  Time of Max   Maximum    Max/    Max/
                                |Flow|   Occurrence   |Veloc|    Full    Full
Link                 Type          CFS  days hr:min    ft/sec    Flow   Depth
-----------------------------------------------------------------------------
1                    CONDUIT      0.06     0  16:13     10.10    0.00    0.03


***************************
Flow Classification Summary
***************************

-----------------------------------------------------------------------------------------
                    Adjusted    --- Fraction of Time in Flow Class ----   Avg.     Avg.
                     /Actual         Up    Down  Sub   Sup   Up    Down   Froude   Flow
Conduit               Length    Dry  Dry   Dry   Crit  Crit  Crit  Crit   Number   Change
-----------------------------------------------------------------------------------------
1                       1.00   0.01  0.00  0.00  0.00  0.99  0.00  0.00    12.75   0.0000


*************************
Conduit Surcharge Summary
*************************

No conduits were surcharged.


Analysis begun on:  Wed Aug 14 12:37:51 2013
Analysis ended on:  Wed Aug 14 12:37:51 2013
Total elapsed time: < 1 sec
```

Case 1: No LID -- Event 2, 8-1-12

```
EPA STORM WATER MANAGEMENT MODEL - VERSION 5.0 (Build 5.0.022)
--------------------------------------------------------------


*********************************************************
NOTE: The summary statistics displayed in this report are
based on results found at every computational time step,
not just on results from each reporting time step.
*********************************************************

****************
Analysis Options
****************
Flow Units ............... CFS
Process Models:
  Rainfall/Runoff ........ YES
  Snowmelt ............... NO
  Groundwater ............ NO
  Flow Routing ........... YES
  Ponding Allowed ........ YES
  Water Quality .......... NO
Infiltration Method ...... HORTON
Flow Routing Method ...... DYNWAVE
Starting Date ............ AUG-12-2001 00:00:00
Ending Date .............. AUG-13-2001 00:00:00
Antecedent Dry Days ...... 0.0
Report Time Step ......... 00:00:30
Wet Time Step ............ 00:00:30
Dry Time Step ............ 01:00:00
Routing Time Step ........ 1.00 sec


WARNING 08: elevation drop exceeds length for Conduit 1

**************************        Volume         Depth
Runoff Quantity Continuity     acre-feet        inches
**************************     ---------       -------
Total Precipitation ......         0.052         0.190
Evaporation Loss .........         0.000         0.000
Infiltration Loss ........         0.000         0.000
Surface Runoff ...........         0.039         0.143
Final Surface Storage ....         0.013         0.047
Continuity Error (%) .....         0.000


**************************        Volume        Volume
Flow Routing Continuity        acre-feet      10^6 gal
**************************     ---------     ---------
Dry Weather Inflow .......         0.000         0.000
Wet Weather Inflow .......         0.039         0.013
Groundwater Inflow .......         0.000         0.000
RDII Inflow ..............         0.000         0.000
External Inflow ..........         0.000         0.000
External Outflow .........         0.039         0.013
Internal Outflow .........         0.000         0.000
Storage Losses ...........         0.000         0.000
Initial Stored Volume ....         0.000         0.000
Final Stored Volume ......         0.000         0.000
Continuity Error (%) .....         0.000


***************************
Time-Step Critical Elements
***************************
None


********************************
Highest Flow Instability Indexes
********************************
```

```
All links are stable.


*************************
Routing Time Step Summary
*************************
Minimum Time Step           :     1.00 sec
Average Time Step           :     1.00 sec
Maximum Time Step           :     1.00 sec
Percent in Steady State     :     0.00
Average Iterations per Step :     2.00


***************************
Subcatchment Runoff Summary
***************************

--------------------------------------------------------------------------------------------------------
                          Total      Total      Total      Total      Total       Total     Peak  Runoff
                         Precip      Runon       Evap      Infil     Runoff      Runoff   Runoff   Coeff
Subcatchment                 in         in         in         in         in    10^6 gal      CFS
--------------------------------------------------------------------------------------------------------
MuldoonCorridor            0.19       0.00       0.00       0.00       0.14        0.01     0.12   0.754


******************
Node Depth Summary
******************

---------------------------------------------------------------------
                               Average  Maximum  Maximum  Time of Max
                                 Depth    Depth      HGL   Occurrence
Node                 Type         Feet     Feet     Feet  days hr:min
---------------------------------------------------------------------
junction             JUNCTION     0.01     0.04     1.04     0  19:53
outfall              OUTFALL      0.01     0.04     0.04     0  19:53


*******************
Node Inflow Summary
*******************

-------------------------------------------------------------------------------------
                                Maximum  Maximum                  Lateral       Total
                                Lateral    Total  Time of Max      Inflow      Inflow
                                 Inflow   Inflow   Occurrence      Volume      Volume
Node                 Type           CFS      CFS  days hr:min    10^6 gal    10^6 gal
-------------------------------------------------------------------------------------
junction             JUNCTION      0.12     0.12     0  19:53       0.013       0.013
outfall              OUTFALL       0.00     0.12     0  19:53       0.000       0.013


**********************
Node Surcharge Summary
**********************

No nodes were surcharged.


*********************
Node Flooding Summary
*********************

No nodes were flooded.


***********************
Outfall Loading Summary
***********************

-----------------------------------------------------------
```

```
                      Flow       Avg.      Max.       Total
                      Freq.      Flow      Flow      Volume
Outfall Node          Pcnt.       CFS       CFS    10^6 gal
-----------------------------------------------------------
outfall               76.36      0.03      0.12       0.013
-----------------------------------------------------------
System                76.36      0.03      0.12       0.013


********************
Link Flow Summary
********************

-----------------------------------------------------------------------------
                               Maximum  Time of Max   Maximum    Max/    Max/
                                |Flow|   Occurrence   |Veloc|    Full    Full
Link                 Type          CFS  days hr:min    ft/sec    Flow   Depth
-----------------------------------------------------------------------------
1                    CONDUIT      0.12     0  19:53     12.56    0.00    0.04


***************************
Flow Classification Summary
***************************

-----------------------------------------------------------------------------------------
                    Adjusted    --- Fraction of Time in Flow Class ----   Avg.     Avg.
                     /Actual         Up    Down  Sub   Sup   Up    Down   Froude   Flow
Conduit               Length    Dry  Dry   Dry   Crit  Crit  Crit  Crit   Number   Change
-----------------------------------------------------------------------------------------
1                       1.00   0.16  0.00  0.00  0.00  0.83  0.00  0.00     8.66   0.0000


*************************
Conduit Surcharge Summary
*************************

No conduits were surcharged.


Analysis begun on:  Tue Dec 17 20:31:12 2013
Analysis ended on:  Tue Dec 17 20:31:12 2013
Total elapsed time: < 1 sec
```

Case 2: With LID Landscaping -- Event 2, 8-1-12

```
EPA STORM WATER MANAGEMENT MODEL - VERSION 5.0 (Build 5.0.022)
--------------------------------------------------------------


*********************************************************
NOTE: The summary statistics displayed in this report are
based on results found at every computational time step,  
not just on results from each reporting time step.
*********************************************************

****************
Analysis Options
****************
Flow Units ............... CFS
Process Models:
  Rainfall/Runoff ........ YES
  Snowmelt ............... NO
  Groundwater ............ NO
  Flow Routing ........... YES
  Ponding Allowed ........ YES
  Water Quality .......... NO
Infiltration Method ...... HORTON
Flow Routing Method ...... DYNWAVE
Starting Date ............ AUG-12-2001 00:00:00
Ending Date .............. AUG-13-2001 00:00:00
Antecedent Dry Days ...... 0.0
Report Time Step ......... 00:00:30
Wet Time Step ............ 00:00:30
Dry Time Step ............ 01:00:00
Routing Time Step ........ 1.00 sec


WARNING 08: elevation drop exceeds length for Conduit 1

**************************        Volume         Depth
Runoff Quantity Continuity     acre-feet        inches
**************************     ---------       -------
Total Precipitation ......         0.052         0.190
Evaporation Loss .........         0.000         0.000
Infiltration Loss ........         0.009         0.034
Surface Runoff ...........         0.032         0.117
Final Surface Storage ....         0.011         0.038
Continuity Error (%) .....         0.000


**************************        Volume        Volume
Flow Routing Continuity        acre-feet      10^6 gal
**************************     ---------     ---------
Dry Weather Inflow .......         0.000         0.000
Wet Weather Inflow .......         0.032         0.011
Groundwater Inflow .......         0.000         0.000
RDII Inflow ..............         0.000         0.000
External Inflow ..........         0.000         0.000
External Outflow .........         0.032         0.011
Internal Outflow .........         0.000         0.000
Storage Losses ...........         0.000         0.000
Initial Stored Volume ....         0.000         0.000
Final Stored Volume ......         0.000         0.000
Continuity Error (%) .....         0.000


***************************
Time-Step Critical Elements
***************************
None


********************************
Highest Flow Instability Indexes
********************************
All links are stable.


*************************
Routing Time Step Summary
*************************
Minimum Time Step           :     1.00 sec
Average Time Step           :     1.00 sec
Maximum Time Step           :     1.00 sec
Percent in Steady State     :     0.00
Average Iterations per Step :     2.00
```

```
***************************
Subcatchment Runoff Summary
***************************

--------------------------------------------------------------------------------------------------------
                          Total      Total      Total      Total      Total       Total     Peak  Runoff
                         Precip      Runon       Evap      Infil     Runoff      Runoff   Runoff   Coeff
Subcatchment                 in         in         in         in         in    10^6 gal      CFS
--------------------------------------------------------------------------------------------------------
MuldoonCorridor            0.19       0.00       0.00       0.03       0.12        0.01     0.10   0.618


******************
Node Depth Summary
******************

---------------------------------------------------------------------
                               Average  Maximum  Maximum  Time of Max
                                 Depth    Depth      HGL   Occurrence
Node                 Type         Feet     Feet     Feet  days hr:min
---------------------------------------------------------------------
junction             JUNCTION     0.01     0.03     1.03     0  19:53
outfall              OUTFALL      0.01     0.03     0.03     0  19:53


*******************
Node Inflow Summary
*******************

-------------------------------------------------------------------------------------
                                Maximum  Maximum                  Lateral       Total
                                Lateral    Total  Time of Max      Inflow      Inflow
                                 Inflow   Inflow   Occurrence      Volume      Volume
Node                 Type           CFS      CFS  days hr:min    10^6 gal    10^6 gal
-------------------------------------------------------------------------------------
junction             JUNCTION      0.10     0.10     0  19:53       0.011       0.011
outfall              OUTFALL       0.00     0.10     0  19:53       0.000       0.011


**********************
Node Surcharge Summary
**********************

No nodes were surcharged.


*********************
Node Flooding Summary
*********************

No nodes were flooded.


***********************
Outfall Loading Summary
***********************

-----------------------------------------------------------
                      Flow       Avg.      Max.       Total
                      Freq.      Flow      Flow      Volume
Outfall Node          Pcnt.       CFS       CFS    10^6 gal
-----------------------------------------------------------
outfall               75.03      0.02      0.10       0.011
-----------------------------------------------------------
System                75.03      0.02      0.10       0.011


********************
Link Flow Summary
********************

-----------------------------------------------------------------------------
                               Maximum  Time of Max   Maximum    Max/    Max/
                                |Flow|   Occurrence   |Veloc|    Full    Full
Link                 Type          CFS  days hr:min    ft/sec    Flow   Depth
-----------------------------------------------------------------------------
1                    CONDUIT      0.10     0  19:53     11.76    0.00    0.03


***************************
```

```
Flow Classification Summary
***************************

------------------------------------------------------------------------------------------
                    Adjusted    --- Fraction of Time in Flow Class ----   Avg.     Avg.
                     /Actual         Up    Down  Sub   Sup   Up    Down   Froude   Flow
Conduit               Length    Dry  Dry   Dry   Crit  Crit  Crit  Crit   Number   Change
------------------------------------------------------------------------------------------
1                       1.00   0.16  0.00  0.00  0.00  0.83  0.00  0.00     8.42   0.0000


*************************
Conduit Surcharge Summary
*************************

No conduits were surcharged.


Analysis begun on:  Tue Dec 17 20:24:39 2013
Analysis ended on:  Tue Dec 17 20:24:40 2013
Total elapsed time: 00:00:01
```

Case 1: No LID -- Event 3, 10yr, 24-hr Event

```
EPA STORM WATER MANAGEMENT MODEL - VERSION 5.0 (Build 5.0.022)
--------------------------------------------------------------


*********************************************************
NOTE: The summary statistics displayed in this report are
based on results found at every computational time step,
not just on results from each reporting time step.
*********************************************************

****************
Analysis Options
****************
Flow Units ............... CFS
Process Models:
  Rainfall/Runoff ........ YES
  Snowmelt ............... NO
  Groundwater ............ NO
  Flow Routing ........... YES
  Ponding Allowed ........ YES
  Water Quality .......... NO
Infiltration Method ...... HORTON
Flow Routing Method ...... DYNWAVE
Starting Date ............ AUG-12-2001 00:00:00
Ending Date .............. AUG-13-2001 00:00:00
Antecedent Dry Days ...... 0.0
Report Time Step ......... 00:00:01
Wet Time Step ............ 00:00:30
Dry Time Step ............ 01:00:00
Routing Time Step ........ 1.00 sec


WARNING 08: elevation drop exceeds length for Conduit 1

**************************        Volume         Depth
Runoff Quantity Continuity     acre-feet        inches
**************************     ---------       -------
Total Precipitation ......         0.486         1.768
Evaporation Loss .........         0.000         0.000
Infiltration Loss ........         0.000         0.000
Surface Runoff ...........         0.470         1.707
Final Surface Storage ....         0.017         0.061
Continuity Error (%) .....        -0.007


**************************        Volume        Volume
Flow Routing Continuity        acre-feet      10^6 gal
**************************     ---------     ---------
Dry Weather Inflow .......         0.000         0.000
Wet Weather Inflow .......         0.469         0.153
Groundwater Inflow .......         0.000         0.000
RDII Inflow ..............         0.000         0.000
External Inflow ..........         0.000         0.000
External Outflow .........         0.469         0.153
Internal Outflow .........         0.000         0.000
Storage Losses ...........         0.000         0.000
Initial Stored Volume ....         0.000         0.000
Final Stored Volume ......         0.000         0.000
Continuity Error (%) .....         0.000


***************************
Time-Step Critical Elements
***************************
Link 1 (1.92%)


********************************
Highest Flow Instability Indexes
********************************
```

```
All links are stable.


*************************
Routing Time Step Summary
*************************
Minimum Time Step           :     0.50 sec
Average Time Step           :     0.99 sec
Maximum Time Step           :     1.00 sec
Percent in Steady State     :     0.00
Average Iterations per Step :     2.00


***************************
Subcatchment Runoff Summary
***************************

--------------------------------------------------------------------------------------------------------
                            Total      Total      Total      Total      Total       Total     Peak  Runoff
                           Precip     Runon       Evap      Infil     Runoff      Runoff   Runoff   Coeff
Subcatchment                   in         in         in         in         in    10^6 gal      CFS
--------------------------------------------------------------------------------------------------------
MuldoonCorridor              1.77       0.00       0.00       0.00       1.71        0.15     3.59   0.966


******************
Node Depth Summary
******************

---------------------------------------------------------------------
                               Average  Maximum  Maximum  Time of Max
                                 Depth    Depth      HGL   Occurrence
Node                 Type         Feet     Feet     Feet  days hr:min
---------------------------------------------------------------------
junction             JUNCTION     0.05     0.19     1.19     0  10:00
outfall              OUTFALL      0.05     0.19     0.19     0  10:00


*******************
Node Inflow Summary
*******************

-------------------------------------------------------------------------------------
                                Maximum  Maximum                  Lateral       Total
                                Lateral    Total  Time of Max      Inflow      Inflow
                                 Inflow   Inflow   Occurrence      Volume      Volume
Node                 Type           CFS      CFS  days hr:min    10^6 gal    10^6 gal
-------------------------------------------------------------------------------------
junction             JUNCTION      3.59     3.59     0  10:00       0.153       0.153
outfall              OUTFALL       0.00     3.59     0  10:00       0.000       0.153


**********************
Node Surcharge Summary
**********************

No nodes were surcharged.


*********************
Node Flooding Summary
*********************

No nodes were flooded.


***********************
Outfall Loading Summary
***********************

-----------------------------------------------------------
```

```
                      Flow       Avg.      Max.       Total
                      Freq.      Flow      Flow      Volume
Outfall Node          Pcnt.       CFS       CFS    10^6 gal
-----------------------------------------------------------
outfall               99.21      0.27      3.59       0.153
-----------------------------------------------------------
System                99.21      0.27      3.59       0.153


********************
Link Flow Summary
********************

-----------------------------------------------------------------------------
                               Maximum  Time of Max   Maximum    Max/    Max/
                                |Flow|   Occurrence   |Veloc|    Full    Full
Link                 Type          CFS  days hr:min    ft/sec    Flow   Depth
-----------------------------------------------------------------------------
1                    CONDUIT      3.59     0  10:00     35.02    0.08    0.19


***************************
Flow Classification Summary
***************************

-----------------------------------------------------------------------------------------
                    Adjusted    --- Fraction of Time in Flow Class ----   Avg.     Avg.
                     /Actual         Up    Down  Sub   Sup   Up    Down   Froude   Flow
Conduit               Length    Dry  Dry   Dry   Crit  Crit  Crit  Crit   Number   Change
-----------------------------------------------------------------------------------------
1                       1.00   0.00  0.00  0.00  0.00  0.99  0.00  0.00    13.98   0.0000


*************************
Conduit Surcharge Summary
*************************

No conduits were surcharged.


Analysis begun on:  Wed Aug 14 12:29:54 2013
Analysis ended on:  Wed Aug 14 12:29:55 2013
Total elapsed time: 00:00:01
```

Case 2: With LID Landscaping -- Event 3, 10yr, 24-hr Event

```
EPA STORM WATER MANAGEMENT MODEL - VERSION 5.0 (Build 5.0.022)
--------------------------------------------------------------


*********************************************************
NOTE: The summary statistics displayed in this report are
based on results found at every computational time step,
not just on results from each reporting time step.
*********************************************************

****************
Analysis Options
****************
Flow Units ............... CFS
Process Models:
  Rainfall/Runoff ........ YES
  Snowmelt ............... NO
  Groundwater ............ NO
  Flow Routing ........... YES
  Ponding Allowed ........ YES
  Water Quality .......... NO
Infiltration Method ...... HORTON
Flow Routing Method ...... DYNWAVE
Starting Date ............ AUG-12-2001 00:00:00
Ending Date .............. AUG-13-2001 00:00:00
Antecedent Dry Days ...... 0.0
Report Time Step ......... 00:00:01
Wet Time Step ............ 00:00:30
Dry Time Step ............ 01:00:00
Routing Time Step ........ 1.00 sec


WARNING 08: elevation drop exceeds length for Conduit 1

**************************        Volume         Depth
Runoff Quantity Continuity     acre-feet        inches
**************************     ---------       -------
Total Precipitation ......         0.486         1.768
Evaporation Loss .........         0.000         0.000
Infiltration Loss ........         0.088         0.318
Surface Runoff ...........         0.385         1.400
Final Surface Storage ....         0.014         0.050
Continuity Error (%) .....        -0.006


**************************        Volume        Volume
Flow Routing Continuity        acre-feet      10^6 gal
**************************     ---------     ---------
Dry Weather Inflow .......         0.000         0.000
Wet Weather Inflow .......         0.385         0.125
Groundwater Inflow .......         0.000         0.000
RDII Inflow ..............         0.000         0.000
External Inflow ..........         0.000         0.000
External Outflow .........         0.385         0.125
Internal Outflow .........         0.000         0.000
Storage Losses ...........         0.000         0.000
Initial Stored Volume ....         0.000         0.000
Final Stored Volume ......         0.000         0.000
Continuity Error (%) .....         0.000


***************************
Time-Step Critical Elements
***************************
Link 1 (1.42%)


********************************
Highest Flow Instability Indexes
********************************
All links are stable.


*************************
Routing Time Step Summary
*************************
Minimum Time Step           :     0.50 sec
Average Time Step           :     0.99 sec
Maximum Time Step           :     1.00 sec
Percent in Steady State     :     0.00
Average Iterations per Step :     2.00
```

```
***************************
Subcatchment Runoff Summary
***************************

--------------------------------------------------------------------------------------------------------
                          Total      Total      Total      Total      Total       Total     Peak  Runoff
                         Precip      Runon       Evap      Infil     Runoff      Runoff   Runoff   Coeff
Subcatchment                 in         in         in         in         in    10^6 gal      CFS
--------------------------------------------------------------------------------------------------------
MuldoonCorridor            1.77       0.00       0.00       0.32       1.40        0.13     2.90   0.792


******************
Node Depth Summary
******************

---------------------------------------------------------------------
                               Average  Maximum  Maximum  Time of Max
                                 Depth    Depth      HGL   Occurrence
Node                 Type         Feet     Feet     Feet  days hr:min
---------------------------------------------------------------------
junction             JUNCTION     0.04     0.17     1.17     0  10:00
outfall              OUTFALL      0.04     0.17     0.17     0  10:00


*******************
Node Inflow Summary
*******************

-------------------------------------------------------------------------------------
                                Maximum  Maximum                  Lateral       Total
                                Lateral    Total  Time of Max      Inflow      Inflow
                                 Inflow   Inflow   Occurrence      Volume      Volume
Node                 Type           CFS      CFS  days hr:min    10^6 gal    10^6 gal
-------------------------------------------------------------------------------------
junction             JUNCTION      2.90     2.90     0  10:00       0.125       0.125
outfall              OUTFALL       0.00     2.90     0  10:00       0.000       0.125


**********************
Node Surcharge Summary
**********************

No nodes were surcharged.


*********************
Node Flooding Summary
*********************

No nodes were flooded.


***********************
Outfall Loading Summary
***********************

-----------------------------------------------------------
                      Flow       Avg.      Max.       Total
                      Freq.      Flow      Flow      Volume
Outfall Node          Pcnt.       CFS       CFS    10^6 gal
-----------------------------------------------------------
outfall               99.14      0.21      2.90       0.125
-----------------------------------------------------------
System                99.14      0.21      2.90       0.125


********************
Link Flow Summary
********************

-----------------------------------------------------------------------------
                               Maximum  Time of Max   Maximum    Max/    Max/
                                |Flow|   Occurrence   |Veloc|    Full    Full
Link                 Type          CFS  days hr:min    ft/sec    Flow   Depth
-----------------------------------------------------------------------------
1                    CONDUIT      2.90     0  10:00     32.74    0.06    0.17


***************************
```

```
Flow Classification Summary
***************************

-----------------------------------------------------------------------------------------
                    Adjusted    --- Fraction of Time in Flow Class ----   Avg.     Avg.
                     /Actual         Up    Down  Sub   Sup   Up    Down   Froude   Flow
Conduit               Length    Dry  Dry   Dry   Crit  Crit  Crit  Crit   Number   Change
-----------------------------------------------------------------------------------------
1                       1.00   0.00  0.00  0.00  0.00  0.99  0.00  0.00    13.78   0.0000


*************************
Conduit Surcharge Summary
*************************

No conduits were surcharged.


Analysis begun on:  Tue Aug 13 11:59:59 2013
Analysis ended on:  Tue Aug 13 12:00:00 2013
Total elapsed time: 00:00:01
```

Appendix F: Russian Jack Springs Park Data and Calculations

1. Russian Jack Soil Information
2. Rainfall Data and Inflow Calculations
3. Outflow data and Calculations

HATTENBURG DILLEY & LINNELL
Engineering Consultants

MEMORANDUM

DATE: March 26, 2012 File No: 11-111-03

TO: Janie Dusel, PE

FROM: Nick Moran, EIT

RE: Field Observations
Russian Jack LID Pilot Project

CIVIL ENGINEERING

GEOTECHNICAL ENGINEERING

TRANSPORTATION ENGINEERING

ENVIRONMENTAL SERVICES

PLANNING

SURVEYING

CONSTRUCTION ADMINISTRATION

MATERIAL TESTING

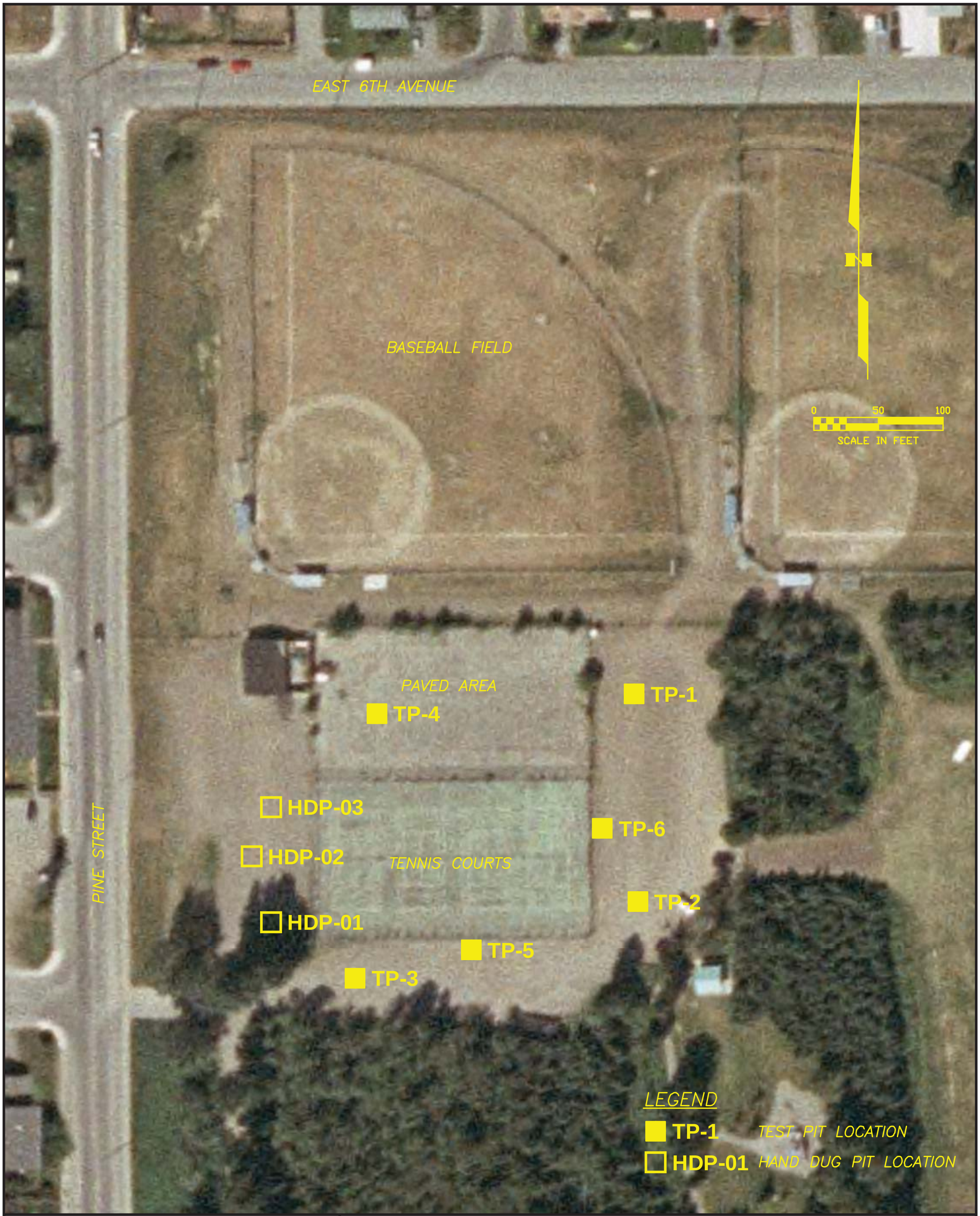
Test pits were excavated to evaluate subsurface conditions in the Russian Jack Parking Area. Three test pits, labeled TP-1 through TP-3, were advanced on October 28, 2011. Three additional test pits, TP-4 through TP-6, were advanced on November 11, 2011. In addition to the test pits, three hand dug pits, HDP-1 through HDP-3, were advanced on January 10 and 11, 2012. Figure 1 presents the locations of Test Pits TP-1 through TP-6, and Hand Dug Pits HDP-1 through HDP-3. The test pits were excavated to nominal depths of 10 feet in order to identify subsurface conditions. Excavation services were provided by Discovery Drilling of Anchorage, Alaska using a rubber-tire backhoe. The Hand Dug Pits were advanced to varying depths from three to five feet by an HDL staff geologist.

Soil samples were collected from the bucket of the backhoe for future laboratory testing, if needed. The subsurface conditions encountered in the test pits were logged. The soils encountered were visually classified according to the Unified Soil Classification System (USCS). Detailed logs of the test pits are presented in Appendix A, Figures A1 through A6. In general, the subsurface conditions consisted of one foot of fill over one to three feet of peat. Silty sand and sandy gravel were encountered below the peat. The sandy gravel should be considered the permeable layer to receive infiltration from surface water. This layer typically was encountered at five to eight feet below grade. No free groundwater was encountered in any of the test pits.

One percolation test was conducted in Test Pit TP-1 and two percolation tests were conducted in TP-2. The percolation tests consisted of preparing a 6 inch diameter test hole. The sides of the test hole were scarified to expose the natural soil surface and any loose material was removed from the bottom of the test hole. The tests were conducted according to Alaska Department of Environmental Conservation procedures for a falling head percolation test. The percolation rates in the sandy gravel ranged from 6 to 10 minutes per inch. The depths and results of the percolation tests can be found in the boring logs, Figures A1 and A2.

Test Pits TP-4 through TP-6 were advanced to determine the extent of the peat layer present in the proposed parking area. TP-4 was advanced in the existing paved area north of the tennis courts and a three-foot layer of peat was found approximately three to six feet below finish grade. TP-5 and TP-6 were advanced next to the tennis court fence in an attempt to determine whether the peat layer was removed during construction of the tennis courts. TP-5 encountered a peat layer from three to five feet below grade. In TP-6, the peat layer was present approximately six feet east of the fence. However, within six feet of the fence there was no peat layer. It appears the peat layer may have been removed beneath portions of the tennis courts, however, HDL suggests assuming a two to three-foot peat layer exists beneath the courts for design/cost estimating purposes.

Hand Dug Pits HDP-1 through HDP-3 were advanced to determine the extent of the peat layer present in the proposed parking area. HDP-1 was advanced in the gravel parking area southwest of the tennis courts and consisted of sandy gravels in the top two feet underlain by wet sandy silts to the depth of the pit at three feet. HDP-2 and HDP-3 were advanced west of the tennis courts. HDP-2 and HDP-3 encountered sandy gravels underlain by a peat layer from two to five feet below grade. It appears the two to three-foot thick peat layer exists beneath the gravel parking area west of the tennis courts.



H:\jobs\11-111 Watershed Management Term (MOA)\11-111-3 LID Pilot Project Design\Russian Jack Project\CAD\Drawings\11111_03_U01, 1=1, 03/23/12 at 16:06 by unknown
LAYOUT: Layout1

HATTENBURG DILLEY & LINNELL
Engineering Consultants

- ENGINEERING
- SURVEYING
- PROJECT MANAGEMENT
- ENVIRONMENTAL
- EARTH SCIENCE
- PLANNING

(907) 564-2120 - ANCHORAGE
(907) 746-5230 - PALMER
WWW.HDLALASKA.COM

RUSSIAN JACK LID PILOT PROJECT
INFILTRATION TEST PIT LOCATIONS
MUNICIPALITY OF ANCHORAGE
ANCHORAGE, ALASKA

DATE:	11/11/2011	DRAWN BY:	MMHN	SHEET:	1 OF 1
SCALE:	1" = 100'	CHECKED BY:	JT	JOB NO.:	11-111-03

HATTENBURG DILLEY & LINNELL
Engineering Consultants

LOG OF BORING

HOLE # TP-1

PROJECT NUMBER : *11-111-03*
PROJECT : *LID Pilot Project Design*
CLIENT : *Municipality of Anchorage*

Station / Location: *Russian Jack Parking Lot*
Offset:
Elevation:

Equipment Type: *New Holland Backhoe*
Drilling Method: *Backhoe*
Field Crew: *Discovery Drilling*

Total Depth: *11.0 feet*
Date: *10/24/2011*
Geologist: *N.Moran*

Ground Water Data

Depth in (ft.)		
Time		
Date		
Symbol		

Depth (Feet)	Sample Data: Sample Type	Number	Blow Count	Sample	Recovery	N-Value	USCS Classification	Frozen Zone	Soil Graphic	SUBSURFACE MATERIAL	
0–1	GRAB	S-1		✋	■					**sandy GRAVEL** gray, moist, dense	0.0
1										**PEAT** brown, moist, soft, Roots and trash present	1.0
2–3	GRAB	S-2		✋	■						
3.5										**slightly gravelly, silty, SAND** grayish brown, moist, medium dense	3.5
5										**sandy GRAVEL w/cobbles** gray, moist, medium dense	5.0
7–8	GRAB	S-3		✋	■					Percolation Rate = 6.7 mpi	
11									BOH 11	Notes: no free water encountered	11.0

A USCS LOG OF TEST HOLE LID PILOT PROJECT.GPJ 2006DATATEMPLATE.GDT 11/15/11

☐ CME Auto Hammer ☐ Cathead Rope Method ☐ 140 lb. hammer with 30 in. drop ☐ 340 lb. hammer with 30 in. drop

Sheet Number 1 of 1

Figure A1

LOG OF BORING

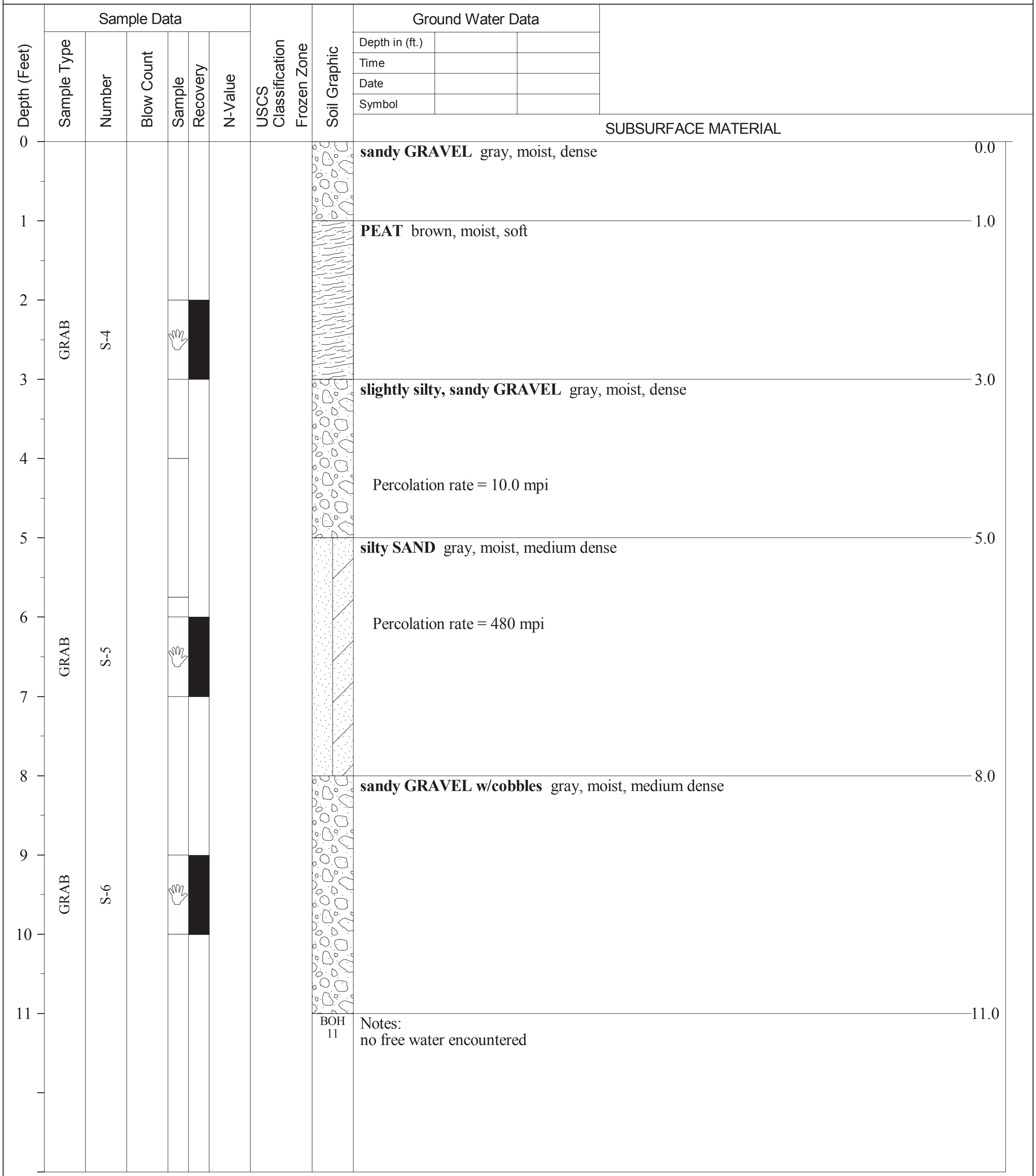
HOLE # TP-2

PROJECT NUMBER : *11-111-03*
PROJECT : *LID Pilot Project Design*
CLIENT : *Municipality of Anchorage*

Station / Location: *Russian Jack Parking Lot*	Equipment Type: *New Holland Backhoe*	Total Depth: *11.0 feet*
Offset:	Drilling Method: *Backhoe*	Date: *10/24/2011*
Elevation:	Field Crew: *Discovery Drilling*	Geologist: *N.Moran*

Ground Water Data

Depth in (ft.)		
Time		
Date		
Symbol		



sandy GRAVEL gray, moist, dense

PEAT brown, moist, soft

slightly silty, sandy GRAVEL gray, moist, dense

Percolation rate = 10.0 mpi

silty SAND gray, moist, medium dense

Percolation rate = 480 mpi

sandy GRAVEL w/cobbles gray, moist, medium dense

Notes:
no free water encountered

☐ CME Auto Hammer ☐ Cathead Rope Method ☐ 140 lb. hammer with 30 in. drop ☐ 340 lb. hammer with 30 in. drop

Figure A2

HATTENBURG DILLEY & LINNELL
Engineering Consultants

LOG OF BORING

HOLE # TP-3

PROJECT NUMBER : *11-111-03*
PROJECT : *LID Pilot Project Design*
CLIENT : *Municipality of Anchorage*

Station / Location: *Russian Jack Parking Lot*
Offset:
Elevation:

Equipment Type: *New Holland Backhoe*
Drilling Method: *Backhoe*
Field Crew: *Discovery Drilling*

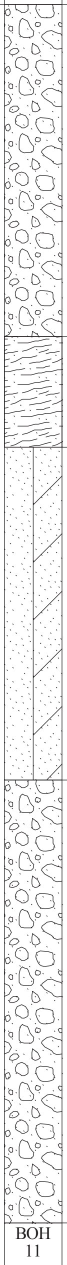
Total Depth: *11.0 feet*
Date: *10/24/2011*
Geologist: *N.Moran*

Ground Water Data

Depth in (ft.)		
Time		
Date		
Symbol		

Depth (Feet)	Sample Type	Number	Blow Count	Sample	Recovery	N-Value	USCS Classification	Frozen Zone
5–6	GRAB	S-7		✋	■			
8–9	GRAB	S-8		✋	■			

Soil Graphic



SUBSURFACE MATERIAL

Depth	SUBSURFACE MATERIAL
0.0	**sandy GRAVEL** gray, moist, dense
3.0	**PEAT** brown, moist, soft
4.0	**silty SAND** gray, moist, medium dense
7.0	**sandy GRAVEL w/cobbles** gray, moist, medium dense
11.0	Notes: no free water encountered

BOH
11

☐ CME Auto Hammer ☐ Cathead Rope Method ☐ 140 lb. hammer with 30 in. drop ☐ 340 lb. hammer with 30 in. drop

Sheet Number 1 of 1

Figure A3

HATTENBURG DILLEY & LINNELL
Engineering Consultants

LOG OF BORING

HOLE # TP-4

PROJECT NUMBER : *11-111-03*
PROJECT : *LID Pilot Project Design*
CLIENT : *Municipality of Anchorage*

Station / Location: *Russian Jack Parking Lot*
Offset:
Elevation:

Equipment Type: *John Deere Backhoe*
Drilling Method: *Backhoe*
Field Crew: *Discovery Drilling*

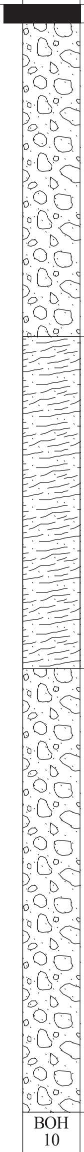
Total Depth: *10.0 feet*
Date: *11/11/2011*
Geologist: *N.Moran*

Ground Water Data

Depth in (ft.)		
Time		
Date		
Symbol		

Sample Data: Sample Type, Number, Blow Count, Sample Recovery, N-Value

USCS Classification | Frozen Zone | Soil Graphic



Depth (Feet)	SUBSURFACE MATERIAL	
0	**Asphalt**	0.0
	sandy GRAVEL gray, moist, dense	0.2
3	**PEAT** brown, moist, soft	3.0
6	**sandy GRAVEL w/cobbles** gray, moist, medium dense	6.0
10	Notes: no free water encountered	10.0

☐ CME Auto Hammer ☐ Cathead Rope Method ☐ 140 lb. hammer with 30 in. drop ☐ 340 lb. hammer with 30 in. drop

Sheet Number 1 of 1

Figure A4

HATTENBURG DILLEY & LINNELL
Engineering Consultants

LOG OF BORING

HOLE # TP-5

PROJECT NUMBER : *11-111-03*
PROJECT : *LID Pilot Project Design*
CLIENT : *Municipality of Anchorage*

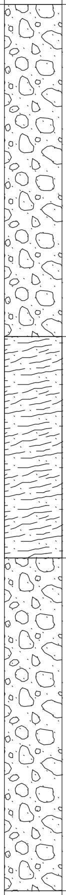
Station / Location: *Russian Jack Parking Lot*
Offset:
Elevation:

Equipment Type: *John Deere Backhoe*
Drilling Method: *Backhoe*
Field Crew: *Discovery Drilling*

Total Depth: *8.0 feet*
Date: *11/11/2011*
Geologist: *N.Moran*

Ground Water Data

Depth in (ft.)		
Time		
Date		
Symbol		



Depth (Feet)	Sample Type	Number	Blow Count	Sample Recovery	N-Value	USCS Classification	Frozen Zone	Soil Graphic	SUBSURFACE MATERIAL	
0									**sandy GRAVEL** gray, moist, dense	0.0
3									**PEAT** brown, moist, soft	3.0
5									**sandy GRAVEL w/cobbles** gray, moist, medium dense	5.0
8								BOH 8	Notes: no free water encountered	8.0

Depth scale: 0, 1, 2, 3, 4, 5, 6, 7, 8

☐ CME Auto Hammer ☐ Cathead Rope Method ☐ 140 lb. hammer with 30 in. drop ☐ 340 lb. hammer with 30 in. drop

Sheet Number 1 of 1

Figure A5

HATTENBURG DILLEY & LINNELL
Engineering Consultants

LOG OF BORING

HOLE # TP-6

PROJECT NUMBER : *11-111-03*
PROJECT : *LID Pilot Project Design*
CLIENT : *Municipality of Anchorage*

Station / Location: *Russian Jack Parking Lot*	Equipment Type: *John Deere Backhoe*	Total Depth: *8.0 feet*
Offset:	Drilling Method: *Backhoe*	Date: *11/11/2011*
Elevation:	Field Crew: *Discovery Drilling*	Geologist: *N.Moran*

Ground Water Data

Depth in (ft.)		
Time		
Date		
Symbol		

Depth (Feet)	Sample Data: Sample Type	Number	Blow Count	Sample Recovery	N-Value	USCS Classification	Frozen Zone	Soil Graphic	SUBSURFACE MATERIAL	
0									**sandy GRAVEL** gray, moist, dense	0.0
5									**sandy GRAVEL w/cobbles** gray, moist, medium dense	5.0
8								BOH 8	Notes: no free water encountered, peat layer present approximately 2 to 5 feet deep and 6 feet east of fence.	8.0

Depth scale: 0, 1, 2, 3, 4, 5, 6, 7, 8

☐ CME Auto Hammer ☐ Cathead Rope Method ☐ 140 lb. hammer with 30 in. drop ☐ 340 lb. hammer with 30 in. drop

Figure A6

Total Rainfall = 2.31 Inches
Area= 44,385 SF
Date = 8/16 - 8/24
Time Interval = 1:00:00 Hour

Date and Time	Rainfall (inches)	Flow (cfs)	Volume (cfs)
8/16/2013 0:00	0	0.000	0.000
8/16/2013 1:00	0	0.000	0.000
8/16/2013 2:00	0	0.000	0.000
8/16/2013 3:00	0	0.000	0.000
8/16/2013 4:00	0	0.000	0.000
8/16/2013 5:00	0	0.000	0.000
8/16/2013 6:00	0	0.000	0.000
8/16/2013 7:00	0	0.000	0.000
8/16/2013 8:00	0	0.000	0.000
8/16/2013 9:00	0	0.000	0.000
8/16/2013 10:00	0	0.000	0.000
8/16/2013 11:00	0	0.000	0.000
8/16/2013 12:00	0	0.000	0.000
8/16/2013 13:00	0	0.000	0.000
8/16/2013 14:00	0.01	0.010	36.988
8/16/2013 15:00	0.01	0.010	36.988
8/16/2013 16:00	0.02	0.021	73.975
8/16/2013 17:00	0.01	0.010	36.988
8/16/2013 18:00	0	0.000	0.000
8/16/2013 19:00	0	0.000	0.000
8/16/2013 20:00	0	0.000	0.000
8/16/2013 21:00	0	0.000	0.000
8/16/2013 22:00	0	0.000	0.000
8/16/2013 23:00	0	0.000	0.000
8/17/2013 0:00	0	0.000	0.000
8/17/2013 1:00	0	0.000	0.000
8/17/2013 2:00	0	0.000	0.000
8/17/2013 3:00	0	0.000	0.000
8/17/2013 4:00	0.01	0.010	36.988
8/17/2013 5:00	0	0.000	0.000
8/17/2013 6:00	0	0.000	0.000
8/17/2013 7:00	0	0.000	0.000
8/17/2013 8:00	0	0.000	0.000
8/17/2013 9:00	0	0.000	0.000
8/17/2013 10:00	0.02	0.021	73.975
8/17/2013 11:00	0	0.000	0.000
8/17/2013 12:00	0	0.000	0.000
8/17/2013 13:00	0	0.000	0.000
8/17/2013 14:00	0	0.000	0.000
8/17/2013 15:00	0	0.000	0.000

8/17/2013 16:00	0	0.000	0.000
8/17/2013 17:00	0	0.000	0.000
8/17/2013 18:00	0	0.000	0.000
8/17/2013 19:00	0	0.000	0.000
8/17/2013 20:00	0	0.000	0.000
8/17/2013 21:00	0.02	0.021	73.975
8/17/2013 22:00	0.07	0.072	258.914
8/17/2013 23:00	0	0.000	0.000
8/18/2013 0:00	0.04	0.041	147.951
8/18/2013 1:00	0.08	0.082	295.902
8/18/2013 2:00	0.04	0.041	147.951
8/18/2013 3:00	0.03	0.031	110.963
8/18/2013 4:00	0.07	0.072	258.914
8/18/2013 5:00	0.1	0.103	369.877
8/18/2013 6:00	0.05	0.051	184.939
8/18/2013 7:00	0	0.000	0.000
8/18/2013 8:00	0.01	0.010	36.988
8/18/2013 9:00	0.02	0.021	73.975
8/18/2013 10:00	0.02	0.021	73.975
8/18/2013 11:00	0.01	0.010	36.988
8/18/2013 12:00	0.01	0.010	36.988
8/18/2013 13:00	0	0.000	0.000
8/18/2013 14:00	0	0.000	0.000
8/18/2013 15:00	0	0.000	0.000
8/18/2013 16:00	0.01	0.010	36.988
8/18/2013 17:00	0.01	0.010	36.988
8/18/2013 18:00	0	0.000	0.000
8/18/2013 19:00	0	0.000	0.000
8/18/2013 20:00	0.01	0.010	36.988
8/18/2013 21:00	0.01	0.010	36.988
8/18/2013 22:00	0	0.000	0.000
8/18/2013 23:00	0	0.000	0.000
8/19/2013 0:00	0	0.000	0.000
8/19/2013 1:00	0	0.000	0.000
8/19/2013 2:00	0	0.000	0.000
8/19/2013 3:00	0	0.000	0.000
8/19/2013 4:00	0	0.000	0.000
8/19/2013 5:00	0	0.000	0.000
8/19/2013 6:00	0	0.000	0.000
8/19/2013 7:00	0.02	0.021	73.975
8/19/2013 8:00	0.02	0.021	73.975
8/19/2013 9:00	0.1	0.103	369.877
8/19/2013 10:00	0.09	0.092	332.890
8/19/2013 11:00	0	0.000	0.000
8/19/2013 12:00	0.06	0.062	221.926
8/19/2013 13:00	0.07	0.072	258.914
8/19/2013 14:00	0	0.000	0.000

8/19/2013 15:00	0.03	0.031	110.963
8/19/2013 16:00	0.05	0.051	184.939
8/19/2013 17:00	0.01	0.010	36.988
8/19/2013 18:00	0.02	0.021	73.975
8/19/2013 19:00	0.01	0.010	36.988
8/19/2013 20:00	0.01	0.010	36.988
8/19/2013 21:00	0.01	0.010	36.988
8/19/2013 22:00	0	0.000	0.000
8/19/2013 23:00	0	0.000	0.000
8/20/2013 0:00	0	0.000	0.000
8/20/2013 1:00	0	0.000	0.000
8/20/2013 2:00	0.02	0.021	73.975
8/20/2013 3:00	0	0.000	0.000
8/20/2013 4:00	0	0.000	0.000
8/20/2013 5:00	0	0.000	0.000
8/20/2013 6:00	0	0.000	0.000
8/20/2013 7:00	0	0.000	0.000
8/20/2013 8:00	0	0.000	0.000
8/20/2013 9:00	0	0.000	0.000
8/20/2013 10:00	0	0.000	0.000
8/20/2013 11:00	0	0.000	0.000
8/20/2013 12:00	0	0.000	0.000
8/20/2013 13:00	0	0.000	0.000
8/20/2013 14:00	0	0.000	0.000
8/20/2013 15:00	0.01	0.010	36.988
8/20/2013 16:00	0.02	0.021	73.975
8/20/2013 17:00	0.03	0.031	110.963
8/20/2013 18:00	0.02	0.021	73.975
8/20/2013 19:00	0.04	0.041	147.951
8/20/2013 20:00	0.01	0.010	36.988
8/20/2013 21:00	0	0.000	0.000
8/20/2013 22:00	0	0.000	0.000
8/20/2013 23:00	0	0.000	0.000
8/21/2013 0:00	0	0.000	0.000
8/21/2013 1:00	0	0.000	0.000
8/21/2013 2:00	0	0.000	0.000
8/21/2013 3:00	0.03	0.031	110.963
8/21/2013 4:00	0.02	0.021	73.975
8/21/2013 5:00	0.02	0.021	73.975
8/21/2013 6:00	0	0.000	0.000
8/21/2013 7:00	0.01	0.010	36.988
8/21/2013 8:00	0.01	0.010	36.988
8/21/2013 9:00	0	0.000	0.000
8/21/2013 10:00	0.02	0.021	73.975
8/21/2013 11:00	0.03	0.031	110.963
8/21/2013 12:00	0.03	0.031	110.963
8/21/2013 13:00	0.03	0.031	110.963

8/21/2013 14:00	0.01	0.010	36.988
8/21/2013 15:00	0.02	0.021	73.975
8/21/2013 16:00	0	0.000	0.000
8/21/2013 17:00	0.01	0.010	36.988
8/21/2013 18:00	0.03	0.031	110.963
8/21/2013 19:00	0.02	0.021	73.975
8/21/2013 20:00	0.01	0.010	36.988
8/21/2013 21:00	0.02	0.021	73.975
8/21/2013 22:00	0.01	0.010	36.988
8/21/2013 23:00	0.05	0.051	184.939
8/22/2013 0:00	0.03	0.031	110.963
8/22/2013 1:00	0.03	0.031	110.963
8/22/2013 2:00	0.01	0.010	36.988
8/22/2013 3:00	0.02	0.021	73.975
8/22/2013 4:00	0.01	0.010	36.988
8/22/2013 5:00	0.02	0.021	73.975
8/22/2013 6:00	0.06	0.062	221.926
8/22/2013 7:00	0.04	0.041	147.951
8/22/2013 8:00	0	0.000	0.000
8/22/2013 9:00	0.01	0.010	36.988
8/22/2013 10:00	0.03	0.031	110.963
8/22/2013 11:00	0.08	0.082	295.902
8/22/2013 12:00	0.03	0.031	110.963
8/22/2013 13:00	0.03	0.031	110.963
8/22/2013 14:00	0.01	0.010	36.988
8/22/2013 15:00	0.03	0.031	110.963
8/22/2013 16:00	0	0.000	0.000
8/22/2013 17:00	0	0.000	0.000
8/22/2013 18:00	0	0.000	0.000
8/22/2013 19:00	0.02	0.021	73.975
8/22/2013 20:00	0.02	0.021	73.975
8/22/2013 21:00	0	0.000	0.000
8/22/2013 22:00	0	0.000	0.000
8/22/2013 23:00	0	0.000	0.000
8/23/2013 0:00	0	0.000	0.000
8/23/2013 1:00	0	0.000	0.000
8/23/2013 2:00	0	0.000	0.000
8/23/2013 3:00	0	0.000	0.000
8/23/2013 4:00	0	0.000	0.000
8/23/2013 5:00	0	0.000	0.000
8/23/2013 6:00	0.01	0.010	36.988
8/23/2013 7:00	0.01	0.010	36.988
8/23/2013 8:00	0.01	0.010	36.988
8/23/2013 9:00	0	0.000	0.000
8/23/2013 10:00	0	0.000	0.000
8/23/2013 11:00	0	0.000	0.000
8/23/2013 12:00	0	0.000	0.000

8/23/2013 13:00	0	0.000	0.000
8/23/2013 14:00	0	0.000	0.000
8/23/2013 15:00	0	0.000	0.000
8/23/2013 16:00	0	0.000	0.000
8/23/2013 17:00	0	0.000	0.000
8/23/2013 18:00	0	0.000	0.000
8/23/2013 19:00	0	0.000	0.000
8/23/2013 20:00	0	0.000	0.000
8/23/2013 21:00	0	0.000	0.000
8/23/2013 22:00	0.02	0.021	73.975
8/23/2013 23:00	0	0.000	0.000
8/24/2013 0:00	0.03	0.031	110.963
8/24/2013 1:00	0.02	0.021	73.975
8/24/2013 2:00	0	0.000	0.000
8/24/2013 3:00	0	0.000	0.000
8/24/2013 4:00	0	0.000	0.000
8/24/2013 5:00	0	0.000	0.000
8/24/2013 6:00	0	0.000	0.000
8/24/2013 7:00	0	0.000	0.000
8/24/2013 8:00	0	0.000	0.000
8/24/2013 9:00	0	0.000	0.000
8/24/2013 10:00	0	0.000	0.000
8/24/2013 11:00	0	0.000	0.000
8/24/2013 12:00	0	0.000	0.000
8/24/2013 13:00	0	0.000	0.000
8/24/2013 14:00	0	0.000	0.000
8/24/2013 15:00	0.01	0.010	36.988
8/24/2013 16:00	0	0.000	0.000
8/24/2013 17:00	0	0.000	0.000
8/24/2013 18:00	0	0.000	0.000
8/24/2013 19:00	0	0.000	0.000
8/24/2013 20:00	0	0.000	0.000
8/24/2013 21:00	0	0.000	0.000
8/24/2013 22:00	0	0.000	0.000
8/24/2013 23:00	0	0.000	0.000
8/25/2013 0:00	0	0.000	0.000
		Peak =	Total Volume
		0.10274373	**8,544**

Rainfall Total= 1.33 inches
Area = 44,385 SF
Date = 9/4/2013
Time Interval = 0:30 minutes

Date and Time	Rainfall (inches)	Flow (cfs)	Volume (cf)
9/4/2013 0:00	0.00	0.000	0.000
9/4/2013 0:30	0.00	0.000	0.000
9/4/2013 1:00	0.05	0.103	184.939
9/4/2013 1:30	0.04	0.082	147.951
9/4/2013 2:00	0.04	0.082	147.951
9/4/2013 2:30	0.01	0.021	36.988
9/4/2013 3:00	0.01	0.021	36.988
9/4/2013 3:30	0.05	0.103	184.939
9/4/2013 4:00	0.04	0.082	147.951
9/4/2013 4:30	0.08	0.164	295.902
9/4/2013 5:00	0.08	0.164	295.902
9/4/2013 5:30	0.02	0.041	73.975
9/4/2013 6:00	0.00	0.000	0.000
9/4/2013 6:30	0.00	0.000	0.000
9/4/2013 7:00	0.00	0.000	0.000
9/4/2013 7:30	0.00	0.000	0.000
9/4/2013 8:00	0.00	0.000	0.000
9/4/2013 8:30	0.01	0.021	36.988
9/4/2013 9:00	0.00	0.000	0.000
9/4/2013 9:30	0.00	0.000	0.000
9/4/2013 10:00	0.00	0.000	0.000
9/4/2013 10:30	0.01	0.021	36.988
9/4/2013 11:00	0.01	0.021	36.988
9/4/2013 11:30	0.00	0.000	0.000
9/4/2013 12:00	0.02	0.041	73.975
9/4/2013 12:30	0.02	0.041	73.975
9/4/2013 13:00	0.08	0.164	295.902
9/4/2013 13:30	0.03	0.062	110.963
9/4/2013 14:00	0.02	0.041	73.975
9/4/2013 14:30	0.00	0.000	0.000
9/4/2013 15:00	0.01	0.021	36.988
9/4/2013 15:30	0.01	0.021	36.988
9/4/2013 16:00	0.06	0.123	221.926
9/4/2013 16:30	0.03	0.062	110.963
9/4/2013 17:00	0.08	0.164	295.902
9/4/2013 17:30	0.01	0.021	36.988
9/4/2013 18:00	0.03	0.062	110.963
9/4/2013 18:30	0.02	0.041	73.975
9/4/2013 19:00	0.04	0.082	147.951

9/4/2013 19:30	0.10	0.205	369.877
9/4/2013 20:00	0.10	0.205	369.877
9/4/2013 20:30	0.03	0.062	110.963
9/4/2013 21:00	0.07	0.144	258.914
9/4/2013 21:30	0.09	0.185	332.890
9/4/2013 22:00	0.03	0.062	110.963
9/4/2013 22:30	0.00	0.000	0.000
9/4/2013 23:00	0.00	0.000	0.000
9/4/2013 23:30	0.00	0.000	0.000
9/5/2013 0:00	0.00	0.000	0.000

Peak =	Total Volume =
0.205	**4919.370**

Total Rainfall = 0.99 inches
Area = 44385 SF
Date = 9/25/2013
Time Interval = 0:30 Minutes

Time	Rainfall (inches)	Flow (cfs)	Volume (cf)
0:59	0	0.00	0.00
1:29	0.08	0.16	295.90
1:59	0.03	0.06	110.96
2:29	0.02	0.04	73.98
2:59	0.03	0.06	110.96
3:29	0.02	0.04	73.98
3:59	0.02	0.04	73.98
4:29	0.03	0.06	110.96
4:59	0.02	0.04	73.98
5:29	0.01	0.02	36.99
5:59	0.03	0.06	110.96
6:29	0.05	0.10	184.94
6:59	0.08	0.16	295.90
7:29	0.11	0.23	406.87
7:59	0.11	0.23	406.87
8:29	0.11	0.23	406.87
8:59	0.06	0.12	221.93
9:29	0.06	0.12	221.93
9:59	0.02	0.04	73.98
10:29	0	0.00	0.00
10:59	0	0.00	0.00
11:29	0	0.00	0.00
11:59	0	0.00	0.00
12:29	0	0.00	0.00
12:59	0	0.00	0.00
13:29	0.01	0.02	36.99
13:59	0	0.00	0.00
14:29	0	0.00	0.00
14:59	0.01	0.02	36.99
15:29	0	0.00	0.00
15:59	0	0.00	0.00
16:29	0	0.00	0.00
16:59	0	0.00	0.00
17:29	0	0.00	0.00
17:59	0	0.00	0.00
18:29	0	0.00	0.00
18:59	0.01	0.02	36.99
19:29	0	0.00	0.00
19:59	0	0.00	0.00

20:29	0.01	0.02	36.99
20:59	0	0.00	0.00
21:29	0	0.00	0.00
21:59	0	0.00	0.00
22:29	0.01	0.02	36.99
22:59	0.01	0.02	36.99
23:29	0.03	0.06	110.96
23:59	0.01	0.02	36.99
		Peak = 0.23	Total Volume = **3,662**

Date and Time		Seconds	Pressure (PSI)	Temperature (C)	Level Surface Elevation (ft)	Barometric Pressure (PSI)	Flow (cfs)	Zero Line Offset	Zero Line Offset	*This assumes constant flow over 1 minute interval.			
								Adjusted Surface Elevation (ft)	Adjusted Flow (cfs)	Volume of water* (cubic feet)	Total Volume	Averaged Time	Average Flow (cfs)
8/16/2013 0:00	M	28800.000	-0.005	60.151	-0.011	14.551	0	0.014	0.000	0.004	**4,853**	8/16/2013 0:00	0
8/16/2013 0:01	M	28860.000	-0.002	60.06	-0.004	14.55	0	0.021	0.000	0.010		8/16/2013 1:00	0.000
8/16/2013 0:02	M	28920.000	-0.004	60.151	-0.01	14.549	0	0.015	0.000	0.004		8/16/2013 2:00	0.000
8/16/2013 0:03	M	28980.000	-0.001	60.151	-0.001	14.548	0	0.024	0.000	0.014		8/16/2013 3:00	0.000
8/16/2013 0:04	M	29040.000	-0.002	60.151	-0.005	14.548	0	0.020	0.000	0.009		8/16/2013 4:00	0.00014379
8/16/2013 0:05	M	29100.000	-0.005	60.151	-0.012	14.549	0	0.013	0.000	0.003		8/16/2013 5:00	0.00012007
8/16/2013 0:06	M	29160.000	-0.002	60.151	-0.005	14.548	0	0.020	0.000	0.009		8/16/2013 6:00	0.00009759
8/16/2013 0:07	M	29220.000	-0.005	60.151	-0.012	14.55	0	0.013	0.000	0.003		8/16/2013 7:00	0.00008733
8/16/2013 0:08	M	29280.000	-0.005	60.151	-0.012	14.551	0	0.013	0.000	0.003		8/16/2013 8:00	0.00010805
8/16/2013 0:09	M	29340.000	-0.004	60.06	-0.01	14.549	0	0.015	0.000	0.004		8/16/2013 9:00	0.00009603
8/16/2013 0:10	M	29400.000	-0.001	60.151	-0.003	14.55	0	0.022	0.000	0.012		8/16/2013 10:00	0.00006740
8/16/2013 0:11	M	29460.000	-0.004	60.151	-0.008	14.549	0	0.017	0.000	0.006		8/16/2013 11:00	0.00004491
8/16/2013 0:12	M	29520.000	-0.001	60.151	-0.003	14.55	0	0.022	0.000	0.012		8/16/2013 12:00	0.00002371
8/16/2013 0:13	M	29580.000	-0.002	60.151	-0.005	14.549	0	0.020	0.000	0.009		8/16/2013 13:00	0.00003224
8/16/2013 0:14	M	29640.000	0.002	60.151	0.004	14.548	2.814E-06	0.029	0.000	0.023		8/16/2013 14:00	0.00003230
8/16/2013 0:15	M	29700.000	-0.006	60.151	-0.015	14.552	0	0.010	0.000	0.002		8/16/2013 15:00	0.00287781
8/16/2013 0:16	M	29760.000	-0.004	60.151	-0.01	14.55	0	0.015	0.000	0.004		8/16/2013 16:00	0.01244886
8/16/2013 0:17	M	29820.000	0	60.151	0.001	14.549	9.041E-08	0.026	0.000	0.018		8/16/2013 17:00	0.01448269
8/16/2013 0:18	M	29880.000	0	60.151	-0.001	14.55	0	0.024	0.000	0.014		8/16/2013 18:00	0.00328084
8/16/2013 0:19	M	29940.000	-0.007	60.06	-0.015	14.551	0	0.010	0.000	0.002		8/16/2013 19:00	0.00177909
8/16/2013 0:20	M	30000.000	-0.009	60.06	-0.02	14.551	0	0.005	0.000	0.000		8/16/2013 20:00	0.00118096
8/16/2013 0:21	M	30060.000	-0.009	60.151	-0.02	14.551	0	0.005	0.000	0.000		8/16/2013 21:00	0.00104724
8/16/2013 0:22	M	30120.000	-0.003	60.151	-0.006	14.548	0	0.019	0.000	0.008		8/16/2013 22:00	0.00073852
8/16/2013 0:23	M	30180.000	-0.004	60.06	-0.009	14.55	0	0.016	0.000	0.005		8/16/2013 23:00	0.00080624
8/16/2013 0:24	M	30240.000	-0.006	60.151	-0.013	14.55	0	0.012	0.000	0.003		8/17/2013 0:00	0.00117568
8/16/2013 0:25	M	30300.000	-0.004	60.06	-0.009	14.551	0	0.016	0.000	0.005		8/17/2013 1:00	0.00094712
8/16/2013 0:26	M	30360.000	-0.007	60.151	-0.016	14.548	0	0.009	0.000	0.001		8/17/2013 2:00	0.00107876
8/16/2013 0:27	M	30420.000	-0.001	60.06	-0.003	14.547	0	0.022	0.000	0.012		8/17/2013 3:00	0.00089509
8/16/2013 0:28	M	30480.000	-0.002	60.06	-0.005	14.546	0	0.020	0.000	0.009		8/17/2013 4:00	0.00068454
8/16/2013 0:29	M	30540.000	-0.004	60.06	-0.009	14.547	0	0.016	0.000	0.005		8/17/2013 5:00	0.00077773
8/16/2013 0:30	M	30600.000	-0.002	60.151	-0.003	14.547	0	0.022	0.000	0.012		8/17/2013 6:00	0.00090261
8/16/2013 0:31	M	30660.000	-0.001	60.06	-0.002	14.547	0	0.023	0.000	0.013		8/17/2013 7:00	0.00114254
8/16/2013 0:32	M	30720.000	-0.006	60.151	-0.014	14.55	0	0.011	0.000	0.002		8/17/2013 8:00	0.00090411
8/16/2013 0:33	M	30780.000	-0.001	60.06	-0.002	14.547	0	0.023	0.000	0.013		8/17/2013 9:00	0.00083037
8/16/2013 0:34	M	30840.000	-0.005	60.06	-0.011	14.547	0	0.014	0.000	0.004		8/17/2013 10:00	0.01272742
8/16/2013 0:35	M	30900.000	-0.005	60.06	-0.012	14.548	0	0.013	0.000	0.003		8/17/2013 11:00	0.00936621
8/16/2013 0:36	M	30960.000	0	60.06	0	14.546	0	0.025	0.000	0.016		8/17/2013 12:00	0.00382937
8/16/2013 0:37	M	31020.000	-0.004	60.06	-0.009	14.549	0	0.016	0.000	0.005		8/17/2013 13:00	0.00221964
8/16/2013 0:38	M	31080.000	-0.002	60.06	-0.004	14.548	0	0.021	0.000	0.010		8/17/2013 14:00	0.00208348
8/16/2013 0:39	M	31140.000	-0.006	59.968	-0.013	14.547	0	0.012	0.000	0.003		8/17/2013 15:00	0.00201959
8/16/2013 0:40	M	31200.000	0.001	60.06	0.002	14.544	5.044E-07	0.027	0.000	0.019		8/17/2013 16:00	0.00199173
8/16/2013 0:41	M	31260.000	-0.008	59.968	-0.017	14.55	0	0.008	0.000	0.001		8/17/2013 17:00	0.00184265
8/16/2013 0:42	M	31320.000	-0.002	60.06	-0.005	14.547	0	0.020	0.000	0.009		8/17/2013 18:00	0.00167480
8/16/2013 0:43	M	31380.000	-0.003	59.968	-0.007	14.547	0	0.018	0.000	0.007		8/17/2013 19:00	0.00143154

Date and Time	Seconds	Pressure (PSI)	Temperature (C)	Level Surface Elevation (ft)	Barometric Pressure (PSI)	Flow (cfs)	Zero Line Offset Adjusted Surface Elevation (ft)	Zero Line Offset Adjusted Flow (cfs)	*This assumes constant flow over 1 minute interval. Volume of water* (cubic feet)	Total Volume	Averaged Time	Average Flow (cfs)
8/16/2013 0:44	M 31440.000	-0.003	59.968	-0.007	14.548	0	0.018	0.000	0.007		8/17/2013 20:00	0.00096990
8/16/2013 0:45	M 31500.000	-0.004	59.968	-0.009	14.545	0	0.016	0.000	0.005		8/17/2013 21:00	0.00102806
8/16/2013 0:46	M 31560.000	-0.002	60.06	-0.004	14.548	0	0.021	0.000	0.010		8/17/2013 22:00	0.02352627
8/16/2013 0:47	M 31620.000	-0.003	59.968	-0.008	14.549	0	0.017	0.000	0.006		8/17/2013 23:00	0.01028699
8/16/2013 0:48	M 31680.000	-0.006	59.968	-0.013	14.548	0	0.012	0.000	0.003		8/18/2013 0:00	0.01461213
8/16/2013 0:49	M 31740.000	-0.001	59.968	-0.003	14.547	0	0.022	0.000	0.012		8/18/2013 1:00	0.03314530
8/16/2013 0:50	M 31800.000	-0.006	59.968	-0.013	14.55	0	0.012	0.000	0.003		8/18/2013 2:00	0.02559627
8/16/2013 0:51	M 31860.000	-0.003	59.968	-0.008	14.548	0	0.017	0.000	0.006		8/18/2013 3:00	0.01670132
8/16/2013 0:52	M 31920.000	-0.005	59.876	-0.012	14.549	0	0.013	0.000	0.003		8/18/2013 4:00	0.02550921
8/16/2013 0:53	M 31980.000	-0.002	59.968	-0.005	14.548	0	0.020	0.000	0.009		8/18/2013 5:00	0.04662895
8/16/2013 0:54	M 32040.000	-0.005	59.968	-0.012	14.551	0	0.013	0.000	0.003		8/18/2013 6:00	0.02821226
8/16/2013 0:55	M 32100.000	-0.007	59.968	-0.017	14.551	0	0.008	0.000	0.001		8/18/2013 7:00	0.00957405
8/16/2013 0:56	M 32160.000	-0.001	59.968	-0.003	14.55	0	0.022	0.000	0.012		8/18/2013 8:00	0.00482101
8/16/2013 0:57	M 32220.000	-0.009	59.968	-0.02	14.55	0	0.005	0.000	0.000		8/18/2013 9:00	0.00744343
8/16/2013 0:58	M 32280.000	-0.004	59.876	-0.01	14.55	0	0.015	0.000	0.004		8/18/2013 10:00	0.01126335
8/16/2013 0:59	M 32340.000	-0.01	59.876	-0.022	14.548	0	0.003	0.000	0.000		8/18/2013 11:00	0.00710483
8/16/2013 1:00	32400	-0.004	59.968	-0.01	14.547	0	0.015	0.000	0.004		8/18/2013 12:00	0.00697263
8/16/2013 1:01	32460	-0.001	59.876	-0.003	14.548	0	0.022	0.000	0.012		8/18/2013 13:00	0.00308919
8/16/2013 1:02	32520	-0.006	59.876	-0.015	14.548	0	0.010	0.000	0.002		8/18/2013 14:00	0.00150936
8/16/2013 1:03	32580	-0.005	59.876	-0.011	14.547	0	0.014	0.000	0.004		8/18/2013 15:00	0.00298351
8/16/2013 1:04	32640	-0.008	59.876	-0.018	14.549	0	0.007	0.000	0.001		8/18/2013 16:00	0.00212215
8/16/2013 1:05	32700	0	59.876	-0.001	14.544	0	0.024	0.000	0.014		8/18/2013 17:00	0.00475987
8/16/2013 1:06	32760	-0.002	59.876	-0.005	14.546	0	0.020	0.000	0.009		8/18/2013 18:00	0.00678368
8/16/2013 1:07	32820	-0.002	59.876	-0.005	14.549	0	0.020	0.000	0.009		8/18/2013 19:00	0.00290272
8/16/2013 1:08	32880	-0.002	59.876	-0.005	14.547	0	0.020	0.000	0.009		8/18/2013 20:00	0.00152036
8/16/2013 1:09	32940	-0.003	59.876	-0.007	14.548	0	0.018	0.000	0.007		8/18/2013 21:00	0.00324338
8/16/2013 1:10	33000	0	59.876	0.001	14.55	9.041E-08	0.026	0.000	0.018		8/18/2013 22:00	0.00219069
8/16/2013 1:11	33060	-0.002	59.968	-0.006	14.548	0	0.019	0.000	0.008		8/18/2013 23:00	0.00159703
8/16/2013 1:12	33120	-0.002	59.876	-0.005	14.547	0	0.020	0.000	0.009		8/19/2013 0:00	0.00104984
8/16/2013 1:13	33180	-0.001	59.876	-0.003	14.548	0	0.022	0.000	0.012		8/19/2013 1:00	0.00101298
8/16/2013 1:14	33240	-0.007	59.785	-0.017	14.549	0	0.008	0.000	0.001		8/19/2013 2:00	0.00087912
8/16/2013 1:15	33300	-0.002	59.876	-0.006	14.55	0	0.019	0.000	0.008		8/19/2013 3:00	0.00071654
8/16/2013 1:16	33360	-0.006	59.876	-0.014	14.549	0	0.011	0.000	0.002		8/19/2013 4:00	0.00066338
8/16/2013 1:17	33420	-0.002	59.876	-0.006	14.549	0	0.019	0.000	0.008		8/19/2013 5:00	0.00046145
8/16/2013 1:18	33480	0	59.876	-0.001	14.544	0	0.024	0.000	0.014		8/19/2013 6:00	0.00041537
8/16/2013 1:19	33540	0	59.876	0	14.549	0	0.025	0.000	0.016		8/19/2013 7:00	0.00098985
8/16/2013 1:20	33600	-0.002	59.876	-0.006	14.55	0	0.019	0.000	0.008		8/19/2013 8:00	0.01344220
8/16/2013 1:21	33660	-0.008	59.785	-0.018	14.551	0	0.007	0.000	0.001		8/19/2013 9:00	0.04382204
8/16/2013 1:22	33720	-0.005	59.785	-0.013	14.551	0	0.012	0.000	0.003		8/19/2013 10:00	0.05566719
8/16/2013 1:23	33780	-0.003	59.785	-0.008	14.548	0	0.017	0.000	0.006		8/19/2013 11:00	0.00900726
8/16/2013 1:24	33840	-0.003	59.785	-0.008	14.547	0	0.017	0.000	0.006		8/19/2013 12:00	0.02489029
8/16/2013 1:25	33900	0	59.785	0.001	14.543	9.041E-08	0.026	0.000	0.018		8/19/2013 13:00	0.03027101
8/16/2013 1:26	33960	0	59.785	0	14.545	0	0.025	0.000	0.016		8/19/2013 14:00	0.01042057
8/16/2013 1:27	34020	-0.005	59.785	-0.011	14.548	0	0.014	0.000	0.004		8/19/2013 15:00	0.00678625

Date and Time	Seconds	Pressure (PSI)	Temperature (C)	Level Surface Elevation (ft)	Barometric Pressure (PSI)	Flow (cfs)	Zero Line Offset Adjusted Surface Elevation (ft)	Zero Line Offset Adjusted Flow (cfs)	*This assumes constant flow over 1 minute interval.			
									Volume of water* (cubic feet)	Total Volume	Averaged Time	Average Flow (cfs)
8/16/2013 1:28	34080	-0.006	59.785	-0.014	14.548	0	0.011	0.000	0.002		8/19/2013 16:00	0.02455598
8/16/2013 1:29	34140	-0.002	59.785	-0.006	14.547	0	0.019	0.000	0.008		8/19/2013 17:00	0.01482542
8/16/2013 1:30	34200	-0.005	59.785	-0.012	14.549	0	0.013	0.000	0.003		8/19/2013 18:00	0.00648911
8/16/2013 1:31	34260	-0.004	59.785	-0.008	14.549	0	0.017	0.000	0.006		8/19/2013 19:00	0.01096705
8/16/2013 1:32	34320	-0.001	59.785	-0.003	14.547	0	0.022	0.000	0.012		8/19/2013 20:00	0.00503001
8/16/2013 1:33	34380	0.002	59.785	0.005	14.546	4.894E-06	0.030	0.000	0.025		8/19/2013 21:00	0.00373591
8/16/2013 1:34	34440	-0.004	59.785	-0.01	14.549	0	0.015	0.000	0.004		8/19/2013 22:00	0.00485229
8/16/2013 1:35	34500	-0.005	59.785	-0.011	14.55	0	0.014	0.000	0.004		8/19/2013 23:00	0.00317614
8/16/2013 1:36	34560	-0.001	59.785	-0.001	14.546	0	0.024	0.000	0.014		8/20/2013 0:00	0.00199914
8/16/2013 1:37	34620	-0.004	59.785	-0.01	14.55	0	0.015	0.000	0.004		8/20/2013 1:00	0.00183052
8/16/2013 1:38	34680	-0.007	59.785	-0.015	14.55	0	0.010	0.000	0.002		8/20/2013 2:00	0.00147579
8/16/2013 1:39	34740	-0.004	59.785	-0.01	14.547	0	0.015	0.000	0.004		8/20/2013 3:00	0.00136868
8/16/2013 1:40	34800	-0.008	59.785	-0.018	14.55	0	0.007	0.000	0.001		8/20/2013 4:00	0.00099824
8/16/2013 1:41	34860	-0.007	59.693	-0.016	14.547	0	0.009	0.000	0.001		8/20/2013 5:00	0.00085527
8/16/2013 1:42	34920	-0.008	59.693	-0.019	14.548	0	0.006	0.000	0.000		8/20/2013 6:00	0.00068438
8/16/2013 1:43	34980	-0.007	59.785	-0.016	14.548	0	0.009	0.000	0.001		8/20/2013 7:00	0.00062971
8/16/2013 1:44	35040	-0.004	59.693	-0.01	14.548	0	0.015	0.000	0.004		8/20/2013 8:00	0.00038499
8/16/2013 1:45	35100	-0.006	59.693	-0.013	14.551	0	0.012	0.000	0.003		8/20/2013 9:00	0.00034624
8/16/2013 1:46	35160	0	59.785	-0.001	14.546	0	0.024	0.000	0.014		8/20/2013 10:00	0.00032241
8/16/2013 1:47	35220	-0.005	59.785	-0.011	14.55	0	0.014	0.000	0.004		8/20/2013 11:00	0.00035323
8/16/2013 1:48	35280	-0.004	59.785	-0.009	14.548	0	0.016	0.000	0.005		8/20/2013 12:00	0.00032669
8/16/2013 1:49	35340	-0.002	59.693	-0.004	14.546	0	0.021	0.000	0.010		8/20/2013 13:00	0.00028633
8/16/2013 1:50	35400	-0.002	59.693	-0.006	14.547	0	0.019	0.000	0.008		8/20/2013 14:00	0.00022060
8/16/2013 1:51	35460	-0.008	59.693	-0.02	14.55	0	0.005	0.000	0.000		8/20/2013 15:00	0.00020870
8/16/2013 1:52	35520	-0.005	59.693	-0.013	14.548	0	0.012	0.000	0.003		8/20/2013 16:00	0.00677943
8/16/2013 1:53	35580	-0.011	59.693	-0.025	14.55	0	0.000	0.000	0.000		8/20/2013 17:00	0.01353568
8/16/2013 1:54	35640	-0.008	59.693	-0.017	14.549	0	0.008	0.000	0.001		8/20/2013 18:00	0.00951828
8/16/2013 1:55	35700	-0.011	59.601	-0.025	14.549	0	0.000	0.000	0.000		8/20/2013 19:00	0.01755948
8/16/2013 1:56	35760	-0.004	59.693	-0.009	14.548	0	0.016	0.000	0.005		8/20/2013 20:00	0.00850504
8/16/2013 1:57	35820	-0.007	59.693	-0.015	14.552	0	0.010	0.000	0.002		8/20/2013 21:00	0.00309798
8/16/2013 1:58	35880	-0.009	59.693	-0.02	14.551	0	0.005	0.000	0.000		8/20/2013 22:00	0.00168028
8/16/2013 1:59	35940	-0.006	59.601	-0.014	14.549	0	0.011	0.000	0.002		8/20/2013 23:00	0.00136635
8/16/2013 2:00	36000	-0.009	59.693	-0.02	14.549	0	0.005	0.000	0.000		8/21/2013 0:00	0.00134933
8/16/2013 2:01	36060	-0.004	59.693	-0.01	14.548	0	0.015	0.000	0.004		8/21/2013 1:00	0.00103051
8/16/2013 2:02	36120	-0.002	59.601	-0.005	14.547	0	0.020	0.000	0.009		8/21/2013 2:00	0.00129868
8/16/2013 2:03	36180	0	59.693	0.001	14.545	9.041E-08	0.026	0.000	0.018		8/21/2013 3:00	0.00731876
8/16/2013 2:04	36240	-0.004	59.601	-0.01	14.547	0	0.015	0.000	0.004		8/21/2013 4:00	0.01515610
8/16/2013 2:05	36300	-0.006	59.601	-0.013	14.548	0	0.012	0.000	0.003		8/21/2013 5:00	0.01265032
8/16/2013 2:06	36360	-0.005	59.601	-0.012	14.546	0	0.013	0.000	0.003		8/21/2013 6:00	0.00718472
8/16/2013 2:07	36420	-0.008	59.601	-0.018	14.549	0	0.007	0.000	0.001		8/21/2013 7:00	0.00372321
8/16/2013 2:08	36480	-0.007	59.601	-0.017	14.547	0	0.008	0.000	0.001		8/21/2013 8:00	0.00529605
8/16/2013 2:09	36540	-0.008	59.601	-0.018	14.548	0	0.007	0.000	0.001		8/21/2013 9:00	0.00423353
8/16/2013 2:10	36600	-0.006	59.601	-0.015	14.547	0	0.010	0.000	0.002		8/21/2013 10:00	0.00407726
8/16/2013 2:11	36660	-0.005	59.601	-0.011	14.545	0	0.014	0.000	0.004		8/21/2013 11:00	0.01425206

Date and Time	Seconds	Pressure (PSI)	Temperature (C)	Level Surface Elevation (ft)	Barometric Pressure (PSI)	Flow (cfs)	Zero Line Offset Adjusted Surface Elevation (ft)	Zero Line Offset Adjusted Flow (cfs)	*This assumes constant flow over 1 minute interval.			
									Volume of water* (cubic feet)	Total Volume	Averaged Time	Average Flow (cfs)
8/16/2013 2:12	36720	-0.006	59.601	-0.014	14.545	0	0.011	0.000	0.002		8/21/2013 12:00	0.01646895
8/16/2013 2:13	36780	-0.004	59.601	-0.009	14.545	0	0.016	0.000	0.005		8/21/2013 13:00	0.01704210
8/16/2013 2:14	36840	-0.003	59.601	-0.006	14.544	0	0.019	0.000	0.008		8/21/2013 14:00	0.01536197
8/16/2013 2:15	36900	-0.004	59.601	-0.01	14.545	0	0.015	0.000	0.004		8/21/2013 15:00	0.01425222
8/16/2013 2:16	36960	-0.002	59.601	-0.004	14.545	0	0.021	0.000	0.010		8/21/2013 16:00	0.00900352
8/16/2013 2:17	37020	-0.006	59.601	-0.015	14.544	0	0.010	0.000	0.002		8/21/2013 17:00	0.00797167
8/16/2013 2:18	37080	-0.006	59.601	-0.014	14.547	0	0.011	0.000	0.002		8/21/2013 18:00	0.00766866
8/16/2013 2:19	37140	0.001	59.601	0.003	14.542	1.379E-06	0.028	0.000	0.021		8/21/2013 19:00	0.01185509
8/16/2013 2:20	37200	-0.005	59.601	-0.011	14.544	0	0.014	0.000	0.004		8/21/2013 20:00	0.01178927
8/16/2013 2:21	37260	-0.003	59.601	-0.006	14.544	0	0.019	0.000	0.008		8/21/2013 21:00	0.00850082
8/16/2013 2:22	37320	-0.003	59.601	-0.006	14.544	0	0.019	0.000	0.008		8/21/2013 22:00	0.00677433
8/16/2013 2:23	37380	-0.003	59.601	-0.008	14.543	0	0.017	0.000	0.006		8/21/2013 23:00	0.02042982
8/16/2013 2:24	37440	-0.002	59.601	-0.006	14.546	0	0.019	0.000	0.008		8/22/2013 0:00	0.02301203
8/16/2013 2:25	37500	-0.003	59.601	-0.006	14.543	0	0.019	0.000	0.008		8/22/2013 1:00	0.01708674
8/16/2013 2:26	37560	-0.006	59.601	-0.014	14.546	0	0.011	0.000	0.002		8/22/2013 2:00	0.01327167
8/16/2013 2:27	37620	-0.003	59.601	-0.008	14.545	0	0.017	0.000	0.006		8/22/2013 3:00	0.01233762
8/16/2013 2:28	37680	-0.003	59.601	-0.008	14.544	0	0.017	0.000	0.006		8/22/2013 4:00	0.00777272
8/16/2013 2:29	37740	-0.002	59.601	-0.004	14.542	0	0.021	0.000	0.010		8/22/2013 5:00	0.00963786
8/16/2013 2:30	37800	0	59.509	0	14.542	0	0.025	0.000	0.016		8/22/2013 6:00	0.02356714
8/16/2013 2:31	37860	-0.002	59.601	-0.006	14.547	0	0.019	0.000	0.008		8/22/2013 7:00	0.03754118
8/16/2013 2:32	37920	-0.001	59.601	-0.003	14.542	0	0.022	0.000	0.012		8/22/2013 8:00	0.01053638
8/16/2013 2:33	37980	0.003	59.601	0.008	14.542	1.57E-05	0.033	0.001	0.032		8/22/2013 9:00	0.00370366
8/16/2013 2:34	38040	-0.003	59.601	-0.007	14.546	0	0.018	0.000	0.007		8/22/2013 10:00	0.01123112
8/16/2013 2:35	38100	-0.002	59.601	-0.004	14.543	0	0.021	0.000	0.010		8/22/2013 11:00	0.03510510
8/16/2013 2:36	38160	-0.003	59.601	-0.008	14.543	0	0.017	0.000	0.006		8/22/2013 12:00	0.01868954
8/16/2013 2:37	38220	-0.005	59.601	-0.011	14.546	0	0.014	0.000	0.004		8/22/2013 13:00	0.02480387
8/16/2013 2:38	38280	-0.003	59.601	-0.008	14.543	0	0.017	0.000	0.006		8/22/2013 14:00	0.01662458
8/16/2013 2:39	38340	0	59.601	-0.001	14.542	0	0.024	0.000	0.014		8/22/2013 15:00	0.00909146
8/16/2013 2:40	38400	-0.004	59.601	-0.009	14.546	0	0.016	0.000	0.005		8/22/2013 16:00	0.00726548
8/16/2013 2:41	38460	0	59.601	-0.001	14.543	0	0.024	0.000	0.014		8/22/2013 17:00	0.00303714
8/16/2013 2:42	38520	0.001	59.601	0.003	14.542	1.379E-06	0.028	0.000	0.021		8/22/2013 18:00	0.00374540
8/16/2013 2:43	38580	0	59.601	-0.001	14.544	0	0.024	0.000	0.014		8/22/2013 19:00	0.00285937
8/16/2013 2:44	38640	0	59.601	0.001	14.541	9.041E-08	0.026	0.000	0.018		8/22/2013 20:00	0.01123474
8/16/2013 2:45	38700	-0.006	59.601	-0.015	14.543	0	0.010	0.000	0.002		8/22/2013 21:00	0.00482633
8/16/2013 2:46	38760	0	59.601	-0.001	14.542	0	0.024	0.000	0.014		8/22/2013 22:00	0.00292085
8/16/2013 2:47	38820	-0.005	59.601	-0.011	14.544	0	0.014	0.000	0.004		8/22/2013 23:00	0.00221270
8/16/2013 2:48	38880	-0.004	59.509	-0.008	14.543	0	0.017	0.000	0.006		8/23/2013 0:00	0.00172629
8/16/2013 2:49	38940	-0.002	59.509	-0.005	14.543	0	0.020	0.000	0.009		8/23/2013 1:00	0.00182241
8/16/2013 2:50	39000	-0.006	59.509	-0.013	14.544	0	0.012	0.000	0.003		8/23/2013 2:00	0.00152799
8/16/2013 2:51	39060	-0.004	59.509	-0.009	14.545	0	0.016	0.000	0.005		8/23/2013 3:00	0.00133991
8/16/2013 2:52	39120	-0.009	59.601	-0.021	14.546	0	0.004	0.000	0.000		8/23/2013 4:00	0.00090221
8/16/2013 2:53	39180	-0.003	59.509	-0.006	14.545	0	0.019	0.000	0.008		8/23/2013 5:00	0.00088450
8/16/2013 2:54	39240	-0.008	59.509	-0.018	14.545	0	0.007	0.000	0.001		8/23/2013 6:00	0.00073093
8/16/2013 2:55	39300	-0.003	59.509	-0.006	14.545	0	0.019	0.000	0.008		8/23/2013 7:00	0.00093885

Date and Time	Seconds	Pressure (PSI)	Temperature (C)	Level Surface Elevation (ft)	Barometric Pressure (PSI)	Flow (cfs)	Zero Line Offset	Zero Line Offset	*This assumes constant flow over 1 minute interval.			
							Adjusted Surface Elevation (ft)	Adjusted Flow (cfs)	Volume of water* (cubic feet)	Total Volume	Averaged Time	Average Flow (cfs)
8/16/2013 2:56	39360	-0.005	59.509	-0.011	14.546	0	0.014	0.000	0.004		8/23/2013 8:00	0.00748053
8/16/2013 2:57	39420	-0.008	59.509	-0.018	14.546	0	0.007	0.000	0.001		8/23/2013 9:00	0.00395426
8/16/2013 2:58	39480	0	59.509	0.001	14.542	9.041E-08	0.026	0.000	0.018		8/23/2013 10:00	0.00192046
8/16/2013 2:59	39540	-0.002	59.509	-0.004	14.542	0	0.021	0.000	0.010		8/23/2013 11:00	0.00138010
8/16/2013 3:00	39600	0	59.509	0.001	14.541	9.041E-08	0.026	0.000	0.018		8/23/2013 12:00	0.00096011
8/16/2013 3:01	39660	-0.005	59.509	-0.011	14.543	0	0.014	0.000	0.004		8/23/2013 13:00	0.00054869
8/16/2013 3:02	39720	-0.002	59.509	-0.004	14.542	0	0.021	0.000	0.010		8/23/2013 14:00	0.00036174
8/16/2013 3:03	39780	0	59.509	0	14.542	0	0.025	0.000	0.016		8/23/2013 15:00	0.00023767
8/16/2013 3:04	39840	-0.002	59.509	-0.006	14.542	0	0.019	0.000	0.008		8/23/2013 16:00	0.00020842
8/16/2013 3:05	39900	0.002	59.509	0.005	14.539	4.894E-06	0.030	0.000	0.025		8/23/2013 17:00	0.00024891
8/16/2013 3:06	39960	-0.004	59.417	-0.01	14.542	0	0.015	0.000	0.004		8/23/2013 18:00	0.00023752
8/16/2013 3:07	40020	-0.001	59.509	-0.002	14.541	0	0.023	0.000	0.013		8/23/2013 19:00	0.00035350
8/16/2013 3:08	40080	-0.005	59.417	-0.011	14.543	0	0.014	0.000	0.004		8/23/2013 20:00	0.00033665
8/16/2013 3:09	40140	-0.005	59.417	-0.013	14.544	0	0.012	0.000	0.003		8/23/2013 21:00	0.00030374
8/16/2013 3:10	40200	-0.002	59.509	-0.004	14.542	0	0.021	0.000	0.010		8/23/2013 22:00	0.00034732
8/16/2013 3:11	40260	0	59.509	0	14.544	0	0.025	0.000	0.016		8/23/2013 23:00	0.00071832
8/16/2013 3:12	40320	0	59.417	-0.001	14.54	0	0.024	0.000	0.014		8/24/2013 0:00	0.00456086
8/16/2013 3:13	40380	-0.002	59.417	-0.004	14.542	0	0.021	0.000	0.010		8/24/2013 1:00	0.01744563
8/16/2013 3:14	40440	-0.001	59.417	-0.002	14.541	0	0.023	0.000	0.013		8/24/2013 2:00	0.00474870
8/16/2013 3:15	40500	0.001	59.417	0.001	14.541	9.041E-08	0.026	0.000	0.018		8/24/2013 3:00	0.00218471
8/16/2013 3:16	40560	0.001	59.417	0.003	14.538	1.379E-06	0.028	0.000	0.021		8/24/2013 4:00	0.00156746
8/16/2013 3:17	40620	0	59.417	0	14.54	0	0.025	0.000	0.016		8/24/2013 5:00	0.00119573
8/16/2013 3:18	40680	-0.001	59.417	-0.003	14.543	0	0.022	0.000	0.012		8/24/2013 6:00	0.00091453
8/16/2013 3:19	40740	0.002	59.326	0.003	14.54	1.379E-06	0.028	0.000	0.021		8/24/2013 7:00	0.00065167
8/16/2013 3:20	40800	0.001	59.417	0.002	14.541	5.044E-07	0.027	0.000	0.019		8/24/2013 8:00	0.00059721
8/16/2013 3:21	40860	-0.006	59.326	-0.013	14.545	0	0.012	0.000	0.003		8/24/2013 9:00	0.00044679
8/16/2013 3:22	40920	-0.007	59.417	-0.016	14.544	0	0.009	0.000	0.001		8/24/2013 10:00	0.00053100
8/16/2013 3:23	40980	-0.002	59.326	-0.005	14.542	0	0.020	0.000	0.009		8/24/2013 11:00	0.00040155
8/16/2013 3:24	41040	-0.003	59.326	-0.008	14.541	0	0.017	0.000	0.006		8/24/2013 12:00	0.00050269
8/16/2013 3:25	41100	0.001	59.326	0.002	14.538	5.044E-07	0.027	0.000	0.019		8/24/2013 13:00	0.00044835
8/16/2013 3:26	41160	-0.004	59.326	-0.009	14.543	0	0.016	0.000	0.005		8/24/2013 14:00	0.00037846
8/16/2013 3:27	41220	-0.002	59.417	-0.006	14.541	0	0.019	0.000	0.008		8/24/2013 15:00	0.00029250
8/16/2013 3:28	41280	-0.005	59.326	-0.011	14.544	0	0.014	0.000	0.004		8/24/2013 16:00	0.00027678
8/16/2013 3:29	41340	-0.006	59.326	-0.014	14.541	0	0.011	0.000	0.002		8/24/2013 17:00	0.00017211
8/16/2013 3:30	41400	-0.007	59.326	-0.016	14.545	0	0.009	0.000	0.001		8/24/2013 18:00	0.00016912
8/16/2013 3:31	41460	-0.003	59.326	-0.007	14.541	0	0.018	0.000	0.007		8/24/2013 19:00	0.00012009
8/16/2013 3:32	41520	-0.006	59.326	-0.014	14.543	0	0.011	0.000	0.002		8/24/2013 20:00	0.00014576
8/16/2013 3:33	41580	-0.009	59.326	-0.021	14.543	0	0.004	0.000	0.000		8/24/2013 21:00	0.00021502
8/16/2013 3:34	41640	-0.004	59.326	-0.009	14.541	0	0.016	0.000	0.005		8/24/2013 22:00	0.00029729
8/16/2013 3:35	41700	0.001	59.326	0.002	14.54	5.044E-07	0.027	0.000	0.019		8/24/2013 23:00	0.00030036
8/16/2013 3:36	41760	-0.003	59.326	-0.007	14.54	0	0.018	0.000	0.007		8/25/2013 0:00	0.00035470
8/16/2013 3:37	41820	-0.007	59.326	-0.016	14.541	0	0.009	0.000	0.001		**Peak =**	**0.05566719**
8/16/2013 3:38	41880	-0.003	59.326	-0.007	14.54	0	0.018	0.000	0.007			
9/4/2013 0:00	484800	0.009		0.022	14.375	0.0001929	0.047	0.001	0.076	**3,443**	9/4/2013 0:00	0

Date and Time	Seconds	Pressure (PSI)	Temperature (C)	Level Surface Elevation (ft)	Barometric Pressure (PSI)	Flow (cfs)	Zero Line Offset	Zero Line Offset	*This assumes constant flow over 1 minute interval.			
							Adjusted Surface Elevation (ft)	Adjusted Flow (cfs)	Volume of water* (cubic feet)	Total Volume	Averaged Time	Average Flow (cfs)
9/4/2013 0:01	484860	0.012		0.027	14.372	0.0003206	0.052	0.002	0.098		9/4/2013 0:30	0.001
9/4/2013 0:02	484920	0.009		0.02	14.375	0.0001523	0.045	0.001	0.068		9/4/2013 1:00	0.007
9/4/2013 0:03	484980	0.01		0.023	14.375	0.0002154	0.048	0.001	0.080		9/4/2013 1:30	0.043
9/4/2013 0:04	485040	0.009		0.022	14.374	0.0001929	0.047	0.001	0.076		9/4/2013 2:00	0.042
9/4/2013 0:05	485100	0.006		0.015	14.376	7.463E-05	0.040	0.001	0.051		9/4/2013 2:30	0.024
9/4/2013 0:06	485160	0.013		0.03	14.373	0.0004164	0.055	0.002	0.112		9/4/2013 3:00	0.016
9/4/2013 0:07	485220	0.014		0.031	14.373	0.0004516	0.056	0.002	0.117		9/4/2013 3:30	0.041
9/4/2013 0:08	485280	0.012		0.027	14.374	0.0003206	0.052	0.002	0.098		9/4/2013 4:00	0.057
9/4/2013 0:09	485340	0.007		0.016	14.372	8.758E-05	0.041	0.001	0.054		9/4/2013 4:30	0.076
9/4/2013 0:10	485400	0.013		0.03	14.372	0.0004164	0.055	0.002	0.112		9/4/2013 5:00	0.091
9/4/2013 0:11	485460	0.008		0.018	14.378	0.0001173	0.043	0.001	0.061		9/4/2013 5:30	0.058
9/4/2013 0:12	485520	0.004		0.009	14.375	2.102E-05	0.034	0.001	0.034		9/4/2013 6:00	0.018
9/4/2013 0:13	485580	0.002		0.004	14.376	2.814E-06	0.029	0.000	0.023		9/4/2013 6:30	0.009
9/4/2013 0:14	485640	0.013		0.03	14.371	0.0004164	0.055	0.002	0.112		9/4/2013 7:00	0.006
9/4/2013 0:15	485700	0.01		0.022	14.372	0.0001929	0.047	0.001	0.076		9/4/2013 7:30	0.005
9/4/2013 0:16	485760	0.013		0.031	14.369	0.0004516	0.056	0.002	0.117		9/4/2013 8:00	0.003
9/4/2013 0:17	485820	0.011		0.024	14.373	0.0002394	0.049	0.001	0.084		9/4/2013 8:30	0.003
9/4/2013 0:18	485880	0.012		0.028	14.37	0.0003509	0.053	0.002	0.102		9/4/2013 9:00	0.004
9/4/2013 0:19	485940	0.01		0.022	14.374	0.0001929	0.047	0.001	0.076		9/4/2013 9:30	0.005
9/4/2013 0:20	486000	0.011		0.024	14.373	0.0002394	0.049	0.001	0.084		9/4/2013 10:00	0.005
9/4/2013 0:21	486060	0.012		0.027	14.374	0.0003206	0.052	0.002	0.098		9/4/2013 10:30	0.004
9/4/2013 0:22	486120	0.006		0.014	14.376	6.289E-05	0.039	0.001	0.048		9/4/2013 11:00	0.007
9/4/2013 0:23	486180	0.008		0.019	14.374	0.0001341	0.044	0.001	0.065		9/4/2013 11:30	0.012
9/4/2013 0:24	486240	0.009		0.021	14.373	0.0001719	0.046	0.001	0.072		9/4/2013 12:00	0.009
9/4/2013 0:25	486300	0.013		0.029	14.373	0.0003828	0.054	0.002	0.107		9/4/2013 12:30	0.022
9/4/2013 0:26	486360	0.01		0.024	14.374	0.0002394	0.049	0.001	0.084		9/4/2013 13:00	0.069
9/4/2013 0:27	486420	0.01		0.022	14.374	0.0001929	0.047	0.001	0.076		9/4/2013 13:30	0.042
9/4/2013 0:28	486480	0.007		0.017	14.374	0.0001018	0.042	0.001	0.058		9/4/2013 14:00	0.042
9/4/2013 0:29	486540	0.008		0.019	14.376	0.0001341	0.044	0.001	0.065		9/4/2013 14:30	0.017
9/4/2013 0:30	486600	0.015		0.034	14.369	0.0005679	0.059	0.002	0.134		9/4/2013 15:00	0.010
9/4/2013 0:31	486660	0.009		0.02	14.371	0.0001523	0.045	0.001	0.068		9/4/2013 15:30	0.012
9/4/2013 0:32	486720	0.01		0.023	14.372	0.0002154	0.048	0.001	0.080		9/4/2013 16:00	0.058
9/4/2013 0:33	486780	0.009		0.02	14.372	0.0001523	0.045	0.001	0.068		9/4/2013 16:30	0.061
9/4/2013 0:34	486840	0.008		0.018	14.374	0.0001173	0.043	0.001	0.061		9/4/2013 17:00	0.116
9/4/2013 0:35	486900	0.006		0.014	14.376	6.289E-05	0.039	0.001	0.048		9/4/2013 17:30	0.045
9/4/2013 0:36	486960	0.007		0.017	14.373	0.0001018	0.042	0.001	0.058		9/4/2013 18:00	0.041
9/4/2013 0:37	487020	0.006		0.013	14.372	5.233E-05	0.038	0.001	0.045		9/4/2013 18:30	0.040
9/4/2013 0:38	487080	0.007		0.015	14.376	7.463E-05	0.040	0.001	0.051		9/4/2013 19:00	0.040
9/4/2013 0:39	487140	0.014		0.033	14.373	0.0005274	0.058	0.002	0.128		9/4/2013 19:30	0.087
9/4/2013 0:40	487200	0.01		0.022	14.372	0.0001929	0.047	0.001	0.076		9/4/2013 20:00	0.169
9/4/2013 0:41	487260	0.01		0.024	14.371	0.0002394	0.049	0.001	0.084		9/4/2013 20:30	0.083
9/4/2013 0:42	487320	0.01		0.023	14.373	0.0002154	0.048	0.001	0.080		9/4/2013 21:00	0.098
9/4/2013 0:43	487380	0.004		0.01	14.376	2.73E-05	0.035	0.001	0.037		9/4/2013 21:30	0.158
9/4/2013 0:44	487440	0.012		0.027	14.373	0.0003206	0.052	0.002	0.098		9/4/2013 22:00	0.079

Date and Time	Seconds	Pressure (PSI)	Temperature (C)	Level Surface Elevation (ft)	Barometric Pressure (PSI)	Flow (cfs)	Zero Line Offset	Zero Line Offset	*This assumes constant flow over 1 minute interval.			
							Adjusted Surface Elevation (ft)	Adjusted Flow (cfs)	Volume of water* (cubic feet)	Total Volume	Averaged Time	Average Flow (cfs)
9/4/2013 0:45	487500	0.007		0.016	14.374	8.758E-05	0.041	0.001	0.054		9/4/2013 22:30	0.037
9/4/2013 0:46	487560	0.007		0.017	14.372	0.0001018	0.042	0.001	0.058		9/4/2013 23:00	0.020
9/4/2013 0:47	487620	0.009		0.021	14.374	0.0001719	0.046	0.001	0.072		9/4/2013 23:30	0.012
9/4/2013 0:48	487680	0.008		0.019	14.373	0.0001341	0.044	0.001	0.065		9/5/2013 0:00	0.008
9/4/2013 0:49	487740	0.008		0.019	14.375	0.0001341	0.044	0.001	0.065		Peak Hour =	0.168608144
9/4/2013 0:50	487800	0.008		0.019	14.375	0.0001341	0.044	0.001	0.065			
9/5/2013 0:00	571200	0.024		0.056	14.567	0.0019575	0.081	0.005	0.293	**1,270**	9/25/13 0:00	
9/25/2013 0:00	1157400	-0.004		-0.01	14.579	0	0.000	0.000	0.000		0:59	0
9/25/2013 0:01	1157460	-0.006		-0.013	14.579	0	0.000	0.000	0.000		1:29	0.011
9/25/2013 0:02	1157520	-0.003		-0.007	14.579	0	0.000	0.000	0.000		1:59	0.026
9/25/2013 0:03	1157580	-0.002		-0.005	14.578	0	0.000	0.000	0.000		2:29	0.013
9/25/2013 0:04	1157640	-0.003		-0.008	14.58	0	0.000	0.000	0.000		2:59	0.012
9/25/2013 0:05	1157700	0.001		0.002	14.578	5.044E-07	0.002	0.000	0.000		3:29	0.013
9/25/2013 0:06	1157760	0		0.001	14.581	9.041E-08	0.001	0.000	0.000		3:59	0.015
9/25/2013 0:07	1157820	-0.006		-0.013	14.582	0	0.000	0.000	0.000		4:29	0.018
9/25/2013 0:08	1157880	-0.003		-0.008	14.581	0	0.000	0.000	0.000		4:59	0.014
9/25/2013 0:09	1157940	-0.001		-0.002	14.578	0	0.000	0.000	0.000		5:29	0.008
9/25/2013 0:10	1158000	-0.004		-0.009	14.58	0	0.000	0.000	0.000		5:59	0.007
9/25/2013 0:11	1158060	-0.003		-0.008	14.578	0	0.000	0.000	0.000		6:29	0.020
9/25/2013 0:12	1158120	-0.008		-0.018	14.58	0	0.000	0.000	0.000		6:59	0.027
9/25/2013 0:13	1158180	-0.006		-0.015	14.579	0	0.000	0.000	0.000		7:29	0.109
9/25/2013 0:14	1158240	-0.002		-0.004	14.578	0	0.000	0.000	0.000		7:59	0.076
9/25/2013 0:15	1158300	-0.004		-0.009	14.578	0	0.000	0.000	0.000		8:29	0.093
9/25/2013 0:16	1158360	-0.003		-0.008	14.576	0	0.000	0.000	0.000		8:59	0.067
9/25/2013 0:17	1158420	-0.005		-0.011	14.578	0	0.000	0.000	0.000		9:29	0.071
9/25/2013 0:18	1158480	-0.012		-0.029	14.578	0	0.000	0.000	0.000		9:59	0.040
9/25/2013 0:19	1158540	-0.002		-0.005	14.571	0	0.000	0.000	0.000		10:29	0.014
9/25/2013 0:20	1158600	-0.003		-0.006	14.575	0	0.000	0.000	0.000		10:59	0.006
9/25/2013 0:21	1158660	-0.006		-0.013	14.575	0	0.000	0.000	0.000		11:29	0.003
9/25/2013 0:22	1158720	-0.005		-0.013	14.577	0	0.000	0.000	0.000		11:59	0.002
9/25/2013 0:23	1158780	-0.008		-0.018	14.576	0	0.000	0.000	0.000		12:29	0.001
9/25/2013 0:24	1158840	-0.003		-0.008	14.572	0	0.000	0.000	0.000		12:59	0.001
9/25/2013 0:25	1158900	-0.009		-0.022	14.575	0	0.000	0.000	0.000		13:29	0.000
9/25/2013 0:26	1158960	-0.001		-0.003	14.573	0	0.000	0.000	0.000		13:59	0.000
9/25/2013 0:27	1159020	-0.007		-0.016	14.575	0	0.000	0.000	0.000		14:29	0.001
9/25/2013 0:28	1159080	0.002		0.004	14.57	2.814E-06	0.004	0.000	0.000		14:59	0.002
9/25/2013 0:29	1159140	-0.003		-0.006	14.57	0	0.000	0.000	0.000		15:29	0.002
9/25/2013 0:30	1159200	-0.003		-0.006	14.57	0	0.000	0.000	0.000		15:59	0.001
9/25/2013 0:31	1159260	-0.006		-0.013	14.574	0	0.000	0.000	0.000		16:29	0.000
9/25/2013 0:32	1159320	0.001		0.002	14.567	5.044E-07	0.002	0.000	0.000		16:59	0.000
9/25/2013 0:33	1159380	-0.002		-0.005	14.57	0	0.000	0.000	0.000		17:29	0.000
9/25/2013 0:34	1159440	-0.005		-0.011	14.572	0	0.000	0.000	0.000		17:59	0.000
9/25/2013 0:35	1159500	-0.001		-0.003	14.572	0	0.000	0.000	0.000		18:29	0.000
9/25/2013 0:36	1159560	0		-0.001	14.571	0	0.000	0.000	0.000		18:59	0.001

Date and Time	Seconds	Pressure (PSI)	Temperature (C)	Level Surface Elevation (ft)	Barometric Pressure (PSI)	Flow (cfs)	Zero Line Offset Adjusted Surface Elevation (ft)	Zero Line Offset Adjusted Flow (cfs)	*This assumes constant flow over 1 minute interval.			
									Volume of water* (cubic feet)	Total Volume	Averaged Time	Average Flow (cfs)
9/25/2013 0:37	1159620	-0.002		-0.006	14.573	0	0.000	0.000	0.000		19:29	0.003
9/25/2013 0:38	1159680	-0.007		-0.016	14.572	0	0.000	0.000	0.000		19:59	0.002
9/25/2013 0:39	1159740	-0.003		-0.006	14.571	0	0.000	0.000	0.000		20:29	0.001
9/25/2013 0:40	1159800	-0.006		-0.014	14.573	0	0.000	0.000	0.000		20:59	0.000
9/25/2013 0:41	1159860	-0.003		-0.008	14.575	0	0.000	0.000	0.000		21:29	0.000
9/25/2013 0:42	1159920	-0.003		-0.007	14.574	0	0.000	0.000	0.000		21:59	0.000
9/25/2013 0:43	1159980	-0.007		-0.017	14.572	0	0.000	0.000	0.000		22:29	0.001
9/25/2013 0:44	1160040	-0.004		-0.01	14.569	0	0.000	0.000	0.000		22:59	0.005
9/25/2013 0:45	1160100	-0.005		-0.011	14.575	0	0.000	0.000	0.000		23:29	0.011
9/25/2013 0:46	1160160	-0.004		-0.01	14.573	0	0.000	0.000	0.000		23:59	0.002
9/25/2013 0:47	1160220	-0.004		-0.009	14.574	0	0.000	0.000	0.000		Peak =	0.109068806

Appendix G: Taku Lake Data and Calculations

1. NCDC AIA Rainfall/Pressure Data and Inflow Calculations
2. Raw Pressure Transducer Data
3. Corrected Pressure Transducer Data and Outflow Calculations

Impervious Parking Area: 12150 SF
Additional Impervious Area (75%): 6629 SF
Pervious Area (30%): 6803 SF
Sum **25582** SF

NCDC Data from AIA				Calculated Values		
Date	**Time**	**SeaLevel Pressure (InHg)**	**Rainfall (inches)**	**Inflow (cfs)**	**Total Rainfall (inches)**	**Inflow Volume (cf)**
7/21/2012	53	29.85		0	0.53	1130
7/21/2012	153	29.86		0		
7/21/2012	253	29.85		0		
7/21/2012	353	29.86	0.02	0.012		
7/21/2012	453	29.86	0.04	0.024		
7/21/2012	553	29.87	0.05	0.030		
7/21/2012	653	29.86	0.01	0.006		
7/21/2012	753	29.86	0.01	0.006		
7/21/2012	853	29.86		0.000		
7/21/2012	953	29.87	0.03	0.018		
7/21/2012	1053	29.87	0.06	0.036		
7/21/2012	1153	29.88	0.09	0.053		
7/21/2012	1253	29.87	0.03	0.018		
7/21/2012	1353	29.87		0.000		
7/21/2012	1453	29.87		0.000		
7/21/2012	1553	29.88		0.000		
7/21/2012	1653	29.88	0.06	0.036		
7/21/2012	1753	29.87	0.05	0.030		
7/21/2012	1853	29.89	0.03	0.018		
7/21/2012	1953	29.89	0.01	0.006		
7/21/2012	2053	29.89	0.01	0.006		
7/21/2012	2153	29.9	0.01	0.006		
7/21/2012	2253	29.89	0.01	0.006		
7/21/2012	2353	29.89	0.01	0.006		
				Peak = 0.053		

NCDC Data from AIA				Calculated Values		
Date	Time	SeaLevel Pressure (InHg)	Rainfall (inches)	Inflow (cfs)	Total Rainfall (inches)	Inflow Volume (cf)
9/19/2012	53	29.81	0	0.000	1.41	3006
9/19/2012	153	29.8	0.01	0.006		
9/19/2012	253	29.76	0.01	0.006		
9/19/2012	353	29.72	0.01	0.006		
9/19/2012	453	29.69	0.01	0.006		
9/19/2012	553	29.65	0.01	0.006		
9/19/2012	653	29.62	0.03	0.018		
9/19/2012	753	29.61	0.03	0.018		
9/19/2012	853	29.59	0.02	0.012		
9/19/2012	953	29.54	0.08	0.047		
9/19/2012	1053	29.55	0.08	0.047		
9/19/2012	1153	29.51	0.06	0.036		
9/19/2012	1253	29.49	0.08	0.047		
9/19/2012	1353	29.49	0.13	0.077		
9/19/2012	1453	29.48	0.17	0.101		
9/19/2012	1553	29.51	0.16	0.095		
9/19/2012	1653	29.48	0.14	0.083		
9/19/2012	1753	29.47	0.1	0.059		
9/19/2012	1853	29.48	0.1	0.059		
9/19/2012	1953	29.51	0.1	0.059		
9/19/2012	2053	29.53	0.08	0.047		
9/19/2012	2153	29.56	0	0.000		
9/19/2012	2253	29.59	0	0.000		
9/19/2012	2353	29.62	0	0.000		
				Peak =		
				0.101		

Date and Time	Sensor: Pres(A) 35.8ft SN#: 316634 Pressure (PSI)	Sensor: Pres(A) 35.8ft SN#: 316634 Temperature (C)	Sensor: Pres(A) 35.8ft SN#: 316634 Depth (ft)
7/21/2012 0:08	14.631	12.465	33.782
7/21/2012 0:23	14.627	12.439	33.774
7/21/2012 0:38	14.628	12.421	33.775
7/21/2012 0:53	14.63	12.427	33.781
7/21/2012 1:08	14.633	12.43	33.787
7/21/2012 1:23	14.635	12.424	33.792
7/21/2012 1:38	14.639	12.415	33.801
7/21/2012 1:53	14.644	12.397	33.813
7/21/2012 2:08	14.646	12.359	33.817
7/21/2012 2:23	14.647	12.357	33.818
7/21/2012 2:38	14.647	12.347	33.818
7/21/2012 2:53	14.645	12.339	33.816
7/21/2012 3:08	14.644	12.295	33.814
7/21/2012 3:23	14.642	12.29	33.808
7/21/2012 3:38	14.639	12.289	33.8
7/21/2012 3:53	14.638	12.294	33.799
7/21/2012 4:08	14.641	12.283	33.805
7/21/2012 4:23	14.64	12.284	33.804
7/21/2012 4:38	14.641	12.263	33.805
7/21/2012 4:53	14.643	12.244	33.81
7/21/2012 5:08	14.645	12.245	33.815
7/21/2012 5:23	14.643	12.216	33.81
7/21/2012 5:38	14.644	12.222	33.812
7/21/2012 5:53	14.647	12.224	33.818
7/21/2012 6:08	14.647	12.231	33.819
7/21/2012 6:23	14.648	12.195	33.823
7/21/2012 6:38	14.649	12.187	33.823
7/21/2012 6:53	14.649	12.197	33.825
7/21/2012 7:08	14.647	12.21	33.819
7/21/2012 7:23	14.647	12.219	33.82
7/21/2012 7:38	14.645	12.217	33.815
7/21/2012 7:53	14.646	12.187	33.817
7/21/2012 8:08	14.648	12.182	33.821
7/21/2012 8:23	14.646	12.216	33.817
7/21/2012 8:38	14.642	12.214	33.807
7/21/2012 8:53	14.646	12.246	33.817
7/21/2012 9:08	14.645	12.264	33.815
7/21/2012 9:23	14.646	12.264	33.818
7/21/2012 9:38	14.644	12.276	33.812
7/21/2012 9:53	14.645	12.296	33.815
7/21/2012 10:08	14.645	12.335	33.815
7/21/2012 10:23	14.647	12.356	33.82
7/21/2012 10:38	14.646	12.362	33.818
7/21/2012 10:53	14.649	12.379	33.824
7/21/2012 11:08	14.647	12.393	33.82

Date and Time	Sensor: Pres(A) 35.8ft SN#: 316634 Pressure (PSI)	Sensor: Pres(A) 35.8ft SN#: 316634 Temperature (C)	Sensor: Pres(A) 35.8ft SN#: 316634 Depth (ft)
7/21/2012 11:23	14.644	12.346	33.814
7/21/2012 11:38	14.648	12.366	33.821
7/21/2012 11:53	14.647	12.292	33.819
7/21/2012 12:08	14.667	9.373	33.866
7/21/2012 12:23	14.672	9.172	33.878
7/21/2012 12:38	14.681	9.415	33.897
7/21/2012 12:53	14.694	10.647	33.929
7/21/2012 13:08	14.69	11.816	33.919
7/21/2012 13:23	14.675	12.199	33.884
7/21/2012 13:38	14.666	12.308	33.863
7/21/2012 13:53	14.674	12.713	33.882
7/21/2012 14:08	14.67	12.928	33.872
7/21/2012 14:23	14.662	12.901	33.855
7/21/2012 14:38	14.653	12.735	33.833
7/21/2012 14:53	14.643	12.652	33.809
7/21/2012 15:08	14.643	12.549	33.81
7/21/2012 15:23	14.647	12.631	33.819
7/21/2012 15:38	14.647	12.757	33.819
7/21/2012 15:53	14.647	12.615	33.819
7/21/2012 16:08	14.648	12.634	33.823
7/21/2012 16:23	14.647	12.834	33.818
7/21/2012 16:38	14.646	12.733	33.817
7/21/2012 16:53	14.647	12.721	33.818
7/21/2012 17:08	14.647	12.637	33.82
7/21/2012 17:23	14.648	12.552	33.823
7/21/2012 17:38	14.647	12.437	33.819
7/21/2012 17:53	14.685	13.089	33.908
7/21/2012 18:08	14.681	13.412	33.898
7/21/2012 18:23	14.683	13.778	33.902
7/21/2012 18:38	14.676	14.075	33.887
7/21/2012 18:53	14.673	14.34	33.88
7/21/2012 19:08	14.68	14.868	33.897
7/21/2012 19:23	14.69	14.015	33.919
7/21/2012 19:38	14.692	12.959	33.923
7/21/2012 19:53	14.696	13.192	33.931
7/21/2012 20:08	14.699	13.382	33.939
7/21/2012 20:23	14.686	13.576	33.911
7/21/2012 20:38	14.677	14.633	33.888
7/21/2012 20:53	14.675	15.5	33.884
7/21/2012 21:08	14.67	15.479	33.872
7/21/2012 21:23	14.667	15.354	33.866
7/21/2012 21:38	14.661	15.192	33.852
7/21/2012 21:53	14.653	14.955	33.833
7/21/2012 22:08	14.653	14.698	33.833
7/21/2012 22:23	14.649	14.258	33.824

Date and Time	Sensor: Pres(A) 35.8ft SN#: 316634 Pressure (PSI)	Sensor: Pres(A) 35.8ft SN#: 316634 Temperature (C)	Sensor: Pres(A) 35.8ft SN#: 316634 Depth (ft)
7/21/2012 22:38	14.653	13.914	33.832
7/21/2012 22:53	14.651	13.646	33.828
7/21/2012 23:08	14.652	13.433	33.832
7/21/2012 23:23	14.652	13.313	33.83
7/21/2012 23:38	14.648	13.222	33.821
7/21/2012 23:53	14.651	13.166	33.828
9/19/2012 0:08	14.61	8.771	33.735
9/19/2012 0:23	14.616	8.759	33.748
9/19/2012 0:38	14.615	8.746	33.746
9/19/2012 0:53	14.622	8.679	33.761
9/19/2012 1:08	14.617	8.695	33.749
9/19/2012 1:23	14.618	8.646	33.753
9/19/2012 1:38	14.619	8.615	33.756
9/19/2012 1:53	14.613	8.588	33.74
9/19/2012 2:08	14.617	8.613	33.75
9/19/2012 2:23	14.613	8.73	33.74
9/19/2012 2:38	14.609	8.753	33.732
9/19/2012 2:53	14.608	8.674	33.731
9/19/2012 3:08	14.608	8.604	33.73
9/19/2012 3:23	14.601	8.611	33.714
9/19/2012 3:38	14.599	8.615	33.709
9/19/2012 3:53	14.591	8.586	33.689
9/19/2012 4:08	14.582	8.564	33.67
9/19/2012 4:23	14.581	8.525	33.668
9/19/2012 4:38	14.576	8.634	33.656
9/19/2012 4:53	14.568	8.644	33.637
9/19/2012 5:08	14.569	8.619	33.638
9/19/2012 5:23	14.565	8.521	33.631
9/19/2012 5:38	14.56	8.586	33.619
9/19/2012 5:53	14.56	8.527	33.618
9/19/2012 6:08	14.549	8.437	33.593
9/19/2012 6:23	14.551	8.45	33.599
9/19/2012 6:38	14.541	8.506	33.576
9/19/2012 6:53	14.538	8.447	33.569
9/19/2012 7:08	14.543	8.388	33.579
9/19/2012 7:23	14.531	8.357	33.551
9/19/2012 7:38	14.529	8.397	33.547
9/19/2012 7:53	14.517	8.351	33.519
9/19/2012 8:08	14.519	8.485	33.524
9/19/2012 8:23	14.518	8.428	33.522
9/19/2012 8:38	14.518	8.517	33.521
9/19/2012 8:53	14.513	8.492	33.509
9/19/2012 9:08	14.516	8.493	33.516
9/19/2012 9:23	14.51	8.557	33.503
9/19/2012 9:38	14.513	8.65	33.509

Date and Time	Sensor: Pres(A) 35.8ft SN#: 316634 Pressure (PSI)	Sensor: Pres(A) 35.8ft SN#: 316634 Temperature (C)	Sensor: Pres(A) 35.8ft SN#: 316634 Depth (ft)
9/19/2012 9:53	14.502	8.606	33.484
9/19/2012 10:08	14.502	9.155	33.485
9/19/2012 10:23	14.491	9.004	33.458
9/19/2012 10:38	14.495	8.94	33.468
9/19/2012 10:53	14.49	8.876	33.457
9/19/2012 11:08	14.491	8.862	33.459
9/19/2012 11:23	14.491	8.84	33.459
9/19/2012 11:38	14.49	8.82	33.458
9/19/2012 11:53	14.491	8.799	33.46
9/19/2012 12:08	14.5	8.782	33.48
9/19/2012 12:23	14.495	8.78	33.468
9/19/2012 12:38	14.483	8.758	33.442
9/19/2012 12:53	14.478	8.723	33.429
9/19/2012 13:08	14.477	8.738	33.428
9/19/2012 13:23	14.469	8.758	33.408
9/19/2012 13:38	14.461	8.769	33.391
9/19/2012 13:53	14.459	8.787	33.386
9/19/2012 14:08	14.457	8.813	33.381
9/19/2012 14:23	14.452	8.833	33.368
9/19/2012 14:38	14.442	8.827	33.346
9/19/2012 14:53	14.46	8.824	33.387
9/19/2012 15:08	14.461	8.82	33.39
9/19/2012 15:23	14.461	8.834	33.389
9/19/2012 15:38	14.486	8.697	33.447
9/19/2012 15:53	14.492	8.472	33.461
9/19/2012 16:08	14.514	8.509	33.512
9/19/2012 16:23	14.523	8.642	33.533
9/19/2012 16:38	14.525	8.719	33.538
9/19/2012 16:53	14.525	8.693	33.538
9/19/2012 17:08	14.534	8.645	33.558
9/19/2012 17:23	14.529	8.656	33.548
9/19/2012 17:38	14.534	8.686	33.559
9/19/2012 17:53	14.562	8.85	33.622
9/19/2012 18:08	14.553	8.949	33.601
9/19/2012 18:23	14.521	8.944	33.529
9/19/2012 18:38	14.515	8.975	33.514
9/19/2012 18:53	14.521	9.017	33.528
9/19/2012 19:08	14.527	9.053	33.542
9/19/2012 19:23	14.52	9.109	33.526
9/19/2012 19:38	14.518	9.156	33.521
9/19/2012 19:53	14.516	9.203	33.518
9/19/2012 20:08	14.521	9.238	33.529
9/19/2012 20:23	14.517	9.233	33.52
9/19/2012 20:38	14.511	9.246	33.506
9/19/2012 20:53	14.512	9.28	33.508

Date and Time	Sensor: Pres(A) 35.8ft SN#: 316634 Pressure (PSI)	Sensor: Pres(A) 35.8ft SN#: 316634 Temperature (C)	Sensor: Pres(A) 35.8ft SN#: 316634 Depth (ft)
9/19/2012 21:08	14.515	9.292	33.516
9/19/2012 21:23	14.516	9.302	33.517
9/19/2012 21:38	14.51	9.315	33.504
9/19/2012 21:53	14.506	9.341	33.495
9/19/2012 22:08	14.504	9.371	33.49
9/19/2012 22:23	14.506	9.381	33.495
9/19/2012 22:38	14.505	9.39	33.492
9/19/2012 22:53	14.508	9.42	33.499
9/19/2012 23:08	14.506	9.463	33.494
9/19/2012 23:23	14.51	9.5	33.503
9/19/2012 23:38	14.511	9.523	33.504
9/19/2012 23:53	14.514	9.522	33.512

Taku Lake
Corrected Pressure Transducer Data and
Outflow Calculations

Data Manipulation and Correction					Manning's Equation Computations for Flow and Volume										
Date and Time for Hourly Data	Hourly Average Measured Absolute Pressure (Ft)	Hourly AIA SEA Level Pressure (InHG)	Hourly AIA Sea Level Pressure (ft)	Computed Depth of Water (Ft)	θ (rad)	Pipe Diameter (d) (ft)	Flow Depth (y) (ft)	Cross Sectional Area (A) (ft^2)	Weddted Perimeter (P_w) (ft)	Hydraulic Radius ('R) (ft)	Slope (ft/ft)	Manning's n (CPEP)	Velocity (V) (ft/s)	Flowrate Q (cfs)	Outflow volume
7/21/2012 0:53	33.778	29.85	33.818	-0.040	0.000	0.333	0.000	0.000	0.000	0.000	0.005	0.013	0.00	0.000	0.000
7/21/2012 1:53	33.798	29.86	33.829	-0.031	0.000	0.333	0.000	0.000	0.000	0.000	0.005	0.013	0.00	0.000	0.000
7/21/2012 2:53	33.817	29.85	33.818	-0.001	0.000	0.333	0.000	0.000	0.000	0.000	0.005	0.013	0.00	0.000	0.000
7/21/2012 3:53	33.805	29.86	33.829	-0.024	0.000	0.333	0.000	0.000	0.000	0.000	0.005	0.013	0.00	0.000	0.000
7/21/2012 4:53	33.806	29.86	33.829	-0.023	0.000	0.333	0.000	0.000	0.000	0.000	0.005	0.013	0.00	0.000	0.000
7/21/2012 5:53	33.814	29.87	33.840	-0.027	0.000	0.333	0.000	0.000	0.000	0.000	0.005	0.013	0.00	0.000	0.000
7/21/2012 6:53	33.823	29.86	33.829	-0.007	0.000	0.333	0.000	0.000	0.000	0.000	0.005	0.013	0.00	0.000	0.000
7/21/2012 7:53	33.818	29.86	33.829	-0.011	0.000	0.333	0.000	0.000	0.000	0.000	0.005	0.013	0.00	0.000	0.000
7/21/2012 8:53	33.816	29.86	33.829	-0.014	0.000	0.333	0.000	0.000	0.000	0.000	0.005	0.013	0.00	0.000	0.000
7/21/2012 9:53	33.815	29.87	33.840	-0.025	0.000	0.333	0.000	0.000	0.000	0.000	0.005	0.013	0.00	0.000	0.000
7/21/2012 10:53	33.819	29.87	33.840	-0.021	0.000	0.333	0.000	0.000	0.000	0.000	0.005	0.013	0.00	0.000	0.000
7/21/2012 11:53	33.819	29.88	33.852	-0.033	0.000	0.333	0.000	0.000	0.000	0.000	0.005	0.013	0.00	0.000	0.000
7/21/2012 12:53	33.893	29.87	33.840	0.052	1.625	0.333	0.052	0.009	0.271	0.032	0.005	0.013	0.82	0.007	25.633
7/21/2012 13:53	33.887	29.87	33.840	0.047	1.532	0.333	0.047	0.007	0.255	0.029	0.005	0.013	0.76	0.006	20.348
7/21/2012 14:53	33.842	29.87	33.840	0.002	0.293	0.333	0.002	0.000	0.049	0.001	0.005	0.013	0.09	0.000	0.019
7/21/2012 15:53	33.817	29.88	33.852	-0.035	0.000	0.333	0.000	0.000	0.000	0.000	0.005	0.013	0.00	0.000	0.000
7/21/2012 16:53	33.819	29.88	33.852	-0.033	0.000	0.333	0.000	0.000	0.000	0.000	0.005	0.013	0.00	0.000	0.000
7/21/2012 17:53	33.843	29.87	33.840	0.002	0.312	0.333	0.002	0.000	0.052	0.001	0.005	0.013	0.10	0.000	0.025
7/21/2012 18:53	33.892	29.89	33.863	0.029	1.190	0.333	0.029	0.004	0.198	0.018	0.005	0.013	0.56	0.002	7.357
7/21/2012 19:53	33.918	29.89	33.863	0.054	1.663	0.333	0.054	0.009	0.277	0.033	0.005	0.013	0.84	0.008	28.062
7/21/2012 20:53	33.906	29.89	33.863	0.042	1.458	0.333	0.042	0.006	0.243	0.027	0.005	0.013	0.72	0.005	16.752
7/21/2012 21:53	33.856	29.9	33.874	-0.019	0.000	0.333	0.000	0.000	0.000	0.000	0.005	0.013	0.00	0.000	0.000
7/21/2012 22:53	33.829	29.89	33.863	-0.034	0.000	0.333	0.000	0.000	0.000	0.000	0.005	0.013	0.00	0.000	0.000
7/21/2012 23:53	33.828	29.89	33.863	-0.035	0.000	0.333	0.000	0.000	0.000	0.000	0.005	0.013	0.00	0.000	0.000

Data Manipulation and Correction					Manning's Equation Computations for Flow and Volume										
Date and Time for Hourly Data	Hourly Average Measured Absolute Pressure (Ft)	Hourly AIA SEA Level Pressure (InHG)	Hourly AIA Sea Level Pressure (ft)	Computed Depth of Water (Ft)	θ (rad)	Pipe Diameter (d) (ft)	Flow Depth (y) (ft)	Cross Sectional Area (A) (ft^2)	Weddted Perimeter (P_w) (ft)	Hydraulic Radius ('R) (ft)	Slope (ft/ft)	Manning's n (CPEP)	Velocity (V) (ft/s)	Flowrate Q (cfs)	Outflow volume
9/19/2012 0:53	33.748	29.81	33.772	-0.025	0.000	0.333	0.000	0.000	0.000	0.000	0.005	0.013	0.00	0.000	0.000
9/19/2012 1:53	33.750	29.8	33.761	-0.012	0.000	0.333	0.000	0.000	0.000	0.000	0.005	0.013	0.00	0.000	0.000
9/19/2012 2:53	33.738	29.76	33.716	0.022	1.049	0.333	0.022	0.003	0.175	0.014	0.005	0.013	0.48	0.001	4.379
9/19/2012 3:53	33.711	29.72	33.671	0.040	1.414	0.333	0.040	0.006	0.236	0.025	0.005	0.013	0.70	0.004	14.833
9/19/2012 4:53	33.658	29.69	33.637	0.021	1.020	0.333	0.021	0.002	0.170	0.014	0.005	0.013	0.46	0.001	3.897
9/19/2012 5:53	33.627	29.65	33.591	0.035	1.325	0.333	0.035	0.005	0.221	0.022	0.005	0.013	0.64	0.003	11.421
9/19/2012 6:53	33.584	29.62	33.557	0.027	1.155	0.333	0.027	0.003	0.192	0.017	0.005	0.013	0.54	0.002	6.510
9/19/2012 7:53	33.549	29.61	33.546	0.003	0.386	0.333	0.003	0.000	0.064	0.002	0.005	0.013	0.13	0.000	0.062
9/19/2012 8:53	33.519	29.59	33.523	-0.004	0.000	0.333	0.000	0.000	0.000	0.000	0.005	0.013	0.00	0.000	0.000
9/19/2012 9:53	33.503	29.54	33.467	0.036	1.347	0.333	0.036	0.005	0.225	0.023	0.005	0.013	0.66	0.003	12.195
9/19/2012 10:53	33.467	29.55	33.478	-0.011	0.000	0.333	0.000	0.000	0.000	0.000	0.005	0.013	0.00	0.000	0.000
9/19/2012 11:53	33.459	29.51	33.433	0.026	1.141	0.333	0.026	0.003	0.190	0.017	0.005	0.013	0.53	0.002	6.194
9/19/2012 12:53	33.455	29.49	33.410	0.045	1.501	0.333	0.045	0.007	0.250	0.028	0.005	0.013	0.75	0.005	18.803
9/19/2012 13:53	33.403	29.49	33.410	-0.007	0.000	0.333	0.000	0.000	0.000	0.000	0.005	0.013	0.00	0.000	0.000
9/19/2012 14:53	33.371	29.48	33.399	-0.028	0.000	0.333	0.000	0.000	0.000	0.000	0.005	0.013	0.00	0.000	0.000
9/19/2012 15:53	33.422	29.51	33.433	-0.011	0.000	0.333	0.000	0.000	0.000	0.000	0.005	0.013	0.00	0.000	0.000
9/19/2012 16:53	33.530	29.48	33.399	0.132	2.718	0.333	0.132	0.032	0.453	0.071	0.005	0.013	1.39	0.044	159.865
9/19/2012 17:53	33.572	29.47	33.387	0.184	3.355	0.333	0.184	0.050	0.559	0.089	0.005	0.013	1.61	0.080	287.324
9/19/2012 18:53	33.543	29.48	33.399	0.144	2.873	0.333	0.144	0.036	0.479	0.076	0.005	0.013	1.45	0.053	189.032
9/19/2012 19:53	33.527	29.51	33.433	0.094	2.241	0.333	0.094	0.020	0.374	0.054	0.005	0.013	1.16	0.023	84.576
9/19/2012 20:53	33.516	29.53	33.455	0.060	1.760	0.333	0.060	0.011	0.293	0.037	0.005	0.013	0.90	0.010	34.892
9/19/2012 21:53	33.508	29.56	33.489	0.019	0.957	0.333	0.019	0.002	0.160	0.012	0.005	0.013	0.43	0.001	2.994
9/19/2012 22:53	33.494	29.59	33.523	-0.029	0.000	0.333	0.000	0.000	0.000	0.000	0.005	0.013	0.00	0.000	0.000
9/19/2012 23:53	33.503	29.62	33.557	-0.054	0.000	0.333	0.000	0.000	0.000	0.000	0.005	0.013	0.00	0.000	0.000

Appendix H:

Analysis for the Commercial Fishing and Agriculture Bank Rain Garden

AWR Engineering, LLC
Alaska Water Resources

Memorandum

To: Kristi Bischofberger, MOA Watershed Manager

From: Janie Dusel, PE

cc: Joe Miller, HDR Project Manager

Date: January 28, 2014

Re: Analysis for the Commercial Fishing and Agriculture Bank Rain Garden

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The purpose of this memorandum is to present the results of a performance analysis completed for a stormwater rain garden located in the parking lot of the Commercial Fishing and Agriculture Bank (CFAB) in Anchorage, Alaska.

Introduction and Project Description

AWR Engineering, LLC and HDR Alaska are assisting the Municipality of Anchorage (MOA) Watershed Management Services (WMS) with performance evaluation of two stormwater rain gardens as required per the current MOA and Alaska Department of Transportation and Public Facilities Alaska Pollutant Discharge Elimination System (APDES) permit. The permit requires qualitative evaluation of one neighborhood rain garden and one public-private community partnership rain garden. (APDES permit, page 16, paragraph iii. See attachment 1.) The community rain garden selected for evaluation was the Taku Lake rain garden, and the evaluation results are presented in the *2013 Low Impact Development Project Performance Monitoring Report.* This memorandum addresses the public-private partnership rain garden.

The APDES permit requires that the performance of each rain garden be evaluated using the same methodology used for evaluating the permit-required Low Impact Development (LID) pilot projects. This includes calculations or models showing changes in runoff quantities and a comparison to a theoretical case of the project constructed without LID practices. The analysis requirements include preparing 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 the project, including area, slope, vegetation type and condition (for pervious surfaces), and nature of impervious surfaces. (APDES permit, page 15. See attachment 1.)

CFAB Rain Garden

The CFAB rain garden was constructed in 2009 as part of an expansion and remodeling project for the CFAB building. WMS partnered with the CFAB owners and provided a portion of the rain garden funding through the MOA Rain Garden Program. The project is located at the corner of Lakeshore Drive and Wisconsin Avenue, near Spenard Road in Anchorage. The project site is in the Fish Creek watershed, which is cataloged as an impaired water body. Figure 1 provides a project vicinity map.

Figure 1: Project Vicinity Map

There is an existing municipal storm drain adjacent to the CFAB site on Wisconsin Avenue that discharges to Fish Creek approximately 2,500 feet downstream from the project site. The rain garden is designed to capture stormwater runoff from the approximately 11,000 square-foot parking lot and from approximately 2,600 square feet of the building roof before this water can enter the municipal storm drain. The average slope of the contributing area is 1.8 percent.

The project site is shown Figure 2.

Figure 2: CFAB Project Site

The rain garden was constructed along the south and west borders of the site, parallel to Wisconsin Avenue and Lakeshore Drive respectively. The western portion of the rain garden includes a central swale with a rock trench for additional stormwater storage capacity. The area around the swale/trench is organic topsoil with a mulch layer on top, and the area is vegetated with small shrubs and grasses. The southern portion of the rain garden features a depressed swale with a layer of rock on top of an organic topsoil layer to provide stormwater storage and encourage infiltration. The surrounding area is topsoil, mulch, and vegetation, similar to the western portion. Both rain garden sections slope toward the southwest corner of the site where a “beehive” storm drain inlet provides overflow for large storm events that exceed the storage and infiltration capacity of the rain garden. A typical section of the rock trench as well as construction photos of the rain garden are provided in Attachment 2.

Monitoring and Reporting Plan

In order to evaluate the rain garden’s performance, inflow and outflow hydrographs were developed for two cases:

> Case 1: As required for new construction per the APDES permit, Case 1 is the hypothetical case of the project constructed without LID. In this case, runoff from the CFAB parking lot and rooftop is routed directly to the storm drain system on Wisconsin Ave. For this case, it was assumed that five percent of the project site would be pervious landscaping, and that the site would be graded traditionally with runoff directed toward a storm drain inlet.

Case 2: Case 2 is the LID case that was constructed, with the rain garden accepting flow from the parking lot and roof top. In the constructed case, the site was graded such that the impervious area flows to the pervious rain garden areas.

Hydrograph Development

Discharge hydrographs were developed using the EPA's Storm Water Management Model (SWMM) Version 5.0. SWMM produces hydrographs using the non-linear reservoir method based on user-defined rainfall parameters, soil conditions, and basin features. Infiltration in pervious areas of the basin was computed using Horton's method within SWMM. Site characteristics are presented in Table 1. The site characteristics listed for Case 1 were based on the site design and on assumptions regarding traditional grading if LID had not been incorporated. The site characteristics for Case 2 were based on the project design drawings.

Table 1: CFAB Site Characteristics

Basin Characteristic	Case 1: No LID	Case 2: Rain Garden
Basin Size (acres)	0.38	0.38
Percent Impervious	95	82
Runoff Routed to	Outlet	Pervious
Infiltration Method	Horton	Horton

The infiltration parameters for use with Horton's method, as shown in Table 2, were selected based on soil information from the project's geotechnical report and from recommended values from the SWMM user's manual. The geotechnical report classifies the upper 14 feet of the site as variations of sandy silt and silty sand. Because percolation testing for the rain garden was not performed as part of the analysis or design, infiltration rates were estimated based on available soils data. Typical infiltration values for silty sand can vary by several orders of magnitude. Published values of saturated hydraulic conductivity for silty sand can range from 0.014 to 14 inches per hour. (Mays, Larry. *Water Resources Engineering*. Hoboken: Wiley, 2005.) Based on this range and on the reported silt content of the soil, a value of 0.43 was selected for the saturated hydraulic conductivity of the native soils. This value is also the recommended value from the SWMM user's manual for loam, which is typically a mixture of sand, silt, and clay. This value may be conservative for the site, but is expected to be a reasonable estimate based on the information available.

Table 2: Horton Infiltration Parameters

Horton Parameters for Runoff	
Maximum Infiltration Rate (in/hr)	3
Minimum Infiltration Rate (in/hr)	0.43
Decay Constant (1/hr)	4

The performance of the rain garden was modeled using the LID modeling options within SWMM. The south portion of the rain garden was modeled as a bioretention area and the west portion was modeled as an infiltration trench. The landscaped areas around the trench and the bioretention area were modeled as pervious areas that accept water from the impervious surfaces. SWMM allows the user to define the parameters of the LID features based on local conditions, and the program then calculates storage and infiltration. Infiltration within the LID feature is calculated using the Green-Ampt infiltration method.

The selected bioretention and infiltration trench parameters are summarized in Table 3. The Green-Ampt values were selected based on the recommendations in the SWMM user's manual for loam (see discussion above). The physical parameters of the LID features were obtained from the project design drawings and construction photos/notes provided by WMS. These are included in Attachment 2. The project geotechnical borings are included in Attachment 3.

Table 3: Rain Garden and Infiltration Trench Parameters

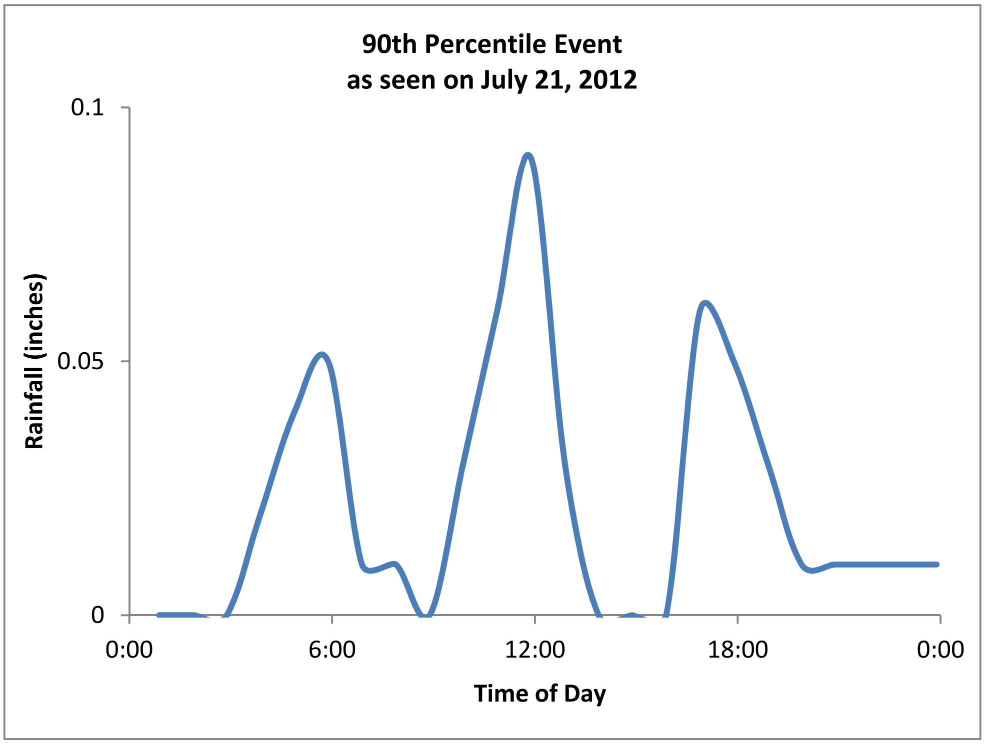
Parameter	Rain Garden (Bioretention)	Infiltration Trench
Area (square feet)	174	270
Surface Roughness (Manning's n)	0.03	0.03
Surface Slope	1.5	0.5
Surface Storage Depth (in)	0	6
Storage Layer Depth (in)	18	30
Storage Layer Void Ratio	0.4	0.4
Vegetation Volume Fraction	0.40	0.05
Soil Thickness (in)	18	N/A
Porosity (volume fraction)	0.453	N/A
Field Capacity (volume fraction)	0.190	N/A
Wilting Point (volume fraction)	0.085	N/A
Conductivity (in/hr)	0.43	0.43
Conductivity Slope	10	N/A
Suction Head (in)	4.33	N/A

The rain garden's performance was evaluated for two rainfall events:

> Event 1: The first event was approximately the 90th percentile rainfall event as described in the MOA's current APDES permit. This event is 0.52 inches of rain in a 24-hour period. In this case, the 90th percentile event is distributed based on hourly rainfall data from Anchorage International Airport. According to this hourly data, a rainfall event nearly identical to the 90th percentile event occurred on July 21, 2012.
>
> Event 2: The second event modeled was the theoretical 10-year, 24-hour rainfall event for Anchorage, as defined in the MOA's Design Criteria Manual. This rainfall event is 1.77 inches distributed over 24 hours using a National Resource Conservation Service (NRCS) Type 1 rainfall distribution. This event was selected to evaluate the rain garden's performance during large rainfall events.

Rainfall Hyetographs for the non-synthetic event (Event 1) is provided in Figure 3.

Figure 3: Event 1 Rainfall Hyetograph



Results

The resulting hydrographs are shown in Figure 4 and Figure 5. These hydrographs represent the discharge from the site into the local storm drain.

Figure 4: Event 1 Hydrograph

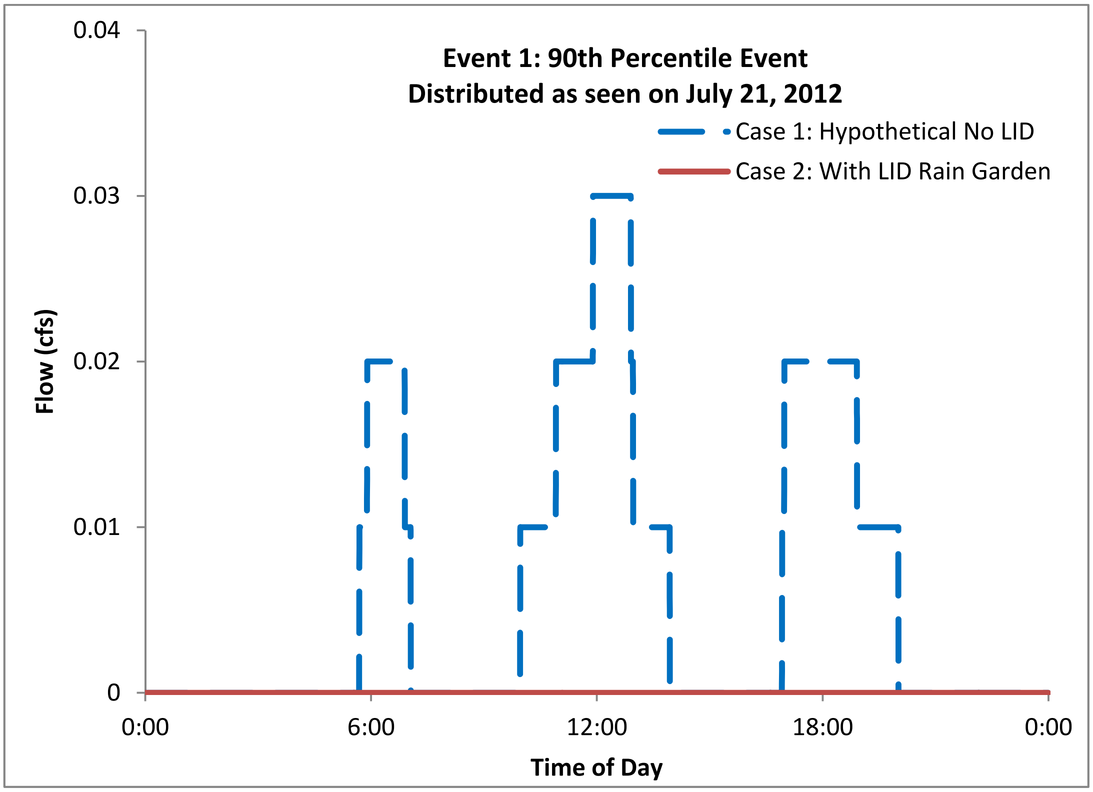


Figure 5: Event 2 Hydrograph

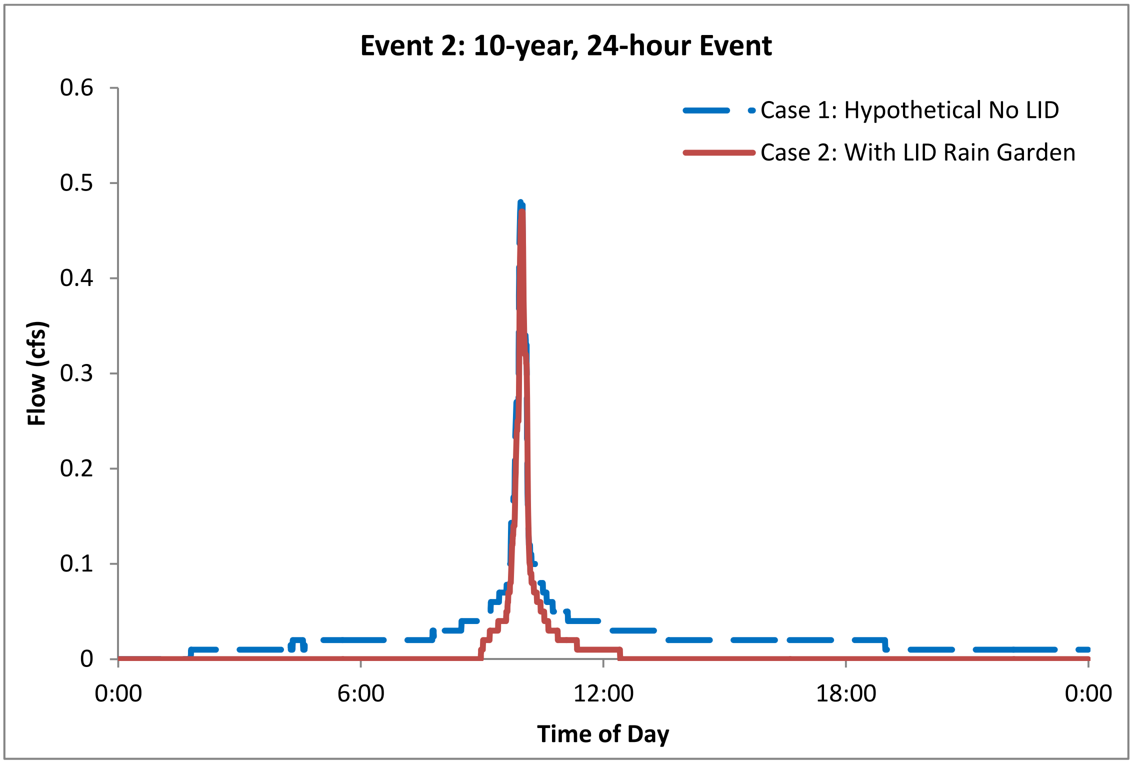


Table 4 shows the peak flow and total volume of runoff for each case. Full modeling output reports are included in Attachment 4.

Table 4: Runoff Results Summary

Case	Event 1: 90th Percentile Rainfall, Distributed as seen on 7-21-12		Event 2: 10-year, 24-hour Rainfall	
	Peak Flow (cfs)	Runoff Vol (cf)	Peak Flow (cfs)	Runoff Vol (cf)
Case 1 - No LID	0.03	610	0.49	2,265
Case 2 – Rain Garden	0	0	0.47	741
Percent Decrease from Case 1 to Case 2	100%	100%	4%	67%

For the 90th percentile event, the modeling results show that the rain garden was able to infiltrate all of the runoff and nothing was discharged to the storm drain system. The 90th percentile event generally represents the largest type of events that LID facilities would be designed to capture. These results indicate that the rain garden is also capturing the smaller events, less than 0.52 inches, which account for most of Anchorage's rain events. LID facilities are typically best suited to these types of events. By capturing runoff from small, frequent events, the rain garden is not only reducing the quantity of stormwater that flows into Fish Creek but is also improving the quality of the stormwater by capturing the first flush of runoff, which is typically the most polluted.

For Event 2, modeling results show that while the rain garden did not have a significant impact on peak flow, it did drastically impact the total volume of runoff. A large event such as the 10-year, 24-hour event, is not typically the design event for LID facilities. But as these results show, rain gardens and other LID facilities can provide watershed benefits during these types of events.

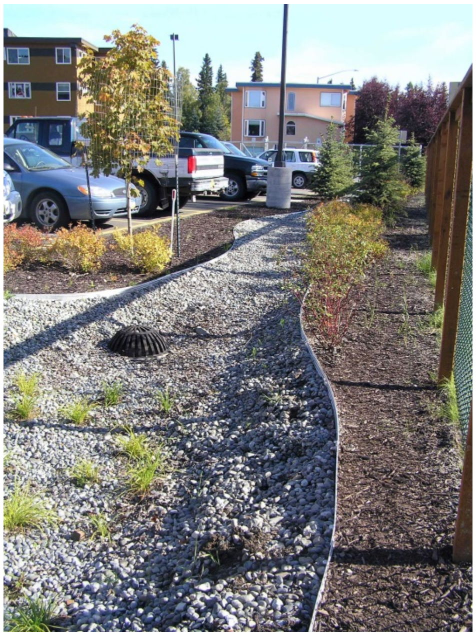
Conclusions and Recommendations for Future Projects

The analysis results show that the CFAB rain garden is performing well. The rain garden is capturing runoff from small, frequent rainfall events and reducing total runoff volume for larger events. For future rain garden construction, percolation testing is recommended in order to provide more accurate data for the receiving soils. This will improve the accuracy of performance evaluations.

As part of this analysis, information regarding the ongoing maintenance and long-term performance of the rain garden was requested from the CFAB rain garden owners. Unfortunately, the information was not available at the time of this memorandum.

Attachments:

1. APDES Permit Excerpt
2. Design Details and Construction Photos
3. Geotechnical Borings
4. SWMM Modeling Output



Southern Portion of Rain Garden
(Wisconsin Ave. Side)

Western Portion of Rain Garden
(Lakeshore Drive Side)

Attachment 1: APDES Permit Excerpt

c) **Green Infrastructure/Low Impact Development (LID) Strategy and Pilot Projects.** Within one year of the effective date of this permit, the permittees must develop a strategy to provide incentives for the increased use of LID techniques in private and public sector development projects within both the MOA and ADOT&PF jurisdictions. The strategy must outline the methods of evaluating the Green Infrastructure/LID pilot projects described below. Permittees must begin implementation of the Green Infrastructure/LID Strategy and pilot projects within two years of the effective date of this permit.

(i) Beginning with the 4th Year Annual Report, the permittees must report on and evaluate the status of five pilot projects that use LID concepts for on-site control of water quality. Projects must involve managing runoff from at least 10,000 square feet of impervious surface. At least three of the five LID pilot projects must be ADOT&PF-owned locations. Parking lot retrofits as required in Part II.B.2.c.vi may be used as pilot projects. At least two of the pilot sites must address drainage areas greater than five acres in size. At least one pilot project must be located in the Chester Creek, Fish Creek, Campbell Creek, or Little Campbell Creek watersheds.

(ii) The permittees must monitor the performance of each pilot project and report the results beginning with the 4th Year Annual Report. The permittees must 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 practices.

- For new construction projects, changes in runoff quantities shall be calculated for development scenarios both with LID practices and without LID practices.

- 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 nature of impervious surfaces.

- The permittees must use these runoff values to evaluate the overall effectiveness of various LID practices and to develop recommendations for future LID practices addressing appropriate use, design, type, size, soil type and operation and maintenance practices. The permittees must use the recommendations to update their final LID criteria, as necessary, and utilize the information obtained through the LID pilot studies to revise the Storm Water Design Criteria Manual(s) no later than five years from the effective date of this permit.

(iii) **Rain Gardens.** Within four years of the effective date of this permit, the permittees must evaluate the effectiveness of rain gardens located in one neighborhood and one public-private community partnership. If feasible, pilot projects should be located within a TMDL watershed listed in Table II.C. The permittees must quantitatively evaluate the effectiveness of the rain gardens as outlined in Part II.B.2.c.ii above.

(iv) **Riparian Zone Management.** Within five years from the effective date of this permit, 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 examine the feasibility of reconstructing MS4 outfalls, and must disconnect at least one major MS4 outfall from discharging from receiving waters using vegetated swales or other appropriate techniques.

(v) **Repair of Public Streets, Roads or Parking Lots.** When public streets, roads or parking lots are repaired as defined in Part VII, the permittees must evaluate the feasibility of incorporating runoff reduction techniques into the repair using canopy interception, 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 feasible, the permittees must consider the use of such practices in the design and repair. These requirements apply only to projects whose design is started after the effective date of this permit. Beginning in the 4th Year Annual Report, the permittees must document and list the locations of street, road and parking lot repair work completed within the last 12 month period that has incorporated such runoff reduction practices.

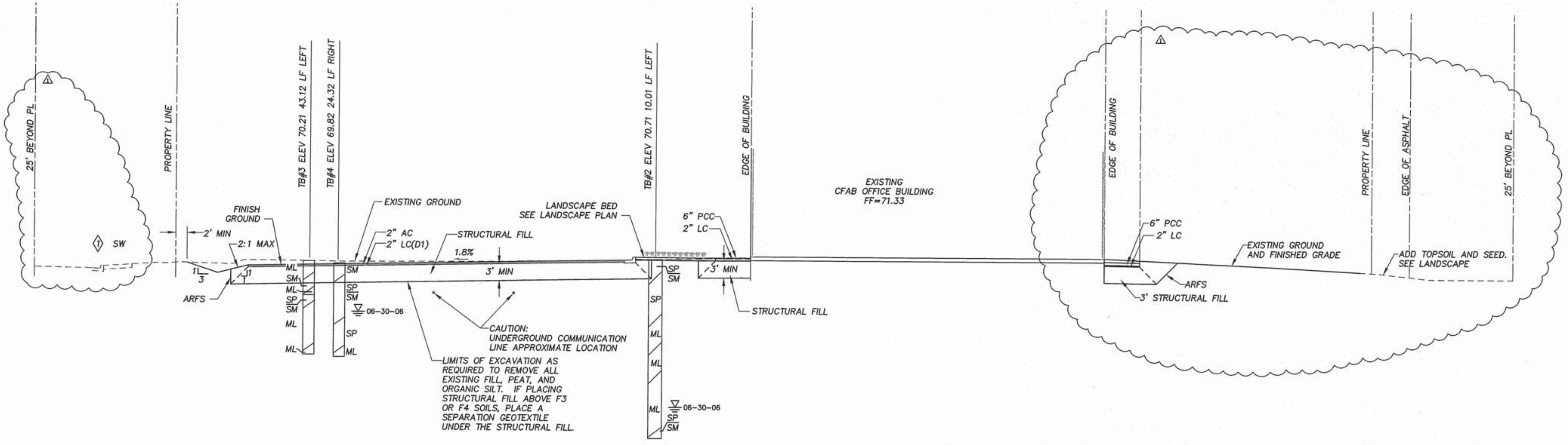
(vi) **Parking Lot Retrofits.** Prior to the expiration date of this permit, each permittee must retrofit at least two public facility parking lots with infiltration, evapotranspiration or reuse techniques designed to retain 100% of the parking lot runoff from the 90th percentile, 24 hour rainfall event. Each retrofit site must be located in a watershed draining to an impaired receiving water listed in Table II.C. The permittees must quantitatively measure the effectiveness of

Attachment 2: Design Details and Construction Photos

P:\Projects\D60046\DESIGN\DSI-CFAB.dwg 2008-9-25 15:46:27 USER: ERS

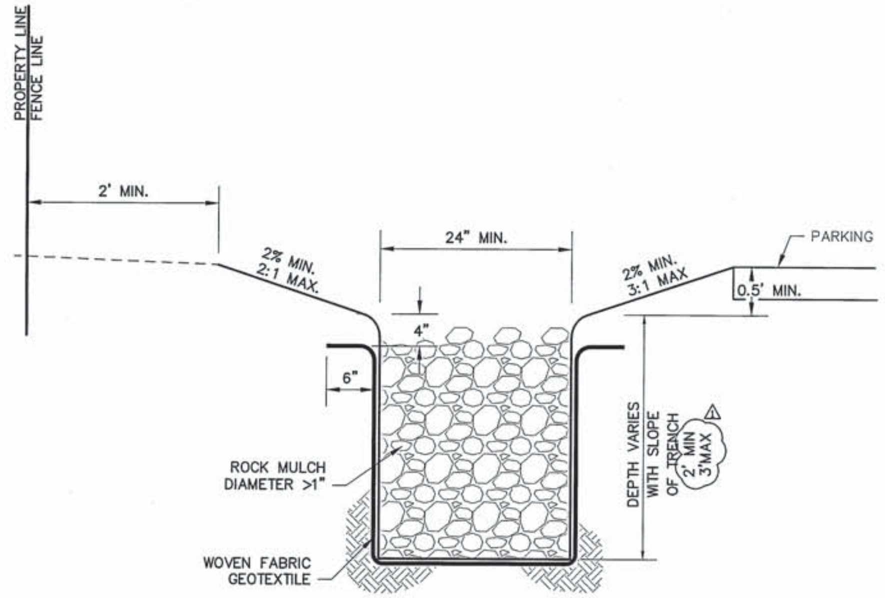
SCRIPT FILE:

DOWL FILE No: 233-35



1 C5.0 TYPICAL SITE SECTION (WEST-EAST)

NTS



2 C5.0 ROCK MULCH SWALE

NTS

BUILDING PERMIT #07-6084

Brad E. Doggett
CE-10360
6/9/09

BEFORE YOU DIG
CALL FOR FREE
UNDERGROUND
LOCATION

Locate Call Center of Alaska
Anchorage Area......................278-3121
Statewide......................800-478-3121
who will notify subscribed utilities only.
Other utilities need to be contacted individually.

DATA	✓BY
San. Sewer	
Storm Sewer	
Water	
Gas	
Telephone	
Electric	
Cable TV	
Easements	
Footing Elev.	
Approved	

REV	DATE	DESCRIPTION	BY
1	6-8-09	EXTENDED SECTION	AJM

REVISIONS

Vertical Datum:

DOWL ENGINEERS
4041 "B" Street Anchorage, Alaska 99503
PHONE (907) 562-2000 FAX (907) 563-3953

SITE CROSS-SECTIONS
AK COMMERCIAL FISHING
& AGRICULTURAL BANK
SPENARD LAKE PARK SUBDIVISION, BLOCK 3, LOT 11A-2
ANCHORAGE, ALASKA

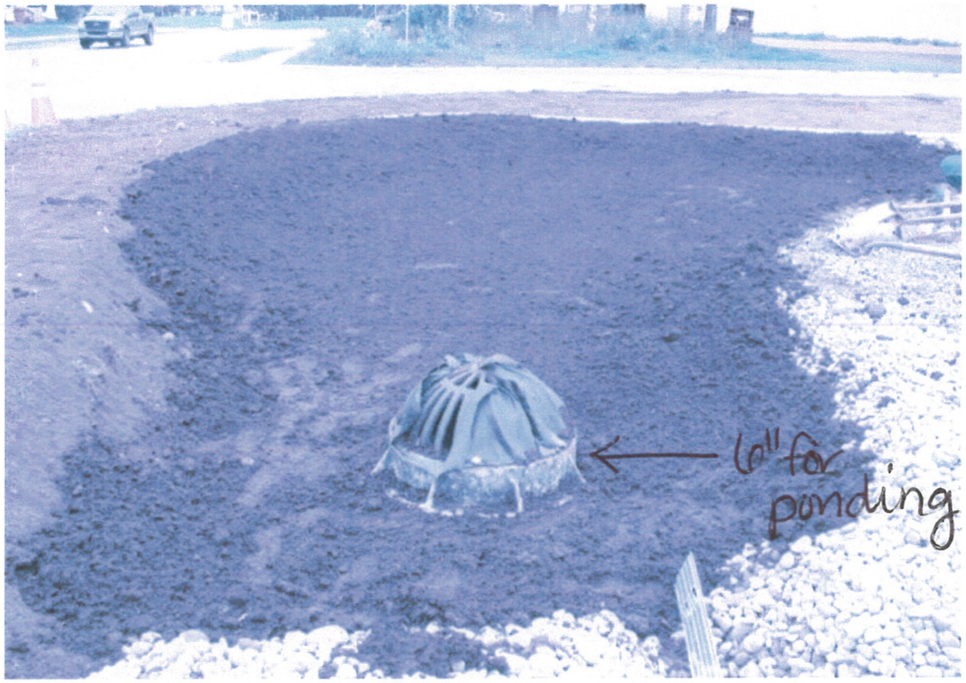
CHECKED BY	KRH
DESIGNED BY	AJM
DRAWN BY	TLK
DATE	03-20-09
W.O. NO.	D60046
F.B. NO.	
REF. DWG	D59431
LOCATION	ANCHORAGE

SCALE
HORZ. NA
VERT. NA

SHEET
C5.0

FILE NO. 233-35

← 18" gravel

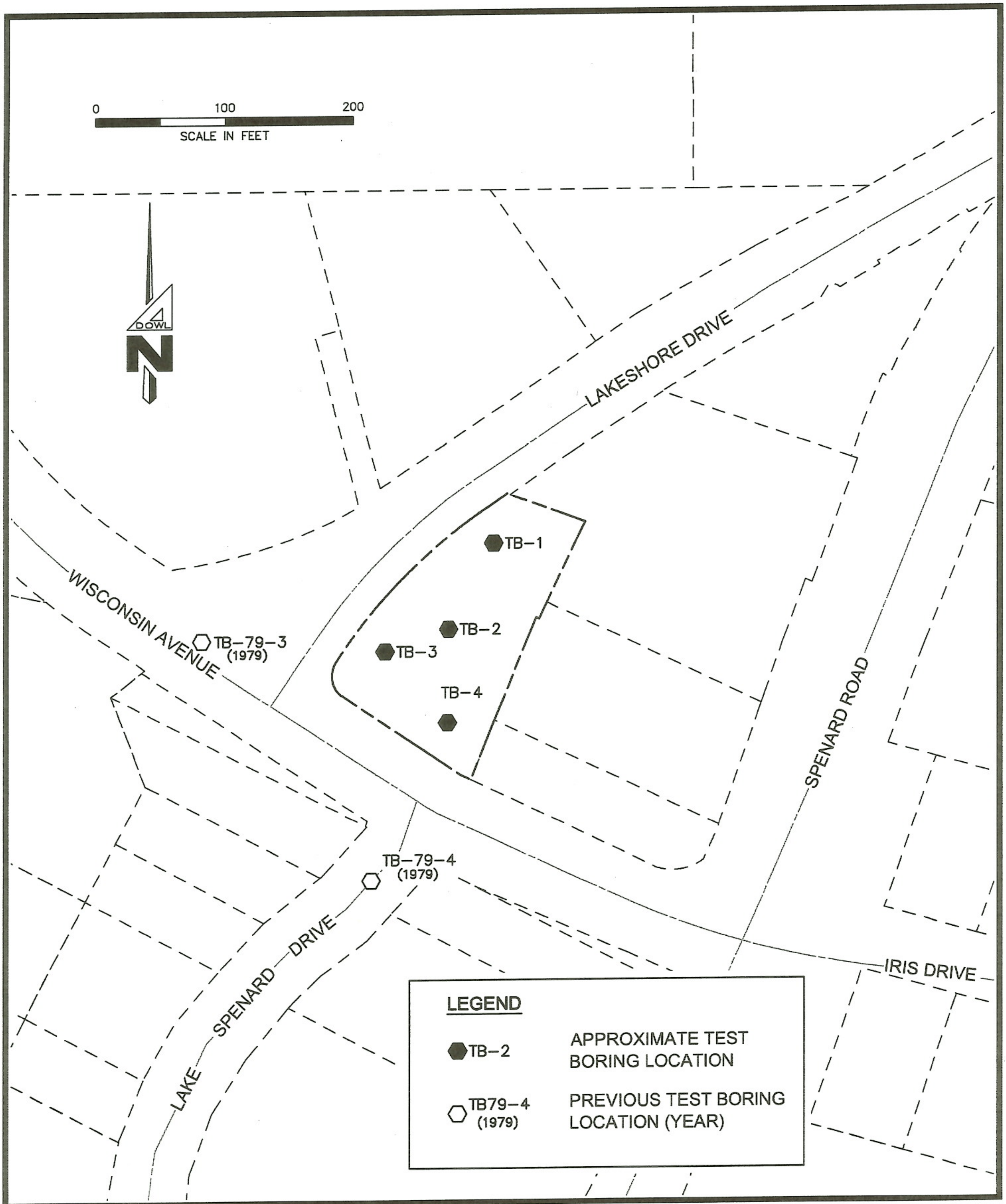


6" for ponding

18" topsoil


CAT

Attachment 3: Geotechnical Borings



P:\Projects\D59431\GEO\GTB-WISC-LAKE.dwg JUL 24 2006 09:38:00 (MBAUER) MOA GRID: 1727/1827 SCALE: AS SHOWN

DOWL ENGINEERS

Test Boring Location Map
C-FAB
OFFICE BUILDING
Anchorage, Alaska

FIGURE A-1

TEST BORING 1

LOCATION: SEE TEST BORING LOCATION MAP
ELEVATION:

DEPTH (FEET)	Other Tests	Moisture Content (%)	Blows / Foot	Sample No.	Sample Type	Soil Class	Frost Depth	Frost Class		DEPTH
0									**GRAVEL SURFACE**	
		5		1	☐	SP SM		F2	**FILL, POORLY GRADED SAND WITH SILT AND GRAVEL,** brown, about 30% gravel, 10% silt, gravel subrounded to 1.5", medium sand, damp, RAP present	2.0
		8	3	2	◪	SM		F2	**FILL, SILTY SAND WITH GRAVEL**, brown, about 20% gravel, 15% silt, nonplastic, gravel subangular to 3/4", medium sand, damp, very loose	4.5
5		9 6	64	3 3A	◪	SP SM		F2	**FILL, POORLY GRADED SAND WITH SILT**, brown, about 10% gravel, 10% silt, fine sand, damp, very dense, **DEBRIS** present (wood, insulation)	7.0
	MA	4	30	4	◪	SP		NFS	**POORLY GRADED SAND**, brown, 1% gravel, 5% silt, gravel subrounded to 3/8", medium sand, damp, medium dense, **COAL** present	
10		5	31	5	◪				wet, dense	14.5
15		19 19	50	6 6A	◪	ML		F4	**SANDY SILT**, gray, about 35% sand, low plasticity, fine sand, wet, stiff	16.0
						ML		F4	**SILT WITH SAND**, mottled gray/brown, about 10% gravel, 15% sand, low plasticity, gravel subangular to 1/4", fine sand, wet, hard	19.5
20		24	27	7	◪	ML		F4	▽ Groundwater encountered at 20.5' while drilling **SILT**, gray, about 10% sand, low plasticity, fine sand, saturated, very stiff ▼	
25		32 23	41	8 8a	◪				low plasticity, hard	26.0
						ML		F4	**SANDY SILT**, brown, about 35% sand, low plasticity, fine sand, saturated, very stiff, sampler full due to heaving sand - blow counts may not be representative	29.5
30		23	54	9	◪	SM		F4	**SILTY SAND**, gray, about 30% silt, fine sand, saturated, very dense	31.5
35						TD=31.5'				

TEST BORING COMPLETED ON 06-29-06
PVC STANDPIPE INSTALLED TO 31.5'
GROUNDWATER MEASURED AT 23' ON 06-30-06

KEY
MA = Mechanical Analysis
TD = Total Depth
▼ = Groundwater After Drilling
☐ = Grab Sample
◪ = SPT Sample
▨ = Shelby Tube - pushed
☒ = 2.5" I.D. Spoon Sample 340# weight, 30" fall

DRILLING CO.: Denali Drilling, Inc.
EQUIPMENT: CME-55
OPERATOR: Aaron Shaw
METHOD: 6 in. hollow-stem auger

CLIENT: ACFAB
PROJECT: C-FAB Office Building
LOGGED BY: Natasha Hayden
BORING COMPLETED: 06-29-06
W.O. D59431

LOG OF EXPLORATION 59431.GPJ BLANK2.GDT 07/24/06

TEST BORING 2

LOCATION: SEE TEST BORING LOCATION MAP
ELEVATION:

Other Tests	Moisture Content (%)	Blows / Foot	Sample No.	Sample Type	Soil Class	Frost Class	Description	DEPTH
	6		1	☐	SP/SM	F2	**GRAVEL SURFACE** **FILL, POORLY GRADED SAND WITH SILT AND GRAVEL,** brown, about 30% gravel, 10% silt, gravel subrounded to 1.5", medium sand, damp	2.0
	4	22	2	◩	SP	NFS	**POORLY GRADED SAND**, brown, about 5% silt, medium sand, damp, medium dense, **COAL** present	
MA	3	27	3	◩			becoming more gravelly, 3% gravel, 3% silt, gravel subangular to 3/8"	
	5	30	4	◩			gravel subangular to 3/4"	9.5
PI=NP	21	14	5	◩	ML	F4	**SILT WITH SAND**, gray, about 15% sand, nonplastic, fine sand, damp, stiff	14.5
	29	11	6	◩	ML	F4	**SILT**, gray, about 5% sand, low plasticity, fine sand, damp, stiff	19.5
	12	36	7	◩	ML	F4	**SANDY SILT**, brown, about 40% sand, low plasticity, fine sand, damp, hard	
	19	43	8	◩			▽ Groundwater encountered at 29' while drilling	29.5
	28	40	9	◩	SP/SM	F2	**POORLY GRADED SAND WITH SILT**, brown, about 10% silt, fine sand, saturated, dense, **COAL** present	31.5

DEPTH (FEET)

TD=31.5'

TEST BORING COMPLETED ON 06-29-06
PVC STANDPIPE INSTALLED TO 31.5'
GROUNDWATER MEASURED AT 26' ON 06-30-06

KEY
MA = Mechanical Analysis
PI = Plasticity Index
LL = Liquid Limit
TD = Total Depth
▼ = Groundwater After Drilling
☐ = Grab Sample
◩ = SPT Sample
▨ = Shelby Tube - pushed
☒ = 2.5" I.D. Spoon Sample 340# weight, 30" fall

DRILLING CO.: Denali Drilling, Inc.
EQUIPMENT: CME-55
OPERATOR: Aaron Shaw
METHOD: 6 in. hollow-stem auger

CLIENT: ACFAB
PROJECT: C-FAB Office Building
LOGGED BY: Natasha Hayden
BORING COMPLETED: 06-29-06
W.O. D59431

DOWL ENGINEERS

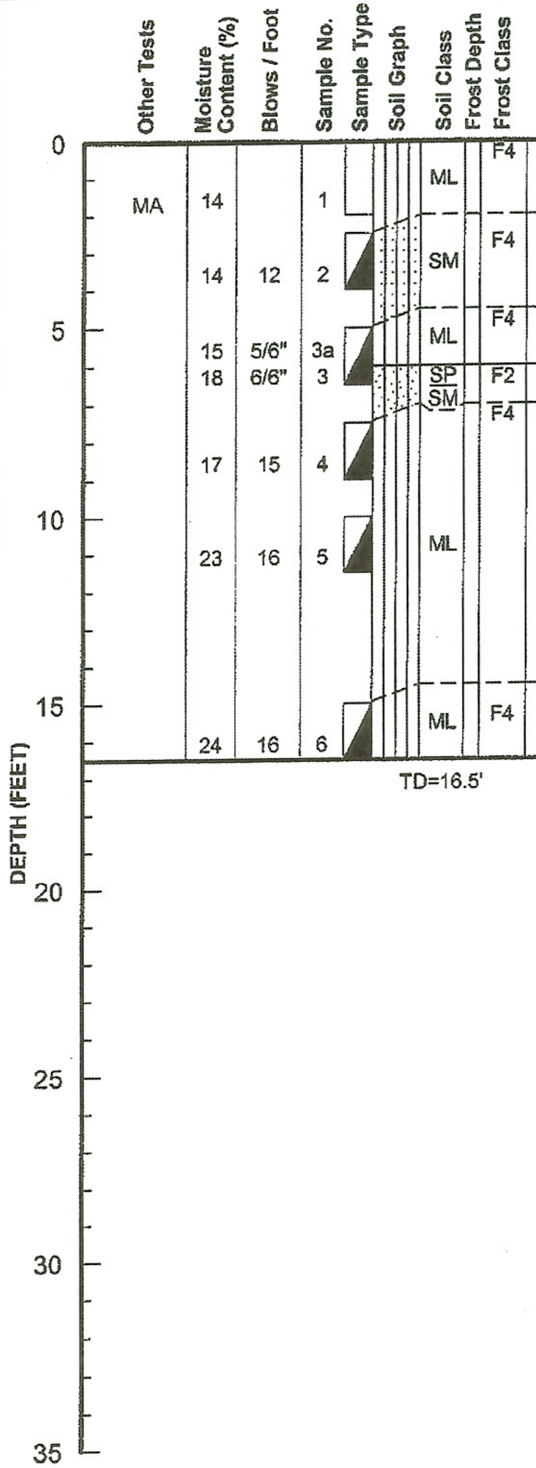
LOG OF TEST BORING 2

FIGURE B-2

LOG OF EXPLORATION 59431.GPJ BLANK2.GDT 07/20/06

TEST BORING 3

LOCATION: SEE TEST BORING LOCATION MAP
ELEVATION:



Other Tests	Moisture Content (%)	Blows / Foot	Sample No.	Sample Type
MA	14		1	☐
	14	12	2	◩
	15	5/6"	3a	◩
	18	6/6"	3	◩
	17	15	4	◩
	23	16	5	◩
	24	16	6	◩

Soil Class	Frost Class		DEPTH
	F4	**GRASS SURFACE**	
ML		**SANDY SILT**, brown, 1% gravel, 37% sand, nonplastic, gravel subrounded to 3/8", fine sand, damp	2.0
SM	F4	**SILTY SAND**, brown, about 40% silt, nonplastic, fine sand, damp, medium dense, **ORGANICS** present to 5% by volume, (rootlets)	4.5
ML	F4	**SANDY SILT**, brown, about 50% sand, nonplastic, fine sand, damp, stiff	6.0
SP SM	F2	**POORLY GRADED SAND WITH SILT**, brown, about 10% silt, nonplastic, fine sand, damp, medium dense, **COAL** present	7.0
ML	F4	**SILT WITH SAND**, brown, about 25% sand, no to low plasticity, fine sand, damp, very stiff mottled gray/brown, becoming siltier, about 15% sand, low plasticity	14.5
ML	F4	**SILT**, mottled gray/brown, about 10% sand, low plasticity, fine sand, damp, very stiff	16.5

TEST BORING COMPLETED ON 06-29-06
NO GROUNDWATER OBSERVED WHILE DRILLING
PVC STANDPIPE INSTALLED TO 16.5'
NO MEASURABLE GROUNDWATER ON 06-30-06

KEY
MA = Mechanical Analysis
TD = Total Depth
☐ = Grab Sample
◩ = SPT Sample
◩ = Shelby Tube - pushed
☒ = 2.5" I.D. Spoon Sample 340# weight, 30" fall

DRILLING CO.: Denali Drilling, Inc.
EQUIPMENT: CME-55
OPERATOR: Aaron Shaw
METHOD: 6 in. hollow-stem auger

CLIENT: ACFAB
PROJECT: C-FAB Office Building
LOGGED BY: Natasha Hayden
BORING COMPLETED: 06-29-06
W.O. D59431

DOWL ENGINEERS

LOG OF TEST BORING 3

FIGURE B-3

TEST BORING 4

LOCATION: SEE TEST BORING LOCATION MAP
ELEVATION:

Other Tests	Moisture Content (%)	Blows / Foot	Sample No.	Sample Type	Soil Class	Frost Depth	Frost Class		DEPTH
								GRAVEL SURFACE	
	19		1	☐	SM		F2	**FILL, SILTY SAND WITH GRAVEL**, brown, about 20% gravel, 15% silt, nonplastic, gravel subrounded to 1.5", medium sand, damp	2.0
	4	26	2	◩			F2	**POORLY GRADED SAND WITH SILT**, brown, about 10% silt, medium sand, damp, medium dense	
	15	17	3	◩	SP/SM			becoming more gravelly, about 5% gravel, 10% silt, gravel subrounded to 1/4"	
							∇	Groundwater encountered at 7.5' while drilling	
	28	21	4	◩			▼	gray, saturated	9.5
	23	31	5	◩	SP		NFS	**POORLY GRADED SAND**, gray, about 5% silt, saturated, dense, **COAL** present	14.5
	19	20	6	◩	ML		F4	**SANDY SILT**, gray, about 40% sand, nonplastic, fine sand, saturated, very stiff	16.5

TD=16.5'

DEPTH (FEET): 0, 5, 10, 15, 20, 25, 30, 35

TEST BORING COMPLETED ON 06-29-06
PVC STANDPIPE INSTALLED TO 16.5'
GROUNDWATER MEASURED AT 8.5' ON 06-30-06

KEY
TD = Total Depth
▼ = Groundwater After Drilling
☐ = Grab Sample
◩ = SPT Sample
▨ = Shelby Tube - pushed
☒ = 2.5" I.D. Spoon Sample 340# weight, 30" fall

DRILLING CO.: Denali Drilling, Inc.
EQUIPMENT: CME-55
OPERATOR: Aaron Shaw
METHOD: 6 in. hollow-stem auger

CLIENT: ACFAB
PROJECT: C-FAB Office Building
LOGGED BY: Natasha Hayden
BORING COMPLETED: 06-29-06
W.O. D59431

LOG OF EXPLORATION 59431.GPJ BLANK2.GDT 07/20/06

DOWL ENGINEERS

LOG OF TEST BORING 4

FIGURE B-4

Attachment 4: SWMM Modeling Output

Event 1 - 90th Percentile
Case 1 - Hypothetical, No LID

```
EPA STORM WATER MANAGEMENT MODEL - VERSION 5.0 (Build 5.0.022)
--------------------------------------------------------------


*********************************************************
NOTE: The summary statistics displayed in this report are
based on results found at every computational time step,
not just on results from each reporting time step.
*********************************************************

****************
Analysis Options
****************
Flow Units ............... CFS
Process Models:
  Rainfall/Runoff ........ YES
  Snowmelt ............... NO
  Groundwater ............ NO
  Flow Routing ........... YES
  Ponding Allowed ........ NO
  Water Quality .......... NO
Infiltration Method ...... HORTON
Flow Routing Method ...... DYNWAVE
Starting Date ............ JUL-10-2013 00:00:00
Ending Date .............. JUL-11-2013 00:00:00
Antecedent Dry Days ...... 0.0
Report Time Step ......... 00:00:30
Wet Time Step ............ 00:00:30
Dry Time Step ............ 00:00:30
Routing Time Step ........ 1.00 sec


**************************        Volume         Depth
Runoff Quantity Continuity     acre-feet        inches
**************************     ---------       -------
Total Precipitation ......         0.017         0.521
Evaporation Loss .........         0.000         0.000
Infiltration Loss ........         0.001         0.026
Surface Runoff ...........         0.014         0.446
Final Surface Storage ....         0.002         0.049
Continuity Error (%) .....         0.000


**************************        Volume        Volume
Flow Routing Continuity        acre-feet      10^6 gal
**************************     ---------     ---------
Dry Weather Inflow .......         0.000         0.000
Wet Weather Inflow .......         0.014         0.005
Groundwater Inflow .......         0.000         0.000
RDII Inflow ..............         0.000         0.000
External Inflow ..........         0.000         0.000
External Outflow .........         0.014         0.005
Internal Outflow .........         0.000         0.000
Storage Losses ...........         0.000         0.000
Initial Stored Volume ....         0.000         0.000
Final Stored Volume ......         0.000         0.000
Continuity Error (%) .....         0.000


***************************
Time-Step Critical Elements
***************************
None


********************************
Highest Flow Instability Indexes
********************************
All links are stable.
```

```
*************************
Routing Time Step Summary
*************************
Minimum Time Step           :     1.00 sec
Average Time Step           :     1.00 sec
Maximum Time Step           :     1.00 sec
Percent in Steady State     :     0.00
Average Iterations per Step :     2.00


***************************
Subcatchment Runoff Summary
***************************

--------------------------------------------------------------------------------------------------------
                          Total      Total      Total      Total      Total       Total     Peak  Runoff
                         Precip      Runon       Evap      Infil     Runoff      Runoff   Runoff   Coeff
Subcatchment                 in         in         in         in         in    10^6 gal      CFS
--------------------------------------------------------------------------------------------------------
CFAB_Parking_andLID        0.52       0.00       0.00       0.03       0.45        0.00     0.03   0.856


******************
Node Depth Summary
******************

---------------------------------------------------------------------
                               Average  Maximum  Maximum  Time of Max
                                 Depth    Depth      HGL   Occurrence
Node                 Type         Feet     Feet     Feet  days hr:min
---------------------------------------------------------------------
Junction             JUNCTION     0.01     0.03     0.11     0  12:52
Outfall              OUTFALL      0.01     0.03     0.03     0  12:52


*******************
Node Inflow Summary
*******************

-------------------------------------------------------------------------------------
                                Maximum  Maximum                  Lateral       Total
                                Lateral    Total  Time of Max      Inflow      Inflow
                                 Inflow   Inflow   Occurrence      Volume      Volume
Node                 Type           CFS      CFS  days hr:min    10^6 gal    10^6 gal
-------------------------------------------------------------------------------------
Junction             JUNCTION      0.03     0.03     0  12:52       0.005       0.005
Outfall              OUTFALL       0.00     0.03     0  12:52       0.000       0.005


**********************
Node Surcharge Summary
**********************

No nodes were surcharged.


*********************
Node Flooding Summary
*********************

No nodes were flooded.


***********************
Outfall Loading Summary
***********************

-----------------------------------------------------------
                      Flow       Avg.      Max.       Total
                      Freq.      Flow      Flow      Volume
```

```
  Outfall Node          Pcnt.       CFS       CFS    10^6 gal
  -----------------------------------------------------------
  Outfall               61.38      0.01      0.03       0.005
  -----------------------------------------------------------
  System                61.38      0.01      0.03       0.005


  ********************
  Link Flow Summary
  ********************

  -----------------------------------------------------------------------------
                                 Maximum  Time of Max   Maximum    Max/    Max/
                                  |Flow|   Occurrence   |Veloc|    Full    Full
  Link                 Type          CFS  days hr:min    ft/sec    Flow   Depth
  -----------------------------------------------------------------------------
  DummyConduit         CONDUIT      0.03     0  12:52      3.07    0.00    0.01


  ***************************
  Flow Classification Summary
  ***************************

  -----------------------------------------------------------------------------------------
                      Adjusted    --- Fraction of Time in Flow Class ----   Avg.     Avg.
                       /Actual         Up    Down  Sub   Sup   Up    Down   Froude   Flow
  Conduit               Length    Dry  Dry   Dry   Crit  Crit  Crit  Crit   Number   Change
  -----------------------------------------------------------------------------------------
  DummyConduit            1.00   0.23  0.00  0.00  0.09  0.67  0.00  0.00     2.17   0.0000


  *************************
  Conduit Surcharge Summary
  *************************

  No conduits were surcharged.


  Analysis begun on:  Mon Jan 20 16:17:19 2014
  Analysis ended on:  Mon Jan 20 16:17:19 2014
  Total elapsed time: < 1 sec
```

Event 1 - 90th Percentile
Case 2 - With LID Rain Garden

```
EPA STORM WATER MANAGEMENT MODEL - VERSION 5.0 (Build 5.0.022)
--------------------------------------------------------------


*********************************************************
NOTE: The summary statistics displayed in this report are
based on results found at every computational time step,
not just on results from each reporting time step.
*********************************************************

****************
Analysis Options
****************
Flow Units ............... CFS
Process Models:
  Rainfall/Runoff ........ YES
  Snowmelt ............... NO
  Groundwater ............ NO
  Flow Routing ........... YES
  Ponding Allowed ........ NO
  Water Quality .......... NO
Infiltration Method ...... HORTON
Flow Routing Method ...... DYNWAVE
Starting Date ............ JUL-10-2013 00:00:00
Ending Date .............. JUL-11-2013 00:00:00
Antecedent Dry Days ...... 0.0
Report Time Step ......... 00:00:30
Wet Time Step ............ 00:00:30
Dry Time Step ............ 00:00:30
Routing Time Step ........ 1.00 sec


**************************        Volume         Depth
Runoff Quantity Continuity     acre-feet        inches
**************************     ---------       -------
Total Precipitation ......         0.017         0.521
Evaporation Loss .........         0.000         0.000
Infiltration Loss ........         0.015         0.475
Surface Runoff ...........         0.000         0.000
Final Surface Storage ....         0.001         0.047
Continuity Error (%) .....         0.000


**************************        Volume        Volume
Flow Routing Continuity        acre-feet      10^6 gal
**************************     ---------     ---------
Dry Weather Inflow .......         0.000         0.000
Wet Weather Inflow .......         0.000         0.000
Groundwater Inflow .......         0.000         0.000
RDII Inflow ..............         0.000         0.000
External Inflow ..........         0.000         0.000
External Outflow .........         0.000         0.000
Internal Outflow .........         0.000         0.000
Storage Losses ...........         0.000         0.000
Initial Stored Volume ....         0.000         0.000
Final Stored Volume ......         0.000         0.000
Continuity Error (%) .....         0.000


***************************
Time-Step Critical Elements
***************************
None


********************************
Highest Flow Instability Indexes
********************************
All links are stable.
```

```
*************************
Routing Time Step Summary
*************************
Minimum Time Step           :     1.00 sec
Average Time Step           :     1.00 sec
Maximum Time Step           :     1.00 sec
Percent in Steady State     :     0.00
Average Iterations per Step :     2.00


***************************
Subcatchment Runoff Summary
***************************

--------------------------------------------------------------------------------------------------------
                          Total      Total      Total      Total      Total       Total     Peak  Runoff
                         Precip      Runon       Evap      Infil     Runoff      Runoff   Runoff   Coeff
Subcatchment                 in         in         in         in         in    10^6 gal      CFS
--------------------------------------------------------------------------------------------------------
CFAB_Parking_andLID        0.52       0.00       0.00       0.47       0.00        0.00     0.00   0.000


***********************
LID Performance Summary
***********************

--------------------------------------------------------------------------------------------------------------
                                       Total      Evap     Infil   Surface    Drain      Init.     Final     Po
                                      Inflow      Loss      Loss   Outflow   Outflow   Storage   Storage     En
Subcatchment      LID Control             in        in        in        in       in         in        in
--------------------------------------------------------------------------------------------------------------
CFAB_Parking_andLID  Bioswale_Wisconsin      0.52      0.00      0.00      0.00      0.00      0.00      0.52
CFAB_Parking_andLID  Trench                0.52      0.00      0.52      0.00      0.00      0.00      0.00

******************
Node Depth Summary
******************

---------------------------------------------------------------------
                               Average  Maximum  Maximum  Time of Max
                                 Depth    Depth      HGL   Occurrence
Node                 Type         Feet     Feet     Feet  days hr:min
---------------------------------------------------------------------
Junction             JUNCTION     0.00     0.00     0.08     0  00:00
Outfall              OUTFALL      0.00     0.00     0.00     0  00:00


*******************
Node Inflow Summary
*******************

-------------------------------------------------------------------------------------
                                Maximum  Maximum                  Lateral       Total
                                Lateral    Total  Time of Max      Inflow      Inflow
                                 Inflow   Inflow   Occurrence      Volume      Volume
Node                 Type           CFS      CFS  days hr:min    10^6 gal    10^6 gal
-------------------------------------------------------------------------------------
Junction             JUNCTION      0.00     0.00     0  00:00       0.000       0.000
Outfall              OUTFALL       0.00     0.00     0  00:00       0.000       0.000


**********************
Node Surcharge Summary
**********************

No nodes were surcharged.


*********************
Node Flooding Summary
```

```
*********************

No nodes were flooded.


***********************
Outfall Loading Summary
***********************

-----------------------------------------------------------
                     Flow       Avg.      Max.       Total
                     Freq.      Flow      Flow      Volume
Outfall Node         Pcnt.       CFS       CFS    10^6 gal
-----------------------------------------------------------
Outfall               0.00      0.00      0.00       0.000
-----------------------------------------------------------
System                0.00      0.00      0.00       0.000


********************
Link Flow Summary
********************

-----------------------------------------------------------------------------
                               Maximum  Time of Max   Maximum    Max/    Max/
                                |Flow|   Occurrence   |Veloc|    Full    Full
Link                 Type          CFS  days hr:min    ft/sec    Flow   Depth
-----------------------------------------------------------------------------
DummyConduit         CONDUIT      0.00     0  00:00      0.00    0.00    0.00


***************************
Flow Classification Summary
***************************

-----------------------------------------------------------------------------------------
                    Adjusted    --- Fraction of Time in Flow Class ----   Avg.     Avg.
                     /Actual         Up    Down  Sub   Sup   Up    Down   Froude   Flow
Conduit               Length    Dry  Dry   Dry   Crit  Crit  Crit  Crit   Number   Change
-----------------------------------------------------------------------------------------
DummyConduit            1.00   1.00  0.00  0.00  0.00  0.00  0.00  0.00     0.00   0.0000


*************************
Conduit Surcharge Summary
*************************

No conduits were surcharged.


Analysis begun on:  Mon Jan 20 16:19:47 2014
Analysis ended on:  Mon Jan 20 16:19:47 2014
Total elapsed time: < 1 sec
```

Event 2 - 10-YR, 24-HR

Case 1 - Hypothetical, No LID

```
EPA STORM WATER MANAGEMENT MODEL - VERSION 5.0 (Build 5.0.022)
--------------------------------------------------------------


*********************************************************
NOTE: The summary statistics displayed in this report are
based on results found at every computational time step,
not just on results from each reporting time step.
*********************************************************

****************
Analysis Options
****************
Flow Units ............... CFS
Process Models:
  Rainfall/Runoff ........ YES
  Snowmelt ............... NO
  Groundwater ............ NO
  Flow Routing ........... YES
  Ponding Allowed ........ NO
  Water Quality .......... NO
Infiltration Method ...... HORTON
Flow Routing Method ...... DYNWAVE
Starting Date ............ JUL-10-2013 00:00:00
Ending Date .............. JUL-11-2013 00:00:00
Antecedent Dry Days ...... 0.0
Report Time Step ......... 00:00:30
Wet Time Step ............ 00:00:30
Dry Time Step ............ 00:00:30
Routing Time Step ........ 1.00 sec


**************************        Volume         Depth
Runoff Quantity Continuity     acre-feet        inches
**************************     ---------       -------
Total Precipitation ......         0.056         1.768
Evaporation Loss .........         0.000         0.000
Infiltration Loss ........         0.003         0.088
Surface Runoff ...........         0.052         1.630
Final Surface Storage ....         0.002         0.050
Continuity Error (%) .....         0.000


**************************        Volume        Volume
Flow Routing Continuity        acre-feet      10^6 gal
**************************     ---------     ---------
Dry Weather Inflow .......         0.000         0.000
Wet Weather Inflow .......         0.052         0.017
Groundwater Inflow .......         0.000         0.000
RDII Inflow ..............         0.000         0.000
External Inflow ..........         0.000         0.000
External Outflow .........         0.052         0.017
Internal Outflow .........         0.000         0.000
Storage Losses ...........         0.000         0.000
Initial Stored Volume ....         0.000         0.000
Final Stored Volume ......         0.000         0.000
Continuity Error (%) .....         0.000


***************************
Time-Step Critical Elements
***************************
None


********************************
Highest Flow Instability Indexes
********************************
All links are stable.
```

```
*************************
Routing Time Step Summary
*************************
Minimum Time Step           :     1.00 sec
Average Time Step           :     1.00 sec
Maximum Time Step           :     1.00 sec
Percent in Steady State     :     0.00
Average Iterations per Step :     2.00


***************************
Subcatchment Runoff Summary
***************************

--------------------------------------------------------------------------------------------------------
                            Total      Total      Total      Total      Total       Total     Peak  Runoff
                           Precip      Runon       Evap      Infil     Runoff      Runoff   Runoff   Coeff
Subcatchment                   in         in         in         in         in    10^6 gal      CFS
--------------------------------------------------------------------------------------------------------
CFAB_Parking_andLID          1.77       0.00       0.00       0.09       1.63        0.02     0.49   0.922


******************
Node Depth Summary
******************

---------------------------------------------------------------------
                                 Average  Maximum  Maximum  Time of Max
                                   Depth    Depth      HGL   Occurrence
Node                 Type           Feet     Feet     Feet  days hr:min
---------------------------------------------------------------------
Junction             JUNCTION       0.02     0.10     0.18     0  09:59
Outfall              OUTFALL        0.02     0.10     0.10     0  09:59


*******************
Node Inflow Summary
*******************

-------------------------------------------------------------------------------------
                                  Maximum  Maximum                  Lateral       Total
                                  Lateral    Total  Time of Max      Inflow      Inflow
                                   Inflow   Inflow   Occurrence      Volume      Volume
Node                 Type             CFS      CFS  days hr:min    10^6 gal    10^6 gal
-------------------------------------------------------------------------------------
Junction             JUNCTION        0.49     0.49     0  09:59       0.017       0.017
Outfall              OUTFALL         0.00     0.49     0  09:59       0.000       0.017


**********************
Node Surcharge Summary
**********************

No nodes were surcharged.


*********************
Node Flooding Summary
*********************

No nodes were flooded.


***********************
Outfall Loading Summary
***********************

-----------------------------------------------------------
                      Flow       Avg.      Max.       Total
                      Freq.      Flow      Flow      Volume
```

```
Outfall Node          Pcnt.       CFS       CFS    10^6 gal
-----------------------------------------------------------
Outfall               92.72      0.03      0.49       0.017
-----------------------------------------------------------
System                92.72      0.03      0.49       0.017


********************
Link Flow Summary
********************

-----------------------------------------------------------------------------
                               Maximum  Time of Max   Maximum    Max/    Max/
                                |Flow|   Occurrence   |Veloc|    Full    Full
Link                 Type          CFS  days hr:min    ft/sec    Flow   Depth
-----------------------------------------------------------------------------
DummyConduit         CONDUIT      0.49      0  09:59      6.80    0.00    0.03


***************************
Flow Classification Summary
***************************

-----------------------------------------------------------------------------------------
                    Adjusted    --- Fraction of Time in Flow Class ----   Avg.     Avg.
                    /Actual         Up    Down  Sub   Sup   Up    Down    Froude   Flow
Conduit              Length    Dry  Dry   Dry   Crit  Crit  Crit  Crit    Number   Change
-----------------------------------------------------------------------------------------
DummyConduit           1.00   0.07  0.00  0.00  0.00  0.93  0.00  0.00     3.22   0.0000


*************************
Conduit Surcharge Summary
*************************

No conduits were surcharged.


Analysis begun on:  Mon Jan 20 16:12:22 2014
Analysis ended on:  Mon Jan 20 16:12:22 2014
Total elapsed time: < 1 sec
```

Event 2 - 10-YR, 24-HR

Case 2 - With LID Rain Garden

```
EPA STORM WATER MANAGEMENT MODEL - VERSION 5.0 (Build 5.0.022)
--------------------------------------------------------------


*********************************************************
NOTE: The summary statistics displayed in this report are
based on results found at every computational time step,
not just on results from each reporting time step.
*********************************************************

****************
Analysis Options
****************
Flow Units ............... CFS
Process Models:
  Rainfall/Runoff ........ YES
  Snowmelt ............... NO
  Groundwater ............ NO
  Flow Routing ........... YES
  Ponding Allowed ........ NO
  Water Quality .......... NO
Infiltration Method ...... HORTON
Flow Routing Method ...... DYNWAVE
Starting Date ............ JUL-10-2013 00:00:00
Ending Date .............. JUL-11-2013 00:00:00
Antecedent Dry Days ...... 0.0
Report Time Step ......... 00:00:30
Wet Time Step ............ 00:00:30
Dry Time Step ............ 00:00:30
Routing Time Step ........ 1.00 sec


**************************        Volume         Depth
Runoff Quantity Continuity     acre-feet        inches
**************************     ---------       -------
Total Precipitation ......         0.056         1.768
Evaporation Loss .........         0.000         0.000
Infiltration Loss ........         0.037         1.175
Surface Runoff ...........         0.017         0.533
Final Surface Storage ....         0.002         0.060
Continuity Error (%) .....         0.000


**************************        Volume        Volume
Flow Routing Continuity        acre-feet      10^6 gal
**************************     ---------     ---------
Dry Weather Inflow .......         0.000         0.000
Wet Weather Inflow .......         0.017         0.005
Groundwater Inflow .......         0.000         0.000
RDII Inflow ..............         0.000         0.000
External Inflow ..........         0.000         0.000
External Outflow .........         0.017         0.005
Internal Outflow .........         0.000         0.000
Storage Losses ...........         0.000         0.000
Initial Stored Volume ....         0.000         0.000
Final Stored Volume ......         0.000         0.000
Continuity Error (%) .....         0.000


***************************
Time-Step Critical Elements
***************************
None


********************************
Highest Flow Instability Indexes
********************************
All links are stable.


*************************
Routing Time Step Summary
*************************
Minimum Time Step           :     1.00 sec
Average Time Step           :     1.00 sec
Maximum Time Step           :     1.00 sec
Percent in Steady State     :     0.00
Average Iterations per Step :     2.00
```

```
***************************
Subcatchment Runoff Summary
***************************

--------------------------------------------------------------------------------------------------------
                          Total      Total      Total      Total      Total       Total     Peak  Runoff
                         Precip      Runon       Evap      Infil     Runoff      Runoff   Runoff   Coeff
Subcatchment                 in         in         in         in         in    10^6 gal      CFS
--------------------------------------------------------------------------------------------------------
CFAB_Parking_andLID        1.77       0.00       0.00       1.17       0.53        0.01     0.47   0.301


***********************
LID Performance Summary
***********************

------------------------------------------------------------------------------------------------------------------
                                       Total      Evap     Infil   Surface    Drain      Init.     Final     Pcnt.
                                      Inflow      Loss      Loss   Outflow   Outflow   Storage   Storage     Error
Subcatchment      LID Control             in        in        in        in        in        in        in
------------------------------------------------------------------------------------------------------------------
CFAB_Parking_andLID  Bioswale_Wisconsin      1.77      0.00      0.00      0.00      0.00      0.00      1.77     -0.1
CFAB_Parking_andLID  Trench                1.77      0.00      1.77      0.00      0.00      0.00      0.00     -0.00

******************
Node Depth Summary
******************

---------------------------------------------------------------------
                               Average  Maximum  Maximum  Time of Max
                                 Depth    Depth      HGL   Occurrence
Node                 Type         Feet     Feet     Feet  days hr:min
---------------------------------------------------------------------
Junction             JUNCTION     0.00     0.10     0.18     0  09:59
Outfall              OUTFALL      0.00     0.10     0.10     0  09:59


*******************
Node Inflow Summary
*******************

-------------------------------------------------------------------------------------
                                Maximum  Maximum                  Lateral       Total
                                Lateral    Total  Time of Max      Inflow      Inflow
                                 Inflow   Inflow   Occurrence      Volume      Volume
Node                 Type           CFS      CFS  days hr:min    10^6 gal    10^6 gal
-------------------------------------------------------------------------------------
Junction             JUNCTION      0.47     0.47     0  09:59       0.005       0.005
Outfall              OUTFALL       0.00     0.47     0  09:59       0.000       0.005


**********************
Node Surcharge Summary
**********************

No nodes were surcharged.


*********************
Node Flooding Summary
*********************

No nodes were flooded.


***********************
Outfall Loading Summary
***********************

-----------------------------------------------------------
                      Flow       Avg.      Max.       Total
                      Freq.      Flow      Flow      Volume
Outfall Node          Pcnt.       CFS       CFS    10^6 gal
-----------------------------------------------------------
Outfall               16.90      0.05      0.47       0.005
-----------------------------------------------------------
System                16.90      0.05      0.47       0.005


********************
Link Flow Summary
********************
```

```
-----------------------------------------------------------------------------
                               Maximum  Time of Max   Maximum    Max/    Max/
                                |Flow|   Occurrence   |Veloc|    Full    Full
Link                 Type          CFS  days hr:min    ft/sec    Flow   Depth
-----------------------------------------------------------------------------
DummyConduit         CONDUIT      0.47     0  09:59      6.72    0.00    0.03


***************************
Flow Classification Summary
***************************

-----------------------------------------------------------------------------------------
                    Adjusted    --- Fraction of Time in Flow Class ----   Avg.     Avg.
                    /Actual         Up    Down  Sub   Sup   Up    Down   Froude   Flow
Conduit              Length    Dry  Dry   Dry   Crit  Crit  Crit  Crit   Number   Change
-----------------------------------------------------------------------------------------
DummyConduit           1.00   0.37  0.00  0.00  0.45  0.18  0.00  0.00     0.61   0.0000


*************************
Conduit Surcharge Summary
*************************

No conduits were surcharged.


Analysis begun on:  Wed Jan 22 13:33:05 2014
Analysis ended on:  Wed Jan 22 13:33:05 2014
Total elapsed time: < 1 sec
```