Aquifer Storage and Recovery Case Study

Site: Shakopee Mdewakanton Sioux Community (SMSC)

Highlights

"Groundwater is the sole source of drinking water in Scott County, where the SMSC is located. Region-wide groundwater demand is increasing, with limited groundwater available. The Community is considering injecting treated effluent from the [Water Reclamation Facility] into the aquifer for use in the future."

-Shakopee Mdewakanton Sioux Community Website

- Currently, the SMSC discharges the majority of their reclaimed water (treated wastewater) to surface water where it is conveyed away from the Community eventually to the Minnesota River.
- The Jordan aquifer is experiencing overdrafting and in some spots on or near the SMSC, is expected to witness drawdown exceeding 50% of the available head by 2030.
- The SMSC has completed a pilot study for injection of treated wastewater into the sand and gravel subsurface layer above the Jordan aquifer. This injection project would help recharge the Jordan and mitigate overdrafting that is subject to further increases due to predicted growth of the tribe and its various industries.
- Pursuit of full- scale injection stalled due to concerns from local units of government and also with the presence of a bedrock valley adjacent to their tribal land that would result in a large portion of the injection volume conveyed away from the site and effectively lost. The SMSC may consider ASR in the future.

Summary

The Shakopee Mdewakanton Sioux Community (SMSC) is a federally recognized tribe formalized under federal reservation status in 1969. They have legal authority over about 4,000 acres of land in Scott County, Minnesota. While the Community is not subject to Minnesota authority, these 4,000 acres are geographically constrained within the state. The tribe itself has a population of only 325, but operates numerous enterprises including two casinos, a hotel and event center, a community center, two gas stations, a grocery store, and an organic farm. These services inflate the effective population of the SMSC to about 15,000 people in terms of water use.

The SMSC strives for self-sufficiency economically through the operation of many enterprises, and socially through providing their own community services. They also have their own public works department which builds and maintains transportation, energy, and water infrastructure. The SMSC draws their water from three groundwater production wells; two in the Jordan aquifer and one in a deeper aquifer. These wells produced a combined 190 million gallons of water per year. The SMSC operates their own drinking water treatment plant which treats to remove iron and manganese by reverse osmosis, as well as a water reclamation and wastewater treatment facility that handles 145 million gallons annually, with a 900 million gallon/year maximum capacity. Approximately 35 million gallons of this treated effluent is used for irrigation of their 18-hole golf course (The Meadows at Mystic Lake), while the rest is discharged to surface water, where it eventually reaches the Minnesota River. The SMSC has a strong conservation mindset and passion for environmental stewardship. The tribe has recognized the wasted potential associated with allowing over 100 million gallons of pumped and twice treated groundwater to be released into the environment.

The SMSC has a growing population, and with the expansion of their current enterprises the Community is expected to augment their water supply through increased groundwater pumping. However, observations of groundwater levels in the Prairie du Chien-Jordan aquifer underlying the Twin Cities metropolitan area have illustrated an unsustainable pattern of use for the region. Predicted drawdown in the Prairie du Chien-Jordan aquifer if groundwater use continues on its current trajectory (as of 2010) will exceed 50% of the available head (Fig. 1). To stymie this overdrafting of the Prairie du Chien-Jordan, injection of highly-treated wastewater has been considered due to the growing population of the SMSC, and increased activity associated with their enterprises. In 2007 the SMSC initiated a pilot study to assess the feasibility of injecting large quantities of treated wastewater (referred to as “reclaimed water”) into the ground.

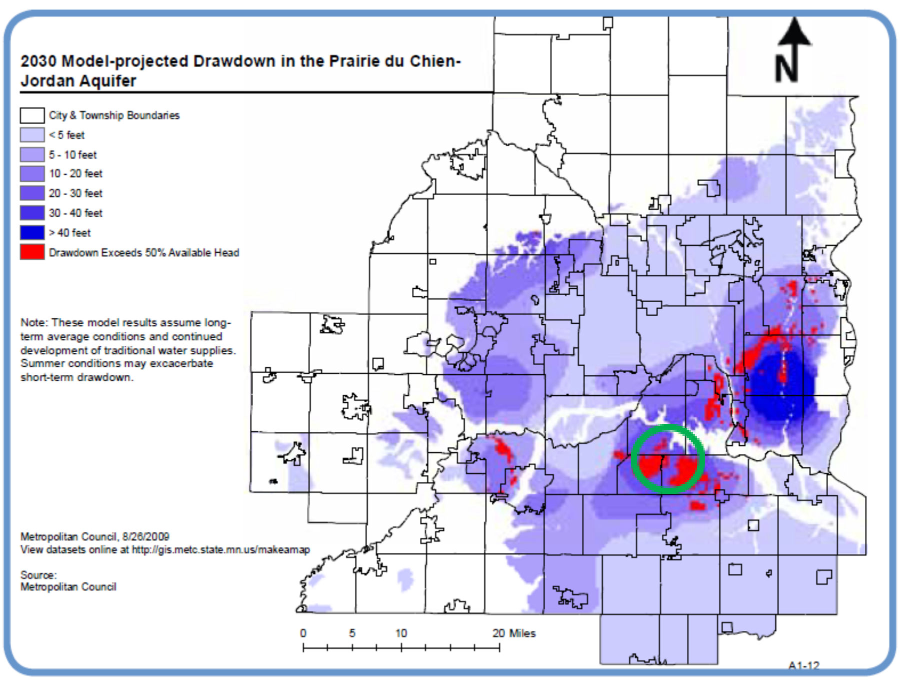

Figure 1: Drawdown predictions for the Prairie du Chien-Jordan aquifer if unsustainable groundwater practices continue to occur in the Twin Cities metro area. Green circle is the location of the SMSC (Source: [1])

The Jordan aquifer underlying the land of the SMSC is overlain by two distinct layers . Nearest the surface is a layer of sandy clay till which overlies a layer of sand and gravel. The pilot study considered injection of reclaimed water into the sand and gravel layer which would allow the water to slowly percolate into the Jordan aquifer. The injection well would be screened across the entire gravel layer directly above the aquifer. Injection would be presumed to occur for 5 months out of the year in the fall, winter, and spring, when water demand from the community and operating enterprises is lowest. This injection period would also occur when the golf course was not being irrigated with reclaimed water, meaning 100% of the fully treated wastewater stream would be available for injection. Currently the water reclamation plant produces about 300 gallons per minute (gpm) of highly quality effluent, however the facility has the capacity to treat up to 1332 gpm. The SMSC is not planning on using a dual-purpose injection and recovery well, nor a targeted well field to recover the injected water after a certain travel time through the aquifer media. Instead, injection is meant to generally recharge the Jordan aquifer, which they expect will mitigate its local depletion and overdrafting. The injection water would eventually be recovered by the SMSC operated production wells in the Jordan Sandstone aquifer, but no specific residence time is desired.

Wastewater treatment at water reclamation facility (WRF) consists of standard preliminary treatment, a unique secondary treatment process, and an advanced tertiary treatment step. As the wastewater enters the reclamation facility it passes through fine screens to remove refuse or other objects that could clog pipes or otherwise compromise the system. After screening, the water enters a vortex grit removal system that removes small, heavy particles like sand. The final step in the preliminary treatment train is primary clarification, which provides quiescent conditions for removal of organics and other particulates that made their way through the first two removal processes. Water flows over a weir from primary clarification to secondary treatment consisting of a Biologically Aerated Filtration (BAF) technology, as well as biosolid treatment and disposal. BAF is a treatment technology used by less than a dozen wastewater treatment and water reclamation facilities in the United States. BAF is especially useful when land is expensive, necessitating a small plant footprint, and when a very high water quality standard is expected for the plant effluent. The BAF process consists of continuous flow of wastewater through an aerated tank containing millions of tiny Styrofoam beads. These beads provide a large surface area for bacteria to grow on, and provide treatment to the wastewater. The plant also currently has additional BAF units that are not in use, but could be brought online when future growth increases treatment demand. While currently 145 million gallons are treated per year, the facility is capable of treating up to 900 million gallons/year. Effluent from the BAF is filtered through a membrane in order to separate any biomass and remaining particulate matter, before being exposed to UV light which inactivates pathogenic microorganisms. After this disinfection step, the final effluent is discharged to a series of wetlands. The discharged water eventually flows through these wetlands to the Minnesota River.

The pilot study was initiated in 2007 and ran through 2012. Additional treatment processes were installed at the WRF consisting of reverse osmosis, UV, and ozone treatment. These extra processes purify the reclaimed water to an even higher standard including the destruction of any recalcitrant organic compounds that are relatively unaffected by conventional biological wastewater treatment. No water was actually injected into the ground as a part of the pilot study, however the interaction between the finished water and the aquifer media was studied through column tests. The pilot plant effluent was divided between two sets of aquifer core samples. One stream was treated with carbon dioxide and lime in order to introduce hardness and adjust the pH, while the other stream did not receive any additional treatment before contacting the core samples. This hydrogeological testing was conducted to study the effect of the aquifer media on the chemistry of the source water, and to quantify the effect of conditioning before injection. A schematic of the pilot study is shown below (Figure 2).

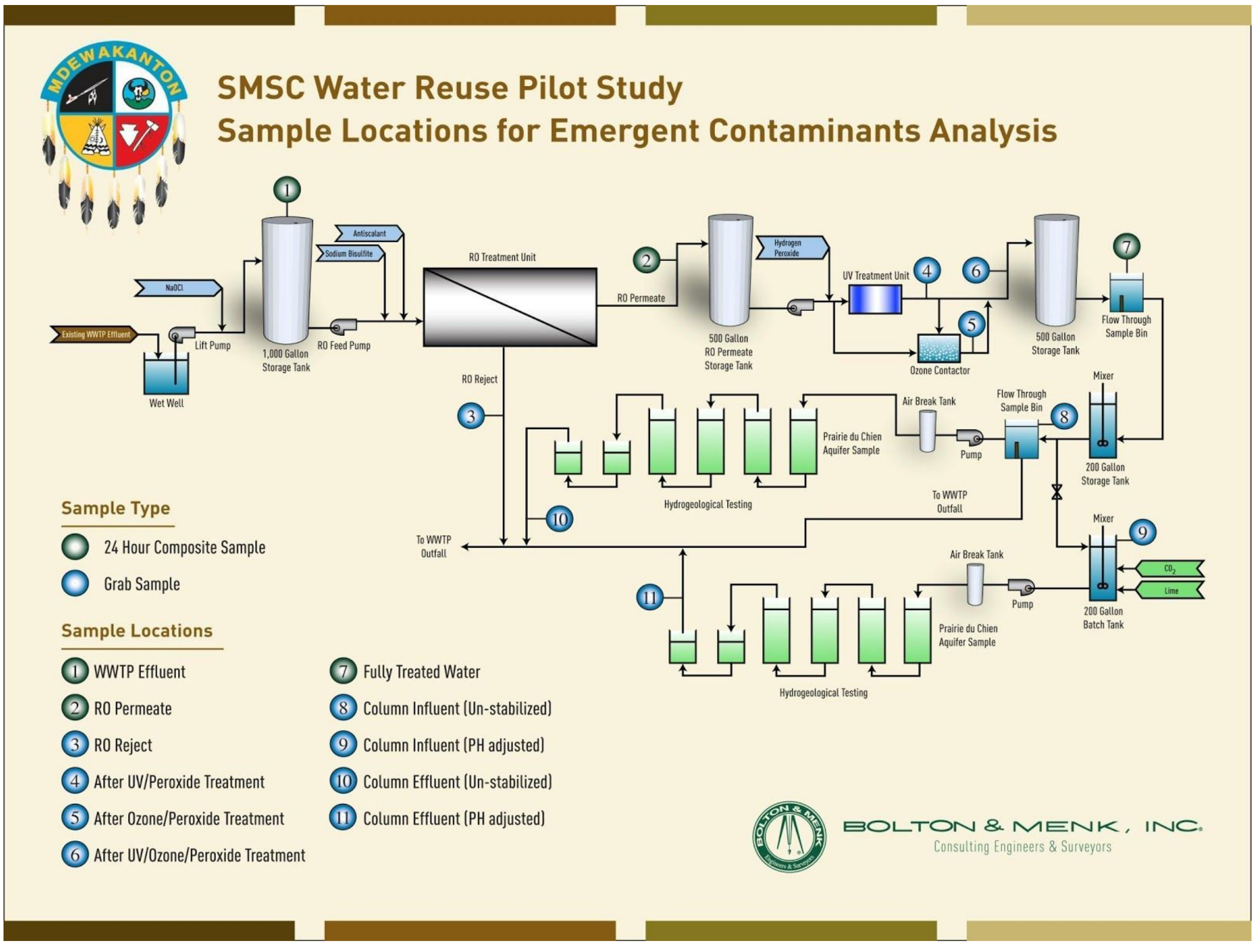

Figure 2: Pilot study schematic. (Source: [2])

One of the most common problems with injection associated with ASR is the mobilization of arsenic from arsenic-bearing aquifer media. Figure 3 depicts concentrations of arsenic in the effluent of the aquifer media columns for both conditioned and unconditioned pilot plant effluent. Also displayed are the typical concentrations of arsenic observed in the two production wells that the Community uses to draw drinking water from the Jordan aquifer, as well as the maximum contaminant limit (MCL) for arsenic in drinking water, set by the United States Environmental Protection Agency (USEPA).

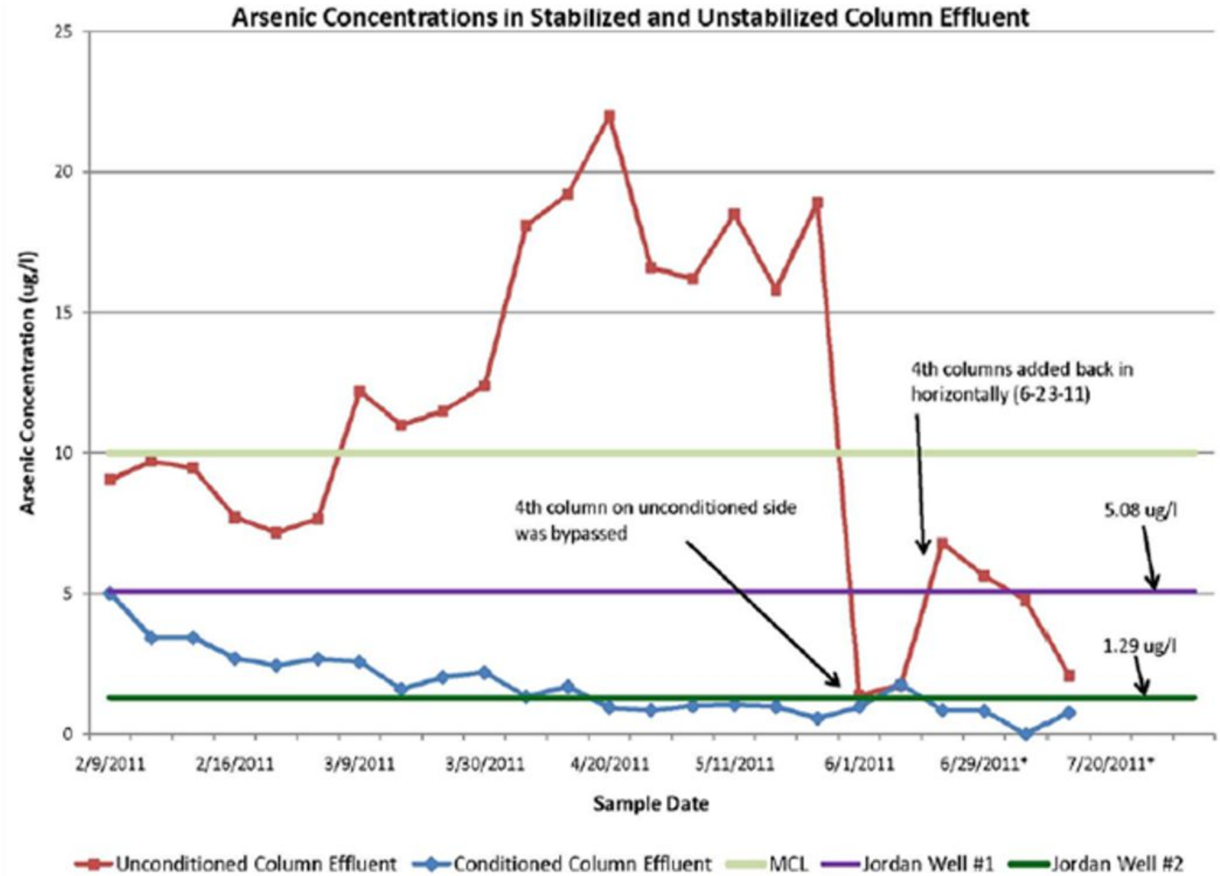

Figure 3: Effects of conditioning pilot plant effluent on arsenic concentrations in column effluent. (Source: [2])

Conditioning of the pilot plant effluent with carbon dioxide and lime results in the mitigation of arsenic mobilization. In fact, the conditioned column effluent contains arsenic concentrations that are lower than the concentrations found in the drinking water source water, and is far below the federal MCL for arsenic. In contrast, the unconditioned column effluent contains concentrations of arsenic that are significantly above the federal MCL for more than half of the test period (Figure 3). It is unclear if the unconditioned column effluent arsenic concentration decreased towards the end of the test period, due to an anomaly with the fourth column. The conditioned column effluent experienced consistent reductions in arsenic concentration throughout the duration of the test period, suggesting that the capacity of the aquifer cores to release arsenic was being depleted.

The column effluents were also sampled for other inorganic constituents. For the conditioned water, calcium levels were similar in the column influent and effluent. Total dissolved solids (TDS) concentrations increased slightly for the conditioned water. Magnesium, strontium, and silicon experienced increases in the conditioned water, but less than what was observed for the unconditioned water. Meanwhile, sodium, potassium, aluminum, and barium increased in the conditioned and unconditioned water at similar levels.
The effectiveness of the additional reverse osmosis, ozone, and UV treatment on the pilot plant effluent was also assessed by sampling the existing water reclamation facility effluent (Site 1 on Figure 2) for a number of common organic contaminants, and comparing to the concentrations found from samples taken after the advanced treatment train (Site 7 on Figure 2).

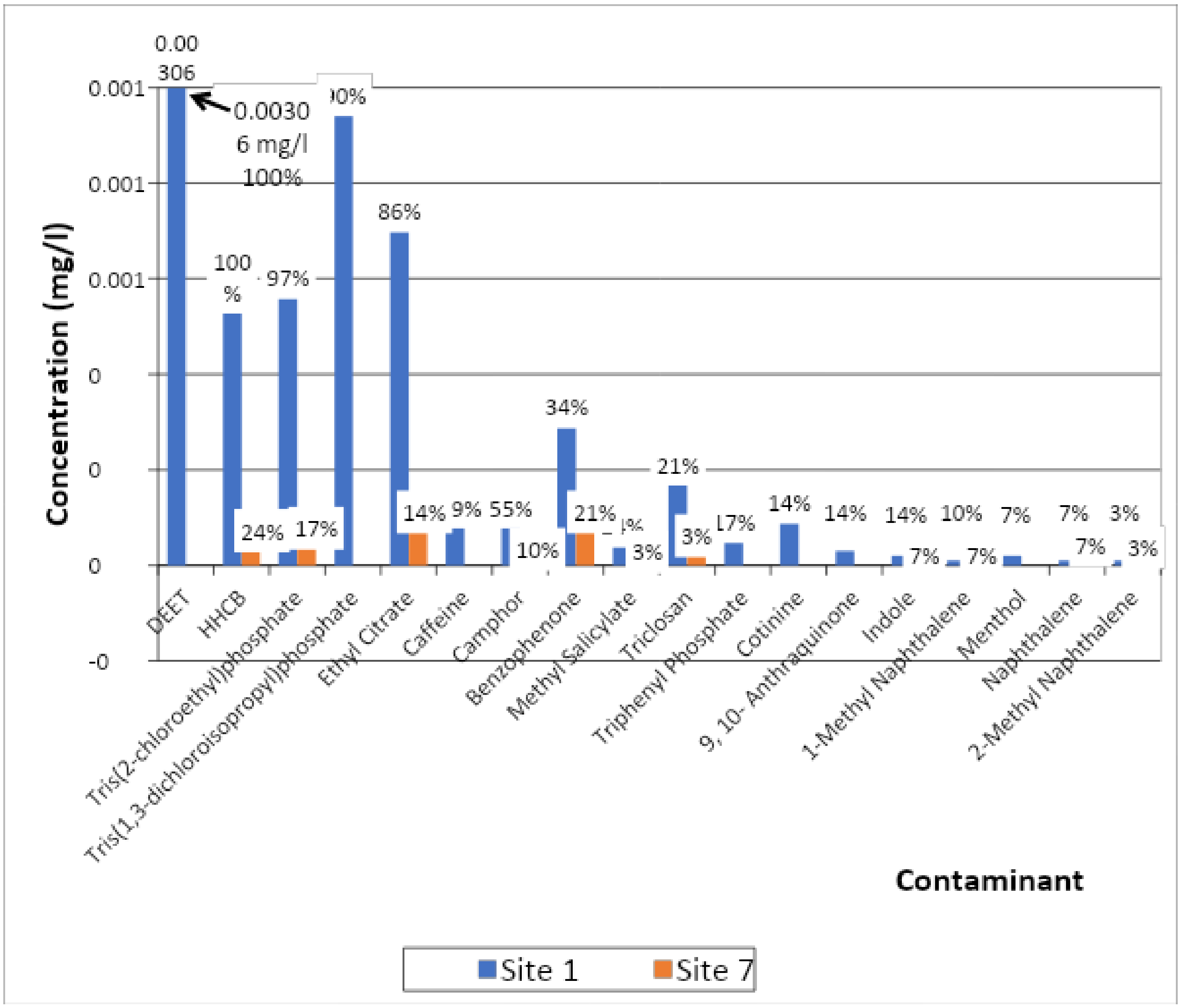

Figure 4: Most common contaminants detected from the WRF effluent, and the fully treated water that has been through the additional treatment process. From June-September 2010. (Source: [2])

Results suggest that destruction or elimination of commonly detected organic contaminants by the additional pilot plant treatment processes is significant (depicted in Figure 4). If injection of treated wastewater were to be pursued, it is likely that scaling-up these advanced treatment processes and conditioning of the injected water would occur. The next step on the way to full-scale injection would be to conduct a preliminary injection phase. One of the three to four planned wells would be dug and injected at a rate of 30-50 gpm. The level of the water table and the chemistry of the surrounding groundwater would be observed through nearby monitoring wells. However, pursuit of this preliminary testing as well as full scale injection has stalled due to concerned parties. The SMSC is concerned that the presence of a bedrock valley adjacent to their tribal land would convey a large portion of their injection volume away from the site, to be lost (Figure 5).

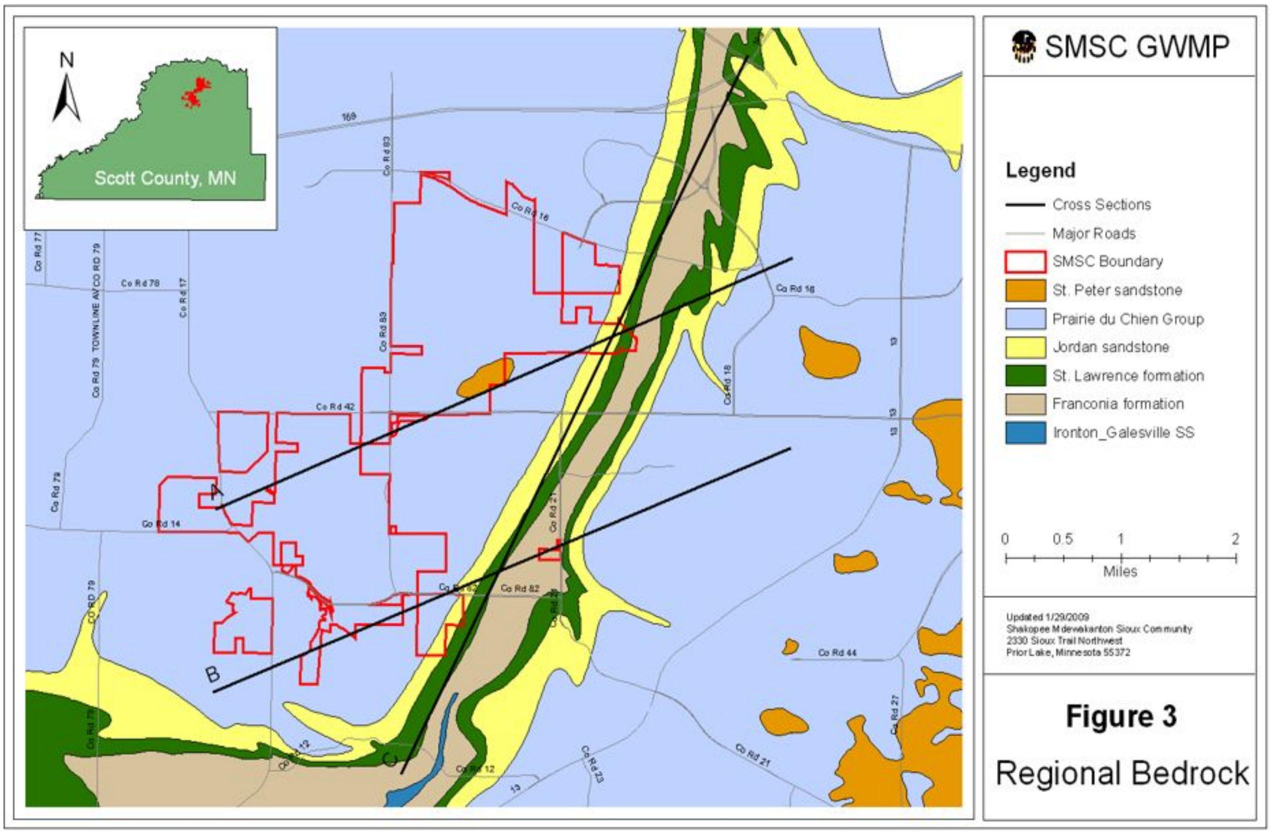

Figure 5: Regional bedrock geology in the vicinity of the SMSC (Source: [2]).

Policy Connections

The USEPA has been supportive of this project, and has expressed willingness to collaborate on the permitting and authorization process. Ultimately the USEPA is the only party that the SMSC needs approval from to move forward, but in the spirit of stewardship towards their neighbors, the Community has taken the response of other entities into account. Other governmental or municipal entities have been less amicable. The Minnesota Department of Health is interested in this project, but cautious about the potential effects associated with the migration of injected groundwater. The more local entities including Scott County and the City of Shakopee, are unconvinced about the project. Shakopee lies on the receiving end of any migration of the injected groundwater and has been vocally opposed towards implementation despite the positive results of the pilot study. On the other hand, the City of Prior Lake, which would be relatively unaffected by injection, has not expressed any opposition. They have also expressed interest in reusing effluent from the SMSC WRF if injection is not ultimately pursued.

Economic Considerations

The injection project would incur a significant cost on the SMSC for an unknown return on that investment. The Community would have to significantly upgrade their WRF, drill new wells, operate these new wells, and continuously monitor the local groundwater. While significant drawdown of the Prairie du Chien-Jordan over the next decade has been predicted, this drawdown will not threaten the availability of adequate drinking water for the SMSC.

Future Projections

The SMSC states on their website that the groundwater injection project is still being considered. While implementation may not occur in the near future, the SMSC displayed positive results from their pilot study, and demonstrated a possible method. They are also willing to share their findings with others who may be interested in these types of resource conservation projects. Ultimately, with time, research, and education, the SMSC feels that injection is possible.

References

1. *Minnesota's Groundwater: Is our use sustainable?* Freshwater Society, 2013.
2. Olmanson, Ole. *Aquifer Recharge on the Shakopee Mdewakanton Sioux Reservation: A Pilot Project in Minnesota*. 2016.
3. O. Olmanson (Personal Communication, October 5th, 2019.
4. "SMSC Land." *Shakopee Mdewakanton Sioux Community*, 2020, shakopeedakota.org/land/water-reclamation-facility/