



Proactive by Design

GEOTECHNICAL

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WATER

CONSTRUCTION
MANAGEMENT

5 Commerce Park North

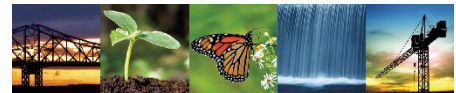
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WORK PLAN

Phase II - Supplemental Hydrogeologic Investigation
Groundwater Management Zone Delineation and Water Supply Investigation
Dartmouth College, Rennie Farm Site
Hanover, New Hampshire
NHDES Site No. 201111109, DES Project No. 277737

This work plan describes proposed Phase II Supplemental Hydrogeologic Investigation activities recommended in **Section 5.0**. Objectives of the proposed tasks include:

- Installation and sampling of monitoring wells to further delineate the limits of 1,4-dioxane in groundwater necessary to establish a Groundwater Management Zone and prepare a Groundwater Management Permit Application for the Site. The proposed monitoring wells are intended to provide future compliance monitoring locations.
- Supplemental investigations within the source area to further characterize the 1,4-dioxane source and support a remedial feasibility evaluation.

Access to the properties identified on the Town of Hanover Tax Map as Map 16 as Block 7, Lot 1 and on Map 13 as Block 19, Lot 1 will be needed to complete certain tasks as described below. The proposed work will be completed as allowed by access.

The following describe the proposed tasks.

TASK 1 - 1,4-DIOXANE/GMZ DELINEATION

Subtask 1.1 - Well Installation

Installation and sampling of five groundwater monitoring well triplets is proposed to provide additional 1,4-dioxane concentration and hydraulic head data needed to evaluate the distribution and transport of 1,4-dioxane downgradient of the Site. Proposed well triplet installation locations are illustrated on **Figure E.2**, and were selected based on the conceptual model described in **Section 3.0**. The following summarize the rationale for the selection of the individual locations.

GZ-18U/L/D – is located on site at the intersection of potential fracture zone (PFZ) 4 and PFZ 9. PFZ 9 transects the area immediately downgradient of the source area.

GZ-20U/L/D – is located along the anticipated axis of 1,4-dioxane transport based on the distribution of 1,4-dioxane on site and predominant northeasterly striking fracture set.



GZ-21U/L/D – is also located along the anticipated axis of 1,4-dioxane transport based on the distribution of 1,4-dioxane on site and predominant northeasterly striking fracture set, but at a location northeast of the proposed location of GZ-20U/L/D and within the topographic center of the lowland area to the east of the Site.

GZ-22U/L/D – is located along PFZ 6 and is proximate to 9 Rennie Road.

GZ-23U/L/D – is located at the intersection of two photo-lineaments (see **Figure 4**) and was selected to provide a monitoring location east of 9 Rennie Road.

Drilling and monitoring well installation methods will be consistent with the drilling methods described in **Section 2.3.1** and consistent with Env-Or 610.04 (Groundwater Monitoring Wells). Except as noted below, GZA anticipates that three separate wells with well screens installed at depths of 10 feet, 50 feet, and 100 feet below ground surface (well triplets), will be constructed at each of the target drill locations described above. The upper well of each well triplet will likely be installed in overburden. Actual well depths will be based on the conditions encountered with well screen depths selected to intersect potential water bearing fractures.

If practicable GZ-22U/L/D may be drilled using air rotary drilling methods similar to those described in **Section 2.3.2** to provide an open borehole for the purpose of performing borehole geophysical logging. Borehole logging and, if 1,4-dioxane is detected (see sampling methods described in **Subtask 1.2**), zone sampling within the borehole would be performed consistent with the methods described in Task 4 and Task 5 of GZA's December 2, 2015 work plan.

Following completion of geophysical logging and, if applicable, zone sampling of the borehole, a multilevel PVC monitoring well will be constructed within the borehole and bentonite and Portland cement and bentonite grout seals constructed within the borehole to limit the potential for vertical transport within the borehole.

Subtask 1.2 - Well Development, Survey, and Sampling

Each of proposed bedrock groundwater monitoring wells constructed with 2-inch inner-diameter (ID) PVC screen and riser sections will be developed by GZA using manual inertia pump and surge block methods. If open-hole bedrock wells are installed, groundwater will be sampled using the methods used to sample wells WSW-1 and GZ-16D described in **Section 2.4**, with purged groundwater containerized until water quality data are available and the purge water disposed of at an appropriate location in the event that 1,4-dioxane is detected in the samples from the well. If open-hole bedrock wells are installed and 1,4-dioxane is not detected in the initial sampling of the wells, the wells will be developed by over pumping using an electric submersible pump and groundwater discharged to the ground surface.

The location and reference point elevations of each of the proposed bedrock wells will be surveyed by a New Hampshire Licensed surveyor.

Each of the proposed sampling locations will be sampled a minimum of two weeks after installation (initial sampling round), and resampled after a further minimum two week period (confirmatory sampling round). Sampling and analytical methods will be as described in **Section 2.4**.



TASK 2 – SUPPLEMENTAL SOURCE AREA CHARACTERIZATION

Additional hydrogeologic and 1,4-dioxane concentration data are needed to delineate and characterize the source area including:

- Bedrock surface elevation;
- Concentration of 1,4-dioxane in overburden and bedrock groundwater;
- Overburden hydraulic conductivity and head;
- Bedrock hydraulic yield and connectivity;
- These data will be used to evaluate;
- The mass of 1,4-dioxane within overburden groundwater in the source area;
- 1,4-dioxane transport within overburden and hydraulic connections to the fractured bedrock groundwater system; and
- Potential source area remedial alternatives including: hydraulic control and treatment; excavation; and electrical heating.

TASK 2.1 – GROUND PENETRATING RADAR SURVEY

A ground penetrating radar (GPR) survey is proposed to evaluate the depth to the bedrock surface within the former animal carcass burial area (source area). The GPR survey would be completed within the area shown on **Figure E.1**. GPR data will be acquired along a series of parallel traverses with a spacing of approximately 2.5 feet between each traverse. The boring logs for GZ-12L, GZ-13L, and GZ-14L will be used to calibrate the GPR equipment.

To the extent possible, the GPR data will be used to prepare a plan illustrating the depth to the top of bedrock within the source area including contours of the bedrock surface elevation.

TASK 2.2 – GROUNDWATER SCREENING

To delineate the extent of 1,4-dioxane in overburden groundwater, GZA proposes collection of groundwater samples throughout the area shown on **Figure E.1** for laboratory analysis of 1,4-dioxane using EPA Method 8260B SIM. To the extent allowed by subsurface conditions groundwater samples will be collected on a regular grid with an approximate 20-foot spacing between sampling locations. Based on the area of the source area and proposed grid spacing, GZA estimates that approximately 36 groundwater samples will be collected.

Groundwater samples will be collected using a direct push drill rig equipped with groundwater sampling tooling. One groundwater sample will be collected from between approximately 6 feet to 8 feet below ground surface, with the intent of collecting groundwater samples from the vertical center of the saturated overburden. Two duplicate samples will be collected during the sampling program for quality assurance purposes.



The results of the analyses of the groundwater samples will be summarized in a table and on a figure.

TASK 2.3 – GROUNDWATER MONITORING WELL INSTALLATION AND SAMPLING

GZA proposes installation of up to four additional overburden/shallow bedrock monitoring well couplets within the source area. The well couplets are proposed to provide additional long-term 1,4-dioxane concentration and hydraulic head monitoring locations, and provide data to further evaluate 1,4-dioxane transport between overburden and bedrock. The proposed well couplets may also be used to provide remedial performance monitoring locations in the event that active source area remediation is practicable.

The well couplets would be constructed consistent with the methods used to construct source area well couplet GZ-14U/L. The locations of the proposed well couplets will be selected based on the results of **Task 2.1** and **Task 2.2**.

Groundwater and soil from drilling the borings and development and sampling of the wells will be placed on the ground surface adjacent to the boring/well within the source area.

Well Development, Survey, and Sampling

Each of proposed groundwater monitoring well couplets will be developed by GZA using manual inertia pump and surge block methods.

The location and reference point elevations of each of the proposed bedrock wells will be surveyed by a New Hampshire Licensed surveyor.

Each of the proposed sampling locations will be sampled a minimum of 2 weeks after installation (initial sampling round), and resampled after a further minimum two week period (confirmatory sampling round). Sampling and analytical methods will be as described in **Section 2.4**.

TASK 2.4 – SOURCE AREA HYDRAULIC TESTING

Hydraulic testing will be performed by GZA within overburden and shallow fractured bedrock within the source area to provide data needed to evaluate the technical feasibility and estimate the practicability of hydraulic control (groundwater extraction) and treatment as a remedial alternative for the source area. The data would also be used to evaluate the practicability of dewatering to manage groundwater if soil excavation and dewatering were used to remove 1,4-dioxane from the source area. The extent of testing will be determined based on the results of the preceding tasks.

GZA assumes that a minimum, of two constant head withdrawal tests utilizing each of the monitoring wells within the source area. Groundwater will be pumped using either an electric submersible pump or suction pump. Groundwater will be containerized in an 8,000-gallon portable tank. The duration of the withdrawal tests and target drawdown levels will be determined based on the observed flow rates and storage capacity within the portable tank.



The constant head tests will be performed sequentially with an approximate 2-day interval between tests to allow groundwater levels to return to static conditions between the tests. Each test will be completed within one day.

Groundwater levels will be monitored manually within selected wells within the source area, with monitoring locations and frequencies adjusted based on the water level responses in the wells. Pressure transducers will be installed within up to eight source area monitoring wells (including the wells selected as withdrawal wells) to provide frequent measurement and record water levels in selected monitoring wells.

This task includes long-term monitoring of hydraulic head using a pressure transducer and data logger installed in monitoring well couplet GZ-14U/L to further evaluate the hydraulic connection between overburden and bedrock at this location, including monitoring of the vertical component of the hydraulic head gradient.

Containerized groundwater will be sampled following the completion of the withdrawal tests and analyzed for VOCs by EPA Method 8260B. The results of the analysis will be used to develop recommendations for disposal of the water.

TASK 3 – DATA EVALUATION AND REPORTING

Data collected during the completion of **Task 1** and **Task 2** will be evaluated relative to the project and task objectives. The work performed, results, and GZA's conclusions and recommendation will be summarized in a report. The report will include figures and tables summarizing the data collected. The report will include:

- An updated Conceptual Site Model;
- A remedial feasibility summary including evaluation of the following potential remedial alternatives: groundwater extraction and treatment; source area soil excavation and dewatering; in-situ electrical heating; monitored natural attenuation; and combinations of these alternatives;
- Conclusions; and
- Recommendations including:
 - A proposed GMZ and revised groundwater monitoring program designed to support an application for GMP if approved by NHDES;
 - A proposed remedial approach for the source area and downgradient plume area; and
 - Reference the geospatial model will be refined with all the data from these studies.

JMW/SRL/RAB:kr

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Attachment: Figures