CDM Smith

Memorandum

To: *Erica Kidd, Watershed Manager, Auburn Water District/Lewiston Water Division*

From: *Laurie Locke, P.E.*
Bob Fitzgerald, P.E.
Anne Malenfant, P.E., PMP

Date: *July 31, 2023*

Subject: *Watershed Delineation Rezoning Review - Gracelawn Pit "Area of Uncertainty"*

This technical memorandum provides an update on CDM Smith's review of the Lake Auburn watershed delineation in the vicinity of the Gracelawn Pit near the southeast shore of Lake Auburn. Building on our independent review of past studies to determine the likely watershed boundary, this scope of work developed a three-dimensional visualization and analysis (3DVA) model of existing/historical data to further investigate groundwater flow in the Gracelawn Pit area and develop recommendations for field investigations that would be needed to more clearly delineate the watershed boundary. The result of the evaluation is confirmation of a boundary proposed by the Maine Drinking Water Program (DWP) and recommendations for further field investigations to more precisely delineate the boundary if needed.

Introduction

A proposed revision to the watershed boundary in the Gracelawn Pit area was recommended in 2021 as part of an environmental and regulatory analysis of the Lake Auburn water supply protection, which would reduce the watershed area by 148 acres (FB Environmental, 2021). In 2022, the Lake Auburn Watershed Protection Commission (LAWPC) requested that CDM Smith provide an independent review of the past studies that were the basis of this revised delineation, including the geologic, water level and water quality data and analyses presented in these reports.

As detailed in an October 5, 2022 technical memorandum, CDM Smith's initial review concluded that the groundwater data support the revised watershed delineation in some areas, and in other areas the data are insufficient to confirm a precise delineation. **Figure 1** depicts a summary of the review, including the revised delineation recommended by FB Environmental in 2021 (red dashed line), the area of uncertainty described in CDM Smith's review (blue dashed line) and direction of groundwater flow (blue arrows).

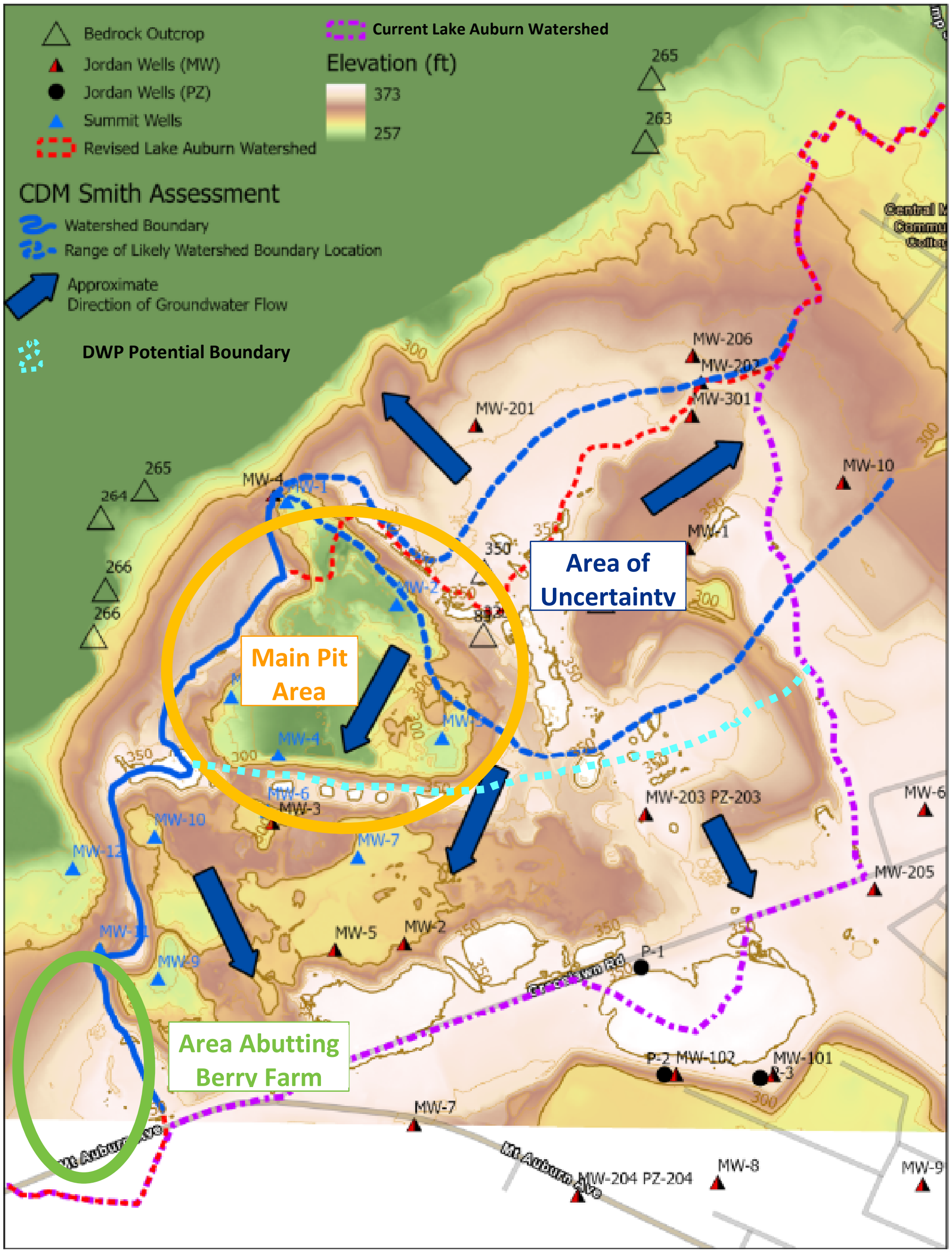

Figure 1 - Site Map Depicting Areas of Uncertainty

In addition to the area of uncertainty highlighted in the October 5, 2022 memorandum, this memorandum addresses questions about groundwater flow in the main pit area and in the southwestern most point of the gravel pit that abuts the Berry Farm. Both areas are shown in

Figure 1, with the main pit area circled in orange and the area abutting the Berry Farm circled in green. LAWPC requested the following in a request for proposal dated March 27, 2023:

- Confirm stratigraphy and groundwater flow directions in the various strata in the area encircled in orange on **Figure 1**. Evaluate groundwater discharge to the lake throughout the study area.

- Determine the direction of groundwater flow in the southwestern most point of the gravel pit that abuts the Berry Farm and that is currently in the watershed.

Finally, the DWP provided a "DWP Potential Boundary" in a March 20, 2023 letter that is shown in turquoise on **Figure 1**. LAWPC requested CDM Smith evaluate whether this line could indicate a watershed boundary not precluded by the current information available and assessment of surficial groundwater flow, and therefore could be established without additional bedrock groundwater investigations.

CDM Smith created a 3DVA model of all relevant hydrogeologic and topographic data to further investigate groundwater flow in the three areas in question. This memorandum summarizes the results and recommended next steps, if further refinement of watershed delineation is needed in the future.

3DVA Model

A 3DVA model of the Gracelawn Pit area was created in Leapfrog Works using the topographical and subsurface data listed in **Table 1**. Visualization of the data in Leapfrog allows for historic data from multiple sources to be viewed and analyzed together in an integrated project space. An example of some of the data, including LIDAR ground surface elevation, aerial photo, seismic profiles, estimated bedrock elevation contours, well locations, well screens, and groundwater levels are shown in **Figure 2**. Most of the data incorporated into the 3DVA model came from three historic hydrogeologic reports:

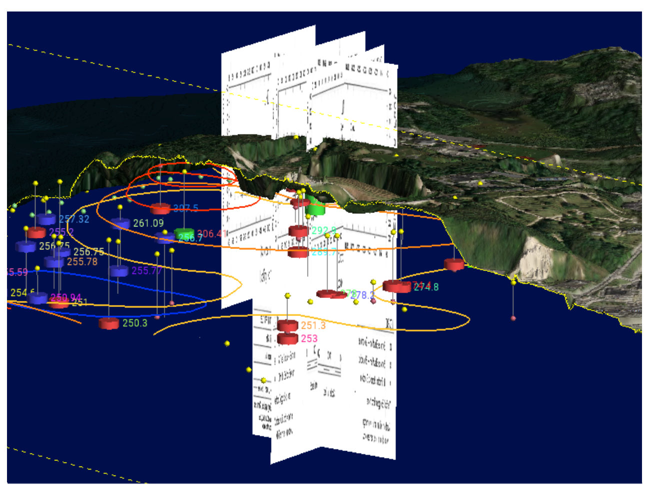

Figure 2 - Example Screenshot from 3DVA Model

- E.C. Jordan Co., Hydrogeologic Investigation, Gracelawn Landfill/Lake Auburn, June 1990 (E.C. Jordan, 1990);

- Woodard and Curran Environmental Services, Supplemental Hydrogeological Study, Auburn Brush Dump, City of Auburn, ME, August 1995 (Woodard and Curran, 1995); and

- Summit Environmental Consultants Inc., Ground Water Assessment, Gracelawn Road Gravel Pit, Auburn, ME, September 2007 (Summit, 2007).

Table 1 - 3DVA Data Sources

Data	Description	Source
Topography	Ground surface elevation	LIDAR for Androscoggin County, 2009
Bathymetry	Lake bottom elevation	University of Maine Farmington, 2001
Well locations	XY location of existing and historic wells and reported reference elevation	▪ E. C. Jordan, 1990 ▪ Woodard and Curran, 1995 ▪ Summit, 2007
Well screen intervals	Depth to top and bottom of well screen	▪ E. C. Jordan, 1990 ▪ Woodard and Curran, 1995 ▪ Summit, 2007
Water levels	Measured groundwater level, reported as elevation	▪ E. C. Jordan, 1990 ▪ Woodard and Curran, 1995 ▪ Summit, 2007 ▪ Ledgewater Monitoring Well Groundwater Elevations, 2023
Depth to rock	Best estimate for depth to rock at drilled wells, including either observed depth to rock, refusal depth, bottom of boring, or bottom of well screen	▪ E. C. Jordan, 1990 ▪ Woodard and Curran, 1995 ▪ Summit, 2007
1976 Seismograph survey	Estimated depth to bedrock at a series of seismic shot holes completed between the pit area and the lake	E. C. Jordan, 1990
1995 Seismic profiles	Four seismic refraction profiles, each approximately 1,000 feet long, establishing depth to bedrock at 50-foot intervals along each seismic line	Woodard and Curran, 1995
Bedrock outcrop locations	Location and estimated elevation of confirmed bedrock outcrop	E. C. Jordan, 1990
Bedrock elevation contours	Estimated bedrock surface elevation interpreted by historic reports	▪ E. C. Jordan, 1990 ▪ Woodard and Curran, 1995

More recent water level data and site maps were incorporated into the 3DVA model, including ten rounds of measured groundwater elevations from June 2015 to March 2023 at a subset of wells. Eight of the ten rounds of groundwater level data monitored only three wells—MW-101, MW-205, and MW-301. Measurements were collected at a different set of four monitoring wells in September 2022 (MW-6, MW-7, MW-8, and MW-707). The same four wells were monitored in March 2023 along with a fifth well MW-12.

Thirty-three well locations with groundwater level measurements are included in the 3DVA model. Since these wells were installed during multiple investigations spanning two decades, there has never been a synoptic round of water level measurements collected at all locations, nor could there be in the future as many of these wells have been abandoned or destroyed. The most complete rounds of water level monitoring were pieced together and viewed side by side to determine groundwater flow directions across the entire area of interest, including 12 wells measured on August 9, 2007, 16 wells measured on May 24, 1990, and 5 wells measured on June 23, 1995. Groundwater flow directions determined from these three measurement rounds were cross checked against rounds of measurements collected for smaller subsets of wells and found to be generally consistent over time, including in more recent measurements from 2022 and 2023.

Measurements of depth to bedrock from all historic reports were used to interpolate a new top of bedrock layer. This dataset included a mixture of logged depth to rock in boreholes, seismic profiles, and estimated depth to bedrock based on drilling refusal, bottom of boring, or bottom of well screen.

The 3DVA model was presented to LAWPC at their June 14, 2023 meeting, along with a summary of observations. A video walkthrough of the 3DVA model was also provided on July 10, 2023. This technical memorandum reflects the summary of observations from the LAWPC meeting, along with recommendations and next steps for possible field investigations.

Possible Field Hydrogeologic Investigations

As discussed above, the 3DVA model allows for historic data from multiple sources to be viewed and analyzed together in an integrated project space. The goal for this project was to more clearly correlate the historical data and understand the areas that would require further field investigation to delineate the watershed boundary inside the "DWP Potential Boundary" area shown in **Figure 1**. The 3DVA can provide guidance for narrowing the scope of field hydrogeologic investigations, which may include:

- Monitoring wells – these would provide gauging of the groundwater, but also provide information during construction of the depth to bedrock and ground profile. The following are specific types of monitoring wells, with information on the data they would provide:
    - Shallow water table well - also referred to as sand and gravel wells, these wells are replenished through surface recharge.
    - Deep overburden wells - location with glacial till overlying the bedrock, separating the sand and gravel well from the bedrock well. This can also create aquifers under pressure (also known as artesian wells).
    - Bedrock wells – wells located in solid rock, often with fractures that transmit usable quantities of water.

- Fracture trace analysis and outcrop mapping – this would provide information on locations of bedrock fractures, prominent fracture zones, and orientation of fractures to better understand possible bedrock groundwater flow.

- Slug testing at newly installed monitoring wells, including falling and rising head tests at each well location. A slug test is where the water level in a "control" well is caused to change suddenly, and the water level response in the control well and surrounding wells is measured. It provides information on the hydraulic properties of the aquifer.

Over the course of a year, three rounds of groundwater gauging at the newly installed wells and existing wells would be recommended, including seasonal high and low gauging rounds. Additional aerial survey should be completed including well location and elevation survey (aerial and ground survey of study area).

Summary of 3DVA Observations and Field Hydrogeologic Investigation Recommendations

The data, water level evaluations, and interpolated bedrock surfaces in the 3DVA model were used to assess groundwater flow as it relates to the watershed boundary. This section summarizes the desktop evaluation for each area of interest.

Area of Uncertainty

Summary of Observations

The area of uncertainty is located near and to the east of an area of high bedrock (so called "bedrock knob") near the center of **Figure 1**, where three triangles indicate the location and elevation of bedrock outcrops. Groundwater level data near the bedrock knob indicate that the water table is in bedrock and is above lake level based on surrounding well data. However, in the reviewed reports there is no well data to indicate bedrock flow direction in this area. Groundwater level data indicate a water table in the sand and gravel level above lake level in the area to the east of the bedrock knob. Available data indicates groundwater flow is generally eastwards in this area, but groundwater may flow either to the northeast, discharging to the lake, or flow to the southeast towards a creek, discharging to the Androscoggin River.

Topography indicates surface drainage flows to the east and southeast towards the creek and ultimately the Androscoggin River. The northern limit of the area of uncertainty coincides with an approximate surface drainage divide indicated by topography. To the south of the uncertainty band, groundwater level and groundwater quality data indicate that the water table is in the surficial sand and gravel with a flow direction away from the lake.

Available data in this area are still inconclusive with respect to precise the location of the watershed divide. Water level data from wells MW-206 and MW-301, located near the northern limit, indicate a northward component of groundwater flow (**Figure 3**). The creek starts to the east of MW-10. The groundwater level at MW-10 is similar to MW-206 and MW-301. Seismic survey indicates that the bedrock surface along the lake shore is below lake level for an interval north of this area and is not a barrier to groundwater flow in the sand and gravel.

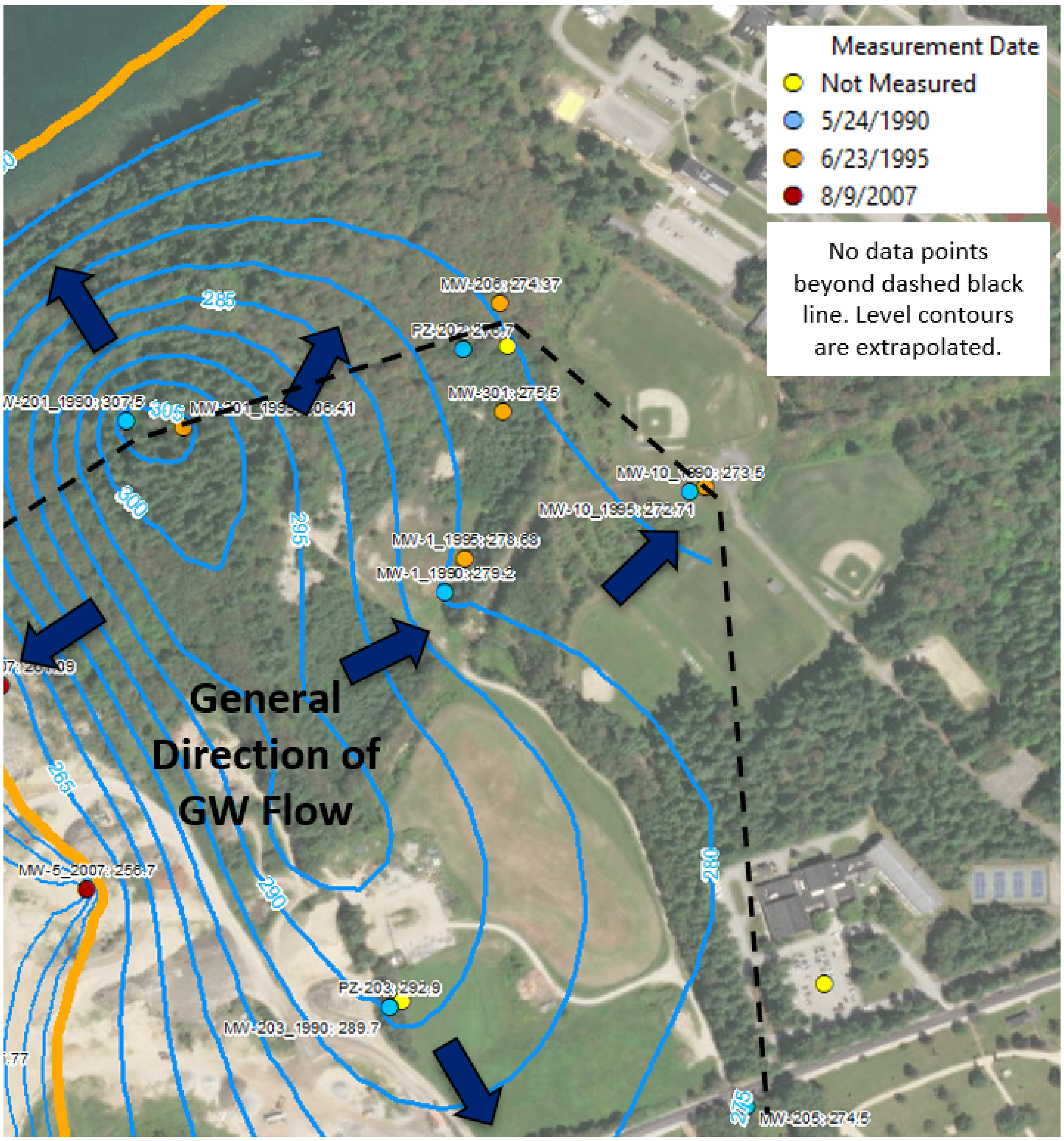

Figure 3 - Groundwater Level Contours in Area of Uncertainty (Feet)

Recommendations for Further Watershed Boundary Refinement

The "DWP Potential Boundary" represents a conservative depiction of the watershed boundary in the area of uncertainty. Additional data and modeling would be needed to delineate the flow divide with more precision if further watershed boundary refinement is desired. Groundwater flow model computations, based on the 3DVA model, would be recommended to provide a refined estimate of groundwater flow directions and the divide location. The flow model estimate would not be definitive but could assist in developing an efficient field program.

Three or more additional monitoring wells, including borings to bedrock, would likely be needed to better delineate the watershed boundary in this area. The groundwater modeling would help identify suitable locations for these wells. Any new wells installed in the future should be surveyed, and water levels should be measured synoptically with other wells in the area at least three times over the course of a year.

Area Abutting Berry Farm

Summary of Observations

A topographic high near the southwest of the Gracelawn Pit property forms the watershed boundary in the area abutting the Berry Farm. Local surface drainage in this area diverts flow to the south to a culvert beneath Mt. Auburn Avenue and away from Lake Auburn (**Figure 4**).

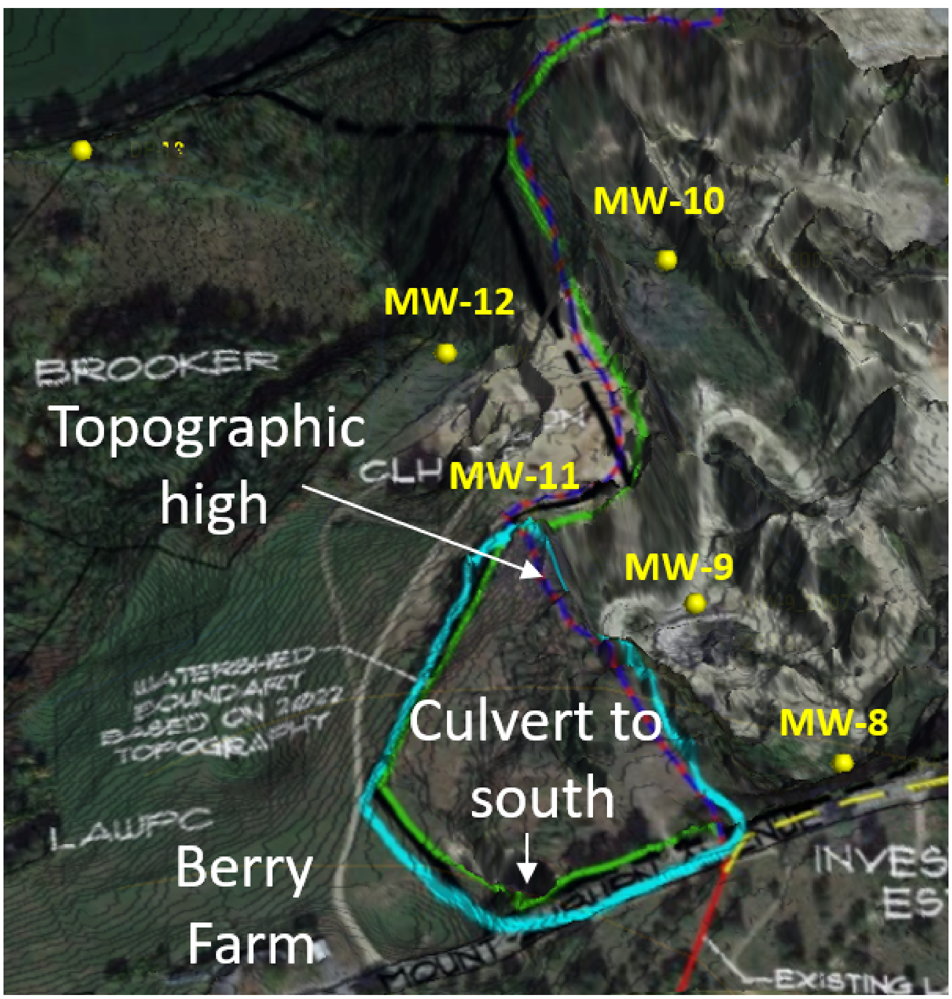

Figure 4 - 3DVA Screenshot of Topography near Area Abutting Berry Farm

No borings or wells have been installed in this area of the property, so stratigraphy or water level data are not available for evaluation. Monitoring wells installed during the 2007 investigation (Summit) just north and east of this area indicate that surficial sand and gravel groundwater levels are below lake level with a gradient to the south and away from the lake (**Figure 5**). It is unknown whether the surficial sand and gravel aquifer characterized by the nearby monitoring wells is continuous across the entire property. Where the sand and gravel aquifer is continuous and below lake level, groundwater can be expected to flow away from the lake.

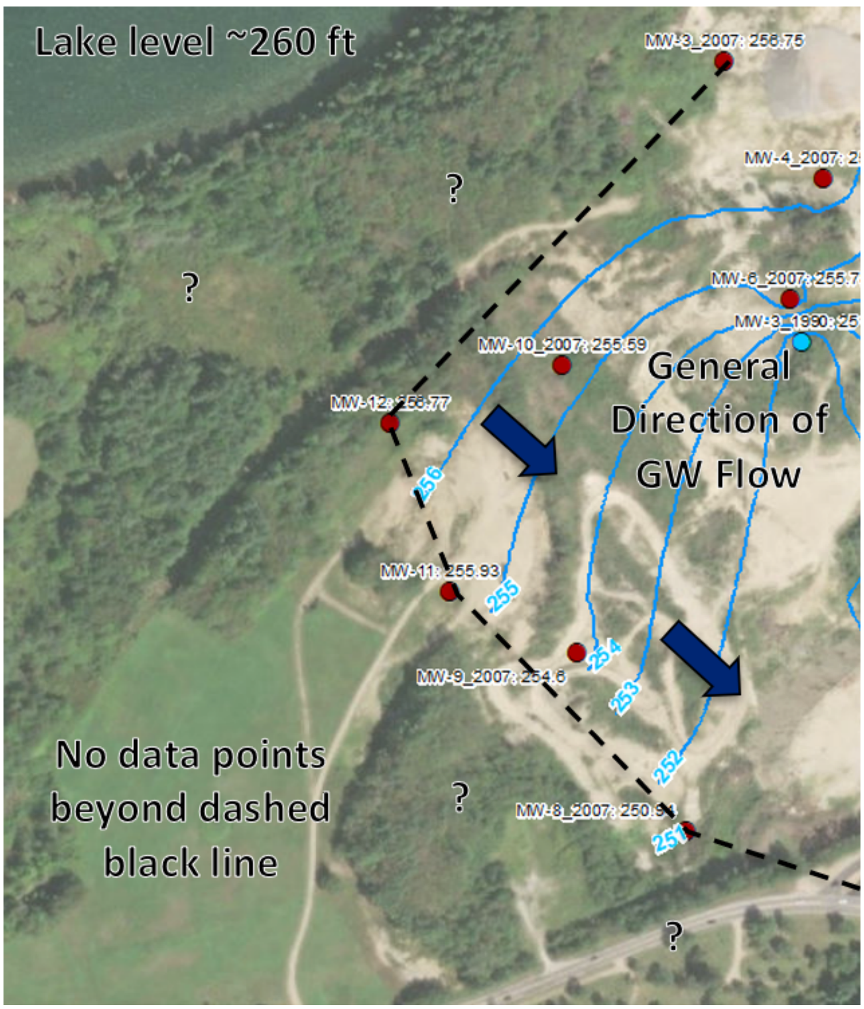

Figure 5 - Groundwater Level Contours near Area Abutting Berry Field (Feet)

However, high bedrock may be present in this area at elevations higher than lake level (~260 feet) that could divert groundwater beneath some of the property towards the lake. The 1990 investigation (E. C. Jordan) reports a bedrock outcrop at elevation 325 feet approximately 800 feet south of the southwest corner of the property.

Recommendations for Further Watershed Boundary Refinement

The current watershed boundary represents a conservative boundary in the area abutting the Berry Farm. Field work would be required for a definitive assessment of bedrock and groundwater levels in this area if further watershed boundary refinement is desired. Two or three borings would likely be needed to reasonably characterize the bedrock surface in this area. Depending on conditions encountered, monitoring wells should be completed at one of the boring locations, at least, and possibly at all boring locations. It might be necessary for one or more of the wells to be completed in bedrock. Groundwater levels at any new wells installed in the future should be measured synoptically with other wells in the area.

Main Pit Area

Summary of Observations

Groundwater levels measured at 16 monitoring wells in the Gracelawn Pit indicate that groundwater levels in the sand and gravel aquifer in most of the pit is below lake level with a gradient to the south away from the lake. Groundwater level data from 1990 to 2023 consistently shows this groundwater flow direction (**Figure 6**).

Stratigraphy in the main pit area circled in **Figure 1** includes a sand and gravel aquifer, a thin layer of till, and underlying bedrock. The saturated thickness of the sand and gravel aquifer is approximately 0 to 30 feet. A thin layer of till and bedrock underlie the sand and gravel. There is no water level or transmissivity data for the underlying bedrock. Additional field work would be required to characterize bedrock groundwater.

Glacial till between the sand and gravel and the bedrock could semi-confine the bedrock aquifer, making it possible that bedrock water levels in the main pit area shown in **Figure 1** are above lake level with a gradient towards the lake. If bedrock flow is towards the lake, the bedrock head will be higher than the sand and gravel head, preventing flow from the sand and gravel to the bedrock. Surface recharge in this area will be intercepted by the water table and flow away from the lake.

Recommendations for Further Watershed Boundary Refinement

The “DWP Potential Boundary” represents a conservative depiction of the watershed boundary in the main pit area. Additional data collection would be needed to determine bedrock water levels and evaluate potential bedrock groundwater discharge to the lake if further watershed boundary refinement is desired. This would likely include borings with wells completed in bedrock at three locations. If feasible, any future bedrock wells should be located near existing sand and gravel monitoring wells. Groundwater levels at any new bedrock wells should be measured synoptically with other wells in the area. Slug tests should be performed in any future bedrock wells to estimate transmissivity and groundwater flow rate in the bedrock.

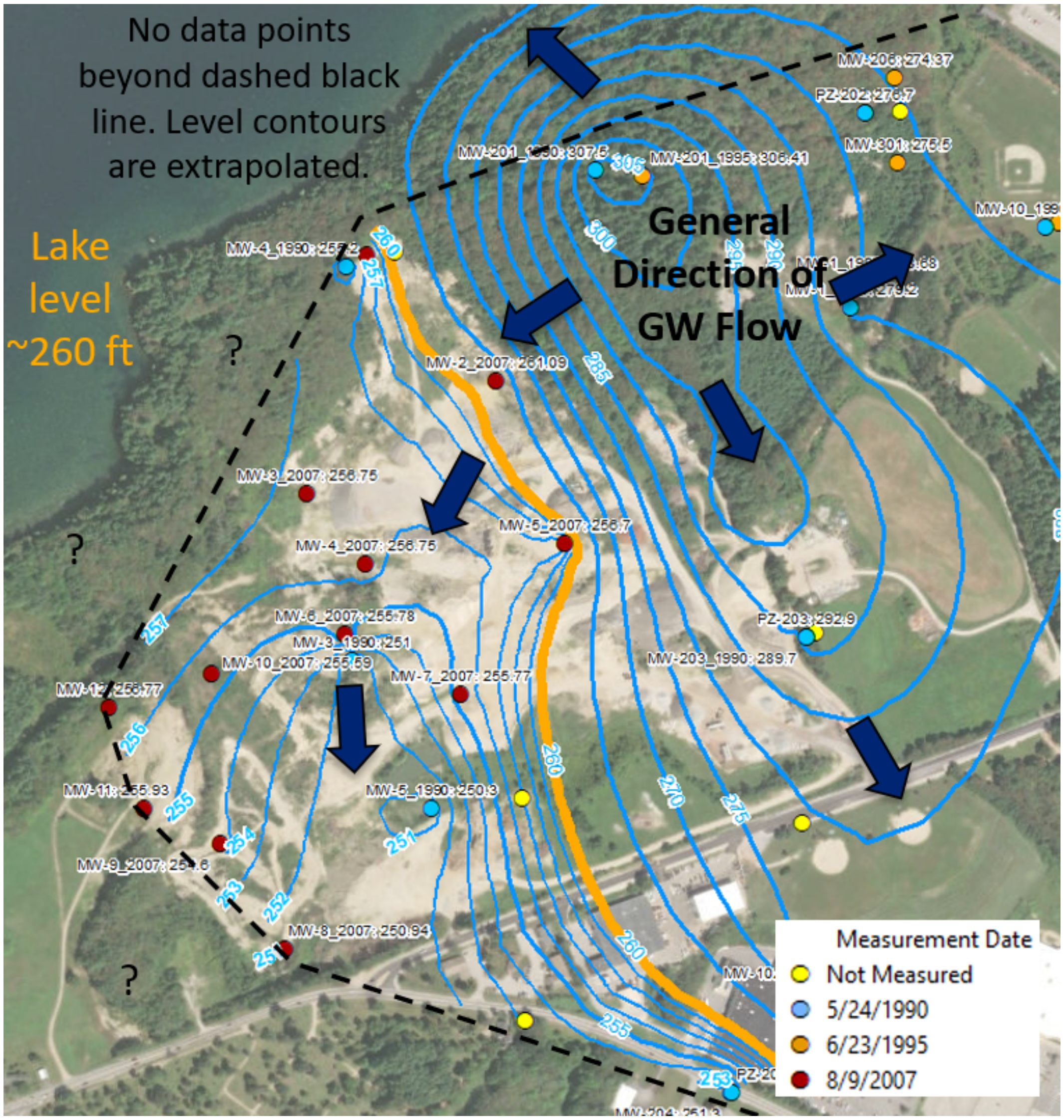

Figure 6 - Groundwater Flow Contours near Main Pit Area

Conclusions and Recommended Next Steps

Through evaluation of the historical data using the 3DVA model, CDM Smith confirms that the "DWP Potential Boundary" on **Figure 1** is a conservative watershed boundary that can be established without further investigations. Topography and hydrogeologic data confirm that both surface drainage and groundwater flow outside of the "DWP Potential Boundary" is away from the lake. While the topography indicates that the surface watershed boundary is closer to the lake than the "DWP Potential Boundary" line in some areas, there is not enough subsurface data to make the same conclusion about groundwater flow with certainty.

If there is a want for additional refinement of the watershed boundary in the three areas of interest, targeted field investigations and groundwater flow modeling would be needed to confirm the direction of groundwater flow, including:

- Groundwater flow modeling in the area of uncertainty;
- Three or more additional monitoring wells, including borings to bedrock, to better delineate the watershed boundary in the area of uncertainty. The groundwater modeling would help identify the suitable number and locations for these wells;
- Two or three borings would likely be needed to reasonably characterize the bedrock surface in the area abutting the Berry Farm. Depending on conditions encountered, monitoring wells could be completed at one of the boring locations, at least, and possibly at all boring locations. It might be necessary for one or more of the wells to be completed in bedrock;
- Two or three borings with wells completed in bedrock would likely be needed in the vicinity of the main pit area circled in **Figure 1**. If feasible, the bedrock wells could be located near existing sand and gravel monitoring wells;
- Slug test should be performed in the new wells to estimate transmissivity and groundwater flow rate in the bedrock;
- All new wells could be surveyed; and
- Groundwater levels at the new wells in all three areas of interest could be measured synoptically with other wells in the Gracelawn area at least three times over the course of a year.

If the results of the field investigations indicate groundwater flow from bedrock into the lake, bedrock fracture trace and analysis and outcrop mapping could be conducted at a later date to better understand bedrock groundwater flow patterns of the watershed area.