Comments on the Vivian Sand Facility Project Public Registry no. 6057.00
by
D.M. LeNeveu
B.Sc. (hons. Physics) M.Sc. (biophysics) B.Ed.
Former member of Canadian Society of Safety Engineering
President LeNeveu Simulations. Inc
On Behalf of
What the Frack Manitoba Inc.
Aug. 20, 2020

1. Introduction

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

- The reference amount of water withdrawn from the aquifer by solution mining of 7.7 million cubic meters per year as documented in the AECOM EAP will be beyond the sustainable yield of the sandstone aquifer of the Winnipeg Formation;
- Pyrite in the sand and shale brought to the surface by the solution mining will generate acid that will mobilize iron oxide and heavy metals contaminating the excess water withdrawn from the aquifer;
- 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 for 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 in the excess slurry water https://www.nature.com/articles/s41545-018-0016-8#:~:text=The%20presence%20of%20degraded%20polyacrylamide,degradation%20under%20various%20environmental%20conditions.;
- Toxic excess 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.

Evidence for these concerns is given in the form of 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 pubic review process of the Wanipigow San Project certified laboratory reports from the NI 43-101technical 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 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 1.36 x 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 cubic meters/min x 60 min/hr x 24 hr/day x 220 days = 7.73 million cubic meters.

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 15% solids in the slurry is no accident. Reports of sand beach 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 . https://www.westerndredging.org/phocadownload/ConferencePresentations/2007_WODA_Florida/Session2B-BeneficialUsesofDredging/4%20-%20Noguchi%20-%20Development%20of%20Simple%20Sand%20Bypass%20System%20Using%20a%20Self-Sinking%20Suction%20Pipe%20with%20Holes.pdf

Figure 1. Beach sand slurry discharge containing 15% solids, 85% water in Japan.

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 an extra 7.7 million cubic meters of water per year by the Vivian Sand Facility Project would not be sustainable.

This is confirmed by 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 draw from 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. Fifty litres per second is 1.58 million cubic meters per year, far below the water demand of the Vivian Sand Facility Project.

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 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-EhXzjpxEH3zI6sdjDQsCmmAPl8Rdivm30ASgLaao

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

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. There is simply no alternative to surface discharge of the surplus water extracted at Vivian by the slurry system containing 85% water.

The information provided here provides conclusive evidence that the withdrawal from the Vivian Sand Facility is beyond the aquifer capacity. The Project will detrimentally affect the water use of the almost the entire southeast portion of Manitoba. This is simply not acceptable. Based on this evidence alone the Project should not proceed. It is incomprehensible that the Project was not rejected outright by Manitoba Water Stewardship as soon as the water use information became available. We must question the responsibility of government authorities to fail to protect our most valuable resource upon which thousands of Manitoban's depend.

3. Pyrite

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 2.

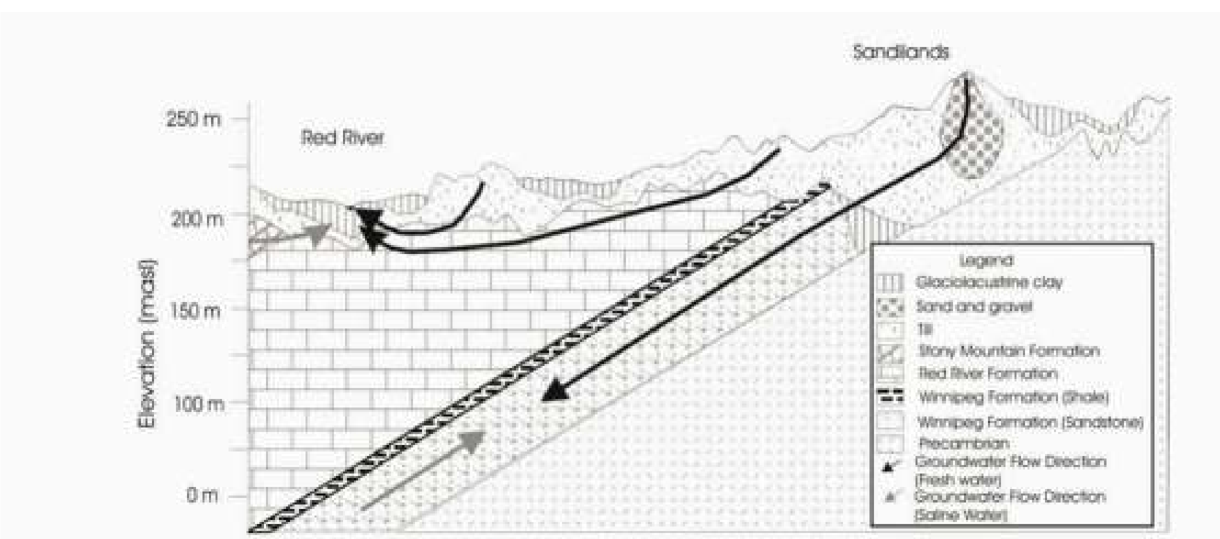


Figure 6 – Simple drawing of the groundwater recharge dynamics in the Southeastern Manitoba. (source – Betcher and Ferguson, 2003)

Figure 2. 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 3.

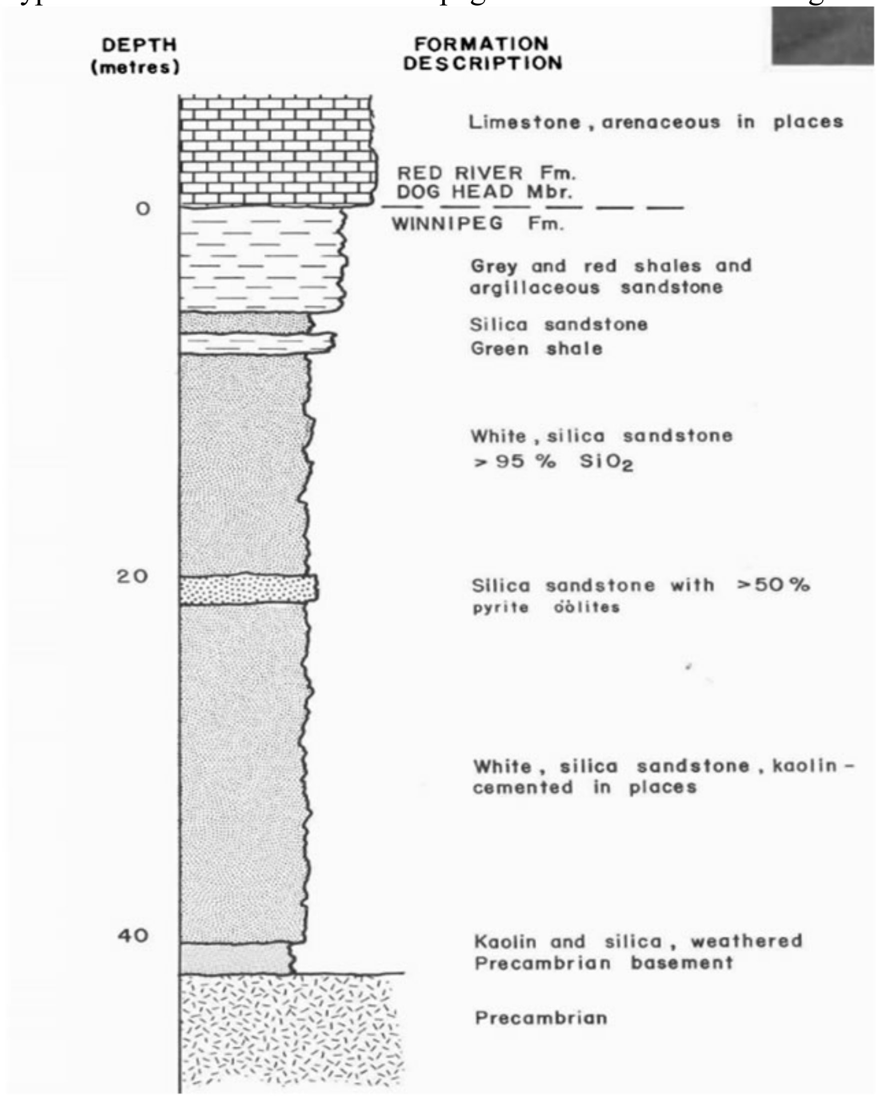


Figure 3. Cross section of the Winnipeg formation from ER84-2 Economic Geography Report Watson 1985 http://www.manitoba.ca/iem/info/libmin/ER84-2.pdf

The Winnipeg formation outcrops at Black Island and on the mainland near Seymourville. A Report of Activities 2016, Manitoba Growth, Enterprise and Trade, by 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/roa16pdfs/GS-17.pdf.

A recent picture at Black Island show in figure 4, 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
The fragility of the shale layer is illustrated by the grey areas of eroded shale that have cascaded down the excavation faces.

Figure 4. 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 5 .

Figure 5. 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 3. 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 4 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 figures 6 and 7.

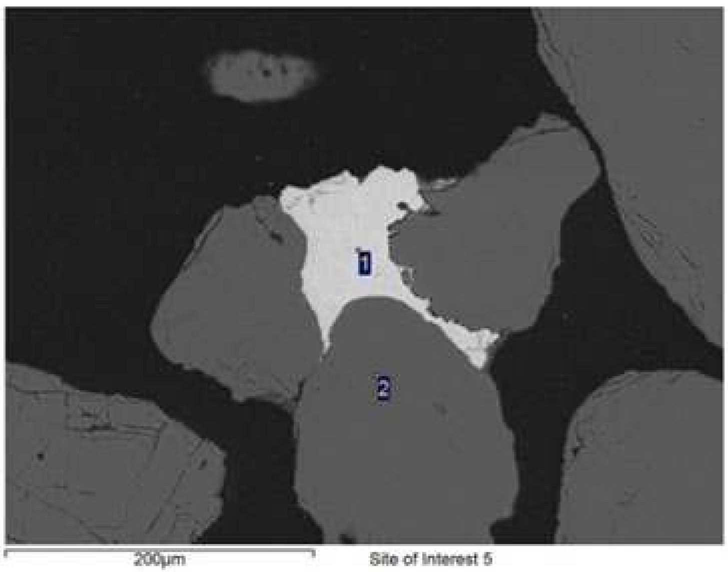


Figure 17: Backscattered Electron Image of Master Composite 6 Minutes Non-Mag -50/+70 Mesh
Quartz grains (grey) are cemented together by pyrite/marcasite (white).

Figure 6. Microscope pictures of marcasite (a form of pyrite) between sand grains from the Winnipeg Formation near Seymourville from the 2014 NI43-101 technical report for Claim Post Resources.

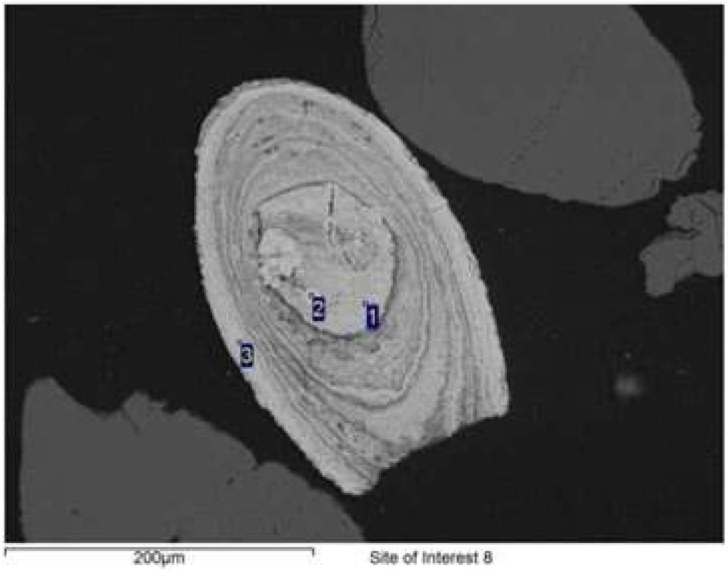


Figure 18: Backscattered Electron Image of Master Composite 6 Minutes Non-Mag -50/+70 Mesh
Rounded pyrite/marcasite grain exhibits concentric layering.

Figure 7. Microscope pictures of marcasite (a form of pyrite) in sand from the Winnipeg Formation near Seymourville from the 2014 NI43-101 technical report for Claim Post Resources.

The results of the acid base accounting test for the sand at Seymourville is shown in figure 8 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 $CaCO_3$/1000 t	5.3
AP	t $CaCO_3$/1000 t	7.34
Net NP	t $CaCO_3$/1000 t	-2.01
NP/AP	ratio	0.73
S	%	0.235
Sulphide1	%	0.10
SO_4	%	0.3
C	%	0.044
CO_3	%	0.035
CO_3 NP	t $CaCO_3$/1000 t	0.58
CO_3 Net NP	t $CaCO_3$/1000 t	-6.76
CO_3 NP	ratio	-0.079

Figure 8. 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 $CaCO_3$ which would act to neutralize acid formed from oxidation of the pyrite. The acid potential is expressed in terms of $CaCO_3$ http://mend-nedem.org/wp-content/uploads/2013/01/1.16.3.pdf A net neutralization potential of -2.01 is equivalent to an 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

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 $CaCO_3$. This is consistent all the $CaCO_3$ 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 the 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 likelyVsomewhat 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 9.

ALS

ALS Canada Ltd.
2103 Dollarton Hwy
North Vancouver BC V7H 0A7
Phone: +1 604 984 0221 Fax: +1 604 984 0218
www.alsglobal.com/geochemistry

To: OUR LINE IN THE SAND
PO BOX 689, STATION MAIN
STEINBACH MB R5G 1M5

Page: 2 - A
Total # Pages: 2 (A - E)
Plus Appendix Pages
Finalized Date: 17-JUL-2020
Account: OLITSA

CERTIFICATE OF ANALYSIS VA20137923

Sample Description	WEI-21	OA-VOL08	OA-VOL08	OA-VOL08	OA-VOL08	OA-ELE07	OA-VOL08	S-IR08	S-GRA06	S-GRA06a	S-CAL06	C-GAS05	C-GAS05	ME-MS61	ME-MS61
Analyte	Recvd Wt.	MPA	FIZZ RAT	NNP	NP	pH	Ratio (N	S	S	S	S	C	CO2	Ag	Al
Units	kg	tCaCO3/1Kt	Unity	tCaCO3/1Kt	tCaCO3/1Kt	Unity	Unity	%	%	%	%	%	%	ppm	%
LOD	0.02	0.3	1	1	1	0.1	0.01	0.01	0.01	0.01	0.01	0.05	0.2	0.01	0.01
#4 sand	0.88	0.6	1	-1	0	8.0	0.00	0.02	<0.01	0.01	0.02	<0.05	<0.2		
#7 sand	0.92													0.02	0.27

Sample Description	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61
Analyte	In	K	La	Li	Mg	Mn	Mo	Na	Nb	Ni	P	Pb	Rb	Re	S
Units	ppm	%	ppm	ppm	%	ppm	ppm	%	ppm	ppm	ppm	ppm	ppm	ppm	%
LOD	0.005	0.01	0.5	0.2	0.01	5	0.05	0.01	0.1	0.2	10	0.5	0.1	0.002	0.01
#4 sand															
#7 sand	<0.005	0.07	2.6	6.7	0.02	47	0.13	0.01	0.7	2.0	40	1.6	2.1	<0.002	0.01

Sample Description	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61
Analyte	Sb	Sc	Se	Sn	Sr	Ta	Te	Th	Ti	Tl	U	V	W	Y	Zn
Units	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	%	ppm	ppm	ppm	ppm	ppm	ppm
LOD	0.05	0.1	1	0.2	0.2	0.05	0.05	0.01	0.005	0.02	0.1	1	0.1	0.1	2
#4 sand															
#7 sand	0.07	0.3	1	<0.2	5.1	<0.05	<0.05	0.82	0.037	0.02	0.5	2	0.1	2.0	3

Figure 9. 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 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_2SO_4 per cubic meter of water. We can calculate the pH based on this. H_2SO_4 completely dissociates into H^+ and HSO_4^-. HSO_4^- can also break up to H^+ and SO_4^{-2} 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_2SO_4 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 or water at Black Island shown in figure 10 was tested with litmus paper and found to be about pH 6 as shown in figure 11. 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 10 is from the oxidized iron (hematite)

Figure 10. Hematite coloured water from acid drainage from Winnipeg Formation sand and overlying shale in the abandoned quarry pit at Black Island. The picture was taken by Don Sullivan Aug. 3, 2020

Figure 11. Litmus paper test showing acidic water from pyrite dissolution at Black Island after almost 100 years of leaching. (witnessed by Don Sullivan Aug. 3, 2020

A third source of pyrite oolite layer shown in figure. 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

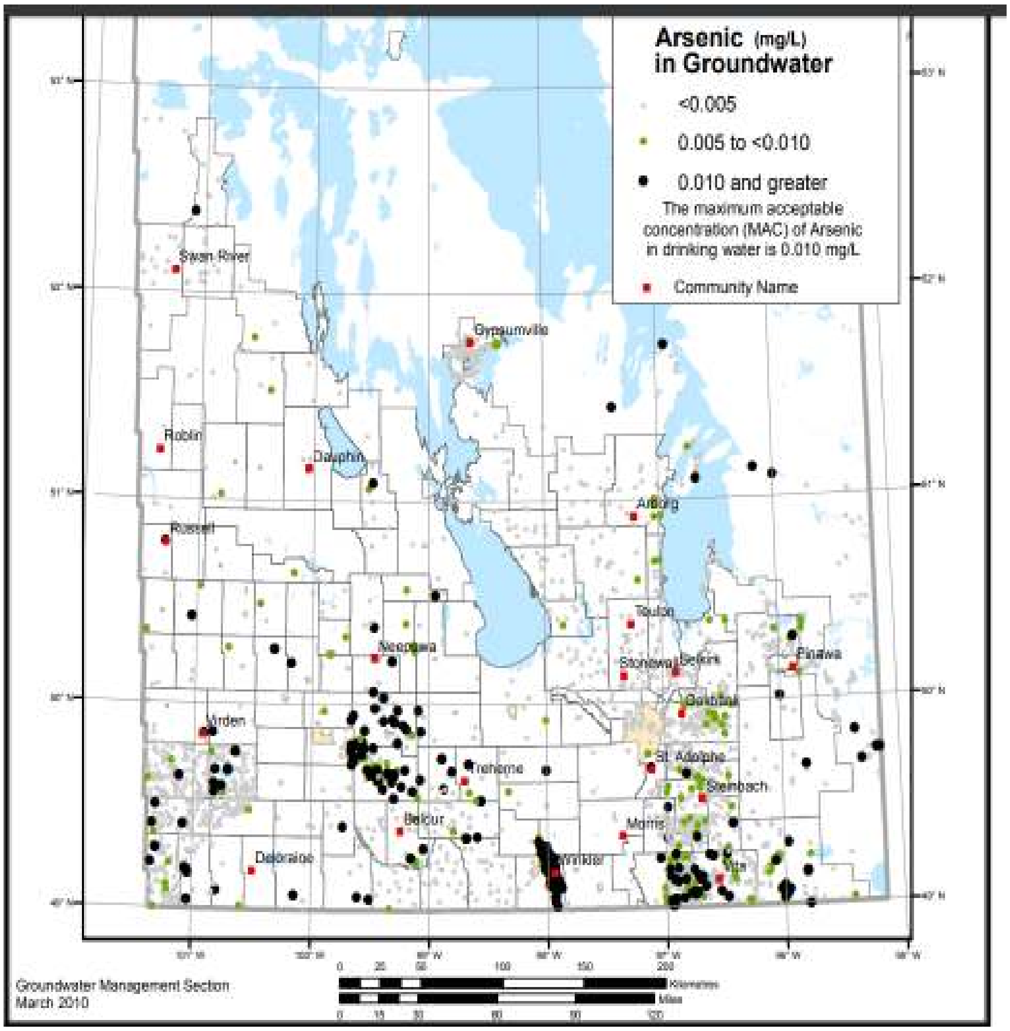


Figure13. Arsenic levels in groundwater in Manitoba from Manitoba Groundwater management section 2010

High levels of arsenic in Virden town water could not be remediated. A new water well supply is being sought. https://www.empireadvance.ca/news/local-news/virden-gets-help-to-fight-arsenic-in-tap-water-1.23903441. The experience at Virden 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 x 0.15 million tonnes x 1 t/m^3 or 0.2 million cubic meters per year. Some water withdrawn from the aquifer the 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 sates 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. 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 topographical map shown in figure 14.

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.

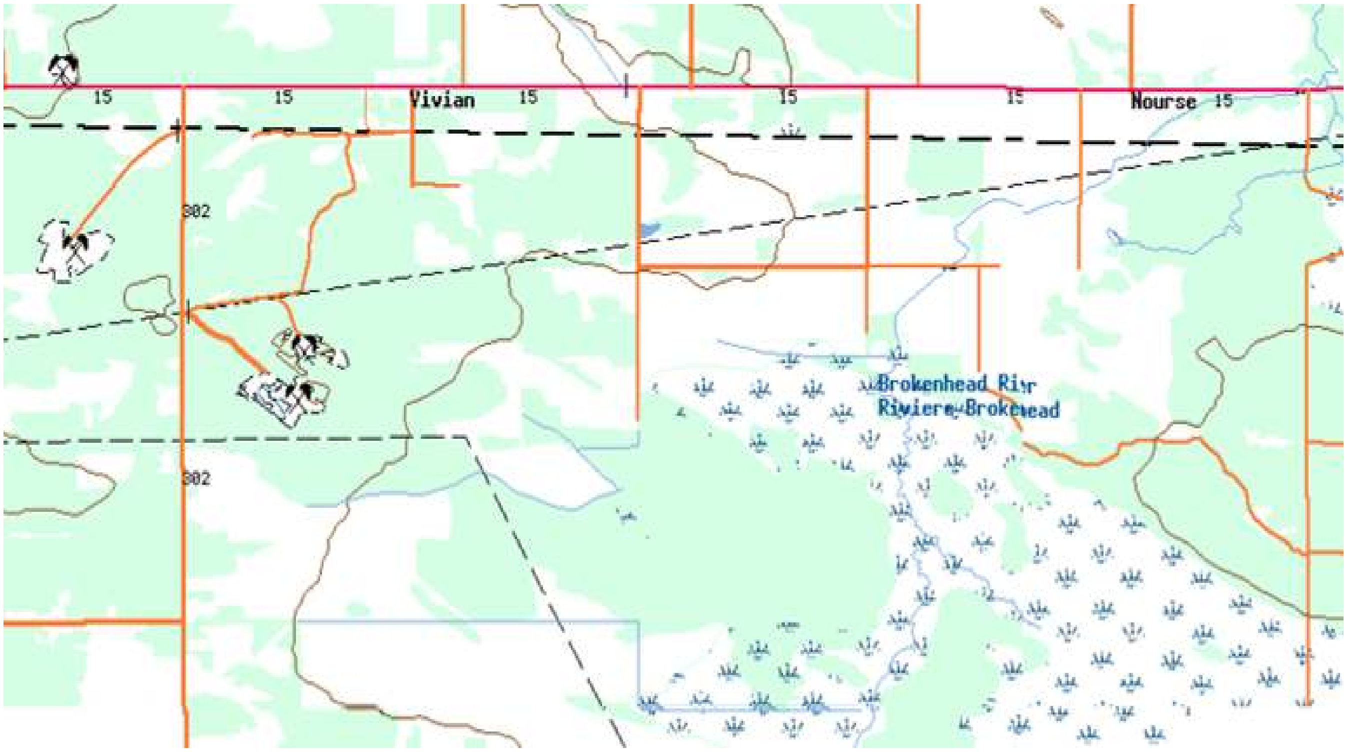


Figure 14. Topographical map of Vivian area showing the natural drainage path to the Brokenhead River.

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 core sample 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 consider, 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/ 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 form 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 4 and 5 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 4 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.

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. 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 that 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. Unsealed CanWhite boreholes 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 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.

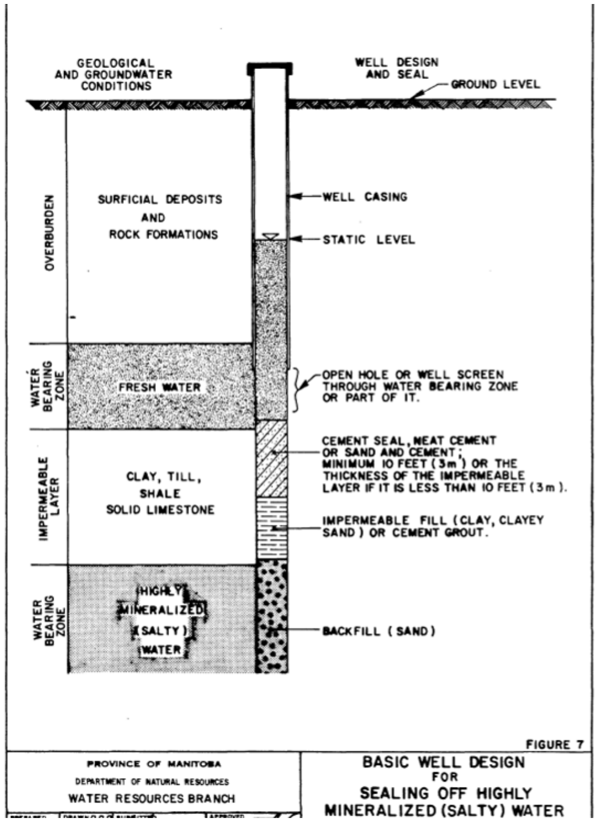


Figure 18. Well design to isolate the Winnipeg formation from the carbonate aquifer above.
http://www.manitoba.ca/sd//////waterstewardship/reports/groundwater/resources/cookscreek.pdf

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.

The certainty of subsidence, borehole leakage, aquifer contamination, and intermixing of aquifer waters as a consequence of this Project should in itself prevent this Project from proceeding.

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 are 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. 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.

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 Fe2+ in the chemical degradation of PAM under environmental conditions. Fe2+ 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 Fe2+ 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. The Fe2+

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 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 kilmetres 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 Rockwood sensitive area, 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 . The 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. 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
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.

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 (SiO2), 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

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 19.

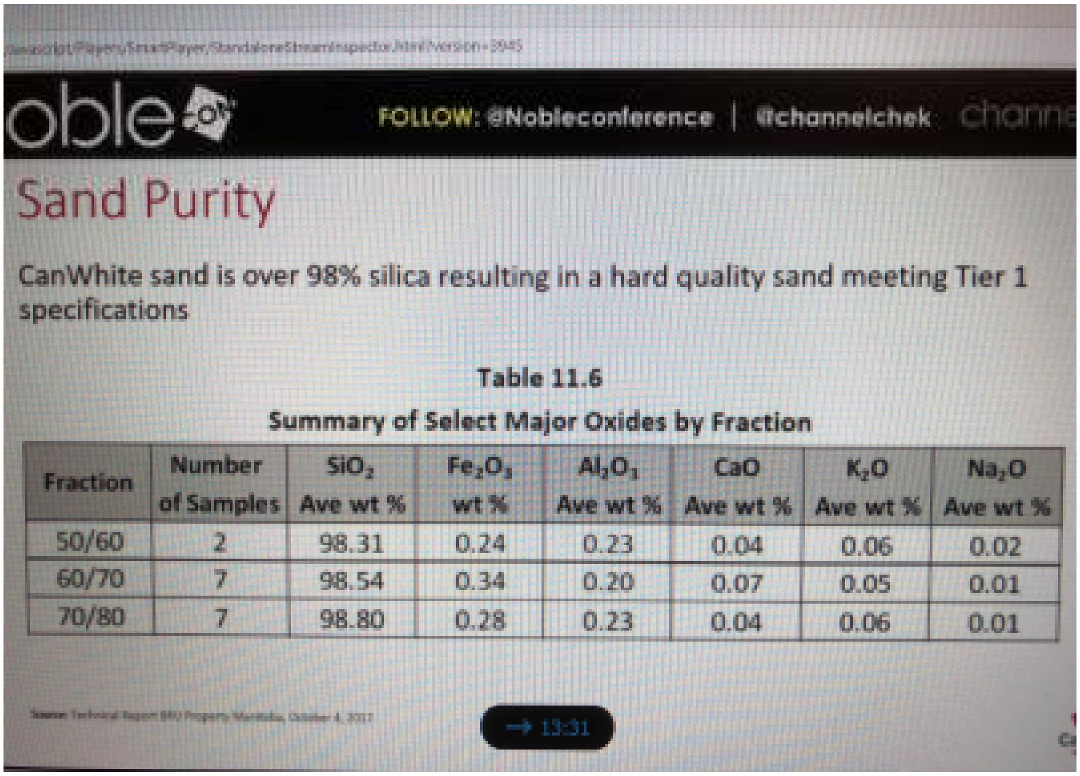


Figure 19. Vivian sand purity from Canwhite noble conference in 2017.

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

Figure 20 shows the purity of sand from various sources in Michigan

Michigan locality	SiO_2	Fe_2O_3	Al_2O_3	TiO_2	MgO	CaO	Na_2O	K_2O	Loss on ignition	Company
Ferrysburg [c]	93.47	0.70	3.65	0.09	0.39	0.67	N. A.	N. A.	0.49	Construction Aggregate Corp.
Muskegon [c]	94.41	0.51	3.22	0.06	0.09	0.14	0.42	0.91	0.32	Nugent Sand Company
Ludington [c]	96 62	1.90	0.3	0.15	0.03	0.8	0.20	N. A.	N. A.	Sargent Sand Company
Saginaw Bay [b]	96 90	1.40	0.4	0.11	0.05	1.0	0.10	N. A.	N. A.	Sargent Sand Company
Bridgman [i]	92 70	0.49	3.96	0.09	0.10	0.22	0.44	1.62	0.42	Manley Brothers of Indiana
Muskegon [i]	92 00	0.57	5.02	N. A.	N. A.	N. A.	0.52	2.05	0.31	McCormick Sand Corp.
Vassar [i]	90.16	1.18	4.66	0.25	0.10	0.21	2.79 t		0.65	Great Lakes Foundry Sand Co.
Yuma [i]	96.16	1.80	0.5	0.1	0.8	1.0	0.35	N. A.	N. A.	Sargent Sand Company
Rockwood [s]	98 95	0.10	0.04	0.01	0.24	0.26	N. A.	N. A.	0.49	Ottawa Silica Company

Figure 20. 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

Figure 21 shows the projected price of frac sand is not expected to recover for the next several years.

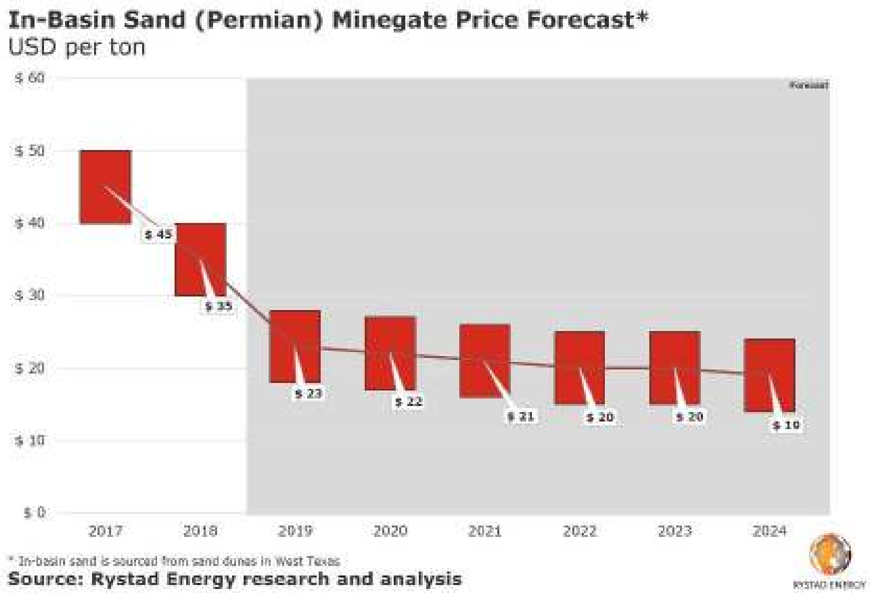


Figure 21. Projected price of frac sand
https://www.rystadenergy.com/newsevents/news/press-releases/Frac-sand-market-still-growing-but-prices-likely-to-stay-flat/#:~:text=Contracted%20prices%20of%20high%2Dquality,Energy's%20latest%20Proppant%20Market%20Report.

Figure 22 shows the market segment for silica sand

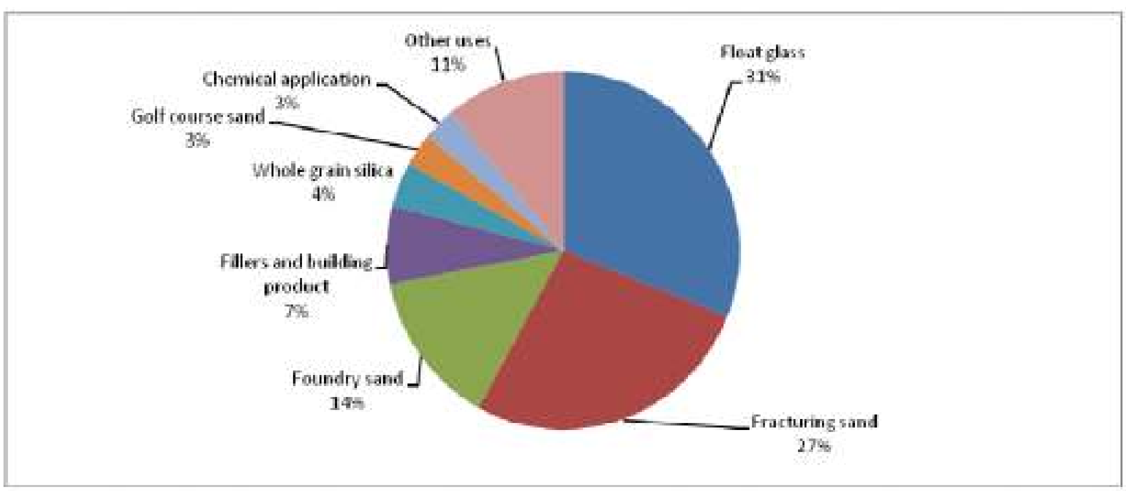


FIGURE 1: The diverse application of silica sand.

Figure 22. Markets for silica sand
http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.736.1246&rep=rep1&type=pdf

From figure 22 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 CO2e 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. 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.

For instance 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 high flow rate of more than 100 tonnes of solid per hour. 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 161.3 pounds of CO2e are produced per million Btu of energy from diesel fuel or 0.0693 kg CO2e 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 CO2 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

Pumping the slurry using diesel fuel would produce of the order of 1.20 kg CO2e per tonne sand per kilometre

For 1.36 million tonnes of sand per year for 5 kilometres the amount of CO2e would be of the order of 8.16 kt. Added to the 34 kt for the plant dryer we are up to 42 kt CO2 eq. This is 1.92 % of Manitoba's CO2e emissions in 2018 for one operation. This is substantial and does not include the CO2e emitted from pumping, drilling and sealing hundreds of boreholes per year. As the pumping site becomes further away the CO2e 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. 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. 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-EhXzjpxEH3zI6sdjDQsCmmAPl8Rdivm30ASgLaao

Figure 22, from the noble conference show the sand size distribution for CanWhite sand

Sample I.D.	42758		42770	
US Standard Sieve No.	Weight %		Weight %	
	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	24.8	66.3
80	31.4	58.9	19.2	85.6
100	23.1	82.0	9.0	94.6
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-size	0.0	= as 16/30	0.0	= as 16/30
in-size	0.0	= as 20/40	0.0	= as 20/40
in-size	1.7	= as 30/50	9.4	= as 30/50
in-size	27.5	= as 40/70	66.3	= as 40/70
in-size	96.0	=as 50/140	89.6	=as 50/140
in-size	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

CanWhite

Figure 22. 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 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

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 know 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 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
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 here identifies the baghouse stack as a major potential for exccedances in slica 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 exccedances 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 addition 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. 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 arsensic, other heavy metals, carcinogenic neurotoxic acrylamide, and fecal matter. Extraction of about 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 cannot be mitigated or addressed by licence conditions. The province has demonstrated failure to enforce the requirement of the Mines and Minerals Act for a mine closure plan and for financial assurance. Due to the weakness in the market for sand and the lack of disclosed long term financial support this Project has a high risk of failure leaving extensive unfunded environmental and physical liabilities. The environmental damage to the aquifer will be permanent and beyond mitigation. There are already environmental liabilities incurred through unsealed exploration boreholes and large amounts of sand withdrawn during exploration activities containing pyritic shale and oolite whose disposal destination is unknown. The sand itself has pyrite. This sand is likely already leaching acid and heavy metals into the carbonate aquifer.

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.

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

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 PM10 concentrations in the CPS EAP. Figure A1 reproduced from the CPS EAP illustrates that significant concentrations over the 50 $\mu g/m^3$ PM 10 limit occur up to one kilomtre 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.

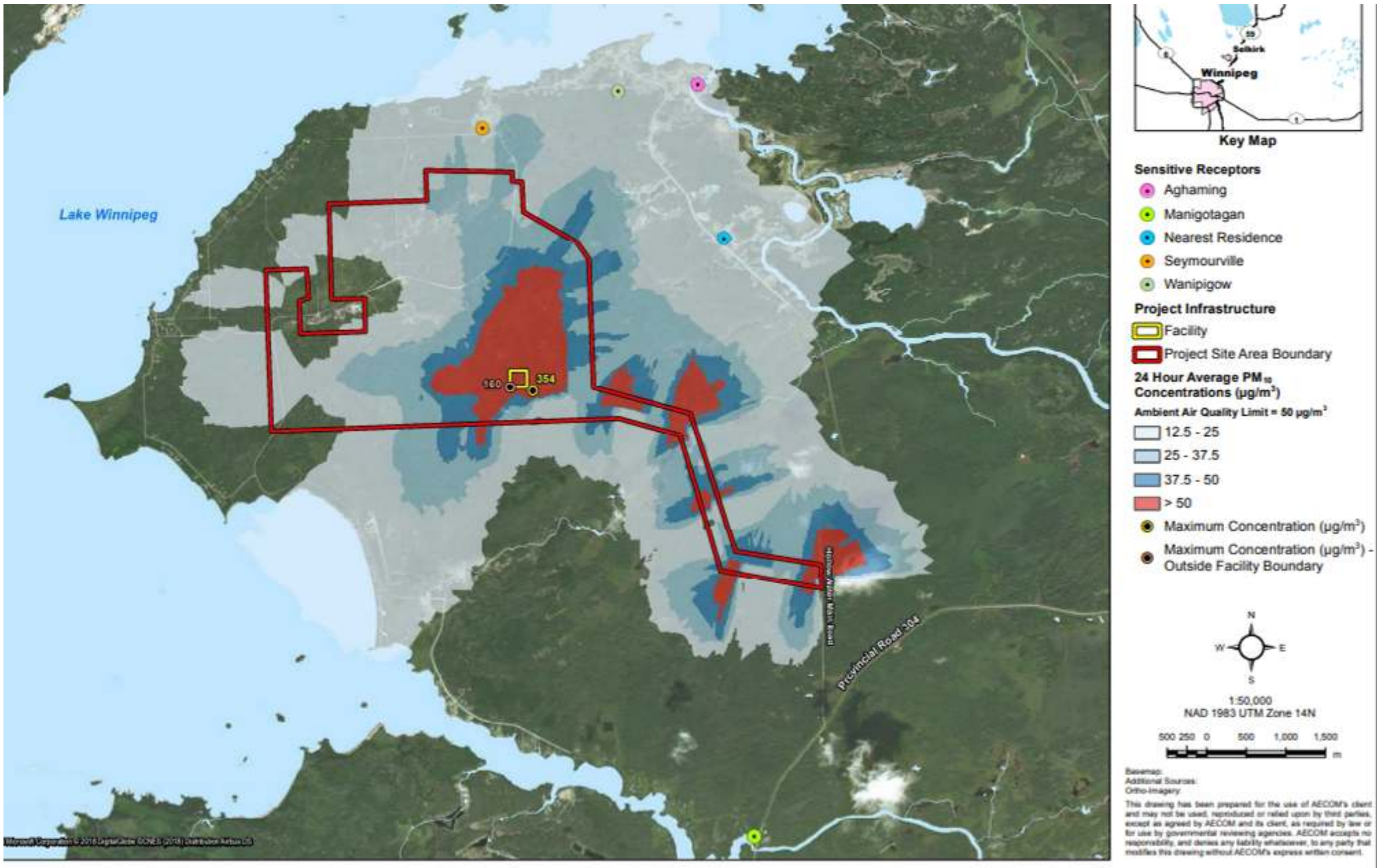


Figure A1. AECOM modelling of PM10 concentrations from the sand processing facility at Wanipigow reproduced from the CPS EAP showing exceedances up to one kilometre north of the plant.
https://www.gov.mb.ca/sd/eal/registries/5991wanipigow/appendix_e_and_f.pdf

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.

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

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)			
									$PM_{2.5}$	PM_{10}	TSP	NO_x
Plant 1 Dryer Baghouse (DC-110)	DRYER	681,884	5,527,507	Vertical	22.86	1.575	15.96	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 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)					
					$PM_{2.5}$	PM_{10}	TSP	NO_x	CO	SO_2
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 in 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 handing rate equations include a 50% moisture and coarse grain size reduction for stockpiles A and B and different wind speed factors. The material handing 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^2)	Emission Rate ($g/s/m^2$)		
				$PM_{2.5}$	PM_{10}	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/chief/ap42/ch11/final/c11s09.pdf https://www3.epa.gov/ttn/chief/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 fro 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 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, 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,

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

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

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

$$S = 1.9x10^{-4} J \frac{s}{1.5}\left(\frac{(365-p)}{235}\right)\frac{f}{15}. \quad (3)$$

Here S is the particulate emission rate in kg/m^2/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

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	"
		100%	**100%**		

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	Winnipeg Formation % 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
	100%	**100%**

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	Winnipeg Formation Sand % 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
		100%	**100%**

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 +20	-20 +40	-40 +50	-50 +70	-70 +100	-100 +200	PAN
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	Master Composite 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

sources	PM10 kg/t	sand rate t/d	Emission rate g/s
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 that 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 are 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 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 exccedances 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.

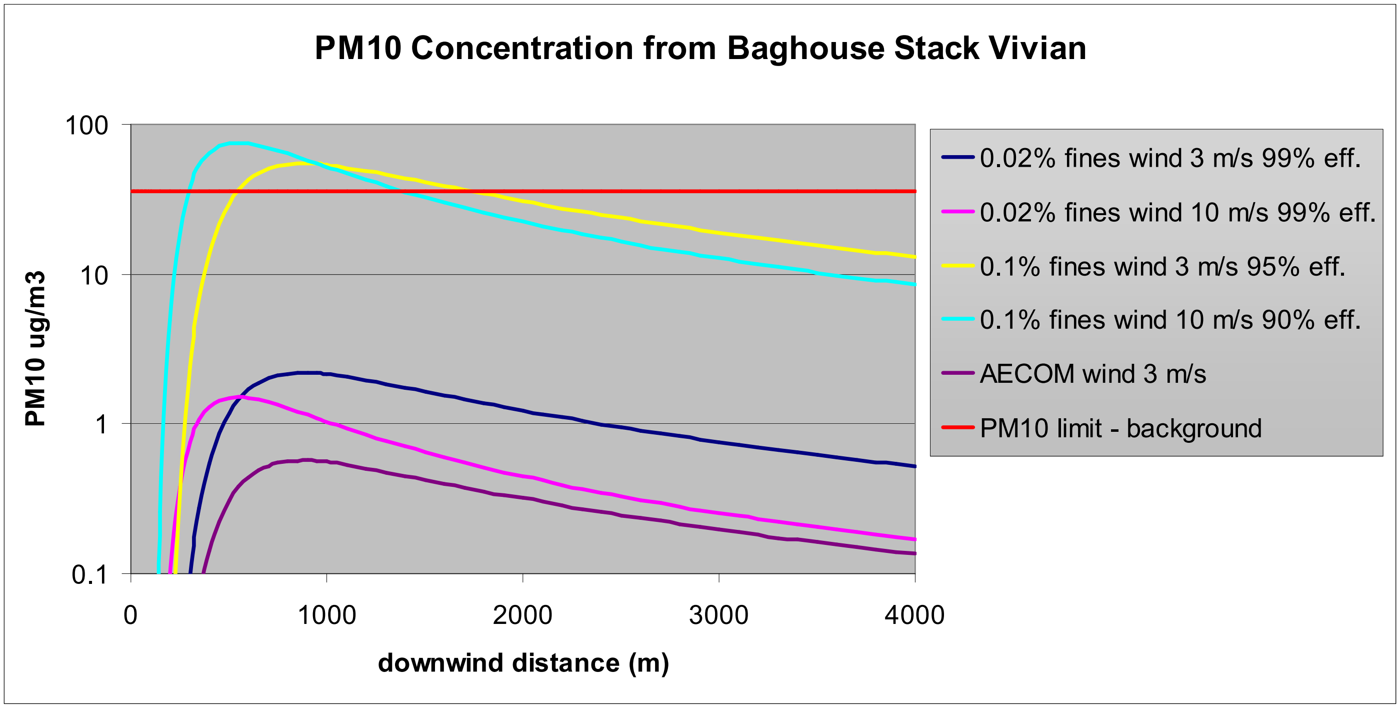


Figure A12. PM10 downwind concentrations for the baghouse stack for various wind speeds, baghouse efficiency and sand fines content

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. A examination of Google maps indicates that about 20 – 30 residences may be within reach of plume exeedances.

AECOM modelling from Wanipigow suggests that the air dispersion modelling for material handling may be underestimated for Vivian. The material handling releases at Vvian 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.

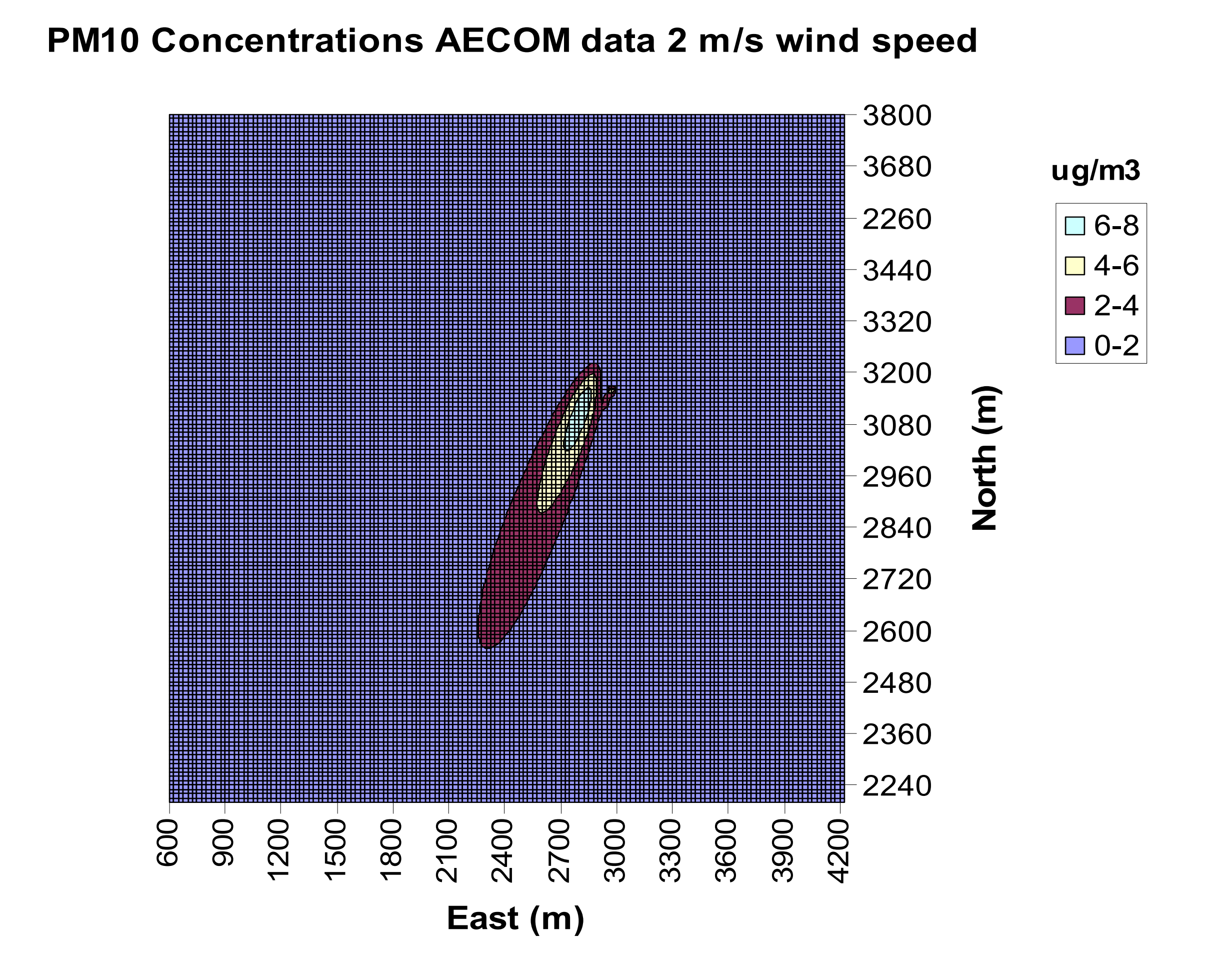


Figure A13. Contour plot of modelled PM10 concentrations above background from the Vivian plant site operations. The wind speed was 2 m/s southwest for atmospheric stability class B. The background concentration of PM10 from the AECOM EAP is 14 µg/m^3. The allowed limit of PM10 for Manitoba is 50 µg/m^3. 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.

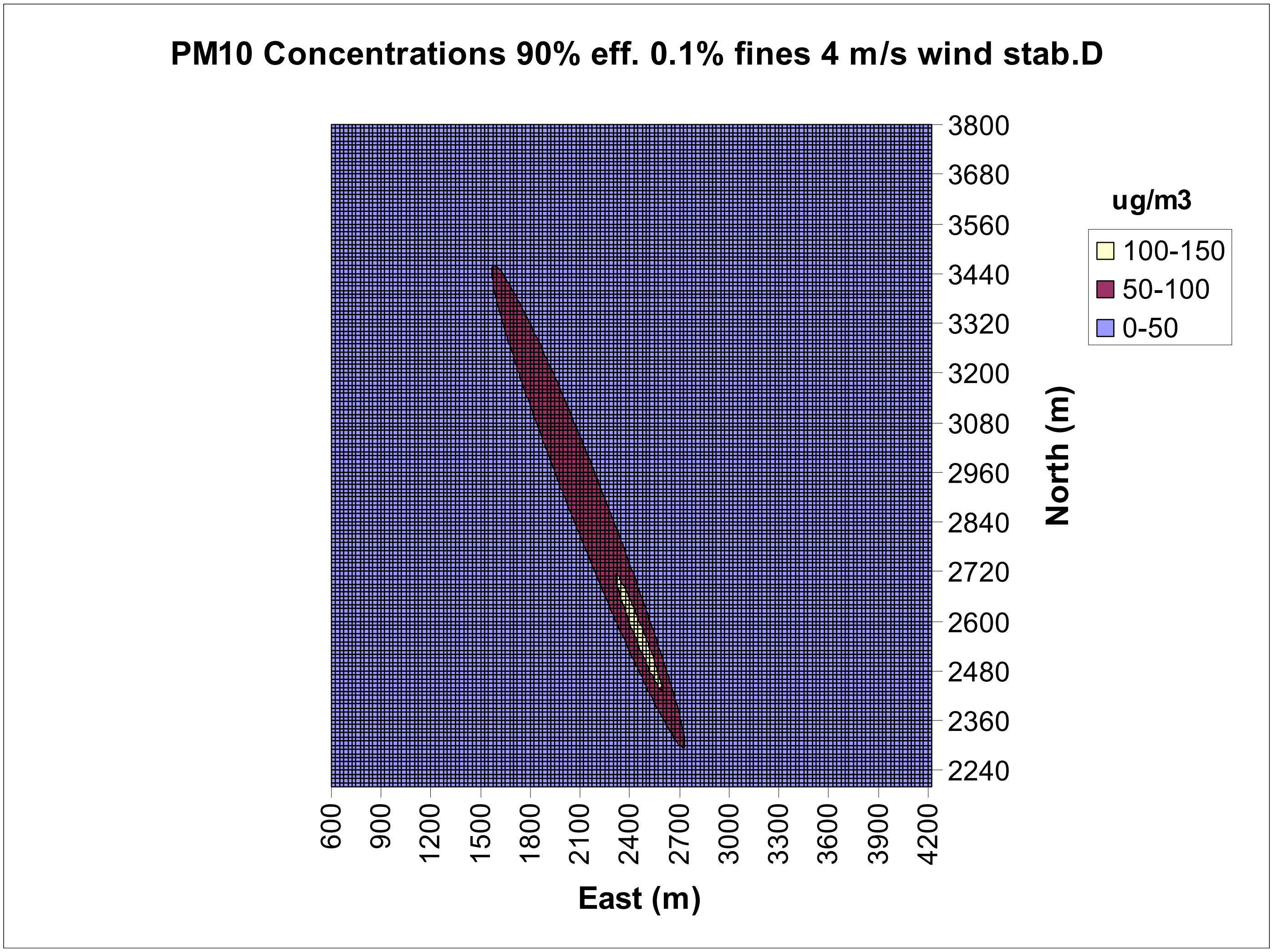
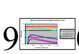


Figure A14. Contour plot of modelled PM10 concentrations above background from the Vivian plant site operations. The wind speed was 4 m/s northwest for atmospheric stability class D. The background concentration of PM10 from the AECOM EAP is 14 μg/m^3. The allowed limit of PM10 for Manitoba is 50 μg/m^3. For this plot the effective limit is 50-14 = 36 μg/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

9  0

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_{eff}) = 50m; x = 500 m = 0.5 km; u_{50} = 6 m/s;

Stability Class "D"

Compute:

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

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

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

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

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

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

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

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 $1.91723\text{x}10^{-5}$ g/m^3 (19.1723 µg/m^3). Rounded to three significant figures as reported by the University of Washington the concentration is 19.2 µg/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

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

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

where **buoyancy flux** is

$$F = g V_s d^2 (T_s - T_a) / 4 T_S$$

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^2

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