

Vivian Sand Extraction Project

Progressive Well Abandonment Plan

Sio Silica Corporation

Project number: 60640258

February 3, 2023

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1. Introduction

1.1 Initiation

AECOM Canada Ltd. (AECOM) was retained by Sio Silica Corporation (Sio Silica) to develop a Progressive Well Abandonment Plan for use during the operation of the Vivian Sand Project located near Vivian, Manitoba. The project involves extraction of silica sand from the Carman Sand Member of the Winnipeg Formation using a series of boreholes (extraction wells) over a period of five years. The Progressive Well Abandonment Plan was a recommendation of the Hydrogeology and Geochemistry Assessment (AECOM 2021) and is required to meet regulatory requirements and protect groundwater quantity and groundwater quality.

1.2 Objectives

The objectives of the Progressive Well Abandonment Plan are to:

- Establish a framework for tracking the drilling, installation, operation and closure of all boreholes, monitoring wells and extraction wells over the life of the Vivian Sand Project.
- Describe protocols for timely abandonment of all boreholes, monitoring wells and extraction wells over the life of the Vivian Sand Project.
- Assess and monitor the effectiveness of the mitigation measures over time.
- Establish a framework for reporting findings to the community and regulatory agencies.

1.3 Background

Sio Silica intends to develop and operate an in-situ sand extraction operation in southeastern Manitoba, and approximately 35 km east of Winnipeg. It will involve extraction of sand resources of the Carman Sand Member of the Winnipeg Formation for commercial and industrial use.

In 2020, AECOM conducted a detailed Hydrogeology and Geochemistry Assessment (AECOM 2021) of the proposed *in-situ* silica sand extraction operation. This assessment included an environmental impact assessment and supported the overall environmental assessment of the extraction component of the project, focusing on aspects that have the potential to impact the quantity or quality of groundwater in the Red River Carbonate or Winnipeg Formation aquifers. The potential for surface water quality impacts due to extraction and storage of other geologic materials (e.g., drill cuttings) was also evaluated.

A three-dimensional regional scale groundwater model was developed to simulate the influence of the project on groundwater levels and groundwater quantity over the life of the project. Overall, project activities were found to have only a minor, short-term and reversible impact on groundwater quantity and quality provided the following monitoring and mitigation plans were implemented:

1. Waste Characterization and Management Plan
2. Water Management Plan
3. Progressive Well Abandonment Plan
4. Groundwater Monitoring and Mitigation Plan

This Progressive Well Abandonment Plan (the Plan) is a core mitigation measure that is required to meet regulatory requirements and protect the groundwater resource.

1.4 Project Activities

The proposed project will consist of the following key activities and components proposed to be permitted under an *Environment Act* Licence:

- Establishment of temporary access trails to annual sand extraction areas to accommodate water well drill rigs.
- Extraction well drilling and installment of sand and water slurry piping infrastructure within each extraction well for several wells per year.
- Construction of above-ground piping, and construction and operation of pumping stations to transport the sand and water slurry directly to the adjacent sand processing facility.
- Dismantling and relocating the above-ground piping and pumping stations to the subsequent annual sand extraction area.
- Return of excess groundwater through the extraction wells to the aquifer following appropriate treatment.
- Progressive decommissioning of annual extraction wells using a concrete cap, bentonite grout and permeable backfill layers in accordance with the *Groundwater and Water Well Act*.
- Progressive annual rehabilitation of well clusters, temporary drill rig access trails, slurry pipe routes and groundwater return pipe routes.

Sand extraction wells will be sequentially drilled, operated and progressively decommissioned over time. Extraction wells will be used to extract sand and groundwater from the Carman Sand Member of the Winnipeg Formation at an approximate depth of 51 m to 76 m (170 ft to 200 ft) below ground surface. Extraction wells will be drilled using dual rotary drilling methods. The Winnipeg Formation is located below thick overburden deposits and the Red River Formation which is comprised of a carbonate aquifer and an underlying shale aquitard that forms the boundary between the Red River Formation and the underlying Winnipeg Formation.

The sequence of activities during sand extraction is presented in Hydrogeology and Geochemistry Assessment (AECOM 2021). Extraction wells will be utilized to extract the sand and groundwater slurry which will be conveyed to a surface dewatering system and collection tank to allow for screening and separation of the majority of the groundwater from the sand. The surplus groundwater will then be passed through a filtration system and ultraviolet (UV) treatment system to destroy any bacteria prior to reinjection into the aquifer. Following operations, the extraction wells will be decommissioned.

Boreholes will be advanced during the project to investigate geotechnical and hydrogeological conditions in advance of extraction activities. Boreholes and monitoring wells will be advanced using mud rotary drilling methods through the overburden. Air rotary drilling methods will be utilized to advance the boreholes through the Red River Carbonate aquifer. Mud rotary drilling will resume in the Winnipeg Shale and Winnipeg Sandstone.

Some boreholes will be completed as monitoring wells to allow for hydrogeological testing, and monitoring of groundwater levels and groundwater quality prior to, during and following extraction activities as described in the Groundwater Monitoring and Mitigation Plan. Boreholes not completed as monitoring wells will be backfilled with cement/bentonite grout to establish a hydraulic seal and prevent migration of surface water and/or groundwater along the borehole annulus as described herein. A locked protective steel surface monument will be installed to maintain the integrity of monitoring wells to allow for groundwater monitoring as described in the Groundwater Monitoring and Mitigation Plan.

2. Regulatory Setting

2.1 *The Groundwater and Well Act*

The installation, operation and abandonment, also referred to as sealing, of groundwater wells in Manitoba is governed by *The Groundwater and Water Well Act (C.C.S.M. C. G110)*. The purpose of the act includes protection and stewardship of Manitoba's aquifers and groundwater and to ensure that the construction, maintenance and sealing of wells and test holes meet standards that protect Manitoba's aquifers and groundwater.

The *Groundwater and Water Well Act* has exclusions for wells or test hole to which *The Mines and Minerals Act (C.C.S.M. C. M162)* applies. Because the Vivian Sand Project is licensed under *The Mines and Minerals Act* and is utilizing groundwater, both acts will be considered in this Progressive Well Abandonment Plan.

The Groundwater and Water Well Regulation establishes the requirements for licensing of well drilling contractors, insurance, permitting, license and renewal fees, well construction and sealing reports, and protocols for emergency response. It defines saline water as “*water that has (a) a concentration of total dissolved solids in excess of 3,500 mg/l; or (b) an equivalent electrical conductivity in excess of 5,000 micro-Siemens/cm.*”

The Well Standards Regulation establishes the requirements for construction and sealing of wells or test holes, interconnection of geologic formations, review of artesian conditions, construction or sealing of flowing artesian wells or test holes, covering of wells or test holes during construction or sealing, materials and additives used in the construction, sealing, rehabilitation, maintenance, or servicing of a well or test hole.

Section 2e) of the Well Standards Regulation requires “*A person must not construct or seal a well or test hole other than in a manner which:*

- (a) Is suitable for the geologic and groundwater conditions existing at the site of the well or test hole;*
- (b) Prevents surface water from entering the well or test hole;*
- (c) Prevents contaminants from entering the well or test hole except in the case of an environmental well or environmental test hole;*
- (d) Seals off water bearing formations that contain contaminants except in the case of an environmental well or environmental test hole; and*
- (e) Prevents the interconnection or mixing of groundwater having distinctly different characteristics within the same aquifer or different aquifers.*

2.1.1 Well Construction Requirements

Well construction is regulated by the *Well Standards Regulation 215/2015* of G110.

Wells are to be constructed such that:

- They are suitable for the geologic and groundwater conditions existing at the site of the well.
- It prevents surface water from entering the well or test hole.
- It prevents contaminants from entering the well.
- It seals off water bearing formations that contain contaminants except in the case of an environmental well or environmental test hole.
- It prevents the interconnection or mixing of groundwater having distinctively different characteristics within the same aquifer or different aquifers.
- It is located at least 1.5 m (5 ft) from any property boundary.
- It is located such that upon completion of construction it is accessible for cleaning, treatment, maintenance, repair, testing, inspection, and visual examination.
- Wells will not be built with well pits if the water is intended for domestic purposes.
- Well casings will be a minimum of 6 m (20 ft) below the surface and a minimum of 30 cm (1 ft) above the ground surface or final constructed surface and be constructed from new watertight materials.
- The well is vented to the outside atmosphere in a manner that will safely disperse all gases.

2.1.2 Well Sealing Requirements

Well construction is regulated by the *Well Standards Regulation 215/2015* of G110. Wells are to be sealed immediately if the following conditions are encountered during construction:

- Any supplemental test holes from which the required information has been obtained.
- Wells or test hole is not completed due to a construction problem or any other reason.
- Dry wells or test holes, unless the well or test hole is being used for monitoring wells or a geotechnical well.
- Wells or test hole is found to have been constructed in contravention of any provision of the Act (G110) and not brought into compliance.

2.2 The Mines and Minerals Act

The object and purpose of *The Mines and Minerals Act* (C.C.S.M. C. M162) is to provide for, encourage, promote and facilitate exploration, development and production of minerals and mineral product in Manitoba, consistent with the principles of sustainable development. Part 6 of the *The Mines and Minerals Act* outlines requirements of drilling including the requirements for a Borehole License. Section 98 requires that “*The holder of a borehole licence shall drill and abandon a borehole in accordance with the regulations and in compliance with such other stipulations and conditions that the director specifies.*”

The Drilling Regulation is administered under *The Mines and Minerals Act* and outlines the requirements that must be addressed when drilling, including licensing of boreholes, managing waste, abandoning boreholes and requirements around movement of fluids between aquifers. Section 6 discusses the movement of fluid between aquifers:

6(1) A licensee shall drill and abandon a borehole in such a manner as to prevent the vertical movement of fluids between permeable water bearing zones penetrated by the borehole.

6(2) For the purposes of this section, a “permeable water bearing zone” means a section of rock that produces water, or a zone in which drilling fluid is lost.

Section 7 discusses the abandonment of boreholes:

The holder of a borehole licence shall, before expiry of the licence, abandon every borehole drilled under the licence by

- (a) Grouting the entire borehole to ground surface using the Tremie technique to place a neat mixture of sulphate resistant (CSA Type 50) grout that will produce a minimum strength of 41,000 kPa; or*
- (b) Using mechanical plugs in combination with Tremie grouting as described in a plan submitted with the borehole licence application, to permanently prevent vertical movement of aquifer fluids between permeable water bearing zones.*

2.3 Abandoned Wells

Manitoba regulations define an abandoned well as “a well or test hole not in present use and not maintained for future use and includes a well or test hole declared by the director”.

Abandoned wells that remain unsealed, abandoned wells may act as conduits for the movement of near-surface contaminants into the aquifer so it is important to properly seal them. Unsealed wells can also pose a risk of interconnecting fresh water and saline water aquifers and if the wells have large diameter openings, pose a hazard to individuals.

The responsibility to seal an abandoned well rests with the owner of the land on which the well is located (the landowner). However, the responsibility for well abandonment will rest with Sio Silica and will be formalized in the land access agreement(s) for any well constructed or operated by Sio Silica. Sio Silica will ensure the well is sealed “in a manner that is sufficient to prevent the vertical movement of water or other substances in it”.

A well which is not currently in use but may be used for water supply purposes in the future is not considered to be abandoned if it is properly maintained. Such wells should have sufficient casing stick-up and be capped to prevent any foreign materials from entering the well.

2.4 Responsibility for Well Sealing and Abandonment

Well sealing must be performed by the owner or licensed well drilling contractor. Well drilling contractors are required to seal wells of the following categories:

- Flowing artesian well
- Injection wells
- Contaminated wells
- Saline wells
- Wells with remaining equipment, pumps, or debris.

In some instances, the proper sealing of an abandoned well can be accomplished by the owner using appropriate techniques and materials to fill and seal the well.

3. Preparation for Well Sealing and Abandonment

Any extraction wells or monitoring wells that are no longer required for project operations or monitoring of groundwater will be decommissioned in a manner that satisfies regulatory requirements outlined above.

In advance of sealing, the well depth will be obtained from the well construction report and then confirmed via direct measurement using a manual water level tape. If the current depth is significantly different than expected there may be an obstruction which may have to be removed prior to sealing. Well construction records will be reviewed to determine the number and nature of geological units and aquifers encountered during well installation.

Depending on the final construction of the well to be sealed, the following items will be removed in advance of sealing:

- Electrical service to the well will be disconnected at the source.
- Pumps or hoses remaining within the well will be removed.
- Any service lines connected to the well will be disconnected and sealed.
- Extraction equipment.

If any equipment such as a pump, debris or an obstruction cannot be removed from the well, a professional engineer or professional geoscientist will need to determine an appropriate method for properly sealing the well.

4. Well Sealing Requirements

All boreholes, monitoring wells and extraction wells installed for the Vivian Sand Project will be properly sealed during their construction and abandonment to meet or exceed regulatory requirements. Requirements for drilling and sealing of boreholes are established by the Drilling Regulation under *The Mines and Minerals Act*. All monitoring wells and water supply wells are interpreted as being classified as Class 1 water wells under the Groundwater and Well Regulation and *The Groundwater and Water Well Act*.

4.1 Timeframe for Sealing

Boreholes, sand extraction wells, groundwater wells and monitoring wells will be sealed as soon as practical after they are no longer required to support project operations or monitor groundwater in accordance with the Groundwater Monitoring and Mitigation Plan. The timeframe for sealing and well abandonment are described below:

- Boreholes and Sand Extraction Wells: Boreholes and extraction wells will be sealed within one year of installation to satisfy the requirements of the Borehole License after they are no longer required for operations. Efforts will be made to seal wells in a timely manner following extraction.

- **Operational Groundwater Monitoring Wells:** Groundwater monitoring wells that are utilized to monitor operational performance of extraction wells will be sealed within one year of the end of sand extraction from nearby well clusters or following completion of post-extraction groundwater monitoring.
- **Long-Term Groundwater Monitoring Wells:** Long-term groundwater monitoring wells will be sealed following completion of post-extraction groundwater monitoring, which is estimated to be five years or more following the end of sand extraction. The Groundwater Monitoring and Mitigation Plan specifies the schedule for monitoring of groundwater.

All boreholes, sand extraction wells, groundwater wells and monitoring wells will be monitored and maintained in good working order until they are sealed.

4.2 Sealing Materials

Sealing materials will meet the requirements of the Drilling Regulation under *The Mines and Minerals Act*, or the Groundwater and Well Regulation and Well Standards Regulation under *The Groundwater and Water Well Act*.

- Grout will be a neat mixture of sulphate resistant (CSA Type 50) grout.
- The grout mixture will be tested in advance to ensure it is able to produce a minimum strength of 41,000 kPa after 28 days of placement.
- Bentonite chips, bentonite pellets, pea gravel, cement or other inert materials may be used to supplement grout and affix a lockable protective well casing at ground surface (monitoring wells only).
- Water from the same aquifer or potable water will be used to mix grout or hydrate bentonite sealing materials.

4.3 Seal Configuration and Implementation

4.3.1 Boreholes

Sealing of boreholes will be completed as follows:

- All drilling equipment and instrumentation will be removed from each borehole in advance of sealing.
- The Tremie pipe will be extended from ground surface to the bottom of the borehole.
- Grout will be mixed to form a neat mixture of sulphate resistant (CSA Type 50) grout. It may be amended with bentonite to improve or reduce flowability to improve pumping or reduce formation loss.
- The grout mixture will produce a minimum strength of 41,000 kPa after 28 days of placement.
- Grout will be mixed in sufficient volume to fill the borehole to ground surface.
- Grout will be placed using Tremie grouting techniques to establish a continuous seal over the entire length of the borehole.
- One day after the grout is placed, the depth to the top of the grout seal will be measured to confirm it extends to within 1.5 m (5 ft) of ground surface. If it does not extend to ground surface due to settlement, formation loss or for other reasons, additional grout will be placed until the surface of the grout plug is stable and within 1.5 m (5 ft) of ground surface.
- The details of the grout mixture and sealing procedure will be documented and submitted to regulatory agencies in fulfillment of reporting requirements.

4.3.2 Sand Extraction Wells

Sealing of sand extraction wells will be completed as follows:

- All drilling or extraction equipment and instrumentation will be removed from each sand extraction well in advance of sealing.
- A mechanical plug will be installed within the well casing to prevent the movement of water within the well casing and allow for the establishment of a cement/grout seal.

- A 3 m (10 ft) long grout plug will then be placed using a Tremie grout system and allowed to set overnight. The depth to the top of the grout plug will be confirmed by manual measurement prior to placement of additional materials.
- Grout will be mixed to form a neat mixture of sulphate resistant (CSA Type 50) grout. It may be amended with bentonite to improve or reduce flowability to improve pumping or reduce formation loss.
- The Tremie pipe will be extended from ground surface to the bottom of the borehole. Grout will be placed using Tremie grouting techniques to establish a continuous seal over the entire length of the borehole. Alternatively, alternating layers of bentonite and pea gravel or suitable native material may be placed to within 1.5 m (5 ft) of ground surface. Where pea gravel or native material and bentonite are used, no more than 15 feet (4.6 m) of pea gravel will be used before another layer of bentonite. Care will be taken to ensure low permeability materials are placed across any interfaces between aquifers (e.g., the limestone to the overburden interface) to prevent vertical mixing of the aquifers.
- One day after the grout and/or sealing materials are placed, the depth to the top of the grout seal will be measured to confirm it extends to ground surface. If it does not extend to ground surface due to settlement, formation loss or for other reasons, additional grout will be placed until the surface of the grout plug is stable and within 1.5 m (5 ft) of ground surface.
- A 1.5 m (5 ft) thick cement cap will be placed above the sealing materials and allowed to set prior to placement of a layer of at least one metre of topsoil and organics mounded and graded on top of the cement to allow for revegetation of the surface of the land and promote runoff.

4.3.3 Shallow Wells

For wells less than 30 m (100 ft) and less than 15 cm (6 in) in diameter the entire well volume will be filled with low permeability sealing materials. Remove the upper 2 m (5 ft) of casing below ground surface. The remainder of the hole will be filled with bentonite, tamped in 30 cm (1 ft) layers to prevent any future excavation from potentially disturbing the sealed well. The well will then be covered with a layer of topsoil, mounded, and graded to allow for some settlement of well sealing materials and to promote runoff.

4.3.4 Small Diameter Wells

Wells constructed with 5 cm (2 in) diameter well casings and screens and a depth greater than 30 feet will be sealed using slurry grout over the full length of the well. The upper 2 m (5 ft) of casing will be removed. The remainder of the borehole will be filled with bentonite, tamped in 30 cm (1 ft) layers to prevent any future excavation from potentially disturbing the sealed well. The well will then be covered with a layer of topsoil, mounded, and graded to allow for some settlement and to promote runoff.

4.3.5 Deep and Large Diameter Wells

For wells greater than 30 m (100 ft) or more than 15 cm (6 in) in diameter, sand and gravel will be used as a filling material by alternating layers of 3 to 5 m (10 to 15 ft) of gravel and 1 m (3 ft) low-permeability (cement and/or bentonite) material. This will create a series of low-permeability layers which will prevent the vertical movement of water within the well.

Wells will be filled with alternating layers of sand and gravel and low-permeability material from the bottom of the well through the screened zone or open hole to approximately 3 m (10 ft) below the bottom of the casing. Bentonite chips will be slowly added until the level of the bentonite chips is about 3 m (10 ft) above the bottom of the casing. This will seal the interface between the bottom of the casing and screened or open hole portion of the well.

The remainder of the well will be slowly filled with alternating layers of 3 to 5 m (10 to 15 ft) of gravel and 1 m (3 ft) of low-permeability material to near ground surface. Low-permeability materials must be placed in the topmost 2 m (5 ft) of casing. The placement of the surface seal will depend on whether any casing is removed.

It is recommended to remove an upper portion of the casing to a depth of 2 m (6 ft) below ground surface). The remainder of the hole should be filled with clay, tamped in 30 cm (1 ft) layers to prevent any future excavation from potentially disturbing the sealed well. The well should then be covered with a layer of topsoil, mounded, and graded to allow for some settlement and to promote runoff.

4.3.6 Flowing Artesian Wells

The entire length of the well will be sealed using cement grout or a suitable mixture of sand-cement or bentonite cement grout. The seals will be confirmed to be stable through routine monitoring.

4.4 Contamination Found During Sealing

Drilling waste will be managed in accordance with the Waste Characterization and Management Plan. This will minimize the potential for sediment and associated wastes to enter boreholes, sand extraction wells or groundwater monitoring wells. All other materials that have the potential to contaminate soil or groundwater will be managed in accordance with Standard Operating Procedures including Spill Management Plans. Surface runoff will be directed away from boreholes and wells to minimize the potential for infiltration of contaminated surface water into the underlying aquifers.

If, during the sealing of an abandoned well, contamination or suspected contamination of groundwater or soil adjacent to groundwater is found, the person performing the work will immediately:

- Stop the sealing work; and
- Report the finding of contamination or suspected contamination by calling Manitoba's emergency response office at 204-944-4888.

The sealing work cannot resume unless authorized by Manitoba Sustainable Development.

Suspected contamination is defined as groundwater or soil emits an odour; is visibly discoloured or is otherwise altered in appearance in such a manner that a reasonable person would believe the groundwater or soil to be contaminated.

5. Quality Assurance and Quality Control

A Quality Assurance and Quality Control Program will be implemented to confirm the grout mixture is consistent over the life of the project and that it meets the specifications required by the Well Standards Regulation and Drilling Regulation. This will involve:

- Employment of licensed well drillers for drilling of boreholes and installation of sand extraction and groundwater monitoring wells.
- Sealing of boreholes by staff with experience installing well seals.
- Utilization of grout mixtures and sealing materials that have been confirmed to meet regulatory requirements.
- Testing of grout mixtures to confirm they meet specified strength requirements.
- Developing and maintaining a database that documents the status of all boreholes, monitoring wells and sand extraction wells.
- Compilation and analysis of information to confirm the Progressive Well Abandonment Plan is effective.
- Management of drilling waste in accordance with the Waste Characterization and Management Plan.
- Monitoring and evaluating groundwater quality data collected under the Groundwater Monitoring and Mitigation Plan.

6. Reporting

Details of the well sealing activities and the materials and methods uses will be provided in a Well Sealing Report to the Manitoba Groundwater Management Section. It will include the details of the grout mixture and sealing procedure including the GPS coordinates of each well.

