TECHNICAL MEMORANDUM

Date:	April 21, 2015	**Project No.:**	063-1076-001.504
To:	Mr. Colin Lund, Chief Entitlement Officer	**Company:**	BD Villages LP
From:	James G. Johnson, LG, LEG Michael Klisch, LHg		
cc:	Mr. Al Fure, PE, Triad		
RE:	**RESERVE AT WOODLANDS INFILTRATION TESTING AND MONITORING STRATEGY KING COUNTY, WASHINGTON**		

1.0 BACKGROUND

Golder Associates Inc. (Golder) is pleased to present this technical memorandum presenting a strategy for monitoring surface water and groundwater during field testing at the infiltration facility constructed at the Reserve at Woodlands (Site) site in King County, Washington. This monitoring strategy was prepared as part of an application to King County for constructing a conveyance pipeline from Horseshoe Lake to the infiltration facility. The Woodlands stormwater infiltration facility is located in the northeast corner of the Site (Figure 1). The infiltration facility was designed and sized (2/3-acre) as a testing facility that can also receive and infiltrate flood water pumped from Horseshoe Lake on an annual basis (as needed). Based on favorable infiltration testing results the facility will be expanded as needed for future stormwater infiltration needs.

Horseshoe Lake is an expression of the groundwater surface and the water quality is expected to be similar to ambient groundwater quality. The lake has a history of rapid winter-season water level increases that threaten surrounding homes. Emergency pumping to lower the lake level has been done by King County on several occasions. Based on information from past emergency pumping events, the Site infiltration test facility was designed to infiltrate up to 140-acre feet of water from Horseshoe Lake over a period of about 10 to 14 days. The first phase infiltration facility at the Site will serve as a test location for evaluating and field verifying the infiltration capacity of the underlying soils and influences on the regional groundwater system. The infiltration test information will be used to evaluate the incremental expansion of the Site infiltration facility over time.

In order to evaluate the long-term performance and feasibility of expanding the infiltration facility at the Site, information will be collected as part of the Horseshoe Lake infiltration events. This memorandum presents a summary of the existing groundwater and surface water monitoring that has occurred on the Woodlands Site. In addition, we present the monitoring strategy to be completed as part of the initial facility testing using Horseshoe Lake water.

2.0 EXISTING SURFACE AND GROUNDWATER MONITORING

Groundwater and surface water monitoring locations have been established at the Site starting in 2006 by Associated Earth Sciences Inc. (AESI) and Golder. Groundwater monitoring wells and surface water monitoring locations are shown on Figure 1. Table 2-1 contains a summary of groundwater monitoring locations at the Site. Groundwater-level monitoring has been completed in the instrumented wells using pressure transducers and data loggers. Groundwater levels were also measured manually in all wells during field visits. No water quality data has been collected from the wells.

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Table 2-1: Groundwater Monitoring Summary

Well or Exploration #	Period of Record		Drilled (feet bgs)	Depth Completed (feet bgs)	Completion Aquifer	Instrumented?
	Begin	End				
MW-10	Dec-06	Present	220	168 to 173	Qpog1c	Yes
MW-11	Dec-06	Present	318	298.5 to 303.5	Th	No
MW-12	Dec-06	Present	79	73.5 to 78.5	Qpog1c	Yes
MW-13	Nov-06	Present	51	38.9 to 48.9	Qpog1c/Qvr	Yes
MW-27	Oct-10	Present	56	45 to 55	Qpog1c	Yes
MW-28	Oct-10	Present	41	30 to 40	Qpog1c	Yes
MW-29	Oct-10	Present	70.5	60 to 70	Qpog1c	Yes
MW-30	Oct-10	Present	70.5	59 to 69	Qpog1c	Yes

Notes:
Th -Hammer Bluff Formation
Qpog1c – Pre-Olympia Coarse Glacial Outwash Deposits
Qvr – Vashon Recessional Outwash

Surface water monitoring is performed at three monitoring locations (Table 2-2). The first two locations are on either side of the culvert crossing on 218th Avenue SE where a wetland on the Site discharges to the Crisp Creek Tributary (monitoring point 9 in Figure 1). The third location is in an un-named ravine at the south end of the Site near the crest of the slopes above the Green River Valley (monitoring point 10 in Figure 1). Two of the monitoring sites are instrumented with pressure transducers to allow surface water depth measurements that can be used with channel measurements to calculate channel/spring flow. Manual stage and discharge measurements are made at all sites with flowing water.

Table 2-2: Surface Water Monitoring Summary

Station ID	Period of Record		Type	Instrumented?
	Begin	End		
Crisp Creek Tributary	Oct-06	Present	Streamflow, Water	Yes
King County West Ravine	Oct-06	Present	Streamflow, Water	No
King County West Wetland	Oct-10	Present	Water Level	Yes

3.0 PROPOSED MONITORING

Our proposed monitoring strategy will include the wells and surface water stations included in Tables 2-1 and 2-2 and shown in Figure 1 (except MW-11). In addition, two seep/spring locations in the Crisp Creek drainage approximately identified in Figure 1 will be added to the surface water monitoring locations once facility use has started.

The seasonal high groundwater elevation in the Qpog1c aquifer below the Woodlands occurs in January and April and the seasonal low groundwater elevation occurs at the end of October. A similar seasonal fluctuation exists in the wetland stage that feeds the Crisp Creek tributary through a culvert under 218th Ave SE.

3.1 Monitoring Frequency

Long-term surface and groundwater monitoring has been ongoing since 2006/2010 and will continue through 2015. A detailed surface and groundwater monitoring schedule for the Woodlands will be completed once a pumping event from Horseshoe Lake is scheduled. Ongoing monitoring completed to date provides characterization of pre-development conditions and facility testing using Horseshoe Lake pumped water will simulate developed conditions. The frequency of future monitoring may be adapted

based on conditions observed as the program progresses (adaptive management). When an infiltration test is performed using Horseshoe Lake water it will likely occur between January and April based on historical groundwater level data and lake stages. In general, we would collect monitoring data immediately prior to the infiltration test and increase the frequency of automated groundwater measurements until the next monitoring interval.

3.2 Monitoring Parameters

Each monitoring event will include collection of groundwater-level measurements in existing wells and discharge and stage measurements at established surface water monitoring sites. Field water quality parameters including pH, temperature, specific conductance, dissolved oxygen, turbidity and redox potential will also be recorded at surface water monitoring stations.

3.2.1 Horseshoe Lake Water Quality

King County completed water quality testing of Horseshoe Lake water prior to emergency pumping events in the past and will be responsible for water quality testing prior to and during future pumping events to the Woodlands Site. Water quality information collected by King County will be shared with BD Villages LP and their consultants prior to the start of pumping to the Site.

4.0 CLOSURE

This monitoring strategy was prepared for BD Villages Partners LP for the Woodlands project site. Please contact us if you have questions and comments.

Sincerely,

GOLDER ASSOCIATES INC.

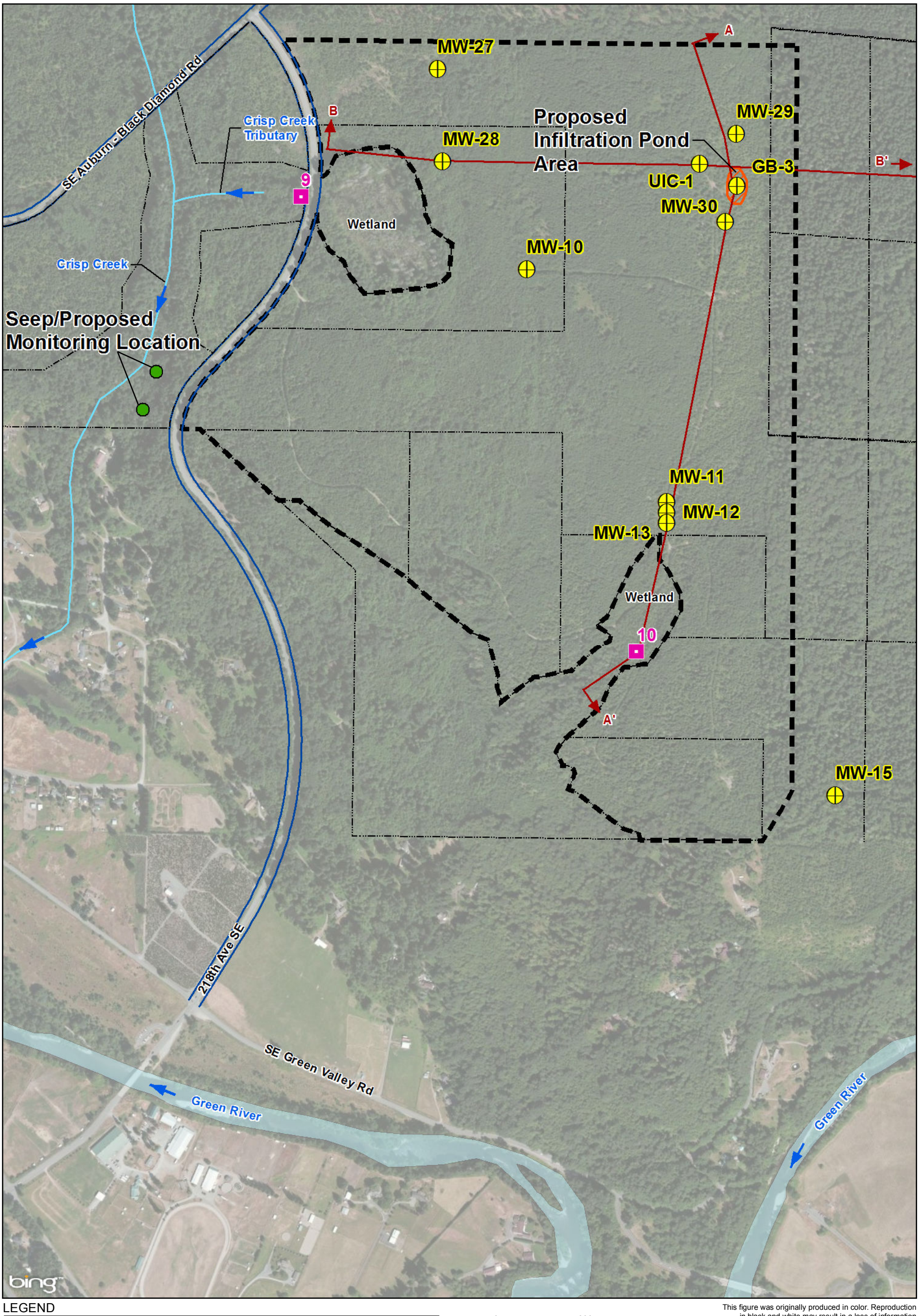
James G. Johnson, LG, LEG
Principal

Michael Klisch, LHg
Senior Hydrogeologist

Attachment: Figure 1 - Site Plan

JGJ/MK/sb

FIGURE



LEGEND

- Seep Observed During Slope Reconnaissance Study April 27-29, 2010
- Existing Surface Water Monitoring Station
- Existing Monitoring Well Location
- A A' Geologic Cross Section
- Lot Boundary
- Existing Road
- Proposed Infiltration Pond
- Creek or River
- Reserve at Woodlands Boundary

0 600
Scale in Feet

Map Projection:
Washington State Plane
North Zone NAD 1983
Source:
Microsoft (Bing Maps imagery),
Golder Associates Inc.

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This figure was originally produced in color. Reproduction in black and white may result in a loss of information.

FIGURE 1
SITE PLAN
BDVILLAGES/THE VILLAGES PROJECT/WA

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