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

Part 1 – MSSAC IR 001 to 015 and 018

IR Number: **MSSAC-IR-001**

Submitted by: MSSAC

Date Submitted: November 8, 2022

Subject Matter: General EAP

Reference:
i) 13 September 2022 Arcadis Technical Review of Sio Silica Corporation's Environment Act Project Proposal; and

ii) 23 July 2021 Can White Sands Corp. Vivian Sand Extraction Project, Environment Act Proposal – Parts 1 and 2 (Public Registry 6119.00)

Preamble: The General EAP is deficient: Splitting the project into an initial 4 year period, when the proposed project will continue for 24 years, does not address the potential impacts of the project over the entire life of the project (Pages 8 - 10, and Arcadis Conclusion #2, Page 10).

Request:
a) Please explain in detail why the potential impacts of the entire project over 24 years was not addressed within the EAP and as part of this licensing process?

Please explain in detail what the potential impacts of the entire project over 24 years will be.

Response:
a) Refer to the Public Comments responses key issue/response 185 filed January 14, 2022:

"The extraction method at this time is proven and repeatable as tests have been conducted and successfully carried out. Separating the Project into 4-5 year groupings, with Notices of Alteration to be filed as needed, will allow for improvements in methodology as well as any changes in environmental impact that might arise from relocating the specific sites of extraction activities. Improvements could include, for example, potential efficiencies in the extraction method to reduce the overall number of wells needed per year. Additionally, land ownership and uses do change over time, and therefore site selection for a full 24 years would not be efficient or appropriate."

Also refer to Responses to the Technical Expert Reports – Geotechnical, filed November 29, 2022 issue 3.

b) Please see the response to MSSAC-IR-001(a).

IR Number: **MSSAC-IR-002**

Submitted by: MSSAC

Date Submitted: November 8, 2022

Subject Matter: General EAP

Reference:

i) 13 September 2022 Arcadis Technical Review of Sio Silica Corporation's Environment Act Project Proposal; and

ii) 23 July 2021 Can White Sands Corp. Vivian Sand Extraction Project, Environment Act Proposal – Parts 1 and 2 (Public Registry 6119.00) Various Documents

Preamble The General EAP is deficient: Closure Planning: Arcadis notes that the CEC decision should be informed by a comprehensive closure plan; the existing documentation does not include the level of detail that would typically be required in such a plan (see also Arcadis Conclusion #11, Page 24).

Request:

a) Please clarify why Closure Planning was not expanded upon and sufficiently addressed as part of this EAP submission and as part of this licensing process?

b) Please provide a comprehensive closure plan.

Response:

a) As stated in the Responses to the Technical Expert Reports – Geotechnical, filed November 29, 2022 issue 12:

"A comprehensive conceptual Closure Plan is not an EAP requirement, as per the Information Bulletin - Environment Act Proposal Report Guidelines. However, based on AECOM's experience it is expected that Sio will be required to prepare a comprehensive Closure Plan as a condition of the EAL.

As indicated in the EAP and the Responses to the Public table submitted to Manitoba Conservation and Climate, Environmental Approvals on January 14, 2022 (Key Issue / Question # 242), a Closure Plan, together with financial assurances, will be developed and submitted to the Manitoba Director of Mines in accordance with The Mines and Minerals Act , the Manitoba Mine Closure Regulation 67/99, and the General Closure Plan Guidelines. A copy of the Closure Plan will be submitted to the EAB by the required date or time frame specified in the EAL.

In accordance with the Manitoba Mine Closure Regulation 67/99, the Closure Plan will include a detailed schedule of costs for proper closure and rehabilitation activities, including costs for programs to monitor and manage the site after closure, if required. Financial assurances based on

the detailed schedule of costs will be provided to the Manitoba government in a form and amount acceptable to the Director of Mines."

b) Please see the response to MSSAC-IR-002(a).

IR Number: **MSSAC-IR-003**

Submitted by: MSSAC

Date Submitted: November 8, 2022

Subject Matter: General EAP

Reference:
i) 13 September 2022 Arcadis Technical Review of Sio Silica Corporation's Environment Act Project Proposal; and

ii) 23 July 2021 Can White Sands Corp. Vivian Sand Extraction Project, Environment Act Proposal – Parts 1 and 2 (Public Registry 6119.00)

Preamble: The General EAP is deficient: Cumulative Effects were not assessed. This is a substantive deficiency (see also Arcadis Conclusion #12, Page 25).

Request:
a) Please clarify why Cumulative Effects were not addressed in the EAP and as part of this licensing process?

b) Please provide an assessment of Cumulative Effects.

Response:
a) As stated in the Responses to the Technical Expert Reports – Geotechnical, filed November 29, 2022 issue 13:

"As per Information Bulletin – Environment Act Proposal Report Guidelines, which was prepared by the Province of Manitoba and applies to all Environment Act Proposals (EAPs) prepared under The Environment Act, the completion and inclusion of a cumulative effects assessment is not an EAP requirement. Therefore, by the standard set by the province, the exclusion of a "cumulative effects assessment" from the EAP is not a deficiency.

It should be noted that although a section on cumulative effects was not included in the EAP, cumulative effects were considered in the Hydrogeology and Geochemistry Assessment Studies that were completed in support of the EAP and the noise assessment which considered cumulative effects in the form of ambient noise. The Hydrogeology and Geochemistry Assessment Studies completed by AECOM considered presence of historical and existing water wells and impact on existing users; a diverse range of groundwater usage including domestic, industrial, irrigation, and livestock; expanded spatial Project boundary; and impact of pumping and development on the aquifer structure, all of which are aspects commonly considered within a cumulative effects assessment.

Other environmental and socioeconomic valued components have been assessed in the EAP as having either no residual adverse impacts (fish and fish habitat) or negligible to minor residual adverse impacts (with the possible exception of up to moderate temporary noise impacts) after

implementation of mitigation measures. These residual adverse Project impacts combined with effects of past, present and reasonably foreseeable future physical activities are not expected to result in an exceedance of regulatory thresholds or other threshold of acceptable change on these other environmental and socioeconomic valued components. This is because Project activities will be limited to small and temporary footprint areas of disturbance on a local and regional landscape that is largely previously disturbed or developed (e.g., agriculture activities). Additionally, Sio Silica will be limiting clearing of vegetation to the extent feasible by using existing roads/trails and other previously disturbed areas and will be rehabilitating and revegetating the disturbed areas annually. Sio Silica will also be implementing monitoring studies and follow-up actions as described in the EAP (e.g., Revegetation Monitoring Program), as committed to in responses to the EAP Technical Advisory Committee and public review comments (e.g., Noise Mitigation Plan) and as required by the Environmental Approvals Branch in an Environment Act Licence."

b) Please see the response to MSSAC-IR-003(a).

IR Number: **MSSAC-IR-004**

Submitted by: MSSAC

Date Submitted: November 8, 2022

Subject Matter: General EAP

Reference:
i) 13 September 2022 Arcadis Technical Review of Sio Silica Corporation's Environment Act Project Proposal; and

ii) 23 July 2021 Can White Sands Corp. Vivian Sand Extraction Project, Environment Act Proposal – Parts 1 and 2 (Public Registry 6119.00)

Preamble: The General EAP is deficient: Management Plans. Only high-level preliminary information was provided for the Management Plans, so there is insufficient detail v (see also Arcadis Conclusion #15, Page 27).

Request:
a) Please clarify why the Management Plans did not include more detail so that they could be properly assessed for adequacy, as part of the EAP submission and as required for this licensing process?

b) Please provide a Management Plan of a level of detail sufficient to confirm if the plans are adequate.

Response: a) As stated in the Responses to the Technical Expert Reports – Geotechnical, filed November 29, 2022 issue 16:

"*Currently, AECOM is preparing draft plans that will be circulated prior to the CEC hearing.*

This issue was previously addressed in the EAP and in our 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 our response to Key Issue / Question # 234 in our 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.*

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."

b) Please see the response to MSSAC-IR-004(a).

IR Number: **MSSAC-IR-005**

Submitted by: MSSAC

Date Submitted: November 8, 2022

Subject Matter: General EAP

Reference:

i) 13 September 2022 Arcadis Technical Review of Sio Silica Corporation's Environment Act Project Proposal; and

ii) 23 July 2021 Can White Sands Corp. Vivian Sand Extraction Project, Environment Act Proposal – Parts 1 and 2 (Public Registry 6119.00)

Preamble: The General EAP is deficient: Confidential Information. In Arcadis's opinion the designation of the Stantec geotechnical report on subsidence as Confidential is not valid (see also Arcadis Conclusion #16, page 27).

Request:

a) Please explain in detail why the geotechnical report by Stantec has not been released in its entirety, with commercially sensitive information redacted if necessary, as part of the EAP submission and as required for this licensing process?

b) Please provide the geotechnical report by Stantec with any necessary redactions to protect commercially sensitive information.

Response:

a) As stated in the Responses to the Technical Expert Reports – Geotechnical, filed November 29, 2022 issue 17:

"The redacted information in the Geotechnical Assessment is commercially sensitive information that could be used by Sio's competitors to gain a competitive advantage over, and therefore prejudice, Sio Silica. Nonetheless, Sio has provided the full unredacted report to the regulator, CEC Commission and the Technical Experts hired by the CEC. Sio has also offered to provide the unredacted version of the report to hearing participants if they sign a Non-Disclosure Agreement. Therefore, the full, unredacted, report will be considered in the EA decision-making process."

b) Please see the response to MSSAC-IR-005(a).

IR Number: **MSSAC-IR-006**

Submitted by: MSSAC

Date Submitted: November 8, 2022

Subject Matter: General EAP

Reference:
i) 13 September 2022 Arcadis Technical Review of Sio Silica Corporation's Environment Act Project Proposal; and

ii) 23 July 2021 Can White Sands Corp. Vivian Sand Extraction Project, Environment Act Proposal – Parts 1 and 2 (Public Registry 6119.00)

Preamble: The General EAP is deficient: Public Engagement: Limited engagement (see also Arcadis Conclusion #17, page 28).

Request:
a) Please explain in detail why Public Engagement was limited as part of this EAP submission and as required for this licensing process?

b) Please provide more detailed Public Engagement.

Response:
a) As stated in the Responses to the Technical Expert Reports – Geotechnical, filed November 29, 2022 issue 18:

> "*Sio rejects Arcadis's claim that "the level of public engagement in this case appears to be less than we would have expected*".
>
> *It is unclear to Sio what information about Sio's public engagement Arcadis reviewed, but Sio has been following the process of public engagement that is required by the EAB and Rural Municipality of Springfield, and other provincial agencies. There have been multiple advertised public engagement opportunities and local events designed to provide information to, and obtain input from, the public regarding the extraction Project specifically, including a virtual public open house on August 24, 2021 which included a question and answer period; an in-person community information session on November 29, 2021 in Anola, Manitoba; the EAP public review process; and a pending Clean Environment Commission Hearing. Sio has also engaged in several other meetings focused on the Facility project or general updates and individual and group meetings with the intent of sharing project information and obtaining feedback from the public and interested stakeholders. Other public meeting dates included: May 26, 2020 virtual meeting; December 15, 2020 virtual meeting; April 9, 10 and 11th 2019 in person meetings in La Broquerie, Anola and Richer; as well as a May 2017 in person meeting in Anola."*

b) Additional information about public engagement was provided in Sio's response to CEC-IR-001.

IR Number: **MSSAC-IR-007**

Submitted by: MSSAC

Date Submitted: November 8, 2022

Subject Matter: Air Quality

Reference:
i) 13 September 2022 Arcadis Technical Review of Sio Silica Corporation's Environment Act Project Proposal; and

ii) 23 July 2021 Can White Sands Corp. Vivian Sand Extraction Project, Environment Act Proposal – Parts 1 and 2 (Public Registry 6119.00)

Preamble: The EAP has no quantitative measurements, no model dispersion analysis near residences, no air quality inventory, no baseline data. See also Arcadis Conclusion #8, Page 20.

Request:
a) Please explain in detail why there are no quantitative measurements, no model dispersion analysis near residences, no air quality inventory, and no baseline data all as related to air quality as part of the EAP and as necessary as part of this licensing process?

b) Please provide quantitative measurements, model dispersion analysis near residences, air quality inventory, and baseline data.

Response:
a) As stated in the Responses to the Technical Expert Reports – Geotechnical, filed November 29, 2022 issue 9:

> "*Arcadis is in agreement that the Extraction Project is unlikely to result in the atmospheric emissions of silica sand that would have a significant negative impact on air quality.*
>
> *However, Arcadis suggests that a quantitative analysis of emissions from mobile and stationary equipment be conducted. It is our opinion that the quantitative analysis proposed by Arcadis, including the development of an air emissions inventory and air dispersion modelling, is not warranted given the scope and scale of the Extraction Project. The vehicles and equipment used for Project activities (listed in Table 2-1 of the EAP) would not all be operating simultaneously and will move around the Project Site as extraction wells are drilled and progressively decommissioned. This equipment is also not all concentrated in one small location, nor is there a large volume of equipment. Where possible, equipment will be electrified thereby further reducing the potential for emissions. For these reasons, Sio concluded that this equipment and activity would not cause significant air quality impacts.*
>
> *The greenhouse gas (GHG) calculations for the EAP (Section 6.3.2) are based on guidance in Canada's Greenhouse Gas Quantification Requirements (Environment and Climate Change Canada, 2019). The annual calculations reflect the full numbers of diesel equipment types,*

expected engine Tier (i.e., age of equipment), hours of operation (detailed in the EAP, Table 6-3) and fuel consumption during extraction operations. The calculation also includes all electrical power consumed for extraction activities.

Although it has not been stated in the EAP, Sio expects that the Environmental Approvals Branch (EAB) will include requirements for air quality monitoring during Project operations within the terms and conditions of the EAL, and Sio will comply with any air quality monitoring requirements as stipulated."

b) Please see the response to MSSAC-IR-007(a).

IR Number: **MSSAC-IR-008**

Submitted by: MSSAC

Date Submitted: November 8, 2022

Subject Matter: Climate Change

Reference:

i) 13 September 2022 Arcadis Technical Review of Sio Silica Corporation's Environment Act Project Proposal; and

ii) 23 July 2021 Can White Sands Corp. Vivian Sand Extraction Project, Environment Act Proposal – Parts 1 and 2 (Public Registry 6119.00)

Preamble: The EAP does not include an assessment of impacts that climate change could have on the environmental performance of the Project (See also Arcadis Conclusion #13, Page 25).

Request:

a) Please explain in detail why there is no assessment of impacts that climate change could have on the environmental performance of the Project as part of this EAP and as necessary for this licensing process?

b) Please provide an assessment of impacts that climate change could have on the environmental performance of the Project.

Response:

a) As stated in the Responses to the Technical Expert Reports – Geotechnical, filed November 29, 2022 issue 14:

> *"As per Information Bulletin – Environment Act Proposal Report Guidelines, which was prepared by the Province of Manitoba and applies to all Environment Act Proposals (EAPs) prepared under The Environment Act, the completion and inclusion of an assessment of impacts that climate change could have on the environmental performance of the Project is not an EAP requirement. However, it should be noted that the impact of climate change, most notably the potential effects on groundwater/aquifer during drought conditions, has been discussed in Responses to the Public table submitted to Manitoba Conservation and Climate, Environmental Approvals on January 14, 2022 (Key Issue / Question # 32)."*

b) Please see the response to MSSAC-IR-008(a).

IR Number: **MSSAC-IR-009**

Submitted by: MSSAC

Date Submitted: November 8, 2022

Subject Matter: Geotechnical

Reference:

i) 13 September 2022 Arcadis Technical Review of Sio Silica Corporation's Environment Act Project Proposal Appendix A - Review of Geotechnical Analysis of Sio Silica Extraction Project Near Vivian Manitoba; and

ii) 23 July 2021 Can White Sands Corp. Vivian Sand Extraction Project, Environment Act Proposal – Parts 1 and 2 (Public Registry 6119.00)

Preamble: Stantec report recommends limiting the competent limestone cap thickness to 15 m or greater, with the interpretation that extraction disturbance zone cavities of approximately 22 m to 40 m top diameter [with a long term top diameter increase by 10 m]; 3 m to 21 m bottom diameter; and extraction depth of 20 m; and extraction zone side wall slope of 65 degrees. Since the well cluster pattern has the wells 18 m apart (i.e. 36 m span between the centre well and two outer wells) the well spacing [<10 m] and cluster diameter would have to be reduced considerably to limit the cavity to a 22 m diameter top diameter. Stantec interprets bending [tensile] as the controlling failure mechanism to determine the long-term allowable span, and that the single beam long term allowable span is 7 m. The assessment of the effects of adjacent extraction areas on stability was run for one model scenario, namely overburden thickness of 33.5 m, caprock thickness of 13.5 m and a 20 m deep and 20 m radius extraction cavity within the sand formation. Arcadis notes that it is recommended that different scenarios be run consistent with some of the models run above for the shear failure and bending failure assessments. Arcadis notes no concerns with the results of the one model scenario run as described above however, it does not reflect the amount of variability identified across the site as part of the various subsurface investigation programs completed on site. It is difficult to comment on the analysis of the carbonate cap integrity when the Stantec main report is not provided [deemed confidential] and the Executive Summary provided is redacted, with black out of presumably pertinent design assumptions. Arcadis accepted the AECOM submission on surface disturbance, but not the geotechnical subsurface response to the extraction disturbance zone [i.e. excavated cavern/voids].

Request:

a) Is it reasonably sustainable that with the proposed well cluster layout and anticipated flowable condition of the silica sands, and stratigraphic variability, that the side wall slopes and span lengths that are likely to occur, will support the overlying strata, and resist a total collapse?

b) What is the basis for establishing the shape of the extraction disturbance cavities [diameter; depth]?

c) What is the anticipated interconnection from well to well, and potential for flowing sands to extend the extraction cavity beyond the well cluster and top and bottom cavity diameters assumed for the well clusters?

d) Explain how the 15 m to 25 m thick fractured limestone, with 0.7 m thick beds, subjected to isostatic rebound and uplift fracturing as mentioned in the original submission, will bridge over a 32 m to 50 m cavern void, especially with an overlying weight of 25 m to 35 m of overburden till. Show all assumptions and calculations.

e) What strength parameters, stratigraphic layering, and fracture pattern were assigned to the limestone cap rock?

f) When the single beam maximum long term allowable span is specified as 7 m by Stantec, and the average competent limestone bedding thickness is given as 0.7 m, how can this limestone cap rock span a 50 m opening without collapse and have none or limited subsidence estimated to be reflected at surface?

g) What types and frequency of monitoring will be used to check for thickness and competence of the limestone layer, as well as the measurement and monitoring of possible subsidence at each of the cluster areas for the 56 clusters per year for 24 years?

Response:

a) The well cluster layout was originally developed utilizing a previous geotechnical model and operational efficiency level per well. Since the EAP filing the geotechnical model has been updated and was filed with the responses to public comments filed January 14, 2022 in Attachment A. The confidential version was also filed to the Approvals Branch and the CEC. Additionally, new efficiencies have also been developed to reduce the overall number of wells needed.

The cluster configuration will now be required to follow the new geotechnical model. A project update letter will be filed with this new configuration prior to the CEC hearing. The Stantec model predicts that if the extraction disturbance is kept 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.

b) The shape is derived from the shape measured by the side scan sonar survey completed on wells after or during a paused extraction, where the walls are left close to vertical in the short-term. Geotechnical analysis predicts further collapse of the immediate cavity wall, but the stability analysis considers the long term expected cavity expansion including this collapse. In the long-term, the collapsed sand would settle to a natural unconsolidated sand angle of repose of 31 degrees in front of a less disturbed cavity wall.

c) There is some potential for interconnection from well to well (which is managed by allowable span) and very limited potential for connection

between well clusters when employing geotechnical design recommendations. The geotechnical model accounted for sand to settle out to its natural angle of repose of 31 degrees and a 100 year time frame. Therefore, no further movement is expected. The total allowable span may contain more than one well, and these wells within the same cluster area may interconnect in the sandstone. The distance between adjacent well clusters is set to eliminate interconnections between adjacent well clusters.

d) The approach, assumptions and calculations as part of the model are outlined in the Geotechnical report. An excerpt of the assumptions made are outlined below:

- Selection of controlling failure scenarios: The geotechnical assessments consider the potential failure scenarios (modes) including shear failure mode, bending (tensile) failure mode, cross-joints failure mode and other failure modes (Caving and Chimneying failures).

- Stability Factors of Safety: A factor of safety of 2.0 is deemed to be reasonably conservative for stability analysis to verify that subsidence will not occur.

- The lifetime of the project: For geotechnical stability design, the design life expectancy for post-extraction stability is set as long-term (quasi-permanent) with a lifetime of 50 to 100 years. It is assumed that if the adverse stability effect is not observed during this time frame, there is minimal risk for the development of adverse effects in the longer term.

- Use of Site data to develop design parameters for BRU property: Stantec assumed that the results of geotechnical borehole logging, point load testing, laboratory testing and ABI/OBI as well as supporting information from other boreholes geological logging are representative of the site-wide rock mass characteristics, with the exception that the thickness of lithologic units varies. Although borehole logging indicates that conditions are relatively consistent, there remains some potential for local variability of rock strength and structure to occur which may contribute to the local settlement.

- Use of monitoring data to develop design parameters: Stantec assumes that the results of settlement monitoring to date, which indicates no apparent early-term settlement, is representative of probable settlement during full-scale mining and the long term. There remains some potential for changes in local support conditions to generate settlement in the short or long term.

- Use of downhole side scan sonar data to develop design parameters: Stantec assumes that the results of downhole side scan sonar of the cavity (void) after mining is representative of the probable behaviour of the void during full-scale mining. There is some potential that additional changes to the cavity and the area of influence of sand extraction may change over the long term.

- Development of operational-level monitoring systems: The geotechnical design includes recommendations for operational monitoring systems to confirm the design assumptions and performance during the extraction process.

- Development of operational-level mitigation options: The design includes operations-level recommendations for mitigation options should monitoring data show changes in design assumptions or if less favourable conditions are observed during operation.

e) The analysis considered overburden thickness variation between 25 and 35 m in the extraction area. Caprock strength was adopted based on the tests on areas with limestone thickness between 10 and 25 m in the extraction area. Shale and limestone/shale rock (which may be fractured) were excluded from the caprock strength (not relied on for caprock strength). Cross-bedded limestone was also excluded from the caprock strength. Design was based on the sequence of competent (predominantly unfractured) caprock which was found to be present. The average Geological Strength Index (GSI) for the competent limestone rock mass was estimated to be 60.8 for the five boreholes in the BRU property and its vicinity. The design GSI value for competent limestone was selected as 60 (i.e. equivalent to the lower quartile of the estimated GSI). Limestone tensile strength was estimated based on laboratory tests on 19 specimens from five different wells. To consider the effect of larger bedding size than the tested samples, a factor of 0.8 was applied to the 3.8 MPa to estimate the limestone tensile strength tests. In addition, to estimate the long-term (100 years) degradation of the tensile strength, a reduction factor of 0.5 was applied. Therefore, a limestone tensile strength of 1.5 MPa was used in the analysis.

f) Stantec estimates that the limestone beddings will behave as a multi beam supporting system for the combined load from overburden and limestone. Although the lower beams can be unsupported and damaged (and potentially collapse into the cavity), a portion of the beam will remain stable and act as a cantilever beam to support the upper stratigraphy. This will result in a progressively smaller unsupported beam span upward. The cavity opening size is limited such that the expected damaged caprock does not reach the upper layers of the caprock and the

undisturbed caprock layers are thick enough to support the overburden load.

g) Sio will be drilling and coring wells regularly in areas of extraction prior to drilling the extraction wells to confirm overburden and limestone thickness. Core samples will be taken and analyzed to confirm limestone competency.

Subsidence monitoring will be ongoing. Once extraction is complete monitoring will continue. There are effective high resolution subsidence monitoring approaches available which Sio Silica has investigated and for long term subsidence monitoring of large areas, one of these, such as aerial drone LiDAR or InSAR, may be used. Monitoring frequency begins with frequent monitoring and frequency increases or decreases based upon monitoring results (more frequent monitoring if subsidence is measured, less frequent if no subsidence is measured).

IR Number: **MSSAC-IR-010**

Submitted by: MSSAC

Date Submitted: November 8, 2022

Subject Matter: Geotechnical

Reference:

i) 13 September 2022 Arcadis Technical Review of Sio Silica Corporation's Environment Act Project Proposal Appendix A - Review of Geotechnical Analysis of Sio Silica Extraction Project Near Vivian Manitoba; and

ii) 23 July 2021 Can White Sands Corp. Vivian Sand Extraction Project, Environment Act Proposal – Parts 1 and 2 (Public Registry 6119.00)

Preamble: The loose fine to medium grade clean sand in the Carman member of the Winnipeg Formation Sandstone is likely "flowable" so as an extraction cavity is formed and it is likely that the extraction zone side wall slope will be much flatter than 65 degrees, since the angle of repose of fine sand under water is in fact typically 15 to 30 degrees [wet] and 34 degrees dry. CanWhite drilled over 40 boreholes between 2017 and 2020 [EAP Part 2 Section 5.5 Bedrock Geology] and described the Carman Member as typically uncemented well sorted, well rounded, and fine to medium grained with a consistent thickness of 20 m to 30 m. Experience in drilling this Carman Member is that the sands are flowable. Use of downhole side scan sonar data to develop design parameters: Stantec has assumed that the results of the downhole side scan sonar of the cavity after mining (as recorded for two trial extraction holes) is representative of probable behaviour of the void during full scale mining. They acknowledge there is potential that additional changes to the cavity and the area of influence of sand extraction may vary over time. Arcadis comments that they have no concern with the side scan sonar approach for data collection, and comment on recommendations for timing of data collection that may assist with quantifying sand formation performance/behaviour. Arcadis does not comment on the adequacy of data being collected only for two trial extraction boreholes.

Request:

a) Why was 65 degrees chosen, presumably from sonar data collected on only 2 test holes, as a side wall slope when the in-situ state of the silica sands, under extraction, would be reasonably expected to be much less than 65 degrees based on the known variability in the silica sand formation?

b) For a critical design element such as this, explain why two test boreholes are adequate for a planned mining cycle that will include many hundreds of wells over a large geographic area, and with 24 years of development?

c) Why wasn't the subsurface sand performance in the void space quantitatively measured in detail during a full-scale test of a well extraction cluster, when variability and risk with the assumptions made have been noted in the EAP documentation and in the subsequent EAP review?

Response:

a) See the response to MSSAC-IR-009(b).

The short-term cavity shape is based on side scan sonar data. The sonar shape shows even some reverse angle (hanging) sand above the filled area. The shape was then used in a stress-deformation model (FLAC) to identify the stress condition for this short-term shape. This FLAC model helps to identify areas where stress is greater than half the sand strength. These areas are expected to slough into the cavity. The resulting stress/strength ratio contour then suggests a 65-degree shape. The sand over time may re-distribute within the cavity to a natural angle of repose of 31 degrees.

b) Results of two side scan sonar surveys were used to estimate the cavity shape for the analysis at this stage. Stantec estimated that the findings from these two side sonar surveys provided the range of expected conditions at the site as the stratigraphy and strength properties of caprock and sand deposits were observed to be relatively uniform. Stantec recommended conducting multi-well testing after issuance of an Environment Act Licence while operations begin with a smaller number of wells and then increase over time. This staged approach will allow Sio Silica to confirm expected conditions before a larger multi well extraction and make adjustments that may be required.

Arcadis's review agreed with the use of side scan sonar.

See also the response to MSSAC-IR-012 (b) and DLN-IR-009(f).

c) Subsurface sand cavern imaging in real-time is not a technology that currently exists for this application. Sonar surveys were taken during paused extraction, then resumed extraction and survey was re-ran after the extraction was complete to see if there was a difference in the shape of the cavern. Generally, the shape remained the same.

IR Number: **MSSAC-IR-011**

Submitted by: MSSAC

Date Submitted: November 8, 2022

Subject Matter: Geotechnical

Reference:

i) 13 September 2022 Arcadis Technical Review of Sio Silica Corporation's Environment Act Project Proposal Appendix A - Review of Geotechnical Analysis of Sio Silica Extraction Project Near Vivian Manitoba; and

ii) 23 July 2021 Can White Sands Corp. Vivian Sand Extraction Project, Environment Act Proposal – Parts 1 and 2 (Public Registry 6119.00)

Preamble: Stantec included as part of their design, recommendations for operation, monitoring systems to confirm the design assumptions and performance during extraction processes. Arcadis in their review noted no concerns with the recommendations presented by Stantec in their document and in fact, Arcadis considers these recommendations to be paramount requirements in the implementation of the actual extraction program.

Request:

a) Explain why the "recommendations" are considered adequate at this level of project sensitivity, and geotechnical risk, in describing monitoring systems to confirm design assumptions and performance during sand extraction, when a full test-scale extraction of a well cluster could be executed, measured, and monitored to demonstrate the expected results in a proactive way, rather than trying to react to inevitable variability that will occur with void formation when sand is extracted from the subsurface?

b) Why wouldn’t subsurface sand performance and void formation be quantitatively measured in detail during a full-scale test of a well extraction cluster, when the variability and risk in subsurface void formation have been noted in the EAP proposal and in the EAP review process?

Response:

a) See the response to DLN-IR-009(f), MSSAC-IR-010(b) and MSSAC-IR-012(b). Stantec recommended multi-well testing after issuance of the EAL to confirm and refine design assumptions. Based upon current information which is believed to effectively characterize site geotechnical conditions, it is not expected that the results of the multi-well testing will vary markedly from expectations. There is limited geotechnical risk associated with this approach. The multi-well testing will be monitored at the surface and subsurface. Monitoring data from the multi-well testing will be utilized to confirm design assumptions. Relatively minor adjustments might be required to design for operational assumptions.

b) See the responses to MSSAC-IR-010(c) and MSSAC-IR-011(a).

IR Number: **MSSAC-IR-012**

Submitted by: MSSAC

Date Submitted: November 8, 2022

Subject Matter: Geotechnical

Reference:

i) 13 September 2022 Arcadis Technical Review of Sio Silica Corporation's Environment Act Project Proposal Appendix A - Review of Geotechnical Analysis of Sio Silica Extraction Project Near Vivian Manitoba; and

ii) 23 July 2021 Can White Sands Corp. Vivian Sand Extraction Project, Environment Act Proposal – Parts 1 and 2 (Public Registry 6119.00)

Preamble: Stantec included in their design, operation-level recommendations for mitigation options should monitoring data show changes in design assumptions, or if less favorable conditions are observed during operations. Arcadis had no concerns with the recommendations made by Stantec, as noted in their review.

Request:

a) Explain why the "mitigation recommendations" are considered adequate when there has not been a test scale extraction of a full well cluster to understand in reality how the well cluster system, sand void, and sand formation in general will actually behave?

b) How will the mitigation response address an in-situ condition that is substantively different than what was assumed in the design, when it is acknowledged and known that the condition of the sand, and the formation of the void within a well cluster, may vary?

c) Why wasn’t sand extraction at a full well cluster scale done, when doing this would have drastically improved your contingency planning and ability to address geotechnical risk?

d) Please provide a report of a test scale extraction of a full well cluster.

Response:

a) Due to the parameters of the geotechnical model that were issued after the original 7 well cluster application was made and new efficiencies reducing the number of wells were identified, there will be a reduced number of wells and cluster size. In consideration for concerns about ‘full-scale’ testing, 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.

Also see the response to DLN-IR-009(f).

b) The Stantec model is considered to be conservative and is designed to achieve little to no subsidence in the immediate extraction area and no subsidence beyond the immediate extraction area. The limestone design GSI value is the lower band of the measured GSI values from boreholes. Reduction factors are also applied to the measured tensile strength tests values for selection of the limestone design tensile strength value to consider variation of the tensile strength due to spatial variation of limestone conditions at site and also changes with time and layering thickness in the extraction area. In addition, any horizontal stress in the caprock was ignored in the model (an additional conservative assumption).

Subsidence monitoring will occur before, during and after extraction activities and will continue long term. Additionally, the first year of activities are on an old highly disturbed gravel quarry, with no homes in the area. Due to the parameters of the geotechnical model that were issued after the original 7 well cluster application was made and new efficiencies reducing the number of wells were identified, there will be a reduced number of wells and cluster size. In consideration for concerns about 'full-scale' testing, 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. Over time, the number of wells per cluster will increase as the extraction activities move farther away which will allow for additional confirmation of the Stantec model as recommended by Stantec. Should results of testing yield requirements for parameter changes, Sio will provide this to the Approvals Branch for review.

c) See the response to MSSAC-IR-012(b). Current testing is understood to be representative of most likely case full scale extraction performance and the conservatism built into the Stantec model is understood to further reduce the geotechnical risk.

d) See the response to MSSAC-IR-012(b).

IR Number: **MSSAC-IR-013**

Submitted by: MSSAC

Date Submitted: November 8, 2022

Subject Matter: Geotechnical

Reference:

i) 13 September 2022 Arcadis Technical Review of Sio Silica Corporation's Environment Act Project Proposal Appendix A - Review of Geotechnical Analysis of Sio Silica Extraction Project Near Vivian Manitoba; and

ii) 23 July 2021 Can White Sands Corp. Vivian Sand Extraction Project, Environment Act Proposal – Parts 1 and 2 (Public Registry 6119.00)

Preamble: The results of settlement monitoring were measured at the ground surface in areas in close proximity to three extraction wells (BRU 92-2, BRU 92-3 and BRU 92-8). The measured values of deformation ranged from 0.000 to 0.002 m as measured over six rounds of monitoring (April to December 2021). Stantec deems that near zero deformation has been measured to date. Arcadis' main concern with this work relates to the distance between the monitoring points and the extraction wells. Given the size of the cavities formed, it would appear that some of the monitoring points may or may not be within the limits of the cavity. Furthermore, a monitoring point should be placed in very close proximity to the extraction well (i.e., within 1 m).

Request:

a) Please explain in detail why closer monitoring points were not used to determine deformation above the cavity and explain why the settlement data collected to date is considered adequate, when the distribution of settlement measuring points used to date are not adequate to measure actual deformations?

b) Explain in detail why a full well cluster extraction process was not instrumented and tested to determine actual settlements, and to quantitatively measure sand formation performance and variability, and then determine actual post production/sand extraction process deformations with a properly designed measurement network?

Response:

a) Distances were selected based on preferred locations that allowed for mobile equipment to move around the monitoring instrument without damaging or interfering with the results of the measurements. This would not be an issue in a regular operation, however due to the nature of testing, there is more mobile equipment around the monitoring instrument. Distances were also based on the ability for the land surveyors to install the monument locations. Monitoring points which are located as much as 15 m from the wells are expected to measure subsidence if it occurs. This behavior was predicted by the geotechnical FLAC analysis.

b) See the responses to MSSAC-IR-012(b) and DLN-IR-009(f).

IR Number: **MSSAC-IR-014**

Submitted by: MSSAC

Date Submitted: November 8, 2022

Subject Matter: Geotechnical

Reference:

i) 13 September 2022 Arcadis Technical Review of Sio Silica Corporation's Environment Act Project Proposal Appendix A - Review of Geotechnical Analysis of Sio Silica Extraction Project Near Vivian Manitoba; and

ii) 23 July 2021 Can White Sands Corp. Vivian Sand Extraction Project, Environment Act Proposal – Parts 1 and 2 Public Registry 6119.00)

Preamble: Stantec has assumed the results of settlement monitoring to date is representative of probable settlement during full scale well cluster mining and the long-term. They acknowledge there is some potential for changes in local support conditions to generate settlement in the short- or long-term. Arcadis comments that it is unclear from the information presented in the report how reflective the current settlement monitoring is relative to what could be expected immediately adjacent to the extraction wells. It is recommended that settlement monitoring be conducted closer to the extraction wells and another trial be conducted to collect the information required to monitor impacts during and post extraction.

Request:

a) Given the concerns raised and recommendations made by the CEC Experts, is Sio Sands Corp. willing to commit to another sand extraction trial to instrument and measure settlements, including at full test scale of a well cluster?

b) How do you propose to deal with formation variability for all extraction well clusters over the lifetime of the project, should the full scale test site of a well cluster be of optimal condition for stability with respect to settlements and/or full scale collapse?

Response:

a) See response MSSAC-IR-012 (b) and DLN-IR-009(f). Sio Silica plans to complete multi-well testing after issuance of the EAL, as operations start out with smaller number of wells and increase.

Sio Silica will be installing measurement devices for subsidence at a high level of accuracy equal to or less than 1mm. A Trigger Action Response Plan (TARP) will be developed with defined protocols to respond to subsidence issues. Subsidence monitoring devices include underground extensometers anchored to the caprock top surface, and piezometers within the overburden and at top of caprock surface within 5 m of the centre of extraction.

b) See response A and response to MSSAC-IR-009c. Well clusters and allowable spans of varying size have been investigated and requirements to achieve stable design are understood and will be used for varying

thicknesses of overburden, caprock thickness and strength, void behavior and number and location of wells.

IR Number: **MSSAC-IR-015**

Submitted by: MSSAC

Date Submitted: November 8, 2022

Subject Matter: Geotechnical

Reference:

i) 13 September 2022 Arcadis Technical Review of Sio Silica Corporation's Environment Act Project Proposal Appendix A - Review of Geotechnical Analysis of Sio Silica Extraction Project Near Vivian Manitoba; and

ii) 23 July 2021 Can White Sands Corp. Vivian Sand Extraction Project, Environment Act Proposal – Parts 1 and 2 (Public Registry 6119.00)

Preamble: Arcadis comments that the sequencing of the extraction process is not discussed in this report. It is recommended that the proponent provide the results of the prescribed work detailed by Stantec in their recommendations and the proponent be asked to provide the modelling results as done for the current report, namely Shear and Bending Failure Mode assessments along with evaluations of the impact multiple extraction wells are having on the local bedrock and overburden with due consideration of the settlement monitoring results.

Request:

a) Given the concerns raised and recommendations made by the CEC Experts, is Sio Silica Corp. going to perform a full-scale tests of sand extraction and detailed performance measurement based on a full well cluster, versus what has been done to date only on a very small number of single boreholes?

b) If a full scale well cluster extraction test is not done, how will basic single well results given to date be used to adequately predict full-scale extraction void development sand formation behavior, given the known variability in the behavior of the in-situ sands?

c) Is Sio Silica Corp. willing to share the modelling results being requested by the CEC Experts to confirm model setup, assumptions, and outputs? Without the sharing of these results, the work cannot be properly evaluated, and without sharing of these results, the licensing process will be flawed.

Response:

a) See the responses to MSSAC-IR-012(b), MSSAC-IR-014 (a) and DLN-IR-009(f).

b) See the responses to MSSAC-IR-012(b), MSSAC-IR-014 (a) and DLN-IR-009(f).

c) Sio is willing to share its modeling results with the CEC experts, yes. However, these results contain confidential information and will only be shared with those CEC technical experts who have signed an NDA.

IR Number: **MSSAC-IR-018**

Submitted by: MSSAC

Date Submitted: November 8, 2022

Subject Matter: Hydrogeological

Reference:

i) 13 September 2022 Arcadis Technical Review of Sio Silica Corporation's Environment Act Project Proposal; and

ii) 23 July 2021 Can White Sands Corp. Vivian Sand Extraction Project, Environment Act Proposal – Parts 1 and 2 and Appendix A (Public Registry 6119.00)

Preamble: See Arcadis conclusion #6 page 18 of their review report. There is insufficient information and therefore a specific concern that the proposed UV treatment of the turbid groundwater will be ineffective, before recharge/injection back to the sand aquifer. The UV treatment will be compromised by the presence of suspended particulate [e.g. due to shale collapse] and other fine suspended material which will prevent the UV from properly treating water to be recharged to the aquifer system.

Request:

a) The water treatment design is noted by the CEC Experts as an early conceptual stage of design and focuses on UV treatment, and there is insufficient information regarding treatment requirements and process to confirm whether there are any additional potentially significant impacts associated with water reinjection - how will Sio Silica Corp. address this significant deficiency in the Project proposal?

Response:

a) As stated in the Responses to the Technical Expert Reports – Geotechnical, filed November 29, 2022, issue 7:

"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. Detailed engineering and design is typically completed during and after the regulatory review process, incorporating input from government agencies and other interested parties. Sio is working with industry leading ultraviolet (UV) treatment specialists and a certified laboratory to determine appropriate equipment selection for UV treatment and filtration.

UV systems are widely used to disinfect industrial and municipal water for potable and non-potable uses and the systems being considered by Sio are all proven, commonly used, and available from many established suppliers. To

support the design of the UV treatment system, Sio will be undertaking additional water quality testing. Several parameters will be monitored in the field and verified by the analytical laboratory to guide system design."

As indicated in Table 1, Response #11 in Sio's 'Response to the Technical Advisory Committee (TAC) Review Comments', posted on the Public Registry on December 20, 2021, Sio also stated:

"*Regarding technical specifications of the UV treatment system, a design dose of 25-30 mJ/cm² is typical for waste water treatment systems designed to meet 200 MPN/100mL fecal coliform limit, but a higher dose may be required based on local water quality and UV lamp fouling estimates. At this preliminary stage, the final design criteria for the UV treatment system are being developed. The final system design may also include a system that provides a target of 3-log (99.9%) inactivation of both Giardia and Cryptosporidium in accordance with local drinking water standards, although this is a higher level of treatment than is typically used in other applications when returning treated water back to the environment. An upstream filtration system may be required*."

"The control narrative related to pumping operation is still in the preliminary design stages, but will include industry-standard operational fail safe requirements such as: alternating Duty/Standby UV disinfection units, the inability for the UV system to be bypassed, separate alarms to indicate lamp failure, low UV intensity and other causes of UV disinfection unit failure. A dedicated programmable logic controller (PLC) may be provided given the mobile nature of the systems, and multiple PLCs may be provided as necessary to ensure continuous treatment, depending on the final controls design."

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

Part 2 – MSSAC IR 016, 017, and 019 to 026

IR Number:	**MSSAC-IR-016**
Submitted by:	MSSAC
Date Submitted:	November 8, 2022
Subject Matter:	Geotechnical
Reference:	13 September 2022 Arcadis Technical Review of Sio Silica Corporation's Environment Act Project Proposal; and 23 July 2021 Can White Sands Corp. Vivian Sand Extraction Project, Environment Act Proposal – Parts 1 and 2 (Public Registry 6119.00)
Preamble:	See Arcadis conclusion #1 page 8 of their review report. Arcadis notes that there is uncertainty in the airlift mining application under full scale and under a range of geological and environmental conditions that are expected to occur. The conceptual extraction well layout consists of each Cluster of 5 wells [revised from 7 wells] with one central well and four [4] wells spaced at 90 degree quadrants. The wells are 18 m distance from the central well and the cluster limit shown as 9 m beyond the outer 4 wells, resulting in a cluster overall diameter of 54 m. It is not apparent how sand can be lifted to surface [from a depth of 20 m and from a cavern diameter of 10+ m] into the casing with the airlift, since the return recharge water will balance the discharge flow [by their admission, with only an effective net pumping of 10 gpm representing the water lost to the separated and screened wet sand]. Accordingly, there should be a minimal drawdown cone/pressure differential created at the base of the well, and hence limited flow of fresh groundwater towards the well carrying a sand slurry for capture at the well casing. Each well is reported to operate for up to 4 to 6 days at rates varying at 40 to 120 USgpm for a combined potential rate of up to 540 USgpm, as required to maintain the slurry. The schematic of the casing installed shows the base of the casing extending a short distance below the base of the shale aquitard. The air lift discharge of GW/sand slurry occurs inside the inner casing. The gravity recharge flow occurs concurrently down the annulus between the inner and outer casings. As soon as the well no longer produces sand, the well will be grouted off. Annual extraction is targeted to be 1,360,000 tonnes per year, with wells spanning over and area of approximately 1.2 square kilometres per year. There are a total of 1,680 wells proposed in the first 4 years and potentially over 10,000 wells over the 24 year period.
Request:	a) Can you clarify or clearly describe with details how this proposed airlift extraction process will work? b) Can you confirm that the effective pumping rate will only be 10 USgpm at each well, since at a pumping rate of 270 USgpm [air lift] per well, that 260 USgpm will be short circuiting the flow with recharged return groundwater

[down the outer annulus] and only 10 USgpm will be separated with the wet sand extraction?

c) Will a rate of 10 USgpm at each well be sufficient to extract the sands?

d) If a differential flow rate of 10 USgpm is adequate to produce the sands to surface, they would be presumed to be quite flowable. How then can the void space created below surface have an angle of repose of 65 degrees?

e) Since the casing only extends a short distance below the shale into the sandstone zone [based on the schematic drawing only], what is the risk that air will migrate into the sandstone formation and reduce the permeability of the sandstone aquifer zone for the long term?

f) Can you clarify what the pumping rate will be per well and per well cluster [i.e. concurrent wells pumping], as there are differing rates and durations reported in the EAP submission?

Response:

a) The extraction process was fully described in Supplemental Filling #1 – Extraction Method filed June 3, 2022 to the CEC and hearing participants.

In addition, As stated in the Responses to the Technical Expert Reports – Geotechnical, filed November 29, 2022 issue number 2:

"Air lifting is a method that is used regularly in the water well drilling industry. It is used locally and internationally to drill wells in various formations. Sio's extraction method combines the traditional method of airlift used to develop water wells and a dual rotary set up usually used to drill wells in unconsolidated formations to extract sand.

Combining all of the collected information, pilot testing results, modelling and design, the environmental effects associated with the proposed extraction methods are generally well-understood."

b) 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.

c) 10 US gpm is not the rate of extraction. Well flow rates vary over time from approximately 40 - 120 US gpm (as stated in Section 2.4 Groundwater Use During Extraction of the Hydrogeology and Geochemistry Assessment) All the water except the approximate 10 US gpm is re-injected in the active well. This is the basis for the 10 US gpm effective rate.

Also refer to the response to MSSAC-IR-016(b).

d) This question is based on an incorrect understanding of the extraction process. Please refer to the response to MSSAC-IR-016(b) and (c) and MSSAC-IR-009(a), (b) and (c).

e) The referenced schematic is an example only and not to scale. A permanent casing will extend into the sandstone aquifer to provide the ability to properly seal the well around the casing in the annulus. This casing will also provide guidance to the extraction tubing which is installed temporarily from an extraction rig to extract the sand. The extraction tubing is 2 pieces, one is a casing and inside is the airline. The airline is the source of the air and this stays inside the production tubing casing that is outside. This depth can be adjusted as required to allow for removal of sand and does not stay close to the shale. This is the basis for the ability to remove the sand; as the air comes out of the airline it does not have anywhere to go because it is inside the production tubing, therefore, it travels to the surface, and this provides the flow mechanism for the sand.

Please also refer to Supplemental Filling #1 – Silica Extraction Method filed June 2, 2022 where the extraction process is described in detail.

In the event that a trace amount of air escapes from the production pipe to the sandstone aquifer, the majority of the trace amount of air will move in the direction of groundwater flow and eventually escape to the atmosphere. In addition, a small amount of air will dissolve in water, and the solubility of air in water follows Henry's Law. Under the atmospheric condition and T=25oC, the solubility of air (21% O2 and 79% N2) is about 23 mg/L, and air solubility increases with pressure. Therefore, the trace amount of air will either move with groundwater flow, dissipate up the wellbore or remain in dissolved phase, and will not have an adverse impact on the permeability of the sandstone aquifer.

Also refer to the Hydrogeology and Geochemistry Assessment Report – Section 8.3:

“In many cases, the impact was simulated to be positive due to reduction of concentrations of iron and manganese when oxygen is introduced into the aquifer or is allowed to mix with water containing lower concentrations of those elements.”

f) Please refer to the response to MSSAC-IR-016(b) and (c).

IR Number: **MSSAC-IR-017**

Submitted by: MSSAC

Date Submitted: November 8, 2022

Subject Matter: Hydrogeological

Reference: 13 September 2022 Arcadis Technical Review of Sio Silica Corporation's Environment Act Project Proposal; and

23 July 2021 Can White Sands Corp. Vivian Sand Extraction Project, Environment Act Proposal – Parts 1 and 2 and Appendix A (Public Registry 6119.00)

Preamble: See Arcadis conclusion #5 page 17 of review report. For each Cluster of 5 wells, a "top extraction disturbance zone" of 22 m to 50 m diameter will be developed [depending on the limestone cap thickness], directly below the Winnipeg Shale, with an underlying cavern or void extending to 20 m [Stantec Jan 14, 2022]. The Winnipeg shale is approximately 3 m in thickness and consists of an interbedded friable deeply weathered shale to high plasticity clay within the local project area [EAP Part 2 Appendix A Part 1 by AECOM]. The overlying Red River Carbonate limestone ranges from 15 m to 25 m in thickness, with an upper layer of 25 m to 35 m of overburden till. There will be an average of 56 clusters developed per year over a 24 year period for a total of approximately 1,344 clusters spaced at 60 m apart. AECOM go to great lengths to discuss grouting of the wells to prevent vertical interconnection, but avoid addressing the risk of shale collapse and the interconnection between the carbonate confined aquifer and the Carman sand confined aquifer that this will create. [AECOM response to questions, Jan 21, 2022 posted Jan 26, 2022]. There are some comments that since 2017 there has been some decline in the differential piezometric head between the two respective confined aquifers. AECOM does note that a fundamental design requirement is to maintain separation of the two confined aquifers.

Request:

a) The CEC Experts consider that the collapse of the shale aquitard is a critical failure mode and therefore a material deficiency in the Project proposal, so please clarify and elaborate on why the work by Stantec does not explicitly evaluate the hydrogeological or Regulatory implications of such a failure?

b) Please advise if any tests or analyses have been undertaken to determine conclusively if the overlying weak fissile fractured shale will collapse into the cavern, with the development of top disturbance diameters of 22 m to 50 m at each well cluster, and thus create a direct interconnection between the Sandstone confined aquifer and the overlying Red River Carbonate - limestone aquifer?

c) Fundamentally, how do you know if the shale aquitard will be able to maintain separation between the aquifer systems, when there will be large voids within the sands below, and large open spans at the top of the well cluster voids?

d) With a collapse of the shale aquitard, and a measured response of either aquifer pressures, or water quality that indicate degradation of the sand aquifer system, how will you respond?

Response:

a) Regarding regulatory implications please refer to CEC-IR-009.

Also refer to Responses to Technical Expert Reports – Hydrogeology – filed on November 29, 2022, response to Issue #7 and Responses to the Technical Expert Reports – Geotechnical, filed November 29, 2022, issue 6.

b) Refer to the response to MSSAC-IR-009, MSSAC-IR-017(a) and RMSF-IR-018.

Due to the parameters of the geotechnical model that were issued after the original 7 well cluster application was made and new efficiencies reducing the number of wells were identified, there will be a reduced number of wells and cluster size. 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. Over time, the number of wells per cluster will increase as the extraction activities move farther away which will allow for additional confirmation of the Stantec model as recommended by Stantec. Should results of testing yield requirements for parameter changes, Sio will provide this to the Approvals Branch for review.

c) Refer to the response to MSSAC-IR-017(a).

d) As stated in the responses to public comments Key Issue/Question #32:

"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."

Please also refer to the Responses to the Technical Expert Reports – Hydrogeology, filed November 29, 2022, issue 7 and issue 8.

IR Number: **MSSAC-IR-019**

Submitted by: MSSAC

Date Submitted: November 8, 2022

Subject Matter: Hydrogeological

Reference: 13 September 2022 Arcadis Technical Review of Sio Silica Corporation's Environment Act Project Proposal; and

23 July 2021 Can White Sands Corp. Vivian Sand Extraction Project, Environment Act Proposal – Parts 1 and 2 and Appendix A (Public Registry 6119.00)

Preamble: See Arcadis conclusion #7 page 19 of their review report. The air lift injection of large quantities of air will introduce oxygen and other microbial contaminants that could impact the groundwater quality, but has not been adequately addressed in the EAP.

Request:

a) Is Sio Silica Corp., prepared to undertake further modelling and assessment to support the conclusion that oxygen introduced by the extraction process, or any other contaminants, will not have an adverse effect on groundwater geochemistry? If not, why is the information provided to date adequate?

Response:

a) As stated in the responses to public comments Key Issue/Question #32:

> *"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."*

As stated in the Responses to the Technical Expert Reports – Geotechnical, filed November 29, 2022, issue 8:

> "*For the reasons outlined below, water quality at nearby water wells would be unchanged or possibly marginally improved as a result of the Extraction Project. Concerns regarding the impact of introducing oxygen into an anaerobic aquifer has been previously addressed in Sio's Responses to the Public table submitted to Manitoba Conservation and Climate, Environmental Approvals on January 14, 2022."*

As explained in response to Key Issue / Question # 33, it is unlikely that dissolved oxygen will facilitate the proliferation of iron bacteria and other microbes. Most of the air utilized during the extraction process will not interact with the aquifer but will return to surface with the sand slurry and return to the atmosphere. The groundwater returned to the aquifer after treatment will contain only a very small volume of dissolved oxygen. Extraction activities will not introduce any biological contaminants into the aquifer.

Also refer to DLN-IR-001 (b), public comments responses Key Issue / Question # 36, and the Responses to the Technical Expert Reports – Hydrogeology, filed November 29, 2022, issue 8.

IR Number: **MSSAC-IR-020**

Submitted by: MSSAC

Date Submitted: November 8, 2022

Subject Matter: Hydrogeological

Reference: 19 September 2022 Technical Review of Sio Silica Corporation's (Formerly CanWhite Sands Corp.) Environment Act Project Proposal (Hollander and Woodbury); and

23 July 2021 Can White Sands Corp. Vivian Sand Extraction Project, Environment Act Proposal – Parts 1 and 2, and Appendix A (Public Registry 6119.00)

Preamble: The Technical Executive summary of the CEC expert review stated that not all of the issues of concern were identified and resolved with the proponent's work. One of the stated purposes of the hydrogeological investigations for this project was to evaluate the potential for the project to impact groundwater quantity, quality and users of the surface and groundwater in a large area east of Winnipeg, Manitoba. Since the project area is extensive and involves many wells pumping over a long period of time it is important to identify areas of concern that could affect existing water well users and communities in the future. Hence, there is a need to assess the impacts of pumping and development on the aquifer structure, extent of drawdown cones, impacts on existing users, intrusion of water of questionable quality, subsidence and potential pathways connecting the limestone and sandstone aquifers. Not all of these aforementioned issues and risks were identified and resolved with the work by the proponent.

Request:

a) How do you know that your project will not affect regional groundwater supplies, from the perspective of induced groundwater depressurizations or drawdowns over the long term?

b) How do you know that your project will not affect water quality, based on how you will produce and recycle groundwater?

c) How do you know that your project will maintain the critical shale aquitard that separates the two aquifer systems in the region of your project?

d) How will you know if your project is affecting the water levels or water qualities of the two regional aquifer systems, and what will you do to mitigate the issues?

e) If your project induces vast vertical interconnections between the two aquifer systems due to a collapse or degradation of the shale aquitard that separates them, and a water quality degradation of the sand aquifer is a result, can you reverse this? How would you reverse this change?

Response:

a) As stated in the Hydrogeology and Geochemistry Assessment Report – Executive Summary:

"*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.*

Groundwater model simulations indicate that groundwater users of the Red River Carbonate aquifer and the Winnipeg Sandstone aquifer beyond a radial distance of approximately 2.2 km from the active extraction wells are unlikely to experience any effects due to extraction activities".

b) Degradation of the Winnipeg Sandstone aquifer as result of mixing with water from the Red River aquifer is not anticipated because both aquifers host fresh water.

As stated in the Hydrogeology and Geochemistry Assessment Section 8.3 – Groundwater Quality:

"*Overall, material impacts to groundwater quality within the Project Area are unlikely because both the Red River Carbonate and Winnipeg Sandstone host fresh and relatively dilute groundwater. Based on the results of geochemical modelling, the activities associated with project operations and post-closure phases of the project were determined to have only a minor impact on groundwater quality. In many cases, the impact was simulated to be positive due to reduction of concentrations of iron and manganese when oxygen is introduced into the aquifer or is allowed to mix with water containing lower concentrations of those elements.*"

Please also refer to the responses to MSSAC-IR-017 and MSSAC-IR-019.

c) Please refer to the response to MSSAC-IR-017.

d) Sio will be developing and implementing a Groundwater Monitoring and Impact Mitigation Plan that includes monitoring the water quality in the sandstone and carbonate aquifers 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.

e) Please refer to the responses to MSSAC-IR-020(b) and MSSAC-IR-017.

IR Number: **MSSAC-IR-021**

Submitted by: MSSAC

Date Submitted: November 8, 2022

Subject Matter: Hydrogeological

Reference: 19 September 2022 Technical Review of Sio Silica Corporation's (Formerly Can White Sands Corp.) Environment Act Project Proposal (Hollander and Woodbury); and

23 July 2021 Can White Sands Corp. Vivian Sand Extraction Project, Environment Act Proposal – Parts 1 and 2 and Appendix A (Public Registry 6119.00)

Preamble: There is a shale layer that separates the two main aquifers and helps to preserve water quality and separate hydraulic pressures and chemistry. The proponent notes that degradation of this shale layer may occur because of project operations which would result of more direct communication between the two main aquifers: Winnipeg Sandstone and the Red River Carbonate. This is a crucial risk to the operation.

Request:

a) What impact(s) may occur with respect to aquifer water levels and water quality, with an increase in direct communication between the two main aquifers involved?

b) What would these impacts be in the short and longer term, and from a regional potable groundwater source and sustainability perspective?

c) How will you know if there are water level or water quality impacts as a result of your operations?

d) How will you measure a water quality impact, and what will you do if there is a water quality degredation?

e) Is a water quality impact reversible? How?

Response:

a) Refer to the responses to MSSAC-IR-017 and MSSAC-IR-020.

b) Refer to the responses to MSSAC-IR-017 and MSSAC-IR-020.

c) Refer to the responses to MSSAC-IR-017 and MSSAC-IR-020.

d) Refer to the responses to MSSAC-IR-017 and MSSAC-IR-020.

e) As indicated in the Hydrogeology and Geochemical Assessment Report, water quality is not anticipated to be materially affected by Project operations.

In situations where water quality impacts are observed, there are many examples of sites where water quality impacts can be reversible. This would depend on the type and extent of impact, source of the impact, and general conditions of the water receiving the impact. Groundwater

flow mechanisms including dilution, dispersion, sorption, decay, dissolution and precipitation may serve to limit or restore any water quality impacts. Many of the governing processes are equilibrium reactions that serve to stabilize concentrations in the absence of other forcing parameters. Determining how to reverse the impact will be specific to the compound under consideration, and therefore a definitive answer to this question cannot be provided.

IR Number: **MSSAC-IR-022**

Submitted by: MSSAC

Date Submitted: November 8, 2022

Subject Matter: Hydrogeological

Reference: 19 September 2022 Technical Review of Sio Silica Corporation's (Formerly CanWhite Sands Corp.) Environment Act Project Proposal (Hollander and Woodbury); and

23 July 2021 Can White Sands Corp. Vivian Sand Extraction Project, Environment Act Proposal – Parts 1 and 2 and Appendix A (Public Registry 6119.00)

Preamble: There was no testing at a pilot-project site in which the aquifer was actually mined out and drawdowns were measured at various locations from a producing well cluster. This is another critically important point.

Request:

a) Does Sio Silica Corp. agree with the CEC Experts that there is a critical need, from a groundwater perspective, that a full production cluster of wells be installed and operated as they will be as part of the full operation? If not why?

b) Does Sio Silica Corp. agree that data measurements of the full production cluster of wells is critical? If not why?

c) Does Sio Silica Corp. believe that it is reasonable to extrapolate data from a very small number of single well tests to the behavior of a full scale well cluster, then multiple well cluster scale, and over the long term (i.e. 24 years of the project lifetime)? If so, why, when it is recognized that there is significant variability in the geologic system in the region of the project? What are the multiple lines of evidence that support your interpretation?

d) What instrumentation would be utilized and measurements taken in a full scale well cluster test for both extraction and post extraction phases?

e) What samples would be taken in a full scale well cluster test in both extraction and post extraction phases?

f) Would data collection occur during both drawdown (extraction) operations and under recovery (post extraction) in a full scale well cluster test?

g) Does Sio Silica agree that it is important that pilot scale testing be completed for a full well cluster, and under both extraction and post extraction (recovery) scenarios? If not, why, and state the multiple lines of evidence that would support your position.

h) What overall duration of testing at pilot scale of a full well cluster (both for extraction and post-extraction) would be required to adequately

define the behavior of the sand extraction system and resultant void spaces?

Responses:

a) At this time, the purpose of any full-scale test would be to refine the monitoring and efficiency levels of the extraction process, it would not be to assess environmental effects. To date, substantial data has been collected to assess the potential effects of the project. It is not normal practice to build a full scale mine to test before approval. Sio is confident in the assessments that have been conducted to date and operations would be confined to the conservative geotechnical model. As is normal practice, the issuance of any licence will set acceptable and safe parameters in addition to what has been set out by Stantec and AECOM's reports. Operating outside of these parameters would not occur.

Due to the parameters of the geotechnical model that were issued after the original 7 well cluster application was made and new efficiencies reducing the number of wells were identified, there will be a reduced number of wells and cluster size. In consideration for concerns about 'full-scale' testing, 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. Over time, the number of wells per cluster will increase as the extraction activities move farther away which will allow for additional confirmation of the Stantec model as recommended by Stantec. Should results of testing yield requirements for parameter changes, Sio will provide this to the Approvals Branch for review.

b) See the response to MSSAC-IR-022(a).

c) See the response to MSSAC-IR-022(a).

d) For groundwater quantity, groundwater levels at select monitoring wells within the zone of influence will be monitored continuously using pressure transducers or automated dataloggers. A barometric logger with a same time interval setting will be deployed above the water table in a select well to monitor barometric pressure fluctuations. Groundwater levels will be corrected to remove the influence of barometric pressure fluctuations and converted to geodetic groundwater elevations to produce hydrographs and evaluate groundwater elevation fluctuation.

For groundwater quality, groundwater quality samples in extraction wells and monitoring wells within the zone of influence will be collected before, during and after sand extraction events to enable a robust analysis of the impact of sand extraction on groundwater water quality

for all parameters under consideration. Real-time groundwater quality measurements could also be collected for some parameters such as pH, temperature, conductivity and DO.

From a geotechnical perspective, please refer to the response to MSSAC-IR014(a).

e) See the responses to MSSAC-IR-022(a) and (d), MSSAC-IR-014(a), and MSSAC-IR-020(d).

f) Yes, as well as before extraction starts. This is standard practice as with any pump test and would be applied for extraction operations, not just testing.

Also refer to the response to MSSAC-IR-022(a).

g) See the response to MSSAC-IR-022(a).

h) See the response to MSSAC-IR-022(a) and MSSAC-IR-014(a).

IR Number: **MSSAC-IR-023**

Submitted by: MSSAC

Date Submitted: November 8, 2022

Subject Matter: Hydrogeological

Reference: 19 September 2022 Technical Review of Sio Silica Corporation's (Formerly CanWhite Sands Corp.) Environment Act Project Proposal (Hollander and Woodbury); and

23 July 2021 Can White Sands Corp. Vivian Sand Extraction Project, Environment Act Proposal – Parts 1 and 2 and Appendix A (Public Registry 6119.00)

Preamble: Hydrogeology Investigations: Step Pump Test- Proper procedure was not followed. Log spacing of 3 observation wells would be better. Poor well efficiency was evident in the data. Pump tests should be rerun and reinterpreted. Hydraulic tests were completed in the main sandstone aquifer at the site but analysis of the data suggests that the pump tests should be re-run and the test data re-interpreted. Drawdown data suggests a leaky connection between the two main aquifers and importantly the test methods should allow for a calculation of the leakage properties of the shale layer that separates the main aquifers.

Request:

a) Based on the interpretations provided by the CEC Experts that state the hydrogeological testing reviewed needs to be redone, are the results of the testing adequate to properly and completely characterize the physical hydrogeological setting in the region of this project? If yes, state the multiple lines of evidence that support your answer, because two significantly experienced hydrogeological experts have stated that the testing data from the hydrogeological investigations needs to be redone.

b) Have the leakage properties of the shale aquitard been adequately quantified? If so, please provide this information.

c) If you do not know the leakage properties of the shale aquitard now, on a regional basis, how will you know in the short and long term if your project is impacting the performance of the shale aquitard in separating the two aquifer systems in the region of the project?

d) What will you measure to determine if your project has impacted the leakage properties/integrity of the shale aquitard?

e) What will you do if your project has impacted the leakage properties/integrity of the shale aquitard?

f) What will you do if your project renders parts of the potable sand aquifer unusable from a water level and/or water quality perspective?

Response: a) As stated in the Responses to the Technical Expert Reports – Hydrogeology, filed November 29, 2022, issue 4:

"The report is unclear as to the basis for the assertion that "analysis of the data suggests that the pump test need [sic] to be redone". As a point of clarification (and as discussed in detail in Section 3.7.2 of the Hydrogeology and Geochemistry Assessment Report), it is acknowledged that the pumping well would have benefited from additional development efforts to improve its hydraulic efficiency. However, several methods were utilized to analyze the pumping test data, many of which do not rely on a hydraulically efficient connection between the pumping well and the aquifer. The pumping well was pumped at a rate that was judged to be representative of an operational scenario, and responses were measured in several observation wells completed in the Red River Carbonate, Winnipeg Shale and Winnipeg Sandstone aquifers, and several distances from the pumping well. The solution that was selected for determination of aquifer properties was able to simultaneously fit drawdown measured in several wells and at a variety of distances. The data from the pumping well was not relied upon for determination of aquifer properties, placing focus on the observation well data.

As noted in Sections 1.2 and 1.3 of the Hydrogeology and Geochemistry Assessment Report, a significant number of hydrogeological investigations have been conducted within the Local Project Area and Regional Project Area by a variety of groups, including well drillers, consulting hydrogeologists, academic researchers, and the provincial government. Many of these studies were regional in nature and compiled extensive hydrogeological information from a variety of data sources, in an effort to characterize the heterogeneity of the aquifer and estimate aquifer properties. A comprehensive summary of hydraulic conductivity measurements was provided in Table 5-1 of the Hydrogeology and Geochemistry Assessment Report and discussed in detail in Section 5.7. Overall, the results indicate that the hydraulic properties of the aquifers are fairly similar over large spatial distances. This comprehensive literature review, and discussions with academic researchers and consultants with extensive experience in the area, formed the basis for this assessment and additional pumping tests for the purposes of determining aquifer properties are not required.

Geometric mean values were derived from the comprehensive database of hydraulic conductivity values presented in Table 5-1 of the report, and used to parameterize the numerical groundwater model. Through the calibration process, aquifer properties were modified following industry-standard practice and the resultant calibrated aquifer properties were similar to measured values. The calibration metrics for the model were well within industry-standard values, as defined by groundwater modelling guidelines produced by provincial government agencies within Canada (British Columbia Ministry of Energy, Mines and Low Carbon Innovation and Ministry of Environment), and

internationally (US EPA; Australian Government National Water Commission), further justifying the position that the aquifer systems are well understood, and the hydrogeological properties of the aquifers assigned in the model are reasonable. Further, a robust sensitivity analysis was conducted to evaluate the impact of variability in hydraulic properties and boundary conditions on simulation results."

b) As stated in the Responses to the Technical Expert Reports – Hydrogeology, filed November 29, 2022, issue 16:

"*The primary purpose of the pumping test was to evaluate the extents of drawdown under a pumping rate similar to that which will be employed during operations. Extraction wells will not be developed or operated as pumping wells, and as such, it was decided that well development was less critical. While this comes at a cost of not being able to rely on pumping well drawdown data for determination of aquifer properties, the volume of water removed and water levels recorded in a number of distal monitoring wells and vibrating wire piezometers allowed for determination of aquifer properties at the scale of the test (kilometres). While well efficiency may be important for water supply well design and determination of aquifer properties from single well response tests, it is not important to this assessment as pumping wells will not be installed or utilized during mining (which is from open boreholes).*

Pumping test data were analyzed using the Theis and Cooper-Jacob solutions without consideration of analytical solutions that accommodate leakage across an overlying confining unit into the pumped aquifer. It is acknowledged that several other analytical solutions are available to evaluate the pumping test data, but a reasonable fit to the distance-drawdown data and displacement-time data was obtained with the Theis and Cooper-Jacob solutions. The results of the analysis were within the range of values reported for other pumping tests within the same aquifer system and are judged to be reasonable. Further, use of a numerical model calibrated to spatially and temporally distributed hydraulic heads was judged to be a more reasonable approach to evaluation of a regional scale problem. The demonstrated ability of the model to simulate hydraulic heads that are a reasonable match to measured values indicates that the model is a useful tool. Slug testing of the shale was limited to one test, but visual observations of a core suggest it is generally a low permeability unit that restricts flow between the Winnipeg Sandstone and Red River Carbonate aquifers. The hydraulic gradients between the two aquifers are relatively small (~0-2m), suggesting that the permeability of the shale is much less important in the study area than previously thought. The relatively small vertical gradients indicate groundwater flow is primarily horizontal through the Project Site Area. The Winnipeg Shale Aquitard is not the only element that limits the interaction between the two aquifers"

Also refer to the response to MSSAC-IR-023(a).

c) Please refer to the response to MSSAC-IR-023(b), and the Responses to the Technical Expert Reports – Hydrogeology, filed November 29, 2022, issue #7 and issue #8.

d) Please refer to the response to MSSAC-IR-023(b) and the Responses to the Technical Expert Reports – Hydrogeology, filed November 29, 2022, issue #7 and issue #8.

e) Please refer to the response to MSSAC-IR-023(b) and the Responses to the Technical Expert Reports – Hydrogeology, filed November 29, 2022, issue #7 and issue #8.

f) As indicated in the Hydrogeology and Geochemical Assessment Report in Section 8 – Conclusions, water quality and quality are not anticipated to be materially affected by Project operations.

Sio will have a stringent Groundwater Monitoring and Mitigation Plan that will monitor aquifer conditions before, during and after extraction activities. A pre-development assessment will be completed for wells near the proposed extraction activities in the area. Groundwater elevations will be monitored in real time so that operations can be stopped if water levels approach pre-determined thresholds that require mitigation. If water levels exceed thresholds, Sio will initiate a Trigger Action Response Plan (TARP) that will initially be aimed at confirming water level measurements, then initiate an investigation into the cause of the exceedance, then determine appropriate mitigation measures and then implement them as required after determining the effect is due to Sio's extraction activities. Should Project activities impact the availability of potable water to nearby residents, Sio will immediately take actions to ensure access to potable water at Sio’s cost.

Please also refer to the responses to MSSAC-IR-021(e), MSSAC-IR-023(b) and the Responses to the Technical Expert Reports – Hydrogeology, filed November 29, 2022, issue #7 and issue #8.

IR Number: **MSSAC-IR-024**

Submitted by: MSSAC

Date Submitted: November 8, 2022

Subject Matter: Hydrogeological

Reference:

i) 19 September 2022 Technical Review of Sio Silica Corporation's (Formerly CanWhite Sands Corp.) Environment Act Project Proposal (Hollander and Woodbury); and

ii) 23 July 2021 Can White Sands Corp. Vivian Sand Extraction Project, Environment Act Proposal – Parts 1 and 2 and Appendix A (Public Registry 6119.00)

Preamble:

Five slug tests are inadequate for regional characterization of the aquifers and of the Winnipeg Shale formation. These tests are inadequate for regional identification of aquifer properties. Slug and bail tests have very limited areal extent and have generally high uncertainties. This can be identified by a nearly one order of magnitude difference in hydraulic conductivity in the Red River Carbonate aquifer. Slug and bail tests can give some insights into aquitards. However, only one test was carried out in the Winnipeg Shale. Basically, the methods of test-analysis assume that the aquifer is being pumped at a constant rate and is completely confined; i.e. there is no leakage through a confining layer. However, one can see from the analysis that drawdown was measured in the carbonate aquifer during the tests. The drawdowns were measurable (note 95-8 VW2 of about 1.5 m) so the shale aquitard appears to exhibit leaky conditions.

Unfortunately, the well test methods that were used do not allow for a calculation of the leakage properties of the shale layer. It is apparent that in the location of the tests, either the shale is non-existent, cracked and/or pervious or there are wells present that interconnect the aquifers. The discussion in the text is at odds with all the available data (see p. 32) where it is stated “this information suggests the Winnipeg shale is an effective barrier to interaction between the two aquifers at this location”. Leaky shale or no shale is apparent here. It is estimated that with sand production, the basic aquifer characteristics of permeability, and porosity will change substantively.

Request:

a) What risks may be realized with respect to modeling predictions if the aforementioned limited data is used to characterize aquifer properties, and if the parameter interpretations input to the analyses/models are not representative?

b) Was adequate data collected to characterize the shale aquitard, which is a key barrier that must remain intact to separate the two aquifer systems? If yes, please outline your response using multiple lines of evidence.

c) How will you know if your project has compromised the shale aquitard, if its properties and continuity are not adequately represented at the onset of the project?

d) The data presented indicates that the shale at this test location is leaky and/or otherwise thin to non-existent - if the shale is compromised, if it is additionally leaky or discontinuous naturally, and should hydraulic gradients change and aquifer properties change with sand production and drawdown, all of which may enhance communication between the carbonate and sand aquifers, what will be the result?

e) Is enhanced vertical communication between the two aquifer systems reversible? If so how?

f) Can this enhanced vertical aquifer communication be effectively or even practically mitigated based on the massive amount of drilling penetrations and areal extent of drilling and sand extraction that is planned in this project? If so, how?

Response:

a) See the Responses to the Technical Expert Reports – Hydrogeology, filed November 29, 2022, Issues #3, #4, #5 and #6 for a discussion of hydraulic testing, aquifer properties and the influence of mining on regional scale aquifer properties.

Several pilot test extractions have been conducted over the past several years by Sio Silica. The data and learnings from these tests have been incorporated into the work to date and will inform the follow up plans, such as the Groundwater Monitoring and Mitigation Plan.

Also refer to the response to MSSAC-IR-12(b).

b) Yes. See the Responses to the Technical Expert Reports – Hydrogeology, filed November 29, 2022, Issues #7, #8 for a discussion of interconnection between the Winnipeg Sandstone and Red River Carbonate aquifers and the implication of a water quality change in response to degradation of the Winnipeg Shale.

c) Please see the Responses to the Technical Expert Reports – Hydrogeology, filed November 29, 2022, issue #7 and #8, for a discussion of interconnection between the Winnipeg Sandstone and Red River Carbonate aquifers and the implication of a water quality change in response to degradation of the Winnipeg Shale.

d) Please see the Responses to the Technical Expert Reports – Hydrogeology, filed November 29, 2022, issue #7 and #8 for a discussion of interconnection between the Winnipeg Sandstone and Red River Carbonate aquifers and the implication of a water quality change in response to degradation of the Winnipeg Shale.

e) Please see the Responses to the Technical Expert Reports – Hydrogeology, filed November 29, 2022, issue #16. It should be clarified that the hydraulic gradients between the two aquifers are relatively small (~0-2m), suggesting that the permeability of the shale is much less important in the study area than previously thought. The relatively small vertical gradients indicate groundwater flow is primarily horizontal through the Project Site Area. The Winnipeg Shale Aquitard is not the only element that limits the interaction between the two aquifers.

f) Please see the Responses to the Technical Expert Reports – Hydrogeology, filed November 29, 2022, issue #7 for a discussion of interconnection between the Winnipeg Sandstone and Red River Carbonate aquifers. Please also refer to the response to MSSAC-IR-023.

The aquifer is already interconnected due to termination of both aquifers at the eastern subcrop. Groundwater modelling evaluated the influence of both alternative scenarios, and indicated that the interconnections could reduce the magnitude and extent of drawdown in the Winnipeg Sandstone (i.e. pumped aquifer) and increase the magnitude and extent of drawdown in the overlying Red River Carbonate aquifer if the shale collapses immediately after each extraction well is drilled. This suggests that overall impacts on the quantity of water will be the same, but they will be distributed more evenly across two aquifers rather than one. The impacts on water quality were simulated to be both positive and negative (depending on the element) and minor.

In the long term, the aquifers will likely remain interconnected within the Project Site Area. Impacts are anticipated to be similar to those presently observed near the numerous water supply wells that interconnect both aquifers. It is AECOM's understanding that these impacts are negligible to minor in the Project Site Area where the groundwater in both aquifers is fresh.

IR Number: **MSSAC-IR-025**

Submitted by: MSSAC

Date Submitted: November 8, 2022

Subject Matter: Hydrogeological

Reference:

i) 19 September 2022 Technical Review of Sio Silica Corporation's (Formerly CanWhite Sands Corp.) Environment Act Project Proposal (Hollander and Woodbury); and

ii) 23 July 2021 Can White Sands Corp. Vivian Sand Extraction Project, Environment Act Proposal – Parts 1 and 2 and Appendix A (Public Registry 6119.00)

Preamble: 3D Digital Model. Shale can be discontinuous regionally, but in the model it is assumed to be continuous and is setup in the model as such. Once excavation cavity develops, aquifer properties will change [e.g. permeability could increase by 1 order of magnitude], and may be significant; this was not addressed in the model. No porosity provided for the sand zone; the sands may liquify and flow. Pressure heads in the two aquifers have been equilibrating since 2018, reflecting wells straddling both aquifers. Saline waters from the west aquifer boundary could migrate east due to overproduction of fresh water, but also density effects can be more significant which were not assessed in the model. The 3-D model grid did not adequately assess the time varying of parameters which would change with cavern or void developments, drawdown cones, and subsidence. Use of constant heads – not known if removed. Insufficient detail given to assess if appropriate calibration has been achieved; especially hydraulic parameters. Need steady state, then transient model – then predictions. There is no matching to existing data base. Model simulation – pumped for 4 years without altering K in sand member or adding potential effects of a shale aquitard failure. Scenarios with 50% and no recharge were assessed; whereas intent is to recharge essentially 100% of the pumped water. Parameter sensitivity – There is Uncertainty in the model predictions. Heterogeneity of the aquifers not assessed, assumed homogeneous. The lithology at the site is described by the proponent in their conceptual model in terms of large zones and/or layers representing homogeneous aquifers and aquitards. However, there is considerable information on material heterogeneity not considered by the proponent. Certainly, if there is any information available at the site on heterogeneities, this should be considered in the numerical model. 3D Model Boundary condition with Wpg Formation Carman Sand Member directly connected to Red River is incorrect.

Request:

a) Given the many notes above, there are misinterpretations, misrepresentations, or short term to long term risks that may be realized based on each of the model setup and/or simulation deficiencies that were identified. Do you agree? If not, provide multiple lines of evidence why you disagree.

b) Why is the shale aquitard modeled as continuous when it is not in reality?

c) Why were density effects, which may affect flows within the aquifer systems, not modeled?

d) The aquifers are modeled as homogeneous; is this representative when in reality they are not and there is regional data that demonstrates they are not?

e) Why is the Carman Sand Member connected to the Red River boundary condition in the model when in reality they are not interconnected?

f) Explain why the zero recharge and 50% groundwater recharge scenarios were modeled, and the 100% recharge scenario was not.

g) Please explain in detail the calibration process and what steps in the process (i.e. steady state, transient, then predictive models) were used to demonstrate a robust and representative model, when it is not clear that appropriate calibration was achieved.

h) The model does not address changes in physical properties of the aquifer system with cavern development that will occur over the first 4 years of development, which are likely to be significant, how then is the model representative? Give multiple lines of evidence.

i) The model does not address changes in physical properties of the shale aquitard system with cavern development that will occur over the first 4 years of development, which are likely to be significant, how then is the model representative? Give multiple lines of evidence.

j) A model is to be representative of the full duration of a project and this one is not; why does the model not simulate the full 24 years of proposed development and only addresses the first 4 years of development?

k) Please elaborate on what "industry standard" methods were used to interpret geology and evaluate the impacts of project operations on groundwater quantity and quality, given that there are several misinterpretations of geology (i.e. continuity and not addressing existing leakance of the shale aquitard) that were not addressed correctly in the model.

Response:

a) AECOM disagrees with the claim that items are missing or misinterpreted/misrepresented. Many of the alleged deficiencies noted in the preamble were, in fact, completed and thoroughly documented in the Hydrogeology and Geochemistry Assessment Report.

Refer to the Responses to the Technical Expert Reports – Hydrogeology, filed November 29, 2022, issues #3, #5, #6, #9, #12, #13 for discussion with regard to porosity estimation and aquifer properties.

Refer to the Responses to the Technical Expert Reports – Hydrogeology, filed November 29, 2022, issues #10 and #28 for discussion with regard to salinity and density effects in the three-dimensional model.

Refer to the Responses to the Technical Expert Reports – Hydrogeology, filed November 29, 2022, issues #5 and #32 for discussion with regard to model calibration approach.

Refer to the Responses to the Technical Expert Reports – Hydrogeology, filed November 29, 2022, issues #13 for discussion with regard to model simulation in response to collapse of the shale aquitard. The hydraulic properties of the shale unit after extraction were adjusted in the FEFLOW groundwater model by way of scenario analysis (shale remains intact vs. degraded) to explore the influence of possible shale degradation in response to mining.

Refer to the Responses to the Technical Expert Reports – Hydrogeology, filed November 29, 2022, issues #17 and #33 for discussion with regard to aquifer heterogeneity.

Refer to the Responses to the Technical Expert Reports – Hydrogeology, filed November 29, 2022, issues #5 and #34 for discussion with regard to boundary condition.

b) As discussed in detail in Section 5.6.3 of the Hydrogeology and Geochemistry Assessment, "*Several boreholes within the Regional Project Area and groundwater model domain do not report the presence of shale, even where it appears on the geologic map and cross sections. Given the long history of groundwater exploration and development in this area, it is possible that these units were not split out as the upper (Red River Carbonate) and lower (Winnipeg Sandstone) aquifers were historically viewed as one groundwater resource. The presence of an aquitard may not have been viewed as important information historically because the shale is not one of the aquifers targeted by water well drillers. Historical drilling methods may not have observed a relatively thin unit. Even contemporary drilling methods employed to install many of the recent wells (i.e. air rotary, dual rotary or mud rotary) do not produce cuttings that are easily logged due to homogenization as they travel upward through the borehole to surface.*

Sedimentary sequences are typically deposited in laterally continuous layers and most boreholes report the presence of the Winnipeg Shale, and it is AECOM's interpretation that the Winnipeg Shale is continuous across the study area from the edge of the Williston Basin at the Sandilands subcrop westward (i.e. where it is mapped on the regional geology maps). This interpretation is consistent with most of the literature reviewed for this study."

The sensitivity of modelling results to the presence, continuity and hydraulic properties of the Winnipeg Shale has also been evaluated and the impacts of this assumption have been characterized as shown in

Tables 6-1 and 6-2 of the Hydrogeology and Geochemistry Assessment Report.

c) Refer to the Responses to Technical Expert Reports – Hydrogeology, filed November 29, 2022, issues #10 and #28 for discussion with regard to salinity and density effects in the three-dimensional model.

d) Refer to the Responses to Technical Expert Reports – Hydrogeology, filed November 29, 2022 issue #17, and #33, for discussion with regard to aquifer heterogeneity.

e) Refer to the Responses to the Technical Expert Reports – Hydrogeology, filed November 29, 2022 issues #5, #18, #31 and #34 for discussion with regard to boundary condition.

f) Refer to the Responses to the Technical Expert Reports – Hydrogeology, filed November 29, 2022 issue #22 for a discussion on the modeled scenarios.

g) Refer to the Responses to the Technical Expert Reports – Hydrogeology, filed November 29, 2022 issue #5 and #32 for discussion with regard to model calibration approach.

h) The author is requested to refer to in the Reponses to the Technical Expert Reports – Hydrogeology, filed November 29, 2022 issues #3, #5, #6, #9, #12 and #13, as questions are the same. Evaluation of the influence of sand extraction on the integrity of the subsurface was conducted by geotechnical engineers (Stantec 2021) as part of related studies to evaluate the possibility of subsidence and inform project design.

i) The author is requested to refer to in the Reponses to the Technical Expert Reports – Hydrogeology, filed November 29, 2022 issues #12 and #13 as questions are the same. See also response MSSAC-IR-025(b) above and MSSAC-IR-023(b).

j) Refer to the Public Comments responses key issue/response 185 filed January 14, 2022:

"The extraction method at this time is proven and repeatable as tests have been conducted and successfully carried out. Separating the Project into 4-5 year groupings, with Notices of Alteration to be filed as needed, will allow for improvements in methodology as well as any changes in environmental impact that might arise from relocating the specific sites of extraction activities. Improvements could include, for example, potential efficiencies in the extraction method to reduce the overall number of wells needed per year. Additionally, land ownership and uses do change over time, and therefore site selection for a full 24 years would not be efficient or appropriate."

The author is also requested to refer to the Reponses to the Technical Expert Reports – Hydrogeology, filed November 29, 2022 issue #1, as questions are the same.

k) Industry standard methods include utilization of staff with education and experience in hydrogeology and groundwater modelling, application of methods that have a sound theoretical basis, following regulatory guidelines, interpretation of data using sound geological principles, conducting an extensive literature review, following industry guidelines for groundwater modelling (e.g. BC MoE 2012), utilization of peer-reviewed software and codes (AQTESOLV Professional 4.5, PHREEQC, FEFLOW, etc.), analysis of environmental samples at Canadian Association for Laboratory Accreditation (CALA) certified laboratories, and application of professional judgment.

   Refer to the Responses to Technical Expert Reports – Hydrogeology, filed November 29, 2022, issues #3, #4, #6, #8, #9, #17, #18 and #19 for discussion with regard to characterization of aquifers and incorporation of field data into the three-dimensional model. The alleged "misinterpretations of geology" are in fact geological simplifications that were knowingly made as is routine in the field of applied hydrogeology.

IR Number: **MSSAC-IR-026**

Submitted by: MSSAC

Date Submitted: November 8, 2022

Subject Matter: Hydrogeological

Reference:

i) 19 September 2022 Technical Review of Sio Silica Corporation's (Formerly CanWhite Sands Corp.) Environment Act Project Proposal (Hollander and Woodbury); and

ii) 23 July 2021 Can White Sands Corp. Vivian Sand Extraction Project, Environment Act Proposal – Parts 1 and 2 and Appendix A (Public registry 6119.00)

Preamble: Geochemistry: The analysis for acid mine drainage, aqueous geochemistry and stable isotopes were carried out at only one location and on limited samples. No water quality changes were evaluated for mining operations or shale collapse impacts. Any impacts related to groundwater quality are not investigated. The goal with regard to water qualify was also somehow unclear, as the report recommends a water quality study which should have been finalized at this point. It should be considered that changes to the flow, pH, and redox conditions within the aquifer due to the mining activities could result of leaching into the aquifer itself. By this pathway, any geochemical changes become exposed via drinking water as well. The geochemical modelling selected a couple of low-risk scenarios and did not seek to address two major issues - a reduced water quality in general, or risk to human, aquatic, or agricultural life. Information on the setup of the model to examine the impact of redox conditions is missing. Standard information such as time series (and the period) or steady state, a list of minerals that was at equilibrium with the water, and which data source were used (XRD or shake flask) needs to be added.

Request:

a) Based on the state of the limited state of geochemical studies and geochemical modelling completed to date, is there confidence that there is a robust understanding of the potential geochemical impacts to the aquifer systems, including possible variability that could be realized? If yes provide multiple lines of evidence why.

b) What are the risks that the groundwater quality will be irreversibly impacted, rendering a source of potable water unusable?

c) How will any change in groundwater chemistry be measured, what are the allowable changes of what parameters, and what actions will be taken if there is a change?

d) Can aquifer water quality changes be measured in real time, over the vast geography and time frame (24 years) proposed here, and practically and effectively acted on in time to mitigate an irreversible degradation of the aquifer system? If yes, how will this be done?

Response:

a) Please refer to the Reponses to the Technical Expert Reports – Hydrogeology, filed November 29, 2022 issue #8.

As indicated in the Hydrogeology and Geochemistry Assessment Section 4.2.2 – Stable Isotopes of Hydrogen and Oxygen: Stable isotopes analyses were carried out on numerous samples from different depths, hydrostratigraphic units and before and after the pumping tests. The depth profile fully captures the variability of isotopic composition and the effect of recharge period on the isotopic signature. Processes such as latitude, altitude, and evaporation that generally alter the lateral variation of isotopic composition via fractionation are regional and are not expected to impact the isotopic composition at the Project Site.

b) Refer to the responses to MSSAC-IR-021(e), MSSAC-IR-017 and MSSAC-IR-020a.

As stated in the Hydrogeology and Geochemistry Assessment Section 8.3 – Groundwater Quality:

"Overall, material impacts to groundwater quality within the Project Area are unlikely because both the Red River Carbonate and Winnipeg Sandstone host fresh and relatively dilute groundwater. Based on the results of geochemical modelling, the activities associated with project operations and post-closure phases of the project were determined to have only a minor impact on groundwater quality. In many cases, the impact was simulated to be positive due to reduction of concentrations of iron and manganese when oxygen is introduced into the aquifer or is allowed to mix with water containing lower concentrations of those elements. Should project operations result in a more interconnected aquifer system comprising the Red River Carbonate aquifer and the underlying Winnipeg Sandstone aquifer, groundwater quality would tend to reflect conservative mixing of the two water types (i.e. limited geochemical reactions). Although the naturally elevated concentrations of dissolved iron and manganese were simulated to decrease in response to aeration or mixing, they may remain elevated above drinking water quality criteria during and following operations.

Although the injection of oxygenated water may reduce concentrations of iron and manganese in the vicinity of extraction wells, it is not anticipated to induce ML/ARD reactions due to the very low to absent concentrations of minerals prone to oxidation (i.e. pyrite and pyrrhotite). This is supported by the presence of very good water quality in both aquifers today. The vertical gradients between the two aquifers are downward and near neutral such that the magnitude of any inter-aquifer exchange during and following project operations is likely to be small."

c) The Hydrogeology and Geochemistry Assessment recommended a Groundwater Monitoring and Impact Mitigation Plan be developed and implemented prior to, during and following operations to establish a robust monitoring program that is able to detect changes in response to operations and guide mitigation measures. It is not a study, but rather an operational monitoring and management plan that will guide implementation of mitigation measures in the event they are required. These are typical of all industrial projects and may be requirements of permits following completion of environmental assessment/permitting. The Groundwater Monitoring and Impact Mitigation Plan will establish a program for monitoring of groundwater levels and quality to confirm the results of the Hydrogeology and Geochemistry Assessment and ensure that operations do not negatively affect the quantity or quality of water in the aquifer.

Also refer to the response to MSSAC-IR-017(d).

d) Yes, some aquifer water quality parameters can be monitored in real-time. Sio intends to install monitoring wells in the areas where operations will occur and monitor long term. As stated in the response to CEC-IR- 003(a), “These monitoring locations will always be between the operations and any landowner wells.“

Also refer to the response to MSSAC-IR-022(d).