**Manitoba Clean Environment Commission**
**Hearing for the Vivian Silica Sand Extraction Project (Project)**

**Sio Silica Corporation (SSC) Responses to Information Requests (IRs) Round No. 1**

**IR Number:** **RMSF-IR-001**

**Submitted by:** Rural Municipality of Springfield

**Date Submitted:** November 16, 2022

**Subject Matter:** Groundwater

**Reference:** AECOM, 2021a: CanWhite Sands Corp.: Vivian Sand Extraction Project Environmental Act Proposal, July 23, 2021, Section 4.1.4.

AECOM, 2021b: CanWhite Sands Corp.: Vivian Sand Extraction Project Environmental Act Proposal, Appendix A: Vivian Sand Extraction Project – Hydrogeology and Geochemistry Assessment Report, July 2021, Figure 1.3.

**Request:**

a) It is indicated that groundwater in the vicinity of the Project is obtained from Red River Carbonate Formation and the Winnipeg Sandstone Formation. It is subsequently indicated that "It is also a significant source of groundwater supply for municipal, industrial, rural residential and agricultural uses".

   Please explain in terms of magnitude and number of users how the Sandstone Formation and also the Carbonate Formation is a source of groundwater supply in the Project area.

b) Figure 1-3 of the Hydrogeology and Geochemistry Assessment Report illustrates there are 17 existing users in the Winnipeg Shale within the Regional Project Area.

   i. Please confirm that the Winnipeg Shale is capable of supporting private water supplies.

   ii. Please provide greater detail how users in the project area depend on groundwater derived from the Winnipeg Shale.

**Response:**

a) Existing groundwater use is described in Section 1.3 of the Hydrogeology and Geochemistry Assessment Report (AECOM 2021). Based on Groundwater Information Network (GIN) data, a total of 1,612 wells are within the Regional Project Area. Of the 1,612 wells, the majority of water wells (93%) are licensed for domestic use. This information was also presented on Figure 1-4 of the Hydrogeology and Geochemistry Assessment Report. As described in Section 1.4, "*groundwater is used primarily for domestic purposes, but also supports other uses. Among the total number of wells within the Regional Project Area, 1,505 water wells are licenced for domestic use, 22 for air conditioning, three (3) for industrial use, two (2) for irrigation use, 54 for livestock watering use, three (3) for municipal water supply and five (5) for other uses*". Within the Project Site Area, an estimated 19 wells are completed in the Winnipeg Sandstone aquifer, with a further 62 wells completed in the Red River Carbonate aquifer. Five wells are completed in the overburden aquifer.

Significant licensed users of groundwater within the model domain are summarized in Table 6-A of the Hydrogeology and Geochemistry Assessment.

b) Information on existing groundwater users was derived from the GIN database. The geological information derived from borehole and water supply well logs was used to construct a three-dimensional geological model that included the Quaternary Sediments, Red River Carbonate, Winnipeg Shale, Winnipeg Sandstone and the Lower Shale / Precambrian Bedrock. Each groundwater well was assigned to a hydrostratigraphic unit based on the reported screen interval, reported well depth or reported borehole depth. Screen intervals were not available for all wells. Further, well databases are known to contain information that may not be accurate or is out of date. It is possible that some wells were incorrectly assigned to the Winnipeg Shale, but that cannot be verified without detailed information on screen intervals, well yield and geology in some cases. This is a known uncertainty associated with work completed to date and is best addressed by completing site-specific well surveys in advance of any groundwater or sand extraction activities.

   i. It is AECOM's view that the shale is not likely to provide sufficient water to support private water supplies. As shown in Table 5-1 of the Hydrogeology and Geochemistry Assessment Report, the hydraulic conductivity of the Winnipeg Shale unit ranged from $1.0 \times 10^{-13}$ to $2.8 \times 10^{-8}$ m/s. Materials in the shale were logged as fine-grained and had weathered to clay in some locations, supporting the assumed low permeability. The Winnipeg Shale is therefore considered to behave as an aquitard and is not likely to meet the needs of typical private water supplies (>25,000 L/day). Further, the shale is relatively thin and separates two aquifers that are much more permeable and thick, making them better groundwater supply targets.

   ii. Groundwater users do not likely rely on groundwater derived from the Winnipeg Shale. Refer to the response above.

**IR Number:** **RMSF-IR-002**

**Submitted by:** Rural Municipality of Springfield

**Date Submitted:** November 16, 2022

**Subject Matter:** Groundwater

**Reference:** AECOM, 2021b: CanWhite Sands Corp.: Vivian Sand Extraction Project Environmental Act Proposal, Appendix A: Vivian Sand Extraction Project – Hydrogeology and Geochemistry Assessment Report, July 2021, Page 22.

**Request:**

1) On Page 22 of the Hydrogeology and Geochemistry Assessment Report, it is suggested that water extracted from the slurry will be passed through an ultraviolet treatment system prior to being re-injected.

   a. Are there plans to include filtration of the water prior to the water passing through the ultraviolet (UV) lamps to control the effectiveness of the UV process?

   b. If filtration is to be incorporated into the process, how will the accumulated solids ("overs") be managed?

**Response:**

1)

   a. Yes, Sio plans to include filtration of the water prior to the water passing through the UV system. This is required to ensure UV lamp effectiveness.

   b. Solids will be managed by first a filter press to remove excess water. Damp fines will be stored in an enclosed tankage before they are taken away from the site. The fines are largely kaolinite clay material and are therefore a salable material to industries such as paper, porcelain, paint, cement filler, cosmetics, medical and others. Sio therefore intends to sell the fines to one of these industries.

**IR Number:** **RMSF-IR-003**

**Submitted by:** Rural Municipality of Springfield

**Date Submitted:** November 16, 2022

**Subject Matter:** Groundwater

**Reference:** AECOM, 2021a: CanWhite Sands Corp.: Vivian Sand Extraction Project Environmental Act Proposal, July 23, 2021, Page 67.

**Request:** It is indicated on Page 67 of the Environmental Act Proposal that the effects of mining are reversible (i.e., the aquifer will recharge over time).

a) With respect to the Red River Carbonate Formation, how much of this conclusion is dependent on the properties of the fine-grained materials that overlie the top of this rock formation?

b) With respect to the Winnipeg Formation, how much of the predicted recovery (i.e., the aquifer will recharge over time) from mining is dependent on the properties of the overlying Winnipeg Shale?

c) To what degree are the predicted recoveries of the Red River Carbonate Formation and the Winnipeg Formation controlled by the recharge in areas where the aquifers are in direct contact with coarse-grained sediments at surface?

**Response:** a) The sensitivity of modelling results and recovery to the properties of the fine-grained materials that overlie the Red River Carbonate was not directly evaluated. Groundwater extraction is from the Winnipeg Sandstone, which is relatively permeable and separated from the fine-grained surficial materials by the Winnipeg Shale aquitard and Red River Carbonate aquifer. Both aquifers are relatively permeable and connected to a known significant source of recharge below the Sandilands Glaciofluvial Complex. Further, other research suggests that recharge through coarse-grained deposits is more important than recharge through the fine-grained deposits. As noted in Section 5.8 of the Hydrogeology and Geochemistry Assessment Report:

"*Previous studies have found that the majority of groundwater recharge in southeastern Manitoba is derived from infiltration through the relatively coarse textured deposits of the Sandilands Interlobate Moraine, Birds Hill Glaciofluvial Complex and localized esker deposits (Betcher 1986; Kennedy 2002; Wang et al. 2008). Recharge rates in the Sandilands area have been found to range from 1.4 x 10-9 m/s (37 mm/year) to 5.5 x 10-9 m/s (504 mm/year) using tritium and chlorofluorocarbon dating methods (Cherry 2000). Ferguson (2004) estimated recharge rates using thermal modelling techniques and found them to range from 1.2 x 10-9 m/s (44 mm/year) to 1.6 x 10-8 m/s (173 mm/year).*

*Wang et al. (2008) estimated that the total lateral recharge from the Sandilands Area to be 1,863,000 m3/year, which was estimated to be 7.2% of the estimated groundwater usage at the time and location of the study in 2008. This led to the conclusion that vertical recharge throughout the remainder of*

*the flow system was of greater importance than it was previously thought to be.*

*Except for the Birds Hill Complex, the remainder of the area is covered by glacial till and glaciolacustrine deposits that exhibit lower permeability. Kennedy (2002) developed and calibrated a regional numerical groundwater model of a portion of the study area. Recharge in the Interlake and Birds Hill regions was implemented as a fitting parameter in the model, and results reported to be 1.0 x 10-8 m/s (315 mm/year) for the Birds Hill Complex, and 2.0 x 10-10 m/s (6 mm/year) for the Interlake region*"

The conclusions of this assessment are thought to be relatively insensitive to material properties of the fine-grained materials, but this could be further evaluated as part of future modelling updates.

b) The sensitivity of modelling results and recovery of water levels in the Winnipeg Sandstone to the properties of the Winnipeg Shale that overlies the Winnipeg Sandstone was partially evaluated through scenario analysis (Table 6-1) and sensitivity analysis (Table 6-2). Results show that simulated drawdown for the base case simulation was 7.5 m, and when the hydraulic conductivity of the shale was decreased and increased by 10 times, the drawdown was simulated to be 7.6 m and 7.8 m, respectively. Overall, this indicates that modelling results and recovery rates for the Winnipeg Shale are relatively insensitive to the hydraulic conductivity of the Winnipeg Shale. The influence of variable hydraulic conductivity of the shale on recovery rates could be further evaluated as part of future modelling updates.

c) The sensitivity of the predicted recoveries in the Red River Carbonate Formation and the Winnipeg Formation to recharge in areas where the aquifers are in direct contact with coarse-grained sediments at surface was not directly evaluated. As noted in response a), other research suggests that recharge through coarse-grained deposits is an important source of recharge, but they are likely most important to the overburden aquifers and Red River Carbonate aquifer. Recharge to the underlying Winnipeg Sandstone aquifer is likely derived primarily from lateral recharge from the Sandilands Glaciofluvial Complex due to its depth and the presence of at least two relatively extensive low permeability units (i.e. fine-grained unconsolidated deposits and Winnipeg Shale) and an overlying permeable and laterally extensive aquifer. The influence of simulated recovery rates to recharge through coarse grained units could be further evaluated as part of future modelling updates.

**IR Number:** **RMSF-IR-004**

**Submitted by:** Rural Municipality of Springfield

**Date Submitted:** November 16, 2022

**Subject Matter:** Details on Proposed Project Operations: Groundwater Flow Rates

**Reference:** AECOM, 2021b: CanWhite Sands Corp.: Vivian Sand Extraction Project Environmental Act Proposal, Appendix A: Vivian Sand Extraction Project – Hydrogeology and Geochemistry Assessment Report, July 2021, Page 22 and Figure 6.7.

**Request:** In the predictive simulations as illustrated in Figure 6.7, during each year's simulated operating period the cumulative pumping is 550 US gallons per minute (gpm) (2,998 m3/day). However, on Page 22 it is indicated that each well will produce from 262 m3/day to 654 m3/day, up to a combined production rate of 2,943 m3/day.

a) Please reconcile the difference in these flow rates and indicate which values should be interpreted as more precise.

b) Do the flow rates described in both Figure 6.7 and on Page 22 imply that between 5 and 11 wells are operating at the same time?

c) Since each typical well cluster contains 7 wells, please confirm that there may be instances where the pumping flow rate will be substantially less than 2,943 m3/day.

**Response:**

a) As described in Section 2.3 and Section 2.4 of the Hydrogeology and Geochemistry Assessment Report, each well cluster will consist of seven wells, installed sequentially and each well will operate for approximately four days at a variable rate ranging from 262 m3/day to 654 m3/day. Wells will have variable production rates over the extraction period and the overall average combined production rate is expected to be 2,943 m3/day. A slightly higher pumping rate of 2,998 m3/day was utilized for the purposes of numerical modelling, which is conservative and very similar to 2,943 m3/day. The 50% reinjection scenario is more representative of planned operations. Assigned pumping rates for each well cluster during numerical modelling were tabulated in Appendix H of the Hydrogeology and Geochemistry Assessment Report. As noted in other IRs (DLN-IR-009 and MSSAC-IR-12), the well configuration and number of wells will be revised downward following the updated geotechnical model.

b) Figure 6-7 (0% reinjection) and Figure 6-8 (50% reinjection) illustrate drawdown at several observation points within the study area in response to operation of extraction wells. The figure does not intend to represent water levels in pumping wells, but rather illustrates the spatial and temporal drawdown effects at ten static observation locations (Figure 6-6) as extraction activities progress as shown on Figure 6-5. Assigned pumping rates for each well cluster during numerical modelling were tabulated in Appendix H of the Hydrogeology and Geochemistry Assessment Report. The table includes the "Production Start Day" and "Production End Day" which defines when each

well cluster will be operational. Up to seven wells may be operating at any given time at variable pumping rates totalling 1,526 m3/day (50% reinjection) or 2,998 m3/day (0% reinjection). The cumulative pumping rate from each cluster will be variable over time as wells are cycled on and off, and as pumping rates at each well are varied to optimize the sand extraction process. Wells within an individual cluster will not be started and stopped at the same time. As noted above, the well configuration and number of wells will be revised downward following the updated geotechnical model. Since the filing of the Extraction Project EAP, new efficiencies have been realized that reduce the number of wells required to produce the same amount of sand which has the potential to reduce the overall volume of water and pumping rate. The pumping rates and well configuration presented and assessed in the Hydrogeology and Geochemistry Assessment Report remain conservative with respect to anticipated refinements.

c) Yes, there may be instances where the pumping rate is substantially less than 2,943 m3/day for reasons explained in response b) above.

**IR Number:** **RMSF-IR-005**

**Submitted by:** Rural Municipality of Springfield

**Date Submitted:** November 16, 2022

**Subject Matter:** Details on Proposed Project Operations: Groundwater Flow Rates

**Reference:** AECOM, 2021b: CanWhite Sands Corp.: Vivian Sand Extraction Project Environmental Act Proposal, Appendix A: Vivian Sand Extraction Project – Hydrogeology and Geochemistry Assessment Report, July 2021, Page 22 and Figure 6.7.

**Request:** In the predictive simulations as illustrated in Figure 6.7, during each year's simulated operating period the cumulative pumping is 550 US gallons per minute (gpm) (2,998 m3/day).

a) Please confirm that during the pumping operational period, treated pumped water may be re-injected into wells in the same cluster during the same time.

b) If treated pumped water is re-injected into the same well cluster at the same time as extracting water, please indicate the expected rates at which treated water is to be re-injected and also the net groundwater withdrawal rate during normal operations.

**Response:**

a) Yes, treated water will be re-injected into operating wells in each well cluster or a neighbouring well cluster. As long as the well is operating water can be gravity fed and re-injected into the Winnipeg Sandstone aquifer.

b) As described in Section 6.10.1 Methods of the Hydrogeology and Geochemistry Assessment Report, several operational scenarios were simulated using the groundwater model. For clarity, the volume of slurry (sand and water) pumped from the aquifer represents 100% of the volume extracted. Based on operational monitoring during pilot extraction events, an estimated 50% of that volume will be solids (sand) and the remaining 50% will be groundwater.

The planned 100% reinjection scenario represents a scenario where nearly all of the extracted groundwater is reinjected. Only the small volume of residual moisture held in the sand (~10 US gpm) is not reinjected. In this scenario, 1,499 m3/day (275 US gpm) of sand is mined and therefore cannot be reinjected. The planned 100% reinjection scenario includes reinjection of all available groundwater (1,499 m3/day or 275 US gpm) less 54 m3/day (10 US gpm), resulting in a reinjection rate of approximately 1,445 m3/day (265 US gpm) as summarized for each well cluster in Appendix H. Therefore, the net extraction rate includes 1,499 m3/day (275 US gpm) of sand and 54 m3/day (~10 US gpm) of groundwater, for a total of approximately 1,553 m3/day (285 US gpm) of sand and groundwater.

A conservative 0% reinjection scenario was simulated to evaluate a highly conservative scenario where no water is reinjected (i.e., both sand and water are removed from the aquifer without any reinjection). The conservative 0% reinjection scenario simulated a reinjection rate of 0 m3/day (0 US gpm). For

this scenario, a total of 2,998 m3/day (550 US gpm) of sand and groundwater would be extracted. The 0% re-injection scenario is highly conservative and was considered in the groundwater model to understand the maximum impact of operational activities on water quantity in both aquifers. In reality, all groundwater except for residual moisture content in the sand will be re-injected into the Winnipeg Sandstone aquifer.

The overall effect of lower net withdrawal rates associated with the planned 100% reinjection scenario is a reduction in the depth and spatial and depth extent of drawdown cones and shortened water level recovery times. Pilot testing has demonstrated that reinjection of essentially all groundwater extracted with the sand slurry is feasible.

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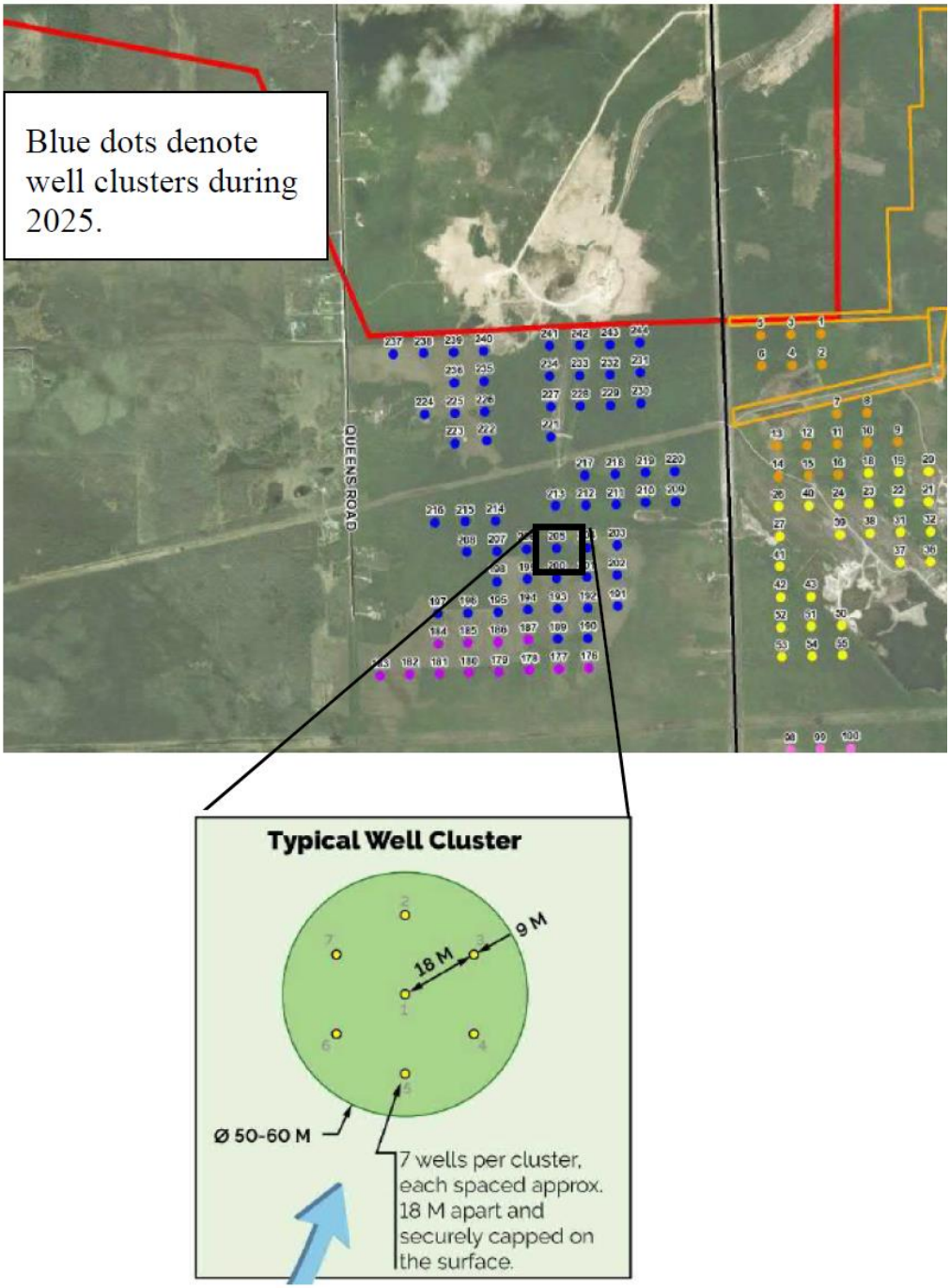
| **IR Number:** | **RMSF-IR-006** |
| **Submitted by:** | Rural Municipality of Springfield |
| **Date Submitted:** | November 16, 2022 |
| **Subject Matter:** | Details on Proposed Project Operations |
| **Reference:** | AECOM, 2021b: CanWhite Sands Corp.: Vivian Sand Extraction Project Environmental Act Proposal, Appendix A: Vivian Sand Extraction Project – Hydrogeology and Geochemistry Assessment Report, July 2021, Page 22 and Figure 2-B. |
| **Request:** | It is indicated on Page 22 that extraction wells within each cluster will be located "approximately 22 m apart". However, in Figure 2-B the conceptual layout of a typical well cluster indicates that the wells will be spaced 18 m apart.<br>a) Please confirm which of these two references is more accurate.<br>b) Please provide the most current designed well spacing in metres within a typical cluster at the present time. |




**Response:**

a) At the time of filing, both the text in Section 2.3 of the Hydrogeology and Geochemistry Assessment Report and Figure 2-B should have reflected a well spacing of 18 m as is shown on the Figure 2-B. As previously stated in the response to RMSF-IR-004, since the filing of the Extraction Project EAP, new efficiencies have been realized that may allow for a reduction in the number

of wells required to produce the same amount of sand which has the potential to increase the distance between wells, reduce the overall volume of extracted groundwater and reduce the sand and groundwater extraction rate. The sand and groundwater extraction rate of 2,998 m3/day (550 US gpm) as represented in the Hydrogeology and Geochemistry Assessment Report remains conservative.

b) The most current well spacing at the time of EAP filing was 18 m between wells in each cluster as shown on Figure 2-B of the Hydrogeology and Geochemistry Assessment Report. Since the EAP filing the geotechnical model that formed the basis of the well cluster design has been updated, and the updated model was filed with the responses to public comments on January 14, 2022 in Attachment A. The confidential version of the model was also filed with the Approvals Branch and the CEC. Additionally, additional operational efficiencies have been identified that will serve to reduce the overall number of wells needed to extract the required volume of sand.

   The cluster configuration will be redesigned to follow the new geotechnical model. A project update letter will be filed with this new configuration prior to the CEC hearing. The geotechnical model predicts that if the extraction disturbance is limited to the allowable dimensions provided in the geotechnical review report, the intact sub-horizontally layered limestone in the caprock will provide sufficient support for the overlying strata.

**IR Number:** **RMSF-IR-007**

**Submitted by:** Rural Municipality of Springfield

**Date Submitted:** November 16, 2022

**Subject Matter:** Details on Proposed Project Operations

**Reference:** AECOM, 2021b: CanWhite Sands Corp.: Vivian Sand Extraction Project Environmental Act Proposal, Appendix A: Vivian Sand Extraction Project – Hydrogeology and Geochemistry Assessment Report, July 2021, Page 19 and Figure A-2.

**Request:** It is indicated on Page 19 that material is anticipated to be extracted from the Winnipeg Sandstone Formation from an approximate depth of 51 m to 76 m. However, the conceptual illustration in Figure A-2 suggests that the Winnipeg Shale lies at a depth of 51 m to 54 m.

a) Please clarify whether the anticipated depth that material is to be extracted from the Winnipeg Sandstone Formation will be at least 54 m.

b) Please describe how the depth of material extraction may change within the Project area.

**Response:**

a) As noted in the title, Figure 2-A is a "Conceptual Illustration of Silica Sand Extraction Method", and it is based on measurements taken from one borehole log at a specific location for illustration purposes only. As shown on Figure 5-4 of the Hydrogeology and Geochemistry Assessment, the interpolated sedimentary bedrock strata (Red River Carbonate, Winnipeg Shale, Winnipeg Sandstone, etc.) dip to the west. As shown on Figure 5-7, the Winnipeg Shale is variably thick, and the interpolated top of the Winnipeg Sandstone varies from approximately 240 m asl to 180 masl across the Project Site Area based on available water well logs. As shown on Figure 5-8, the base of the Winnipeg Sandstone ranges from approximately 200 masl to 160 masl within the Project Site Area. The target formation is the Winnipeg Sandstone, and the majority of the material will be obtained from that geological unit, with the elevation of the top and bottom of the extraction zone determined based on local geological conditions and the elevation of the interface with overlying and underlying strata. As shown on Figure 5-8, the thickness of the Winnipeg Sandstone is between 20 m and 25 m across the Project Site Area.

b) See the response to RMSF-IR-007(a) for estimated depth to the top and bottom of the Winnipeg Sandstone across the Project Site Area. The Winnipeg Sandstone dips to the west and the top and bottom of the unit become progressively deeper. Therefore, extraction wells and the depth of material extraction will be progressively deeper from east to west across the Project Area. Local-scale heterogeneity may also locally require refinement to extraction depths to a lesser degree.

**IR Number:** **RMSF-IR-008**

**Submitted by:** Rural Municipality of Springfield

**Date Submitted:** November 16, 2022

**Subject Matter:** Details on Proposed Project Operations

**Reference:** AECOM, 2021a: CanWhite Sands Corp.: Vivian Sand Extraction Project Environmental Act Proposal, July 23, 2021, Page vi and Figure 1-1.

**Request:** It is indicated that through 2025, approximately 0.18% of the silica sand resource will removed and that over the full 24-year lifespan of the project approximately 1.06% of the silica sand will be removed.

a) Given the precise nature of these values, please explain how these results were determined.

b) In determining these values, please describe how the anticipated volumes of material extracted, the Project area and interpreted thickness of the Winnipeg formation contribute to the calculated percentage of silica sand to be removed.

**Response:** a) It should be noted that dates were provided when the EAP was originally filed assuming extraction to commence in 2021. This is no longer the case, so "year numbers" are now being used such as, year 1, year 2, etc.

In years 0 - 4 with year 0-1 being an initial ramp up time with potential up to 1,176,000 tonnes to a targeted final yearly tonnage of 1,360,000 tonnes, as described in section 2.2.2. of the EAP. This would equate to an approximate total of 5,628,000 tonnes of sand for the proposed 4 year timeline of the EAP.

Sio Silica has been granted mineral claims over a large area of the Winnipeg Sandstone that was estimated in 2019 to contain 3,202 Mt of sand in-place in the Bru area of Sio's minerals claims which includes the 24 year mine life area. 5.628 Mt is approximately 0.18% of the total in-place sand associated with Sio's mineral claims.

The same calculation can be done for the total 24 year mine life, with 1,360,000 tonnes of sand produced per year for 24 years which is equal to 1.06%.

This can be further calculated to include the 24 year mine life over 100% of the mineral claims associated with Sio which is estimated at 10.577 billion tonnes of sand. The 24 year mine life would equate to approximately 0.31% of the overall claims currently allocated under Sio.

Of note, there are also many areas where Sio does not have any mineral claims, so the total volume of in-place sand estimated is only a portion of what physically exists. Please refer to Figure 1-1 for a map of all Sio claims in the Bru area in **Appendix A**.

b) Total in-place values were estimated based on publicly available data, and Sio's exploration and extraction well drilling program. Upwards of 30 wells have been drilled for sampling and formation characterization and analysis in the

area. This data was utilized in the Stantec resource model to determine the in-place sand for all Sio mineral claims.

**IR Number:** **RMSF-IR-009**

**Submitted by:** Rural Municipality of Springfield

**Date Submitted:** November 16, 2022

**Subject Matter:** Details on Proposed Project Operations

**Reference:** AECOM, 2021a: CanWhite Sands Corp.: Vivian Sand Extraction Project Environmental Act Proposal, July 23, 2021, Page 15.

**Request:** It is understood that the slurry removed from each well during operations will be drained, the extracted water then filtered and then made available for re-injection.

a) Please provide details how the approximate rate of approximately 10 US gallons per minute of water to be removed with the sand was determined.

**Response:**

a) An estimated water loss of 54 m3/day (10 US gpm) was initially estimated by Sio Silica staff based on flow monitoring and laboratory testing conducted during field trials. During development of the groundwater model, AECOM undertook an assessment to determine a reasonable value for use in the groundwater model as described below. The planned slurry extraction rate is 2,998 m3/day, of which 1,499 m3/day is expected to be sand, and the remaining 1,499 m3/day is expected to be groundwater. The sand will be conveyed to a mechanical separation and processing plant, where the sand will be allowed to drain through gravity drainage at a minimum, which would allow the moisture content of the sand to reduce to residual moisture contents. Literature review of typical residual moisture content values for sand range from less than 1% to approximately 5%. Clean washed sand is likely to have a relatively low residual moisture content as the clay sized materials will be removed during washing. A loss of 10 US gpm equates to a residual moisture content of approximately 3.6% which was judged to be reasonable in the context of literature values. Therefore, the value of 54 m3/day (10 US gpm) was adopted as the volume of water that was retained by the sand, and hence unavailable for reinjection. Process improvements may allow for refinement of these values over time.

**IR Number:** **RMSF-IR-010**

**Submitted by:** Rural Municipality of Springfield

**Date Submitted:** November 16, 2022

**Subject Matter:** Details on Proposed Project Operations

**Reference:** AECOM, 2021a: CanWhite Sands Corp.: Vivian Sand Extraction Project Environmental Act Proposal, July 23, 2021, Figure 2-3.

**Request:** It is indicated that extraction of the silica sand will result in the development of horizontal arrays of rooms and pillars in the Winnipeg Sandstone.

a) Please articulate how the extraction process will result in a defined room and pillar arrangement.

b) Please provide estimated dimensions of the rooms and pillars within the well cluster arrangement that are expected to be developed from the extraction process.

c) Please explain how the shear strength of the sandstone within the Winnipeg Formation may be affected by the extraction process.

d) Please estimate the probability of collapse of the overlying strata as a result of the extraction process and the perceived consequence of such an event.

**Response:**

a) The extraction process will be carried out by drilling wells which when sand is extracted, generate voids in the sandstone. These wells are drilled in clusters which can be thought of as rooms. Clusters are offset from one another and sufficient space (pillars) between clusters have been investigated and designed to allow sufficient beams over rooms and sufficient distance between pillars to achieve stable conditions.

b) While immediately after each well's drilling pillars might exist between individual extraction wells in each cluster, these pillars are expected to settle out shortly after extraction completion leaving a larger combined void. The dimension of the resulting "room" depends on the number of wells in each well's cluster. The well numbers and spacing in each cluster will be arranged to follow the allowable extraction disturbance zone dimensions provided in Table 9 of the Geotechnical report.

c) The shear strength of the sandstone within the Winnipeg formation will be locally affected by the extraction process as the process will liberate the sand and generate a void in the immediate area. Sonar surveys indicate that immediately and shortly after extraction, Sandstone remains competent, standing up at angles greater than 65 degrees. Over time it is expected that sandstone immediately adjacent to open voids will partially slough into the open void and settle to a 31 degree angle of repose. This strength reduction is expected to be reduced with distance from the void. Most loss of strength is understood to occur in the immediate area of each well cluster with minimal affects beyond the area.

d) Some collapse of the overlying strata may occur but collapse is expected to be limited and to not spread to the surface. Extraction well clusters have been

designed to reduce the probability of collapse and to further limit the impact of collapse to little to no subsidence in the immediate area of the extraction voids and to no subsidence beyond the immediate area of the extraction voids.

See also the response to MSSAC -IR-009.

**IR Number:** **RMSF-IR-011**

**Submitted by:** Rural Municipality of Springfield

**Date Submitted:** November 16, 2022

**Subject Matter:** Site Characterization

**Reference:** AECOM, 2021b: CanWhite Sands Corp.: Vivian Sand Extraction Project Environmental Act Proposal, Appendix A: Vivian Sand Extraction Project – Hydrogeology and Geochemistry Assessment Report, July 2021, Figures 1-4, 3-1, 3-2 and 3-4.

**Request:** A relatively large number of wells in the vicinity of Bru 95-7 are shown in Figure 1-4 and Figure 3-1. However, referring to Figure 3-2, it appears that only two of these wells were monitored during the pumping test (Obs 23901 and Obs 66124). It is understood that both of these wells are open in the Red River Carbonate Formation.

a) Please confirm that Obs 23901 and Obs 66124 were the only two "off-site" wells that were equipped with data loggers during the Bru 95-7 pumping test.

b) Referring to Figure 3-4, the drawdown at a well marked "unknown" is indicated. Please describe in detail how water levels in this well were monitored during the pumping test.

**Response:** a) The monitoring network for the constant rate pumping test is shown in Table 3-B of the Hydrogeology and Geochemistry Assessment Report. It included a pumping well, four vibrating wire piezometers at a radial distance of 89.3 m from pumping well, three nested monitoring wells at a radial distance of 338 m from the pumping well, two additional nested monitoring wells a radial distance of 1,211 m from the pumping well, and three domestic wells at radial distances of 491 to 960 m from the pumping well. Of those wells, six were competed in the Red River Carbonate, two were completed in the Winnipeg Shale, and four monitoring wells were completed in the Winnipeg Sandstone. Pressure transducers were installed in one pumping well and 12 monitoring wells, including three domestic wells (Obs 23901, Obs 66124 and Unknown Well Obs S1).

b) Water levels in Unknown Well Obs S1 (screened in Winnipeg Sandstone) were monitored using both manual methods and a pressure transducer. As described in Section 3.6 of the Hydrogeology and Geochemistry Assessment Report, the well was outfitted with a Solinst Levelogger pressure transducer lowered to a known depth within the well and affixed using nylon string. The pressure transducer was programmed to start before the pumping test, and monitoring continued beyond the end of the pumping test. Water level measurements were recorded by the pressure transducer at a frequency of one measurement per 30 seconds. Many groundwater level measurements were also periodically collected to support data validation. A barometric pressure transducer was also installed and programmed to record barometric pressure fluctuations over the duration of testing. This data was utilized to correct the water level measurements collected by all other pressure transducers for barometric pressure fluctuations. Although not described in the text, the well is

operated as a geoexchange well that utilizes groundwater as a source of heat and/or cooling for the associated residence. This is evident based on the cyclic low amplitude increases and decreases in water levels throughout over the duration of monitoring. As shown on Figure 3-2, air temperatures were near or below zero degrees Celsius for the majority of the test, supporting the need for heating and geoexchange well use.

**IR Number:** **RMSF-IR-012**

**Submitted by:** Rural Municipality of Springfield

**Date Submitted:** November 16, 2022

**Subject Matter:** Site Characterization

**Reference:** AECOM, 2021b: CanWhite Sands Corp.: Vivian Sand Extraction Project Environmental Act Proposal, Appendix A: Vivian Sand Extraction Project – Hydrogeology and Geochemistry Assessment Report, July 2021.

**Request:** It is understood that vibrating wire piezometers were installed in grouted-in borehole Bru 95-8.

a) Please describe what measures were undertaken to ensure that these piezometers provided reliable data prior to and after final installation.

**Response:**

a) The vibrating wire piezometers were installed by hydrogeologists that have significant experience working with VWPs and similar instrumentation to depths approaching 1,000 m. They are familiar with calibration and installation protocols and have received training and mentoring from the manufacturer on several occasions over the past 15 to 20 years. The instruments are factory calibrated near Maple Ridge, British Columbia, and were shipped overland in boxes with the instruments protected in foam and bubble wrap. Upon arrival, the instruments were inspected by trained personnel and confirmed to be in good condition. As described in Method Section 3.4.4 of the Hydrogeology and Geochemistry Assessment, "*Prior to installation, VWP sensor membranes were saturated by submerging them in a pail of water for more than 24 hours in an inverted position. Once saturated, initial readings were taken with no load applied immediately before installation. These initial readings were used to apply correction factors to the post-installation readings*".

   As part of this exercise, the instrument is typically raised and lowered within a water-filled vessel to confirm it is able to capture changes in the measured hydraulic head that are consistent with the range of movement of the sensor. During installation, "*VWP sensors were secured to one-inch diameter Schedule 80 PVC tremmie pipe and lowered into the borehole until the target depth was reached*". Combined with the subsequent geodetic survey of each borehole, this allowed for determination of the elevation of the sensor. Care was taken to avoid over pressuring the sensors during grouting of each borehole following industry-standard methods. "*The four VWP cables were connected to the DT2055B multichannel datalogger furnished by RST Instruments and programed to record data at 30 second intervals.*" Following installation, the equations in each datalogger were validated against information provided in calibration sheets from the manufacturer, and the pressure measurements were converted to geodetic groundwater elevations. The resultant groundwater elevations were compared to those observed in the borehole prior to installation of VWPs and in nearby wells and at the resultant groundwater elevations were judged to be reasonable. VWP installation records and RST calibration records were also provided in Appendix D of the Hydrogeology and Geochemistry Assessment.

**IR Number:** **RMSF-IR-013**

**Submitted by:** Rural Municipality of Springfield

**Date Submitted:** November 16, 2022

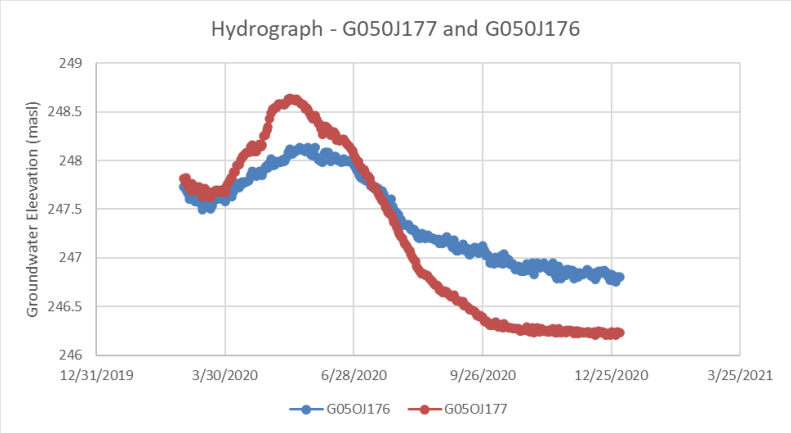
**Subject Matter:** Site Characterization

**Reference:** AECOM, 2021b: CanWhite Sands Corp.: Vivian Sand Extraction Project Environmental Act Proposal, Appendix A: Vivian Sand Extraction Project – Hydrogeology and Geochemistry Assessment Report, July 2021, Table 5-B.

**Request:** It is understood that hydrograph data should be available for Province of Manitoba wells G050J177 and G050J176. Hydrographs do not appear to be illustrated in Table 5-B.

a) Please provide hydrograph data for Province of Manitoba wells G050J177 and G050J176 for the specified illustration time in Table 5-B.

**Response:** a) The hydrographs for Manitoba wells G050J177 and G050J176 were omitted from the report because the wells are outside the Project Site Area. See below.



**IR Number:** **RMSF-IR-014**

**Submitted by:** Rural Municipality of Springfield

**Date Submitted:** November 16, 2022

**Subject Matter:** Groundwater Modelling: Clarification of Calibrated Aquifer Properties

**Reference:** AECOM, 2021b: CanWhite Sands Corp.: Vivian Sand Extraction Project Environmental Act Proposal, Appendix A: Vivian Sand Extraction Project – Hydrogeology and Geochemistry Assessment Report, July 2021, Section 6.9.3 and Figure 5-4.

**Request:**

a) In reference to Figure 5-4, the Lower Shale/Precambrian Bedrock is represented with a model layer that extends to an elevation of 0.0 m (i.e., mean sea level). The model layer is assigned a hydraulic conductivity that is 7 orders of magnitude less than the overlying Winnipeg Sandstone.

   i. What data were available to constrain the assignment of the hydraulic conductivity of the Lower Shale/Precambrian bedrock?

   ii. Are the model results sensitive to the hydraulic conductivity assigned to this model layer?

b) In reference to Section 6.9.3 on the presentation of calibrated aquifer properties:

   i. How were the vertical hydraulic conductivities assigned? Was a vertical anisotropy ratio arrived at or was a ratio of 1:10 simply assumed?

   ii. Are the model results sensitive to the vertical hydraulic conductivities?

   iii. What data were considered when assigning the values of specific storage to the various units?

   iv. Are the model results sensitive to the specified values of specific storage?

**Response:**

a)

i. Within the Project Site Area, there is very limited information available to characterize the Lower Shale/Precambrian Bedrock. As shown in Table 5-1 of the Hydrogeology and Geochemistry Assessment Report and discussed in detail in Section 5.7, the calibrated hydraulic conductivity of the Lower Shale / Precambrian was $1.2 \times 10^{-12}$ m/s, which is within the range of values reported in Freeze and Cherry (1979) for shale. A singular test in a monitoring well installed in the Winnipeg Shale as part of this investigation reported a hydraulic conductivity of $2.8 \times 10^{-8}$ m/s. The authors of this report have conducted extensive permeability testing in igneous and metamorphic rocks of the Canadian Shield outside of this study area and found that it can range from approximately $10^{-5}$ m/s for very shallow subaearially exposed weathered bedrock to on the order of $10^{-12}$ m/s for deeply buried fresh bedrock under significant confining pressure. It is acknowledged that the hydraulic properties of these very deep units are poorly constrained, but they are not likely important to the conclusions and recommendations of the Hydrogeology and Geochemistry Assessment

given their depth and likely low permeability in comparison to the overlying units.

ii. A sensitivity analysis for vertical hydraulic conductivity of the Lower Shale/Precambrian Bedrock was not conducted. Although not explicitly evaluated by the numerical groundwater model, modelling results are not likely sensitive to reasonable values of hydraulic conductivity assigned to the Lower Shale / Precambrian aquifer.

The shale and underlying bedrock typically have a relatively low hydraulic conductivity and the anisotropy in sedimentary units such as shale that often results in a higher horizontal hydraulic conductivity than vertical hydraulic conductivity. This is likely to minimize the upward flux to the Winnipeg Sandstone.

b)

i. As discussed in Section 6.9.3 and presented in Table 6-C of the Hydrogeology and Geochemistry Assessment Report, the hydraulic properties of each layer are anisotropic. Similar to the work of Kennedy (2002) and others, an assumed anisotropy ratio of 10H:1V was assigned to the majority of hydrostratigraphic units, owing to their sedimentary depositional history. Only one unit (Red River Carbonate) utilized isotropic hydraulic properties and the resultant hydraulic conductivity value and anisotropy ratio was determined through calibration.

ii. A sensitivity analysis explicitly evaluating the effect of vertical hydraulic conductivity of hydrostratigraphic units was not conducted. However, as shown in Table 6-2 of the Hydrogeology and Geochemistry Assessment Report, an extensive sensitivity analysis that investigated both horizontal and vertical hydraulic conductivity together was investigated. In AECOM's opinion, modelling results are not likely sensitive to the vertical hydraulic conductivity of the Winnipeg Sandstone but are likely sensitive to the vertical hydraulic conductivity of the glacial sediments and the Winnipeg Shale as illustrated through scenario analyses presented in Table 6-1. The vertical hydraulic conductivity of the Winnipeg Shale will have the greatest impact on the relative proportion of groundwater derived from the Winnipeg Sandstone versus the overlying Red River Carbonate. Changes would not likely affect the overall volume of water removed from the aquifer system but would affect the spatial extent and magnitude of drawdown in each aquifer, with both positive and negative impacts.

iii. As indicated in Section 6.8, of the Hydrogeology and Geochemistry Assessment Report, the specific storage, hydraulic conductivity, recharge rates were calibrated to 72-hour pumping test data to generate an acceptable match between simulated and observed transient groundwater levels. The calibration exercise was informed by the extensive body of literature reporting aquifer properties as shown in Table 5-1 of the Hydrogeology and Geochemistry Assessment Report.

iv. A sensitivity analysis of specific storage was not conducted as part of this assessment, but results are relatively well constrained by literature values and the range of reported values is relatively small.

**IR Number:** **RMSF-IR-015**

**Submitted by:** Rural Municipality of Springfield

**Date Submitted:** November 16, 2022

**Subject Matter:** Impact Assessment: Impact of Re-injection of Water on Predictive Scenarios.

**Reference:** AECOM, 2021b: CanWhite Sands Corp.: Vivian Sand Extraction Project Environmental Act Proposal, Appendix A: Vivian Sand Extraction Project – Hydrogeology and Geochemistry Assessment Report, July 2021.

**Request:** Further clarification is requested on how the re-injection of water is handled in the analyses of predictive scenarios reported.

a) For the case of 0% re-injection, is the pumped water simply removed from the model, or is it assigned as increased recharge either within or beyond the limits of the groundwater flow model?

b) For the case of 50% re-injection, is the re-injection assumed to occur at the same location as the extraction and also within the Winnipeg Sandstone?

c) Assuming the re-injection occurs at the same location as the extraction and also within the Winnipeg Sandstone, within the model, is the specified pumping rate from the equivalent well at the center of a cluster assigned a pumping rate of 550 US gallons per minute/2 = 280 US gallons per minute?

d) As per 3) above, if the specified pumping rate assigned is not 280 US gallons per minute, please provide the specified rate used.

**Response:**

a) The water is removed from the model.

b) The re-injection of water is not explicitly simulated by the model. Rather, the effective pumping rates were adjusted downward to simulate the net effect of pumping of sand and groundwater, and reinjection of surplus groundwater. Also refer to the response to RMSF-IR-005.

c) Please refer to the response to RMSF-IR-005. The pumping rates assigned to each well cluster during operations are presented in Appendix H of the Hydrogeology and Geochemistry Assessment Report and range from 1,444 m3/day (265 US gpm) to 1,499 m3/day (275 US gpm) for the scenario involving reinjection of all surplus groundwater. The difference is the result of water retained in the sand as residual moisture.

d) See Response c).

**IR Number:** **RMSF-IR-016**

**Submitted by:** Rural Municipality of Springfield

**Date Submitted:** November 16, 2022

**Subject Matter:** Impact Assessment: Predictive Scenarios.

**Reference:** AECOM, 2021b: CanWhite Sands Corp.: Vivian Sand Extraction Project Environmental Act Proposal, Appendix A: Vivian Sand Extraction Project – Hydrogeology and Geochemistry Assessment Report, July 2021, Page 74 and Figures 6-7 and 6-8.

**Request:** The report identifies that the predictions shown in Figure 6-7 correspond to Scenario 4 (p. 74) and that the predictions shown in Figure 6-8 correspond to Scenario 5. However, the same pumping histories are shown in Figures 6-7 and 6-8.

a) Please explain the rationale for similar pumping histories in these two scenarios rather than an expectation that the pumping rate in Figure 6-8 be at 50% of 550 US gallons per minute illustrated in Figure 6-7.

**Response:**

a) The pumping history shown on Figure 6-8 does not reflect the pumping history simulated by Scenario 5. This graph should reflect pumping rates that follow a similar temporal pattern to those shown, but vary in magnitude from approximately 280 US gpm to 0 US gpm seasonally as illustrated in Appendix H of the Hydrogeology and Geochemistry Assessment Report.

**IR Number:** **RMSF-IR-017**

**Submitted by:** Rural Municipality of Springfield

**Date Submitted:** November 16, 2022

**Subject Matter:** Impact Assessment: Predictive Scenarios.

**Reference:** AECOM, 2021b: CanWhite Sands Corp.: Vivian Sand Extraction Project Environmental Act Proposal, Appendix A: Vivian Sand Extraction Project – Hydrogeology and Geochemistry Assessment Report, July 2021, Figures 6-7 to 6-13.

**Request:** Synchronizing the pumping histories presented in Figures 6-7 and 6-8 with the maps of predicted drawdowns (Figures 6-9 to 6-13), it appears that a key result is that water levels recover completely relatively soon after the yearly pumping ends. For example, for 2021 pumping ends on about Day 60 (since 2021/09/01) and no drawdowns are predicted for Days 90 or 180 (pumping resumes in 2022, at about Day 210).

a) Based on these results, please confirm that the effects of mining are assumed to have no effect on the properties of the Winnipeg Sandstone, either during or after pumping.

For Scenarios 4 and 5, it is interpreted that the mining will degrade the Winnipeg Shale, such that its hydraulic conductivity changes to that assigned for the Winnipeg Sandstone.

b) Based on these results, how large of an area of the Winnipeg Shale is anticipated to be degraded each year?

c) Is the anticipated degradation of the Winnipeg Shale expected to be permanent, such that the area of degradation expands progressively between Figures 6-9 and 6-13?

**Response:** a) Please refer to the Responses to the Technical Expert Reports – Hydrogeology, filed November 29, 2022, issue #3:

*"The project proposes to remove a very small proportion of the overall volume of sand in the Winnipeg Sandstone aquifer and will leave residual water-filled voids where the sand has been extracted. It is understood that this will increase the overall storativity of the aquifer as the effective porosity of the water-filled void will be 100%. Between the voids, the sandstone aquifer will not be disturbed by mining and will remain intact. Local hydrogeological properties (e.g., hydraulic conductivity and storativity) will be quite variable depending on whether measurements are collected within a water-filled void or within the intact aquifer between the voids. However, the scale of the project is regional, and the response of the aquifer to sand removal will be governed by regional aquifer properties as measured at the scale of the Representative Elementary Volume (REV), as the source of recharge is from both surface and distal inputs near the Sandilands Complex east of the project. Reasonable efforts were undertaken to simulate the effects of sand extraction and groundwater reinjection on the aquifer and adjacent well users. Similar to other conventional*

*underground mining projects, it is not possible to directly measure the magnitude of any change in aquifer properties prior to completion of mining. The numerical groundwater model developed for this assessment implemented time-variant changes in hydraulic properties around the production wells, in an effort to simulate the response of the aquifer to sand extraction. The cessation of pumping over winter months was simulated to allow groundwater elevations to recover each year. In recognition of the uncertainty associated with any modelling efforts, a Groundwater Monitoring and Mitigation Plan will be developed and implemented to monitor groundwater levels and quality before, during and after mining to verify modelling results and ensure groundwater users are protected. Protocols will be established to survey existing domestic wells in advance of operations, monitor groundwater quantity and quality during and following project operations, and respond if there are any well owner complaints. Mitigation measures will be developed to avoid and/or mitigate any well interference issues, as required by The Water Rights Act. Mitigations may include lowering of pumps, provision of alternate water supply or adjustment of operations. Findings will be reported to the community on a regular basis."*

b) Please refer to the Responses to the Technical Expert Reports – Hydrogeology, filed November 29, 2022, issue #6. For Scenarios 4 and 5, hydraulic connection between the overlying Red River Carbonate increased by assigning the aquifer properties of the Winnipeg Shale to those of the Winnipeg Sandstone within 200 m of production wells. This would result in an estimated area of 188 ha (Year 0) to 691 ha (Years 1 through 4) with the potential for degradation of the Winnipeg Shale based on the simplified assumptions taken during groundwater modelling.

c) Correct, for Scenarios 4 and 5, the model simulates the progressive expansion of the area of shale degradation between Figures 6-9 and 6-13. After the sand is mined from the Winnipeg Sandstone, Scenarios 4 and 5 assumed that the overlying Winnipeg Shale will degrade, and the hydraulic properties will be permanently changed.

**IR Number:** **RMSF-IR-018**

**Submitted by:** Rural Municipality of Springfield

**Date Submitted:** November 16, 2022

**Subject Matter:** Impact Assessment: Predictive Scenarios.

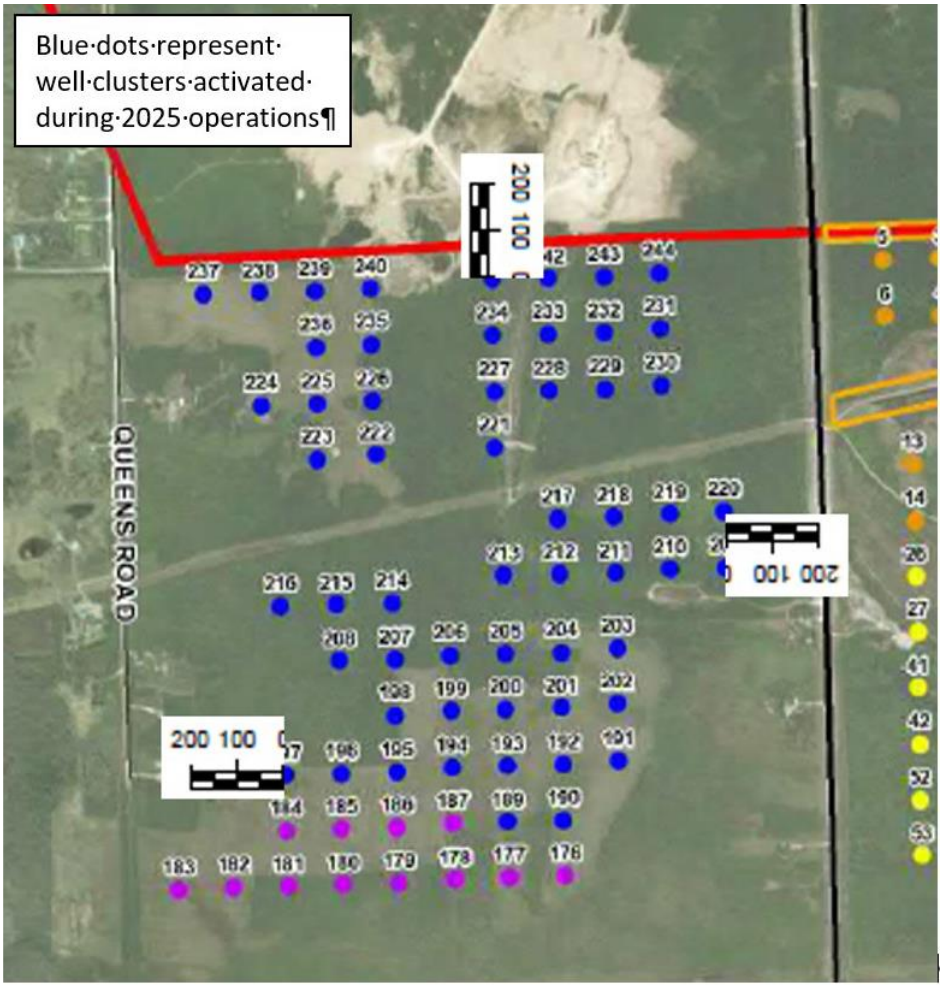
**Reference:** AECOM, 2021b: CanWhite Sands Corp.: Vivian Sand Extraction Project Environmental Act Proposal, Appendix A: Vivian Sand Extraction Project – Hydrogeology and Geochemistry Assessment Report, July 2021, Figure 6-5.

**Request:**

a) With respect to the simulation of shale degradation, how has the radial extent of the degradation zone (200 m around a production well) been estimated?

b) As the center of production shifts over time, is the degraded shale zone expected to expand or simply shift?

c) Referring to the excerpt below (taken from Figure 6-5 of the July 2021 Hydrogeology and Geochemistry Assessment Report), is the extent of the degraded shale assumed to extend to the limits of the 2025 wells plus 200 m?



**Response:**

a) The radial extent of the degradation zone was estimated by hydrogeologists at the time of model development, which was in advance of completion of geotechnical modelling. Extraction well clusters are spaced less than 200 m apart, and the result is an assumed area of shale degradation that extends across the footprint of extraction activities each year, and beyond that footprint a radial distance of 200 m. Modelling results are likely relatively insensitive to this assumption unless the radius is reduced to distances lower than one half the distance between extraction well clusters.

   It is important to note that this was a simulation to determine potential effects and not necessarily an expected result. Table 9 of the Geotechnical Analysis for Sio Silica Extraction Project establishes the maximum allowable spans for each extraction cavity and was included in the responses to public comments for the Extraction EAP. It is anticipated that the extents of shale degradation will be similar to the extent of each extraction cavity, which ranges from 14 m to 40 m. Sio Silica will be adhering to this design and these parameters as set out in Table 9 by Stantec.

b) The degraded shale zone is assumed to progressively expand over time. This assumption will be validated during operations.

c) Yes, that is correct. See Response a) for additional detail.