Technical Memorandum

Date: 5/27/2025

From: Christian Langevin

To: David Crass

Project: SSP-Nicolet College

Subject: **Review of Well Site Investigation Report for Well No. 9**

1. Introduction

On May 8, 2025, S.S. Papadopulos & Associates, Inc. ("SSP&A") entered into an agreement with Michael Best & Friedrich LLP ("MB&F") to conduct a technical review of the Well Site Investigation Report (WSIR) for Well No. 9 (MSA 2024) and a review of the Wisconsin Department of Natural Resources' (WDNR) response to the WSIR. On May 12, 2025, the City of Rhinelander held a public meeting on the proposed Well No. 9. Presentations from that meeting are available online and were also reviewed by SSP&A. Lastly, written correspondence from Jared Niewoehner (WDNR) to Brad Stuczynski (MSA Professional Services, Inc.), dated November 7, 2024, was obtained by Nicolet College. The correspondence describes separate WDNR calculations not provided elsewhere. This technical memorandum summarizes the findings from the review performed by SSP&A of these documents.

2. Background

The water system for the City of Rhinelander (City) consists of five municipal groundwater wells. The wells are referred to as #4, #5, #6, #7, and #8. Wells #7 and #8 were taken offline in 2019 due to the presence of per- and polyfluoroalkyl substances (PFAS) detected in the raw water. With Wells #7 and #8 offline, the City cannot safely meet the average day and maximum day demands based on typical engineering practices.

The City conducted a search for a new site that would support installation of a high capacity well. Three different sites were evaluated. They are referred to as Test sites 9-1, 9-

Technical Memorandum (Continued)

To: David Crass

Date: 5/20/2025

2, and 9-3. Test site 9-2 is located on Nicolet College property and has been identified as a viable option for installation of a new, high capacity municipal well. On behalf of the City, MSA Professional Services, Inc. submitted a Well Site Investigation Report (WSIR) for the proposed high capacity well, referred to as Well #9, to the WDNR for approval. The WDNR approved the WSIR and the well site location subject to conditions specified in its response.

The goal for Well #9 is to support a pumping capacity of 500 gallons per minute (gpm), as indicated in the WSIR; however, the WSIR acknowledges that "*actual capacity may be less depending upon the specific borehole geology"* and that *"Two or more final wells may be required on the well site to yield 500 gpm."* The WSIR also states "*A future well #10 (with pitless unit) on the same parcel could be added if Well #9 does not yield a minimum of 500 gpm alone."* In its response to the WSIR, WDNR recommends to "*limit the pumping at this well site to 12,000,000 gallons per month,"* which is about 280 gpm, just over half of the design rate. The WDNR response letter does not provide information on how the recommended rate of 12 million gallons per month was determined. WDNR slides presented at the May 12, 2025 meeting indicate that Well #9 will likely pump at a rate similar to the combined rate of Wells #7 and #8, which is about 266 gpm.

3. Review Findings

The WSIR describes the evaluation of three different test sites: 9-1, 9-2, and 9-3. The WSIR concludes that Test site 9-2, located on Nicolet College property, is the preferred site for installation of a new high capacity well. A pumping test at Test well 9-2 produced 62 gpm. Test sites 9-1 and 9-3 had limited water production and were deemed not viable for a final well.

According to the WSIR, conditions at Test site 9-1 were determined to be insufficient for installation of a high capacity well. Problems were encountered with the test well. The WSIR mentions the presence of fine material and a low 20 gpm yield. The well construction information for Test site 9-1 is not included in Appendix C, so this information could not be verified. Test site 9-1 is located in the same area as production Wells #5 and #6.

Technical Memorandum (Continued)

To: David Crass

Date: 5/20/2025

Production Well #5 has a high pumping capacity (1,800 gpm) and is located less than 1/10 of a mile from Test Well 9-1. It is possible that Test Well 9-1 was installed in an isolated area of low permeability materials and that much higher yields, on the order of the yields for Wells #5 and #6, could be obtained within 10s to 100s of feet of Test Well 9-1. Based on the limited information in the WSIR, further exploration in this area could be warranted.

Test site 9-2 is stated as the favored location for the new, high capacity municipal well for several reasons. Compared to the other municipal well locations, Test site 9-2 is located relatively far from potential contamination sources. With the detection of PFAS in Wells #7 and #8, it makes sense for the City to explore locations further away from the airport and other known areas with PFAS contamination. Based on the information provided in the WSIR and the review by WDNR, Test site 9-2 also consists of the following favorable conditions:

- The bedrock in this area is relatively deep, and hydraulic testing at test well 9-2 suggests that a high capacity well should be possible.
- The well site meets minimum separation distances to contamination sources.
- Except for the presence of elevated chloride concentrations, which may be attributable to road salt application, the water quality at Test site 9-2 is favorable for a municipal well.
- The site is close to City infrastructure (road access, water main, and electrical service).

The goal is for the new high capacity well to support a pumping capacity of 500 gpm. This design capacity can be put into context by comparing it to the actual pump capacities (as shown in WSIR Table 1-5) for Wells #4 (1,800 gpm), #5 (1,800 gpm), #6 (1,000 gpm), #7 (650 gpm), and #8 (400 gpm). Compared with these other wells, the design capacity for Well #9 seems reasonable for the area.

Technical Memorandum (Continued)

To: David Crass

Date: 5/20/2025

Three of the primary hydrologic concerns with operating a new 500 gpm capacity well at Test site 9-2 include the following.

- Private wells in the area may be affected. WDNR notes in its response letter that the proposed Well #9 "*has the potential to draw down water levels in nearby private wells, especially under increasing future demand scenarios.*" This is a valid concern. Furthermore, in the meeting slides from May 12, 2025, WDNR recommends that the City: "*Develop a plan for mitigating potential impacts to existing private wells surrounding the existing Dodgeville municipal wells either by replacing existing private wells with deeper wells or by extending City water service to an area, should private wells become impacted by the municipal wells.*" This is a good suggestion. The concern about adverse impacts to private wells can and should be addressed by the City through new well assistance or water service extension.

- Surface waters in the area may be adversely affected. It is very likely that a new high capacity well will lower water levels in Hess Lake and perhaps other nearby surface waters. In the meeting slides from May 12, 2025, WDNR estimated the volume of Hess Lake to be around 34.9 million gallons. This lake volume is compared to the capacity to pump 21.6 million gallons per month. The lake volume is equivalent to the amount of water that would be pumped in about one and one-half months from a well operating at 500 gpm. The meeting slides do not contain any further information about this comparison, but it is reasonable to conclude that the capacity to pump is relatively large compared to the water volume of Hess Lake. This may warrant further analysis through additional hydrologic modeling prior to well installation, design of a continuous water-level program to monitor the effects of pumping, or both.

- The WDNR Surface Water Data Viewer shows the presence of numerous mapped wetlands within the area around Test site 9-2. There are mapped wetlands on the Nicolet College property adjacent to Test site 9-2, though the status of these

Technical Memorandum (Continued)

To: David Crass

Date: 5/20/2025

wetlands is unclear. The proximity of these wetlands to the proposed Well #9 is clearly shown in the Proposed Site Plan (Appendix H of the WSIR). The proposal is for Well #9 to be cased to a depth of 80 feet and screened beneath that to a depth of 110 feet. The effects of Well #9 on these wetlands will depend on the type of aquifer material present between land surface and the bottom of the well casing. The presence of low-permeability material will cause the effects of the pumping to spread out over a larger area and be less severe than if more permeable material between land surface and the bottom of well casing were present. The construction data for Test Well 9-2 (Appendix D in the WSIR) do not note the presence of low-permeability material, which means that water table declines near the well may be relatively large. It is reasonable to expect that pumping from a future Well #9 will adversely affect nearby wetlands, especially those wetlands on Nicolet College property directly west of the proposed site. Nicolet College should evaluate the benefits of these wetlands and recognize that they may no longer function as wetlands once a high capacity well is in operation.

The WSIR describes several technical analyses designed to estimate the hydrologic effects of proposed Well #9. The following comments are aimed at those analyses.

- One of the best ways to predict how the groundwater system will respond to a high capacity well is to simulate the pumping effects using a groundwater model. The WSIR indicates that groundwater modeling was performed by the Wisconsin Rural Water Association (WRWA) "*Source Water Protection Program, A. Aslesen, August 2024.*" The predicted Zone of Contribution (ZOC) and Time of Travel (TOT) metrics, and their graphical representation on the map in Appendix K, are useful for predicting the effect of the proposed high capacity well. It would have been helpful to see more details about the ZOC and TOT metrics in the WSIR. For example, it is unclear how or if lakes are included in the model and whether the analysis uses a two-dimensional or three-dimensional representation for groundwater flow.

Technical Memorandum (Continued)

To: David Crass

Date: 5/20/2025

- The Theis calculation described in the WSIR was repeated by SSP&A and confirmed to be correct. The Theis calculation provides an estimate of how much the water table will decline in response to groundwater pumping. This decline in the water table surface from its original position is called "drawdown." Drawdown is largest near the well and decreases radially outward from the well. The Zone of Influence (ZOI) is defined as the area inside a circle with drawdown greater than or equal to one foot. The Theis calculation is based on the well pumping at the maximum rate of 500 gpm continuously for a period of 30 days without any recharge. The radius of the ZOI was confirmed to be 1,425 feet.

- The ZOI intersects with Hess Lake, thus the water level in Hess Lake could drop by a foot or more in response to pumping.

- The Theis equation can also be used to calculate the drawdown at shorter distances to predict how water levels will change near the well. Application of the Theis equation for a radial distance of 100 feet from the well provides a drawdown of more than 20 feet. This suggests that the adjacent wetland areas may experience substantial water level declines and may no longer be able to support saturated conditions.

- The ZOI is determined based on the radial distance to the calculated drawdown of one foot. Although this is common practice, the value of one foot is arbitrary. Water level declines caused by a pumping well extend out much farther than the one-foot ZOI. For example, using the same parameters and the Theis equation, the radial distance to a 0.1-foot drawdown circle is about 2,310 feet.

- There is conflicting information in the WSIR regarding aquifer parameters used for the ZOC modeling and the parameters used for the ZOI calculation. For the ZOC calculation, the WSIR indicates that a hydraulic conductivity value of 110 ft/day was used in the model with an aquifer thickness of 80 feet. Aquifer transmissivity, which is the product of hydraulic conductivity and aquifer thickness, is calculated from these numbers to be 8,800 ft^2/day. For the ZOI calculation with the Theis equation,

Technical Memorandum (Continued)

To: David Crass

Date: 5/20/2025

the WSIR indicates that a transmissivity value was estimated based on the results of a pumping test (presumably at Test Well 9-2). The transmissivity from the pumping test, after a conversion to consistent units, is 1,730 ft^2/day, about five times less than the transmissivity value used in the groundwater model.

- As with most hydrologic analyses, there is a lack of information on important hydrologic parameters. Determining appropriate values to use in these types of analyses is not straightforward, as highlighted in the previous bullet point. This lack of information introduces a large amount of uncertainty in the predicted system behavior described in the WSIR.

Results from a separate ZOI calculation are included in the slides posted from the May 12, 2025 meeting under the section "Town and Country Engineering's slides." Slide number five in the document shows a "2,773-foot Buffer" around Test site 9-2. Although there is no further description in the document about this buffer, it appears to be related to a separate ZOI calculation that is described in the November 7, 2024 correspondence between the WDNR and MSA Professional Services, Inc. Using different input and assumptions (different aquifer parameters, one year of pumping instead of 30 days, and a pumping rate based on the combined average rate of Wells #7 and #8), WDNR calculated that one foot of drawdown would occur at a radial distance of 2,773 feet. Table 1 compares the WSIR values with the WDNR values.

Table 1. Values used in the Theis calculations. The WSIR column lists the values that were used for the Zone of Influence calculation in the Well Site Investigation Report. The WDNR column lists the values provided in the November 7, 2024 correspondence between the WDNR and MSA Professional Services, Inc.

	WSIR	WDNR
Time, *t* (days)	30	365
Pumping Rate, *Q* (gallons per minute)	500	266
Transmissivity, *T* (feet squared per day)	1,730	2,800

Technical Memorandum (Continued)

To: David Crass

Date: 5/20/2025

Storativity, *S* (dimensionless)	0.1	0.15
Specified Drawdown (feet)	1	1
Calculated Radial Distance, *r* (feet)	1,425	2,773

The WDNR results could not be verified with an independent Theis calculation. By using the WDNR values from Table 1, an independent Theis calculation predicts that the radial distance to one foot of drawdown is 3,340 feet, more than 500 feet further from the pumping well than the WDNR-calculated value.

Theis calculations are sometimes approximated using a simpler, but less accurate, Cooper-Jacob equation. By using the numbers from the WDNR column in Table 1, the simpler Cooper-Jacob equation calculates the radial distance to be 2,773 feet, suggesting that WDNR used the Cooper-Jacob equation for its analysis. A limitation with the Cooper-Jacob analysis, however, is that it cannot be used for certain parameter combinations (see, for example, the description of the "critical value for u"). Specifically, the parameter combination in the WDNR column of Table 1 is outside the valid range of the Cooper-Jacob approximation. For this reason, the Theis equation must be used instead.

It should be recognized that the exact numbers produced by these calculations have a great deal of uncertainty. By slightly varying input parameters within reasonable ranges, the predicted one-foot drawdown distance can vary over tens to hundreds of feet.

4. Conclusions

The following conclusions and recommendations from this review are summarized as follows:

- In its response letter, WDNR concluded that "*the City has demonstrated that an additional water source is needed to meet demands for public use.*" This review is in agreement with that finding.

Technical Memorandum (Continued)

To: David Crass

Date: 5/20/2025

- Although it is unclear why further exploration was not considered near Test site 9-1, the analysis presented in the WSIR and confirmed in WDNR's response suggesting that Test site 9-2 appears to be a viable option for a new high capacity pumping well. It is worth reiterating, however, that 500 gpm may not be possible to achieve with a single well. It may be necessary to construct two or more high capacity wells at this location.

- It is reasonable to expect that pumping from a new high capacity well at Test site 9-2 will affect wetlands and surface waters near the well. Wetlands adjacent to the pumping well may no longer function as wetlands and water levels in nearby lakes could drop by a foot or more.

- Pumping from a new high capacity well at Test site 9-2 could affect nearby private wells. If this were to occur, it is recommended that the City help with new well assistance or water service extension.

- There is a paucity of water level data in the area around Test site 9-2. It is recommended that the City monitor water levels in surface waters and groundwater wells in the area prior to installation of a new well and after a new well has become operational. Water level data collected over this period are essential for quantifying the effect of a new well on aquifer conditions in the area and would help the City better understand and manage the hydrologic impacts.

- Areas around municipal wells are often protected from possible sources of contamination. The City of Rhinelander has a Wellhead Protection Ordinance designed for this purpose. The current version of the ordinance (3.07.17) designates a Groundwater Protection Overlay District based on the locations of Wells #4, #5, #6, #7, and #8. It is expected that the Groundwater Protection Overlay District will be updated to include Well #9. Nicolet College should review the Wellhead Protection Ordinance as it will affect development in the area, including the type of development than can occur on Nicolet College property.

Technical Memorandum (Continued)

To: David Crass

Date: 5/20/2025

I hope that the foregoing comments are useful and can help with upcoming decisions. Please do not hesitate to contact me if I can provide additional information or clarification on these findings.

Sincerely,

S.S. Papadopulos & Associates, Inc.

Christian D. Langevin

Christian Langevin, PhD
Principal Hydrologist