

# **Comments on the Vivian Sand Facility Project Public Registry no. 6057.00**

by

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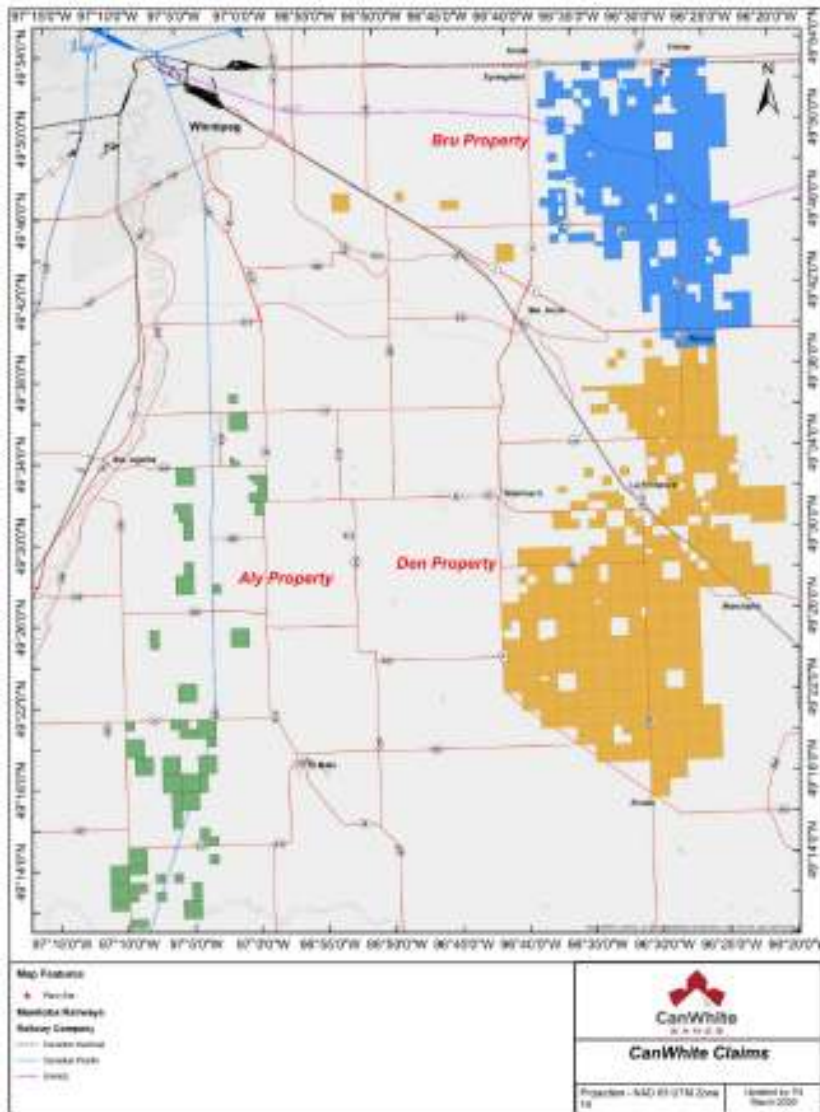
## **1. Introduction**

The major concerns we have with the Vivian sand Facility Project include;

- The amount of water withdrawn by solution mining will be beyond the sustainable yield of the sandstone aquifer of the Winnipeg Formation;
- Pyrite in the sand, and oolite within the aquifer and pyrite in the shale layer above the aquifer will generate acid when exposed to air injected for sand extraction. The acid will mobilize heavy metals in the shale, sand, and oolite such as arsenic. The aquifer will be contaminated even before the sand is extracted;
- Leaking oil from the compressor used to inject air can enter the aquifer adding to the contamination;
- Improperly sealing of the hundreds of boreholes that will be drilled per year to supply sand to the processing plant will provide a contamination route for surface fecal matter and other toxins to enter the sandstone aquifer and the overlying carbonate aquifer;
- Subsidence due to sand and water withdrawal will damage extraction borehole seals and cause the boreholes to be depressed drain holes further enabling surface fecal matter to enter both the carbonate and sandstone aquifers;
- The teratogenic, carcinogenic neurotoxin acrylamide will be generated in the clarifier from the breakdown of polyacrylamide flocculent under the action of sunlight, iron ions and acid from pyrite in the slurry water. [https://www.nature.com/articles/s41545-018-0016-8#:~:text=The%20presence%20of%20degraded%20polyacrylamide,degradation%20under%20various%20environmental%20conditions.](https://www.nature.com/articles/s41545-018-0016-8#:~:text=The%20presence%20of%20degraded%20polyacrylamide,degradation%20under%20various%20environmental%20conditions.;);
- A closed loop slurry system returning recycled water back to the extraction site to dilute concentrated extracted sand is not feasible due to water balance problems and escalating acidity from the pyrite sources in the aquifer necessitating the release of excess contaminated water to the surface environment;
- The toxic excess slurry water will follow the natural drainage pathway into the Brokenhead River and seep into the carbonate aquifer as it migrates;
- Industrial activity, noise, continuous lights and silica dust will drive down property values in the local area and detrimentally effect the quality of local life;
- Nearby residents will suffer from stress and anxiety about the safety of their water and air and the risk to their health and the health of their children;
- Weak, unsubstantiated markets for the sand product will threaten the financial viability of the Project increasing likelihood of stranded environmental liabilities;
- Residents including children near Vivian will be potentially exposed to harmful levels of silica dust that in the long term will cause silicosis and other irreversible fatal health outcomes;

- There has been no consultation with first nations and Métis as required under section 35 of the Constitution Act;
- No independent qualified experts have thoroughly reviewed the project. We call for a joint federal and provincial hearing.

Figure 1 illustrates the extent of this mega project. Extraction boreholes over this vast area will penetrate both the carbonate and Winnipeg formation aquifers from which most of southeast Manitoba draws their water.



**Figure 1.** Extent of CanWhite mineral rights

Evidence for the concerns raised here is supported by credible references including peer reviewed papers, government reports, photographs, certified laboratory reports, and statements from the EAP. In some cases transparent calculations are made. All references are given in the form of URL's and occasionally citations immediately after statements of evidence. In Appendix 1, more complex modeling is done of air dispersion for silica dust. All the relevant equations are presented and verification of implemented equations is presented. To discredit or dismiss the evidence from this report would require dismissal of the supporting primary studies, references, laboratory studies, photographs, and information from the EAP. In the public review process of the Wanipigow Sand Project certified laboratory reports from the NI 43-101 technical

report of 2014 by Claim Post on the Wanipow sand showed that there was pyrite in the sand that presented an acid drainage risk. A declaration with no supporting evidence by the proponent that the Wanipigow sand contained no pyrite was accepted in the Wanipigow approval process. We present similar evidence here that the Vivian sand, along with shale and oolite that will be brought up in the extraction process contain pyrite. The CanWhite proponent with no supporting evidence has already made statements that their sand contains no pyrite. Acceptance of such unsupported statements by the proponent and dismissal of certified laboratory evidence and other scientific evidence given by a reviewer is unacceptable in a credible review process and renders the entire process a sham.

## 2. Water draw on the sandstone aquifer

The AECOM Environmental Act Proposal EAP for the Project gives the estimated annual sand production rate to be 1.36 million tonnes per year. <https://www.gov.mb.ca/sd/eal/registries/6057canwhite/index.html>. The EAP gives the solids content of the slurry to be 15%. The annual amount of water withdrawn from the aquifer will therefore be up to  $1.36 \times 0.85/0.15 = 7.7$  million tonnes of water. Using a density of water of one tonne per cubic meter, the volume of water withdrawn will be 7.7 million cubic meters. To confirm this amount we note the EAP gives the flow rate of the water into an outdoor clarifier that runs 24/7 from April to November to be 24,416 litres per minute. Assuming continuous operation for 220 days per year the amount flowing into the clarifier for a year is  $24.416 \text{ cubic meters/min} \times 60 \text{ min/hr} \times 24 \text{ hr/day} \times 220 \text{ days} = 7.73$  million cubic meters.

The 15% solids in the slurry is no accident. Reports of sand beach sand recovered by slurry pumping in Japan state for long distance transportation of slurry by pipe a solid content of no more than 15% is required to prevent pipe blockage. The discharge of beach sand from a slurry pipe in Japan is shown in figure 2 . [https://www.westerndredging.org/phocadownload/ConferencePresentations/2007\\_WODA\\_Florida/Session2\\_B-BeneficialUsesofDredging/4%20-%20Noguchi%20-%20Development%20of%20Simple%20Sand%20Bypass%20System%20Using%20a%20Self-Sinking%20Suction%20Pipe%20with%20Holes.pdf](https://www.westerndredging.org/phocadownload/ConferencePresentations/2007_WODA_Florida/Session2_B-BeneficialUsesofDredging/4%20-%20Noguchi%20-%20Development%20of%20Simple%20Sand%20Bypass%20System%20Using%20a%20Self-Sinking%20Suction%20Pipe%20with%20Holes.pdf)



**Figure 2.** Beach sand slurry discharge containing 15% solids, 85% water in Japan.

The EAP states

*“Water for the Wet Plant is comprised of 100% recycled water originating when the slurry sand and water arrives at the Wet Plant. The sand is removed, water is treated (as explained in Section 2.3.1), and the water is returned to the to the slurry line system at the extraction site, creating a loop system (illustrated in Figure 2-1) for bringing slurry to the facility for processing. This obviates the need for additional water from the on-*

*site well for operation of the Wet Plant. The domestic water will be sourced from a well on the Processing Facility property.”*

The EAP gives the water content in the sand stockpiled from the wet plant as 15% water. If the sand as it first comes out of the aquifer at the extraction site contains 15% water and 85% sand it is theoretically possible to dilute the sand slurry to 15% solid and 85% water without having excess water to discharge in the process. Water balance in a closed slurry loop is not easy to manage. If on average the sand coming out of the aquifer has less than 15% water before entering the closed loop excess water must be found for dilution to 85% water in the slurry line. If on average the sand from the aquifer has more than 15% water there will be excess water that must be disposed of. Fluctuations can be mitigated by the water storage tank at the plant site but overall averages that are not consistent with the loss of water to the stockpiles (15%) present a problem with water balance. This is verified by statement in the publication, D.G. Jones , O.W. Hargrove & T.M. Morasky (1979) Lime/Limestone Scrubber Operation and Control, Journal of the Air Pollution Control Association, 29:10, 1099-1105,

*“In a closed loop water system, the fresh water added to the scrubber exactly balances with the water discharged both as water vapor in the flue gas and as liquid water contained in the sludge solids”*

<https://www.tandfonline.com/doi/pdf/10.1080/00022470.1979.10470901>

In the limestone scrubber limestone slurry is circulated through flue gas to remove SO<sub>2</sub>. In the Vivian wash plant there is no flue gas discharge. Evaporation in the wash plant should be much less than water loss to stockpiled sand. The 15% water loss to the sand stockpiles must on average be exactly balanced by 15% water in the sand extracted from the aquifer. Dilution to 85% water, 15% sand is to occur in the slurry line provided by recycled water from the return loop. Any deviation from 85% water, 15% sand, in the slurry line will cause problems. More concentrated sand will cause potential pipe blockage problems as discussed in the beach sand slurry example in Japan. More dilute sand concentration will cause potential supply quota problems and will result in escalating dilution unless there is discharge of excess water. The paper by Jones et al. also discusses the importance of pH control in the system. This pH control is discussed further in section 3.

If recycling were feasible, the minimum water draw from the aquifer will be the water retained in the sand piles at 15%. This amounts to 1.36 million tonnes sand x 0.15 water/sand / 1.0 tonnes/cubic meter (density of water) = 204,000 cubic metres of water per year which is still a substantially draw on the aquifer.

The EAP does not discuss the closed slurry line water balance problem or pH control and gives no evidence that a closed loop slurry line is feasible.

It is very dubious that the sand can be mobilized directly from the aquifer at only 15% water. The sand in the aquifer is already be saturated with water. Water will be mobilized in preference to sand in pumping. It is difficult to conceive of how the sand can be mobilized from the aquifer at only 15% water. Injected air is known to fluidize dry sand but this requires fluidized bed technology where the air is injected below the sand through a bed of pipes with small holes. <https://mymodernmet.com/mark-rober-liquid-sand-experiment/>. Such a pipe bed would not be feasible for underground extraction in the aquifer.

Figure 3a illustrates large tanks used to hold water and sand extracted from the aquifer by CanWhite during exploration activities. Figure 3b shows the drainage path of excess water from the extracted sand. This evidence indicates that the sand when first drawn from the aquifer will have excess water in excess of 15%. If so there will be definitely excess water to be disposed of and a draw on the aquifer approaching 7.7 million cubic meters per year.



**Figure 3a.** Tanks near Vivian used to hold the water and sand drawn directly from the aquifer by CanWhite exploratory drilling, May 31, 2020



**Figure 3b.** Drainage path for excess water from sand extracted from the Winnipeg Formation aquifer near Vivian, September 8, 2019

Much of the CanWhite exploration sand extraction took place in the spring to early summer according to transcribed recordings of Springfield council meetings. <http://laserfiche.springfield-or.gov/weblink/Browse.aspx?startid=28270>. September 1 – 8 2019 had only a total of 25.6 mm of rain with the most, 18.5 mm occurring on September 1. Manitoba all summer was experiencing a severe drought. <https://www.cbc.ca/news/canada/manitoba/severe-drought-farmers-declare-disaster-1.5264877>. The spring also experienced drought conditions. [https://www.gov.mb.ca/sd/pubs/water/drought/2019/drought\\_conditions\\_report\\_june\\_2019.pdf](https://www.gov.mb.ca/sd/pubs/water/drought/2019/drought_conditions_report_june_2019.pdf). The dry conditions in Manitoba during this period can not explain the drainage path shown in Figure 3b. Transcribed recordings from the Springfield council meeting on July 16, 2019 and an article in the Beausejour Clipper of July 25, 2019 state that CanWhite had a cessation of testing activities previous to the council meeting due to wetness. <https://newspaperarchive.com/browse/ca/mb/beausejour/beausejour-clipper-weekly/2019/jul-25-p-20/>. July 2019 had only three days of significant rainfall in the Anola area in July, 53.3 mm on July 9, 17.8 mm on July 10 and 27.4 mm on July 14. <https://www.accuweather.com/en/ca/anola/r0e/july-weather/2290443?year=2019&view=list>. June 2019 had no days with rainfall over 8 mm. <https://www.accuweather.com/en/ca/anola/r0e/june-weather/2290443?year=2019&view=list>. May had only one day over 9 mm of rainfall, May 05, 2010 with 12.7 mm. <https://www.accuweather.com/en/ca/anola/r0e/may-weather/2290443?year=2019&view=list>. This evidence establishes that the water drainage around the CanWhite exploration site occurring in the spring and early summer of 2019 was from excess water drained from sand extracted from boreholes not rainfall. The evidence shows that there is excess water in sand extracted from the aquifer before entering the slurry line.

The EAP does not give the water content mixed with sand as it is first withdrawn from the boreholes before entering the slurry line. Without such information the claim in the EAP that no discharge of excess water will occur is not supported.

Even if the closed system loop were in equilibrium, with no excess water discharged, water contamination by oxidization of pyrite in the sand, shale and pyritic oolite in the slurry would continue to increase as the water is recycled. The acidity of the water would increase to the extent that pumps and wash plant tanks would

severely corrode. Necessary pH control would be lost. The recycling of slurry water would not be sustainable. The contamination by pyrite is discussed in more detail in the section 3.

From this analysis we conclude that recycling of slurry water is not feasible. Without water recycling the estimate of the draw on the aquifer of 7.7 million tonnes cubic meter per year is valid.

Based on an average of 329 litres of water use per day per person in Canada this is enough water for 64,121 people. <https://jewel885.com/2018/03/14/canadians-rank-2nd-behind-u-s-per-capita-water-consumption-much-use-read/>

The peer reviewed paper, Sustainability of the Bedrock Aquifer Systems in South Central Manitoba: Implications for Large-Scale Modelling by Paula L. Kennedy and Allan D. Woodbury in Canadian Water Resources Journal Vol. 30(4): 281–296 (2005) states, <https://www.tandfonline.com/doi/pdf/10.4296/cwrj3004281>

*“We note that for a case of 2% increase in pumping rate every five years (comparable to population increase),... the percent of recharge taken by well extraction has increased to 55% from the base sustainability case. This value is greater than the maximum suggested value of 50% of recharge, indicating that the system is no longer sustainable.”*

This statement is made pertaining to an increased demand on the sandstone aquifer based on population increase over a period of twenty years beginning in 2005. The paper indicates that a withdrawal of up to 7.7 million cubic meters of water per year by the Vivian Sand Facility Project would not be sustainable.

A study by Friesen Drilling that gives as estimate of the recharge to the carbonate and sandstone aquifers to be 47 million cubic meters. The same report gives the average transmissivity of 50,000 U.S.G.P.D./ft. for the carbonate aquifer and a transmissivity of 5,000 U.S.G.P.D./ft. for the Winnipeg Sandstone Aquifer. <https://www.gov.mb.ca/sd/eal/registries/6013springfield/EAPspringfield.pdf>. From this we estimate that the recharge to the sandstone aquifer would be in the same ratio as the transmissivities or one tenth. Thus the annual recharge to the sandstone aquifer would be 4.7 million cubic meters, far below the potential maximum draw of 7.7 million tonnes of the Vivian Project alone. This does not include all the other draws to the aquifer that by 2025 according to the Kennedy and Woodbury paper would be beyond sustainable by population grown alone without the massive draw by the Vivian Project.

We note that a water pipeline proposal to deliver water at a rate of 50 litres per second to western Manitoba in 2005 was not recommended in hearings of the Clean Environment Commission (CEC). The pipeline project did not proceed. [http://manitobawildlands.org/water\\_projects\\_pvwc.htm](http://manitobawildlands.org/water_projects_pvwc.htm). Fifty litres per second is 1.58 million cubic meters per year. Based on this CEC hearing conclusions the Vivian Project should not proceed.

One other possibility exists. Excess water withdrawn from the aquifer could be returned to the aquifer.

The AECOM EAP states,

*"Extraction will involve temporary water well drill holes that are located on small sites for relatively brief periods of time. Water and sand exist naturally together in the formation and, assisted only by injection of air, they will flow to the surface as slurry."*

From this statement we infer the sand slurry will be withdrawn assisted only by air and that no water withdrawn from the aquifer will be returned to the aquifer. We will show that the water withdrawn from the aquifer will be contaminated with acid, iron, heavy metals including arsenic and acrylamide from pyrite dissolution and cannot therefore be returned to the potable aquifers that serve most of southeast Manitoba.

The extraction process using high pressure air can be expected to mobilize sediment and shale into the aquifer water from the layer above the aquifer. A resident close to one of the exploration sand extraction sites reported brown coloured well water at the time of sand extraction by Canwhite.

[https://ici.radio-canada.ca/nouvelle/1723440/silice-manitoba-forage-environnement-eau-contamination?fbclid=IwAR2J4hgBiilt\\_lZe\\_J-EhXzjpxEH3zI6sdjDQsCmmAPI8Rdivm30ASgLaao](https://ici.radio-canada.ca/nouvelle/1723440/silice-manitoba-forage-environnement-eau-contamination?fbclid=IwAR2J4hgBiilt_lZe_J-EhXzjpxEH3zI6sdjDQsCmmAPI8Rdivm30ASgLaao)

In the oil and gas industry surplus produced water is injected into deep saline aquifers. Studies have shown that this injection pressurizes the saline aquifer in some cases above the fracture limit of the overlying caprock. (OFR-1996-02 Alberta Research Council Alberta Geological Survey, Stephan Bachu Manager 1988-08-31) [https://ags.aer.ca/document/OFR/OFR\\_1996\\_14.pdf](https://ags.aer.ca/document/OFR/OFR_1996_14.pdf)

Pressure from injection of surplus water from the slurry line in Vivian would similarly cause local pressure in the aquifers that would back up wells. The injection pressure would stir up the till overlying the carbonate aquifer or the shale above the sandstone causing turbidity and degradation of the water quality of the aquifers as well as introducing contamination from the acid and heavy metals caused by the pyrite dissolution.

We conclude that excess water cannot be returned to the aquifers.

Pumping the slurry from the remote distances shown in figure 1 that would be required as nearby sources are depleted is not feasible. The pumping costs would escalate. The access rights to the land crossed by the slurry pipes and return lines would become difficult to obtain. Landowners would have to be compensated for the spill liabilities. This is off particular concern due to the acid and heavy metals in the slurry lines and return lines. Eventually trucks would have to be used and excess water withdrawn with the sand from the aquifer would have to be discharged at the extraction site. The added problem of truck traffic has not been discussed in the EAP.

The information provided here provides evidence that the withdrawal of water for the Vivian Sand Facility will be beyond the aquifer capacity. The Project will detrimentally affect the water supply of the almost the entire southeast portion of Manitoba. Spillage of excess water could contaminate the carbonate aquifer and the Brokenhead River. Injected air will oxidize pyrite and contaminate the sandstone aquifer with acid and heavy metals as discussed further in section 3. This is simply not acceptable.

### **3. Pyrite and Aquifer Contamination**

A well known source of acid rock drainage (ARD) is pyrite. A geology Textbook, Physical Geology by Steven Earle, states in section 5.2 states.

*“Even a rock with 1% or 2% pyrite can produce significant ARD. Some of the worst examples of ARD are at metal mine sites, especially where pyrite-bearing rock and waste material have been mined from deep underground and then piled up and left exposed to water and oxygen.”*

<https://opentextbc.ca/geology/chapter/5-2-chemical-weathering/>

The sand extraction occurs in the Winnipeg Formation that is overlain by a layer of shale, the carbonate aquifer and a surface layer of till with sand and gravel deposits as shown in figure 4.

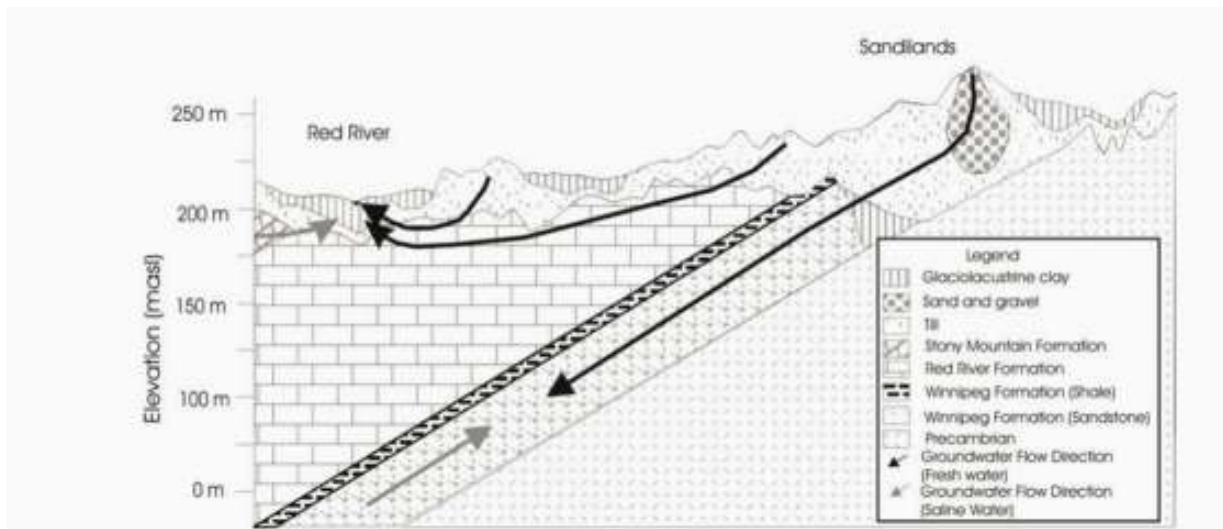
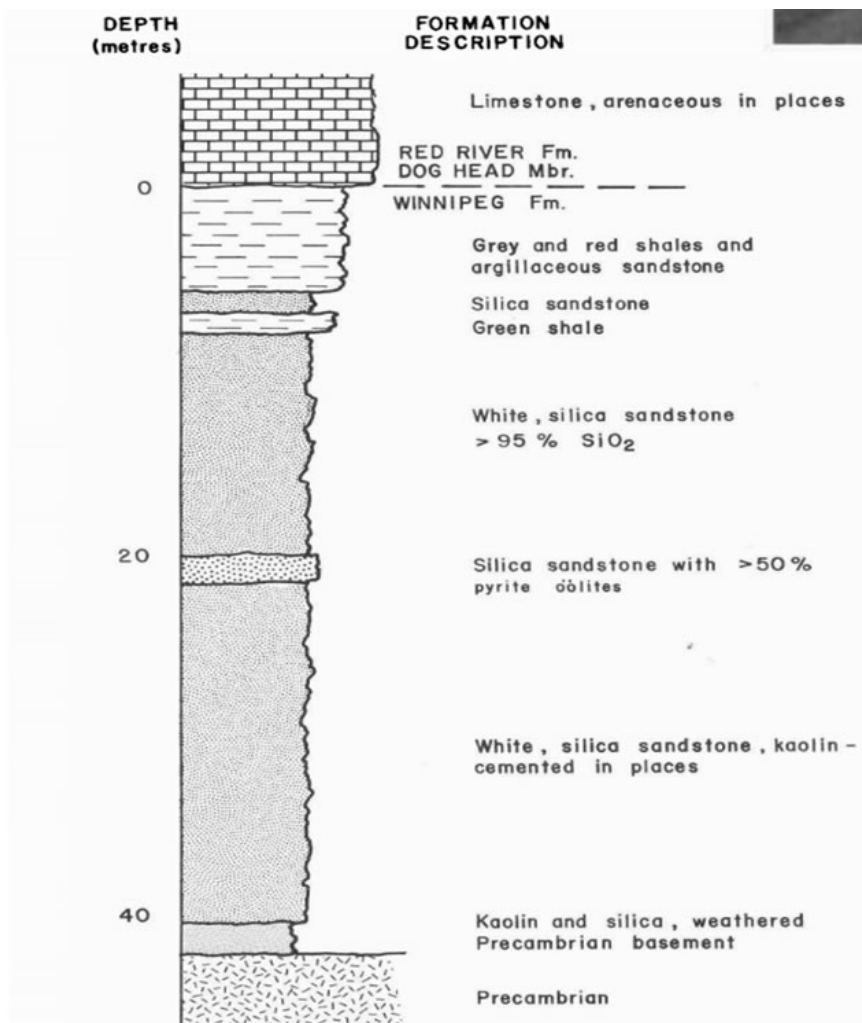


Figure 6 – Simple drawing of the groundwater recharge dynamics in the Southeastern Manitoba. (source – Betcher and Ferguson, 2003)

**Figure 4.** Geology of the Winnipeg Formation near Vivian <https://web.viu.ca/earle/geol304/grasby-betcher.pdf>

A typical cross section of the Winnipeg Formation is shown in figure 5.





**Figure 5.** Cross section of the Winnipeg formation from ER84-2 Economic Geography Report Watson 1985 <http://www.manitoba.ca/iem/info/libmin/ER84-2.pdf>

The Winnipeg formation outcrops at Black Island and on the mainland near Seymourville. A Report of Activities 2016, Manitoba Growth, Enterprise and Trade, by K. Lapenskie states,

*“Two major lithological units occur on Black Island, a lower sandstone unit overlain by pyritic shale. In places, the shale is composed of up to 50% pyrite nodules.”*

<https://www.manitoba.ca/iem/geo/field/roal6pdfs/GS-17.pdf>.

A recent picture at Black Island show in figure 6, illustrates the acid drainage from excavation faces of the abandoned sand quarry pit at Black Island. Water running off the shale layer shows intense staining of the sand below from the oxidized iron from the pyrite in the shale layer on top of the sand. The acid will mobilize heavy metals such as arsenic found in the shale.

[https://www.gov.mb.ca/sd/waterstewardship/reports/groundwater/quality/distribution\\_trace\\_elements.pdf](https://www.gov.mb.ca/sd/waterstewardship/reports/groundwater/quality/distribution_trace_elements.pdf)

The fragility of the shale layer is illustrated by the grey areas of eroded shale that have cascaded down the excavation faces.



**Figure 6.** Acid drainage from excavation faces of the Winnipeg Formation sand overlain by shale at Black Island. The picture was taken by Don Sullivan Aug. 3, 2020

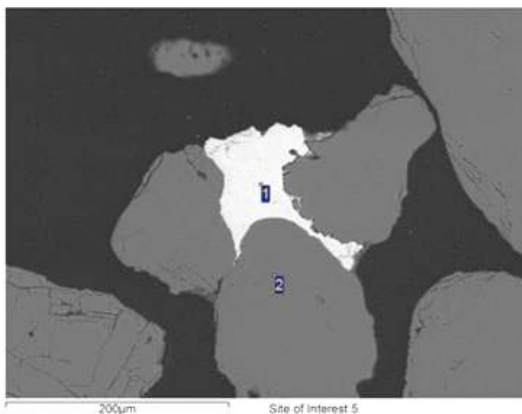
The same shale fragments that are shown cascading down the sand faces at Black Island were found in the CanWhite sand piles extracted by exploration solution mining near Vivian as shown in figure 7.



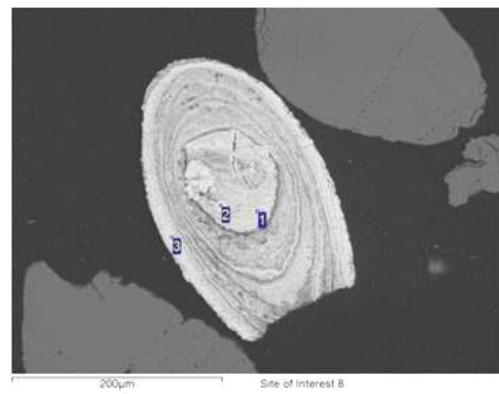
**Figure 7.** Shale fragments in the sand extracted by CanWhite exploration solution mining near Vivian.

This shale verifies that the shale layer overlying the sand in the Vivian area is extracted and brought to the surface along with the sand by the CanWhite solution mining method. The purple shale is consistent with the illustration of figure 5. The shale will begin to oxidize in the aquifer when exposed to the air used in the sand extraction. Heavy metal and contamination of the aquifer will occur even before the sand is extracted. The shale shown above will be in the slurry carried to the Vivian sand processing facility. Oxidation will occur in the slurry lines, the wash plant and the clarifier contaminating the slurry water with heavy metals, iron and acid. The shale fragments will likely end up as over sized fragments screened into in the over/fine sand stockpile outdoors shown in the EAP.

The sand itself in figure 6 at Black Island shows yellow staining. The sand taken from the same formation on the mainland near Seymourville was found to contain marcasite a form of pyrite. The marcasite in the sand is shown in microscope pictures from the 2014 NI 43-101 technical report of Claim Post Inc. reproduced in figure 8.



**Figure 17: Backscattered Electron Image of Master Composite 6 Minutes Non-Mag -50/+70 Mesh**  
Quartz grains (grey) are cemented together by pyrite/marcasite (white).



**Figure 18: Backscattered Electron Image of Master Composite 6 Minutes Non-Mag -50/+70 Mesh**  
Rounded pyrite/marcasite grain exhibits concentric layering.

**Figure 8.** Electron microscope pictures of marcasite (a form of pyrite) between sand grains from the Winnipeg Formation near Seymourville. The marcasite is shown in white. Pictures were reproduced from the 2014 NI43-101 technical report of Claim Post Resources.

The results of the acid base accounting test for the sand at Seymourville is shown in figure 9 below.

*Claim Post Resources Inc. – Seymourville – Project 14466-001 – Interim*

**Table 9: Standard Acid Base Accounting Test Results**

Parameter	Unit	Master Composite A
LIMS		12782-APR14
Paste pH		6.16
Fizz Rate	---	1
Sample weight	g	2.03
HCl added	mL	20.00
HCl	Normality	0.10
NaOH	Normality	0.10
Vol NaOH to pH=7.0	mL	13.41
Final pH		2.08
NP	t CaCO <sub>3</sub> /1000 t	5.3
AP	t CaCO <sub>3</sub> /1000 t	7.34
Net NP	t CaCO <sub>3</sub> /1000 t	-2.01
NP/AP	ratio	0.73
S	%	0.235
Sulphide1	%	0.10
SO <sub>4</sub>	%	0.3
C	%	0.044
CO <sub>3</sub>	%	0.035
CO <sub>3</sub> NP	t CaCO <sub>3</sub> /1000 t	0.58
CO <sub>3</sub> Net NP	t CaCO <sub>3</sub> /1000 t	-6.76
CO <sub>3</sub> NP	ratio	-0.079

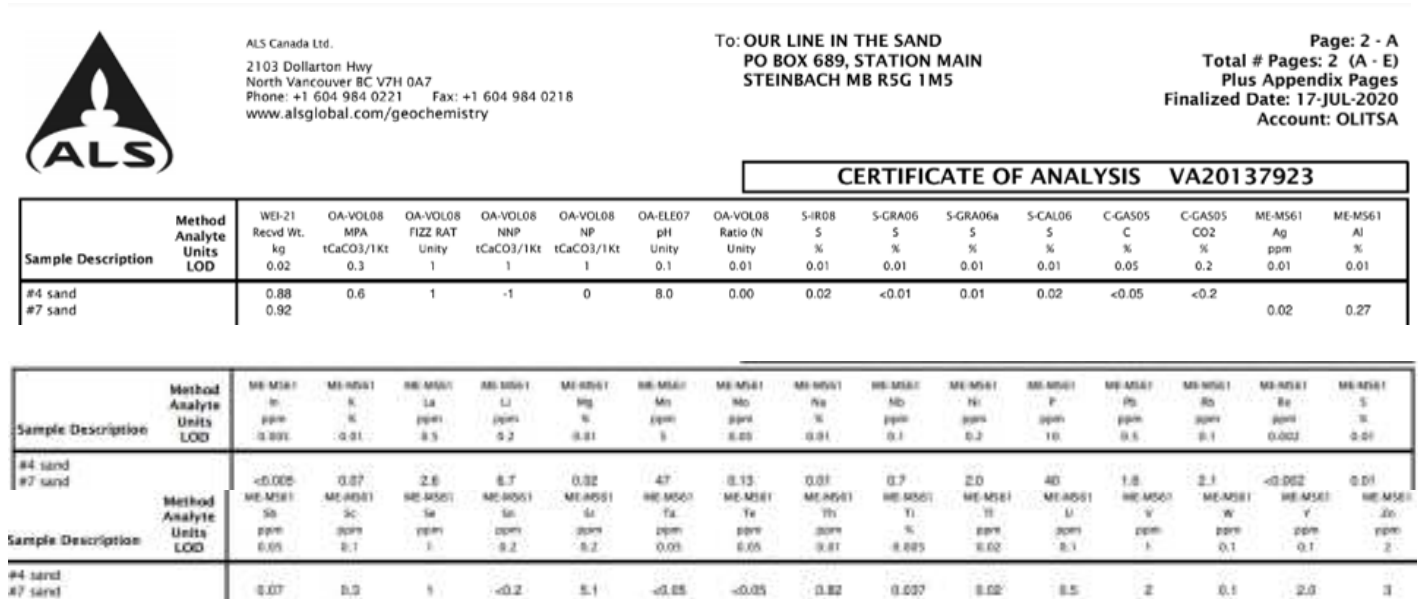
**Figure 9.** Acid base accounting results from Winnipeg formation sand at Seymourville from the 2014 NI43-101 technical report for Claim Post Resources.

The acid base accounting test showed a sulphide content of 0.235% from the iron sulphide (pyrite) in the sand. The sand also contained a small amount of CaCO<sub>3</sub> which would act to neutralize acid formed from oxidation of the pyrite. The acid potential is expressed in terms of CaCO<sub>3</sub> <http://mend-nedem.org/wp-content/uploads/2013/01/1.16.3.pdf> A net neutralization potential of -2.01 is equivalent to a net acid potential of 2.01 tonnes of sulphuric acid per 1000 tonnes of sand.

These results were submitted to the public review of the Wanipigow Sand Project. The proponent declared that there was no pyrite in the sand. The Approvals Branch did not act on the certified laboratory report information in the NI 43-101 technical report. It appears that the unsupported declaration of the proponent was accepted over certified lab results from a NI 43-101 technical report. [https://www.gov.mb.ca/sd/eal/registries/5991wanipigow/public\\_comments\\_batch\\_two.pdf](https://www.gov.mb.ca/sd/eal/registries/5991wanipigow/public_comments_batch_two.pdf)

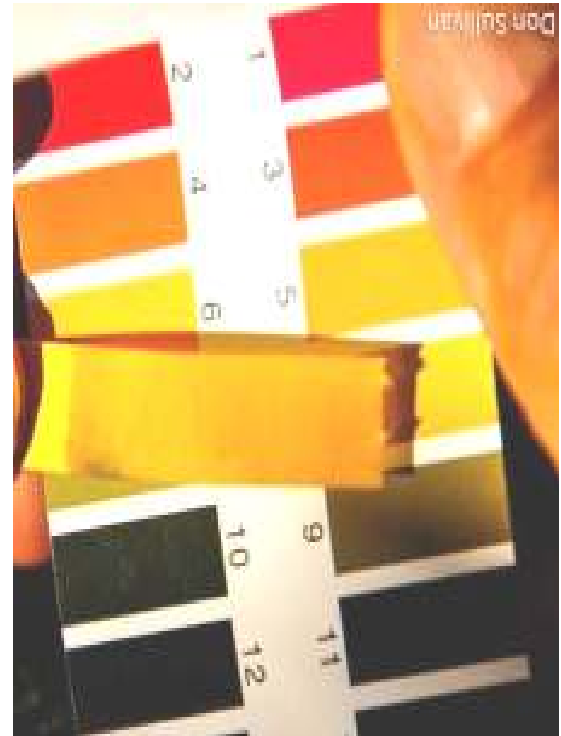
This is no guarantee that the acid potential at Vivian will be the same as at Seymourville but since it is the same formation the results should be similar. Sand samples taken from the sand at Vivian that had been exposed and weathered for about one year were sent for analysis by ASL laboratories. The results showed the

presence of 0.02% sulphide and no CaCO<sub>3</sub>. This is consistent with all the CaCO<sub>3</sub> consumed by neutralization of the acid produced over a year of weathering. There was still sulphide present verifying that the sand at Vivian contains pyrite. The actual acid potential of freshly extracted sand at Vivian will be higher since that samples analyzed had weathered for about one year. The 2 tonnes of acid per 1000 tonnes of sand from the analysis at Seymourville is likely somewhat higher than for extracted sand at Vivian because some of the pyrite will oxidize in the aquifer in Vivian when exposed to the injected air. The acid released to the slurry water is likely between 0.625 and 2 tonnes of acid per 1000 tonnes of sand. The ALS report has rounded this to one significant figure of 0.6 tonnes. The acid base accounting results and trace metal analysis of the Vivian sand is given in figure 10.



**Figure 10.** Trace Metal and Acid Base accounting results by ALS Laboratories for Vivian sand.

Canwhite plans to produce 1.36 million tonnes of sand per year or 1360 kilotonnes according to the EAP. This means the Vivian sand itself can produce at least 816 tonnes of acid per year. It will dissolve in the 7.7 million cubic meters of water extracted. The concentration will be 0.000106 tonnes of H<sub>2</sub>SO<sub>4</sub> per cubic meter of water. We can calculate the pH based on this. H<sub>2</sub>SO<sub>4</sub> completely dissociates into H<sup>+</sup> and HSO<sub>4</sub><sup>-</sup>. HSO<sub>4</sub><sup>-</sup> can also break up to H<sup>+</sup> and SO<sub>4</sub><sup>-2</sup> but not completely so let's just use the first dissociation. <https://www.youtube.com/watch?v=JW-jDdKVq20>. We must first calculate the molar concentration of H<sub>2</sub>SO<sub>4</sub> which has a molecular weight of 98 g/mol. We have 0.00106 M. Ph is the negative log of the hydrogen concentration. The pH is 2.97 or ~ 3 For the sand at Seymourville with 2 tonnes of acid per kilotonne of sand the pH would be 2.44. The pH of water at Black Island shown in figure 11a was tested with litmus paper and found to be about pH 6 as shown in figure 11b. This water had run off the excavation faces and mixed with groundwater so was considerably diluted but still acid. This confirms the sand, shale and will produce acid. The intense red colour in figure 11a is from the oxidized iron (hematite)



**Figure 11 a. and b** Hematite coloured water from acid drainage from Winnipeg Formation sand and overlying shale in the abandoned quarry pit at Black Island and litmus paper test showing acidic water from pyrite dissolution at Black Island after almost 100 years of leaching. The pictures were taken by Don Sullivan Aug. 3, 2020. The pH test was witnessed by Don Sullivan.

A third source of pyrite oolite layer shown in figure 12. The 2014 NI 43 101 report of Claim Post gives the pyrite content of the oolite layer to be 75% . Pyritic oolite nodules were found in the exposed CanWhite sand piles near Vivian demonstrating that the extraction process mobilizes the oolite into the slurry where the pyrite will oxidize to form more acid and mobilize more heavy metal. The pyritic oolite is brought up to the surface in the sand slurry at Vivian as shown in figure 12



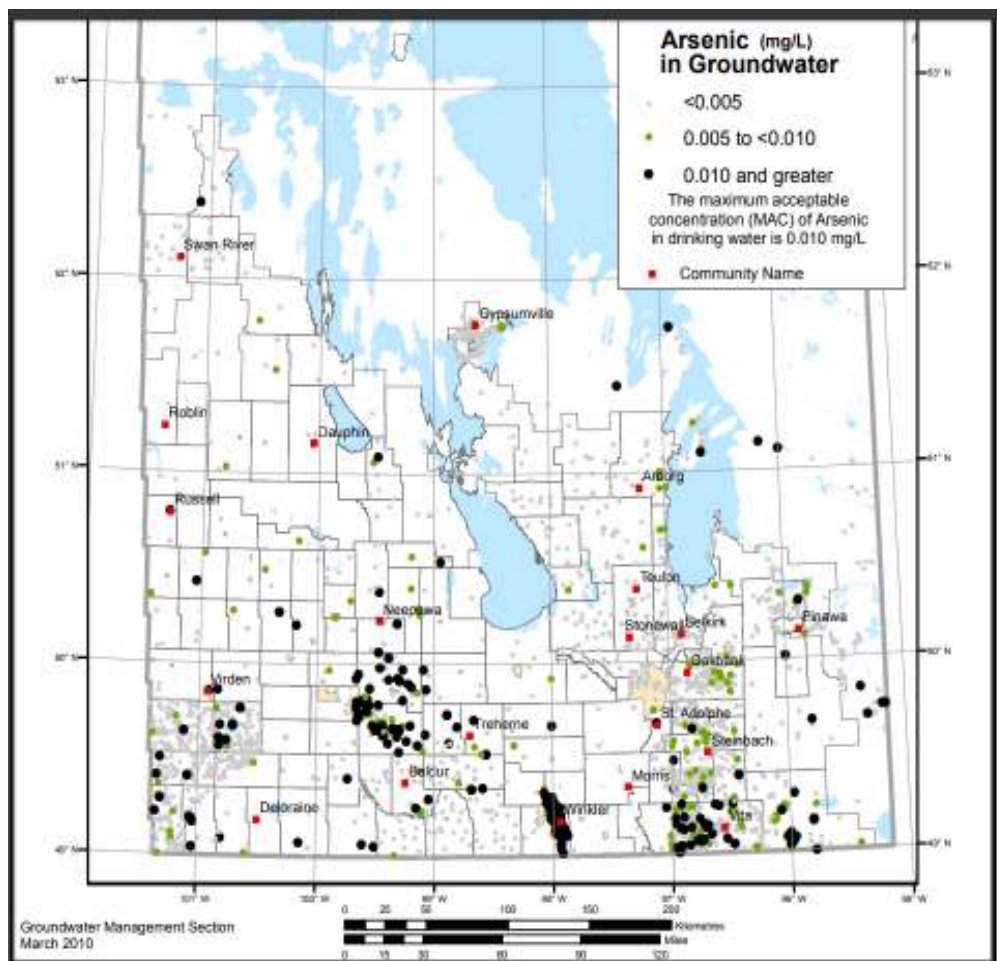
**Figure 12.** Pyritic oolite nodules from exposed CanWhite sand piles near Vivian.

The three sources of pyrite at Vivian, the shale, the sand and the oolite will begin to leach acid and heavy metals into the aquifer upon exposure to the compressed air used to extract sand as described in the EAP.

Over pumping on the aquifer itself can result in drawing of arsenic from arsenic rich overlying strata as discovered in the San Joaquin valley in California.

<https://www.sciencedaily.com/releases/2018/06/180605112141.htm>.

Southeast Manitoba already has arsenic levels near the allowed limit of 0.01 mg/L (0.01 ppm) groundwater as shown in figure 13 (green dots). [http://www.manitoba.ca/sd/pubs/water/drinking\\_water/map\\_arsenic.pdf](http://www.manitoba.ca/sd/pubs/water/drinking_water/map_arsenic.pdf).



**Figure 13.** Arsenic levels in groundwater in Manitoba from Manitoba Groundwater management section 2010

The extracted sand from exploration activities shown in figure 3a must be treated as pyritic waste due to the three sources of pyrite described here. This sand cannot be disposed of in a near surface environment where it will be exposed to air and moisture. Acid leaching and mobilized heavy metals could leach into the carbonate aquifer. The EAP does not mention how the sand from exploration activities will be disposed.

High levels of arsenic in Viridian town water could not be remediated. A new water well supply is being sought. <https://www.empireadvance.ca/news/local-news/viridian-gets-help-to-fight-arsenic-in-tap-water-1.23903441>. The experience at Viridian illustrates that remediation of a contaminative aquifer is not possible.

The AECOM EAP for the Vivian Sand Facility states the sand from the wash plant will be stockpiled outside at 15% moisture content according to the EAP. The amount of water stored in the stockpiles will be about  $1.36 \times 0.15$  million tonnes  $\times 1 \text{ t/m}^3$  or 0.2 million cubic meters per year. Some water withdrawn from the aquifer may evaporate in the clarifier but most of the  $7.7 - 0.2 = 7.5$  million cubic meters of water appears to be surplus. 7.5 million cubic meters will cover the 17 hectare plant cleared area to a depth of at least 44 meters. The EAP states that excess water will be stored in an outdoor storage tank shown in figure 2-2 of EAP part 1. This tank is far too small to accommodate the 7.5 million cubic meters of excess water. We have already demonstrated that recycling the water through the slurry lines to the extraction site is not feasible due to acid that will be formed from the pyrite. The only reasonable conclusion is that the water will be discharged on site to follow the natural drainage path to the Brokehead River about 3.5 kilometres to the southeast as illustrated in the maps shown in figure 14.



**Figure 14 a and b.** Topographical map (a) of Vivian area and surface composition map (b) showing the natural drainage path to the Brokenhead River. Sand and gravel deposits are shown in brown in the drainage path to from the Vivian plant site area to the Brokenhead River.

The EAP states,

*“Construction of ditching within the Project site, as required, will assist in directing runoff flow and maintaining natural drainage pathways through low areas and will contain water runoff from disturbed areas. The wet process will not discharge water to the land surface. A non-toxic biodegradable flocculant will be used for fines settling in a contained system.*

*Construction of the permanent access road to the processing facility will include the installation of culverts to equalize surface water flow and maintain natural drainage pathways as required.”*

Section 4.3.1 of the EAP states,

*“The on-line Atlas of Canada Toporama mapping tool (Natural Resources Canada, n.d.) indicates surface water drainage at the Project Site occurs within ditches and low drainage areas. Surface water drainage flows east for approximately 1 km along roadside ditches before entering a low drainage area flowing northwest. Water connects to another roadside ditch flowing north, then turning east, water discharges into the Brokenhead River, which flows north for approximately 65 km until connecting to Lake Winnipeg.”*

This would suggest that any released water would follow natural drainage. The statement that the wet process will not discharge water to the land surface does not appear to be credible. The large volume of extracted water must go somewhere and no dedicated culvert or drainage ditch is in the EAP plans to carry this volume of excess water. Some of the water containing acid and heavy metals will be expected to infiltrate into the carbonate aquifer as it drains. This is discussed further in section 5.

The sand and gravel deposits provide a direct route for contamination to enter the carbonate aquifer.

Another source of aquifer contamination is from the screw air compressors of the type that would be used for continuous air injection for three days of extraction in the CanWhite process. These compressors can leak oil. <https://air-compressor.net/causes-and-solutions-for-oil-leakage-from-screw-air-compressors/>. The leaked oil can be injected into the aquifer. This type of leakage may be episodic and difficult to detect and control.

Leakage of oil from screw air compressors is common in industry.

<http://compressors.matteicomp.com/blog/the-truth-about-rotary-screw-compressors>.



CanWhite should be required to have independent borehole core samples of Vivian sand, shale and oolite undergo an acid base accounting test by a certified laboratory. The particulate size distribution of the sand from the sand core samples should be determined. Samples withdrawn by the solution mining technique are unacceptable due to exposure to air during extraction that would cause leaching of the pyrite.

#### **4. Improperly sealed boreholes**

The Mines and Minerals Act has not been enforced for the advanced exploration carried out by CanWhite Sands near Vivian Manitoba.

Here is the definition for a mine in the Manitoba Mines and Minerals Act;

<https://web2.gov.mb.ca/laws/statutes/ccsm/m162e.php>

*“mine” means an opening or excavation in the ground that is established or maintained for the purpose of mining and includes*

- (a) a quarry,*
- (b) machinery, plant, buildings, premises, stockpiles, storage facilities, waste dumps or tailings, whether below or above ground, that are used for, or in connection with, mining,*
- (c) a crusher, mill, concentrator, furnace, refinery, processing plant or place that is used for, or in connection with, washing, crushing, sifting, drying, oxidizing, reducing, leaching, roasting, smelting, refining, treating or conducting research on mineral bearing substances, and*
- (d) an abandoned mine and abandoned mine tailings; («mine»).*”

The Act says,

*“Filings before commencement of work*

*74(2)*

*Subject to subsections (3) and(4), a holder of a claim shall not commence or recommence work on an advanced exploration project until*

- (a) the holder files with the director*
  - (i) written notice of the intended date of commencement or recommencement of the work, and*
  - (ii) a closure plan prepared in accordance with the regulations; and*
- (b) the director approves the closure plan and accepts the security provided with the plan for the performance of rehabilitation.*

*advanced exploration project” means*

- (a) excavation of an exploration shaft, adit or decline,*
- (b) construction of an all-weather access road to an advanced exploration site,*
- (c) diversion, alteration or damming of a natural watercourse for purposes of bulk sampling, mine development or mining,*
- (d) de-watering of a shaft, adit or decline for underground exploration and development purposes,*
- (e) removal of a bulk sample of at least 500 tonnes of material for testing, and*
- (f) any other project that is prescribed as an advanced exploration project;*

*“closure plan” means a plan that sets out a program for protection of the environment during the life of a project and for rehabilitation of the project site upon closing of the project and that includes the provision of security to the Crown for performance of rehabilitation work;*

CanWhite began advanced exploration in 2018. CanWhite removed over 500 tonnes of sand through boreholes at the Centre Line Road and Vivian sites for mine development. According to the Act CanWhite should have filed a mine closure plan before doing this advanced exploration work. The Act is not being enforced.

A mine includes the stockpiles and the processing plant according to the definition of a mine. CanWhite must submit a closure plan for the processing plant. The closure plan should have been submitted prior to the EAP and available for public review. The EAP should not proceed until the closure plan for the processing plant and the stockpiles and plant area are submitted. The closure plan includes financial security for rehabilitation. Thus CanWhite must submit financial security in case of abandonment of the processing facility as a prerequisite for the Approvals process.

According to the Act the processing plant is part of the mine and cannot be separated out as is being done in the Approval. The closure plan should include all of the mining activities including the reclamation of the land where extraction is occurring and detailed plans for sealing of the boreholes plus provisions for inspection of those boreholes. The Act must be enforced. The Approvals process and the advanced exploration work already done by CanWhite is in violation of the Act. The Manitoba Government has failed to enforce the Act.

Since both the boreholes and the processing plant are considered together in the Mines and Minerals Act the sealing of boreholes and potential land subsidence from the mining operations must be considered as part of the Approvals for the processing plant. The boreholes and slurry lines are part of the necessary infrastructure to supply product to the processing facility. Subsidence occurs after the mining has occurred and is part of the surface land disturbed and required for the processing plant. Both land subsidence, potential for slurry line leakage and potential aquifer contamination from leaking CanWhite boreholes must be considered, but are omitted from the EAP.

There is abundant evidence that solution mining and aquifer pumping can lead to land subsidence. For instance a USGS publication [https://pubs.usgs.gov/gip/gw\\_ruralhomeowner/](https://pubs.usgs.gov/gip/gw_ruralhomeowner/) states,

*“As the limestone or salt is dissolved naturally by ground water or by industrial solution-mining of the salt, the overlying material can collapse into the resulting cavern.”*

Subsidence can cause well failure and leakage. <https://roscoemoss.com/wp-content/uploads/techmemos/TechMemo010-2CompressionSectionsProtectAgainstSubsidenceEffects.pdf>

Another USGS publication is titled Land Subsidence from Ground-water Pumping.

<https://geochange.er.usgs.gov/sw/changes/anthropogenic/subside/> This article identifies collapse of well casing as one of the many detrimental effects of land subsidence.

Figures 6 and 7 illustrate the fragility of the shale layer above the sandstone aquifer. The presence of shale mixed in with extracted sand from the CanWhite exploratory solution mining clearly illustrates that the integrity of the shale layer will be compromised. Illustrations of the shale cascading down excavation faces at Black Island shown in figure 6 demonstrate that any shale remaining after solution mining will collapse into the cavity left sand extraction. Figure 15 further illustrates the fragility of the shale that was brought to the surface by the exploration sand extraction at Vivian. The USGS publications verify that subsidence can occur.



**Figure 15.** Fragility of shale brought to the surface by solution mining sand extraction from about 200 feet below the surface near Vivian.

Subsidence or sink holes will cause borehole seal damage and potential leakage of surface fecal matter into the carbonate aquifer. Each borehole has the potential to create its own drain hole into the carbonate and sandstone aquifers as shown in figure 16. The evidence for this as documented here is overwhelming.



Protruding well casing in Cochise County is a sign for identifying historical subsidence. This well pad is displaced approximately 3 feet.

**Figure 16.** Land subsidence caused by declining groundwater from over pumping, exposing a borehole in Willcox Basin Arizona. Pumping from the borehole has created its own unsealed drain hole. Imagine hundreds of these boreholes filled with water from septic fields and manure following heavy rains draining into the carbonate and sandstone aquifers.

<https://www.arcgis.com/apps/MapJournal/index.html?appid=c5758018997c402b863c11e36727ed31>

Rutulis of the Manitoba Hydrotechnical Services Division reports buried sinkholes in the carbonate aquifer in a publication, Groundwater resources in the rural municipality of Springfield (a synopsis 1990), verifying

that subsidence can occur in this area.

<https://www.gov.mb.ca/sd/waterstewardship/reports/groundwater/resources/springfield.pdf>

Observations of the boreholes after the exploration drilling program by CanWhite near Vivian illustrated in figure 17 reveal that the boreholes were not sealed externally around the casing. Even without land subsidence, unsealed or improperly sealed boreholes can be a route for bacterial contamination to enter the carbonate and sandstone aquifers.

In the Walkerton incident in 2000, fecal manure sprayed on a field entered an improperly sealed well following heavy rains. At least seven people died and 2300 others became ill.

<https://www.sciencedirect.com/science/article/pii/S0085253815536120>. The potential for hundreds of CanWhite boreholes per year to be a source of aquifer surface fecal contamination from septic fields or animal manure is very high. The Mines Branch that is responsible for licensing boreholes likely does not have the capacity to inspect the sealing of hundreds of boreholes per year.



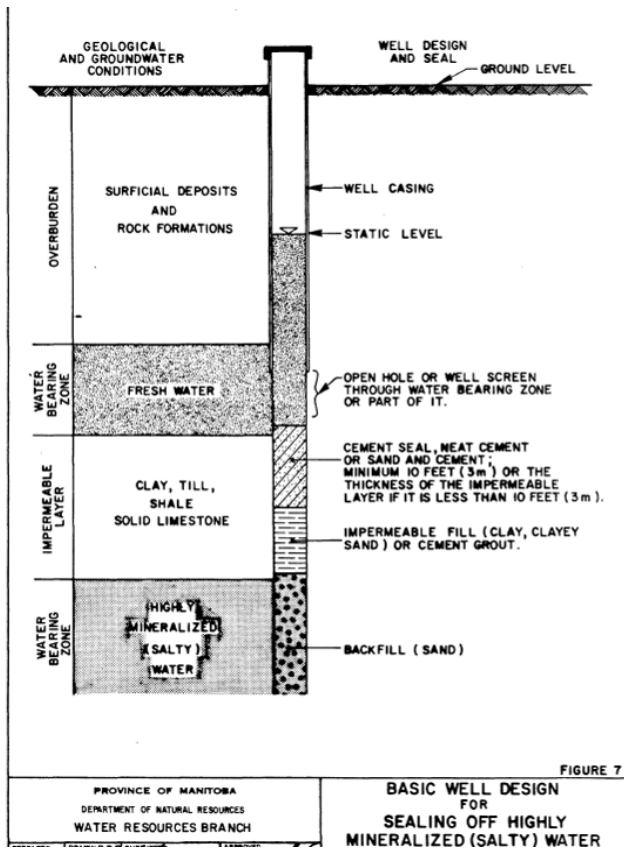
**Figure 17.** CanWhite boreholes with no grout or sealing around the casing near Vivian spring, 2020.

Another insoluble problem is the requirement to seal boreholes in the shale layer separating the carbonate and sandstone aquifers. A Manitoba government report Construction and Sealing of Wells in Manitoba states,

*“A well or test hole must be constructed or sealed in a manner which prevents the interconnection or mixing of groundwater having distinctively different characteristics within the same aquifer or different aquifers. Specifically: • A well or test hole must not be constructed or sealed in a manner that allows the interconnection or mixing of groundwater between the Winnipeg Formation and any overlying aquifer, including aquifers within the Stonewall, Stony Mountain or Red River Formations”*

[https://www.gov.mb.ca/sd/waterstewardship/water\\_quality/wells\\_groundwater/pdf/2017\\_constructing\\_and\\_sealing\\_wells\\_for\\_contractors.pdf](https://www.gov.mb.ca/sd/waterstewardship/water_quality/wells_groundwater/pdf/2017_constructing_and_sealing_wells_for_contractors.pdf) This is in accordance with Manitoba's Groundwater and Water Well Act.

The sealing requirements for the shale layer above the Winnipeg formation is illustrated in figure 18.

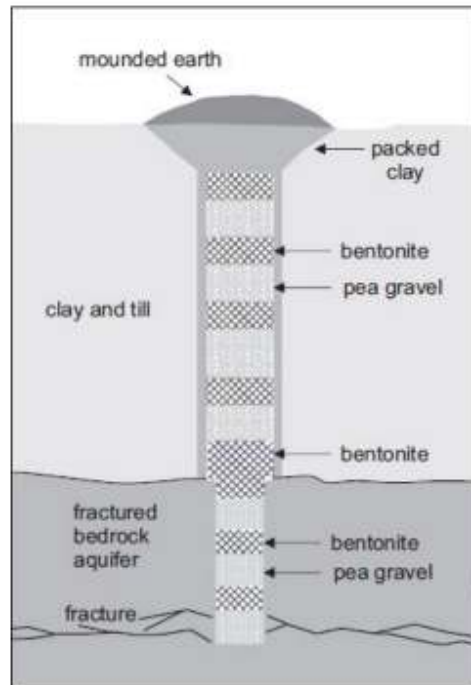
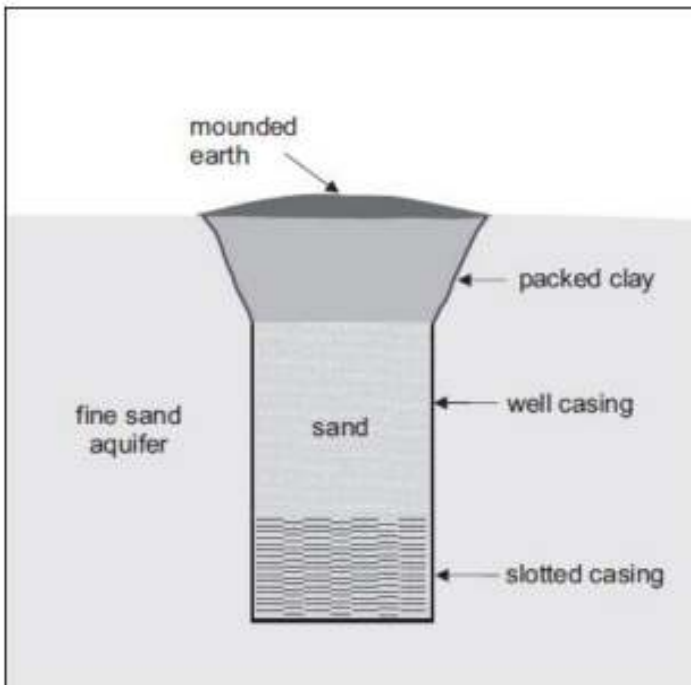
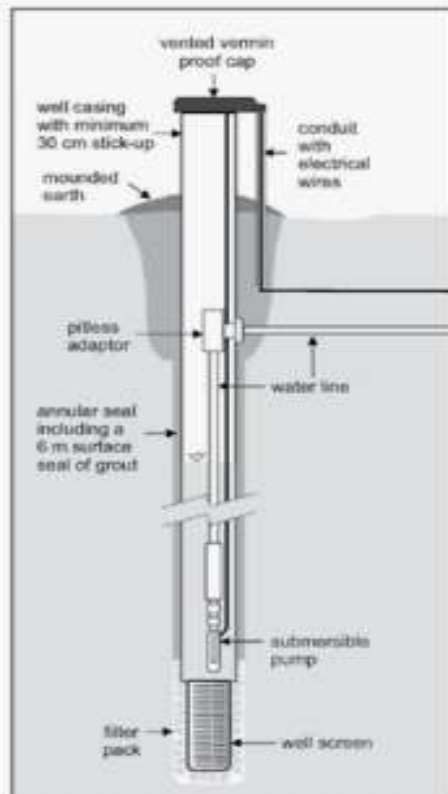
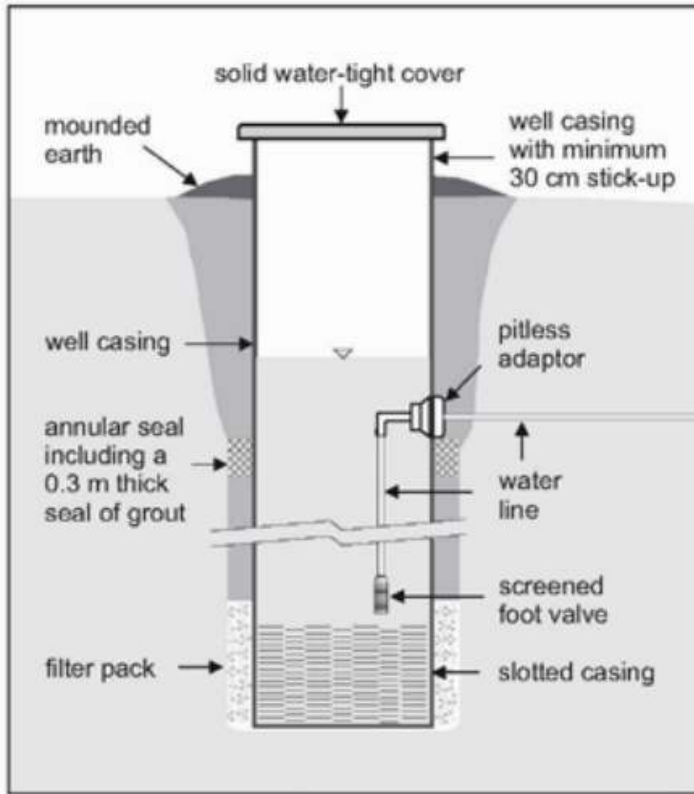


**Figure 18.** Well design to isolate the Winnipeg formation from the carbonate aquifer above.  
<http://www.manitoba.ca/sd/////waterstewardship/reports/groundwater/resources/cooks creek.pdf>

It has been demonstrated that the solution mining and subsidence will destroy the shale layer making sealing of the shale layer around the CanWhite boreholes impossible.

Figure 1 Illustrates the extent of the area over which CanWhite has mineral rights. This entire area could eventually be penetrated with thousands of boreholes for sand extraction all providing a route for contamination.

The MB guidelines for abandoning large diameter recommend removing the casing at least 4 feet below ground surface. Compacted clay is to be placed on top of the cut off casing as shown in figure 19. The compacted clay is dome shape extending beyond the casing wall and mounded above the ground surface to shed water. The well itself is supposed to have a grout or seal around the casing as shown in figure 19.  
[https://www.gov.mb.ca/sd/pubs/water-science-management/groundwater/publication/2017\\_guide\\_for\\_sealing\\_abandoned\\_wells\\_for\\_well\\_owners.pdf](https://www.gov.mb.ca/sd/pubs/water-science-management/groundwater/publication/2017_guide_for_sealing_abandoned_wells_for_well_owners.pdf)



**Figure 19.** Recommended casing sealing and sealing for abandonment of a large and small diameter wells and boreholes.

Figure 20 a and b shows the surface expression of a CanWhite abandoned borehole sealed near Ross Manitoba about 20 kilometres south of Vivian.



**Figure 20 a and b** Surface expression of abandoned sealed CanWhite borehole near Ross Manitoba in a slight depression (no mounding) with clay sealing on top of the cut off borehole.

Figure 21 shows inspection of the borehole sealing.



**Figures 21 a and b** Showing inspection by Dennis LeNeveu and Tangi Bell of the sealing of an abandoned CanWhite borehole near Ross Manitoba.

The landowner granted permission for the inspection. The borehole was cut off about 8 inches below ground surface not at least four feet required in the guidelines. As shown in figure 21, the clay on top of the borehole was not dome shaped and did not fan about beyond the diameter of the borehole. The plug seal on top of the cut off borehole was not mounded above ground surface. In fact the surface of the plug clay seal was in a

slight depression as show in figure 20. The top 6 inches of the undisturbed ground around the borehole was black top soil. Under top soil was brown sandy soil. There was no grout or sealing around the borehole casing. The shovel experienced less resistance right next to borehole indicating a disturbed zone with higher permeability than the surrounding sandy soil next to the borehole. Water poured to a depth of 6 inches in the hole dug out drained in 25 minutes. The drainage was likely down through the disturbed zone around the borehole toward the carbonate aquifer.

Our inspection revealed that an abandoned CanWhite borehole was not properly sealed and not mounded with an impermeable material. Other boreholes that were drilled in the same area had no surface expression and could not be found. The lack of surface mounding and surface expression of abandoned CanWhite boreholes impede inspection and any necessary remediation. Steel boreholes could be perhaps found with metal detectors. Boreholes improperly sealed in the manner revealed by our inspection are at high risk for contamination from surface fecal matter in a high precipitation run-off event.

The evidence presented here for subsidence, borehole leakage, aquifer contamination, and intermixing of aquifer waters as a consequence of this Project should in itself prevent this Project from proceeding without a full joint provincial and federal environmental hearing.

## **5. Polyacrylamide Flocculent**

The EAP says

*“A substance which promotes the clumping of particles. For the Project, a food-grade biodegradable polymer will act as the flocculant to facilitate fines settling during the sand wash process.*

*Water treatment will involve an outdoor clarifier capable of handling a minimum of 6,450 gpm (24,416 l/min), using food grade biodegradable flocculant (anionic polyacrylamide) as an aid for fines settling. The levels of flocculant remaining in the water after leaving the clarifier will be virtually undetectable. The water treatment system closely resembles that of a typical water treatment facility. The levels of flocculant remaining in the water after leaving the clarifier will be virtually undetectable.”*

The sediment from the clarifier will contain polyacrylamide (PAM) which is pressed into a filter cake.

The EAP on page 12 states the raw sand contains 0.46% fines (clay/silt not fine sand). At 1.36 million tonnes of sand per year there would be 6256 tonnes of clay/silt. The filter cake will also contain some of the fine sand that is not screened out in the wash plant. The EAP does not give the fine sand content of the water routed to the clarifier.

The EAP states,

*“The Filter Cakes will be stored in an enclosed structure on-site and periodically transported from the Processing Facility in appropriate containment for use in alternate markets.”*

The market for clay, silt and fine sand coated with polyacrylamide is not identified in the EAP.

From the engineering tool box the density of wet sand is 1.9 tonnes per cubic meter. The density of wet clay is 1.76 tonnes per cubic meter. [https://www.engineeringtoolbox.com/dirt-mud-densities-d\\_1727.html](https://www.engineeringtoolbox.com/dirt-mud-densities-d_1727.html). Using



a density of 1.8 tonnes per cubic meter the volume of the filter cakes not including the fine sand would be at least 3476 cubic metres per year. This would require a building at least 19 metres by 19 metres by 10 metres for amount of filter cake produced in a year. What happens the next year? Since a market for clay, silt and fine sand coated with polyacrylamide probably does not exist, the filter cake material must likely be disposed of. The EAP does not identify the location or method of disposal of the filter cake should a market not be found. The EAP should identify this market.

A peer reviewed paper in NPJ Clean Water Nature Partner Journal by Xiong et al., 2018, states

*“Although the PAM used in environmental systems has a very high MW, it is well known that PAM can undergo degradation by a variety of mechanisms, significantly increasing its mobility and potentially leading to the release of acrylamide monomer, a known toxin and potential carcinogen*

*Many previous studies have demonstrated the importance of dissolved oxygen and Fe<sup>2+</sup> in the chemical degradation of PAM under environmental conditions. Fe<sup>2+</sup> can be released by oxidative dissolution of pyrite minerals or other iron-bearing clays, which simultaneously acidifies the fluid. Photolytic degradation of PAM in the presence of oxygen is similar to chemical degradation: light exposure generates free radicals (such as hydroxyl radicals) that yield carbon-centered polymer radicals leading to chain scission Model studies show significant photolytic degradation of PAM under illumination by a 125 W lamp with a photon flux of 5.4 μmol/s.*

*Although PAM is relatively nontoxic to humans, animals, fish, or plants, the acrylamide monomer can be adsorbed via dermal exposure and inhalation, and it is a known neurotoxin and a potential carcinogen: it is immediately dangerous at concentrations of 0.06 mg/L and is lethal (LD50) at 150–200 mg/kg body weight.*

*Acrylamide is highly soluble in water (log Kow = -0.67) and is therefore highly mobile in the environment. Several studies support the hypothesis that naturally occurring microbes in soils, sediments, and water systems can degrade acrylamide to the nontoxic products ammonia and acrylic acid over periods of days to months. In aquatic systems, complete degradation of acrylamide likely occurs within 2 weeks. However, in tap water, acrylamide can persist for more than 2 months.”* <https://www.nature.com/articles/s41545-018-0016-8>

The clarifier tank will have Fe<sup>2+</sup> ions from the oxidation of pyrite in the sand, shale and oolite in the slurry from the extraction process. If the clarifier tank is not covered it will also be exposed to sunlight. Otherwise the tanks will likely be exposed to indoor lights. The Fe<sup>2+</sup> ions and perhaps photolytic degradation will certainly generate extremely toxic acrylamide that will be dissolved in the water from the clarifier tank.

The Minnesota Department of Health guidance allowed level of acrylamide in drinking water is 0.2 ppb. <https://www.health.state.mn.us/communities/environment/risk/docs/guidance/gw/acrylainfo.pdf>

As discussed in section 2 and 3 of this report, the excess 7.5 million cubic meters of water from the clarifier tank will likely be discharge on site and allowed to drain naturally to the Brokenhead River a distance of 3.5 kilometres to the southeast. Some acrylamide may degrade in the drainage path but for drainage times from rains less than 2 weeks acrylamide will enter the Brokenhead River. In the flowing river water with less exposure to microbes the acrylamide is likely to persist for at least two months similar to tap water. During this time damage to aquatic organisms and fish will certainly occur. The distance from Vivian to the mouth of the Brokenhead according to the EAP is about 65 kilometres. This does not include the tortuosity of the river which is normally about 3.0 <https://www.theguardian.com/science/alexs-adventures-in-numberland/2015/mar/14/pi-day-2015-pi-rivers-truth-grime>. The current in the Brokenhead will vary. A

tubing trip from south of Beausejour to Great Woods a distance of about 15 kilometres by river is about 2 to 3 hours. <https://wearedreamboats.com/pages/river-tubing-manitoba>. Thus the current is often 5 to 7.5 kilometres per hour. Contamination can be expected to reach the mouth of the river in less than 40 hours. Most of the acrylamide is likely to persist to the mouth where it will be deposited in the sediment.

When the acrylamide infiltrates to the carbonate aquifer during drainage as occurred with trichloroethylene in the RM of Rockwood, degradation in the aquifer would likely be very slow due to the purity of the water and absence of organics that are a necessary feedstock for microbes.

[https://www.gov.mb.ca/sd/pubs/water/drinking\\_water/final\\_factsheet\\_tce.pdf](https://www.gov.mb.ca/sd/pubs/water/drinking_water/final_factsheet_tce.pdf). The biological half-life of trichloroethylene is normally considered to be of the order of two days under aerobic conditions. (Lorah et al., 2001, Bioremediation Journal, Vol. 5 Issue 2).

[https://www.tandfonline.com/doi/abs/10.1080/20018891079221#:~:text=Under%20methanogenic%20conditions%2C%20biodegradation%20rates,life%20of%20about%202%20days\).&text=In%20the%20aerobic%20microcosm%20experiments,indicating%20that%20methanotrophs%20were%20involved](https://www.tandfonline.com/doi/abs/10.1080/20018891079221#:~:text=Under%20methanogenic%20conditions%2C%20biodegradation%20rates,life%20of%20about%202%20days).&text=In%20the%20aerobic%20microcosm%20experiments,indicating%20that%20methanotrophs%20were%20involved). The trichloroethylene has persisted in the carbonate aquifer in the Rockwood sensitive area since the early 1990's, almost thirty years to date. This is a substantial evidence that when the acrylamide enters the aquifer it will persist for decades. The Rockwood experience provides further evidence that aquifer contamination is long term and cannot be remediated.

The contamination will be ongoing as long as the processing plant continues operation. Persistent contamination of the carbonate aquifer with highly toxic acrylamide is almost certain to occur according to the established peer reviewed evidence provided here. In addition to carcinogenic and neurotoxic effect studies have shown that acrylamide can cross the placental barrier and cause developmental effects in the fetus. <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3621181/>. It is simply unacceptable to expose the residents in the Vivian area to this serious risk whose likelihood of occurrence according to the evidence presented here is very high.

The contamination risk to the Brokenhead River contravenes section 36(3) of the Fisheries Act.

*“36(3) Subject to subsection (4), no person shall deposit or permit the deposit of a deleterious substance of any type in water frequented by fish or in any place under any conditions where the deleterious substance or any other deleterious substance that results from the deposit of the deleterious substance may enter any such water.”* <https://laws-lois.justice.gc.ca/eng/acts/f-14/FullText.html>

There is very little doubt deleterious substances will eventually reach the mouth of the Brokenhead River where these substances will deposit in sediments. The Brokenhead River mouth and upstream is an important spawning area for Lake Winnipeg. One example of an effort to protect fish stocks on the Brokenhead is the construction of a fishway at the Kenbro Dam by the Brokenhead Restoration Committee.

[https://www.gov.mb.ca/sd/waterstewardship/fisheries/regulations/pdf/mbfish\\_2009.pdf](https://www.gov.mb.ca/sd/waterstewardship/fisheries/regulations/pdf/mbfish_2009.pdf).  
[https://www.gov.mb.ca/sd/waterstewardship/fisheries/regulations/pdf/mbfish\\_2009.pdf](https://www.gov.mb.ca/sd/waterstewardship/fisheries/regulations/pdf/mbfish_2009.pdf)

The Chestnut Lamprey Eel with an extant population on the Brokenhead River was assessed as vulnerable and of special concern on schedule 3 of Species at Risk Act [https://www.registrelep-sararegistry.gc.ca/virtual\\_sara/files/cosewic/sr\\_chestnut\\_lamprey\\_0911\\_eng.pdf](https://www.registrelep-sararegistry.gc.ca/virtual_sara/files/cosewic/sr_chestnut_lamprey_0911_eng.pdf).

Based on the detriment to fish and fish habitat, the endangerment of a species at risk and the serious risk to the aquifers and resident health a Federal Impact Assessment in conjunction with Manitoba Clean Environment Commission Hearings should be convened.

<https://laws-lois.justice.gc.ca/eng/acts/I-2.75/>

## 6. Industrial activity and reduction of Property values and Mitigation of Risk

There is no doubt that the continuous operation of the plant including periodic employee traffic, lights and outdoor noise from loading of rail cars and material handling activities, will be disruptive to the nearby residents. This industrial activity combined with the threat of exposure to silica dust no matter how well controlled will drive down property values. <http://www.sandpointtimes.com/pdf/Frac-Sand-Impact-Tourism-Property-Values.pdf>. The ongoing threat of exposure to silica dust from plant operations and the threat of contamination of drinking water, well drawdown and water turbidity due to air injection will contribute to stress and anxiety of nearby residents. The EAP lists socioeconomic issues in a rudimentary fashion in table 6-1 in part 2 of the EAP. The table contains simple x's to indicate potential socioeconomic effect with no quantification or discussion of these effects. There is no discussion of mitigation measures such as compensation for reduction of property values and contamination, deterioration in water quality or well drawdown. CanWhite should be responsible for financing an independently conducted base line survey of well water in the area including concentration of all trace metals such as arsenic, barium, and chromium, and radium, radon, turbidity, and hardness. The well water should also be tested for turbidity and fecal chloroform.

The EAP attempts to minimize the potential harm to water quality and supply and to air quality. The evidence we provide here clearly demonstrates these risks have been grossly underestimated to the extent of negligence with obvious proponent bias in the assessment of these risks. There is no benefit to those living nearby from the Project only harm except for a few who might be employed within the facility.

## 7. Market Potential and Financial Viability

The EAP does not discuss financial viability of this Project in terms of detailed costs and potential revenue from the product. There is no market research. Potential markets for the product have been listed with no supporting evidence that the markets actually exist or the size and location of such markets.

The Minnesota Star Tribune reports,

*“In western Wisconsin, 10 frac sand processing plants have closed over the past 18 months. That’s one-third of the industry’s dry sand milling capacity, said Kent Syverson, a geology professor at the University of Wisconsin-Eau Claire and a sand-industry consultant..*

*Jordan Sands of Minnesota was selling sand for about \$20 a ton at the start of March — a price below the firm’s break-even point. Over the past few years, oil producers in Texas and New Mexico largely have switched from Northern White to sand mined regionally.”*

<https://www.startribune.com/minnesota-wisconsin-frac-sand-mines-crushed-by-oil-industry-shifts/569168022/?fbclid=IwAR27U7Zt96aDxHuzCJ2cHAj9Ycngegw-GrFHK6mBm5Y6mnff3HtwL0d7HaI>

The Northern white sand from Wisconsin and Minnesota is high quality silica sand. The sand at Vivian and Wisconsin are similar deposits of the Ordovician age.

<https://dnr.wi.gov/topic/Mines/documents/SilicaSandMiningFinal.pdf>

The EAP states with out supporting evidence,

*“The Vivian Sand Facility Project (the ‘Project’) is being developed for the purpose of supplying high-quality silica sand for use in a variety of markets such as the renewable energy industry (e.g. solar panel*

production), electronics (e.g. cellphones, computer chips), oil and gas operations, telecommunications (e.g. fibre optics), sports field applications (e.g. golf courses) and the glass and ceramics production industry.”

Solar panels are normally fabricated using high purity quartzite rock.

<http://www.suncyclopedia.com/en/polysilicon-from-sand-to-solar-cells-it-starts-here/>

In a paper in the Journal of Physics conference series in 2020, Darvis et al. write,

“Silicon is very rarely found in pure form, silicon can be found in the form of silica compounds (SiO<sub>2</sub>), so to produce pure silicon, high silica purity is needed. Silica that is used for raw materials for making solar panels must have a purity of 99.99%. Quartz sand cannot be used as a raw material for pure silicon for the manufacture of solar panels with ordinary washing processes. This requires a breakthrough in the process of processing quartz sand into pure silica as a raw material for making silicon with high purity that reaches the standard.” D. Darvis et al 2020 J. Phys.: Conf. Ser. 1434 012021

<https://ui.adsabs.harvard.edu/abs/2020JPhCS1434a2021D/abstract>.

The Dow Corning ceramic plant in East Selkirk that used silica sand from the Winnipeg formation from Black Island closed in 1993 because the project was not economically feasible.

[https://redrivernorthtourism.com/wp-content/uploads/2016/06/heritage\\_tour.pdf](https://redrivernorthtourism.com/wp-content/uploads/2016/06/heritage_tour.pdf)

If there is a robust market for high quality silica sand for the renewable market the closed mines in Wisconsin and Minnesota would have supplied this market.

That the sand at Vivian is of the similar purity as the Wisconsin sand is demonstrated by a purity analysis given in an video by Somji a Director of CanWhite at a noble conference in 2017 shown in figure 22.

oble **FOLLOW: @Nobleconference | @channelchek**

## Sand Purity

CanWhite sand is over 98% silica resulting in a hard quality sand meeting Tier 1 specifications

**Table 11.6**  
Summary of Select Major Oxides by Fraction

Fraction	Number of Samples	SiO <sub>2</sub> Ave wt %	Fe <sub>2</sub> O <sub>3</sub> wt %	Al <sub>2</sub> O <sub>3</sub> Ave wt %	CaO Ave wt %	K <sub>2</sub> O Ave wt %	Na <sub>2</sub> O Ave wt %
50/60	2	98.31	0.24	0.23	0.04	0.06	0.02
60/70	7	98.54	0.34	0.20	0.07	0.05	0.01
70/80	7	98.80	0.28	0.23	0.04	0.06	0.01

Source: Technical Report BRJ Property Manitoba, October 4, 2017

→ 13:31

**Figure 22.** Vivian sand purity from Canwhite noble conference in 2017.

<https://noble.mediasite.com/mediasite/Play/3bd1bc6031ca470fa4364db528295ba81d?catalog=88b4f8c61c9e48d6a6aab5f4bfb5550f21>

Figure 23 shows the purity of sand from various sources in Michigan

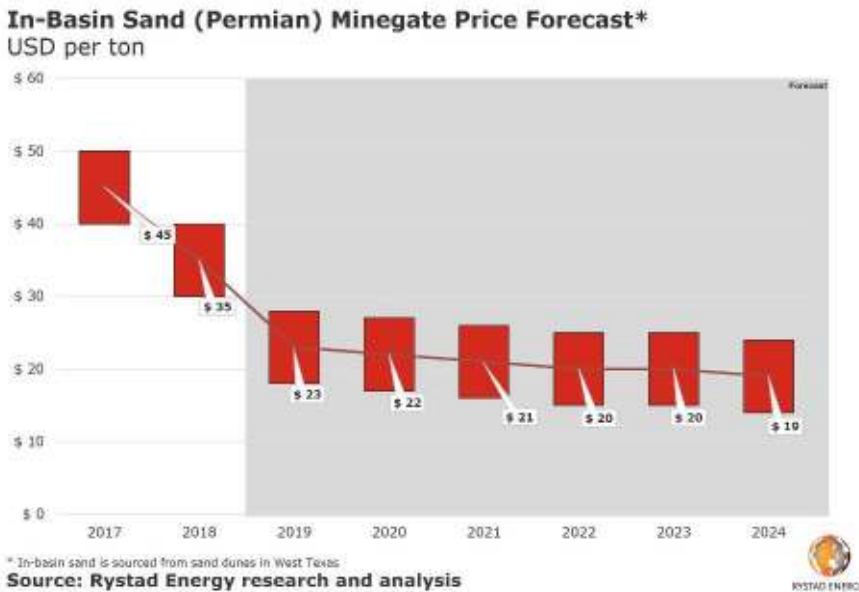
Michigan locality	SiO <sub>2</sub>	Fe <sub>2</sub> O <sub>3</sub>	Al <sub>2</sub> O <sub>3</sub>	TiO <sub>2</sub>	MgO	CaO	Na <sub>2</sub> O	K <sub>2</sub> O	Loss on ignition	Company
Ferrysburg <sup>c</sup>	93.47	0.70	3.65	0.09	0.39	0.67	N. A.	N. A.	0.49	Construction Aggregate Corp.
Muskegon <sup>c</sup>	94.41	0.51	3.22	0.06	0.09	0.14	0.42	0.91	0.32	Nugent Sand Company
Ludington <sup>c</sup>	96.62	1.90	0.3	0.15	0.03	0.8	0.20	N. A.	N. A.	Sargent Sand Company
Saginaw Bay <sup>b</sup>	96.90	1.40	0.4	0.11	0.05	1.0	0.10	N. A.	N. A.	Sargent Sand Company
Bridgman <sup>i</sup>	92.70	0.49	3.96	0.09	0.10	0.22	0.44	1.62	0.42	Manley Brothers of Indiana
Muskegon <sup>i</sup>	92.00	0.57	5.02	N. A.	N. A.	N. A.	0.52	2.05	0.31	McCormick Sand Corp.
Vassar <sup>i</sup>	90.16	1.18	4.66	0.25	0.10	0.21	2.79 t		0.65	Great Lakes Foundry Sand Co.
Yuma <sup>i</sup>	96.16	1.80	0.5	0.1	0.8	1.0	0.35	N. A.	N. A.	Sargent Sand Company
Rockwood <sup>s</sup>	98.95	0.10	0.04	0.01	0.24	0.26	N. A.	N. A.	0.49	Ottawa Silica Company

**Figure 23.** Purity of silica sand at various locations in Michigan.

Note that the sand at Rockwood is higher purity than at Vivian.

[https://www.michigan.gov/documents/deq/gimdl-cr11\\_216124\\_7.pdf](https://www.michigan.gov/documents/deq/gimdl-cr11_216124_7.pdf)

Figure 24 shows the projected price of frac sand is not expected to recover for the next several years.



**Figure 24.** Projected price of frac sand

<https://www.rystadenergy.com/newsevents/news/press-releases/Frac-sand-market-still-growing-but-prices-likely-to-stay-flat/#:~:text=Contracted%20prices%20of%20high%2Dquality,Energy's%20latest%20Proppant%20Market%20Report.>

Figure 25 shows the market segment for silica sand

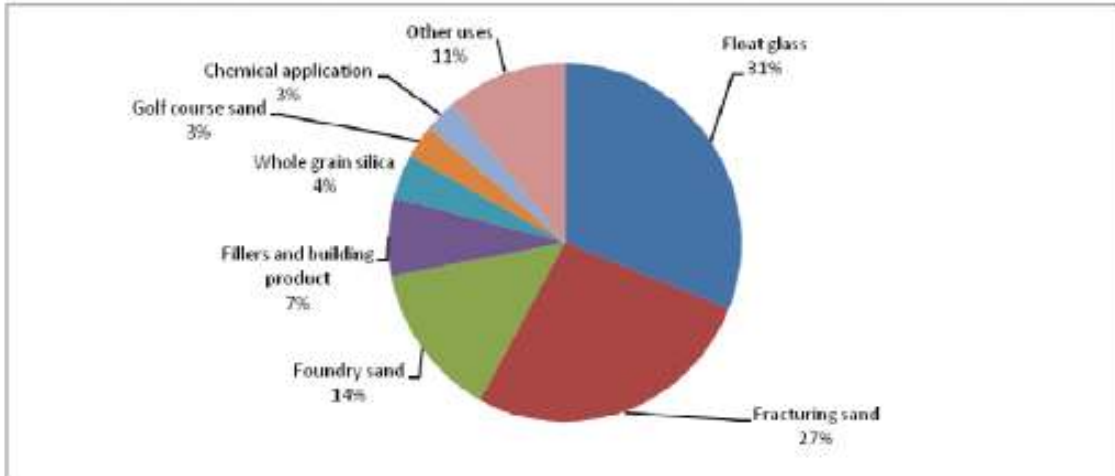


FIGURE 1: The diverse application of silica sand.

Figure 25. Markets for silica sand

<http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.736.1246&rep=rep1&type=pdf>

From figure 25 the glass making and hydraulic fracturing are the largest markets for silica sand. With the collapse of the fracturing sand market, the glass sand market will be saturated. The market indications presented here show that the cost of construction of a new sand processing facility is simply not viable considering the closing of existing facilities in Minnesota and Wisconsin where the facility investment has already been made.

We conclude the risk stranded assets and stranded environmental liabilities due to failure of the Vivian sand Project is very large. Financial assurance and a mine closure plan have not been filed despite the requirements of the Mines and Minerals Act. The Project approvals should be suspended until the mine closure plan is filed and made public for all reviewers and the financial assurance is secured

## 8. GHG

The EAP states

*“Overall, the Project is estimated to generate approximately 34,324 tonnes of CO<sub>2</sub>e annually during dryer operations...”*

Omitted is the GHG associated with pumping 1.36 million tonnes of sand to the plant by slurry as well as the GHG associated with drilling and sealing of the required boreholes and pumping the sand slurry from the aquifer. Since the boreholes will be in various locations, some remote from electrical supply, the required power is bound to be fossil fuel. Figure 26 shows a mobile compressor used by CanWhite during extraction that undoubtedly uses fossil fuel.



**Figure 26.** Compressor used by CanWhite to inject air for sand extraction from the Winnipeg Formation aquifer

It could be argued the GHG associated with borehole drilling and sealing and pumping from the aquifer is part of the mining operation and not germane to this phase of the Project. However the slurry lines are not part of mining and are required to feed the plant.

The power required to pump a sand slurry through a pipe 20.6 cm in diameter is given in a paper by Heywood et al., to be 1.45 kWh per tonne of solid per kilometre or 5.22 MJ per tonne solid per kilometre. This power output is for a flow rate of more than 100 tonnes of solid per hour which would be applicable for the CanWhite operation. The solid in the study contained 83% sand and 17% clay at a solid mass fraction of 0.216 in the slurry

[https://www.researchgate.net/publication/316974587\\_Troubleshooting\\_a\\_556m\\_sand\\_slurry\\_pipeline](https://www.researchgate.net/publication/316974587_Troubleshooting_a_556m_sand_slurry_pipeline)

161.3 pounds of CO<sub>2</sub>e are produced per million Btu of energy from diesel fuel or 0.0693 kg CO<sub>2</sub>e per MJ. . <https://www.eia.gov/tools/faqs/faq.php?id=73&t=11>. Pumping the slurry using diesel fuel would produce 0.362 kg CO<sub>2</sub> per tonne of sand per kilometre at 100% efficiency. The estimate would be somewhat different for a 15% solid slurry but this should be a reasonable estimate.

Diesel generators are usually not more than 30% efficient.

[https://vtechworks.lib.vt.edu/bitstream/handle/10919/78374/Wheeler\\_KR\\_T\\_2017.pdf?sequence=1](https://vtechworks.lib.vt.edu/bitstream/handle/10919/78374/Wheeler_KR_T_2017.pdf?sequence=1)

Pumping the slurry using diesel fuel would produce of the order of 1.20 kg CO<sub>2</sub>e per tonne sand per kilometre.

For 1.36 million tonnes of sand per year for 5 kilometres the amount of CO<sub>2</sub>e would be of the order of 8.16 kt. Added to the 34 kt for the plant dryer we are up to 42 kt CO<sub>2</sub> eq. This is 1.92 % of Manitoba's CO<sub>2</sub>e emissions in 2018 for one operation. This is substantial and does not include the CO<sub>2</sub>e emitted from pumping, drilling and sealing hundreds of boreholes per year. As the pumping site becomes further away the CO<sub>2</sub>e produced and pumping costs would increase. For a pumping distance of 10 km or more this facility would be a large final emitter of over 50 kt and be required to report GHG emissions to statistics Canada. If recycling of the slurry water to the extraction site actually were to occur the GHG from slurry pumping would almost double. In 2018 Manitoba had only 8 large final emitters.

<https://climatechangeconnection.org/emissions/manitoba-ghg-emissions/manitoba-large-final-emitters->

[lfe/#:~:text=Large%20Final%20Emitters%20\(LFEs\)%20are,GHG\)%20emissions%20to%20Statistics%20Canada](#)

It appears the EAP has underestimated the GHG produced unless electrical power can be used for all the slurry and borehole pumping requirements.

## 9. First Nation and Métis Consultation

Section 35 of the Constitution Act specifies the duty to consult with aboriginal peoples including the Métis. [https://www.aadnc-aandc.gc.ca/eng/1100100014664/1100100014675#chp1\\_1](https://www.aadnc-aandc.gc.ca/eng/1100100014664/1100100014675#chp1_1). The vast area of the mineral rights of CanWhite cover the traditional are of many first nations and Métis. The Manitoba-Minnesota Transmission Project (MMTP) hearings were for an area very close to and overlapping the area of CanWhite mineral rights. Extensive first nation consultation occurred as part of these hearings.

[https://www.hydro.mb.ca/docs/regulatory\\_affairs/projects/mmtp/condition\\_22\\_summary\\_of\\_consultation\\_to\\_date.pdf](https://www.hydro.mb.ca/docs/regulatory_affairs/projects/mmtp/condition_22_summary_of_consultation_to_date.pdf). The area of affected land for the Manitoba-Minnesota transmission line was a fraction of the area of the CanWhite mineral claim. [https://docs2.cer-rec.gc.ca/ll-eng/llisapi.dll/fetch/2000/90464/90548/140190/3116766/3421803/3466610/3559486/A91763-1\\_BON\\_-\\_MMTP\\_-\\_Written\\_Evidence\\_-\\_A6E111.pdf?nodeid=3560581&vernum=-2](https://docs2.cer-rec.gc.ca/ll-eng/llisapi.dll/fetch/2000/90464/90548/140190/3116766/3421803/3466610/3559486/A91763-1_BON_-_MMTP_-_Written_Evidence_-_A6E111.pdf?nodeid=3560581&vernum=-2). First nations must be fully consulted in a formal section 35 process led by the Federal Government.

## 10. Silica Dust


Brent Bullen has stated for radio-canada, “Our sand is no different from the sand in Grand Beach, the Sandilands, or the dunes people play in.”

[https://ici.radio-canada.ca/nouvelle/1723440/silice-manitoba-forage-environnement-eau-contamination?fbclid=IwAR2J4hgBiilt\\_lZe\\_J-EhXzjpxEH3zI6sdjDQsCmmAPI8Rdivm30ASgLaao](https://ici.radio-canada.ca/nouvelle/1723440/silice-manitoba-forage-environnement-eau-contamination?fbclid=IwAR2J4hgBiilt_lZe_J-EhXzjpxEH3zI6sdjDQsCmmAPI8Rdivm30ASgLaao)

Figure 27, from the noble conference show the sand size distribution for CanWhite sand

Sample ID	42758		42770	
	Weight %		Weight %	
US Standard Sieve No.	Retained	Cumulative	Retained	Cumulative
6	-	0.0	-	0.0
8	-	0.0	-	0.0
10	0.0	0.0	0.0	0.0
12	0.0	0.0	0.0	0.0
14	0.0	0.0	0.0	0.0
16	0.0	0.0	0.0	0.0
18	0.0	0.0	0.0	0.0
20	0.0	0.0	0.0	0.0
25	0.0	0.0	0.0	0.0
30	0.0	0.0	0.0	0.0
35	0.0	0.0	0.0	0.0
40	0.0	0.0	0.0	0.0
45	0.2	0.2	1.0	1.0
50	1.5	1.7	8.4	9.4
60	8.5	10.1	32.2	41.6
70	17.4	27.5	24.9	66.3
80	31.4	58.9	18.2	85.8
100	23.1	82.0	9.0	94.8
120	10.9	92.9	3.1	97.6
140	4.8	97.7	1.3	99.0
170	1.4	99.1	0.5	99.4
200	0.5	99.6	0.4	99.8
230	0.2	99.8	0.1	100.0
pan	0.2	100.0	0.0	100.0
total	100.0		100.0	
in-situ	0.0	= as 16/30	0.0	= as 16/30
in-situ	0.0	= as 20/40	0.0	= as 20/40
in-situ	1.7	= as 30/50	9.4	= as 30/50
in-situ	27.5	= as 40/70	66.3	= as 40/70
in-situ	96.0	= as 50/140	89.6	= as 50/140
in-situ	70.2	= as 70/140	32.6	= as 70/140
ISO Mean Dia. (mm)	0.191		0.236	
Median Dia. (mm)	0.184		0.229	

July 2017





**Figure 27.** Particle size distribution of CanWhite sand from Noble conference in 2017

The 230 mesh size corresponds to 70 micron particle size. 0.2% of the particles in the pan are below 70 microns in size. The fraction below and including 100 microns (140 mesh) is 7.1% for the Vivian sand. This is definitely not beach sand that people can play in as claimed by Bullen in the radio-CBC interview.

The EAP describes several sources where the fine silica particles that can cause silica dust are sorted in the wash and dry plant. By doing so the EAP verifies that the Vivian sand contains fine silica particles. A final screening of fine particles and oversize particles are collected and stockpiled outside in the overs/fine stockpile. The size and size fraction of fines in this stockpile are not given. Some of the fines will be washed out in the wash plant along with fine clay silt particles and sent to the clarifier. In the clarifier the clay, silt and some fine sand is to be precipitated by a flocculent and pressed into a filter cake. The filter cake is stored in a building at the facility. The particle size distribution and size fraction in the filter cake is not given. The remaining fine particulate will remain in the large stockpiles of sand that will be processed in the dry plant. The size distribution and size fraction of the fines in the stockpiled sand is not given. Some of the fines particulate will be emitted from the dryer stack and some from the baghouse stack. Most of the fines will be collected on baghouse filters to be collected and sold or disposed of. Critical information of the quantity of the fines in the various places is not supplied in the EAP. This information is necessary for a meaningful estimate of the airborne dispersion modeling studies carried out by AECOM.

It should be stressed that airborne modelling of fine particulate is not well developed and verified. The modeling uses mitigation factors based on engineering judgement. The modelling is subject to large uncertainties. Some of the emission sources used by AECOM are not well established. For instance for emissions from stockpiles AECOM used EPA equations developed for coal piles.

<https://www3.epa.gov/ttn/chief/ap42/ch11/final/c11s09.pdf>

<https://www3.epa.gov/ttn/chief/ap42/ch11/bgdocs/b11s09.pdf>.

Environment Canada (EC) gives equations estimates of emissions from sand and aggregate stockpiles for NPRI reporting. The equations are for yearly emissions and are not designed for modelling of fluctuating emissions dependent on wind speed. The EC stockpiles use only one threshold limit for wind of for the number of days in a year with wind over 5.27 m/s. [https://www.canada.ca/en/environment-climate-change/services/national-pollutant-release-inventory/report/pits-quarries-guide.html#s8\\_9](https://www.canada.ca/en/environment-climate-change/services/national-pollutant-release-inventory/report/pits-quarries-guide.html#s8_9)

AECOM uses EPA relationships for material handling. These are the same as EC material handling equations. EACOM uses mitigation factors for material handling emissions due to the sand being wet at 15% despite that the material handling equations have a moisture factor. These equations for material handling do not include a factor for the fines content indicating the rudimentary nature of these equations.

In general the AECOM source contributions to the dust emissions from the stockpiles, stack drops and material handling are less that from stack emissions.

AECOM use unsupported data for baghouse, dryer and silo stack emissions. The largest of these emissions are the dryer and baghouse stacks. There is general data for baghouse filter efficiency from about 95 to 99.5 percent. <https://dnr.wi.gov/topic/Mines/documents/SilicaSandMiningFinal.pdf>. The EAP states The removal efficiency of 99.5% and 98.1% were assumed for baghouse and scrubber, respectively (based on US EPA 1995; Section 11.19.1) Section 11.9.1 of AP 42 Fifth Edition 1995 Compilation of air pollutant emission factors volume I: stationary point and area sources fifth edition Sand and Gravel Processing from states “work in progress” <https://nepis.epa.gov/Exe/ZyPDF.cgi/20005IRB.PDF?Dockey=20005IRB.PDF>

The data for baghouse efficiency could be used to estimate baghouse stack release if the fines fraction for PM10 and PM2.5 were known for the sand sent to the baghouse from the dryer. This information is unavailable. Critical information is the efficiency of the baghouse filters. This can be up to 99.5% but to achieve this consistently requires continued maintenance. Over time baghouse filters can leak.

An Internet publication by Baghouse.com states

*“Baghouse failure: The four main reasons why baghouse filters fail prematurely are abrasion, exceeding the maximum operating temperature, chemical attack and fire. If the filter system is undersized, then the filters will suffer increased wear. We often see people try to use cartridges in applications ill-suited for them such as those with irregular-shaped material, sticky materials, or high temps. During regular maintenance or when stored improperly, cages can be bent, damaged, warped and or even corroded. Improper installation of filter bags can also result in early bag failure and loss of cleaning effectiveness. Common sources of condensation and moisture in a baghouse are leaking gaskets around the doors and airlocks or upset conditions in the process. Moisture can weaken the filter media, causing filter leaks or failures, and allow dust to bypass the filters.”* <https://www.baghouse.com/2020/01/28/other-causes-of-baghouse-filter-failure/>

Many Baghouse difficulties originate as problems with the main Blower, or Fan and the supply and exhaust Ductwork. <https://www.baghouse.com/2011/02/04/dust-collector-troubleshooting-guide/>

Many cases of baghouse failure have been documented. [http://www.etsi-inc.com/Section\\_Cat\\_Content\\_Detail.asp?ID=78&SID=1006&SCAT=108](http://www.etsi-inc.com/Section_Cat_Content_Detail.asp?ID=78&SID=1006&SCAT=108)

There is a financial incentive to avoid maintenance and replacement of baghouse filters. There is no specified inspection for the baghouse by an independent agency to ensure efficiency is maintained. The air dispersion modelling done in this report identifies the baghouse stack as a major potential for exceedances in silica dust emissions. The modelling shows that the exceedances can occur over several kilometres and for any wind direction. It is remarkable that potential exceedances occur over all wind speeds and wind directions. This means if the baghouse begins to leak exceedances can occur virtually everyday. Each day a different receptor would receive the exceedances depending on the wind direction. The exceedances occur over all wind speeds because for low wind speeds the stack emission rate results in a higher effective stack height. For high wind speeds the plume gets bent over and has a lower effective stack height but more wind dispersion. The two effects are compensating so that the exceedances persist over a wide range of wind speeds. It must be emphasized that all residents within about a 2 kilometre radius are at risk for persistent repeated silica dust overexposures. As time goes on the baghouse is more likely to leak with less than vigilant maintenance. This risk cannot be discounted especially without rigorous independent inspection. A mitigation measure of real time PM10 and PM2.5 monitors on the stack emissions and around the perimeter of the site are essential. These monitors themselves would have to be rigorously and regularly tested inspected and maintained. Any time an alarm occurs, operations must shut down and the source must be identified and remediated.

There is insufficient attention being applied to the silica dust exposure potential in the EAP both for the workers and the nearby residents.

Section 6.3.1.2 of the EAP states

*“Components of the Dust Management Plan will include the following: • Dust (particulate matter) will be monitored in the ambient air during the Project construction and operation phases to confirm that mitigation measures that have been put in place are effective and to allow for the implementation of additional engineering and/or operational controls to further control dust if required. • The monitoring program will include the periodic collection of air samples at sampling stations established throughout the Processing*

*Facility and at the nearby sensitive receptors as identified during air quality modelling. • The monitoring program will also include sampling and testing for silica dust (total quartz and respirable crystalline) to ensure the potential for silica dust exposure is effectively controlled and mitigated. • CanWhite will consult with MBCC prior to initiation of construction to determine an acceptable monitoring frequency for both the general (total) dust and silica dust monitoring programs.”*

This is a vague description of silica dust monitoring with no plan for real time monitoring. Real time monitoring is essential to prevent ongoing exposure.

The EAP states,

*“All required personal protective equipment (PPE) will be provided to employees. Special training in relation to the handling of silica will be administered to all employees.”*

This vague statement lacks detail in the required safety training and employee protection necessary to protect employees from silica dust exposure especially in areas such as the baghouse, dryer and silo stacks and all ventilation systems. This EAP statement confirms there is a risk of silica dust exposure contrary to the media statements by Bullen. The baghouse should be under negative pressure and equipped with a clean change room where clean protective clothing and air supplied respirators worn by all employees entering the baghouse. Protective clothing must be removed on the contaminated side, bagged and sent for disposal or to a specialized laundry. The laundry must be designed to ensure that there is no dust exposure from protective clothing contaminated with silica dust. A respirator fit program is required run by qualified industrial hygienist.

Similar precautions must be taken for all maintenance work on ventilation systems, stacks and other enclosed spaces subject to silica dust exposure.

Outdoor workers for the material handling of sand stockpiles conveyors and other sand moving equipment must also be protected from exposure. At a minimum filtered enclosed cabs for front end loaders and other moving equipment must be supplied. Entry to the machines should be remote from area of potential exposure. When close to the sand outside of enclosed vehicles respirators should be worn.

Employees should be equipped with personal silica dust exposure monitors that are checked regularly. Incidents of overexposure must be fully investigated and mitigated.

The attitude expressed by one of the Directors that the sand is similar to beach sand does not demonstrate the proper management culture that is necessary to ensure employees are protected from the serious threat of silicosis and cancer. There appears to be an inadequate understanding and appreciation of the serious danger of exposure to silica dust by the Directors. There is insufficient specification of building design, protective clothing and safety program staffed by qualified safety professionals and hygienists that is necessary for this Facility. Without proper protection working in this facility would be a death sentence especially for those who enter the baghouse and other enclosed spaces with silica dust.

## **10. Conclusion**

CanWhite should be required to have all wells in the Vivian area base line tested independently for trace metals including Fe, As, Ba, Cr, Ra and radon. The well water should also be tested for turbidity and fecal chloroform. Independently retrieved core samples of sand from the Winnipeg Formation near Vivian should

be tested in a certified laboratory for trace metal content and acid base accounting. Core samples should be meshed to determine particle size distribution with particular emphasis on the fines content and distribution below 100 microns. Any sand extracted by CanWhite exploration drilling should be located and disposed of in a manner that would prevent acid and heavy metal drainage into the carbonate aquifer.

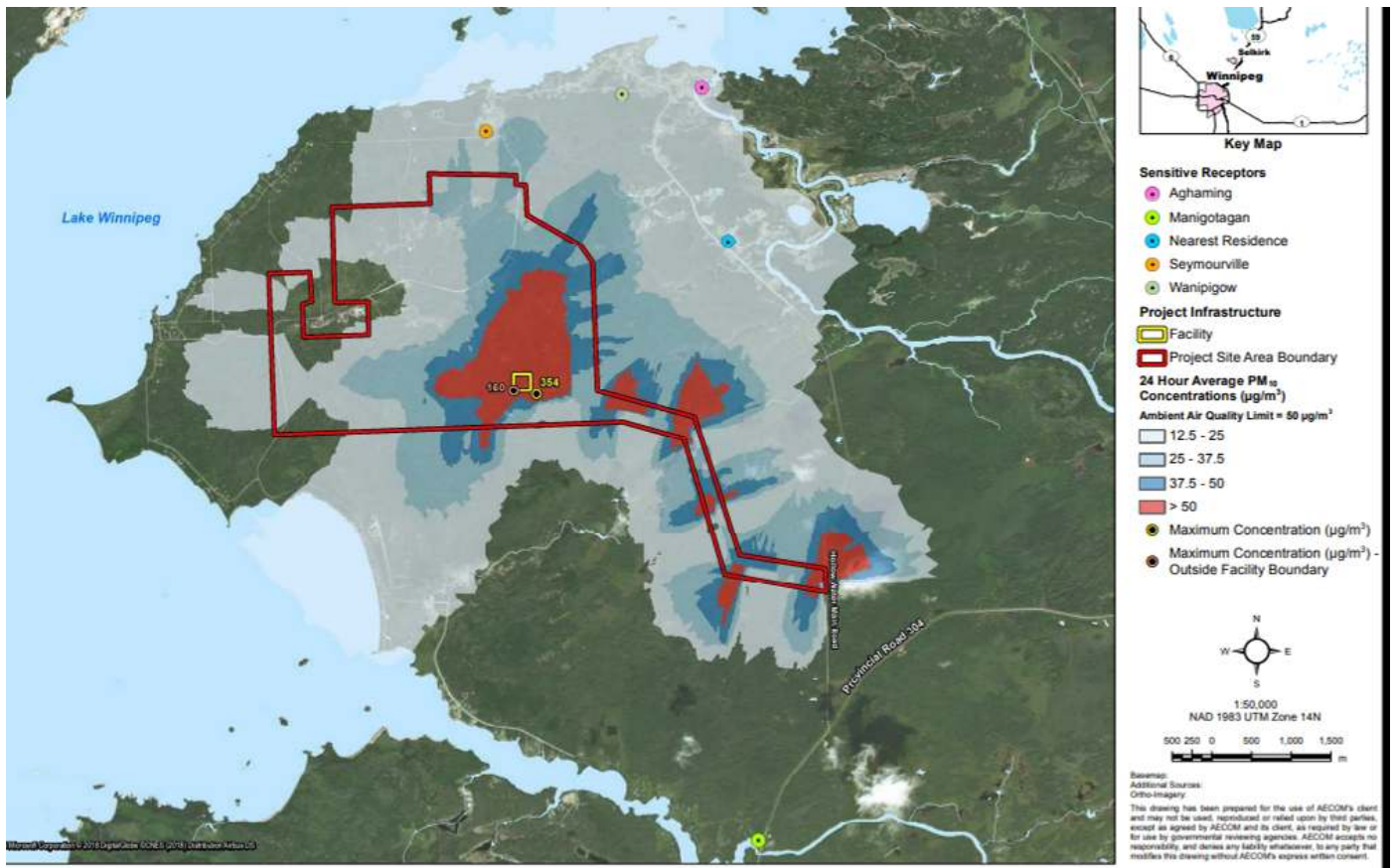
The Vivian Sand Project will irreparably damage the carbonate and sandstone aquifers by contamination with arsenic, other heavy metals, carcinogenic neurotoxic acrylamide, and fecal matter. Contamination of the sandstone aquifer from oxidation of pyrite in the sand, oolite and shale by injected air will contaminate the aquifer with acid and heavy metals before even sand extraction occurs. Oil leakage for the air compressor may contaminate the sandstone aquifer. Subsidence around boreholes caused by the cavities from sand withdrawal and the removal of aquifer water will damage boreholes seals and cause the boreholes to be drain holes for surface fecal matter from manure and septic fields. Improperly sealed CanWhite boreholes will exacerbate this risk. The risk of contamination of both aquifers by fecal matter will be pronounced in heavy rains. Extraction of up to 7.7 million cubic meters of water by solution mining of the sand will cause turbidity and excessive drawdown of the sandstone aquifer far in excess of the sandstone aquifer sustainable limit. This will affect much of the water supply for residents and businesses in southeast Manitoba. Nearby residents will be exposed to the risk of silicosis and cancer from exposure to airborne silica dust. Property value of nearby residents will fall and the residents will experience stress and anxiety from plant industrial activities and from concerns about exposure to silica dust and water shortage and contamination. The damage caused by this project will be permanent and cannot be mitigated or addressed by licence conditions. The GHG implications of this Project have been underestimated by failure to consider GHG from slurry and borehole pumping. Due to the weakness in the market and an over supply of high purity silica sand and the lack of disclosed long term financial support this Project has a high risk of failure. The province has demonstrated failure to enforce the requirement of the Mines and Minerals Act for a mine closure plan and for financial assurance. Project failure will leave extensive unfunded environmental and physical liabilities.

Due to contraventions of the Fisheries Act, endangerment of a species at risk, the chestnut lamprey eel and due to the endangerment to the health and drinking water of many residents in southeast Manitoba, a Federal Impact Assessment in conjunction with Manitoba Clean Environment Commission Hearings should be convened. A full section 35 aboriginal consultation should be held by the Federal Government.

This Project must be suspended immediately pending outcome of joint Federal Impact Assessment and provincial CEC hearings and section 35 aboriginal consultations.

## **Appendix 1. Gaussian Plume Modelling Vivian**

First we examine air dispersion modelling done for a similar facility for processing sand from the Winnipeg Formation. The modelling for the proposed Canadian Premium Sand Facility in Wanipigow also done by AECOM showed exceedances at nearby residences in Seymourville without inclusion of the stockpiles. Figure A1 shows one scenario of the modelling for PM<sub>10</sub> concentrations in the CPS EAP. Figure A1 reproduced from the CPS EAP illustrates that significant concentrations over the 50 µg/m<sup>3</sup> PM 10 limit occur up to one kilometre downwind from the Plant operations as shown in red. According to the EAP the closest residence at Vivian is 54 meters from the CanWhite processing facility.



**Figure A1.** AECOM modelling of PM10 concentrations from the sand processing facility at Wanipigow reproduced from the CPS EAP showing exceedances up to one kilometre north of the plant.

[https://www.gov.mb.ca/sd/eal/registries/5991wanipigow/appendix\\_e\\_and\\_f.pdf](https://www.gov.mb.ca/sd/eal/registries/5991wanipigow/appendix_e_and_f.pdf)

The largest emitters according to the AECOM modelling at Wanipigow reproduced in figure A2 was from material handling activities of loaders, dump trucks and a dozer. Similar material handling activities will be required at Vivian. One could argue that the lower amount of fines in the sand from the wash plant being handled at Vivian rather than raw sand at Wanipigow would result in lower emission rates Vivian. However the material handling equations specified by Environment Canada and the EPA shown below do not contain any terms for the percentage of fines.

**Table 10. Modelled Source Parameters – Point Sources**

Source ID	Source Description	Source parameters				UTM Coordinate		Emission Rates (g/s)				
		Height (m)	Diameter (m)	Temp (K)	Velocity (m/s)	mE	mN	PM <sub>2.5</sub>	PM <sub>10</sub>	NO <sub>x</sub>	SO <sub>2</sub>	CO
STCK1	DOZER1	2	0.122	709	50	687130.53	5670632.60	0.0472	0.0472	0.6611	0.0440	0.1431
STCK2	LOADER1	3	0.122	709	50	687136.18	5670622.18	0.0111	0.0111	0.1556	0.0103	0.0337
STCK3	LOADER2	3	0.122	709	50	687144.42	5670478.52	0.0111	0.0111	0.1556	0.0103	0.0337
STCK4	DUMP TRUCK 1	2	0.122	709	50	687137.04	5670609.60	0.0267	0.0267	0.3741	0.0249	0.0810
STCK5	DUMP TRUCK 2	2	0.122	709	50	687150.07	5670468.11	0.0267	0.0267	0.3741	0.0249	0.0810
STCK6	HAUL TRUCK 1KM	2	0.122	AMBIENT	0	690987.41	5668050.13	0.002	0.06	0.00066	0.000007	0.000163
STCK7	HAUL TRUCK 2KM	2	0.122	AMBIENT	0	689986.29	5668171.09	0.002	0.06	0.00066	0.000007	0.000163
STCK8	HAUL TRUCK 3KM	2	0.122	AMBIENT	0	689530.05	5669016.05	0.002	0.06	0.00066	0.000007	0.000163
STCK9	HAUL TRUCK 4KM	2	0.122	AMBIENT	0	689294.65	5669962.52	0.002	0.06	0.00066	0.000007	0.000163
STCK10	HAUL TRUCK 5KM	2	0.122	AMBIENT	0	688436.46	5670179.84	0.002	0.06	0.00066	0.000007	0.000163
STCK11	HAUL TRUCK 6KM	2	0.122	AMBIENT	0	687396.38	5670402.43	0.002	0.06	0.00066	0.000007	0.000163
STCK12	DRYER	6	0.5	AMBIENT	12	687198.91	5670605.29	0.0066	0.007	0.112		
STCK13	SCREEN	6	0.5	AMBIENT	12	687213.95	5670603.85	0.0015	0.0015			

**Figure A2.** Source parameters from Appendix A of the AECOM CPS EAP [https://www.gov.mb.ca/sd/eal/registries/5991wanipigow/appendix\\_e\\_and\\_f.pdf](https://www.gov.mb.ca/sd/eal/registries/5991wanipigow/appendix_e_and_f.pdf)

The method and equations used for determination of the rates from figure A2 at Wanipigow were not documented.

By comparison the tables from the Vivian EAP are reproduced in figure A3 to A5.

**Table 6: Modelled Point Source Parameters**

Point Source Name	Source ID	UTM X (km)	UTM Y (km)	Stack Orientation	Stack Height (m)	Eq Stack Diameter (m)	Exit Velocity (m/s)	Exit Temperature (K)	Emission Rate (g/s)			
									PM <sub>2.5</sub>	PM <sub>10</sub>	TSP	NO <sub>x</sub>
Plant 1 Dryer Baghouse (DC-110)	DRYER	681,884	5,527,507	Vertical	22.86	1.575	16.96	372.15	0.021	0.136	0.288	0.869
Plant 1 Nuisance Baghouse (DC-120)	SCREEN	681,895	5,527,510	Vertical	22.86	1.016	16.71	333.15	0.00418	0.028	0.058	
Silo 610 Bin Vent Dust Collection (BV-310)	SILO1	681,878	5,527,529	Horizontal	35.0	0.180	16.74	333.15	0.00383	0.029	0.053	
Silo 620 Bin Vent Dust Collection (BV-620)	SILO2	681,877	5,527,514	Horizontal	35.0	0.180	16.74	333.15	0.00383	0.029	0.053	
Silo 630 Bin Vent Dust Collection (BV-630)	SILO3	681,877	5,527,499	Horizontal	35.0	0.180	16.74	333.15	0.00468	0.035	0.065	
Silo 640 Bin Vent Dust Collection (BV-640)	SILO4	681,877	5,527,484	Horizontal	35.0	0.180	16.74	333.15	0.00468	0.035	0.065	
Loadout Spout (SP-420)	SPOUT1	681,872	5,527,529	Horizontal	11.4	0.180	8.73	333.15	0.000010	0.000070	0.000140	
Loadout Spout (SP-430)	SPOUT2	681,872	5,527,514	Horizontal	11.4	0.180	8.73	333.15	0.000010	0.000070	0.000140	
Loadout Spout (SP-440)	SPOUT3	681,872	5,527,499	Horizontal	11.4	0.180	8.73	333.15	0.000010	0.000070	0.000140	
Loadout Spout (SP-450)	SPOUT4	681,872	5,527,484	Horizontal	11.4	0.180	8.73	333.15	0.000010	0.000070	0.000140	
Loadout Bin Vent Dust Collection (BV-410)	BINV1	681,940	5,527,488	Horizontal	24.6	0.180	16.74	333.15	0.000104	0.000687	0.001453	
Loadout Bin Vent Dust Collection (BV-420)	BINV2	681,937	5,527,489	Horizontal	19.0	0.180	16.74	333.15	0.000104	0.000687	0.001453	
Loadout Bin Vent Dust Collection (BV-430)	BINV3	681,943	5,527,490	Horizontal	19.0	0.180	16.74	333.15	0.000104	0.000687	0.001453	
Loadout Bin Vent Dust Collection (BV-440)	BINV4	681,937	5,527,486	Horizontal	19.0	0.180	16.74	333.15	0.000104	0.000687	0.001453	
Loadout Bin Vent Dust Collection (BV-450)	BINV5	681,943	5,527,487	Horizontal	19.0	0.180	16.74	333.15	0.000104	0.000687	0.001453	

**Figure A3.** Point source emission rates for AECOM air dispersion modelling from Vivian EAP

No detailed explanation could be found in the quoted references, US EPA (1995) Section 11.19.1 Table 11.19.1-1 and from US EPA (2006a) Section 11.12 and Table 11.12-1 the EAP for the emission rate values in Figure A3. <https://www3.epa.gov/ttnchie1/ap42/ch11/final/c11s1902.pdf> <https://www3.epa.gov/ttnchie1/ap42/ch11/final/c11s12.pdf>

Table 7: Modelled Volume Source Parameters

Volume Source Name	Source ID	Effective Height (m)	Initial Sigma Y (m)	Initial Sigma Z (m)	Emission Rate (g/s)					
					PM <sub>2.5</sub>	PM <sub>10</sub>	TSP	NO <sub>x</sub>	CO	SO <sub>2</sub>
40/140 Stockpile A - Tripper-Drop	STPA	4.5	1.4	2.1	0.00012	0.0008	0.0017			
40/140 Stockpile B - Stacker-Drop	STPB	4.5	1.4	2.1	0.00009	0.0006	0.0013			
Overs/Fines Stockpile-Drop	STPFINE	4.5	1.4	2.1	0.00268	0.0177	0.0375			
Up-loading Material Area 1	LOAD1	1.5	1.4	0.70	0.00065	0.00430	0.0091			
Up-loading Material Area 2	LOAD2	1.5	1.4	0.70	0.00015	0.00098	0.0021			
Road (LINE VOLUME *7)	RD	3.4	5.7	3.2	0.0220	0.0304	0.0843	0.531	0.125	0.0074
Railcar mover (LINE VOLUME *25)	RAIL	3.4	6.1	3.2	0.0206	0.0212	0.0212	0.302	0.065	0.0198
Access Road (LINE VOLUME * 35)	ARD	1.7	11.6	1.6	0.0269	0.0538	0.1933	0.275	0.155	0.0009
Hopper Discharge Conveyor-Drop	CDRP1	0.3	0.47	0.14	0.00090	0.0046	0.0125			
Hopper Discharge Conveyor-Drop	CDRP2	0.3	0.47	0.14	0.00090	0.0046	0.0125			
Hopper Discharge Conveyor-Drop	CDRP3	0.3	0.47	0.14	0.00090	0.0046	0.0125			

Figure A4. Volume source emission rates for AECOM air dispersion modelling from Vivian EAP

The EPA emission factors for conveyor drop were for crushed stone. They are the same as the EC emission factors for conveyor drop of crushed stone. The relationship between fines in crushed stone and stockpiled sand is unknown. Unsupported emission factor reductions were applied to the conveyor drop values by AECOM to account for partially closed transfer points and moisture content. There is a large uncertainty associated with the emission rates. <https://www3.epa.gov/ttnchie1/ap42/ch11/final/c11s1902.pdf>

Unsupported reduction factors applied by AECOM to the material handling rate equations include a 50% moisture and coarse grain size reduction for stockpiles A and B and different wind speed factors. The material handling equation specified in the EPA and in EC already includes a moisture factor and does not have provisions for coarse grain size. Considering this equation is commonly used for aggregate handling, coarse grain considerations are presumably already included.

Explanation of the emission rates for up-loading material could not be found.

The material handling emission rates are much smaller than the rates from Figure A2 for Wanipigow.

Table 8: Modelled Wind Speed Dependent Source Parameters

Area Source Name	Source ID	Release Height (m)	Area (m <sup>2</sup> )	Emission Rate (g/s/m <sup>2</sup> )		
				PM <sub>2.5</sub>	PM <sub>10</sub>	TSP
40/140 Stockpile A - Wind Driven Emission	STPAW	14.3	3500	0.0000112	0.0000739	0.000156
40/140 Stockpile B - Wind Driven Emission	STPBW	7.47	1500	0.0000112	0.0000739	0.000156
Overs/Fines Stockpile-Wind Driven Emission	STPFW	4.27	200	0.0000112	0.0000739	0.000156

Figure A5. Stockpile emission rates for AECOM air dispersion modelling from Vivian EAP.

The point source Gaussian Plume Dispersion Equation is used for modelling done here. The Gaussian Plume Dispersion Equations are the basis of EPA AERMOD computer model used by AECOM for the Vivian EAP

For this study equations for Environment and Climate Change Canada (EC) for sand and aggregate quarries for NPRI reporting requirements are used. The material handling equations are the same EPA by AECOM. The equations used by AECOM for stockpile wind erosion are obtained from EAP equations developed for coal piles. The equations from EC for wind erosion from stockpiles are very different in character from the EPA coal equations used by AECOM. <https://www3.epa.gov/ttn/chie1/ap42/ch11/final/c11s09.pdf> <https://www3.epa.gov/ttn/chie1/ap42/ch11/bgdocs/b11s09.pdf>. For instance the EC equations have a minimum wind requirement but no further wind dependence. The EC equations have a fines content term while the coal equations do not. However use of the EC equations for wind erosion from stockpiles like the coal equations used by AECOM yield relatively low emissions primarily because of the anticipated low fines

content of the larger sand piles from the wash plant. The smaller overs/fines stockpile will have much higher fines content but has a very much smaller surface area.

Airborne particulate emission rates are calculated by AECOM from EPA release rate equations. The same equations are specified by Environment and Climate Change Canada for NPRI required reporting of particulate emissions from sand quarries. [https://www.canada.ca/en/environment-climate-change/services/national-pollutant-release-inventory/report/pits-quarries-guide.html#s8\\_9](https://www.canada.ca/en/environment-climate-change/services/national-pollutant-release-inventory/report/pits-quarries-guide.html#s8_9), [http://www.burncohowesound.com/wp-content/uploads/2016/08/5.7\\_A\\_APP%20Emission%20Estimate.pdf](http://www.burncohowesound.com/wp-content/uploads/2016/08/5.7_A_APP%20Emission%20Estimate.pdf).

The emission rate equations for material handling are given by,

$$E = 0.0016k \frac{\left(\frac{U}{2.2}\right)^{1.3}}{\left(\frac{M}{2}\right)^{1.4}} \quad \text{and} \quad (1)$$

$$R = CEM_h \left(1 - \frac{A}{100}\right). \quad (2)$$

Here  $U$  is the mean wind speed in m/s,  $M$  is the material moisture content in percent,  $k$  is the particle size multiplier,  $E$  is the emission factor in tonnes per day,  $R$  is the emission rate in tonnes/day,  $M_h$  is the material handled in tonnes per day,  $C$  is a unit conversion factor, in tonnes per kilogram (0.001), and  $A$  is the efficiency of a dust control technique. For PM10  $k$  is 0.35. For PM2.5  $k$  is 0.053.

The moisture content of frac sand stockpiles for the dry processing plant is typically 2 to 8 percent. <https://www.moisttech.com/applications/mineral-moisture-sensor/frac-sand/>

The emission rate equations for wind erosion from stockpiles is

$$S = 1.9 \times 10^{-4} J \frac{s}{1.5} \left(\frac{365 - p}{235}\right) \frac{f}{15}. \quad (3)$$

Here  $S$  is the particulate emission rate in kg/m<sup>2</sup>/day,  $s$  is fine silt or particulate content in weight percent,  $p$  is the number of days with precipitation > 0.254 mm,  $f$  is the percentage of time that the unobstructed wind is greater than 19.3 km/h, and  $J$  is the particulate aerodynamic factor.

The particulate aerodynamic factor for PM10 is 0.5 and for PM2.5 is 0.2.

[https://www.canada.ca/en/environment-climate-change/services/national-pollutant-release-inventory/report/pits-quarries-guide.html#s8\\_9](https://www.canada.ca/en/environment-climate-change/services/national-pollutant-release-inventory/report/pits-quarries-guide.html#s8_9)

To obtain the emission rate for the stockpile,  $S$ , must be multiplied by the surface area of the stockpile. The surface area,  $A_c$ , of a right conical stockpile is given by.

$$A_c = \pi r \sqrt{r^2 + h^2}. \quad (4)$$

Here  $r$  is the stockpile radius and  $h$  is the stockpile height



The stockpiled sand processed in the wash plant will be relatively pure sand with silt, clay and sediment removed. The silt content required for the stockpile release given in Equation (3) refers to particles less than 75 microns in size.

<file:///C:/Users/Owner/Downloads/2.A.5.a%20Quarrying%20and%20mining%20of%20minerals%20other%20than%20coal%202019.pdf>

For the stockpile source equations specified by EC the percentage of fines in the sand is required and for an independent estimate of releases from the sand stockpiles and the baghouse stack. Size distributions for Black Island sand to be used for glass making are given in figures A6 to A8 from OF96-4 Sodium Silicate Study Bench-Scale Tests with Silica Sands of Manitoba by Ash Associates Toronto, Ontario 1996 Manitoba Energy and Mines <https://www.manitoba.ca/iem/info/libmin/OF96-4.pdf>

**SIZE DISTRIBUTION OF CRUDE UNPROCESSED SANDS**

Each of the dried unprocessed sands was analyzed for its "as received" size distribution. No effort was made to brake up any of the concretions or agglomerates. Individual size fractions were examined microscopically for presence of agglomerated particles. Results are given in Table 2.

**Table 2**  
Size Distribution of "As Received" Sands

Winnipeg Formation (Black Island)			% Individual	% Cumulative	Comments
+ 4	Mesh		5.17	5.17	100% agglomerated grains
- 4 + 8	"		2.20	7.37	100% "
- 8 + 12	"		1.41	8.78	100% "
- 12 + 20	"		2.26	11.04	100% "
- 20 + 30	"		2.85	13.89	<10% "
- 30 + 40	"		8.86	22.75	NO agglomerates
- 40 + 50	"		17.23	39.98	NO "
- 50 + 70	"		25.84	65.82	NO "
- 70 + 100	"		27.16	92.98	NO "
- 100 + 140	"		5.57	98.55	NO "
- 140	"		1.45	1.45	NO "
			<b>100%</b>	<b>100%</b>	

**Figure A6.** Particle size distribution for as received Black Island sand to be used for glass making by Ash Associates

**Table 3**

Mesh Size	Winnipeg Formation	
	% Individual	% Cumulative
+ 30 M.	2.9	2.9
- 30 + 40 M.	7.78	10.68
- 40 + 50 M.	15.71	26.39
- 50 + 70 M.	26.84	53.23
- 70 + 100 M.	37.72	90.95
- 100 + 140 M.	8.26	98.21
- 140 M.	0.79	100.00
	<b>100%</b>	<b>100%</b>

**Figure A7.** Size Distribution of Black Island sand after Attrition Scrubbing

## 7.1 SIZE DISTRIBUTION OF FINAL SCREENED PRODUCT

**Table 8**

		Winnipeg Formation Sand	
		% Individual	% Cumulative
+ 30 Mesh		0.08	0.08
- 30 + 40 "		7.88	7.96
- 40 + 50 "		22.66	30.62
- 50 + 70 "		34.72	65.34
- 70 + 100 "		33.76	99.10
-100 + 140 "		0.88	99.98
- 140 "		0.02	100.00
		<b>100%</b>	<b>100%</b>

**Figure A8.** Particle size distribution from unprocessed, washed and final screened sand from Black Island (Winnipeg formation). Final screening was done first with a 30 mesh and then by a 100 mesh

The sand size for the Winnipeg Formation at various sites is given in figure A9 from Economic Geography Report ER84-2 <http://www.manitoba.ca/iem/info/libmin/ER84-2.pdf>

**TABLE 7**  
**Sieve Analyses of Ordovician (Winnipeg Formation) Sands**

Sample No.	Location	mesh size						PAN
		+ 20	-20 + 40	-40 + 50	-50 + 70	-70 + 100	-100 + 200	
Drill hole 2 (Avg.)	Seymourville	0.2	3.3	16.3	33.3	24.9	18.0	4.0
Drill hole 1 (Avg.)	Seymourville	0.2	10.5	21.9	34.2	20.9	10.9	1.4
22.81.12	Punk Island	0.0	1.0	8.0	75.4	12.2	3.0	0.5
72.81.14	Seymourville	0.1	14.1	33.5	34.2	12.8	5.2	1.0
82.81.1	Black Island	0.1	12.2	20.2	26.9	20.8	17.4	2.5

**Figure A9.** Particle size distribution of Winnipeg formation sand from various sites <http://www.manitoba.ca/iem/info/libmin/ER84-2.pdf>

The particle size distribution for sand from the Winnipeg formation near Seymourville from the NI43-101 technical report of 2014 is shown in figure A10

**TABLE 13.2**  
**MASTER COMPOSITE SCREEN ANALYSIS**

Sample ID	Master Composite	
	wt/g	Wt %
Initial Weight	1001.35	100
+20M	25.64	2.6
-20M/+30M	30.67	3.1
-30M/+40M	69.00	6.9
-40M/+50M	137.85	13.8
-50M/+70M	235.78	23.5
-70M/+100M	242.37	24.2
-100M/+140M	100.56	10.0
-140M/+200M	25.37	2.5
-200M/+270M	18.08	1.8
-270M/+325M	6.69	0.7
-325M	99.04	9.9

**Figure A10.** Size distribution of sand from the Winnipeg formation near Seymourville from the 2014, NI43-101 technical report by Claim Post Inc. (from the sedar.com site)

The various size distributions all for Winnipeg formation sand illustrate the particle size is highly variable even from different drill holes in the same site. The fines fraction below 100 microns can vary from 15% at Seymourville to about 1.45% at Black Island.

The micron sizes of various meshes used for screening sand is given in Figure A11.

Mesh	Micron	Inches
4	4760	0.185
6	3360	0.131
8	2380	0.093
12	1680	0.065
16	1190	0.046
20	840	0.0328
30	590	0.0232
40	420	0.0164
50	297	0.0116
60	250	0.0097
70	210	0.0082
80	177	0.0069
100	149	0.0058
140	105	0.0041
200	74	0.0029
230	62	0.0023
270	53	0.0021
325	44	0.0017
400	37	0.0015
625	20	0.0008
1250	10	0.0004
2500	5	0.0002

**Figure A11.** Particle size in microns for various mesh sizes used for screening sand.

<https://www.espimetals.com/index.php/faq/327-technical-data/stainless-steel/334-understanding-mesh-sizes>

**Table 1.** Values for emissions sources used in the air dispersion modelling for this report

<b>sources</b>	<b>PM10 kg/t</b>	<b>sand rate t/d</b>	<b>Emission rate g/s</b>
dryer stack point AECOM	0.00251	4693	0.136
baghouse stack AECOM	0.00052	4564	.028
silo bin vent 610 AECOM	0.0024	1027	0.029
silo bin vent 620 AECOM	0.0024	1027	0.029
silo bin vent 630 AECOM	0.0024	1255	0.035
silo bin vent 640 AECOM	0.0024	1255	0.035
stock pile A tripper drop		2400	Eqn 1& 2 E=0
stock pile B tripper drop		2400	Eqn 1&2 E=0
overfines stockpile drop		4800	Eqn 1&2 E=0
stockpile wind erosion wind < 5.27 m/s			0
uploading material area 1		2400	Eqn 1&2 E=0
uploading material area 2		2400	Eqn 1&2 E=0
baghouse stack 0.02% fines 99% eff,	0.002	4564	0.1056
baghouse stack 0.08% fines 95% eff.	0.1	4564	2.641
baghouse stack 0.08% fines 90% eff.	0.1	4564	5.282

The EC material handling equations 1 and 2 were applied to stock pile drops and uploading material. The results vary with wind speed. To be conservative the efficiency of the dust control technique was set to zero. The moisture content is included in the equations therefore no reduction factor was applied for the 15% moisture content other than entering that value in equation 1.

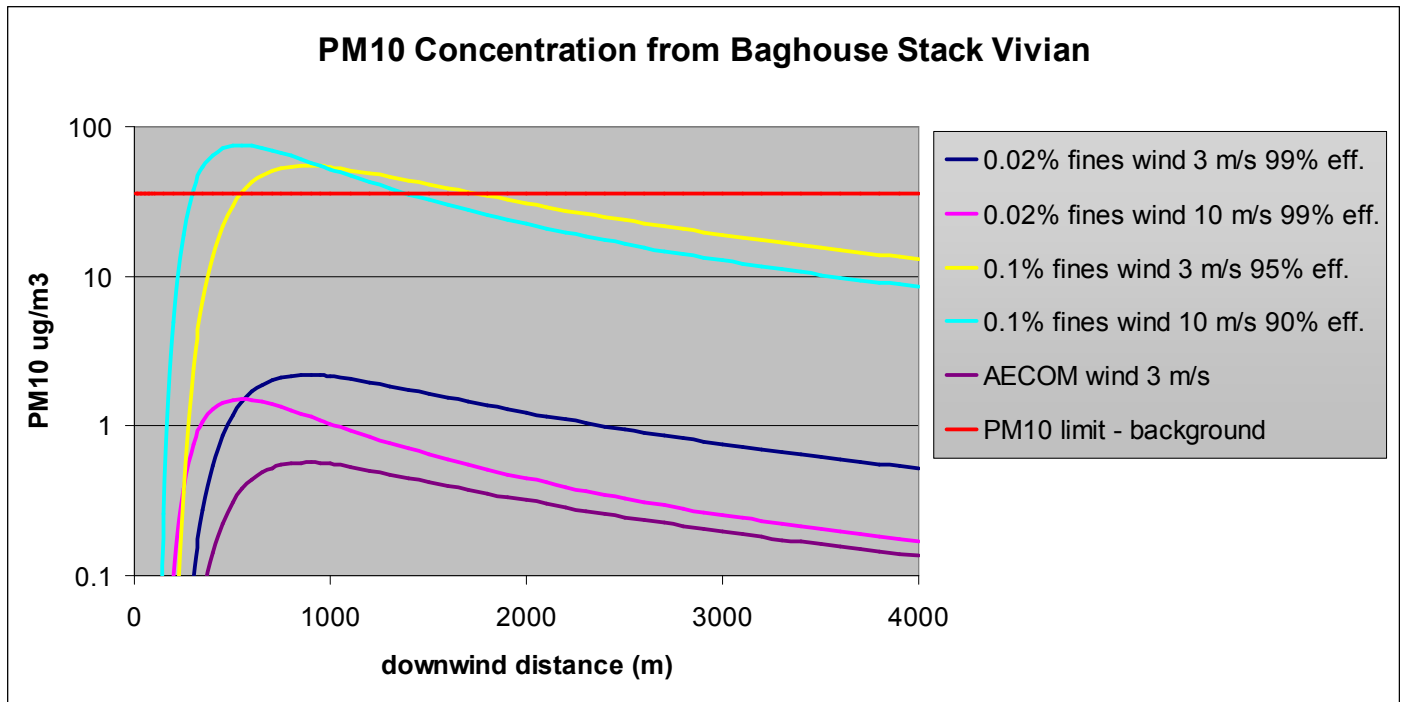
Other emission sources documented in the AECOM EAP that are insignificant compared to those listed in Table 1 were omitted.

The last three entries in the table were obtained from the % fines content in the sand, the baghouse efficiency and the sand processing rate for the baghouse. The 0.02% fines in final washed and screened sand was taken from the data for Black Island sand for glass making by Ash Associates. From the other sand samples from the Winnipeg formation this sand had the lowest size distribution below 100 microns at 1.45 %. The Vivian sand had 0.2% sand in the pan but about 7.1 % below and including 100 microns. Based on this we can expect that the size distribution of the fines in the Vivian sand will be higher than 0.02%.

The last three entries in Table 1 illustrate that baghouse stack has the potential to be the largest emission source. All the emission source data for the stacks given by AECOM appear to be unsupported. The last three entries based on baghouse efficiency, and fines content suggest that baghouse stack emission rate used by AECOM (or the dryer stack emission rate) is a large underestimate.

Simple Gaussian plume dispersion modelling from the baghouse stack alone demonstrate shown in figure A12 that exceedances to nearby residents can occur for a fines content of about 0.1 percent or more in the sand sent to the dry pant and for a baghouse with an efficiency of 95% or less. Baghouse efficiencies can decrease with time and require routine maintenance. Fines content can vary substantially for different sand samples as shown in the figures above. The exceedances due the baghouse stack alone can persist up to two kilometres. The contour plot of figure A13 using AECOM data for the stack releases and EC equations for material handling with no efficiency factor applied give no exceedances. When the a baghouse efficiency of 90% and a fines content of 0.1 % the contour plot shown in figureA 14 The contour plots of figure A14

show exceedances as expected from the plots of baghouse stack release alone. The exceedance area is relatively narrow. As the wind shifts the exposure area will shift.



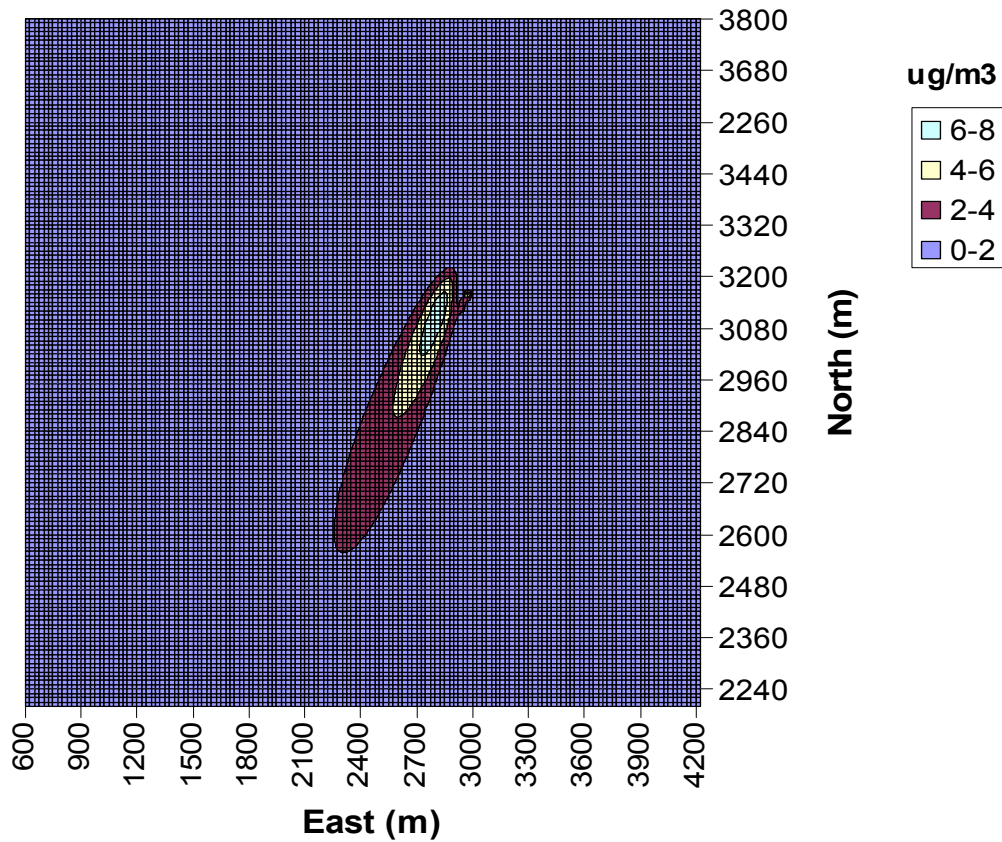
**Figure A12.** PM10 downwind concentrations for the baghouse stack for various wind speeds, baghouse efficiency and sand fines content

The stack release plots of figure A12 illustrate the exceedances are relatively insensitive to wind speed. The reason for this is that the effective stack height diminishes with increasing wind speed due to the bent over plume phenomenon for most air stability conditions. This means that overexposures can be relatively persistent cycling with wind direction. An examination of Google maps indicates that about 20 – 30 residences may be within reach of plume exceedances.

AECOM modelling from Wanipigow suggests that the air dispersion modelling for material handling may be underestimated for Vivian. The material handling releases at Vivian may be less than Wanipigow because no raw sand is handled at Vivian. However the equations specified for material handling by the EPA and EC (the equations are the same) do not have terms for fines content. Judgement factors were likely used for efficiencies at Vivian that were not applied Wanipigow. No detail of the material handling modelling was given in the EAP at Wanipigow so no determination can be made as to the reason for the higher releases from material handling near the plant site at Wanipigow compared to Vivian. This type of modelling is subject to large uncertainties and cannot be relied upon for such a critical health risk. Real time air monitoring is essential to limit the risk of exposure to nearby residents.

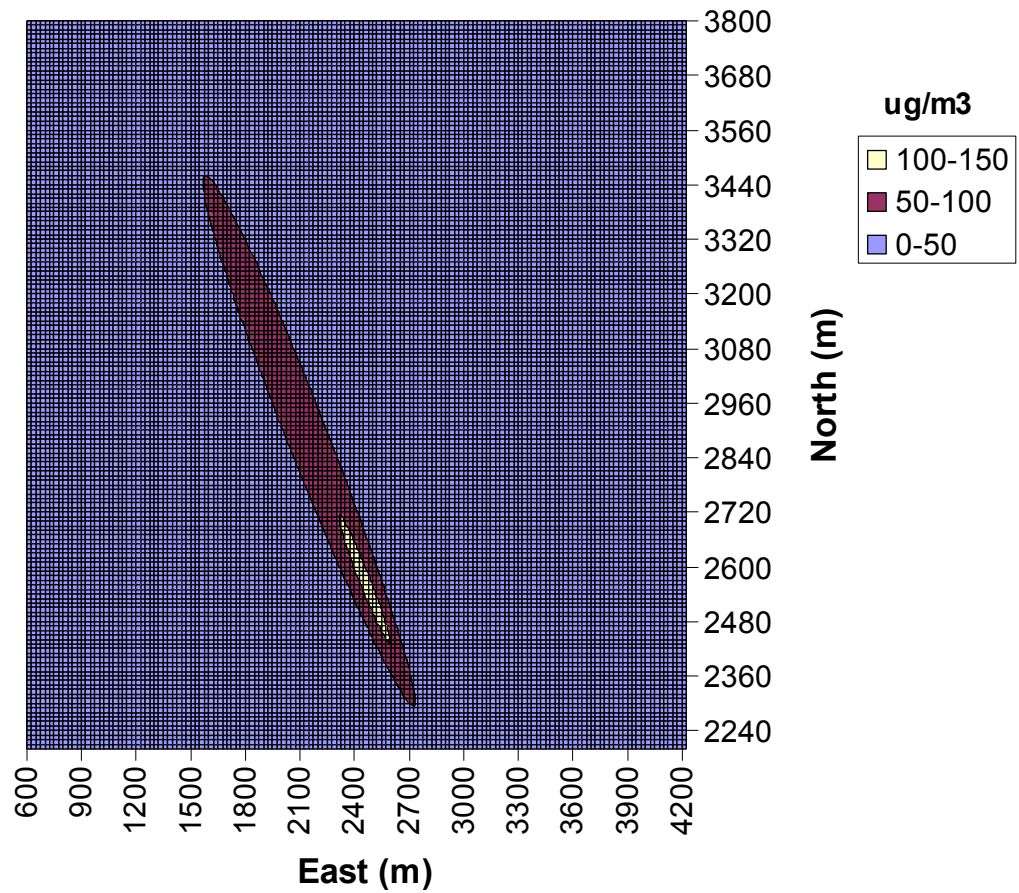
The modelling done in this report illustrates that exceedances can occur from the baghouse stack alone.

### PM10 Concentrations AECOM data 2 m/s wind speed



**Figure A13.** Contour plot of modelled PM10 concentrations above background from the Vivian plant site operations. The wind speed was 2 m/s southwest for atmospheric stability class B. The background concentration of PM10 from the AECOM EAP is 14  $\mu\text{g}/\text{m}^3$ . The allowed limit of PM10 for Manitoba is 50  $\mu\text{g}/\text{m}^3$ . The ambient air temperature used was 30C. The effective stack heights for the baghouse and dryer were calculated based on stack hot gas release data supplied in the AECOM EAP.

### PM10 Concentrations 90% eff. 0.1% fines 4 m/s wind stab.D



**Figure A14.** Contour plot of modelled PM10 concentrations above background from the Vivian plant site operations. The wind speed was 4 m/s northwest for atmospheric stability class D. The background concentration of PM10 from the AECOM EAP is  $14 \mu\text{g}/\text{m}^3$ . The allowed limit of PM10 for Manitoba is  $50 \mu\text{g}/\text{m}^3$ . For this plot the effective limit is  $50 - 14 = 36 \mu\text{g}/\text{m}^3$ . The ambient air temperature used was 30C. The effective stack heights for the baghouse and dryer were calculated based on stack hot gas release data supplied in the AECOM EAP. The baghouse stack release was calculated with a baghouse filter efficiency for fines of 90.0% and a fines concentration in the sand from the dryer of 0.1%. The Paquill atmospheric stability class was D.

<http://faculty.washington.edu/markbenj/CEE357/CEE%20357%20air%20dispersion%20models.pdf>

The Gaussian plume model implemented here can be verified from an example calculation by Professor Tim Larsen of the University of Washington. In the example calculation the model input parameters were 10 g/s for the emission rate, 6 m/s for the wind speed, and 50 m for the stack (source) height. The observation point was 500 meters downstream on the centre line of the plume. The example calculation from the University of Washington is illustrated in Figure A15 below.

## Example Calculation

*Given:*

$Q = 10$  grams/sec;  $h (=h_{\text{eff}}) = 50\text{m}$ ;  $x = 500 \text{ m} = 0.5 \text{ km}$ ;  $u_{50} = 6 \text{ m/s}$ ;

Stability Class "D"

*Compute:*

$C(500, 0, 0)$ , i.e., the ground level concentration ( $z = 0$ ) at plume centerline, 500 meters downwind.

$$\sigma_z = ax^b = 32.093(0.5)^{0.81066} = 18.3\text{m}$$

$$\Theta = 0.017453293(8.3330 - 0.72382\ln[0.5]) = 0.1542\text{radians}$$

$$\sigma_y = 465.11628x(\tan\Theta) = 465.11628(0.5)[\tan(0.1542)] = 36.1\text{m}$$

$$C(x, y, z) = \frac{Q}{2\pi u \sigma_y \sigma_z} \left\{ \exp\left(\frac{-(z-h)^2}{2\sigma_z^2}\right) + \exp\left(\frac{-(z+h)^2}{2\sigma_z^2}\right) \right\} \left\{ \exp\left(\frac{-(y)^2}{2\sigma_y^2}\right) \right\}$$

$$C(500, 0, 0) = \frac{10}{2\pi (6)(36.1)(18.3)} \left\{ \exp\left(\frac{-(0-50)^2}{2(18.3)^2}\right) + \exp\left(\frac{-(0+50)^2}{2(18.3)^2}\right) \right\} \left\{ \exp\left(\frac{-(0)^2}{2(36.1)^2}\right) \right\}$$

$$C(500, 0, 0) = \frac{10}{2\pi (6)(36.1)(18.3)} \{0.0479\}\{1\} = 1.92 \times 10^{-5} \text{ g/m}^3 = 19.2 \mu\text{g/m}^3$$

**Figure A15.** Example calculation for the Gaussian Plume Equation from the University of Washington <http://faculty.washington.edu/markbenj/CEE357/CEE%20357%20air%20dispersion%20models.pdf>

The concentration at 500 meters downwind from the Gaussian Plume Equation implemented for this report using the example parameters from the University of Washington is  $1.91723 \times 10^{-5} \text{ g/m}^3$  ( $19.1723 \mu\text{g/m}^3$ ). Rounded to three significant figures as reported by the University of Washington the concentration is  $19.2 \mu\text{g/m}^3$ . The calculated value from University of Washington example and the value from the equation implemented here match to the reported three significant figures. This exact match verifies the implementation of the Gaussian plume equation developed for this report.

The effective stack height for various wind speed was determined by equations from the University of Washington in Figure A16



# Plume Rise

**Buoyant plume:** Initial buoyancy >> initial momentum

**Forced plume:** Initial buoyancy ~ initial momentum

**Jet:** Initial buoyancy << initial momentum

- For neutral and unstable atmospheric conditions, **buoyant rise** can be calculated by

$$\Delta h_{plume\ rise} = \frac{21.425F^{0.75}}{\bar{u}} \quad (F < 55\ m^4 / s^3)$$

$$\Delta h_{plume\ rise} = \frac{38.71F^{0.6}}{\bar{u}} \quad (F > 55\ m^4 / s^3)$$

where **buoyancy flux** is

$$F = gV_s d^2 (T_s - T_a) / 4T_s$$

$V_s$ : Stack exit velocity, m/s  
 $d$ : top inside stack diameter, m  
 $T_s$ : stack gas temperature, K  
 $T_a$ : ambient temperature, K  
 $g$ : gravity, 9.8 m/s<sup>2</sup>

**Figure A16.** Effective stack height equations.

Parameter values for determining the effective stack height were taken from the EAP.

<http://courses.washington.edu/cee490/PlumeD4.pdf>

<http://www.dartmouth.edu/~cushman/courses/engs43/Chapter8.pdf>