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

Sio Silica Corporation (SSC) Responses to MSSAC KGS Expert Review Report on Items for Discussion
February 13, 2023 CEC Submissions for Vivian Silica Sand Extraction Project

February 20, 2023

Sio Silica has reviewed the submission made by MSSAC from KGS and would like to provide the following response.

1.0 Geotechnical Void Space Stability

In reference to Section 1.0 Geotechnical Void Space Stability of the KGS report Sio provides the following comments:

1.1 Fundamental Concern of how the limestone caprock will bridge the void space and support overlying weight of overburden

The overburden is supported either by the strength of the caprock and/or by cantilevering of caprock beams. Details of the mechanism by which the limestone will bridge the void and support the overburden is described in the geotechnical assessment report. Stantec completed site investigations and laboratory testing to collect area specific information on the thickness, structure and competence of the limestone caprock to inform the geotechnical design basis. Potential failure modes were identified, and numerical modelling and other assessment was carried out to identify stable void space/limestone caprock/overburden configurations. The results were reviewed and confirmed as reasonable and aligned with accepted engineering standards by Stantec internal reviewers, third party independent reviewers, and CEC expert reviewers.

1.2 Connectivity of adjacent wells within the same well cluster

The current design considers the potential that wells within the same well cluster may connect and create a larger disturbed zone. The geotechnical stability analysis identified the maximum allowable disturbed zone that the combined wells in a cluster are allowed to develop. This is the basis for the variation in wells per cluster from 1 to 5. Well clusters are distanced from each other to prevent interconnection between the adjacent well clusters.

1.3 Input parameters to models (bedrock cohesion and GSI)

The design GSI value is based on geotechnical logging data from 5 boreholes within Sio's mineral claims area. The limestone's compressive and tensile strengths are based on laboratory tensile and compression tests and field tests (Point Load Tests) data. The sandstone cohesion is back-calculated based on the sonar data which showed sandstone stability in the cavity after extraction.

1.4 Extraction limits and limestone thickness

Although areas with thinner limestone exist in the general site, Sio is limiting extraction to areas with a minimum competent limestone thickness of 15 m. Based upon geotechnical logs and the geological model that identifies limestone thicknesses ranging from 10 to 48m, a 15 m thickness was

selected as the minimum to provide the required factor of safety for the void size shown in Table 9 of the geotechnical report. The Stantec geotechnical model used more than 1420 water well logs, 46 Sio Silica geological boreholes, 7 geotechnical boreholes, 1 ATV/OTV borehole and 2 side scan sonar borehole results to develop the limestone and overburden thickness recommendations for the extraction area. Stantec recommended, as a design requirement, to limit extraction to areas with competent limestone thicker than 15m.

1.5 Bedding planes, cross joints, and other vertical jointing and fracturing

Acoustic and Optical televiewer (ATV/OTV) scans and geotechnical borehole logs to-date show that although cross joints are located at the upper and lower zones of limestone (in contact with till and shale, respectively) the main portion of the limestone is horizontally bedded and is predominantly unfractured. Sio Silica will also be advancing several angled boreholes to allow for completion of downhole ATV/OTV surveys that will enable better characterization of subvertical fracturing and possible refinement of the geotechnical stability model based on the results of the surveys. Depending on the results of these surveys, Sio may make minor refinements to the geotechnical model and extraction plan.

1.6 Vertical drill holes cannot detect vertical joints

Although no angled/inclined boreholes have been drilled to date, the vertical boreholes have not shown continuous vertical joints in the massive part of the limestone, which indicates that if vertical jointing is present, joint spacing may be high and the continuity of jointing may be low. Sio Silica will also be advancing several angled boreholes to allow for completion of downhole ATV/OTV surveys that will enable better characterization of subvertical fracturing and possible refinement of the geotechnical stability model based on the results of the surveys. Depending on the results of these surveys, Sio may make minor refinements to the geotechnical model and extraction plan.

1.7 Bedding plane thickness in the area

Although the upper and lower fractured portion of the limestone may include tightly spaced bedding and joints, the geotechnical stability excluded those zones from the stability analysis. The ATV/OTV data showed bedding thicknesses in the range of 0.6 to 0.8 m in the massive part of the limestone. Similar thicknesses were also observed in the geotechnical borehole logging. An average bedding thickness of 0.7m was used for the competent limestone in the geotechnical analysis.

1.8 Basis for new Extraction Plan

Following the issuance of the updated geotechnical model recommendations (Table 9), Sio Silica initiated an update to the geological model. This entailed a drilling program over the summer and early fall of 2022 to infill additional data and refine the model. Following the update of the geological model Sio developed a new extraction plan which applied the constraints from the geotechnical model (Table 9), new tonnage values from the most recent extraction testing and related efficiencies gained since. Placement of clusters and the number of wells per cluster were based on the geological model and the geotechnical constraints. The new Extraction plan was provided to Stantec for review and approval. In Sio's development of the Extraction plan, consideration was also given to placement of clusters based on minimum offsets from homes, other wells, roads and utilities as well as previously disturbed land where possible.

1.9 Well Abandonment

Sio intends to abandon wells as soon as possible following extraction. A timeline of up to a year is noted in the Progressive Well Abandonment Plan in case of a need for additional monitoring for some extraction wells, or a delay in access to the wells. In most cases wells will be abandoned within a week to two weeks of extraction.

There is no current plan to backfill voids. The void space will be filled with groundwater and a portion of disturbed sand as seen on the sonar image. The groundwater will be primarily derived from re-injected groundwater and the Winnipeg Sandstone Aquifer. The geotechnical model assumes no backfilling of the void space occurs and is designed for the worst-case scenario. Critical assessments such as degradation of tensile strength, increase in cavity radius and seismic loading were assessed for 100 years. The long-term cavity radius was defined as stable for 50 to 100 years.

1.10 Commitment to Additional Testing

As Sio has stated before, the new Extraction Plan allows for commencement of extraction with one to two well clusters. These extraction cluster sizes have already been proven by single and two well cluster testing. Sio has also committed to additional extraction testing for three to five well clusters upon issuance of licence. A plan will be developed for a full monitoring program of the testing for both geotechnical and hydrogeological parameters. These results will be shared with the regulator.

1.11 TARP development

Sio Silica agrees that a robust Trigger Action Response Plan (TARP) is required and Sio is committed to the development of a TARP system as per Stantec's recommendations.

As a point of clarification, at the time of submission of an EAP, applicants are not required to have completed their monitoring plans.

This issue was previously addressed in the EAP and in Sio's Vivian Sand Extraction Project (File# 6119.00) - Environment Act Proposal Review Responses to the Public table submitted to Manitoba Conservation and Climate, Environmental Approvals on January 14, 2022, and posted on the Public Registry on January 25, 2022. Please refer to Sio's response to Key Issue / Question # 234 in the Responses to the Public which includes the following:

> *"It is best and common practice for mitigation and monitoring plans, and operating procedures, to be prepared in association with or on completion of detailed design of the Project, and for these plans to be reviewed and updated periodically. In this manner, continual environmental planning is built into both the commencement and on-going operation of the Project, and environmental management reflects current operational, legislative and permitting requirements.*
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> *Thus, it is essential that such plans and operating procedures be handled as 'living documents' to ensure that they will be subject to ongoing and periodic revisions to capture operational refinements that are acquired through experience, monitoring and inspection, compliance review, equipment upgrades, and follow-up assessments. Plans and procedures will also be reviewed and revised when there are any changes to licensing and permitting conditions, applicable legislation, or roles and responsibilities within Sio. Maintaining current plans and*

procedures will allow for continuous operational improvement and further protection of the environment. Where required revisions to these documents will be prepared with the cooperation of the applicable regulatory authority and will be provided for regulator review."

Final versions will be completed during the final design stage of the Project and prior to operations commencing. They will incorporate any applicable conditions in the Environment Act License and any other authorizations, permits and approvals issued for the Project.

1.12 Means and method to re-stabilize underground void space should subsidence or settlement occur beyond allowable threshold

Sio has always had a zero-tolerance policy for subsidence since the commencement of the project. Therefore, the geotechnical assessment has been designed so that no subsidence is expected as a result of this Project. All ground settlement monitoring to date supports the results of the modelling: there has been little/no settlement measured at the ground surface and the design utilizes a very conservative approach of an applied factor of safety of 2.0, which is considered conservative.

2.0 Groundwater Well Extraction Operations

In reference to Section 2.0 Geotechnical Void Space Stability of the KGS report Sio provides the following comments:
It is agreed that the net aquifer groundwater loss will have important implications on the long-term sustainability of the water supply. This was the basis for the in-field hydrogeological testing and numerical groundwater modelling conducted as part of the Hydrogeology and Geochemistry Assessment. During operations, it will be important to monitor water levels and the volume of water extracted from, and re-injected to, the aquifers to ensure water use is within regulated limits, and that private water wells are protected. The Groundwater Monitoring and Mitigation Plan and TARP will ensure appropriate responses to unforeseen observations and protection of groundwater users. It is agreed that aquifer recharge occurs on an annual basis with peak water levels typically observed in the spring/summer, but there does not appear to be a significant lag in groundwater level response to significant recharge events due to the presence of coarse and relatively permeable materials underlying the primary recharge area for both aquifers comprising the Sandilands Glaciofluvial Complex. It is agreed that seasonal and interannual variability in meteoric inputs (i.e. recharge) to the groundwater flow system will be important to monitor. The TARP will allow for detection of unacceptable impacts to groundwater wells and direct appropriate responses whether induced by natural variability or anthropogenic activities. The well extraction process has been demonstrated to allow for simultaneous sand extraction and reinjection of groundwater.

Based on the adjusted extraction footprint and feedback received during IRs, the groundwater model has been updated to reflect the revised net groundwater extraction rate. Based on recent updates to the Extraction Plan and water/material balance, the net loss from the aquifer is presently estimated to be approximately 15% of the volume of sand extracted during mining, with the goal of further reducing the consumptive use of water over time with operational improvements. The purpose of the Groundwater Monitoring and Mitigation Plan is to both monitor the response of the system to project operations and direct responses to avoid impacts to groundwater resources and well owners. If

unacceptable impacts are detected, they will be mitigated to avoid impacts to 3rd party well owners. The Groundwater Monitoring and Mitigation Plan includes completion of annual Water Well Inventory to ensure all wells are identified and monitored during operations with the goal of avoiding any unacceptable impacts.

3.0 Groundwater – Water Quality and Water Levels

With reference to the Groundwater Monitoring and Mitigation Plan, KGS summarized that: "*the Project will not contaminate the sandstone or carbonate aquifers, and water quality is not anticipated to be materially affected by Project operations*", and stated: "*From our perspective, while the referred to monitoring and impact mitigation plan requires careful review, fundamentally based on geology and geotechnical perspectives it is not apparent how this can be maintained and achieved, when it is apparent that the shale aquitard separating the two aquifers will be unsupported and collapse into the top of the sand extraction zone void within each sandstone production well cluster, resulting in enhanced and multiple direct interconnections of the aquifers*". As described in the Hydrogeology and Geochemistry Assessment, water quality is fresh in the Red River Carbonate and Winnipeg Sandstone aquifers within the project area. The groundwater gradients between the two wells are near zero to slightly downward and there is therefore very little hydraulic head driving exchange of waters between the two aquifers at present. This is anticipated to persist into the future following project operations. Despite more then 1000 reported wells interconnecting the two aquifers across the regional study area (Wang,J., 2008), the only reported water quality impacts occur in the Red River Carbonate Aquifer closer to the Red River. In that area, upwelling of saline water from the Winnipeg Sandstone Aquifer under historically strong upward groundwater gradients resulted in salination of the overlying Red River Carbonate in proximity to the interconnected wells. Even if the groundwater from the aquifers is mixed, water quality modelling suggested the resultant chemistry will reflect conservative mixing of the two waters with similar or slightly better water quality.

With reference to the re-injection of groundwater following filtration and UV treatment, KGS summarized that: "*It will be important to explore this during the CEC process and revising SIO groundwater quality modeling predictions. There may be benefit, for example, to look at water quality treatment for some metals*". It is agreed that water treatment is an important mitigation measure that Sio plans to utilize in an abundance of caution. Sio has no intention to re-inject any water or substances other than the produced, filtered and UV treated water that came from the Winnipeg Sandstone Aquifer during extraction operations. Sio will employ stringent monitoring of re-injected water to ensure that water quality is maintained. As the system is enclosed, controlled and not combined with any other processes, the likelihood and source of any contamination is extremely limited. If any contamination is found, re-injection would be shut down until the issue can be resolved. Because the volume of water extracted during operations will be relatively small, and the quantity of water in the Winnipeg Sandstone Aquifer is relatively large, treatment of extracted groundwater for naturally occurring metals (e.g. iron, manganese, etc.) is not likely to materially change water quality in the aquifers in the long term. Iron, manganese and other metals are derived from dissolution of natural minerals in the aquifer that would likely redissolve following reinjection of treated groundwater until dynamic geochemincal equilibrium conditions are restored.

With reference to seasonal variability in groundwater recharge, KGS noted: "*While the SIO operations are proposed to be seasonal, this lag time response for recharge, should there be a series of wetter than average, or drier than average years (in terms of aquifer recharge) could have an enhanced overall effect on the aquifer resource. It will be important to discuss what this may look like for long term aquifer water levels with SIO operations if there are a series of dry years back to back and what this may mean for regional water levels, and for any needs to adjust trigger levels within the groundwater monitoring and mitigation plan*". It is agreed that variability in precipitation, evapotranspiration and groundwater recharge is an important consideration for regional water management planning and management. However, it should be noted that Integrated Watershed Management Planning (IWMP) and the regulation of groundwater use is the responsibility of the Government of Manitoba, not Sio Silica. The outcomes of IWMP can be leveraged into Groundwater Monitoring and Mitigation Plans, and the underlying Trigger Action Response Plans (TARPs) as warranted.

Reference:
Wang, J., Betcher, R.N., and G.C. Phipps, 2008. Groundwater Resource Evaluation in Southeastern Manitoba. Conference proceedings of GeoEdmonton'08: 61st Canadian Geotechnical Conference and 9th Joint CGS/IAH-CNC Groundwater Conference, September 21-24, 2008, Edmonton, Canada.

4.0 Groundwater Monitoring and Mitigation Plan

With reference to the Draft Groundwater Monitoring and Mitigation Plan and the proposed Water Well Inventory, KGS stated: "*All of these activities as described in the Groundwater Monitoring and Mitigation Plan are critical and must be included in SIO's project work, prior to sand extraction/production operations. Specifics regarding the numbers of wells to be visited and characterized is not included, and likely will come from the results of the desktop study. There should be a commitment based on a percentage basis (or otherwise) in terms of how many wells will be measured, detailed, and sampled as part of the baseline. The number of wells with detailed data gathering must be representative of the total number of potentially affected 3rd party well users*". For clarity, Sio intends to make attempts to contact every well owner (i.e. 100%) within the anticipated zone of influence of operations to document the location and condition of each well so that it can be incorporated into the Groundwater Monitoring and Mitigation Plan, and monitoring and the TARP can be implemented with full knowledge of all groundwater wells in the area. If well owners are not interested in participating in the well inventory, Sio will utilize the knowledge of the regional aquifer system and information obtained from other well owners to protect all 3rd party well owners.

With reference to the Draft Groundwater Monitoring and Mitigation Plan and the proposed groundwater monitoring network, KGS stated: "*In our opinion three to five regionally distributed additional monitoring sites should be established outside of the project estimated zone of influence (outside of the "regional" zone described in the monitoring plan) to record a baseline condition, and to record the aquifer conditions outside of the estimated project zone of influence, throughout the life of the project. This also provides some robustness in the monitoring network if the original model simulations underestimate the regional zone of influence of the project. Some of the existing Provincial long-term monitoring wells could also become part of this broader based monitoring network, as they exist with long-term data records collected to date, and data is readily available from them*". It is agreed that the regional monitoring well network should include at least three to five spatially distributed

monitoring wells. Further, as noted in the Groundwater Monitoring and Mitigation Plan, the use of some of the existing Provincial long-term monitoring wells will also be explored. It is agreed that the long-term dataset offered by many of the monitoring locations will serve as useful baseline data (e.g. Figures 5-12, 5-13 and 5-14 of the Hydrogeology and Geochemistry Assessment).

With reference to the proposed groundwater monitoring network, KGS stated: "*An instrument for measuring pressures within the shale aquitard is not described in the plan, but should be included at each of these installations. This could be done using an inverted grouted in place vibrating wire piezometer, for example*". It is agreed that this may be beneficial in proximity to operations where vertical groundwater gradients may temporarily change in response to project operations, but those gradients will respond more rapidly in instruments installed in the aquifers rather than the aquitards. There will likely be little value in vibrating wire piezometer (VWP) data at great distances from extraction wells. The Winnipeg Shale is relatively thin and it may be difficult to install vibrating wire piezometers at all monitoring locations. The VWP data from the shale maybe be more appropriate for incorporation into the geotechnical TARP.

With reference to the frequency of groundwater sampling, KGS stated: "*There is not a summary of exactly how many samples will be collected based on the final number of installed monitoring sites, which should be included specifically such that there is no uncertainty as to how often and how many groundwater quality samples will be collected and assessed for quality. The two sample events prior to operations (baseline monitoring) are unlikely to be sufficient to establish baseline water quality, and should be increased in number. The use of regional Provincial water quality records to supplement this is appropriate, but does not replace additional monitoring/sampling in the project wells to establish a baseline water quality. The other proposed schedule/frequency of groundwater quality monitoring events is in general appropriate for this type of project, and the once per month sampling within the Operational Performance Monitoring Zone is a must*". For clarity, samples will be collected from ALL monitoring wells within each of the Groundwater Monitoring Zones at the frequency specified in Table B of the Groundwater Monitoring and Mitigation Plan. It is agreed that two sampling events prior to operations may not be sufficient to establish baseline groundwater quality. The need for additional sampling will be evaluated following the collection of the second sample. Alternatively, Sio may elect to collect baseline samples at a quarterly frequency in advance of operations to expand the baseline description of water quality in areas where there is limited information. It is agreed that the regional Provincial water quality records will be useful in supplementing the dataset.

With reference to the TARP, Stages 1, 2 and 3 events and responses, it is agreed that further refinements and consideration can be given to lag in groundwater recharge and variability in meteoric parameters and groundwater recharge over time. It is agreed that contact information for the team responsible for implementing the Groundwater Monitoring and Mitigation Plan will need to be provided to 3rd Party well owners to allow them to report issues at any time of day or night, including weekends. The plan aims to avoid the need for mitigation of impacts without advanced knowledge and notice.

5.0 Waste Characterization and Management Plan

With reference to the Draft Waste Characterization and Management Plan, KGS stated: "*From our perspective, the planned laboratory testing program is appropriate for this scale of project, however a*

justification for the 1 sample testing protocol per 500 tonnes of shale produced, should be reviewed within the context of the hearing process, as it may under represent the amount of testing required, since the tonnage of shale produced within the project may vary widely".

The recommended sampling frequency for waste material for the characterization of acid rock drainage and metal leaching is 1 sample per 1,000 tonnes of waste material (MEND 2009). Confirmatory testing is generally based on less frequent sampling (1 sample per 20,000 tonnes or so, etc.). For this project, the frequency was increased to 1 per 500 tonnes or less which provides better coverage because the estimated tonnage of excavated Winnipeg Shale is estimated to be less than 700 tonnes during the first 5 years of operation. If the volume of Winnipeg Shale excavation changes, the frequency of sampling will be adjusted accordingly to meet or exceed the recommended sampling frequency by MEND (2009). Because the plan is linked to the volume of each waste material, there is no need to adjust the sampling frequency. Rather, the number of samples would increase commensurate with the volume of waste material generated.

Details on the configuration and design of engineered material containment features, material stockpiles, water management structures and associated surface water monitoring were omitted from this plan because the material will be hauled to an external licenced facility for disposal and not permanently stored at the Project site. Surface water quality monitoring will not be required to monitor the behaviour of waste as it will not be stored on site.