INFILTRATION FEASIBILITY ASSESSMENT

Miller-Walker Basin Stormwater Retrofit Planning
King County, Washington

Prepared for: HDR

Project No. 130190 • July 17, 2014

Aspect CONSULTING

earth + water

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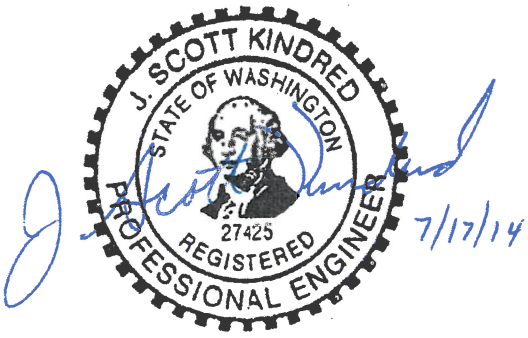

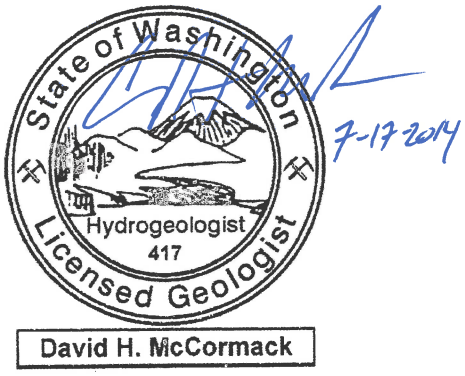

J. Scott Kindred, PE
Associate Water Resources Engineer
skindred@aspectconsulting.com

David H. McCormack, LEG, LHG
Senior Associate Engineering Geologist
dmccormack@aspectconsulting.com

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Executive Summary

The Miller and Walker Creeks basins are located in southwestern King County and drain into Puget Sound in the City of Normandy Park, west of Sea-Tac Airport. The watersheds are highly urbanized, and most of the stormwater draining to the streams is untreated. Stormwater retrofits are needed to improve the stream flows and water quality to protect Miller and Walker Creeks and Puget Sound.

This report provides a stormwater infiltration feasibility assessment for the Miller-Walker basin. This infiltration feasibility assessment will be used to support identification of stormwater retrofit opportunities for the Miller-Walker Basin Stormwater Retrofit Planning Study sponsored by the King County Water and Land Resource Division (WLRD), the cities of Burien, Normandy Park and SeaTac, and the Port of Seattle.

Both shallow infiltration (generally less than 10-feet-deep) and deep infiltration (generally greater than 10-feet-deep) are addressed in this assessment. Shallow infiltration feasibility was considered a function of four factors: landslide hazard, surficial permeability, surface slope gradient, and the potential for shallow groundwater mounding. Deep infiltration feasibility was considered a function of three factors: landslide hazard, depth to permeable unsaturated zone, and thickness of permeable unsaturated zone. Geographic Information System (GIS) layers of each factor were created and the infiltration feasibility of each unique combination of factors (referred to as hydrogeomorphic units) was evaluated. Maps of infiltration feasibility were created for the basin and the results are summarized below:

- **Shallow Infiltration Feasibility**: The lower-lying portions of the study area with recessional outwash soils are considered to have good or moderate feasibility for shallow infiltration. The remainder of the basin, including slightly over half the basin area, is not expected to be suitable for shallow infiltration due to the presence of low permeability glacial till soils at the surface or high potential for groundwater mounding.
- **Deep infiltration Feasibility**: Deep infiltration may be feasible in significant portions of the basin, including many of the higher elevation areas covered with glacial till that are unsuitable for shallow infiltration. The low-lying areas in the southern portion of the study area are groundwater discharge zones and are unlikely to be suitable for deep infiltration.

The feasibility assessments provided in this report are suitable for identification and evaluation of potential infiltration solutions. Subsurface explorations, infiltration testing, and additional analysis are recommended to support design of project-specific stormwater management facilities that utilize infiltration.

This project has been funded in part by the United States Environmental Protection Agency (EPA) under Puget Sound Ecosystem Restoration and Protection Cooperative Agreement Grant PC-00J20101 with Washington State Department of Ecology. The contents of this document do not necessarily reflect the views and policies of the EPA, nor does mention of trade names or commercial products constitute endorsement or recommendation for use.

1 Introduction

This report provides a stormwater infiltration feasibility assessment for the Miller-Walker Basin Stormwater Retrofit Planning Study sponsored by the King County Water and Land Resource Division (WLRD), the Cities of Burien, Normandy Park and SeaTac, and the Port of Seattle. As shown on Figure 1, the Miller and Walker Creeks basins are located in southwestern King County, and drain into Puget Sound in the City of Normandy Park, west of Sea-Tac Airport. Walker Creek is a tributary to Miller Creek, and, as shown on Figure 2, the two creeks join near the mouth of Miller Creek. The creek watersheds are in the jurisdictions of unincorporated King County, City of Burien, City of SeaTac, and the City of Normandy Park. In addition, a small portion of Sea-Tac Airport drains to the basin (not shown on Figure 2), and is under the jurisdiction of the Port of Seattle.

The study area for this assessment, shown on Figure 2, is defined by the perimeter of the Miller Creek and Walker Creek drainage basins with the exception of land owned by the Port of Seattle. The Port of Seattle is subject to different stormwater requirements than the other portions of the Basin and is excluded from this assessment.

Much of the Miller and Walker Creek watershed was developed prior to the adoption of stormwater management regulations in 1990. As documented in the Miller Walker Creeks Basin Plan (King County 2006), the aquatic habitat in the creeks is highly degraded due to urbanized hydrology, erosional incision of drainages, sediment filled road undercrossings, direct stormwater discharges, channelization, and lack of native vegetation. Based on macro-invertebrate monitoring results using the Benthic Index of Biotic Integrity (B-IBI) scoring system, the health of Miller and Walker Creeks have been categorized as poor to very poor on numerous occasions (http://pugetsoundstreambenthos.org). In addition, coho salmon (an EPA listed species) experience pre-spawn mortality in Miller and Walker Creeks, dying shortly after entering the fresh water and before they have a chance to spawn (http://www.kingcounty.gov/ environment/ watersheds/central-puget-sound/miller-walker-creeks/salmon-monitoring.aspx). With the low rate of development and redevelopment in the Miller-Walker basin, it will take decades before the newer stormwater regulations will help improve stream hydrology and water quality in the basin. Stormwater retrofit projects, with strong reliance on low impact development (LID) elements, are necessary in order to improve the streams more quickly.

This infiltration feasibility assessment is one piece of a larger study to conduct an overall stormwater assessment of the basin and identify opportunities for stormwater retrofit projects. This study relies on existing information and is intended to support stormwater management planning for the basin. Previous work conducted by Aspect Consulting, LLC (Aspect) in the basin for the Port of Seattle has provided a large body of subsurface information and a relatively well developed understanding of the basin's hydrogeology.

The feasibility of both shallow and deep infiltration is evaluated in this assessment. Shallow infiltration generally relies on vertical infiltration directly from the LID facility (typically a bioretention swale, tree-box, or pervious pavement) and is generally suitable in relatively flat areas with permeable surface soils. If surface soils are relatively impermeable but underlain by a sufficiently thick unsaturated zone of permeable soils (receptor horizon), the LID facility may be

equipped with a deep infiltration drain that conveys treated stormwater to permeable soils beneath the low-permeability surface soils. Deep infiltration drains convey water to the deeper unsaturated soils and improve the flow control (reduction in peak runoff) provided by the LID facility. Deep infiltration (defined as deeper than 10 feet below the ground surface) may be accomplished using dug drains (typically less than 20 feet deep) or drilled drains (typically between 20 and 150 feet deep). Deep infiltration drains may require permitting under the Washington State underground injection control (UIC) program (Ecology, 2006).

The remainder of this report has been organized into the following sections:

- Section 2: A review of the physical characteristics of the basin, including topography, geology, and hydrogeology;
- Section 3: The infiltration feasibility assessment including an evaluation of the infiltration factors, evaluating the infiltration feasibility of each combination of infiltration factors (referred to as hydrogeomorphic units) and creation of maps showing the distribution of infiltration feasibility within the basin; and
- Section 4: A summary of the results.

2 General Study Area Topography, Geology, and Hydrogeology

This section summarizes the topography, geology, and hydrogeology of the study area. Section 3 explains how this information is used in the infiltration feasibility assessment.

2.1 Information Sources

Sources of geologic and hydrogeologic information include geologic mapping by Booth and Waldron (2004) and Troost et al. (2005), and subsurface geologic and hydrogeologic information obtained from a groundwater study conducted by Aspect for the Port of Seattle (Aspect, 2008). The Port of Seattle study covered approximately 90 percent of the study area for this assessment, excluding the small segment of the basin north of SW 116th Street. The 2008 groundwater study included an extensive review of existing boring and well logs, groundwater elevation monitoring, development of a conceptual model that included 14 hydrostratigraphic units above the bedrock, and construction of a numerical groundwater model that simulated groundwater flow and contaminant transport in the vicinity of the Sea-Tac Airport.

One of the important considerations for determining the feasibility of deep infiltration is the presence of a permeable unsaturated zone (typically advance outwash) beneath the low-permeability surface soils (typically glacial till). Due to Sea-Tac Airport being located in the study area, a relatively large number of suitably deep explorations have been conducted in the past. This existing data, previously compiled and interpreted by Aspect (2008), provide information on relevant hydrostratigraphic units to support assessment of deep infiltration feasibility.

2.2 Topography

As shown on the shaded relief topographic map in Figure 3, the study area rises from sea level at the mouth of Miller creek to elevations of approximately 475 feet above mean sea level (amsl). Miller Creek flows from northeast to southwest and portions of the creek drainage are deeply incised below an elevation of 200 feet amsl. The northern half of the basin is characterized by rolling glaciated upland terrain all above an elevation of 300 feet amsl.

2.3 Geology

The surficial geology of the Puget Sound basin results from long periods of erosion and non-glacial sedimentation in depositional environments similar to those present today, punctuated by multiple glacial advances into the Puget Sound lowland. The most recent glaciation, the Vashon Stade of the Fraser glaciation, ended about 13,000 years ago, and the resulting landform consists of glacially sculpted uplands composed of north to south elongated glacial drumlins and flutes, and broad river valleys and waterways of Puget Sound. Post-glacial erosion has locally incised the uplands and created steep-sided ravines and steep bluffs near coastal areas and river valleys. Alluvial soils have been deposited in river and stream valleys since the end of the Vashon glaciation.

Figure 4 illustrates the surficial geology for the study area. The geologic units that are present at the surface and in the shallow surface are divided into the following general categories (older to younger):

- **Older Glacial and Nonglacial Deposits:** Pre-Fraser-glaciation-age fine-grained deposits $Qpf_{(f)}$ are mapped in southern portions of the Miller Creek channel and the nearby hillside. These deposits include soils of glacial and nonglacial origins. Due to the relatively high percentage of fine soil particles typical of these deposits, they are generally considered poor for infiltration.

- **Vashon Deposits:** Deposited during the recent Vashon glaciation, these deposits include the following units (from oldest to youngest): advance outwash (Qva), glacial till (Qvt), ice-contact deposits (Qvi), and recessional outwash (Qvr). The advance outwash is a predominately sandy unit that lies stratigraphically below the glacial till. Where present, it is generally considered relatively permeable. The glacial till covers much of the high plateau area and generally consists of a dense mixture of silt, sand, and gravel considered relatively impermeable. The Aspect 2008 study indicated an average glacial till thickness of about 15 feet. The ice-contact deposits are commonly transitional in texture between glacial till and outwash deposits and are mapped in isolated areas in the north of the study area. The permeability of the ice-contact deposits is generally between that of glacial till and advance outwash. Vashon recessional outwash, generally consisting of relatively permeable sand and gravel, is relatively extensive in the low-lying areas of the study area. Recessional outwash is often underlain by glacial till and may contain shallow groundwater.

- **Post-glacial (Recent) Deposits:** Deposited since the most recent glaciation, these deposits include alluvial deposits (Qal), wetland deposits (Qw), beach deposits (Qb), and modified land (m). The alluvial and beach deposits, which are typically relatively permeable, occur in depositional areas near the mouth of Miller Creek. Wetland deposits are generally associated with surface water bodies and are typically saturated and unsuitable for infiltration. The modified land is associated with the Sea-Tac Airport re-grading.

The complex geologic and glacial history of the site area has resulted in multiple periods of erosion and deposition. Thus, it should be noted that not all of the above hydrostratigraphic or geologic units are typically present at any one location.

Figure 5 shows the elevation contours for the top of the advance outwash hydrostratigraphic unit used in the Aspect (2008) groundwater study. Subtracting this surface from the ground surface elevation generally provides an indication of the depth to a permeable receptor horizon for deep infiltration. It should be noted that the advance outwash hydrostratigraphic unit is missing from the low-lying areas in the southern portion of the study area (shown as blank on Figure 5). This area without advance outwash is a groundwater discharge zone, and is generally not expected to be suitable for deep infiltration.

2.4 Hydrogeology

Based on our review of existing information, three hydrostratigraphic units of importance have been identified in the study area: near-surface perched groundwater, the recessional outwash aquifer, and the advance outwash aquifer. This section summarizes the characteristics and implications of these units.

Near-surface perched water occurs when low-permeability soils are present near the ground surface. In particular, perched groundwater frequently occurs on the glacial till that covers most of the upland portion of the study area. Depending on a variety of factors, such as facility size and horizontal permeability, groundwater mounding on glacial till can reduce the infiltration

capacity of the facility by an order of magnitude or more in comparison with short-term infiltration testing results and, in most situations, render shallow infiltration ineffective.

The recessional outwash aquifer occurs in the recessional outwash deposits in the low-lying portions of the study area. This aquifer may be perched on top of glacial till deposits that underlie the recessional outwash, or in areas where the glacial till is not present, may be in direct connection with the advance outwash aquifer or older geologic units. The depth to groundwater in the recessional outwash was not a significant parameter in the 2008 groundwater study (Aspect, 2008) and is not well documented. Elevations of the recessional outwash aquifer can be inferred in places based on the presence of lakes, streams, and wetlands. In addition to Miller and Walker Creeks, a number of lakes and wetlands are shown on Figure 4.

The advance outwash aquifer was a significant aquifer in the 2008 groundwater study (Aspect Consulting LLC., 2008) and flow in the aquifer was simulated in the groundwater model. A map of the groundwater elevations in the advance outwash aquifer was developed based on these modeling results and is provided in Figure 6. As shown on this figure, groundwater elevations are estimated to range from less than 75 feet amsl in the lower portion of the Miller Creek Basin to approximately 375 feet amsl in the northern portion of the basin. Based on these contours, this aquifer generally discharges to Miller and Walker Creeks in the southern end of the study area.

2.5 Sensitive and Critical Areas (Wetlands, Steep Slopes, Stream Buffers, Geologic Hazards, Wellhead Protection, Floodplains)

Figure 7 shows sensitive and critical areas within the Study Area based on available GIS data. The sensitive and critical areas categories include floodplains, wetlands, stream buffers, landslide hazard areas, earthquake hazard zones, critical aquifer recharge areas and wellhead protection zones. The potential impact of each on stormwater infiltration is discussed below:

- **Floodplains**: Generally, most floodplains are considered poor for shallow infiltration because they are located in areas with shallow groundwater and high mounding potential. In addition, most floodplains are located in groundwater discharge zones and are generally unsuitable for deep infiltration.
- **Wetlands**: Wetlands are categorized as low permeability areas with high mounding potential areas and would be classified as “poor” for shallow stormwater infiltration. If the wetland is perched on glacial till, it may be theoretically suitable for deep infiltration but construction within a mapped wetland is generally not allowed.
- **Stream buffers**: In general, most stream buffers are unsuitable for shallow infiltration because they are located in areas with shallow groundwater and high mounding potential. In addition, stream buffers tend to be located in groundwater discharge zones and are generally unsuitable for deep infiltration.
- **Landslide hazard areas**: Due to the potential for groundwater rise associated with stormwater infiltration, landslide hazard areas are generally unsuitable for both shallow and deep infiltration.
- **Earthquake hazard zones**: Earthquake hazard zones are typically mapped in areas with saturated sandy soils at risk for liquefaction during an earthquake. These areas can be

suitable for stormwater infiltration and it's unlikely that the small and generally short-lived increases in the water table associated with stormwater infiltration would significantly increase the liquefaction hazard. Therefore, earthquake hazard zones were considered generally feasible for infiltration for this study. However, the design engineer for any project within an earthquake hazard zone should consider the effects of stormwater infiltration during their liquefaction analysis and make the final assessment during design.

- **Critical Aquifer Recharge Areas (CARA) and Wellhead Protection Zones:** The public water supply wells within the Miller-Walker basin (identified in the 2008 groundwater study) are completed in deep aquifers below the upper (advance outwash) aquifer and would not be impacted by stormwater infiltration. Therefore, areas mapped as CARA and/or wellhead protection zones were considered generally feasible for shallow and deep infiltration for purposes of this study.

3 Infiltration Feasibility Assessment

Infiltration feasibility was based on evaluation of factors that affect infiltration potential and identification of hydrogeomorphic units that represent unique combinations of these factors. A total of six factors were used, as follows:

- Surficial geology/gross unit hydraulic conductivity;
- Surface slope gradient;
- Proximity to landslide hazard areas;
- Potential for shallow mounding;
- Depth to permeable unsaturated zone; and
- Thickness of permeable unsaturated zone.

The following sections provide a description of these factors and how they were used to evaluate shallow and deep infiltration feasibility.

3.1 Evaluation of Infiltration Factors

This section provides a summary of the six factors used to evaluate shallow and deep infiltration feasibility.

3.1.1 Surficial Geology/Permeability

Mapped surficial geology is important because it facilitates estimation of the permeability of the surface soils and is a major factor in assessing feasibility and cost effectiveness of shallow infiltration. Surficial geology for the study area is discussed in Section 2.3 and presented on Figure 4. Each of the geologic units included within the study area were categorized into broad permeability categories, as follows:

High permeability (>10 inches/hour):

- Beach Deposits (Qb)
- Vashon Recessional Outwash (Qvr)

Moderate permeability (2-10 inches/hour):

- Alluvium (Qal)
- Vashon Advance outwash (Qva)

Low permeability (0-2 inches/hour):

- Modified Land (m)
- Wetland Deposits (Qw)
- Vashon Ice-contact Deposits (Qvi)

- Vashon Glacial Till (Qvt)
- Pre-Fraser-Glaciation-Age Fine-Grained Deposits ($Qpf_{(f)}$)
- Any areas mapped as a wetlands by King County or City of Burien.

Shallow infiltration is generally considered more feasible in locations with higher permeability. Based on the geologic mapping discussed in Section 2.1 and the permeability categories discussed above, a map of surface permeability is provided on Figure 8. As shown on the figure, much of the study area has low surficial permeability due to the presence of glacial till and other low permeability deposits. The low-lying portions of the study area with recessional outwash soils are mapped as high permeability. A relatively small portion of the study area is mapped as moderate permeability, primarily due to the presence of advance outwash and alluvium.

3.1.2 Surface Slope Gradient

Shallow infiltration is generally considered more feasible in flat areas and less feasible on steep slopes due to the potential for shallow infiltration to migrate along a perching layer and daylight at the ground surface or in a crawl space/basement down slope from the infiltration facility. In addition, surface slope can affect the cost of construction of shallow infiltration facilities, due to the addition of weirs or other structures to create storage on steep slopes.

Surface slope was calculated based on Light Detection and Ranging (LiDAR) elevation data prepared by Puget Sound LiDAR Consortium (2004). The study area was divided into the following surface slope categories:

- **Low Gradient (good for infiltration):** Less than 5 percent;
- **Moderate Gradient:** Between 5 percent and 15 percent; and
- **High Gradient (poor for infiltration):** Greater than 15 percent.

The definition of these categories is generally based on Aspect's observations of slopes that typically have water seepage issues. As shown on Figure 9, most of the study area is relatively flat (i.e., low or moderate surface slope gradient), with the most significant area with slopes greater than 15 percent occurring just north of the southern end of Miller Creek.

3.1.3 Landslide Hazard Areas

Increased groundwater recharge can, in some situations, increase the potential for landslides. Therefore, infiltration facilities generally should not be located close to slopes that may be susceptible to landsliding (referred to as landslide hazard areas).

This planning-level analysis of landslide hazard areas relied on mapping of geologic hazards by the municipalities within the basin, primarily the City of Burien. The study area was divided into the following two landslide hazard categories:

- **High to Moderate Landslide Hazard**: Within 500 feet of a mapped slope hazard area; and
- **Low Landside Hazard**: All other areas.

As shown on Figure 10, most of the study area is mapped as having a low landslide hazard. The only areas mapped as high to moderate are two areas of steep slopes in the southern portion of

the study area and a few small slivers of land along the western boundary of the study area. These areas are mapped as "poor" for both shallow and deep stormwater infiltration.

These categories and their mapped extents should be considered guidelines that generally identify the potential landslide hazard associated with increased infiltration. The actual risk depends on the amount of infiltration and site-specific geology and groundwater conditions. The potential impacts of any proposed infiltration facility on landslide hazard areas should be evaluated by a qualified geotechnical professional. Site-specific explorations and slope stability modeling may be necessary to evaluate the landslide hazard during the design phase of future projects.

3.1.4 Potential for Shallow Groundwater Mounding

Groundwater mounding can reduce the performance of shallow infiltration facilities if the groundwater mound rises up to the bottom of the facility. This can occur due to perching of infiltrating stormwater on near-surface low permeability soils (such as glacial till), or because the site is underlain by a shallow aquifer (typically the recessional outwash aquifer in this study area). This phenomenon is important because the near-surface soils may be relatively permeable, suggesting good infiltration capacity, but the actual performance of the full-scale facility may be limited by the capacity of the mounded stormwater to flow horizontally. In practice, the infiltration performance of the facility during sustained runoff events may be an order of magnitude less than the performance based on measured vertical permeability of the near surface soils.

As shown on Figure 11, the study area is divided into low, moderate, and high mounding potential with high mounding potential resulting in poor infiltration feasibility. This map is based on the following assumptions:

- Areas mapped as low-permeability geologic units in Section 3.1.1 are mapped as having a high mounding potential due to perching.
- Areas mapped as advance outwash are considered to have low mounding potential.
- Areas mapped as either recessional outwash or alluvium that appear to be less than 10 feet higher than the nearby surface water body were considered to have high mounding potential.
- Areas mapped as either recessional outwash or alluvium that appeared to be between 10 and 20 feet above the nearby surface water body were considered to have moderate mounding potential.
- Areas mapped as either recessional outwash or alluvium that appear to be greater than 20 feet above the nearby surface water body were considered to have low mounding potential.

3.1.5 Depth to Permeable Unsaturated Zone

Deep infiltration is generally suitable when a permeable, unsaturated soil horizon exists beneath low-permeability surface soils. Given the geologic setting of the study area, this permeable unsaturated zone generally occurs in the unsaturated advance outwash deposits beneath the glacial till and above the advance outwash aquifer. The depth to this permeable unsaturated zone is important because it can affect the feasibility and cost of deep infiltration.

The depth to the permeable unsaturated zone was estimated by subtracting the top elevation of the advance outwash (Figure 5) from the ground surface elevations. As shown on Figure 12, the study areas can be divided into the following categories:

- **Shallow (less than 20 feet)**: If the advance outwash is within 20 feet of the ground surface, it is generally relatively cost-effective to install either dug or drilled infiltration drains (i.e., gravel-filled excavations or dry wells that penetrate into more permeable zones).
- **Intermediate (20 to 50 feet):** If the advance outwash is first encountered between a depth of 20 and 50 feet below the ground surface, it is generally feasible and relatively cost-effective to install drilled drains. Dug drains are generally difficult to install to depths greater than 20 feet and are probably not suitable for areas mapped as moderate mounding potential.
- **Deep (greater than 50 feet):** Depths exceeding 50 feet make installation of drilled drains and other approaches less feasible and cost-effective. Based on cross-sections provided in the 2008 (Aspect, 2008) groundwater study, it appears that the depth to the advance outwash may be greater than 50 feet in the higher elevation portions of the study area, such as the area in the northern portion of the study area and other hills scattered across the study area.
- **Advance Outwash Not Present:** The advance outwash has been completely eroded away in the low-lying region in the southern end of the study area. This area is also a groundwater discharge zone and is mapped as "poor" for deep infiltration.

3.1.6 Thickness of Permeable Unsaturated Zone

As discussed previously, deep infiltration is generally suitable when a permeable, unsaturated soil horizon (advance outwash within the study area) exists beneath low-permeability surface soils (generally glacial till). As laid out in the UIC guidance manual (Ecology, 2006), deep infiltration drains should not extend deeper than 5 feet above the seasonal high water table. Therefore, deep infiltration is only feasible if the permeable unsaturated zone is at least 5 feet thick. In addition, the capacity of a deep infiltration drain increases as the screened interval increases so a thicker permeable unsaturated zone will provide higher drain capacity. For these reasons, deep infiltration is more feasible and cost effective as the thickness of the permeable unsaturated zone increases.

The depth to the permeable unsaturated zone was estimated by first calculating the depth to groundwater and then subtracting the depth to the permeable unsaturated zone discussed in Section 3.1.5. The depth to groundwater was estimated by subtracting the advance outwash water table elevations (shown in Figure 6) from the ground surface elevations. It should be noted that the water table elevations shown in Figure 6 are based on limited data and should be considered an approximate representation of the seasonal high water table. Actual water table elevations are likely to differ from Figure 6 due to spatial uncertainty and seasonal fluctuation. However, in most cases, the results of the analysis would not be significantly affected by these differences. As shown on Figure 13, the study areas can be divided into the following categories:

- **High Thickness (greater than 30 feet)**: Deep infiltration is generally effective if the thickness of the permeable unsaturated zone is greater than 30 feet.
- **Moderate Thickness (10 to 30 feet):** Deep infiltration may be less effective if the thickness of the permeable unsaturated zone is between 10 and 30 feet.
- **Low and Zero Thickness (less than 10 feet or confined):** Deep infiltration is generally not feasible if the thickness of the permeable unsaturated zone is less than 10 feet. Areas where the advance outwash water level elevation is above the top of the advance outwash (a

confined aquifer with zero unsaturated thickness) are also not suitable for deep infiltration and are identified as a separate category on the figure.

- **Advance Aquifer Not Present:** The advance outwash has been completely eroded away in the low-lying region in the southern end of the study area. This area is also a groundwater discharge zone and is unlikely to be suitable for deep infiltration.

3.2 Hydrogeomorphic Units

Each unique combination of the above infiltration feasibility factors defines a hydrogeomorphic unit, as listed in Table 1 for shallow infiltration and Table 2 for deep infiltration. (Tables 1 and 2 are presented in this report after the main body of text). As discussed below, different factors were used to define hydrogeomorphic units for the shallow and deep infiltration feasibility assessments. The infiltration feasibility for each hydrogeomorphic unit was evaluated and then categorized based on a combination of infiltration potential, cost effectiveness, and potential hazard.

3.2.1 Shallow Infiltration Hydrogeomorphic Units

Shallow infiltration (generally less than 10 feet deep) feasibility is a function of the following factors:

- Surficial geology/permeability;
- Surface slope gradient;
- Potential for groundwater mounding; and
- Proximity to landslide hazard areas.

Table 1 identifies each of the hydrogeomorphic units and the respective infiltration feasibility for shallow infiltration. There is a potential for up to 54 unique hydrogeomorphic units. Each of the hydrogeomorphic units was assigned to one of the following shallow infiltration classifications:

Good: Hydrogeomorphic units were categorized as good if shallow infiltration is considered both feasible and cost effective and unlikely to pose any significant hazards. Generally, LID facilities located on low gradient slopes with high or moderate infiltration rates (greater than 2 inches/hour), are feasible and are generally considered cost-effective.

Moderate: Hydrogeomorphic units were categorized as moderate if infiltration was considered feasible but may be less cost-effective and/or there may be moderate risk. This classification was generally applied to hydrogeomorphic units that do not meet the criteria for the "good" classification but do meet all of the following criteria:

- Low landslide hazard; and
- Mostly favorable ratings for the other criteria with up to one unfavorable rating or two "moderate" ratings.

Poor: Hydrogeomorphic units were categorized as poor if the infiltration feasibility is likely to be low or there are relatively high potential risks. This classification was generally applied to all the hydrogeomorphic units with a high or moderate landslide hazard or a low permeability rating. It also applied to hydrogeomorphic units that had multiple unfavorable ratings in the other categories.

Table 3 provides a summary of the criteria used to determine the shallow infiltration feasibility categories.

Table 3: Criteria for Shallow Infiltration Feasibility Categories

Feasibility	Permeability	Surface Slope	Groundwater Mounding	Landslide Hazard
Good	Generally the most favorable rating with up to one moderate rating			Low
Moderate	Generally the most favorable rating with up to two moderate ratings			Low
Poor	Generally one or more least favorable rating.			Low
	Any rating			High to moderate

3.2.2 Deep Infiltration Hydrogeomorphic Units

Deep infiltration (generally greater than 10 feet deep) feasibility is a function of the following factors:

- Landslide hazard areas;
- Depth to deep infiltration receptor horizon; and
- Thickness of deep infiltration receptor horizon.

Table 2 identifies each of the deep infiltration hydrogeomorphic units and the respective deep infiltration feasibility. There is a potential for up to 18 unique hydrogeomorphic units. Each of the hydrogeomorphic units were assigned to one of the following deep infiltration classifications:

Good: Hydrogeomorphic units were categorized as good if deep infiltration is likely to be both feasible and cost-effective due to the higher potential for a suitable deep infiltration receptor horizon and low potential for impacting landslide hazard areas. The "good" classification was applied to the following hydrogeomorphic units:

- Low landslide hazard, permeable unsaturated zone thickness greater than 30 feet, and depth of permeable unsaturated zone less than 50 feet; and
- Low landslide hazard, permeable unsaturated zone thickness between 10 and 30 feet, and depth of permeable unsaturated zone less than 20 feet.

Moderate: Hydrogeomorphic units were categorized as moderate if deep infiltration may be feasible and cost-effective, and there is a low potential for impacting landslide hazard areas. The "moderate" classification was applied to the following hydrogeomorphic units:

- Low landslide hazard, permeable unsaturated zone thickness greater than 30 feet, and depth to permeable unsaturated zone greater than 50 feet; and
- Low landslide hazard, permeable unsaturated zone thickness between 10 and 30 feet, and depth to permeable unsaturated zone greater than 20 feet.

Poor: Hydrogeomorphic units were categorized as poor if deep infiltration is unlikely to be feasible or there is the potential for adversely impacting landslide hazard areas. This classification was generally applied to hydrogeomorphic units with high to moderate slide hazard and permeable unsaturated thickness less than 10 feet.

Table 4 provides a summary of the criteria used to determine the shallow infiltration feasibility categories.

Table 4: Criteria for Deep Infiltration Feasibility Categories

Feasibility	Unsaturated Zone Thickness	Depth to Permeable Unsaturated Zone	Landslide Hazard
Good	>10 feet	< 50 feet	Low
Moderate	>10 feet	Any depth	Low
Poor	<10 feet	Any depth	Low
	Any rating		High to moderate

4 Summary of Results

This report presents the results of an infiltration feasibility assessment for the Miller-Walker Basin. Maps of infiltration feasibility were created and the results are summarized below:

- **Shallow Infiltration Feasibility**: As shown on Figure 14, the lower-lying portions of the study area with recessional outwash soils are considered to have good or moderate feasibility for shallow infiltration. The remainder of the basin, including slightly over half the basin area, is not expected to be suitable for shallow infiltration due to the presence of low permeability glacial till soils at the surface or high potential for groundwater mounding.
- **Deep infiltration Feasibility**: As shown on Figure 15, deep infiltration may be feasible in significant portions of the study area, including many of the higher elevation areas covered with glacial till that are unsuitable for shallow infiltration. The relatively thin till cap in the study area supports the feasibility of dug or drilled drains through the till. The low-lying areas in the southern portion of the study area are groundwater discharge zones and are unlikely to be suitable for deep infiltration.

The feasibility assessments provided in this report are suitable for identification and evaluation of potential infiltration solutions. Subsurface explorations, infiltration testing, and additional analysis are recommended to verify the information that provides the basis for the assessments included in this report.

References

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Puget Sound Lidar Consortium, 2004, Lidar Bare Earth ASCII data: Seattle, Washington, (http://rocky2.ess.washington.edu/data/raster/lidar/lidardata/index.htm#DEMs_and_geo-referenced_topographic).

Troost, K.G, Booth, D.B., Wisher, A.P., and Shimel, S.A., 2005, A Geologic Map of Seattle – A Progress Report, United State Geological Survey, Open File Report 2005-1252.

Washington State Department of Ecology (Ecology), 2006, Guidance for UIC wells that manage stormwater, December 2006, Publication Number 05-10-067.

Limitations and Credits

Work for this project was performed and this report prepared in accordance with generally accepted professional practices for the nature and conditions of work completed in the same or similar localities, at the time the work was performed. It is intended for the exclusive use of HDR and King County for specific application to the referenced study area. This report does not represent a legal opinion. No other warranty, expressed or implied, is made.

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This project was also supported by the Miller and Walker Creeks Stewardship program, which is funded by the cities of Burien, Normandy Park and SeaTac, the Port of Seattle, and King County.

TABLES

Table 1: Shallow Infiltration Hydrogeomorphic Units

Miller-Walker Basin Stormwater Retrofit Planning
King County, Washington

Geology/Permeability
G1 = High permeability
G2 = Moderate Permeability
G3 = Low permeability

Surface Slope
S1 = Low: <5%
S2 = Moderate: 5-15%
S3 = High: >15%

Proximity to Slide Hazard Area
SH1 = Low Hazard
SH2 = High to Moderate Hazard

Mounding Potential
GW1 = Low Mounding Potential
GW2 = Moderate Mounding Potential
GW3 = High Mounding Potential

Unit	Permeability	Slope	Landslide Hazard	Depth to UWBZ	Shallow Infiltration Feasibility
G1-S1-SH1-GW1	G1	S1	SH1	GW1	Good
G1-S1-SH1-GW2	G1	S1	SH1	GW2	Good
G1-S1-SH1-GW3	G1	S1	SH1	GW3	Moderate
G1-S1-SH2-GW1	G1	S1	SH2	GW1	Poor
G1-S1-SH2-GW2	G1	S1	SH2	GW2	Poor
G1-S1-SH2-GW3	G1	S1	SH2	GW3	Poor
G1-S2-SH1-GW1	G1	S2	SH1	GW1	Good
G1-S2-SH1-GW2	G1	S2	SH1	GW2	Moderate
G1-S2-SH1-GW3	G1	S2	SH1	GW3	Poor
G1-S2-SH2-GW1	G1	S2	SH2	GW1	Poor
G1-S2-SH2-GW2	G1	S2	SH2	GW2	Poor
G1-S2-SH2-GW3	G1	S2	SH2	GW3	Poor
G1-S3-SH1-GW1	G1	S3	SH1	GW1	Poor
G1-S3-SH1-GW2	G1	S3	SH1	GW2	Poor
G1-S3-SH1-GW3	G1	S3	SH1	GW3	Poor
G1-S3-SH2-GW1	G1	S3	SH2	GW1	Poor
G1-S3-SH2-GW2	G1	S3	SH2	GW2	Poor
G1-S3-SH2-GW3	G1	S3	SH2	GW3	Poor
G2-S1-SH1-GW1	G2	S1	SH1	GW1	Good
G2-S1-SH1-GW2	G2	S1	SH1	GW2	Moderate
G2-S1-SH1-GW3	G2	S1	SH1	GW3	Poor
G2-S1-SH2-GW1	G2	S1	SH2	GW1	Poor
G2-S1-SH2-GW2	G2	S1	SH2	GW2	Poor
G2-S1-SH2-GW3	G2	S1	SH2	GW3	Poor
G2-S2-SH1-GW1	G2	S2	SH1	GW1	Moderate
G2-S2-SH1-GW2	G2	S2	SH1	GW2	Moderate
G2-S2-SH1-GW3	G2	S2	SH1	GW3	Poor
G2-S2-SH2-GW1	G2	S2	SH2	GW1	Poor
G2-S2-SH2-GW2	G2	S2	SH2	GW2	Poor
G2-S2-SH2-GW3	G2	S2	SH2	GW3	Poor
G2-S3-SH1-GW1	G2	S3	SH1	GW1	Poor
G2-S3-SH1-GW2	G2	S3	SH1	GW2	Poor
G2-S3-SH1-GW3	G2	S3	SH1	GW3	Poor
G2-S3-SH2-GW1	G2	S3	SH2	GW1	Poor

Table 1: Shallow Infiltration Hydrogeomorphic Units

Miller-Walker Basin Stormwater Retrofit Planning
King County, Washington

Geology/Permeability

G1 = High permeability
G2 = Moderate Permeability
G3 = Low permeability

Surface Slope

S1 = Low: <5%
S2 = Moderate: 5-15%
S3 = High: >15%

Proximity to Slide Hazard Area

SH1 = Low Hazard
SH2 = High to Moderate Hazard

Mounding Potential

GW1 = Low Mounding Potential
GW2 = Moderate Mounding Potential
GW3 = High Mounding Potential

Unit	Permeability	Slope	Landslide Hazard	Depth to UWBZ	Shallow Infiltration Feasibility
G2-S3-SH2-GW2	G2	S3	SH2	GW2	Poor
G2-S3-SH2-GW3	G2	S3	SH2	GW3	Poor
G3-S1-SH1-GW1	G3	S1	SH1	GW1	Poor
G3-S1-SH1-GW2	G3	S1	SH1	GW2	Poor
G3-S1-SH1-GW3	G3	S1	SH1	GW3	Poor
G3-S1-SH2-GW1	G3	S1	SH2	GW1	Poor
G3-S1-SH2-GW2	G3	S1	SH2	GW2	Poor
G3-S1-SH2-GW3	G3	S1	SH2	GW3	Poor
G3-S2-SH1-GW1	G3	S2	SH1	GW1	Poor
G3-S2-SH1-GW2	G3	S2	SH1	GW2	Poor
G3-S2-SH1-GW3	G3	S2	SH1	GW3	Poor
G3-S2-SH2-GW1	G3	S2	SH2	GW1	Poor
G3-S2-SH2-GW2	G3	S2	SH2	GW2	Poor
G3-S2-SH2-GW3	G3	S2	SH2	GW3	Poor
G3-S3-SH1-GW1	G3	S3	SH1	GW1	Poor
G3-S3-SH1-GW2	G3	S3	SH1	GW2	Poor
G3-S3-SH1-GW3	G3	S3	SH1	GW3	Poor
G3-S3-SH2-GW1	G3	S3	SH2	GW1	Poor
G3-S3-SH2-GW2	G3	S3	SH2	GW2	Poor
G3-S3-SH2-GW3	G3	S3	SH2	GW3	Poor

Table 2: Deep Infiltration Hydrogeomorphic Units

Miller-Walker Basin Stormwater Retrofit Planning
King County, Washington

Proximity to Potential Slide Hazard Area

SH1 = Low Hazard

SH2 = High to Moderate Hazard

Thickness of Permeable Unsat Zone

U1 = High Thickness: > 30 ft

U2 = Moderate Thickness: 10-30 ft

U3 = Low Thickness: < 10 ft

Depth to Permeable Unsaturated Zone

D1 = Shallow Depth: <20 ft

D2 = Intermediate Depth: 20-50 ft

D3 = Deep Depth: >50 ft

Unit	Landslide Hazard	Unsaturated Zone Thickness	Depth to Perm. Unsat. Zone	Deep Inf. Feasibility
SH1-U1-D1	SH1	U1	D1	Good
SH1-U1-D2	SH1	U1	D2	Good
SH1-U1-D3	SH1	U1	D3	Moderate
SH1-U2-D1	SH1	U2	D1	Good
SH1-U2-D2	SH1	U2	D2	Moderate
SH1-U2-D3	SH1	U2	D3	Moderate
SH1-U3-D1	SH1	U3	D1	Poor
SH1-U3-D2	SH1	U3	D2	Poor
SH1-U3-D3	SH1	U3	D3	Poor
SH2-U1-D1	SH2	U1	D1	Poor
SH2-U1-D2	SH2	U1	D2	Poor
SH2-U1-D3	SH2	U1	D3	Poor
SH2-U2-D1	SH2	U2	D1	Poor
SH2-U2-D2	SH2	U2	D2	Poor
SH2-U2-D3	SH2	U2	D3	Poor
SH2-U3-D1	SH2	U3	D1	Poor
SH2-U3-D2	SH2	U3	D2	Poor
SH2-U3-D3	SH2	U3	D3	Poor

FIGURES

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Miller and Walker Creeks Basin

0 6,000 12,000
Feet

Vicinity Map

Miller-Walker Stormwater Infiltration Feasibility
Burien, Washington

Aspect CONSULTING	JUL-2014	BY: JSK / HRL	FIGURE NO. 1
	PROJECT NO. 130190	REV BY: ---	

Basemap Layer Credits || Copyright:© 2014 Esri
Sources: Esri, DeLorme, HERE, TomTom, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), swisstopo, and the GIS User Community

GIS Path: T:\projects_8\MillerWalker_130190\Delivered\2014_07_10\1 Vicinity Map.mxd || Coordinate System: NAD 1983 StatePlane Washington North FIPS 4601 Feet || Date Saved: 7/15/2014 || User: hlovelace || Print Date: 7/16/2014

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Duwamish River

Arbor Lake

Project Extent

Lora Lake

Lake Burien

Miller Creek

Walker Creek

N

0 2,000 4,000

Feet

Aerial Imagery Date: August 2011

Aerial Imagery

Miller-Walker Stormwater Infiltration Feasibility
Burien, Washington

Aspect CONSULTING	JUL-2014	BY: JSK / HRL	FIGURE NO. 2
	PROJECT NO. 130190	REV BY: ---	

Basemap Layer Credits || Source: Esri, DigitalGlobe, GeoEye, i-cubed, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

GIS Path: T:\projects_8\MillerWalker_130190\Delivered\2014_07_10\2 Aerial Imagery.mxd || Coordinate System: NAD 1983 StatePlane Washington North FIPS 4601 Feet || Date Saved: 7/15/2014 || User: hlovelace || Print Date: 7/16/2014

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SW 116TH ST
S 116TH ST
SW 128TH ST
S 128TH ST
4TH AVE SW
4TH AVE S
SW 136TH ST
S 136TH ST
DES MOINES MEMORIAL DR S
SW 146TH ST
S 146TH ST
SW 148TH ST
1ST AVE S
SW 152ND ST
S 152ND ST
SW 160TH ST
S 160TH ST
SW 168TH ST
S 168TH ST
SW 171ST ST
S 171ST ST
SW 174TH ST
SW NORMANDY RD
S NORMANDY RD

0 2,000 4,000
Feet

Project Extent
Street
Watercourse
Waterbody

Ground Surface Contours
25 ft Contours
50 ft Contours
100 ft Contours

LiDAR Elevation
High : 488 ft
Low : 4 ft

Ground Surface Elevations

Miller-Walker Stormwater Infiltration Feasibility
Burien, Washington

Aspect Consulting	JUL-2014	BY: JSK / HRL	FIGURE NO. 3
	PROJECT NO. 130190	REV BY: ---	

Basemap Layer Credits || Sources: Esri, DeLorme, HERE, TomTom, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), swisstopo, and the GIS User Community

GIS Path: T:\projects_8\MillerWalker_130190\Delivered\2014_07_10\3 Ground Surface Elevations.mxd || Coordinate System: NAD 1983 StatePlane Washington North FIPS 4601 Feet || Date Saved: 7/16/2014 || User: hlovelace || Print Date: 7/16/2014

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Geologic References:
Booth & Waldren (2004)
Troost et al. (2005)
Wetland Reference:
US Fish and Wildlife Service

0 2,000 4,000
Feet

N

- Project Extent
- Wetlands
- Landslide Hazard

Ground Surface Contours
- 25 ft Contours
- 50 ft Contours
- 100 ft Contours

Geologic
- m - Modified Land
- Qw - Wetlands
- Qb - Beach deposits
- Qal - Alluvium
- Qvr - Vashon recessional deposits
- Qvi - Vashon ice-contact deposits
- Qvt - Vashon subglacial till
- Qva - Vashon advance outwash deposits
- Qpf(f) - Pre-Fraser glaciation age deposits (fine grain)
- Water

Surficial Geologic Units

Miller-Walker Stormwater Infiltration Feasibility
Burien, Washington

Aspect Consulting	JUL-2014	BY: JSK / HRL	FIGURE NO. 4
	PROJECT NO. 130190	REV BY: ---	

Basemap Layer Credits || Sources: Esri, DeLorme, HERE, TomTom, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), swisstopo, and the GIS User Community

GIS Path: T:\projects_8\MillerWalker_130190\Delivered\2014_07_10\4 Geology.mxd || Coordinate System: NAD 1983 StatePlane Washington North FIPS 4601 Feet || Date Saved: 7/15/2014 || User: hlovelace || Print Date: 7/16/2014

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Area Not Included in Groundwater Model

Advance Outwash Not Present

GIS Path: T:\projects_8\MillerWalker_130190\Delivered\2014_07_10\5 TopElevAdvOutwash.mxd || Coordinate System: NAD 1983 StatePlane Washington North FIPS 4601 Feet || Date Saved: 7/15/2014 || User: hlovelace || Print Date: 7/16/2014

Project Extent

Elevation of top of Advance Outwash Deposit

- 10 ft Contour
- 50 ft Contour
- 100 ft Contour

Advance Outwash Top Elevation

- High : 426 ft
- Low : 30 ft

0 2,000 4,000 Feet

Top of the Advance Outwash Deposit

Miller-Walker Stormwater Infiltration Feasibility
Burien, Washington

Aspect Consulting	JUL-2014	BY: JSK / HRL	FIGURE NO. 5
	PROJECT NO. 130190	REV BY: ---	

Basemap Layer Credits || Sources: Esri, DeLorme, HERE, TomTom, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), swisstopo, and the GIS User Community

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GIS Path: T:\projects_8\MillerWalker_130190\Delivered\2014_07_10\6 Water Table Elevation.mxd || Coordinate System: NAD 1983 StatePlane Washington North FIPS 4601 Feet || Date Saved: 7/16/2014 || User: hlovelace || Print Date: 7/16/2014

Project Extent

No Presence of Advance Outwash

Ground Surface Contours

Advance Outwash Groundwater Elevation

25 ft Contour

50 ft Contour

100 ft Contour

0 2,000 4,000

Feet

Water Table Elevation of the Advance Outwash Aquifer

Miller-Walker Stormwater Infiltration Feasibility
Burien, Washington

Aspect Consulting	JUL-2014	BY: JSK / HRL	FIGURE NO. 6
	PROJECT NO. 130190	REV BY: ---	

Basemap Layer Credits || Sources: Esri, DeLorme, HERE, TomTom, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), swisstopo, and the GIS User Community

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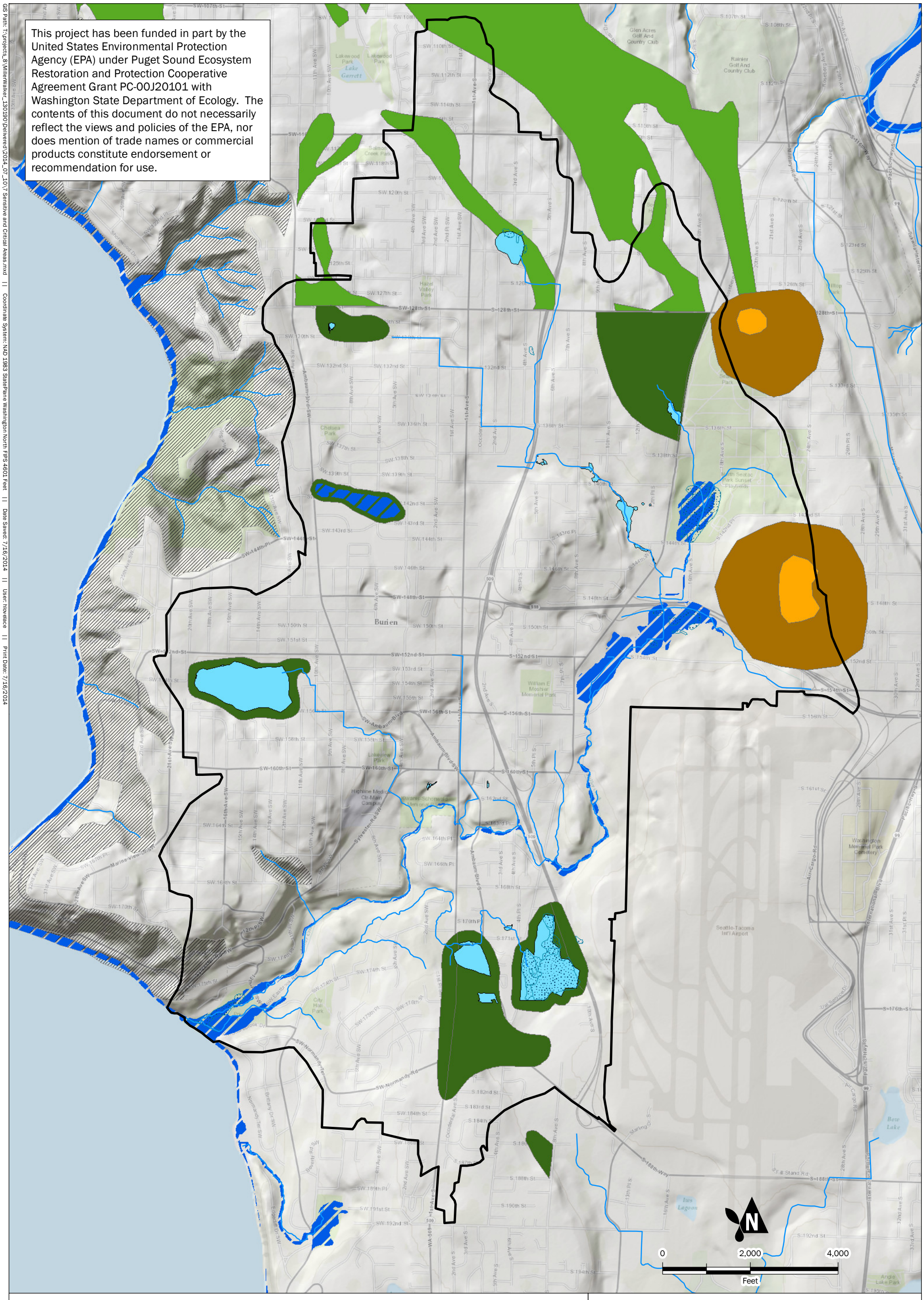

- Project Extent
- Wetlands (US Fish and Wildlife Service)
- Wetlands (City of Burien)
- Landslide Hazard (King County)
- Well Head Protection Zones 1yr (King County)
- Well Head Protection Zones 10yr (King County)
- Floodplain (Federal Emergency Management Agency)
- Critical Aquifer Recharge Area (CARA) (King County)
- Aquifer Recharge Areas (City of Burien)

Sensitive and Critical Areas

Miller-Walker Stormwater Infiltration Feasibility
Burien, Washington

Aspect Consulting	JUL-2014	BY: JSK / HRL	FIGURE NO. 7
	PROJECT NO. 130190	REVISED BY: ---	

Basemap Layer Credits || Sources: Esri, DeLorme, HERE, TomTom, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), swisstopo, and the GIS User Community

GIS Path: T:\projects_8\MillerWalker_130190\Delivered\2014_07_10\7 Sensitive and Critical Areas.mxd || Coordinate System: NAD 1983 StatePlane Washington North FIPS 4601 Feet || Date Saved: 7/16/2014 || User: hlovelace || Print Date: 7/16/2014

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GIS Path: T:\projects_8\MillerWalker_130190\Delivered\2014_07_10\8 Surface Permeability.mxd || Coordinate System: NAD 1983 StatePlane Washington North FIPS 4601 Feet || Date Saved: 7/16/2014 || User: hlovelace || Print Date: 7/16/2014

Project Extent

Ground Surface Contours

25 ft Contours

50 ft Contours

100 ft Contours

Permeability

High Permeability (>10in/hr)

Moderate Permeability (2-10in/hr)

Low Permeability (0-2in/hr)

0 2,000 4,000 Feet

Surface Permeability

Miller-Walker Stormwater Infiltration Feasibility
Burien, Washington

Aspect Consulting	JUL-2014	BY: JSK / HRL	FIGURE NO. 8
	PROJECT NO. 130190	REV BY: ---	

Basemap Layer Credits || Sources: Esri, DeLorme, HERE, TomTom, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), swisstopo, and the GIS User Community

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GIS Path: T:\projects_8\MillerWalker_130190\Delivered\2014_07_10\9 Surface Slope.mxd || Coordinate System: NAD 1983 StatePlane Washington North FIPS 4601 Feet || Date Saved: 7/16/2014 || User: hlovelace || Print Date: 7/16/2014

Project Extent

Ground Surface Contours

- 25 ft Contours
- 50 ft Contours
- 100 ft Contours

LiDAR-derived Percent Slope

- Low Gradient: 0 to 5
- Moderate Gradient: 5 to 15
- High Gradient: > 15

0 2,000 4,000 Feet

Surface Slope

Miller-Walker Stormwater Infiltration Feasibility
Burien, Washington

Aspect Consulting	JUL-2014	BY: JSK / HRL	FIGURE NO. 9
	PROJECT NO. 130190	REV BY: ---	

Basemap Layer Credits || Sources: Esri, DeLorme, HERE, TomTom, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), swisstopo, and the GIS User Community

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GIS Path: T:\projects_8\MillerWalker_130190\Delivered\2014_07_10\10 Landslide Hazard Areas.mxd || Coordinate System: NAD 1983 StatePlane Washington North FIPS 4601 Feet || Date Saved: 7/15/2014 || User: hlovelace || Print Date: 7/16/2014

Project Extent
Wetlands
Landslide Hazard

Ground Surface Contours
25 ft Contours
50 ft Contours
100 ft Contours

Landslide Hazard
Low Hazard
High to Moderate Hazard

0 2,000 4,000
Feet

Landslide Hazard Areas

Miller-Walker Stormwater Infiltration Feasibility
Burien, Washington

Aspect Consulting	JUL-2014	BY: JSK / HRL	FIGURE NO. 10
	PROJECT NO. 130190	REV BY: ---	

Basemap Layer Credits || Sources: Esri, DeLorme, HERE, TomTom, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), swisstopo, and the GIS User Community

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GIS Path: T:\projects_8\MillerWalker_130190\Delivered\2014_07_10\11_Mounding Potential.mxd || Coordinate System: NAD 1983 StatePlane Washington North FIPS 4601 Feet || Date Saved: 7/16/2014 || User: hlovelace || Print Date: 7/16/2014

Project Extent
Wetlands

Ground Surface Contours
25 ft Contours
50 ft Contours
100 ft Contours

Mounding Potential
Low Mounding Potential
Moderate Mounding Potential
High Mounding Potential

N

0 2,000 4,000
Feet

Shallow Groundwater Mounding Potential

Miller-Walker Stormwater Infiltration Feasibility
Burien, Washington

Aspect Consulting	JUL-2014	BY: JSK / HRL	FIGURE NO. 11
	PROJECT NO. 130190	REV BY: ---	

Basemap Layer Credits || Sources: Esri, DeLorme, HERE, TomTom, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), swisstopo, and the GIS User Community

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GIS Path: T:\projects_8\MillerWalker_130190\Delivered\2014_07_10\12 DepthToPermeableUnsatZone.mxd || Coordinate System: NAD 1983 StatePlane Washington North FIPS 4601 Feet || Date Saved: 7/16/2014 || User: hlovelace || Print Date: 7/16/2014

Advance Outwash Not Present

0 2,000 4,000 Feet

N

Project Extent

Ground Surface Contours

25 ft Contour

50 ft Contour

100 ft Contour

Depth to Permeable Unsaturated Zone

Shallow (< 20 ft)

Intermediate (20-50 ft)

Deep (> 50 ft)

Depth to Permeable Unsaturated Zone

Miller-Walker Stormwater Infiltration Feasibility
Burien, Washington

Aspect Consulting	JUL-2014	BY: JSK / HRL	FIGURE NO. 12
	PROJECT NO. 130190	REV BY: ---	

Basemap Layer Credits || Sources: Esri, DeLorme, HERE, TomTom, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), swisstopo, and the GIS User Community

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Advance Outwash
Not Present

N

0 2,000 4,000
Feet

Project Extent

Ground Surface Contours
- 25 ft Contours
- 50 ft Contours
- 100 ft Contours

Thickness of Permeable Unsaturated Zone
- High: > 30 ft
- Moderate: 10 - 30 ft
- Low: 0 - 10 ft
- Zero Thickness (Confined Aquifer)

Thickness of Permeable Unsaturated Zone

Miller-Walker Stormwater Infiltration Feasibility
Burien, Washington

Aspect Consulting	JUL-2014	BY: JSK / HRL	FIGURE NO. 13
	PROJECT NO. 130190	REV BY: ---	

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GIS Path: T:\projects_8\MillerWalker_130190\Delivered\2014_07_10\13 Thickness of Receptor Horz.mxd || Coordinate System: NAD 1983 StatePlane Washington North FIPS 4601 Feet || Date Saved: 7/16/2014 || User: hlovelace || Print Date: 7/16/2014

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Unincorporated King County

Burien

SeaTac

Normandy Park

SW 116TH ST
S 116TH ST
SW 128TH ST
S 128TH ST
4TH AVE S
4TH AVE SW
SW 136TH ST
S 136TH ST
SW 146TH ST
S 146TH ST
SW 148TH ST
1ST AVE S
DES MOINES MEMORIAL DR S
SW 152ND ST
S 152ND ST
SW 160TH ST
S 160TH ST
SW 168TH ST
S 168TH ST
SW 171ST ST
S 171ST ST
SW 174TH ST
SW NORMANDY RD
S NORMANDY RD

N

0 2,000 4,000
Feet

Project Extent
Juristiction Boundary
Street

Ground Surface Contours
25 ft Contour
50 ft Contour
100 ft Contour

Shallow Infiltration Potential
Good
Moderate
Poor

Shallow Infiltration Feasibility

Miller-Walker Stormwater Infiltration Feasibility
Burien, Washington

Aspect CONSULTING	JUL-2014	BY: JSK / HRL	FIGURE NO. 14
	PROJECT NO. 130190	REV BY: ---	

Basemap Layer Credits || Sources: Esri, DeLorme, HERE, TomTom, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), swisstopo, and the GIS User Community

GIS Path: T:\projects_8\MillerWalker_130190\Delivered\2014_07_10\14 Shallow Infiltration Feasibility.mxd || Coordinate System: NAD 1983 StatePlane Washington North FIPS 4601 Feet || Date Saved: 7/16/2014 || User: hlovelace || Print Date: 7/16/2014

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Unincorporated King County

Burien

SeaTac

Normandy Park

SW 116TH ST
S 116TH ST
SW 128TH ST
S 128TH ST
4TH AVE S
SW 136TH ST
4TH AVE SW
S 136TH ST
SW 146TH ST
S 146TH ST
SW 148TH ST
1ST AVE S
DES MOINES MEMORIAL DR S
SW 152ND ST
S 152ND ST
SW 160TH ST
S 160TH ST
SW 168TH ST
S 168TH ST
SW 171ST ST
S 171ST ST
SW 174TH ST
SW NORMANDY RD
S NORMANDY RD

0 2,000 4,000
Feet

Project Extent
Juristiction Boundary
Street

Ground Surface Contours
25 ft Contour
50 ft Contour
100 ft Contour

Deep Infiltration Potential
Good
Moderate
Poor

Deep Infiltration Potential

Miller-Walker Stormwater Infiltration Feasibility
Burien, Washington

Aspect CONSULTING	JUL-2014	BY: JSK / HRL	FIGURE NO. 15
	PROJECT NO. 130190	REV BY: ---	

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GIS Path: T:\projects_8\MillerWalker_130190\Delivered\2014_07_10\15 Deep Infiltration Potential.mxd || Coordinate System: NAD 1983 StatePlane Washington North FIPS 4601 Feet || Date Saved: 7/16/2014 || User: hlovelace || Print Date: 7/16/2014