GELMAN SCIENCES INC. WESTERN AREA GSI WORK PLAN

SCIO TOWNSHIP WASHTENAW COUNTY, MI

PREPARED FOR GELMAN SCIENCES INC.

FOR SUBMITTAL TO THE

MICHIGAN DEPARTMENT OF ENVIRONMENT, GREAT LAKES AND ENERGY (EGLE)



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Attachments

- Attachment 2 F&V SOP (Pore Water Sampling)
- Attachment 3 Area B Conceptual Model
- Attachment 4 Area C Conceptual Model



1.0 INTRODUCTION/BACKGROUND

This Groundwater-Surface Water Interface ("GSI") work plan for the Gelman Sciences Inc. ("Gelman") is being provided to the Michigan Department of Environment, Great Lakes and Energy ("EGLE") to satisfy the requirements of the proposed Fourth Amended and Restated Consent Judgment ("4th Amended CJ") incorporated by reference by the Washtenaw County Circuit Court's June 1, 2021 "Order to Conduct Response Activities to Implement and Comply with Revised Cleanup Criteria" (the "Response Activity Order").

The 4th Amended CJ defines the Western Area Groundwater-Surface Water Interface objective as follows: "Defendant shall prevent 1,4-dioxane from venting into surface waters in the Western Area at concentrations above the Generic GSI Cleanup Criterion, except in compliance with Part 201, including MCL 324.20120e ("Groundwater-Surface Water Interface Objective" for the Western Area)." (Section V.B.2.a.)

The 4th Amended CJ outlines the requirements for a GSI Investigation Work Plan (this document) in Section V.B.2.b. These requirements are that within 90 days of entry of the 4th Amended CJ, Gelman shall submit to EGLE for its review and approval a work plan for investigation of the groundwater-surface water interface in the Western Area and a schedule for implementing the work plan.¹ Gelman's work plan shall include:

- An evaluation of the Western Area and identification of any areas where the GSI pathway is relevant, i.e., any areas where 1,4-dioxane in groundwater is reasonably expected to vent to surface water in concentrations that exceed the Generic GSI Criterion based on evaluation of the factors listed in MCL 324.20120e(3); and
- A description of the Response Activities Gelman will take to determine whether 1,4-dioxane in groundwater is venting to surface water in any such areas in concentrations that exceed the Generic GSI Criterion.

According to the EGLE document "Groundwater-Surface Water Interface Pathway Compliance Options", April 2018, key elements in determining pathway relevancy include the following:

- There must be a hydraulic connection between the contaminated groundwater and surface water to have a groundwater/surface water interface. This includes an intermittent stream or water body that has flow until the groundwater table drops below the stream bottom. Intermittent streams are protected for acute and chronic risks. An ephemeral stream or water body only has flow during periods of surface runoff (rain or snowmelt). By definition an ephemeral stream would not have a groundwater surface water interface.
- 2. The hydraulic connection must transport contaminated groundwater to the surface water; a 'losing' surface water body would have a hydraulic connection with groundwater but would not transport contaminated groundwater to the surface water body.
- 3. The designation of groundwater "not in an aquifer" does not eliminate the need to evaluate the GSI pathway. Groundwater "not in an aquifer" may be hydraulically connected to a surface water body and may vent or be reasonably expected to vent in concentrations that exceed generic GSI risk-based screening levels (RBSLs)/criteria (See Appendix A).
- 4. The applicable generic GSI RBSLs/criteria for all appropriate hazardous substances released or otherwise affected (reactions, breakdown byproducts, etc.) and appropriate WQS for physical characteristics are or could be exceeded in representative samples at GSI monitoring points.

¹ Gelman submitted its initial draft GSI Investigation Work Plan on August 30, 2021, within 90 days of entry of the Response Activity Order. After receiving input from EGLE and at EGLE's request, Gelman is submitting this revised GSI Investigation Work Plan.



5. Contaminated groundwater is discharging into a separate storm sewer that discharges to a surface water body.

If the pathway for venting groundwater is determined to be not relevant, further evaluation is not necessary.

2.0 AREAS WHERE THERE IS A GSI POTENTIAL (WESTERN AREA)

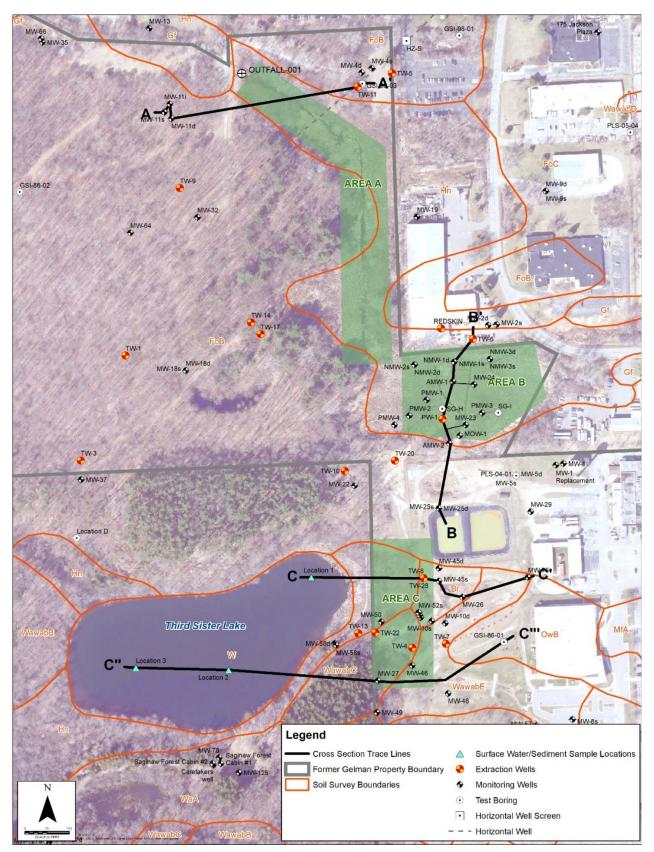
Many investigations of the surface waters of the Western Area (the portion of the Gelman site that is west of Wagner Road) have been completed by Gelman and others. The report "Gelman Summary Report of Groundwater and Surface Water Interactions within the Honey Creek Area" (March 2019) describes/summarizes much of this work. Based on the findings presented in this report, along with our analysis of other historical information, we have determined that there are three general areas where 1,4-dioxane associated with the Gelman Site has the potential to interface with surface water at concentrations approaching or exceeding the 280 ug/L EGLE Part 201 1,4-Dioxane Generic Groundwater-Surface Water Interface Criterion. These areas are:

- Area A The north/south portion of the unnamed tributary (referred as the Honey Creek Tributary or HCT for this document) from to the Gelman NPDES Outfall-001 to the northwest corner of the Gelman "Marshy Area."
- 2. Area B The Gelman Marshy Area including the east/west portion of the HCT along the northern boundary of the Marshy Area.
- 3. Area C The wetland area on the east side of Third Sister Lake.

Figure 1 depicts the general locations of Areas A, B and C along with cross sections used to present conceptual models for these areas.

The following report sections further describe these areas relative to their potential to have a completed GSI pathway, discuss the conceptual models for these areas, and present our proposed work plan, where appropriate.









2.1 AREA **A**

Area A is generally the north-south and northwest-southeast portions of the HCT up to the Gelman NPDES Outfall-001. This area is shown on Figure 1.

2.1.1 SUMMARY OF CONCEPTUAL MODEL

A cross section depicting our conceptual model for Area A is provided as Attachment 1. The conceptual site model for Area A is that there is a potential (albeit a low one) for groundwater containing concentrations of 1,4-dioxane over the GSI criterion to discharge into the HCT along Area A.

2.1.2 DISCUSSION/SUPPORT

Area A is primarily wetland along the HCT. This area is very difficult to access and is not accessible using conventional drilling equipment without constructing engineered drill platforms. Shallow water-bearing zones in this area do not appear to discharge to the HCT, based on comparison of groundwater and surface water elevation data. An example of a monitoring well completed in the shallow water-bearing zone/aquifer is MW-11s. Hydraulic heads at MW-11s are lower than those in the HCT (see table below) indicating that groundwater does not discharge to surface water in this area. In addition, shallow groundwater elevations are higher than those in deeper groundwater zones, indicating that hydraulic gradients are conducive to downward vertical groundwater migration, not upward migration, and discharge to surface water (see table below). The shallowest water-bearing zones in this reach overlie more substantial aquifers that are primarily associated with the transport of 1,4-dioxane.

	Screen Interval (feet below ground)	Groundwater Elevation (feet amsl)
MW-11s	14-16	898.33
MW-11i	39-41	885.99
MW-11d	87-90	878.74

- Water level data collected 9/20/2017.

- HCT Elevation in this area approximately = approximately 902.5 ft amsl

Because of this downward hydraulic potential, the lateral movement of groundwater is competing with a downward flow potential. This strong downward flow potential minimizes the lateral flow of groundwater in the shallow water bearing zones toward the HCT.

Some minor venting of groundwater into the HCT in Area A remains possible. 1,4-Dioxane concentrations in wells in portions of this area indicate 1,4-dioxane concentrations in this area may exceed 280 ug/L.

2.1.3 PATHWAY ANALYSIS

Our assessment of site data suggests that the likelihood for groundwater to be interacting with the HCT in Area A is low, and the possibility that such groundwater contains 1,4-dioxane concentrations approaching 280 ug/L is even lower. That said, the potential for such interaction cannot be ruled out and therefore investigations into the GSI pathway are recommended.



2.1.4 PROPOSED WORK PLAN

Access to Area A is very difficult and significant effort (clearing and stabilization) would be necessary to position even a small drilling rig in this area. As such, Gelman is proposing that a hand-driven pore water sampler be used to profile groundwater out of the base of the HCT in this area. Pore water samples would be collected at transects along Area A, with three samples collected at each transect (east side, center, and west side of the HCT). The proposed locations of the transects are shown on Figure 2 below.

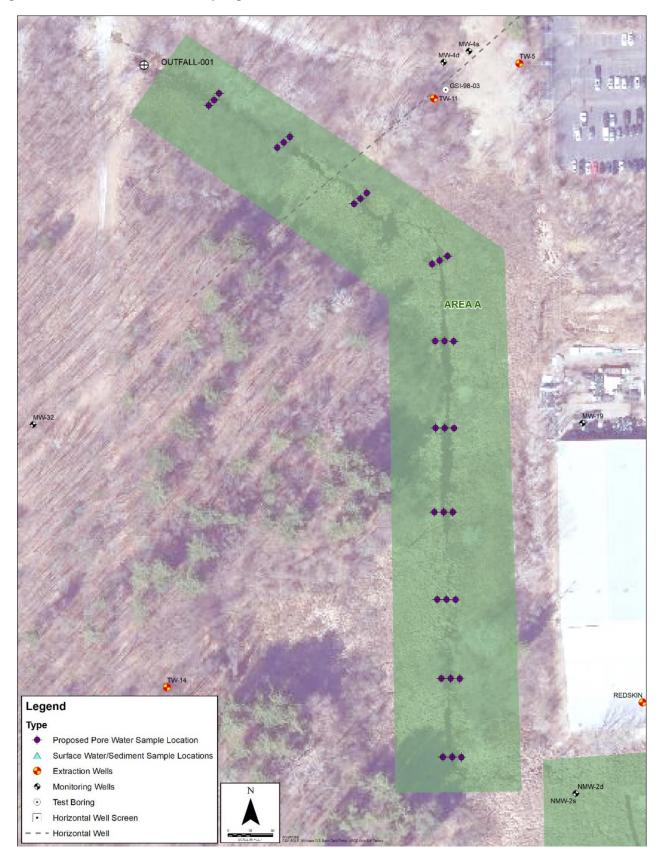
Pore-water sampling will be conducted in accordance with procedures outlined F&V SOP F-25 (Attachment 2). It is recommended that this work be completed in the winter months under frozen or partially frozen conditions when access is likely to be substantially better.

Based on the laboratory analytical results from the pore water samples, up to two locations exhibiting the highest concentrations will be selected for installation of a staff gauge and shallow piezometer to allow comparison of water levels and vertical hydraulic gradients between the HCT and shallow groundwater. During the drilling of the piezometers, if boring data indicate that the groundwater level is more than 5-feet below the streambed, no piezometer will be installed.

The staff gauge and piezometer locations and elevations will be surveyed. Surface water and groundwater levels will be recorded on a quarterly basis for one year to evaluate seasonal variations.



Figure 2 – Area A Pore Water Sampling Transects





2.2 AREA **B**

Area B consists of a wetland on the north side of the property owned by Gelman and is commonly referred to at the site as the "Marshy Area". The northern border of the Marshy Area is the HCT. This general area is shown on Figure 1.

2.2.1 SUMMARY OF CONCEPTUAL MODEL

A cross section showing our conceptual model for Area B is provided as Attachment 3. The conceptual site model for the Marshy Area is that surface water associated with the HCT is no longer contained in the former HCT channel due to vegetation build-up in the channel that causes water to fan out into a larger surface area of the Marshy Area. This surface water either discharges as surface water along the indistinct HCT corridor or develops a hydraulic mound that recharges the underlying groundwater. In neither case would groundwater be venting to the surface water. However, based on the potential for seasonal variations, there may be intermittent upward flow from groundwater to surface water that could cause discharge of groundwater above the GSI criterion.

2.2.2 DISCUSSION/SUPPORT

Numerous investigations have been conducted and multiple monitoring wells and borings have been installed to monitor groundwater conditions in the Marshy Area.

The Marshy Area topography is very flat, ranging in elevation from approximately 902 to 904 feet amsl. A topographic map of the Marshy Area (1-foot contour interval) is provided below as Figure 3.



Figure 3 – Topographic Map of Marshy Area (1-foot contour interval)

Source: Washtenaw County GIS, 2018 Aerial Photograph

In recent years, vegetation buildup along the HCT in the Marshy area (mostly phragmites) has restricted the flow in the HCT, causing surface water to back up into the low-lying Marshy Area. As a result, much of the Marshy Area is consistently inundated with water. There is no longer a clear division between water in the HCT and the Marshy Area as there was in the past. The filling in of the HCT is shown below on aerial photos taken in 1997 (top) and 2020 (bottom).





Source: Washtenaw County GIS

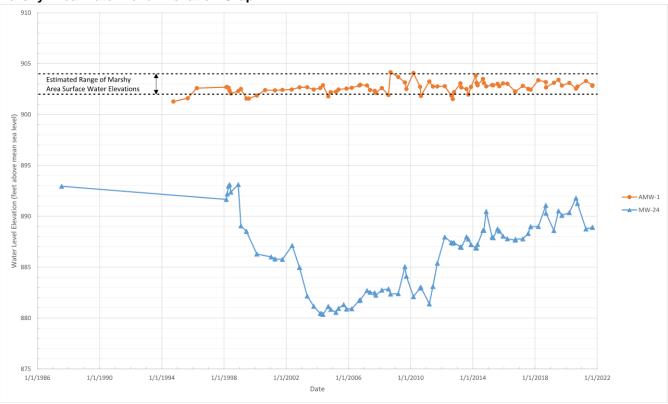
Water entering the Marshy Area comes from precipitation that falls into the Marshy Area and its sub watershed, as well as discharge from First and Second Sister Lakes, which flows into the HCT and toward/into the Marshy Area. USGS measurements in 2003 estimated the base flows coming out of the First and Second Sister Lakes to be 0.11 to 0.79 ft³/s (50-354 gpm).

Surface water elevations in the Marshy Area are not routinely measured. Based on the topographic surface elevations and limited measurements, the surface water is expected to range in elevation between 902 and 904 feet above mean sea level (amsl).

The subsurface in the Marshy Area consists of peat underlain by marl and other fine- to coarse-grained deposits. The peat and other fine-grained deposits contain residual 1,4-dioxane in groundwater associated with a historical release to the Marshy Area that has back-diffused into the materials. Groundwater extraction and the slow downward flux of groundwater has lowered 1,4-dioxane concentrations in the Marshy Area over time.

Materials underlying the peat and marl and shallow sand/gravel have a head that is generally lower, resulting in a downward vertical gradient that is approximately 0.7 to 0.8 ft/ft downward. A hydrograph of MW-24, located within the Marshy Area at a depth of approximately feet 23-25 feet below ground level, is provided below. These water level data demonstrate the lower head which results in a downward potential from the shallower deposits into the

deeper deposits. Some shallower wells, such as AMW-1, have head values within the estimated range of Marshy Area surface water elevations (902 to 904 feet amsl) that indicate the possibility of an intermittent upward vertical gradient. A hydrograph of AMW-1, screened from 3.5 to 6.5 feet below ground level, is shown below.



Marshy Area Water Level Elevation Graph

Historically, 1,4-dioxane levels in groundwater sampled from the Marshy Area have been as high as 202,000 ug/L. Gelman has been operating an extraction well (PW-1) in the Marshy Area since 1994. Operation of this extraction well along with natural processes (downward flux of groundwater) have substantially reduced 1,4-dioxane levels in Marshy Area groundwater. 1,4-Dioxane concentrations in the Marshy Area are summarized on maps prepared by Gelman on a semi-annual basis.

PW-1 currently operates at a flow rate of approximately 1 to 4 gpm. The approximate mass reduced by PW-1 is 1,073 pounds (May 1997 through June 2021). It is important to note that water migrating downward from the Marshy Area into underlying aquifers is subject to capture by multiple Gelman extraction wells in addition to PW-1.

The approximate range of 1,4-dioxane concentrations in groundwater samples from the peat are between 100 and 6,800 ug/L. 1,4-Dioxane concentrations in groundwater sampled from the marl are in the range of 1,200 to 2,700 ug/L. Below the marl, interbedded sands and fine-textured deposits are encountered. 1,4-Dioxane concentrations in monitoring wells screened within these deposits range from approximately 60 to 1,000 ug/L, but higher concentration zones are anticipated to be present locally in areas not sampled.

The flux of groundwater from the Marshy Area to the HCT is little to none due to the low permeability of the peat and consistently downward vertical hydraulic gradients measured in this area between the peat/marl and the underlying aquifers. USGS flow measurements collected during a low-flow period in 2003 suggest that during very dry periods, groundwater can discharge to surface water in the Marshy Area at a rate of approximately 30 gpm, which represents a worst-case scenario. The conditions observed in 2003 no longer exist today. The distinct channel of the HCT is no longer evident, and flooded conditions prevail over most of the Marshy Area, reducing the potential for groundwater to be discharging into surface water. Rather, surface water flooding of the Marshy Area is typical under current conditions and creates a hydraulic mound that drives water into the subsurface.

A drone photo taken in July 2021 (below) shows an undefined HCT channel and flood inundation in the Marshy Area (Figure 4). This flooding typically extends as far south as PW-1 which is mounded up due to the flooding.

Figure 4 – Drone Photo of Marshy Area



Drone photo taken 7/20/21

1,4-Dioxane surface water concentrations in the HCT near the Marshy area have ranged from 293 ug/L (2/25/87) to <1 ug/L (9/25/18). Since their peak in the late 1980s, the 1,4-dioxane concentrations in the HCT in the Marshy area have decreased substantially. The most recent sample collected by EGLE in October 2020 had a 1,4-dioxane concentration of 1.5 ug/L. The low concentration of 1,4-dioxane in the HCT in Area A is another line of evidence that groundwater with 1,4-dioxane is not venting to the HCT.

2.2.3 PATHWAY ANALYSIS

EGLE guidance states "The hydraulic connection must transport contaminated groundwater to the surface water; a 'losing' surface water body would have a hydraulic connection with groundwater but would not transport contaminated groundwater to the surface water body." At least as long surface water is present in the Marshy Area outside a channelized area with a downward vertical hydraulic gradient, there is no completed GSI pathway. Our assessment of site data suggests that the likelihood for groundwater to be venting to Marshy Area surface water is low. However, more information would be needed to confirm this, and investigations into the GSI pathway are thus proposed.

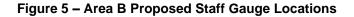


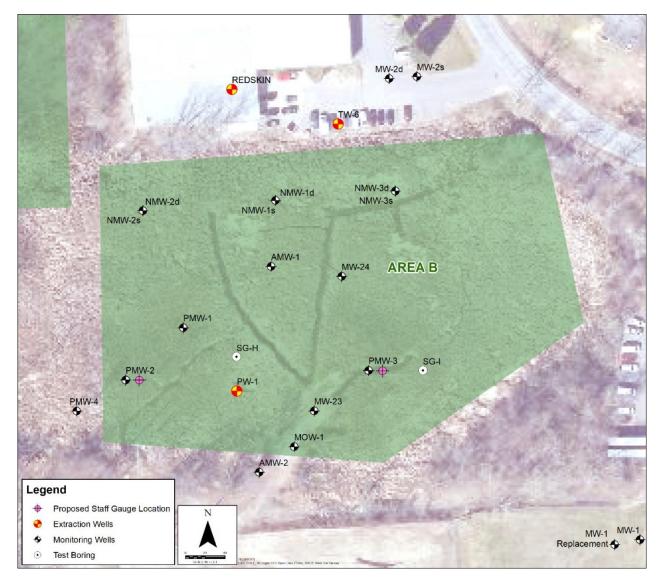
2.2.4 PROPOSED WORK PLAN

Gelman proposes to collect information regarding possible seasonal variations in the vertical hydraulic gradient by installing two staff gauges in the Marshy Area near two wells consistently showing the highest concentrations (PMW-2 and PMW-3 on Figure 5 below). Recent groundwater concentrations have ranged from 5700-6800 ug/L at PMW-2 and 5400-6500 ug/L at PMW-3.

The staff gauge locations and elevations will be surveyed to allow comparison with water level data collected at existing Marshy Area monitoring wells. Water level data will be collected at the two staff gauges, PMW-2 and PMW-3, on a quarterly basis for one year to evaluate seasonal variations.

If the data indicate an upward hydraulic potential, Gelman proposes to collect a corresponding surface water sample at each staff gauge location where an upward potential is indicated.







2.3 AREA C

2.3.1 SUMMARY OF CONCEPTUAL MODEL

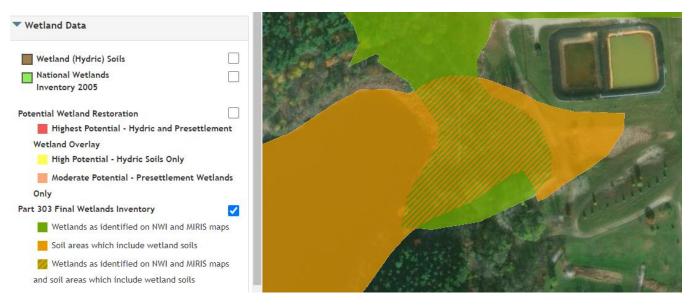
A cross-section depicting our conceptual model for Area C is provided as Attachment 4. The conceptual site model for Area C is that there is a potential for shallow/perched groundwater possibly containing 1,4-dioxane over the GSI Criterion to migrate along the former/current drainage channels toward Third Sister Lake and to vent into either the wetland area on the east side of Third Sister Lake or into Third Sister Lake. It should be noted that deeper groundwater in this area with elevated 1,4-dioxane concentrations that is being actively remediated is at a significantly lower head than Third Sister Lake and is not discharging into Third Sister Lake or the wetland on the east side of the lake.

2.3.2 DISCUSSION/SUPPORT

Area C consists of the eastern portion of Third Sister Lake along with the adjacent wetland area east of the lake. Area C receives drainage from a large portion of the developed portion of the former Gelman campus. There are two distinct conveyances that contribute water to Area C. These conveyances are shown on Figure 1.

The wetland along the eastern border of Third Sister Lake is characterized as Forested Wetland and Hydric Soils. There is typically not standing water in this wetland, suggesting a potential GSI compliance point in this area is near the eastern edge of Third Sister Lake. Figure 5 shows the approximate extent of wetland areas in the eastern area of Third Sister Lake (Source: EGLE Wetland Viewer).

Figure 6 – Area C Wetlands



1,4-Dioxane was historically detected in both water samples and sediment samples collected from Third Sister Lake. More recent samples by Apex, a consultant to U of M, has not identified 1,4-dioxane in either the water or sediment collected from Third Sister Lake (2018 Annual Report for Water and Sediment Sampling Conducted at Saginaw Forest in Ann Arbor, Michigan, Apex Companies, LLC, November 13, 2019). The early detections of 1,4-dioxane in the lake water and sediment samples were likely attributed to surface water runoff associated with Gelman's former spray irrigation.

The hydraulic head of Third Sister Lake is at an elevation of approximately 904 feet amsl (Washtenaw County GIS). The primary 1,4-dioxane plume in this area is deeper and associated with groundwater at an elevation of 890 ft amsl. As such, this groundwater and 1,4-dioxane are not discharging into either the wetland or Third Sister Lake.



Any interaction between groundwater and the wetland/lake would be through very shallow perched water bearing zones, which have not been investigated.

2.3.3 PATHWAY ANALYSIS

The potential for a shallow (i.e. 0-10 foot) interaction between groundwater and Third Sister Lake cannot be ruled out by our conceptual model and existing data. As such, we propose the collection of additional data in Area C.

2.3.4 PROPOSED WORK PLAN

Gelman proposes to drill a series of shallow borings to determine 1,4-dioxane concentrations in shallow/perched groundwater that may be interfacing with Third Sister Lake. The proposed locations for borings/wells are shown on Figure 7. Additionally, one staff gauge will be installed and surveyed at the eastern edge of Third Sister Lake. The water level elevation at the staff gauge will be recorded on a quarterly basis for one year to evaluate seasonal variations in GSI conditions.

Vertical aquifer profiling using the WaterlooAPS characterization method will be performed to provide information on hydrostratigraphy and to allow groundwater sampling at multiple discrete depths. Hydrologic information provided by the WaterlooAPS profiling method includes an approximate measure of hydraulic conductivity (the "index of hydraulic conductivity") that is estimated from the measured flow rate and pressure of water injected as the probe is advanced. This parameter is calculated in real time, which enables selection of sampling intervals in relatively permeable zones. Each aquifer profiling location will be characterized to a minimum depth of 20 feet. Samples will be collected and submitted to Gelman for 1,4-dioxane analysis.

This work will require a wetlands permit. Gelman proposes to have a professional wetlands delineation made for this area in advance of the proposed investigation to determine the boundaries of the existing wetland to support the required wetlands permit application.

3.0 SCHEDULE

F&V proposes to implement this investigation during the winter months to help facilitate access to Areas A, B, and C. As such, field activities as outlined in this work plan would be conducted January 2022 through April 2022, weather dependent. F&V will prepare a report of its findings within two months of the data collection (estimated to be Summer of 2023).



Figure 7 – Area C Proposed Boring Locations

