KGS GROUP

**Kontzamanis Graumann Smith MacMillan Inc.**
3rd Floor - 865 Waverley St
Winnipeg, MB R3T 5P4

**P** 204-896-1209
**F** 204-896-0754
**kgsgroup.com**

February 14, 2023

DD West LLP
300-305 Broadway Street
Winnipeg, Manitoba R3C 3J7

Attention: Ms. Krista Boryskavich
Senior Associate

**Re: SIO Silica Project – MSSAC Expert Review Report on Items for Discussion**

Dear Ms. Boryskavich:

KGS Group is pleased to provide our summary of items and issues that remain as items the MSSAC should bring forward for discussion during the upcoming Clean Environment Commission (CEC) hearings. This summary follows reviews of all the information compiled to date, including during the 2 rounds of Information Requests (IR's), regarding the SIO silica extraction project near Vivian, Manitoba. Please note that KGS Group has not reviewed the clean (non-redacted) version of the geotechnical analyses by SIO and their consultants.

# 1.0 GEOTECHNICAL VOIDSPACE STABILITY

Of fundamental consideration is how will the approximate 15 m to 25 m thick fractured and jointed limestone strata bridge over a potentially 32 m to 50 m wide cavern void, especially with an overlying weight of 25 m to 35 m of overburden tills and clays. Sonar data provided by SIO regarding cavity geometry formed during single well tests indicate cavity dimensions in the order of 30 m, and development of cavern roofs or crowns that encroach upon or expose the shale aquitard. Adjacent wells within clusters may result in interconnectivity between voidspaces that will increase this unsupported span length. Please also note that vertical limestone thickness in places has been reported as thin as 10 m, and is expected to vary.

Geotechnical failure modes for the upper carbonate strata assume certain thresholds for bedrock cohesion, and relatively uniform homogeneous rock masses based on the Geological Strength Index (GSI) chosen in the analysis. SIO acknowledges that the analysis is based on competent layered limestone, and that "design was based on the sequence of competent (predominantly unfractured) caprock which was found to be present." Some of the failure modes reported include some reliance on cantilever support from partially failed rock strata, and it is unclear how it was determined whether or when a failure would cease to propagate, once started.

**Kontzamanis Graumann Smith MacMillan Inc.**
3rd Floor - 865 Waverley St
Winnipeg, MB R3T 5P4

**P** 204-896-1209
**F** 204-896-0754
**kgsgroup.com**

A key item in the geotechnical modeling is the assumption of a massive competent bedrock limestone zone 15 m to 25 m in thickness, without bedding planes, cross joints, or other vertical jointing/fracturing. This competent caprock over a broad area is unlikely given the history of extensive glacial rebound in this area which would have imparted or enhanced existing vertical fracturing with the uplift stresses, along with the historical tectonic/glaciotectonic stress history, and prior paleokarst processes. It is well known and documented within scientific papers that groundwater resources developed within the carbonate bedrock strata in Manitoba are a result of aquifers comprised of interconnected zones of horizontal bedding plane partings and vertical joint sets, with enhancement by prior paleokarst processes, which allow for flow of groundwaters through this aquifer system. The carbonate strata in the region of this project are developed as a potable water aquifer.

As noted by Arcadis in their review for the Clean Environment Commission (CEC), the 10 referenced drill holes provided included only 10 to 13 m of limestone thickness plus one borehole reporting 21 m thickness, which does not support the overall assumed 15 m to 25 m of competent limestone overlying the sandstone within the region of the project. Vertical drilled boreholes, and recovered core runs, will not indicate the presence or spacing of vertical fractures or joints, unless the borehole is advanced directly into one. There is no data on the vertical joint spacing for the project. Based on typical similar bedrock within Manitoba (where observable in quarry or bedrock outcrop, for examples), minor joint spacing is often in the order of 2 m to 5 m, with regional “master joints” spaced in the order of 10 m to 10’s of m, a pattern which is repeatable spatially. Horizontal bedding plane spacing can vary from centimeters to tens of centimeters. This would mean that “plates” of discrete limestone caprock may be exposed within the developed cavern roof span, subject to displacement by gravity into a voidspace below. In the geotechnical analysis, with a single beam 7 m long, acting as a multibeam cantilever in bending failure mode to support the roof, if the vertical fracture pattern in the limestone caprock ranges in spacing less than 7 m for example, the beam failure mode is not representative and is not valid. Hence the roof will not support itself, as has been described.

All of the above has implications on the stability of the ground in general, specifically regarding stability of the shale aquitard (also a groundwater quality issue), and overall ground surface subsidence. There has been a new well cluster configuration developed by SIO and their consultants, and environmental assessment done on the new well layout, but it is not clear in communication why the layout changes were made and what were the controlling geotechnical factors which necessitated the change.

Related to this are the assumptions of the geometry of the sands within the voidspace and their angle of repose. Within the newly issued progressive well abandonment plan, these wells/clusters may sit idle for up to a year before being decommissioned, and it is not clear if the well abandonment plan will include a methodology to successfully complete backfilling the voidspaces below the production well casings. SIO has also estimated natural widening of the voidspaces with sand settlement that will increase span widths by an additional 5 m within the first 100 years, based on modeling. These changes in sand geometry in the voidspace over time can also lead to enhanced instability of the shale aquitard, and subsidence, in the longer term (i.e. over the year the wells sit idle, the sands settle, and subsidence/instability occurs; if the voidspaces are not backfilled, they will additionally expand in dimension over time).

As stated prior in our IR's it is our view that SIO should perform sand extraction on a test cluster and take all the monitoring and measurements to demonstrate how the voidspace and sands within it will behave, when producing sand from a well cluster, not a single well. SIO has since stated that "SIO has elected to start its operations at a location that allows for a reduced number of wells in a cluster, some as small as 1-2 wells. SIO will also conduct a multi-well test after the issuance of an Environment Act Licence while starting with single well production. Therefore, a ramp up period will occur with the initial phase of operations limited to smaller well clusters, where the design assumptions and Stantec's modeling will be confirmed by monitoring and minor adjustments might be required to the design. Should results of testing yield requirements for parameter changes, SIO will provide this to the Approvals Branch for review." There is no description/plan about how SIO will do this, what they will measure, and where. This is critical and should be provided for evaluation within the CEC hearing process. SIO also refers to a Trigger Action Response Plan (TARP) for subsidence that will be created – this is critical and should be provided for evaluation. It has not been shared to date, and it should include means and methods to re-stabilize underground voidspaces should subsidence or settlements occur that are beyond the allowable thresholds set in the TARP.

## 2.0 GROUNDWATER – WELL EXTRACTION OPERATIONS

Net aquifer groundwater loss from the aquifer with sand extraction operations requires some clarity. This has implication to the long-term sustainability of the aquifer water supply, and on shorter timeframes, the potential for interference with regional 3rd party well water supplies. In addition, the aquifer recharge that occurs on an annual basis to the aquifer undergoes a time lag until the recharge is measured within the aquifer water levels. 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. Overall, there is some uncertainty on how this well extraction process will actually work in practice.

In reviewing the Sio Silica Supplemental Information Document #1 Silica Extraction Method, June 2,2022, it appears the intent will be to have the outer casing grouted in place and only intruding a short distance into the underlying sandstone zone. The inner "temporary " casing with inside air return hose will be moved vertically up and down into the sandstone unit, such that return flow of water will discharge at the exit of the fixed casing (flow occurs in the annulus outside of the temporary casing, and inside the grouted in outer casing). The inside casing can be extended down deeper, such that the return flow (40 to 120 gpm) first will flow back into the formation and potentially scour sand before being drawn back up inside the temporary casing by the airlift. In the schematic it is not obvious that the inner temporary casing will be extended down below the outer fixed casing.

SIO has stated that “10 US gpm was the anticipated effective pumping rate at the time that the assessment was conducted, however this rate does vary. During operations, actual rates will be measured and documented to confirm assumptions and allow for refinements of the extraction process. The water loss is accounted for by the wet sand that will move from the extraction, be dewatered and then enter the slurry loop because the sand is not 100% dry when it moves from the wellbore to the slurry loop. Please note that the 270 US gpm and 260 US gpm referenced is per cluster, not per well. Well flow rates vary over time from approximately 40 - 120 US gpm.” Our questions remain for exploration here “Is it correct the 10 Usgpm is a net loss to the aquifer? Individual wells will be airlifted with flows estimated between 40 and 120 Usgpm, with approximately 10 Usgpm lost from the aquifer (between approximately 8 and 25% of produced water then lost from the aquifer)?” Flow rates such as these during production, and the resultant aquifer drawdown, will need to be assessed against the regional 3rd party water supply wells. This issue ties back to the recently issued groundwater monitoring and mitigation plan, as this groundwater extraction will create drawdown in the aquifer. There needs to be a well inventory completed and a robust 3rd party response plan in place in case any 3rd party loses their well water supply, or experiences a water quality change, due to SIO activities.

If in-well sand production flow rates of 40 to 120 USGPM are actual, the sand formation is likely poorly consolidated. As has been stated by prior, the void space created below surface everywhere is thus unlikely to have an angle of repose of 65 degrees, especially in the longer term when it is acknowledged by SIO that the sand angle of repose will trend toward the natural angle of repose (31 degrees). This issue is also tied back to general geotechnical stability and voidspace shape/span, and also ties back to the well abandonment plan, as these wells may sit idle for a year or more, with sand sloughing and sand voidspace geometry changes that could influence geotechnical stability, including in the long term if the voidspaces below the production well casings are not backfilled. The sonar images shared by SIO, of single well voidspaces immediately following sand production, indicate much steeper voidspace sidewalls, but these voidspace sidewall geometries may be temporary. The steeper voidspace sidewall geometries were assumed in SIO’s geotechnical stability analyses, and may not be representative, overall, and in particular over time or if an adjacent production well within the cluster encroaches on previously established voidspaces.

**Kontzamanis Graumann Smith MacMillan Inc.**
3rd Floor - 865 Waverley St
Winnipeg, MB R3T 5P4
**P** 204-896-1209
**F** 204-896-0754
**kgsgroup.com**

# 3.0 GROUNDWATER - WATER QUALITY AND WATER LEVELS

SIO has stated that "In accordance with Sio's Groundwater Monitoring and Impact Mitigation Plan, water quality in the sandstone and carbonate aquifers will be monitored before, during and following operations to confirm that water quantity and quality is preserved in both aquifers. The results will be evaluated by a professional hydrogeologist or geochemist with experience evaluating water quality, with results provided to regulatory agencies for review. In summary, the Project will not contaminate the sandstone or carbonate aquifers, and water quality is not anticipated to be materially affected by Project operations." 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.

Another related issue is the water treatment that will be done prior to re-injection of the produced water, back to the aquifer. SIO states "It should be noted that the use of UV is purely precautionary, as contamination is not expected during the sand extraction process. UV will be utilized in an abundance of caution. Based on the available technology, and the work done to date, Sio is confident that water can be effectively treated utilizing UV and filtration, and that reinjection of water into the aquifer will not cause any significant impacts to water quality. At the time of submission of an EAP, applicants are not required to have completed their detailed engineering and design." We have asked during the IR process whether there are any other water quality parameters to treat prior to reinjection? If not, what is the basis for your interpretation? 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.

SIO states that "Based on the findings of the hydrogeology and geochemical assessment, groundwater quantity will be largely preserved within the project area due to the seasonal operation of sand extraction wells and reinjection of surplus groundwater following separation of solids. Based on the results of field testing, water levels were simulated to recover relatively rapidly, with approximately 80% recovery approximately two days following the end of production at each well cluster. Groundwater levels are anticipated to return to static water level conditions approximately 20-80 days after production ceases at each well cluster." As mentioned prior, the aquifer recharge that occurs on an annual basis to the aquifer in this region of Manitoba undergoes a time lag until the recharge is measured within the aquifer water levels. 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.

# 4.0 GROUNDWATER MONITORING AND MITIGATION PLAN

This DRAFT document was received February 7th. It is a key document that will govern how the aquifer groundwater resource will be protected if SIO's project is licensed to proceed. Key items that will be required within this plan are in general covered within the document, however from the our perspective, there are areas to explore and further develop as part of the CEC process, as described below.

There is a need to perform a well inventory of the region of the project, this is a normal part of obtaining a groundwater license from the Province of Manitoba. A desktop/database inventory is planned, with a "site walkover" to perform some ground truthing of well locations. Property owners within the zone of groundwater drawdown influence will also be interviewed and intrusive measurements performed to determine specific information regarding their water well supply (i.e. pump depth setting, well specific capacity, static water levels, and available drawdown), and will also include some baseline water quality sampling. 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.

The groundwater monitoring network proposed by SIO is reasonable based on the various stages of development of the project, however it was based on groundwater model simulations. 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.

Kontzamanis Graumann
Smith MacMillan Inc.
3rd Floor - 865 Waverley St
Winnipeg, MB R3T 5P4
P 204-896-1209
F 204-896-0754
kgsgroup.com

Monitoring well installations at each proposed location are planned within the overburden, the carbonate aquifer, and within the sandstone, which is appropriate, and necessary. These installations will provide the ability to not only record groundwater levels, but also allow for groundwater sampling, which is critical. 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. Manual and automated groundwater level measurements are planned, which is appropriate. All groundwater monitoring zones described in the monitoring plan include continuous monitoring, including out to 2 to 5 years post-operations. This is important to be adhered to throughout the project.

The frequency of groundwater sampling for monitoring of water quality is also provided for each monitoring zone. 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.

The impact mitigation plan outlines the trigger levels for water levels and water quality which will result in an action to protect the aquifer systems. This is critical to the long-term care of the groundwater resource in the vicinity of the project. Stage 1 response events are classified as stable or changes that are occurring that are not unexpected. Here, there should be some development around the lag in recharge timing to the regional aquifer system, and how this may vary if there are a sequence of wetter than normal years, or drier than normal years, that may regionally impact aquifer water levels. Stage 2 events are “early warnings” where water levels or quality has diverged from the established baseline. Stage 3 responses relate to immediate risks where changes in water levels or quality require immediate attention. A Stage 3 event for water quality would be a change in quality that exceeds the applicable water quality standards applied to the project, which will be potable water/drinking water standards for this project.

Trigger levels for water levels and water quality within the carbonate and sandstone aquifers are detailed and are based on the seasonal and multi-year trends observed in the long-term Provincial monitoring wells. The rationale is reasonable. It will be important to review and possibly revise the chosen triggers and thresholds on the basis of the 3rd part well inventory work, because sensitivity to water levels and water quality variability will be likely found within the well inventory work, at individual, local wells. One other item that is missing from the mitigation plan is that there will need to be a method for a 3rd party well owner to reach the team responsible for the monitoring and mitigation plan on a 24/7/365 basis, with a protocol or team established to execute the various levels of response as necessary and as outlined in the monitoring and mitigation plan, on an as-needed basis.

# 5.0 PROGRESSIVE WELL ABANDONMENT PLAN

This DRAFT document was received February 7th. It is a key document that will govern how the aquifer groundwater resource will be protected if SIO's project is licensed to proceed, and when the various wells are finished production, and need to be abandoned/sealed to protect the aquifer resource. Key items that will be required within this plan are in general covered within the document, and are appropriately tied to the Groundwater and Water Well Act in Manitoba, and in general describes the various regulations that apply to this kind of work. However from our perspective, there are areas to explore and further develop as part of the CEC process, as described below.

There are time frames of one year where various operational wells will be awaiting final decommissioning and the potential geotechnical effects of this should be addressed relative to void space stability, as described and discussed in earlier sections of this report. In addition, it is not clear how the various voidspaces will be backfilled, if at all, as the document refers generally to the wells themselves, and not necessarily the voidspaces below.

# 6.0 WASTE CHARACTERIZATION AND MANAGEMENT PLAN

This DRAFT document was received February 7th. It is a key document that will govern how the aquifer groundwater resource will be protected if SIO's project is licensed to proceed, and outlines the Acid Rock Drainage (ARD) and Metals Leaching (ML) testing that will be performed on the various geological materials involved in SIO's proposed sand extraction project. The testing is recommended to be sure that there is an understanding about how the geological materials will behave geochemically when produced, and whether there are any risks to an adverse environmental result should there be any geochemical changes that occur with the produced materials. For example, metals testing (selenium and aluminum) were deemed important for the shale and sandstone materials, which would be an output of the ML testing. 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 he context of the hearing process,

KGS GROUP

**Kontzamanis Graumann Smith MacMillan Inc.**
3rd Floor - 865 Waverley St
Winnipeg, MB R3T 5P4

**P** 204-896-1209
**F** 204-896-0754
**kgsgroup.com**

as it may under represent the amount of testing required, since the tonnage of shale produced within the project may vary widely.

In terms of mitigation measures, the planned procedures are reasonable for the scale of the project, however some engineered containment/drainage for all material stockpile areas should be detailed as part of this plan. This allows for an additional level of environmental protection, and adds some ease in sampling effectiveness and methods for monitoring surface water runoff. The additional procedural mitigation measure of segregating and separately storing shale produced from drilling of various project boreholes will be an important mitigation component for the project to adhere to over the life of the development.

We anticipate this review and identification of key issues served the needs of the MSSAC at this time. Please contact the undersigned if you require anything further.

Prepared By:

Jason Mann, M.Sc., P.Geo. FGC
Environmental department Head and Principal

Approved By:

J. Bert Smith, M.Sc., P.Eng. FEC
Principal

# STATEMENT OF LIMITATIONS AND CONDITIONS

## Limitations

This report has been prepared for (DD West LLP) in accordance with the agreement between KGS Group and (DD West LLP) (the "Agreement"). This report represents KGS Group's professional judgment and exercising due care consistent with the preparation of similar reports. The information, data, recommendations and conclusions in this report are subject to the constraints and limitations in the Agreement and the qualifications in this report. This report must be read as a whole, and sections or parts should not be read out of context.

This report is based on information made available to KGS Group by (DD West LLP). Unless stated otherwise, KGS Group has not verified the accuracy, completeness or validity of such information, makes no representation regarding its accuracy and hereby disclaims any liability in connection therewith. KGS Group shall not be responsible for conditions/issues it was not authorized or able to investigate or which were beyond the scope of its work. The information and conclusions provided in this report apply only as they existed at the time of KGS Group's work.

## Third Party Use of Report

Any use a third party makes of this report or any reliance on or decisions made based on it, are the responsibility of such third parties. KGS Group accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions undertaken based on this report.