TO: Md Abdullah Al Masud, District Engineer, Jackson District Office, Field Operations Section, Drinking Water and Environmental Health Division

FROM: Brock Howell, Hydrogeologist, Source Water Unit, Environmental Health Section, Drinking Water and Environmental Health Division

DATE: September 6, 2024

SUBJECT: Aquifer Test Review – "Type I Hydrogeological Evaluation Report Well 5 (Future Production Well 5)" Madison Charter Township, Section 15, Madison Township, Lenawee County, Michigan, WSSN 4006

Summary

The Department of Environment, Great Lakes, and Energy (EGLE), Drinking Water and Environmental Health Division (DWEHD), Source Water Unit (SWU), has reviewed the aquifer report "Hydrogeological Evaluation Report, Baldwin Road Well Field Well #5, Madison Charter Township, Lenawee County, Michigan", which was submitted by Tetra Tech in February 2024, and the redo aquifer testing data submitted in June 2024.

Based upon the information provided, Well 5 passed the screening process according to the Adverse Resource Impact (ARI) criteria of Part 327, Great Lakes Preservation, of the Natural Resources and Environmental Protection Act, 1994 PA 451, as amended.

Madison Charter Township is looking to add a Type I Public Supply Well (Well 5) with a proposed capacity of 620 gallons per minute (gpm) to their current system capacity. As such, The Madison Charter Township contracted Tetra Tech to conduct a hydrogeological study for the proposed Type I well (Well 5). EGLE approved the installation of a test production well for the Madison Charter Township in July 2023. Well 5 was completed in November 2023, and the initial 24-hour aquifer pumping test commenced on December 14, 2023, which was evaluated in March 2024, and deemed insufficient due to poor oversight and improper development during well construction. Well 5 was redeveloped and a second 24-hour aquifer test was conducted at Well 5 on June 6, 2024, at a rate of 620 gpm. This report provides a hydrogeologic evaluation of Well 5, with a proposed capacity of 620 gpm. Monitoring wells (OW-2 and OW-3) associated with the aquifer test of Well 5 were used for the current hydrogeological analysis, with Well 3 pumping continuously between 215 gpm and 302 gpm.

The Static Water Levels (SWLs) were measured in Well 5, OW-2, and OW-3 for the current evaluation following appropriate DWEHD policy and procedure ODWMA-399-003. Based on the SWLs collected, groundwater flow is relatively flat with a slight northerly gradient. Regionally groundwater flows to the east-northeast.

Results of the June 2024, aquifer test were analyzed using the method of Theis (1935). Recovery data was subjected to an analysis using the Agarwal (1980) method. Assuming an aquifer thickness of 90 feet, Tetra Tech estimated a transmissivity (T) value of 8081.14 square feet per day (ft^2/day). The storativity (S) value estimated by Tetra Tech was 0.01292.

As part of SWU's review, a re-analysis of the time-drawdown data provided for this project was completed using several methods that included the Cooper-Jacob (1946), Theis (1935), Papadopulos-Cooper (1967), and Agarwal (1980) methods. Assuming an aquifer thickness of 90 feet with partial penetrating wells, SWU estimated the T associated with Well 5 to be 7,604 ft^2/day. SWU estimated the S associated with Well 5 to be 0.0152

Assuming a SWL of approximately 2.46 feet below ground level (bgl) in Well 5, the predicted 100-day pumping water level in Well 5 was estimated by Tetra Tech to be approximately 36.56 feet bgl at 620 gpm with their estimated 75 percent well efficiency.

Additionally, SWU staff re-analyzed the 100-day drawdown pumping continuously at a rate of 620 gpm. The calculated/estimated well-efficiency is approximately 62 percent. Applying the 62 percent efficiency modifier to the 100-day drawdown, the 100-day pumping water level is estimated to be 43.91 feet bgl at 620 gpm. This estimation suggests that there will be approximately 111 feet of remaining drawdown available in the well if the pump is set at 155 feet bgl, which would be five feet above the top of the screen.

Based on the analysis of the hydraulic characteristics, subsurface lithology, and the resultant characterization, indicates that the aquifer associated with Well 5 behaves as a confined aquifer.

From the information provided by Tetra Tech, SWU staff concluded that Well 5 can support the capacity of 620 gpm. However, Well 5 should *not* exceed 892,800 gallons per day (gpd) for any given 24-hour cycle. Based on the 100-day drawdown calculated and the potential for interference from other wells, it is suggested that the pump intake should be placed at a depth of 155-feet bgl, which would be five feet above the top of the screen.

According to Tetra Tech, the water quality analysis at the site from Well 5 did not exceed primary drinking water standards. However, Iron was detected above secondary drinking water criteria.

Site Location
Water well records in the report place Well 5, in Madison Township, Section 15 (T07S-R03E), Lenawee County, Michigan. The Site is located 0.43 mile south of Cadmus Road, and 1,190 feet northeast (71 degrees) of service road entrance onto Baldwin

Highway in Madison Charter Township, Michigan. The Site is located on the Jasper, Michigan, USGS 1:24,000 quadrangle, Lenawee County, Michigan.

The well locations for Well 5, Well 3, OW-2, and OW-3 were generally provided in accordance with the DWEHD policy and procedure ODWMA-399-003, "Aquifer Test Requirements for Public Water Supply Wells." Information for these wells is also included in Wellogic, the state-wide groundwater database.

Latitude and longitude information for these wells were collected with a hand-held global position system and interpolation-map, and can, therefore, be considered accurate to the level of precision required. A Wellogic identification number (Wellogic ID number), as well as the latitude and longitude of each well included in the aquifer characterization of this site, are provided in Table 1.

Table 1. Location Information

Well Identification	Wellogic ID Number	Latitude (degrees)	Longitude (degrees)
Well 5	46000020044	41.868465 °	-84.05316 °
Well 3	46000000170	41.867812 °	-84.053561 °
OW-2	46000019999	41.868358 °	-84.053072 °
OW-3	Not yet available	41.868474 °	-84.053527 °

Corrections or additions to location information should be directed to Anita Ladouceur, Environmental Quality Analyst, SWU, at 517-643-2574.

Area Hydrogeology

Well 5 lies within an area where the glacial and surficial geology (drift) is mapped as glacial outwash sand and gravel, and postglacial alluvium. The material consists of pale brown to pale reddish brown, fine to coarse sand alternating with layers of small gravel to heavy cobbles. The drift is a mixed lithology of sedimentary, igneous, and metamorphic rocks that are well- to poorly-sorted, but generally well-stratified, although in places cross-bedded. Morphologically the outwash occurs as fluvial terraces along present and abandoned drainage ways, as fans and sheets flanking end moraines, and as deltas along glacial lake margins. The deposits may also be present as narrow belts of Holocene alluvium inset below outwash terraces along present streams (Farrand and Bell, 1982). Drift thickness at the well site is probably in the range of 101 to 200 feet, although in the surrounding area the drift is mapped with a thickness of 51 to 100 feet. As an aquifer the drift is usually unconfined at or near the surface and present as interbedded aquifers, aquitards, and aquicludes with depth (WMU, 1981).

Review of the U.S. Geological Survey's, *Jasper, MI Quadrangle, Michigan, 7.5- minute Series Topographic Map,* indicates the land surface elevation is approximately 760 feet above mean sea level (amsl), and 760 feet amsl on both Google Earth Pro, and USGS topoview spot elevation web-service.

Stratigraphically, the uppermost bedrock in the vicinity of Well 5 is mapped as early Mississippian age Coldwater Shale (Milstein, 1987). The Coldwater Shale is normally not considered an aquifer because it does not provide water to wells in sufficient quantities and the water is generally of poor quality.

Summary of Well Construction

Well 5, OW-2, and OW-3 were used for the current hydrogeologic evaluation with Well 3 pumping continuously between 215 and 302 gpm. Table 2 summarizes the well information, including the well ID, Wellogic ID number, casing diameter, casing depth, and borehole depth.

Table 2: Summary of Well Construction

Well Identification	Wellogic ID Number	Casing Diameter (inches)	Casing Depth (feet bgl*)	Borehole Depth (feet bgl*)
Well 5	46000020044	12	160	185
Well 3	46000000170	10	135	180
OW-2	46000019999	2	180	187
OW-3	Not yet available	2	185	190

*bgl = below ground level

Driller's logs depict the unconsolidated drift material to an approximate depth of 190 feet below ground surface to a total depth explored of approximately 190 feet below ground surface. The 190 feet of unconsolidated material is depicted as predominantly clays with sand layers in the upper 100 feet followed by sand and gravel with minor clay to the total depth explored.

Groundwater Flow Direction and Gradient

SWLs were measured in the three wells (Well 5, OW-2, and OW-3) used for the current hydrogeologic evaluation before the pumping test, according to DWEHD policy and procedure ODWMA-399-003. Based on the SWLs collected, groundwater flow is relatively flat with a slight northerly gradient. Regionally groundwater flows to the east-northeast. Static water elevations at the site are shown in Table 3.

Table 3: Static Water Elevation Data

Well Identification	Top of Casing (feet amsl)	Static Water Levels from Top of Casing* (feet)	Static Water Level* (feet bgl)	Static Water Elevation* (feet amsl)	Distance from WELL 5 (feet)
Well 5	768.42	6.38	2.46	762.05	0
Well 3	NM	NM	NM	NM	262
OW-2	768.50	6.08	3.33	762.42	45.5
OW-3	769.51	7.50	2.83	762.04	100

*Based on static water levels collected on June 6, 2024, Prior to starting the constant rate test. NM = Not measured

Summary of Aquifer Tests and Data Analysis

A 24-hour aquifer test was conducted at Well 5 on December 14, 2023, which was evaluated in March 2024, and deemed insufficient due to poor oversight and improper development during well construction. A follow up down-well camera investigation confirmed the poor development was the case. Well 5 was redeveloped and a second 24-hour aquifer test was conducted at Well 5 on June 6, 2024. The June 2024, aquifer test was completed at a rate of 620 gpm. Changes in water levels were measured and recorded in Well 5, OW-2, and OW-3. The monitoring wells OW-2 and OW-3 are located 45.5 and 100 feet away from Well 5, respectively.

Tetra Tech analyzed the time-drawdown and recovery data to obtain aquifer hydraulic characteristics. The time-drawdown data was analyzed using the method of Theis (1935). Recovery data was subjected to an analysis using the Agarwal (1980) method. The analyses provided T and S values as shown in Table 4.

Table 4: Summary of Consultant's T and S Values

Wells Analyzed	Solution Method	Transmissivity (T) (ft^2/day)	Storativity (S) (Unitless)
OW-2	Theis (1935)	7,790.40	0.03
OW-2	Agarwal (1980)	7,648.71	0.01896
OW-3	Theis (1935)	8616.50	0.002686
OW-3	Agarwal (1980)	8268.95	0.000016
Average		**8081.14**	**0.01292**

For the aquifer associated with Well 5, Tetra Tech estimated an average T value of 8081.14 ft^2/day for the aquifer test conducted in June 2024. The average S value was estimated to be 0.01292 (see Table 4). The aquifer thickness was reported to be approximately 90 feet thick.

SWU staff re-analyzed the time-drawdown data provided for this project using several methods that included the Cooper-Jacob (1946), Theis (1935), Papadopulos-Cooper (1967), and Agarwal (1980) methods. The analysis was completed using the aquifer analysis software AQTESOLV for Windows, version 4.50 (Duffield, 2007). From these analyses, the Papadopulos-Cooper (1967) and Agarwal (1980) methods show the most reasonable analysis given the associated lithology and data and information provided by Tetra Tech for the Madison Charter Township, Well 5 site.

Assuming an aquifer thickness of 90 feet with partial penetrating wells, SWU estimated the T associated with Well 5 to be 7,604 ft^2/day. SWU estimated the S associated with Well 5 to be 0.0152.

The response of the aquifer to the withdrawal of groundwater and the resultant characterization indicates that the aquifer associated with Well 5 behaves as a confined aquifer.

100-Day Drawdown

It is an accepted practice to predict drawdown for 100 days of continuous pumping with no recharge to the aquifer. Tetra Tech used a method similar to the AQTESOLV® Forward Solution from the late-drawdown data to 100 days, the average hydraulic parameter values summarized in Table 4 were used as inputs to the analytical solution, and the 100-day safe yield values for Well 5 were estimated with Well 5 pumping at a rate of 620 gpm. Assuming a SWL of approximately 2.46 feet bgl in Well 5, the predicted 100-day pumping water level in Well 5 was estimated to be approximately 36.56 feet bgl with their estimated 75 percent well efficiency. This estimation suggests that there will be approximately 118 feet of remaining drawdown available in the well if the pump is set at 155 feet bgl, which would be five feet above the top of the screen.

SWU staff re-analyzed the 100-day drawdown pumping continuously at a rate of 620 gpm. The calculated/estimated well-efficiency is approximately 62 percent. Applying the 62 percent efficiency modifier to the 100-day drawdown, the 100-day pumping water level is estimated to be 43.91 feet bgl at 620 gpm. This estimation suggests that there will be approximately 111feet of remaining drawdown available in the well if the pump is set at 155 feet bgl, which would be five feet above the top of the screen

Tetra Tech concludes that Well 5 can safely yield 620 gpm for 100 days and suggested a safe pump setting for Well 5 to be at least 155 feet bgl. SWU agrees with the suggested safe pump setting of 155 feet bgl for Well 5.

Interference

Interference is defined as the drawdown in a well caused by pumping a nearby well or wells. The total effect on any one well is the total of all drawdown interferences created by nearby pumping wells (Driscoll, 1986). Effects of interference, especially in confined aquifers for extended periods of pumping, can be far reaching. It appears from the derivative analysis of the time-drawdown data performed by SWU, that Well 5 experienced some minor cyclical interference during the aquifer test suggesting that nearby wells were potentially cycling on and off within the respective radius of influence.

Conclusion and Recommendation

Based on the information presented in the report along with other supporting documentation submitted by Tetra Tech, SWU staff concluded that Well 5 can support the capacity of 620 gpm. However, Well 5 should *not* exceed 892,800 gpd, for any given 24-hour cycle. Based on the 100-day drawdown calculated and the potential for interference from other wells, it is suggested that the pump intake should be placed at a depth of 155feet bgl, which would be five feet above the top of the screen.

cc: Dana DeBruyn, EGLE
Travis Bauer, EGLE

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