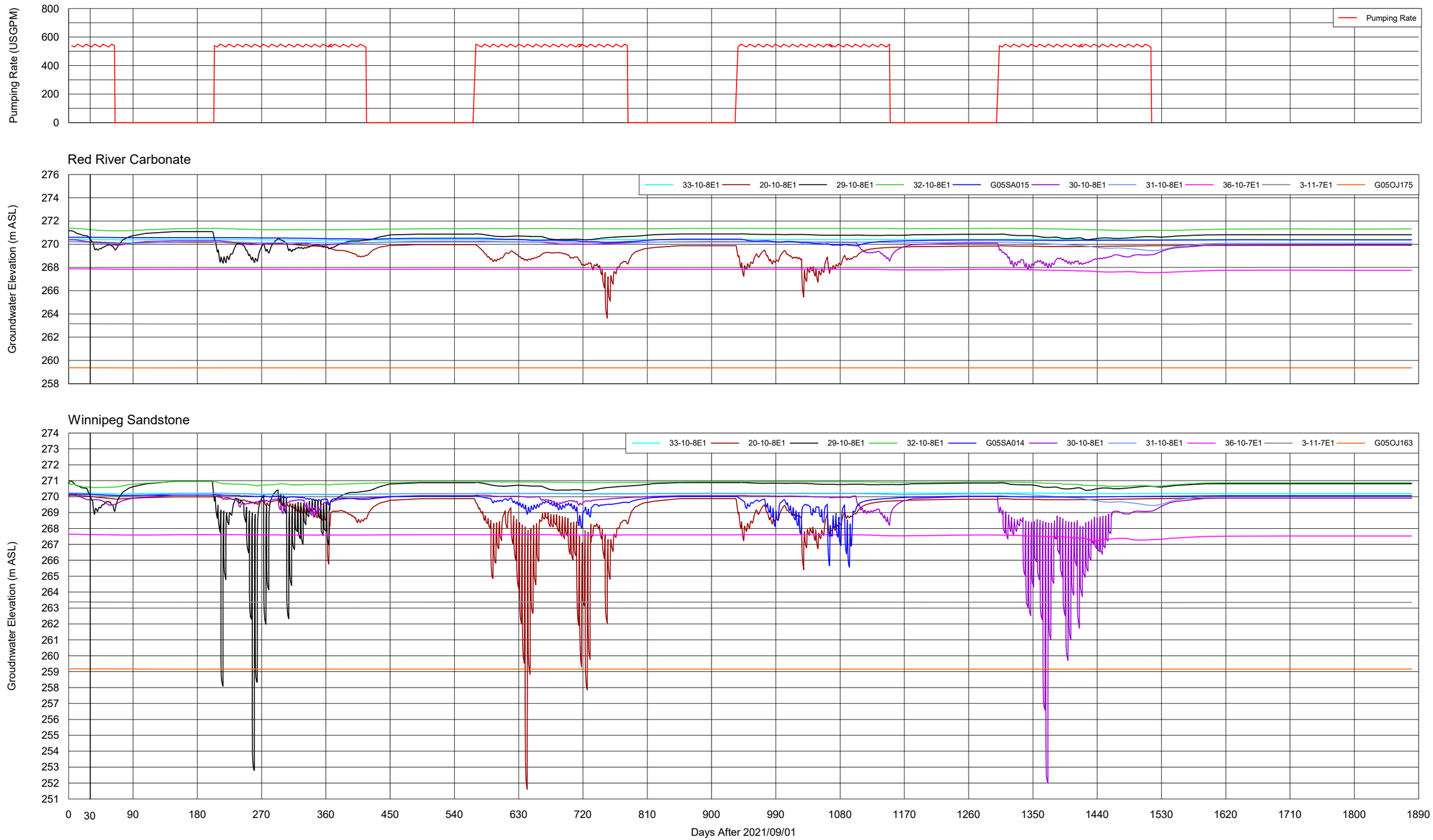

Figure 6-7. Simulated Drawdown and Recovery Hydrograph with 0% Re-Injection (Operations and Post-Closure)

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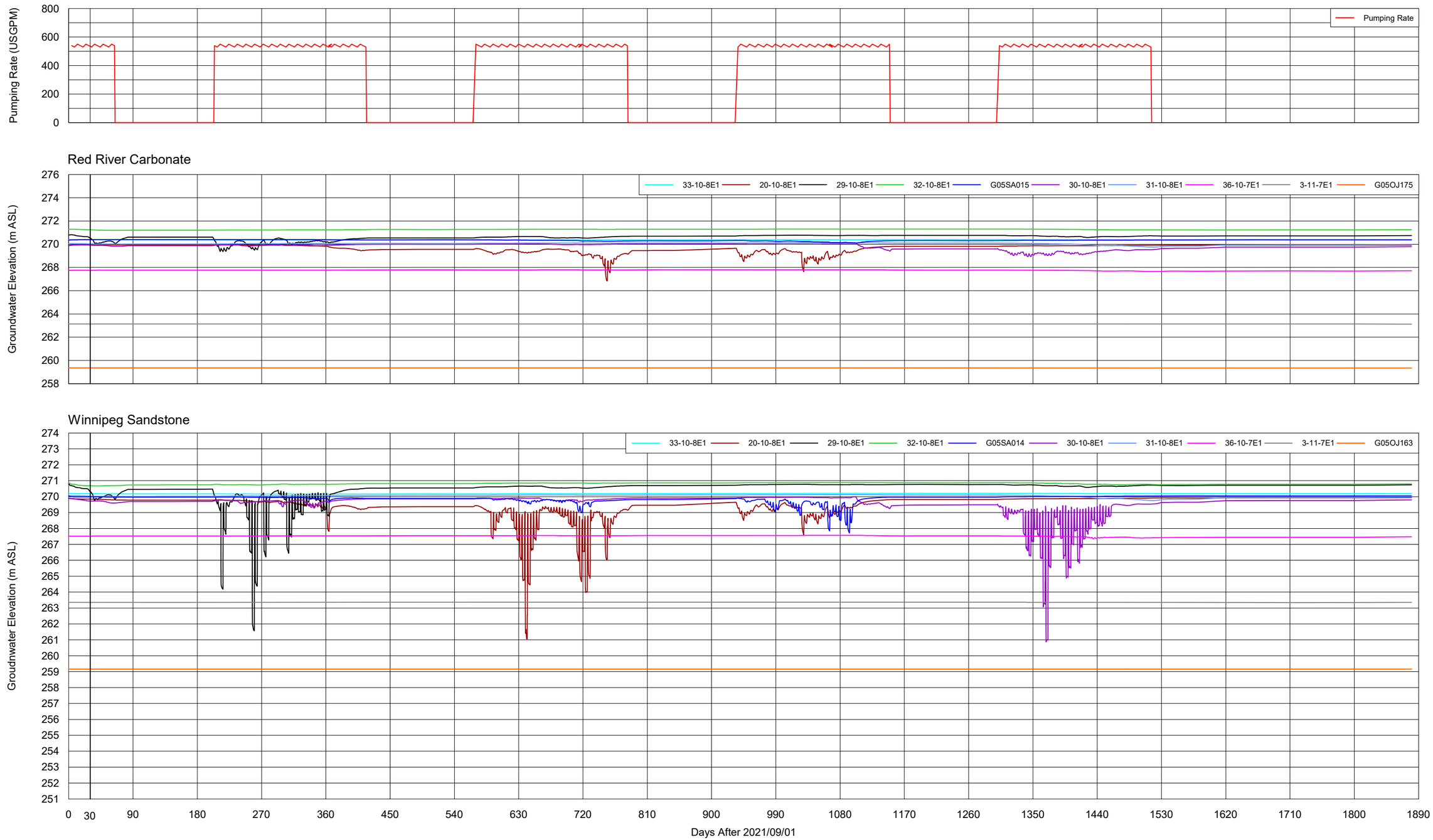
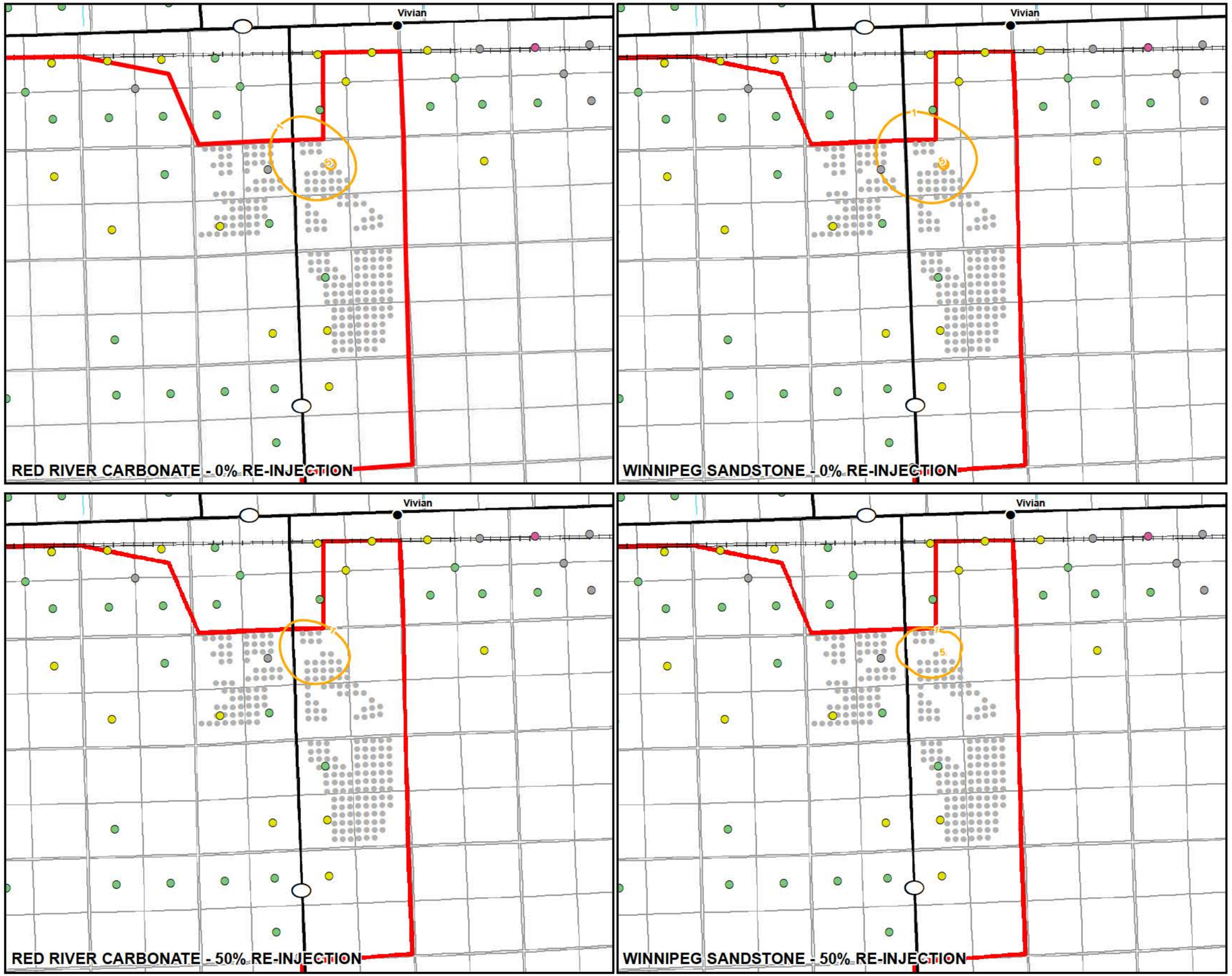


Figure 6-8. Simulated Drawdown and Recovery Hydrograph with 50% Re-Injection (Operations and Post-Closure)

AECOM



Legend

- Production Well
- Project Site

General Features

- Highway
- Railway
- Watercourse

Existing Groundwater Users by Aquifer

- Quaternary Sediment
- Red River Carbonate
- Winnipeg Shale
- Winnipeg Sandstone
- Lower Shale / Precambrian

Drawdown Year 0

- Day 0 (No Drawdown)
- Day 30
- Day 90 (No Drawdown)
- Day 180 (No Drawdown)

DRAFT

1:60,000
NAD 1983 UTM Zone 14N

1,000 500 0 1,000 2,000 m

Basemap: Canvec, Manitoba Land Initiative

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Figure: 6-9

SIMULATED DRAWDOWN (YEAR 0)

VIVIAN SAND EXTRACTION PROJECT
HYDROGEOLOGY AND GEOCHEMISTRY ASSESSMENT
CANWHITE SANDS CORPORATION
Project No.: 60640258 Date: April 2021

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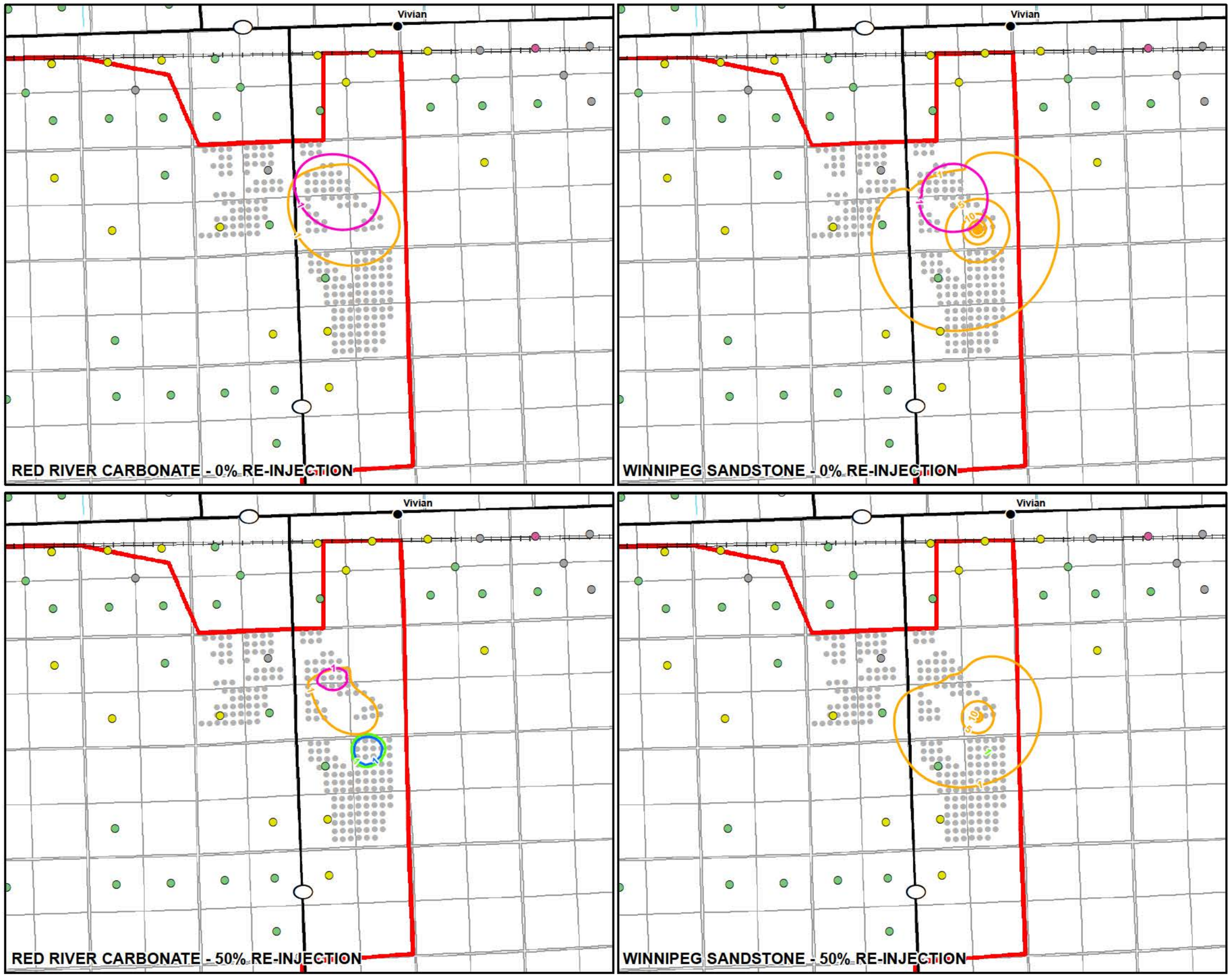

Legend

- Production Well
- Project Site

General Features

- Highway
- Railway
- Watercourse

Existing Groundwater Users by Aquifer

- Quaternary Sediment
- Red River Carbonate
- Winnipeg Shale
- Winnipeg Sandstone
- Lower Shale / Precambrian

Drawdown Year 1

- Day 270
- Day 360
- Day 450
- Day 540

1:60,000
NAD 1983 UTM Zone 14N

1,000 500 0 1,000 2,000 m

Basemap: Canvec, Manitoba Land Initiative

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Figure: 6-9

SIMULATED DRAWDOWN (YEAR 1)

VIVIAN SAND EXTRACTION PROJECT
HYDROGEOLOGY AND GEOCHEMISTRY ASSESSMENT
CANWHITE SANDS CORPORATION
Project No.: 60640258 Date: April 2021

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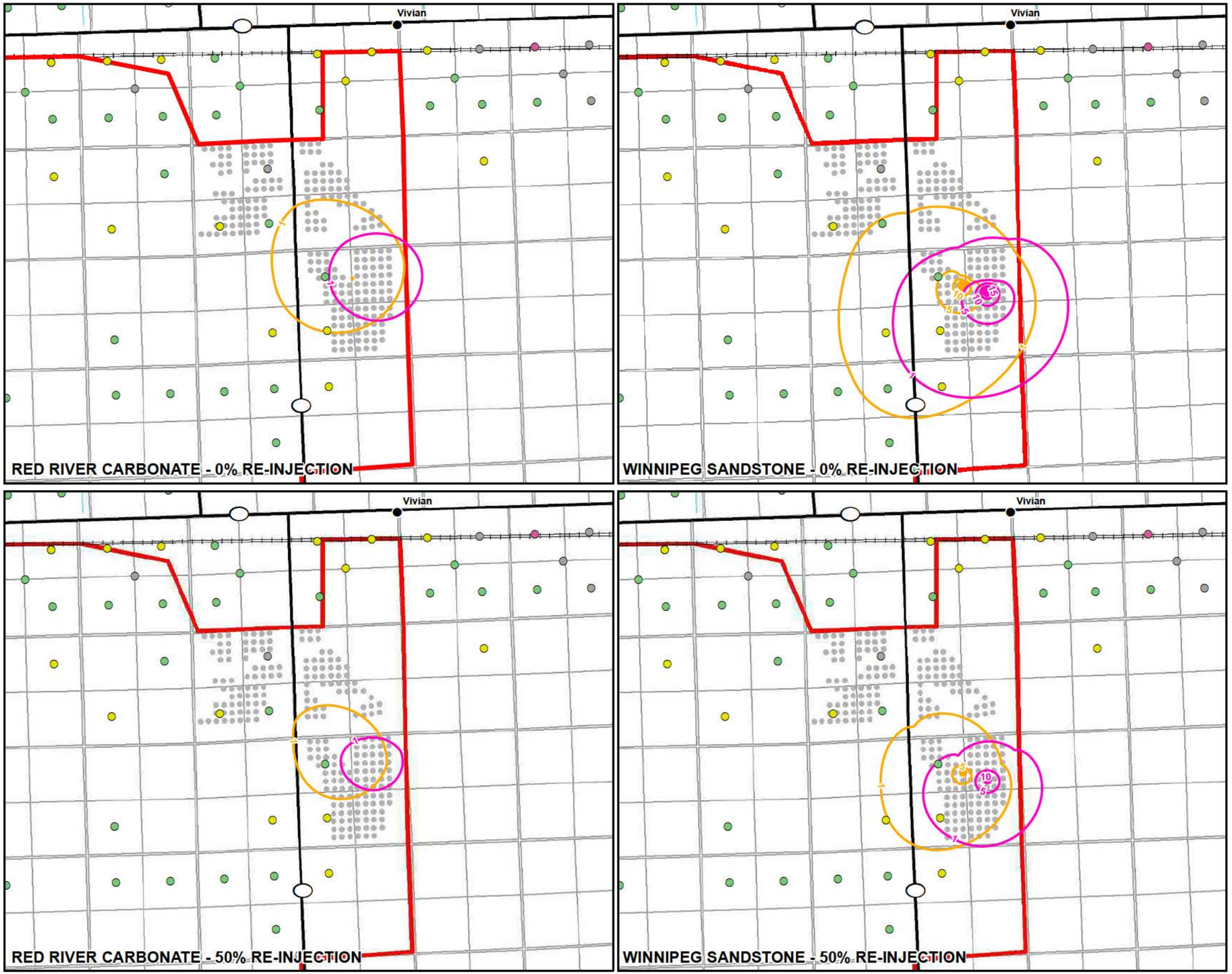

Legend

- Production Well
- Project Site

General Features

- Highway
- Railway
- Watercourse

Existing Groundwater Users by Aquifer

- Quaternary Sediment
- Red River Carbonate
- Winnipeg Shale
- Winnipeg Sandstone
- Lower Shale / Precambrian

Drawdown Year 2

- Day 630
- Day 720
- Day 810 (No Drawdown)
- Day 900 (No Drawdown)

DRAFT

1:60,000
NAD 1983 UTM Zone 14N

1,000 500 0 1,000 2,000 m

Basemap: Canvec, Manitoba Land Initiative

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Figure: 6-11

SIMULATED DRAWDOWN (YEAR 2)

VIVIAN SAND EXTRACTION PROJECT
HYDROGEOLOGY AND GEOCHEMISTRY ASSESSMENT
CANWHITE SANDS CORPORATION
Project No.: 60640258 Date: April 2021

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Project Management Initials: Designer: Checked: Approved:
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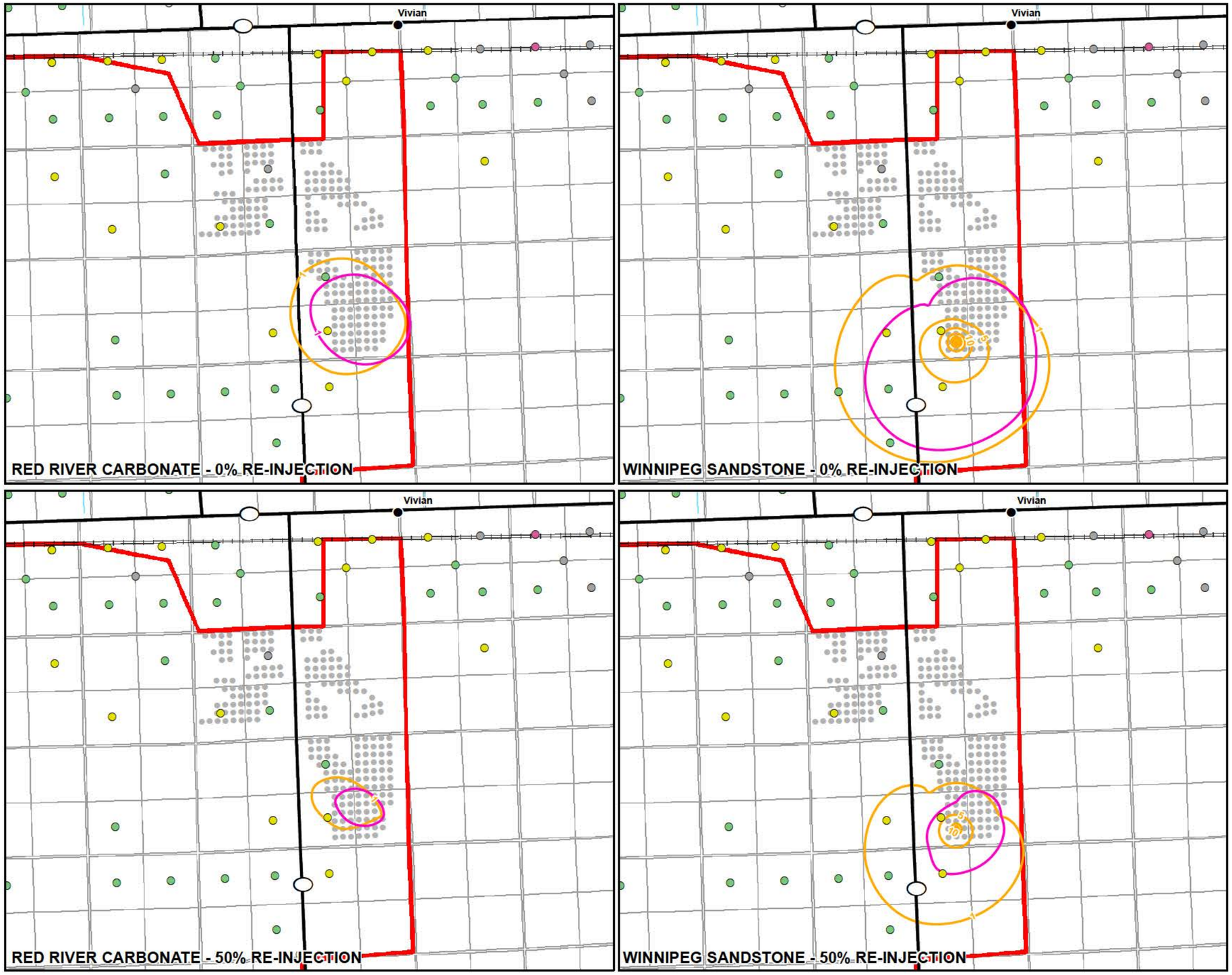

Basemap: Canvec, Manitoba Land Initiative

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Figure: 6-12

SIMULATED DRAWDOWN (YEAR 3)

VIVIAN SAND EXTRACTION PROJECT
HYDROGEOLOGY AND GEOCHEMISTRY ASSESSMENT
CANWHITE SANDS CORPORATION
Project No.: 60640258 Date: April 2021

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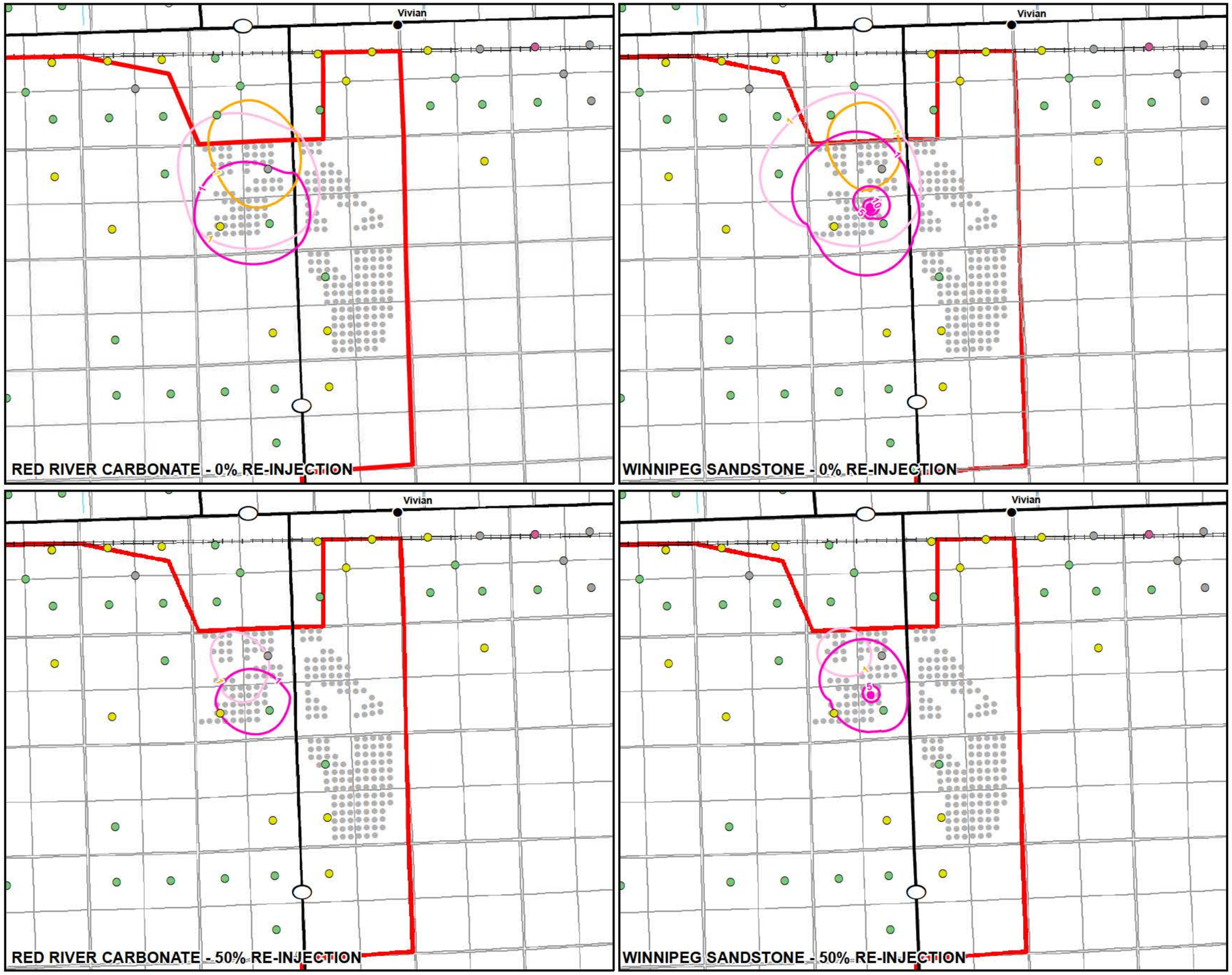

Legend

- Production Well
- Project Site

General Features

- Highway
- Railway
- Watercourse

Existing Groundwater Users by Aquifer

- Quaternary Sediment
- Red River Carbonate
- Winnipeg Shale
- Winnipeg Sandstone
- Lower Shale / Precambrian

Drawdown Year 4

- Day 1350
- Day 1440
- Day 1530
- Day 1620 (No Drawdown)
- Day 1710 (No Drawdown)
- Day 1800 (No Drawdown)
- Day 1880 (No Drawdown)

DRAFT

1:60,000
NAD 1983 UTM Zone 14N

1,000 500 0 1,000 2,000 m

Basemap: Canvec, Manitoba Land Initiative

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Figure: 6-13

SIMULATED DRAWDOWN (YEAR 4)

VIVIAN SAND EXTRACTION PROJECT
HYDROGEOLOGY AND GEOCHEMISTRY ASSESSMENT
CANWHITE SANDS CORPORATION
Project No.: 60640258 Date: April 2021

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Project Management Initials: Designer: Checked: Approved:
ANSI B 279.4mm x 431.8mm

Tables

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Table 3-1. Well Construction Details

Station Name	Well Tag ID	Target Stratigraphic Unit	Installed By	Easting	Northing	Well Standpipe Diameter	Well Standpipe Type	Well Screen or Open Hole Diameter	Well Screen Type	Surface Casing Diameter	Surface Casing Type	Elevations				Depths					Comments
												Ground Surface	Top of Pipe	Top of Screen	Bottom of Screen	Stickup	Borehole Depth	Depth to Top of Screen or open interval	Depth to Bottom of Screen or open interval	Depth to Bottom of Screen or open interval	
				m	m	m	-	m	-	m	-	m ASL	m ASL	m ASL	m ASL	m AGS	m BGS	m BGS	m BGS	m BTOP	
Groundwater Monitoring Wells																					
Bru 95-5	-	Red River Carbonate	Friesen Drillers	682208	5527628	N/A	N/A	0.121	Open hole	0.127	PVC	275.193	276 225	237.38	230 94	1 03	44 25	37 81	44 25	45.28	Previously installed by Canwhite.
Bru 95-6	4506	Winnipeg Sandstone	Friesen Drillers	682199	5527624	0 051	PVC	0.051	PVC	0.127	PVC	275.041	275 843	222.59	219 54	0.802	57 00	52.45	55 50	56.30	
Bru 95-9	4544	Winnipeg Shale	Friesen Drillers	682203	5527621	0 051	PVC	0.051	PVC	0.127	PVC	275.191	275 844	227.34	227 03	0.653	48.16	47 85	48.16	48.81	
Bru 96-1	4558	Winnipeg Sandstone	Friesen Drillers	683064	5527787	0 051	PVC	0.051	PVC	0.127	PVC	273.215	273.799	223.99	220 94	0.584	53 34	49 23	52 28	52.86	
Bru 96-2	4559	Red River Carbonate	Friesen Drillers	683062	5527791	0 051	PVC	0.121	Open hole	0.127	PVC	273.304	274 005	237.34	231 55	0.701	41.76	35 97	41.76	42.46	Shale trap used to secure 0.051m well standpipe against limestone borehole wall immediately below the socket and 0.13m diameter PVC liner.
Water Supply Wells																					
Bru 95-7	4560	Winnipeg Sandstone	Friesen Drillers	681865	5527612	0 305	Steel	0.305	Stainless Steel	N/A	N/A	277.120	277 927	223.17	204 88	0.807	74 98	53 95	72 24	73.04	Drilled with a 0.41m diameter surface casing, which was removed after the well install.
Vibrating Wire Piezometers																					
Bru 95-8 (Four nested VWP sensors)	N/A	Red River Carbonate (2) Winnipeg Shale (1) Winnipeg Sandstone (1)	Paddock Drilling	681953	5527630	N/A	N/A	NA	N/A	0.110	Steel	277.271	278 387	N/A	N/A	1.116	55 09	N/A	N/A	N/A	Tripletube HQ drilling from top of limestone to bottom of hole. Borehole diameter 0 096m. HW casing at surface with a 0.025m VWP housing box welded to the top.

Notes:

m BGS = meters below ground surface.

m AGS = meters above ground surface.

m ASL = meters above sea level.

m BTOP = meters below top of piezometer pipe.

1 - Pre-existing montoring wel installed by Canwhite

- unknown

Survey data taken on Dec 1, 2020 by David Atkinson (AECOM).

Prepared for: Canadian White Sands Corp.

Table 4-1. Description of Rock Samples for Geochemical Assessment

Sample ID	Lithology	Northing	Easting	Depth	Geological Unit	Description/Comments
		m	m	m BGS		
Bru 121-1_24.38 - 24.83	Carbonate	5515834	685310	24.38 to 24.83	Red River Carbonate	Carobonate rock core collected from core box in CanWhite storage in Steinbach.
Bru 146_36.82 - 37.13		5504548	685001	36.82 to 37.13	Red River Carbonate	Carobonate rock core collected from core box in CanWhite storage in Steinbach.
Bru 95-8 40.16 - 40.65		5527630	681953	40.16 to 40.65	Red River Carbonate	Carbonate sample collected at drill pad during drilling.
Bru 121-1_36.57 - 37.00	Shale	5515834	685310	36.57 to 37.00	Winnipeg Shale	Shale rock core collected from core box in CanWhite storage in Steinbach.
Bru 146_49.86 - 50.29		5504548	685001	49.86 to 50.29	Winnipeg Shale	Shale rock core collected from core box in CanWhite storage in Steinbach.
Bru 95-8_49.39 - 49.79		5527630	681953	49.39 to 49.79	Winnipeg Shale	Shale sample collected at drill pad during drilling.
Bru 95-3	Sandstone	5527622	682214	NA	Winnipeg Sandstone	Sample collected from surface pile.
Bru121-1 174-179		5515834	685310	174 to 179	Winnipeg Sandstone	Sample contains concretions of brown color containing iron oxide minerals.
Bru146_189-194		5504548	685001	189 to 194	Winnipeg Sandstone	Sample contains concretions of brown color containing iron oxide minerals and remnants from overlying shale.

Table 4-2. Results of Semi-quantitative Phase Analysis (wt.%) XRD-Rietveld

	Sample ID	**Bru 121-1_ 24.38 - 24.83**	**Bru 146_ 36.82 - 37.13**	**Bru 95-8_ 40.16 - 40.65**	**Bru 121-1_ 36.57 - 37.00**	**Bru 146_ 49.86 - 50.29**	**Bru 95-8_ 49.39 - 49.79**	**Bru 95-3**	**Bru121-1_ 174-179**	**Bru146_ 189-194**
	Depth (m.b.g.s)	24.38 to 24.83	36.82 to 37.13	40.16 to 40.65	36.57 to 37.00	49.86 to 50.29	49.39 to 49.79	NA	174 to 179	189 to 194
	Geological Unit	Red River Carbonate	Red River Carbonate	Red River Carbonate	Winnipeg Shale	Winnipeg Shale	Winnipeg Shale	Winnipeg Sandstone	Winnipeg Sandstone	Winnipeg Sandstone
	Lithology Description	Carbonate	Carbonate	Carbonate	Shale	Shale	Shale	Sandstone	Sandstone	Sandstone
	Acid Generating Status	Non-PAG	Non-PAG	Non-PAG	Uncertain	Non-PAG	Uncertain	Non-PAG	Non-PAG	Non-PAG
Mineral Composition (Formula)										
Quartz	SiO_2	3.2	3.7	3.0	32.4	11.3	0.4	98.3	97.3	98.7
Pyrite	FeS_2	-	-	-	0.6	-	1.3	-	-	-
Illite/Muscovite	$KAl_2(AlSi_3O_{10})(OH)_2$	1.0	1.0	1.4	35.3	55.4	31.1	-	-	-
Calcite	$CaCO_3$	79.1	80.4	79.2	0.3	0.5	2.7	0.2	-	0.2
Ankerite	$CaFe(CO_3)_2$	13.0	10.9	11.8	0.5	1.0	-	-	-	-
K-Feldspar	$K(AlSi_3O_8)$	3.3	3.6	4.2	26.5	26.3	35.3	-	-	-
Albite-low calcian	$NaAlSi_3O_8$ - $CaAl_2Si_2O_8$	-	-	-	-	-	-	0.4	0.9	0.7
Clinochlore	$Mg_5Al(AlSi_3O_{10})(OH)_8$	-	-	-	-	-	2.3	-	-	-
Siderite	$FeCO_3$	0.2	0.2	0.2	0.3	-	-	-	0.9	0.1
Hematite	Fe_2O_3	0.2	0.2	0.2	0.3	0.7	-	-	-	-
Dolomite	$CaMg(CO_3)_2$	-	-	-	-	-	0.9	0.2	-	-
Anatase	TiO_2	-	-	-	0.2	0.8	0.7	-	-	-
Goethite	α-$Fe^{3+}O(OH)$	-	-	-	-	-	5.1	-	-	-
Rutile	TiO_2	-	-	-	-	-	0.9	-	-	-
Iron	α-Fe	-	-	-	-	-	-	-	0.1	0.1
Gypsum	$CaSO_4 \cdot 2H_2O$	-	-	-	-	-	1.0	-	-	-
Kaolinite	$Al_2Si_2O_5(OH)_4$	-	-	-	3.6	4.0	18.4	0.9	0.8	0.2
	Total	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

Notes:

"-" : Minerals were not identified by XRD

Table 4-3. Comparison of Total Recoverable Constituents to Crustal Abundance

Sample ID	Units	Detection Limit	Average Crustal Abundance in Rocks						Bru 121-1_ 24.38 - 24.83	Bru 146_ 36.82 - 37.13	Bru 95-8_ 40.16 - 40.65	Bru 121-1_ 36.57 - 37.00	Bru 146_ 49.86 - 50.29	Bru 95-8_ 49.39 - 49.79	Bru 95-3	Bru 121-1_ 174 to 179	Bru 146_ 189 to 194	Correlation between Trace Metals and Al, Fe and Mn			Organic Carbon[a]
Depth (m.b.g.s)			Price (1997)[b]						24.38 - 24.83	36.82 - 37.13	40.16 - 40.65	36.57 - 37.00	49.86 - 50.29	49.39 - 49.79	NA	174 - 179	189 - 194				
Lithology Description									Carbonate	Carbonate	Carbonate	Shale	Shale	Shale	Sandstone	Sandstone	Sandstone				
Geological Unit			Carbonate[b]	CarbonateX5[c]	Shale[b]	Shale X5[c]	Sandstone[b]	Sandstone X5[c]	Red River Formation	Red River Formation	Red River Format on	Red River Format on	Red River Formation	Red River Formation	Winnipeg Formation	Winnipeg Format on	Winnipeg Formation	Aluminum	Iron	Manganese	
Acid Generating Status									Non-PAG	Non-PAG	Non-PAG	Uncertain	Non-PAG	Uncertain	Non-PAG	Non-PAG	Non-PAG				
Parameters																					
Organic Carbon (C)[a]	%	-	-	-	-	-	-	-	0.2	0.1	0.2	0.04	0	0.19	0.03	0.03	0.02	-0.11	0.28	0.91	1.00
Aluminum (Al)	%	0.01	0.42	2.1	8	40	2.5	12.5	0.15	0.16	0.2	1.56	1.7	1.49	0.1	0.09	0.05	1.00	0.75	-0.14	-0.11
Antimony (Sb)	ppm	0.05	0.2	1	1.5	7.5	0.01[d]	0.05[d]	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	-	-	-	-
Arsenic (As)	ppm	1	1	5	13	65	1	5	1.7	0.8	0.7	30.4	13.3	24.2	0.9	1.5	0.2	0.90	0.73	-0.11	-0.02
Barium (Ba)	ppm	5	10	50	580	2900	10[d]	50[d]	10	10	10	30	40	30	<10	<10	<10	0.98	0.63	-0.93	-0.67
Beryllium (Be)	ppm	0.1	0.1[d]	0.5[d]	3	15	0.1[d]	0.5[d]	0.18	0.18	0.24	1.01	1.26	0.92	<0.05	<0.05	<0.05	0.99	0.62	-0.94	-0.67
Bismuth (Bi)	ppm	0.02	-	-	-	-	-	-	0.02	0.02	0.02	0.18	0.1	0.12	0.01	0.01	0.01	0.93	0.65	-0.10	-0.08
Boron	ppm	10	20	100	100	500	35	175	10	10	10	70	70	50	<10	<10	<10	0.98	0.54	-0.96	-0.71
Cadmium (Cd)	ppm	0.01	0.035	0.175	0.3	1.5	0.01[d]	0.05[d]	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	-	-	-	-
Caesium (Cs)	ppm	0.05	0.1[d]	0.5[d]	5	25	0.1[d]	0.5[d]	0.25	0.21	0.32	1.05	1.04	0.73	0.05	<0.05	<0.05	0.97	0.57	-0.37	-0.36
Calcium (Ca)	%	0.01	30.23	151.15	2.21	11.05	3.91	19.55	>25.0	>25.0	>25.0	0.81	0.43	1.32	0.21	0.03	0.12	0.77	0.91	0.96	0.83
Cerium (Ce)	ppm	0.05	11.5	57.5	59	295	92	460	9.41	8.86	13.5	54.6	28.7	36.1	2.19	1.67	1.48	0.90	0.63	0.04	0.05
Chromium (Cr)	ppm	1	11	55	90	450	35	175	4	4	5	24	42	58	2	3	2	0.90	0.95	-0.03	0.10
Cobalt (Co)	ppm	0.1	0.1	0.5	19	95	0.3	1.5	**1.7**	**1.6**	**1.5**	16.9	22	20.6	0.4	0.6	0.2	0.99	0.81	-0.12	-0.07
Copper (Cu)	ppm	0.5	4	20	45	225	1[d]	5[d]	3.3	5.7	3.2	24.9	24.8	7.4	**6.6**	1	0.8	0.85	0.31	-0.26	-0.39
Gallium (Ga)	ppm	0.1	4	20	19	95	12	60	0.75	0.73	0.97	6.65	7.8	8.17	0.27	0.18	0.12	0.99	0.83	-0.08	-0.02
Germanium (Ge)	ppm	0.1	0.2	1	1.6	8	8	40	<0.05	<0.05	<0.05	0.13	0.05	0.07	<0.05	<0.05	<0.05	-0.42	-0.42	-0.03	-0.08
Gold (Au)	ppm	0.02	0.001[d]	0.005[d]	0.001[d]	0.005[d]	0.001[d]	0.005[d]	**<0.02**	**<0.02**	**<0.02**	**<0.02**	**<0.02**	**<0.02**	**<0.02**	**<0.02**	**<0.02**	-	-	-	-
Hafnium (Hf)	ppm	0.05	0.3	1.5	2.8	14	3.9	19.5	0.09	0.09	0.12	0.08	0.26	0.34	0.15	0.13	0.09	0.63	0.88	-0.09	0.12
Indium (In)	ppm	0.02	0.01[d]	0.05[d]	0.1	0.5	0.01[d]	0.05[d]	0.011	0.008	0.01	0.016	0.02	0.047	<0.005	<0.005	<0.005	0.63	1.00	-0.29	0.15
Iron (Fe)	%	0.01	0.38	1.9	4.72	23.6	0.98	4.9	0.49	0.47	0.58	1.59	2.23	5.56	0.22	0.65	0.3	0.75	1.00	0.07	0.28
Lanthenum (La)	ppm	0.1	1[d]	5[d]	92	460	30	150	4.1	3.8	**5.2**	18.7	12.6	15	1	0.8	0.7	0.95	0.71	0.06	0.07
Lead (Pb)	ppm	0.2	9	45	20	100	7	35	1.3	1.3	1.1	13.1	7.4	4.6	1.1	0.9	6.3	0.75	0.31	-0.37	-0.40
Lithium (Li)	ppm	1	5	25	66	330	15	75	2.8	2.5	3.5	17.6	25.7	25.7	1.9	1.9	1.3	0.98	0.85	-0.10	-0.03
Magnesium (Mg)	%	0.01	4.7	23.5	1.5	7.5	0.7	3.5	1.53	1.3	1.49	0.39	0.45	0.41	0.04	0.01	0.02	-0.19	-0.16	0.95	0.75
Manganese (Mn)	ppm	2	1100	5500	850	4250	10[d]	50[d]	305	265	321	101	64	206	24	45	33	-0.14	0.07	1.00	0.91
Mercury (Hg)	ppm	0.01	0.04	0.2	0.4	2	0.03	0.15	0.01	0.01	0.01	0.25	0.05	0.03	<0.01	<0.01	<0.01	0.57	0.04	-0.63	-0.55
Molybdenum (Mo)	ppm	0.05	0.4	2	2.6	13	0.2	1	0.07	0.14	0.13	0.22	0.41	0.54	0.06	0.09	0.06	0.86	0.94	0.04	0.14
Nickel (Ni)	ppm	0.5	20	100	68	340	2	10	3	4	3.1	38	52.6	25.8	1.2	1.3	0.5	0.96	0.57	-0.21	-0.27
Niobium (Nb)	ppm	0.05	0.3	1.5	11	55	0.01[d]	0.05[d]	0.07	0.07	0.08	<0.05	<0.05	0.21	**0.06**	<0.05	<0.05	1.00	1.00	0.01	0.42
Phosphorus (P)	ppm	0.01	400	2000	700	3500	170	850	820	600	870	2180	490	580	30	30	20	0.52	0.16	0.32	0.20
Potassium (K)	%	0.01	0.27	1.35	2.66	13.3	1.07	5.35	0.08	0.09	0.11	0.88	0.95	0.49	0.02	0.01	0.01	0.96	0.54	-0.17	-0.24
Rhenium	ppm	0.001	-	-	-	-	-	-	0.002	0.001	0.001	0.013	0.01	0.003	<0.001	<0.001	<0.001	0.80	0.14	-0.92	-0.81
Rubidium (Rb)	ppm	0.2	3	15	140	700	60	300	3.9	3.8	5.4	36.8	41.2	22.7	1	0.3	0.2	0.97	0.57	-0.15	-0.21
Scandium (Sc)	ppm	0.1	1	5	13	65	1	5	0.9	0.9	1.1	4.2	3.4	6.1	0.1	0.1	0.1	0.92	0.91	0.10	0.21
Selenium (Se)	ppm	1	0.08	0.4	0.6	3	0.05	0.25	0.3	**0.5**	**0.7**	**13.1**	<0.2	0.3	<0.2	0.2	<0.2	0.65	0.00	-0.44	-0.52
Silver (Ag)	ppm	0.01	0.01[d]	0.05[d]	0.07	0.35	0.01[d]	0.05[d]	<0.01	0.01	0.01	**0.4**	0.1	0.02	0.01	0.01	0.01	0.62	0.10	-0.16	-0.26
Sodium (Na)	%	0.01	0.04	0.2	0.96	4.8	0.33	1.65	0.02	0.02	0.02	0.03	0.02	0.02	0.01	<0.01	<0.01	0.55	0.21	0.18	0.03
Strontium (Sr)	ppm	0.5	610	3050	300	1500	20	100	198.5	205	205	91.7	141.5	34.2	3	1.9	1.9	0.00	-0.18	0.81	0.52
Sulfur (S)	%	0.01	0.12	0.6	0.24	1.2	0.024	0.12	0.07	0.03	0.05	0.23	0.07	0.69	<0.01	0.01	0.01	0.61	0.95	0.11	0.39
Tantalum (Ta)	ppm	0.05	0.01[d]	0.05[d]	0.8	4	0.01[d]	0.05[d]	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	-	-	-	-
Tellurium (Te)	ppm	0.05	-	-	-	-	-	-	<0.01	<0.01	<0.01	0.03	0.01	0.09	<0.01	<0.01	<0.01	-0.89	0.92	1.00	1.00
Thallium (Tl)	ppm	0.02	0.01[d]	0.05[d]	1.4	7	0.82	4.1	0.03	0.02	0.02	0.21	0.29	0.1	0.02	0.03	<0.02	0.90	0.41	-0.41	-0.48
Thorium (Th)	ppm	0.01	1.7	8.5	12	60	1.7	8.5	0.9	0.9	1.2	10.8	11.5	11.6	0.4	0.3	0.3	1.00	0.80	-0.11	-0.07
Tin (Sn)	ppm	0.3	0.1[d]	0.5[d]	6	30	0.1[d]	0.5[d]	<0.2	0.2	<0.2	0.4	0.5	0.6	<0.2	<0.2	<0.2	0.85	0.89	-0.45	0.23
Titanium (Ti)	%	0.01	0.04	0.2	0.46	2.3	0.15	0.75	<0.005	<0.005	<0.005	0.007	0.006	0.036	0.006	<0.005	<0.005	0.26	0.93	0.93	0.98
Tungsten (W)	ppm	0.1	0.6	3	1.8	9	1.6	8	<0.05	<0.05	<0.05	0.2	0.07	0.12	<0.05	<0.05	<0.05	-0.55	-0.28	0.12	0.07
Uranium (U)	ppm	0.05	2.2	11	3.7	18.5	0.45	2.25	0.64	0.6	0.73	**30**	11.65	0.4	0.14	0.16	0.14	0.68	0.13	-0.23	-0.35
Vanadium (V)	ppm	1	20	100	130	650	20	100	6	6	8	17	18	60	1	1	1	0.71	0.99	0.19	0.39
Yttrium (Y)	ppm	0.05	30	150	26	130	40	200	2.83	2.62	3.16	19.95	4.68	8.9	0.51	0.33	0.27	0.75	0.44	0.03	0.02
Zinc (Zn)	ppm	1	20	100	95	475	16	80	6	11	6	28	34	38	12	2	2	0.95	0.83	-0.08	-0.02
Zirconium (Zr)	ppm	0.5	-	-	-	-	-	-	2.3	2.2	2.8	5.1	8.3	10.7	4.4	3.8	2.9	0.83	0.92	-0.22	-0.02

Notes:

[a] Organic Carbon is calculated from the difference between Total Carbon and Total inorganic Carbon (derived from ABA test see Table X-4).

[b] From Price (1997) Appendix 3 Distribution of the elements in the Earth's crust (Sedimentary Rocks).

[c] Enrichment criteria based upon crustal abundance data multiplied by a factor of 5.

[d] Order of magnitude estimate from Price (1997) - most conservative value used.

[e] From Vine and Tourtelot (1970) Table 2.

- Data not available for these elements.

Exceeds Screening Criteria for Carbonates.

Exceeds Screening Criteria for Shales.

Exceeds Screening Criteria for Sandstones.

Lower limit of detection exceeds criteria from one or both compilations.

Table 4-4. Acid Base Accounting (ABA) Results

Sample ID	Depth (m.bgs)	Lithology Description	Geological Unit	Weight, Sample Received	Fizz Test	Paste pH	Total C	Total Inorganic Carbon (TIC)	Carbon Dioxide (CO_2)	$CaCO_3$ Equiv.	Total S	Sulphate Sulphur - HCl Extractable	Sulphate Sulphur - Carbonate Extractable	Sulphide Sulphur Total minus Carbonate Leach	Acid Generation Potential (AP)	Mod. ABA Neutralization Potential (NP)	Net Neutralization Potential NNP=NP-AP	Neutralization Potential Ratio NPR = NP/AP	Acid Generation Status
				kg			%	%	%	t $CaCO_3$/kt	%	%	%	wt%	$tCaCO_3$/kt	$tCaCO_3$/kt	$tCaCO_3$/kt	-	
Detection Limit				0.02	1	0.10	0.05	0.01	0.20	-	0.010	0.01	0.01	0.01	0.3	1	1	0.01	-
Bru 121-1_24.38 to 24.83	24.83-24.83	Carbonate	Red River Formation	3.36	4	8.00	11.00	10.80	39.6	900.00	0.07	< 0.01	< 0.01	< 0.01	2.2	868	866	394.55	Non-PAG
Bru 146_36.82 to 37.13	36.82-37.13	Carbonate	Red River Formation	3.18	4	8.00	10.90	10.80	39.6	900.00	0.04	< 0.01	< 0.01	< 0.01	1.3	820	819	630.77	Non-PAG
Bru 95-8_40.16 to 40.65	40.16-40.65	Carbonate	Red River Formation	3.66	4	8.30	10.85	10.65	39	887.50	0.05	< 0.01	< 0.01	< 0.01	1.6	821	819	513.13	Non-PAG
Bru 121-1_36.57 to 37.00	36.57-37.00	Shale	Winnipeg Formation	2.5	1	7.40	0.11	0.07	0.3	5.83	0.23	< 0.01	0.06	< 0.01	7.2	10	3	1.39	Uncertain
Bru 146_49-86 to 50.29	49.86-50.29	Shale	Winnipeg Formation	2.24	1	7.80	0.05	0.05	0.2	4.17	0.07	< 0.01	0.01	< 0.01	2.2	5	3	2.27	Non-PAG
Bru 95-8_49.39 to 49.79	49.39-49.79	Shale	Winnipeg Formation	2.54	2	7.50	0.55	0.36	1.3	30.00	0.64	< 0.01	0.12	< 0.01	20	25	5	1.25	Uncertain
Bru 95-3	NA	Sandstone	Winnipeg Formation	6.00	1	8.50	0.12	0.09	0.3	7.50	0.02	< 0.01	< 0.01	< 0.01	0.6	6	5	10.00	Non-PAG
Bru 121-1_174 to 179	174-179	Sandstone	Winnipeg Formation	1.04	1	7.00	0.12	0.09	0.3	7.50	0.01	< 0.01	0.01	< 0.01	0.3	3	3	10.00	Non-PAG
Bru 146_189 to 194	189-194	Sandstone	Winnipeg Formation	0.3	1	8.10	0.07	0.05	0.2	4.17	< 0.01	< 0.01	0.02	< 0.01	< 0.3	4	< 4	> 13.33	Non-PAG

Notes:

*AP = Total Sulphur*31.25*

$CaCO_3$ Equivalency = Total Inorganic Carbon (TIC)(100/12)*10*

NNP = Modified NP-AP

Sulphate Sulphur determined by 25% HCl Leach with S by ICP.

Sulphide Sulphur determined by Sobek 1:7 Nitric Acid Leach with S by ICP Finish.

Insoluble S is acid insoluble S (Total S - (Sulphate S + Sulphide S)).

Mod. ABA Neutralization Potential - MEND Acid Rock Drainage Prediction Manual, MEND Project 1.16.1b (pages 6.2-11 to 17), March 1991.

Table 4-5. MEND Shake Flask Extraction Results

Sample ID	Units	CDWQ MAC	CDWQ AO	MWQSOG MAC	MWQSOG AO	FIGQG Agricultural	CCME Irrigation	MWQSOG Irrigation	CCME Livestock	MWQSOG Livestock	CCME FAL Acute	CCME FAL Chronic	MWQSOG FAL Acute	MWQSOG FAL Chronic	Bru 121-1 24.38 - 24.83	Bru 146 36.82 - 37.13	Bru 95-8 40.16 - 40.65	Bru 121-1 36.57 - 37.00	Bru 146 49.86 - 50.29	Bru 95-8 49.39 - 49.79	Bru 95-3	Bru 121-1 174 to 179	Bru 146 189 to 194	Correlation with Trace Metals and Al, Fe and Mn		
Depth (m.b.g.s)															24.38 to 24.83	36.82 to 37.13	40.16 to 40.65	36.57 to 37.00	49.86 to 50.29	49.39 to 49.79	NA	174-179	189-194			
Lithology Description															Carbonate	Carbonate	Carbonate	Shale	Shale	Shale	Sandstone	Sandstone	Sandstone			
Geological Unit															Red River Formation	Red River Formation	Red River Formation	Winnipeg Formation	Winnipeg Formation	Winnipeg Formation	Winnipeg Formation	Winnipeg Formation	Winnipeg Formation	Aluminum	Iron	Manganese
Acid Generating Status															Non-PAG	Non-PAG	Non-PAG	Uncertain	Non-PAG	Uncertain	Non-PAG	Non-PAG	Non-PAG			
Inorganic																										
Hardness (as $CaCO_3$)	mg/L	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	68.2	63.3	70	292	106	839	19.6	4.36	17.2	-	-	-
pH (Lab)	-	NG	7.0-10.5	NG	6.5-8.5	6.5-9	NG	NG	NG	NG	6.5-9	6.5-9	NG	NG	8.08	8.17	8.2	8.07	8.18	7.94	7.05	-	-	-	-	-
Dissolved Metals																										
Aluminum (Al)	mg/L	NG	NG	NG	NG	NG	5	5	5	5	0.005-0.1[f]	0.005-0.1[f]	NG	NG	**0.131**	**0.179**	**0.144**	<0.0050	<0.0050	<0.0050	**1.26**	**1.88**	**0.713**	1.00	0.37	0.92
Antimony (Sb)	mg/L	0.006	NG	0.006	NG	2.0	NG	NG	NG	NG	NG	NG	NG	NG	0.00016	0.00013	<0.00010	0.00012	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	-1.00	-	-1.00
Arsenic (As)	mg/L	0.01	NG	0.01	NG	0.005	0.1	0.1	0.025	0.025	0.005	0.005	0.34	0.15	<0.0010	<0.0010	<0.0010	**0.0307**	0.0029	<0.0010	0.0014	<0.0010	<0.0010	-	-	1.00
Barium (Ba)	mg/L	1	NG	1	NG	0.5	NG	NG	NG	NG	NG	NG	NG	NG	0.0106	0.0084	0.0128	0.0937	0.0961	0.0845	0.0052	0.0118	0.0051	-0.13	-0.10	0.59
Beryllium (Be)	mg/L	NG	NG	NG	NG	0.0053	0.1	0.1	0.1	0.1	NG	NG	NG	NG	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	-	-	-
Bismuth (Bi)	mg/L	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	-	-	-
Boron (B)	mg/L	5	NG	5[f]	NG	0.5	0.5 - 6[b]	0.5 - 6[b]	5	5	29	1.5	NG	NG	0.068	0.042	0.071	0.415	0.204	1.2	0.025	0.016	<0.010	-0.89	1.00	0.95
Cadmium (Cd)	mg/L	0.007	NG	0.005	NG	0.000017	0.0051	0.0051	0.08	0.08	0.0023-0.0057[j]	0.00017-0.00036[j]	0.00221 - 0.0058[j]	0.00026 - 0.00051[j]	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	-	-	-
Calcium (Ca)	mg/L	NG	NG	NG	NG	NG	NG	NG	1000	1000	NG	NG	NG	NG	16.8	16.2	17.7	77.4	27.2	246	6.25	0.96	4.94	-0.92	0.35	0.96
Chromium (Cr)[g]	mg/L	0.05	NG	0.05	NG	0.05	0.0049	NG	0.05	NG	0.0089	0.0089	0.616-1.347[h]	0.08-0.175[j]	<0.00050	<0.00050	<0.00050	<0.00050	0.00098	<0.00050	0.00194	0.00376	0.00103	0.99	0.22	1.00
Cobalt (Co)	mg/L	NG	NG	NG	NG	0.05	0.05	0.05	1	1	NG	NG	NG	NG	0.00011	<0.00010	<0.00010	0.00153	0.00017	0.00141	0.00022	0.00015	0.00014	0.54	0.96	0.57
Copper (Cu)	mg/L	2	1	NG	≤	2	0.2-1[b]	0.2-1[b]	0.5 - 5[f]	0.5 - 5[f]	0.00257 - 0.004[j]	0.00257 - 0.004[j]	0.0147 - 0.0362[j]	0.00972 - 0.022[j]	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	0.0015	-	-	-
Iron (Fe)	mg/L	NG	0.3	NG	≤ 0.3	0.3	5	5	NG	NG	0.3	0.3	NG	NG	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030	**0.311**	0.161	0.06	0.37	1.00	1.00
Lead (Pb)	mg/L	0.005	NG	0.01	NG	0.005	0.2	0.2	0.1	0.1	0.00359-0.007	0.00359-0.007	0.072 - 0.198[j]	0.0028 - 0.0077[j]	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	0.00094	0.00028	0.00016	0.11	0.96	1.00
Lithium (Li)	mg/L	NG	NG	NG	NG	NG	2.5	2.5	NG	NG	NG	NG	NG	NG	0.0052	0.005	0.0069	0.0821	0.0496	0.0908	<0.0050	0.0089	0.0091	0.75	-1.00	0.68
Magnesium (Mg)	mg/L	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	6.37	5.55	6.28	24	9.23	54.5	0.974	0.476	1.18	-0.89	-0.18	0.92
Manganese (Mn)	mg/L	0.12	≤ 0.02	NG	≤ 0.050	0.2	0.2	0.2	NG	NG	7.24 - 14.88[k]	0.12 - 0.64[k]	NG	NG	0.00067	<0.00050	0.0005	0.00149	<0.00050	0.054	0.00103	<0.00050	0.00071	0.92	1.00	1.00
Mercury (Hg)	mg/L	0.001	NG	0.001	NG	0.001	NG	NG	0.003	0.003	0.000026	0.000026	NG	NG	**<0.000050**	**<0.000050**	**<0.000050**	**<0.000050**	**<0.000050**	**<0.000050**	**<0.000050**	-	-	-	-	-
Molybdenum (Mo)	mg/L	NG	NG	NG	NG	0.073	0.01 - 0.05[c]	0.01 - 0.05[c]	0.5	0.5	0.073	0.073	NG	NG	0.00099	0.00092	0.00077	0.00623	0.00608	0.00016	0.00012	0.00032	0.00077	-0.86	-0.95	-0.27
Nickel (Ni)	mg/L	NG	NG	NG	NG	NG	0.2	0.2	1	1	0.103 - 0.150	0.103 - 0.150	0.508 - 1.14[j]	0.056 - 0.127[j]	<0.00050	0.00059	<0.00050	0.0101	<0.00050	0.00162	0.00083	0.00067	<0.00050	0.47	1.00	-0.43
Phosphorus (P)	mg/L	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	-	-	-
Potassium (K)	mg/L	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	6.82	6.32	8.03	53.9	29.7	63.9	1.16	0.493	0.313	-0.84	0.98	0.72
Selenium (Se)	mg/L	0.05	NG	0.01	NG	0.001	0.02 - 0.05[d]	0.02 - 0.05[d]	0.05	0.05	0.001	0.001	NG	NG	**0.0022**	**0.00997**	**0.0165**	**1.64**	**0.00747**	**0.0118**	<0.00050	**0.00203**	<0.00050	-0.54	-	-0.32
Silicon (Si)	mg/L	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	1.44	1.79	2.14	2.26	2.32	4.61	2.68	2.96	1.56	0.83	0.68	0.92
Silver (Ag)	mg/L	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	0.00025	NG	NG	<0.000050	<0.000050	<0.000050	0.000066	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	-	-	-
Sodium (Na)	mg/L	NG	≤ 200	NG	≤ 200	NG	NG	NG	NG	NG	NG	NG	NG	NG	2.23	1.99	2.16	19.5	9.87	15.4	0.354	0.757	0.356	-0.77	-0.12	0.52
Strontium (Sr)	mg/L	7.0	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	0.12	0.109	0.123	0.505	0.164	1.03	0.017	0.00841	0.0165	-0.88	0.16	0.90
Sulphur (S)	mg/L	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	6.6	4.87	13.2	86.2	9.59	288	2.45	<0.50	0.7	-0.65	1.00	0.96
Thallium (Tl)	mg/L	NG	NG	NG	NG	0.0008	NG	NG	NG	NG	0.0008	0.0008	NG	NG	<0.00010	<0.00010	<0.00010	0.00024	<0.00010	0.00012	<0.00010	<0.00010	<0.00010	-	-	-1.00
Tin (Sn)	mg/L	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	-	-	-
Titanium (Ti)	mg/L	NG	NG	NG	NG	0.1	NG	NG	NG	NG	NG	NG	NG	NG	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	0.115	0.037	0.025	0.09	0.96	1.00
Uranium (U)	mg/L	0.02	NG	0.02	NG	0.01	0.01	0.01	0.2	0.2	0.033	0.015	NG	NG	0.00065	0.000931	0.000456	**0.117**	0.0137	0.000182	0.000228	0.000207	0.000134	-0.70	0.91	-0.19
Vanadium (V)	mg/L	NG	NG	NG	NG	0.1	0.1	0.1	0.1	0.1	NG	NG	NG	NG	0.0032	0.0042	0.004	<0.0010	0.0016	<0.0010	0.002	<0.0010	0.0018	-0.83	1.00	-0.76
Zinc (Zn)	mg/L	NG	≤ 5	NG	≤ 5	0.01	1 - 5[e]	1 - 5[e]	50	50	0.075 - 0.209[d]	0.007 - 0.036[d]	0.127 - 0.286[j]	0.128 - 0.288[j]	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	-	-	-

Notes:

CDWQ MAC Canadian Drink ng Water Quality Maximum Acceptable Concentration Guidelines (Updated in September 2020 version)

CDWQ Other Canadian Drink ng Water Quality (CDWQ) Aesthetic Objec ive (AO) (Updated n September 2020 Version)

CCME rigation Canadian Council of Ministers of the Environment Water Qual ty Guidel nes for he Protection of Agricultural Water - Irrigation Water Use

CCME Livestock Canadian Council of Ministers of the Environment Water Qual ty Guidelines for the Protection of Agricultural Water - Livestock Water Use

FIGQG Agricu tural Federal Interim Groundwater Quality Guide ines - Groundwater Quality Guidelines for Federal Contaminated Sites - Agricultural Land Use - Tables 1.1-1.7 (coarse gra n size)

MWQSOG MAC Manitoba Wa er Qua ity Standards Objectives and Guidelines (Tier II) - Protection of Drink ng Water Use - Max mum Acceptab e Concentration

MWQSOG AO Manitoba Water Qua ity Standards Objectives and Guidelines (Tier III) - Pro ection of Drink ng Water Use - Aesthetic Objectives

MWQSOG Irrigation Manitoba Wa er Qua ity Standards Objectives and Guidelines (Tier II) - Protection of Irrigation Water Use

MWQSOG Livestock Manitoba Water Qua ity Standards Objectives and Guidelines (Tier III) - Pro ection of Livestock Water Use

CCME FAL Canadian Council of Ministers of the Env ronment Water Quality Guidelines to protect freshwater aquatic life

Chronic Guidelines o protect freshwater aquat c life (30-day average guidelines)

Acute Guide ines to protect freshwater aquatic life (Maximum allowable concen ration [MAC] gu delines)

MWQSOG FAL Mani oba Water Quality Standards Objectives and Guide ines (Tier I) - Protection of Aquatic Life and Wildlife

Chronic Guidelines o protect freshwater aquat c life (30-day or 4-day average gu de ines)

Acute Guide ines to protect freshwater aquatic life (one-hour Maximum guidelines)

[a] Applicable guideline varies depending on the water filtration method.

[b] Applicable guideline varies depending on the type of crop irrigated.

[c] The concentration should not exceed 10 µg/L for continuous use on all soils or 50 µg/L for short-term use on acidic soils.

[d] Applicable guideline is 20 µg/L for continuous use on all so ls 50 µg/L for intermittent use on all soils.

[e] Applicable guideline is pH dependant.

[f] Applicable guideline is dependant on the type of livestock.

[g] The Cr guideline varies with speciation. Most stringent Cr(VI) guideline is app ied

[h] The maximum concentration in livestock drinking water should not exceed 2000 µg/L or 1000 µg/L in cases where the feed of animals containins fluoride.

Applicable guideline is pH dependant.

[j] Applicable guideline varies with water hardness (110-286 mg/L). The guideline was calculated based on the range of hardness values observed in the samples.

[k] Applicable manganese long-term guideline is calculated using the CWQG calculator (Provided in Appendix B CCME). Applicable manganese short-term guideline is calculated using the Benchmark calculator (Provided in Appendix B CCME).

[l] Applicable guideline calculated based on pH hardness and dissolved organic carbon.

NG No Guideline

< Denotes concentra ion less than indicated de ection limit

- Not analyzed

NS No Standard

Exceeds CCME FAL Chronic*

Exceeds CCME FAL Acute *

Exceeds MWQSOG Chronic

Exceeds MWQOG Acute

Exceeds at least one (Federal or Manitoba) applicable guideline for protection of drink ng water

Exceeds two or more applicable guidel nes

Detection limit exceeds one or more applicable guidelines

*** When the value of the acute and chron c guidelines are equal exceedances are denoted as exceeding for acute exposure*

Table 4-6. Isotope Analysis - Oxygen-18 and Deuterium

Sample ID	Hydrostratigraphic Unit	Depth (mBGS)	δ2H (‰)	δ18O (‰)
BRU 95-8 33.61 - 33.83	Red River Carbonate	33.61	-96.85	-10.90
BRU 95-8 35.06 - 35.16	Red River Carbonate	35.06	-99.78	-11.44
BRU 95-8 37.12 - 37.28	Red River Carbonate	37.12	-101.23	-13.14
BRU 95-8 38.28 - 38.4	Red River Carbonate	38.28	-100.56	-12.04
BRU 95-8 38.85 - 38.97	Red River Carbonate	38.85	-103.83	-12.11
BRU 95-8 40.8 - 40.92	Red River Carbonate	40.8	-98.98	-11.91
BRU 95-8 42.14 - 42.25	Red River Carbonate	42.14	-100.63	-12.41
BRU 95-8 43.25 - 43.37	Red River Carbonate	43.25	-100.23	-12.23
BRU 95-8 44.5 - 44.61	Red River Carbonate	44.5	-100.79	-12.34
BRU 95-8 45.695 - 45.83	Red River Carbonate	45.695	-102.37	-12.75
BRU 95-8 46.76 - 46.885	Red River Carbonate	46.76	-102.26	-12.75
BRU 95-8 47.94 - 48.115	Red River Carbonate	47.94	-104.57	-11.86
BRU 95-8 48.91 - 49.07	Winnipeg Shale	48.6	-107.90	-10.76
BRU 95-8 48.6 - 48.85	Winnipeg Shale	48.91	-111.68	-9.95
BRU 95-8 49.27 - 49.39	Winnipeg Shale	49.27	-110.21	-9.13
BRU 95-8 49.94 - 50.045	Winnipeg Shale	49.94	-108.01	-12.61
BRU 95-8 50.17 - 50.29	Winnipeg Shale	50.17	-109.11	-8.23
BRU 95-8 50.5 - 50.6	Winnipeg Shale	50.5	-107.35	-10.22
BRU 95-8 52.02 - 52.12	Winnipeg Shale	52.02	-105.52	-12.90
BRU 95-8 Drill Water 8:40 am	Winnipeg Sandstone	-	-103.8	-13.97
BRU 95-8 Drill WAter 11:30 am	Winnipeg Sandstone	-	-103.8	-14.03
BRU 95-8 Drill Water 12:30 pm	Winnipeg Sandstone	-	-104.7	-14.38
BRU Drill Water 1:30 Pm	Winnipeg Sandstone	-	-104.5	-14.26
BRU Drill Water 9:00 am	Winnipeg Sandstone	-	-105.7	-14.72
BRU 95-7 S1	Winnipeg Sandstone	-	-105.8	-14.14
BRU 95-7 S2	Winnipeg Sandstone	63.1	-106.4	-14.27
BRU 95-7 S3	Winnipeg Sandstone	63.1	-106.4	-14.48
BRU 95-7 S3-2	Winnipeg Sandstone	63.1	-106.4	-14.53
BRU 95-7 S4	Winnipeg Sandstone	63.1	-106.2	-14.3
BRU 95-7 S5	Winnipeg Sandstone	63.1	-107.4	-14.76
BRU 95-7 S6	Winnipeg Sandstone	63.1	-106.6	-14.44
BRU 95-7 S7	Winnipeg Sandstone	63.1	-106.8	-14.46

Notes:

m BGS: meter below ground surface

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Table 4 7. Groundwater Quality Analytical Results Discharge to Groundwater

Parameter	CDWQ MAC	CDWQ AO	MWQSOG MAC	MWQSOG AO	FIGQG Agricultural	CCME Irrigation	CCME Livestock	MWQSOG Irrigation	MWQSOG Livestock	Units	BRU 95-5	BRU 95-5	BRU 95-6	BRU 95-6	BRU 95-7 (S1)	BRU 95-7 (S4)	BRU 95-7	BRU 95-9	BRU 95-9	BRU 95-9	BRU-96-1	BRU 96-1	BRU 96-2	BRU 96-2 (DUP)	RPD	BRU 96-2	Unknown	Unknown	Wel 66124	Well 23901	Well 23901
Sample ID											BRU 95-5	BRU 95-5	BRU 95-6	BRU 95-6	BRU 95-7 (S1)	BRU 95-7 (S4)	BRU 95-7	BRU 95-9	BRU 95-9	BRU 95-9	BRU-96-1	BRU 96-1	BRU 96-2	BRU 96-2 (DUP)		BRU 96-2	Unknown	Unknown	Wel 66124	Well 23901	Well 23901
Pre/Mid/Post Pump Test											Pre-test	Post-test	Pre-test	Post-test	Pre-test	Mid-test	Post-test	Pre-test	Post-test	NA	Pre-test	Post-test	Pre-test	Pre-test		Post-test	Pre-test	Post-test	Pre-test	Pre-test	Post-test
Lithology											Carbonate	Carbonate	Sandstone	Sandstone	Sandstone	Sandstone	Sandstone	Shale	Shale	Shale	Sandstone	Sandstone	Carbonate	Carbonate		Carbonate	Sandstone	Sandstone	Shale	Carbonate	Carbonate
Sample Date											2020-Nov-15	2020-Dec-02	2020-Nov-15	2020-Dec-02	2020-Nov-25	2020-Nov-29	2020-Dec-01	2020-Nov-24	2020-Dec-02	2021-Feb-04	2020-Nov-13	2020-Dec-02	2020-Nov-14	2020-Nov-14		2020-Dec-02	2020-Nov-15	2020-Dec-02	2020-Nov-15	2020-Nov-18	2020-Dec-02
Lab Sample ID											L2530033-1	L2536193-4	L2530033-2	L2536193-2	L2533700-2	L2535510-2	L2535510-1	L2533700-1	L2536193-3	L2554881-1	L2530033-3	L2536193-5	L2530033-4	L2530033-5		L2536193-7	L2530033-7	L2536193-1	L2530033-6	L2532264-1	L2536193-6
Lab Job Number											L2530033	L2536193	L2530033	L2536193	L2533700	L2535510	L2535510	L2533700	L2536193	L2554881	L2530033	L2536193	L2530033	L2530033		L2536193	L2530033	L2536193	L2530033	L2532264	L2536193
Field Parameters																															
Temperature, Field	NS	≤ 15	NS	≤ 15	NS	NS	NS	NS	NS	C	4.2	4.4	4.7	4.8	6.2	5.6	5.6	5.1	4.4	5.34	5.2	5.5	5.2	5.2	0	5.5	6.5	-	10.1	6.2	-
pH Field	NS	7.0-10.5	NS	6.5-8.5	6.5-9	NS	NS	NS	NS	pH units	7.54	7.73	7.72	8.50	7.84	7.89	7.97	7.56	8.04	7.75	8.01	**9.44**	7.91	7.91	0	7.91	7.64	-	8.13	8.03	-
pH, Lab	NS	7.0-10.5	NS	6.5-8.5	6.5-9	NS	NS	NS	NS	pH units	8.33	8.16	8.35	8.12	8.11	-	8.36	8.09	8.35	8.11	8.44	8.49	8.39	8.38	0	8.18	8.27	8.18	8.46	8.48	8.13
Specific Conductivity, Field	NS	NS	NS	NS	NS	NS	NS	NS	NS	µS/cm	535	525	483	594	439.8	443.2	444.2	482.1	502	322	581	569	383	383	0	415.5	511	-	562	541	-
Specific Conductivity, Lab	NS	NS	NS	NS	NS	NS	NS	NS	NS	µS/cm	543	535	497	518	428	-	453	471	617	515	594	589	395	396	0	421	510	515	578	536	546
Conductivity Field	NS	NS	NS	NS	NS	NS	NS	NS	NS	µS/cm	323	318.5	298	364.8	281.5	279.4	279.2	298.8	304.4	515	361	357.3	238	238	0	261.1	330.2	-	402.4	346.5	-
Salinity	NS	NS	NS	NS	NS	NS	NS	NS	NS	ppt	0.26	0.25	0.23	0.29	0.21	0.21	0.21	0.23	0.24	-	-	0.28	-	-	NC	0.20	0.25	-	0.27	0.26	-
Dissolved Oxygen Field	NS	NS	NS	NS	NS	NS	NS	NS	NS	%L	-	43.3	-	2.1	47.2	43.3	74.8	1.7	8.4	-	-	4.0	-	-	NC	3.1	62.4	-	68.6	59.1	-
Dissolved Oxygen, Field	NS	NS	NS	NS	NS	NS	NS	NS	NS	mg/L	3.95	5.48	3.1	0.27	5.60	5.33	9.09	0.21	1.06	0.28	5.6	0.49	3.6	3.6	0	0.39	7.36	-	7.39	7.01	-
ORP	NS	NS	NS	NS	NS	NS	NS	NS	NS	mV	-62	60.7	10.0	23.0	-31.3	-61.3	-49.1	-76.1	94.3	115	63	91.4	-93	-93	0	4.5	-46.2	-	60.2	70.0	-
Turbidity Field	≤ 0.1 - 1[g]	NS	≤ 0.1 - 1[g]	NS	NS	NS	NS	NS	NS	NTU	**42**	**21.05**	**31**	-	**8.35**	0.33	**24.74**	-	-	-	**105**	-	**25**	**25**	0	**29.83**	**1.14**	-	-0.10	0.33	-
Turbidity Lab	≤ 0.1 - 1[g]	NS	≤ 0.1 - 1[g]	NS	NS	NS	NS	NS	NS	NTU	-	-	-	-	**6.50**	-	-	**1240**	-	**171**	-	-	-	-	-	-	-	-	-	0.26	-
Total Suspended Solids	NS	NS	NS	NS	NS	NS	NS	NS	NS	mg/L	4.2	11.1	69.6	403	5.7	-	< 3	1150	9450	186	117	78.7	36.8	88.4	-	31.5	< 3	< 3	< 3	< 3	< 3
Total Dissolved Solids (Lab)	NS	500	NS	500	3000	500 - 3500 [b]	3000	500 - 3500 [b]	3000	mg/L	277	258	264	292	239	-	245	269	489	302	358	340	224	229	2	217	259	247	337	319	313
General Parameters and Anions																															
Hardness (as CaCO3)	NS	NS	NS	NS	NS	NS	NS	NS	NS	mg/L	268	265	238	-	196	-	197	211	-	204	116	110	112	113	1	125	247	249	0.99	0.51	0.42
Alkalin ty, Total (As CaCO3)	NS	NS	NS	NS	NS	NS	NS	NS	NS	mg/L	302	299	273	302	246	-	244	276	1010	285	260	271	197	199	0	212	284	283	309	284	290
Hydroxide (OH)	NS	NS	NS	NS	NS	NS	NS	NS	NS	mg/L	< 0.34	< 0.34	< 0.34	< 0.34	< 0.34	-	< 0.34	< 0.34	< 0.34	<0.340	< 0.34	< 0.34	< 0.34	< 0.34	NC	< 0.34	< 0.34	< 0.34	< 0.34	< 0.34	< 0.34
Bicarbonate (as CaCO3)	NS	NS	NS	NS	NS	NS	NS	NS	NS	mg/L	358	365	322	369	300	-	287	337	1230	348	304	313	231	233	1	258	346	346	362	330	353
Biochemical Oxygen Demand	NS	NS	NS	NS	NS	NS	NS	NS	NS	mg/L	-	-	-	-	< 2	-	11.3	< 6	-	9.3	-	-	-	-	NC	-	-	-	-	-	-
Carbonate (as CaCO3)	NS	NS	NS	NS	NS	NS	NS	NS	NS	mg/L	4.92	< 0.6	5.16	< 0.6	< 0.6	-	5.28	< 0.6	5.52	<0.6	6.72	9	4.68	4.44	5	< 0.6	< 0.6	< 0.6	7.08	8.04	< 0.6
Chemical Oxygen Demand	NS	NS	NS	NS	NS	NS	NS	NS	NS	mg/L	-	-	-	-	-	-	< 20	38	-	40	-	-	-	-	NC	-	-	-	-	< 20	-
Dissolved Organic Carbon (DOC)	NS	NS	NS	NS	NS	NS	NS	NS	NS	mg/L	1.74	2.01	0.87	2.12	1.55	-	1.58	1.75	16.9	7.03	0.5	1.66	1.45	1.46	1	3.65	2.89	2.06	1.66	1.99	1.87
Fluoride	1.5	NS	1.5	NS	0.12	1	1 - 2 [h]	1	1 [d]	mg/L	**0.325**	**0.331**	**0.383**	**0.382**	**0.406**	**0.416**	**0.411**	**0.392**	**0.481**	**0.397**	**0.882**	**0.876**	**0.549**	**0.544**	1	**0.499**	**0.358**	**0.35**	**0.343**	**0.286**	**0.278**
Ammonia-N	NS	NS	NS	NS	NS	NS	NS	NS	NS	mg/L	0.41	0.202	0.415	0.389	0.498	-	0.59	0.446	0.81	0.318	0.415	0.38	0.322	0.305	5	0.288	0.418	0.429	0.011	0.043	0.018
Nitrate plus Nitrite (N)	NS	NS	10	NS	100	NS	100	NS	100	mg/L	< 0.07	< 0.0051	< 0.07	< 0.0051	< 0.0051	-	< 0.0051	< 0.0051	< 0.0051	0.0083	< 0.07	< 0.0051	< 0.07	< 0.07	NC	< 0.0051	< 0.07	< 0.0051	< 0.07	< 0.0051	< 0.0051
Nitrate (as N)	10	NS	10	NS	13	NS	NS	NS	NS	mg/L	< 0.02	< 0.005	< 0.02	< 0.005	< 0.005	< 0.02	< 0.005	< 0.005	< 0.005	0.0069	< 0.02	< 0.005	< 0.02	< 0.02	NC	< 0.005	< 0.02	< 0.005	< 0.02	< 0.005	< 0.005
Nitr te (as N)	1	NS	3.2	NS	0.06	NS	10	NS	10	mg/L	< 0.01	< 0.001	< 0.01	< 0.001	< 0.001	< 0.01	< 0.001	< 0.001	< 0.001	0.0013	< 0.01	< 0.001	< 0.01	< 0.01	NC	< 0.001	< 0.01	< 0.001	< 0.01	< 0.001	< 0.001
Chloride	NS	≤ 250	NS	≤ 250	100	100 - 900 [b]	NS	100 - 900 [b]	NS	mg/L	1.78	1.01	1.48	1.63	1.04	1.32	1.52	1.87	37.4	7.03	22.9	22.4	2.56	2.57	0	2.76	1.04	1.03	2.7	2.87	2.94
Sulphide	NS	0.05	NS	NS	NS	NS	NS	NS	NS	mg/L	< 0.018	**0.079**	< 0.018	< 0.018	0.023	-	0.02	< 0.18	**< 1.8**	<0.018	< 0.018	< 0.018	< 0.018	< 0.018	NC	< 0.018	< 0.018	0.021	< 0.018	0.024	0.03
Sulphide (as H2S)	NS	NS	NS	0.05	0.002	NS	NS	NS	NS	mg/L	**< 0.019**	**0.085**	**< 0.019**	**< 0.019**	**0.024**	-	**0.021**	**< 0.19**	**< 1.9**	**<0.019**	**< 0.019**	**< 0.019**	**< 0.019**	**< 0.019**	NC	**< 0.019**	**< 0.019**	**0.022**	**< 0.019**	**0.026**	**0.032**
Sulphate	NS	500	NS	≤ 500	100	NS	1000	NS	1000	mg/L	4.6	3.22	6.92	8.01	5.23	5.69	5.83	6.84	37.2	10.9	33.5	32.1	14.4	14.5	1	13.4	4.14	3.81	5.68	9.07	8.37
Dissolved Metals																				0											
Aluminum	NS	NS	NS	NS	5	5	5	5	5	mg/L	< 0.001	< 0.001	0.0032	0.0029	< 0.001	< 0.001	< 0.001	0.0012	0.006	0.003	0.0085	0.0027	0.0025	0.0011	NC	0.0025	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Antimony	0.006	NS	0.006	NS	2.0	NS	NS	NS	NS	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	0.00065	0.00033	< 0.0001	< 0.0001	< 0.0001	< 0.0001	NC	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Arsenic	0.01	NS	0.01	NS	0.005	0.1	0.025	0.1	0.025	mg/L	0.00155	0.00153	0.00052	0.00056	0.00031	< 0.0001	< 0.0001	0.00088	0.00179	0.00128	0.00036	0.00063	0.00018	0.00018	0	0.00027	0.00168	0.00149	0.00046	0.0007	0.00061
Barium	1	NS	1	NS	0.5	NS	NS	NS	NS	mg/L	0.11	0.11	0.0835	0.0898	0.0951	0.0952	0.0964	0.0567	0.054	0.049	0.0473	0.0426	0.0564	0.0564	0	0.0556	0.1	0.105	0.00125	0.00024	0.00019
Beryllium	NS	NS	NS	NS	0.0053	0.1	0.1	0.1	0.1	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	<0.000010	< 0.0001	< 0.0001	< 0.0001	< 0.0001	NC	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Bismuth	NS	NS	NS	NS	NS	NS	NS	NS	NS	mg/L	< 0.00005	< 0.00005	< 0.00005	< 0.00005	< 0.00005	< 0.00005	< 0.00005	< 0.00005	< 0.00005	<0.000050	< 0.00005	< 0.00005	< 0.00005	< 0.00005	NC	< 0.00005	< 0.00005	< 0.00005	< 0.00005	< 0.00005	< 0.00005
Boron	5	NS	5	NS	0.5	0.5 - 6 [b]	5	0.5 - 6 [b]	5	mg/L	0.156	0.155	0.251	0.339	0.214	0.202	0.212	0.334	0.299	0.346	**0.692**	**0.605**	0.302	0.28	8	0.266	0.196	0.18	0.147	0.142	0.097
Cadmium	0.0007	NS	0.006	NS	0.000017	0.0051	0.080	0.080	0.080	mg/L	< 0.000005	< 0.000005	< 0.000005	< 0.000005	< 0.000005	< 0.000005	< 0.000005	< 0.000005	< 0.000005	**0.0000847**	< 0.000005	< 0.000005	< 0.000005	< 0.000005	NC	< 0.000005	< 0.000005	< 0.000005	< 0.000005	< 0.000005	< 0.000005
Calcium	NS	NS	NS	NS	NS	NS	1000	NS	1000	mg/L	50.7	48.5	45.1	45.1	36.4	36.7	35.2	43.1	22.1	39.7	26.4	22.9	24.7	24.5	1	27.1	44.6	43.5	0.206	0.118	0.102
Cesium	NS	NS	NS	NS	NS	NS	NS	NS	NS	mg/L	< 0.00001	< 0.00001	0.000018	0.000059	0.000014	< 0.00001	< 0.00001	0.000011	0.000089	0.000102	0.000012	0.000056	< 0.00001	< 0.00001	NC	< 0.00001	< 0.00001	< 0.00001	< 0.00001	< 0.00001	< 0.00001
Chromium[h]	0.05	NS	0.05	NS	0.05	0.0049	0.05	NS	NS	mg/L	< 0.0001	< 0.0001	< 0.0001	0.0002	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	<0.000010	< 0.0001	0.00013	< 0.0001	< 0.0001	NC	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Cobalt	NS	NS	NS	NS	0.05	0.05	1	0.05	1	mg/L	< 0.0001	< 0.0001	0.00072	0.0007	0.0004	< 0.0001	< 0.0001	< 0.0001	0.0007	0.00034	0.00025	0.00022	< 0.0001	< 0.0001	NC	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Copper	2	1	NS	5	2	0.2 - 5 [e]	0.5 - 5 [e]	0.2 - 5 [e]	0.5 - 5 [e]	mg/L	< 0.0002	0.0007	< 0.0002	0.00028	< 0.0002	< 0.0002	< 0.0002	< 0.0002	0.0007	0.00052	< 0.0002	< 0.0002	< 0.0002	< 0.0002	NC	< 0.0002	< 0.0002	< 0.0002	0.0241	0.00035	0.0005
Iron	NS	0.3	NS	< 0.3	0.3	5	NS	5	NS	mg/L	**0.626**	**0.44**	0.054	< 0.01	24	18	**47.4**	**0.63**	< 0.01	<0.010	< 0.01	0.259	< 0.01	8	0.199	**0.886**	0.016	0.015	< 0.01	< 0.01	< 0.01
Lead	0.005	NS	0.01	NS	0.005	0.2	0.1	0.2	0.1	mg/L	< 0.00005	< 0.00005	< 0.00005	< 0.00005	< 0.00005	< 0.00005	< 0.00005	< 0.00005	< 0.00005	0.000168	< 0.00005	< 0.00005	< 0.00005	< 0.00005	NC	< 0.00005	< 0.00005	< 0.00005	0.000177	< 0.00005	< 0.00005
Lithium	NS	NS	NS	NS	2.5	NS	2.5	NS	NS	mg/L	0.0161	0.0164	0.0159	0.0166	0.018	0.0194	0.0189	0.0221	0.0334	0.0265	0.0314	0.0336	0.0114	0.0109	4	0.0121	0.0171	0.0173	0.0017	< 0.001	< 0.001
Magnesium	NS	NS	NS	NS	NS	NS	NS	NS	NS	mg/L	34.4	35	30.4	32.8	25.5	26.5	26.4	25.2	19	25.5	12.2	12.8	12.4	12.5	1	13.9	32.8	34.1	0.116	0.0524	0.0405
Manganese	0.12	≤ 0.02	NS	≤ 0.050	0.2	0.2	NS	0.2	NS	mg/L	0.00903	0.00932	**0.0279**	**0.0454**	**0.0256**	0.017	0.0168	0.0146	0.00464	0.00538	0.0107	**0.0313**	0.00306	0.00303	1	0.00297	0.0155	0.0151	0.00147	0.00018	< 0.0001
Mercury	0.001	NS	0.001	NS	0.001	NS	0.003	NS	0.003	mg/L	< 0.000005	< 0.000005	< 0.000005	< 0.000005	< 0.000005	-	< 0.000005	< 0.000005	< 0.000005	<0.0000050	< 0.000005	< 0.000005	< 0.000005	< 0.000005	NC	< 0.000005	< 0.000005	< 0.000005	< 0.000005	< 0.000005	< 0.000005
Molybdenum	NS	NS	NS	NS	0.073	0.01 - 0.05 [c]	0.5	0.01 - 0.05 [c]	0.5	mg/L	0.00215	0.00146	0.00205	0.00392	0.0224	0.00195	0.00193	0.00154	**0.0344**	0.00693	0.00332	0.00534	0.0084	0.00788	8	0.0076	0.00171	0.00163	0.0125	0.000974	0.000939
Nickel	NS	NS	NS	NS	NS	0.2	1	0.2	1	mg/L	< 0.0005	< 0.0005	< 0.0005	0.00087	< 0.0005	< 0.0005	< 0.0005	< 0.0005	0.00158	0.00114	< 0.0005	< 0.0005	< 0.0005	< 0.0005	NC	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005
Phosphorus (Dissolved)	NS	NS	NS	NS	NS	NS	NS	NS	NS	mg/L	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	< 0.030	0.033	< 0.03	< 0.03	<0.030	< 0.03	< 0.03	< 0.03	< 0.03	NC	< 0.03	< 0.03	< 0.03	< 0.03	0.057	0.065
Phosphorus (Tota)	NS	NS	NS	NS	NS	NS	NS	NS	NS	mg/L	0.0156	0.0108	0.088	0.206	0.0281	-	0.0321	0.852	9.6	-	0.113	0.0724	0.0458	0.135	**99**	0.0556	0.0164	0.0096	0.0191	0.0583	0.0483
Potassium	NS	NS	NS	NS	NS	NS	NS	NS	NS	mg/L	4.33	4.71	4.88	5.66	4.39	4.74	4.57	7.58	32.1	16.4	7.93	10.8	3.86	3.93	2	3.98	4.51	5.36	0.195	1.41	1.22
Rubidium	NS	NS	NS	NS	NS	NS	NS	NS	NS	mg/L	0.00223	0.00255	0.00293	0.00569	0.00182	0.00168	0.00164	0.00473	0.0332	0.0249	0.00404	0.00911	0.00199	0.00199	0	0.00214	0.00167	0.00195	< 0.0002	0.00058	0.0006
Selenium	0.05	NS	0.01	NS	0.001	0.02 - 0.05 [d]	0.05	0.02 - 0.05 [d]	0.05	mg/L	< 0.00005	< 0.00005	< 0.00005	0.000096	< 0.00005	< 0.00005	< 0.00005	< 0.00005	0.000912	0.000096	< 0.00005	0.000101	< 0.00005	< 0.00005	NC	0.00023	< 0.00005	< 0.00005	< 0.00005	< 0.00005	< 0.00005
Silicon	NS	NS	NS	NS	NS	NS	NS	NS	NS	mg/L	7.9	7.46	6.71	7.11	7.04	7.15	7.19	5.19	5.13	5.5	4.1	3.84	4.73	4.61	3	4.74	7.74	8.01	7.01	6.58	6.49
Silver	NS	NS	NS	NS	NS	NS	NS	NS	NS	mg/L	< 0.00001	< 0.00001	< 0.00001	< 0.00001	< 0.00001	< 0.00001	< 0.00001	< 0.00001	< 0.00001	<0.000010	< 0.00001	< 0.00001	< 0.00001	< 0.00001	NC	< 0.00001	< 0.00001	< 0.00001	< 0.00001	< 0.00001	0.000018
Sodium	NS	≤ 200	NS	≤ 200	NS	NS	NS	NS	NS	mg/L	14.2	14.7	17	18.6	19.4	22.8	25.5	19.1	72.7	31.3	82.4	87.1	41.4	41.3	0	43.3	14.2	16.4	138	135	134
Strontium	7.0	NS	NS	NS	NS	NS	NS	NS	NS	mg/L	0.325	0.318	0.321	0.334	0.258	0.254	0.246	0.304	0.208	0.336	0.179	0.178	0.139	0.132	5	0.148	0.311	0.309	0.00144	0.00048	0.00039
Sulfur elemental	NS	NS	NS	NS	NS	NS	NS	NS	NS	mg/L	1.35	1.29	2.2	3.11	1.88	2.07	2.29	2.42	14.3	4.1	11	11.8	4.78	4.36	9	4.8	1.09	1.51	1.64	3.28	3.21
Tellurium	NS	NS	NS	NS	NS	NS	NS	NS	NS	mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	<0.00020	< 0.0002	< 0.0002	< 0.0002	< 0.0002	NC	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Thallium	NS	NS	NS	NS	0.0008	NS	NS	NS	NS	mg/L	< 0.00001	< 0.00001	< 0.00001	< 0.00001	< 0.00001	< 0.00001	< 0.00001	< 0.00001	0.000035	<0.000010	< 0.00001	< 0.00001	< 0.00001	< 0.00001	NC	< 0.00001	< 0.00001	< 0.00001	< 0.00001	< 0.00001	< 0.00001
Thorium	NS	NS	NS	NS	NS	NS	NS	NS	NS	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	<0.00010	< 0.0001	< 0.0001	< 0.0001	< 0.0001	NC	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Tin	NS	NS	NS	NS	NS	NS	NS	NS	NS	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	0.00021	< 0.0001	< 0.0001	< 0.0001	< 0.0001	NC	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Titanium	NS	NS	NS	NS	0.1	NS	NS	NS	NS	mg/L	< 0.0003	< 0.0003	< 0.0003	< 0.0003	< 0.0003	< 0.0003	< 0.0003	< 0.0003	< 0.0003	<0.00030	0.00045	< 0.0003	< 0.0003	< 0.0003	NC	< 0.0003	< 0.0003	< 0.0003	< 0.0003	< 0.0003	< 0.0003
Tungsten	NS	NS	NS	NS	NS	NS	NS	NS	NS	mg/L	< 0.0001	< 0.0001	0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	0.00293	0.00053	< 0.0001	0.00043	< 0.0001	< 0.0001	NC	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Uranium	0.02	NS	0.02	NS	0.01	0.01	0.2	0.01	0.2	mg/L	0.0001	0.000058	0.000308	0.000208	0.000083	0.000028	0.00003	0.000062	0.00121	0.000542	0.000391	0.000992	0.000069	0.000071	3	0.000135	0.000062	0.000068	0.000019	0.000094	0.000105
Vanadium	NS	NS	NS	NS	0.1	0.1	0.1	0.1	0.1	mg/L	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	0.00103	<0.00050	< 0.0005	< 0.0005	< 0.0005	< 0.0005	NC	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005
Zinc	NS	≤ 5	NS	≤ 5	0.01	1 - 5 [e]	50	1 - 5 [e]	50	mg/L	< 0.01	0.0023	0.009	**0.0197**	**0.0106**	0.0013	0.0034	< 0.01	< 0.01	0.0044	0.0023	0.0035	< 0.01	< 0.01	NC	0.0011	< 0.01	0.0011	0.0075	< 0.01	0.0014
Zirconium	NS	NS	NS	NS	NS	NS	NS	NS	NS	mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	<0.00020	< 0.0002	< 0.0002	< 0.0002	< 0.0002	NC	< 0.0002	< 0.0002	< 0.0002	0.00038	< 0.0002	< 0.0002
PAHs																									NC						
Acenaphthene	NS	NS	NS	NS	0.0058	NS	NS	NS	NS	mg/L	-	-	-	-	< 0.00002	-	< 0.00002	-	-	-	-	-	-	-	NC	-	-	-	-	-	-
Acenaphthylene	NS	NS	NS	NS	0.046	NS	NS	NS	NS	mg/L	-	-	-	-	< 0.00002	-	< 0.00002	-	-	-	-	-	-	-	NC	-	-	-	-	-	-
Acridine	NS	NS	NS	NS	0.00005	NS	NS	NS	NS	mg/L	-	-	-	-	< 0.00002	-	< 0.00002	-	-	-	-	-	-	-	NC	-	-	-	-	-	-
Anthracene	NS	NS	NS	NS	0.000012	NS	NS	NS	NS	mg/L	-	-	-	-	< 0.00001	-	< 0.00001	-	-	-	-	-	-	-	NC	-	-	-	-	-	-
Fluorene	NS	NS	NS	NS	0.003	NS	NS	NS	NS	mg/L	-	-	-	-	< 0.00002	-	< 0.00002	-	-	-	-	-	-	-	NC	-	-	-	-	-	-
Naphthalene	NS	NS	NS	NS	0.0011	NS	NS	NS	NS	mg/L	-	-	-	-	< 0.00005	-	< 0.00005	-	-	-	-	-	-	-	NC	-	-	-	-	-	-
Phenanthrene	NS	NS	NS	NS	0.0004	NS	NS	NS	NS	mg/L	-	-	-	-	< 0.00005	-	< 0.00005	-	-	-	-	-	-	-	NC	-	-	-	-	-	-
Benz(a)anthracene	NS	NS	NS	NS	0.000018	NS	NS	NS	NS	mg/L	-	-	-	-	< 0.00001	-	< 0.00001	-	-	-	-	-	-	-	NC	-	-	-	-	-	-
Benzo(a)pyrene	0.00004	NS	0.00001	NS	0.00001	NS	NS	NS	NS	mg/L	-	-	-	-	< 0.000005	-	< 0.000005	-	-	-	-	-	-	-	NC	-	-	-	-	-	-
Benzo(b+j)fluoranthene	NS	NS	NS	NS	0.00048	NS	NS	NS	NS	mg/L	-	-	-	-	< 0.00001	-	< 0.00001	-	-	-	-	-	-	-	NC	-	-	-	-	-	-
Benzo(g,h,i)perylene	NS	NS	NS	NS	0.00017 [h]	NS	NS	NS	NS	mg/L	-	-	-	-	< 0.00002	-	< 0.00002	-	-	-	-	-	-	-	NC	-	-	-	-	-	-
Benzo(k)fluoranthene	NS	NS	NS	NS	0.00048	NS	NS	NS	NS	mg/L	-	-	-	-	< 0.00001	-	< 0.00001	-	-	-	-	-	-	-	NC	-	-	-	-	-	-
Chrysene	NS	NS	NS	NS	0.0001	NS	NS	NS	NS	mg/L	-	-	-	-	< 0.00002	-	< 0.00002	-	-	-	-	-	-	-	NC	-	-	-	-	-	-
Dibenz(a,h)anthracene	NS	NS	NS	NS

Table 4 8. Groundwater Quality Results Discharge to Surface Water

Parameter	CCME FAL Acute	CCME FAL Chronic	MWQSOG FAL Acute	MWQSOG FAL Chronic	Units	BRU 95-5	BRU 95-5	BRU 95-6	BRU 95-6	BRU 95-7 (S1)	BRU 95-7 (S)	BRU 95-7	BRU 95-9	BRU 95-9	BRU 95-9	BRU-96-1	BRU 96-1	BRU 96-2	BRU 96-2 (DUP)	RPD	BRU 96-2	Unknown	Unknown	Wel 6612	Well 23901	Well 23901
					Samp e ID	BRU 95-5	BRU 95-5	BRU 95-6	BRU 95-6	BRU 95-7 (S1)	BRU 95-7 (S)	BRU 95-7	BRU 95-9	BRU 95-9	BRU 95-9	BRU-96-1	BRU 96-1	BRU 96-2	BRU 96-2 (DUP)		BRU 96-2	Unknown	Unknown	Wel 6612	Well 23901	Well 23901
					Pre/Post Pump est	Pre-test	Post-test	Pre-test	Post-test	Pre-test	Mid-test	Post-test	Pre-test	Post-test	NA	Pre-test	Post-test	Pre-test	Pre-test		Post-test	Pre-test	Post-test	Pre-test	Pre-test	Post-test
					Lithology	Red River Carbonate	Carbonate	Red River Carbonate	Red River Carbonate	Red River Carbonate	Red River Carbonate	Red River Carbonate	Winnipeg Sha e	Winnipeg Sha e	Winnipeg Shale	Winnipeg Sandstone	Winnipeg Sandstone	Red River Carbonate	Red River Carbonate		Red River Carbonate	Winnipeg Sandstone	Winnipeg Sandstone	Winnipeg Shale	Red River Carbonate	Red River Carbonate
					Sample Date	2020-Nov-15	2020-Dec-02	2020-Nov-15	2020-Dec-02	2020-Nov-25	2020-Nov-29	2020-Dec-01	2020-Nov-2	2020-Dec-02	2021-Feb-0	2020-Nov-13	2020-Dec-02	2020-Nov-1	2020-Nov-1		2020-Dec-02	2020-Nov-15	2020-Dec-02	2020-Nov-15	2020-Nov-18	2020-Dec-02
					Lab Samp e ID	L2530033-1	L2536193-	L2530033-2	L2536193-2	L2533700-2	L2535510-2	L2535510-1	L2533700-1	L2536193-3	L255 881-1	L2530033-3	L2536193-5	L2530033-	L2530033-5		L2536193-7	L2530033-7	L2536193-1	L2530033-6	L253226 -1	L2536193-6
					Lab ob Number	L2530033	L2536193	L2530033	L2536193	L2533700	L2535510	L2535510	L2533700	L2536193	L255 881	L2530033	L2536193	L2530033	L2530033		L2536193	L2530033	L2536193	L2530033	L253226	L2536193
Field Parameters																										
Temperature, Fie d	NS	NS	NS	NS	°C	2		7	8	6.2	5.6	5.6	5.1		5.3	5.2	5.5	5.2	5.2	0	5.5	6.5	-	10.1	6.2	-
pH, Field	6.5-9	6.5-9	NS	NS	-	7.5	7.73	7.72	8.50	7.8	7.89	7.97	7.56	8.0	7.75	8.01	**9.44**	7.91	7.91	0	7.91	7.6	-	8.13	8.03	-
pH, Lab	6.5-9	6.5-9	NS	NS	pH units	8.33	8.16	8.35	8.12	8.11	-	8.36	8.09	8.35	8.11	8.	8. 9	8.39	8.38	0	8.18	8.27	8.18	8. 6	8. 8	8.13
Spec fic Conductivity, Lab	NS	NS	NS	NS	µS/cm	5 3	535	97	518	28	21	53	71	617	515	59	589	395	396	0	21	510	515	578	536	5 6
Specific Conductivity, Field	NS	NS	NS	NS	µS/cm	535	525	83	59	39.8	3.2	.2	82.1	502	322	581	569	383	383	0	15.5	511	-	562	5 1	-
Conductivity, Field	NS	NS	NS	NS	µS/cm	323	319	298	365	282	279	279	299	30	515	361	357	238	238	0	261	330	-	02	3 7	-
Salinity	NS	NS	NS	NS	ppt	0.26	0.25	0.23	0.29	0.21	0.21	0.21	0.23	0.2	-	-	0.28	-	-	NC	0.20	0.25	-	0.27	0.26	-
Dissolved Oxygen, Field	NS	NS	NS	NS	%L	-	3.3	-	2.1	7.2	3.3	7 .8	1.7	8	-	-	0	-	-	NC	3.1	62	-	68.6	59.1	-
Dissolved Oxygen[a], Field	NS	NS	NS	NS	mg/L	3.95	5. 8	3.1	0.27	5.60	5.33	9.09	0.21	1.06	0.28	5.6	0. 9	3.6	3.6	0	0.39	7.36	-	7.39	7.01	-
ORP	NS	NS	NS	NS	mV	-62	60.7	10.0	23.0	-31.3	-61.3	- 9.1	-76.1	9 3	115.0	63	91.	-93	-93	0	5	- 6.2	9.1	60.2	70.0	-
Turbidity, Field	Variable[d]	Var able[d]	Variable[d]	Variable[d]	NTU	2	21.05	31	-	8.35	0.33	2 .7	-	-	-	105	-	25	25	0	29.83	1.1	-	-0.10	0.33	-
Turbidity, Lab	Variable[d]	Var able[d]	Variable[d]	Variable[d]	NTU	-	-	-	-	6.50	-	-	12 0	-	171	-	-	-	-	-	-	-	-	-	0.26	-
Total Dissolved Sol ds (Lab)	NS	NS	NS	NS	mg/L	277	258	26	292	239	-	2 5	269	89	302	358	3 0	22	229	2	217	259	2 7	337	319	313
Total Suspended Solids	Var able[h]	Var able[h]	NS	NS	mg/L	2	11.1	69.6	03	5.7	-	< 3	1150	9 50	186	117	78.7	36.8	88.	**82**	31.5	< 3	< 3	< 3	< 3	< 3
General Parameters and Anions																										
Hardness (as CaCO3)	NS	NS	NS	NS	mg/L	268	265	238	2 7	196	-	197	211	133	20	116	192	113	113	1	125	2 7	2 9	0.99	0.51	0. 2
Alkalinity, Total (As CaCO3)	NS	NS	NS	NS	mg/L	302	299	273	302	2 6	-	2	276	1010	285	260	271	197	199	1	212	28	283	309	28	290
Hydroxide (OH-)	NS	NS	NS	NS	mg/L	< 0.3	< 0.3	< 0.3	< 0.3	< 0.3	-	< 0.3	< 0.3	< 0.3	<0.3 0	< 0.3	< 0.3	< 0.3	< 0.3	NC	< 0.3	< 0.3	< 0.3	< 0.3	< 0.3	< 0.3
Bicarbonate (as CaCO3)	NS	NS	NS	NS	mg/L	358	365	322	369	300	-	287	337	1230	3 8	30	313	231	233	1	258	3 6	3 6	362	330	353
Biochemical Oxygen Demand	NS	NS	NS	NS	mg/L	-	-	-	-	< 2	-	11.3	< 6	-	9.3	-	-	-	-	NC	-	-	-	-	-	-
Carbonate (as CaCO3)	NS	NS	NS	NS	mg/L	92	< 0.6	5.16	< 0.6	< 0.6	-	5.28	< 0.6	5.52	<0.6	6.72	9	68	<0.6	5	< 0.6	< 0.6	< 0.6	7.08	8.0	< 0.6
Chemical Oxygen Demand	NS	NS	NS	NS	mg/L	-	-	-	-	< 20	-	< 20	38	-	0	-	-	-	-	NC	-	-	-	< 20	-	-
Dissolved Organic Carbon (DOC)	NS	NS	NS	NS	mg/L	1.7	2.01	0.87	2.12	1.55	-	1.58	1.75	16 9	7.03	0.5	1.66	1. 5	1. 6	1	3.65	2.89	2.06	1.66	1.99	1.87
Fluoride	0.12	0.12	NS	NS	mg/L	**0 325**	**0 311**	**0 383**	**0 382**	**0 406**	**0 416**	**0 411**	**0 302**	**0 401**	**0 397**	**0 882**	**0 876**	**0 549**	**0 544**	1	**0 499**	**0 358**	**0 35**	**0 343**	**0 286**	**0 276**
Ammonia-N	0.1 -12.6[b]	0.1 -12.6[b]	0.85 -29.98 [a b]	0.79 - 9.60 [b]	mg/L	0. 1	0.202	0. 15	0.389	0. 98	-	0.59	0. 6	0.81	0 318	0. 15	0.38	0.322	0.305	5	0.288	0. 18	0. 29	0.011	0.0 3	0.018
Nitrate plus Nitrite (N)	NS	NS	10	10	mg/L	< 0.07	< 0.0051	< 0.07	< 0.0051	< 0.0051		< 0.0051	< 0.0051	< 0.0051	0.0083	< 0.07	< 0.0051	< 0.07	< 0.07	NC	< 0.0051	< 0.07	< 0.0051	< 0.07	< 0.0051	< 0.0051
Nitrate (as N)	12	3	NS	NS	mg/L	< 0.02	< 0.005	< 0.02	< 0.005	< 0.005	< 0.02	< 0.005	< 0.005	< 0.005	0.0069	< 0.02	< 0.005	< 0.02	< 0.02	NC	< 0.005	< 0.02	< 0.005	< 0.02	< 0.005	< 0.005
Nitrite (as N)	0.06	0.06	NS	NS	mg/L	< 0.01	< 0.001	< 0.01	< 0.001	< 0.001	< 0.01	< 0.001	< 0.001	< 0.001	0.0013	< 0.01	< 0.001	< 0.01	< 0.01	NC	< 0.001	< 0.01	< 0.001	< 0.01	< 0.001	< 0.001
Chloride	6. 0	120	NS	NS	mg/L	1.78	1.01	1. 8	1.63	1.0	1.32	1.52	1.87	37	7.03	22.9	22.	2.56	2.57	0	2.76	1.0	1.03	2.7	2.87	2.9
Sulphide	NS	NS	NS	NS	mg/L	< 0.018	0.078	< 0.018	< 0.018	0.023	-	0.02	< 0.18	< 1.8	<0.018	< 0.018	< 0.018	< 0.018	< 0.018	NC	< 0.018	< 0.018	0.021	< 0.018	0.02	0.03
Sulphide (as H2S)	NS	NS	NS	NS	mg/L	< 0.019	0.083	< 0.019	< 0.019	0.02	-	0.021	< 0.19	< 1.9	<0.019	< 0.019	< 0.019	< 0.019	< 0.019	NC	< 0.019	< 0.019	0.022	< 0.019	0.026	0.032
Sulphate	NS	NS	NS	NS	mg/L	6	3.22	6.92	8.01	5.23	5.69	5.83	6.8	37 2	10.9	33.5	32.1	1 .	1 .5	1	13.	.1	3.81	5 68	9.07	8.37
Dissolved Metals																										
Aluminum	0.005-0 1[e]	0.005-0 1[e]	NS	NS	mg/L	< 0.001	< 0.001	0.0032	0.0029	< 0.001	< 0.001	< 0.001	0.0012	0.006	0 003	0.0085	0.0027	0.0025	0.0011	NC	0.0025	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Antimony	NS	NS	NS	NS	mg/L	< 0.0001	< 0.0001	< 0.0001	0.00015	< 0.0001	< 0.0001	< 0.0001	0.00065	0.000 8	< 0.0001	0.00033	< 0.0001	< 0.0001	< 0.0001	NC	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Arsenic	0.005	0.005	0.3	0.15	mg/L	0.00155	0.00153	0.00052	0.00056	0.00031	< 0.0001	< 0.0001	0.00088	0.00179	0.00128	0.00036	0.00063	0.00018	0.00018	0	0.00027	0.00168	0.001 9	0.000 6	0.00070	0.00061
Barium	NS	NS	NS	NS	mg/L	0.11	0.11	0.0835	0.0898	0.0951	0.0962	0.096	0.0567	0.05	0. 0 9	0. 0 73	0. 0 26	0.056	0.056	0	0.0556	0.1	0.105	0.00125	0.0002	0.00019
Beryl um	NS	NS	NS	NS	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	<0.00010	< 0.0001	< 0.0001	< 0.0001	< 0.0001	NC	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Bismuth	NS	NS	NS	NS	mg/L	< 0.00005	< 0.00005	< 0.00005	< 0.00005	< 0.00005	< 0.00005	< 0.00005	< 0.00005	< 0.00005	<0.000050	< 0.00005	< 0.00005	< 0.00005	< 0.00005	NC	< 0.00005	< 0.00005	< 0.00005	< 0.00005	< 0.00005	< 0.00005
Boron	29	1.5	NS	NS	mg/L	0.156	0.155	0.251	0.339	0.21	0.202	0.212	0.33	0.299	0 3 6	0.692	0.605	0.302	0.28	8	0.266	0.196	0.18	0.1 7	0 1 2	0.097
Cadmium	0.0022-0.0057[f]	0.00017-0.00036 [g]	0.00021 - 0.0058 [h]	0.00026 - 0.00051 [g]	mg/L	< 0.000005	< 0.000005	< 0.000005	< 0.000005	< 0.000005	< 0.000005	< 0.000005	< 0.000005	< 0.000005	0.000008 7	< 0.000005	< 0.000005	< 0.000005	< 0.000005	NC	< 0.000005	< 0.000005	< 0.000005	< 0.000005	< 0.000005	< 0.000005
Calcium	NS	NS	NS	NS	mg/L	50.7	8.5	5.1	5.1	36.	36.7	35.2	3.1	22.1	39.7	26.	22.9	2. 7	2. 5	1	27.1	6	3.5	0.206	0.118	0.102
Cesium	NS	NS	NS	NS	mg/L	< 0.00001	< 0.00001	0.000018	0.000059	0.00001	< 0.00001	< 0.00001	0.000011	0.00089	0.000102	0.000012	0.000056	< 0.00001	< 0.00001	NC	< 0.00001	< 0.00001	< 0.00001	< 0.00001	< 0.00001	< 0.00001
Chromium[i]	0.0089	0.0089	0.616-1.3 7[h]	0.08-0.175[h]	mg/L	< 0.0001	< 0.0001	< 0.0001	0.0002	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	<0.00010	< 0.0001	0.00013	< 0.0001	< 0.0001	NC	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Cobalt	NS	NS	NS	NS	mg/L	< 0.0001	< 0.0001	0.00072	0.0007	0.000	< 0.0001	< 0.0001	< 0.0001	0.0007	0.0003	0.00025	0.00022	< 0.0001	< 0.0001	NC	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Copper	0.00257 - 0.00 [k]	0.00257 - 0.00 [k]	0.01 7 -0.0362[e]	0.00972 - 0.022[e]	mg/L	< 0.0002	< 0.0007	< 0.0002	0.00028	< 0.0002	< 0.0002	< 0.0002	< 0.0002	0.0007	0.00052	< 0.0002	< 0.0002	< 0.0002	< 0.0002	NC	< 0.0002	< 0.0002	< 0.0002	**0 0241**	0.00035	0.0005
Iron	0.3	0.3	NS	NS	mg/L	**0 609**	**0 845**	0.05	< 0.01	0.198	< 0.01	**0 474**	**0 623**	< 0.01	<0.010	< 0.01	< 0.01	0.259	0.2	8	0.199	**0 864**	0.016	0.015	< 0.01	< 0.01
Lead	0.00359-0.007	0.00359-0.007	0.072 - 0.198[e]	0.0028 - 0.0077[e]	mg/L	< 0.00005	< 0.00005	< 0.00005	< 0.00005	< 0.00005	< 0.00005	< 0.00005	< 0.00005	< 0.00005	0.000168	< 0.00005	< 0.00005	< 0.00005	< 0.00005	NC	< 0.00005	< 0.00005	< 0.00005	0.000177	< 0.00005	< 0.00005
Lithium	NS	NS	NS	NS	mg/L	0.0161	0.016	0.0159	0.0166	0.018	0.019	0.0189	0.022	0.033	0.0265	0.031	0.0336	0.011	0.0109	3	0.0121	0.0171	0.0173	0.0074	< 0.001	< 0.001
Magnesium	NS	NS	NS	NS	mg/L	3	35	30	32.8	25.5	26.5	26	25.2	19	25.5	12.2	12.8	12.	12.5	1	13.9	32.8	3 . 1	0.116	0.052	0.0 05
Manganese	7.2 - 48.1	0.12 - 0.6 [l]	NS	NS	mg/L	0.00903	0.00932	0.0279	0.0 13	0.0256	0.017	0.0168	0.01 6	0.00 6	0.00538	0.0107	0.0313	0.00306	0.00303	1	0.00207	0.0155	0.0151	0.001 7	0.00018	< 0.0001
Mercury	0.000026	0.000026	NS	NS	mg/L	< 0.000005	< 0.000005	< 0.000005	< 0.000005	< 0.000005		< 0.000005	< 0.000005	< 0.000005	<0.0000050	< 0.000005	< 0.000005	< 0.000005	< 0.000005	NC	< 0.000005	< 0.000005	< 0.000005	< 0.000005	< 0.000005	< 0.000005
Molybdenum	0.073	0.073	NS	NS	mg/L	0.00215	0.001 6	0.00205	0.00392	0.0022	0.00195	0.00193	0.0015	0.03	0.00693	0.00332	0.0053	0.008	0.00788	8	0.0076	0.00171	0.00163	0.00125	0.00097	0.000939
Nickel	0.103 - 0.150	0.103 - 0.150	0.508 - 1 1 [e]	0.056 - 0.127[e]	mg/L	< 0.0005	< 0.0005	< 0.0005	0.0008 7	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	0.00158	0.011	< 0.0005	< 0.0005	< 0.0005	NC	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005
Phosphorus (Dissolved)	NS	NS	NS	NS	mg/L	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	< 0.030	0.033	< 0.03	< 0.03	<0.030	< 0.03	< 0.03	< 0.03	< 0.03	NC	< 0.03	< 0.03	< 0.03	< 0.03	0.057	0.063
Phosphorus (Total)	NS	NS	NS	NS	mg/L	0.0156	0.0188	0.088	0.206	0.0281		0.0321	0.852	9 6	-	0.113	0.072	0 0 58	0.135	**99**	0.0556	0.016	0.0096	0.0191	0.0583	0.0 83
Potassium	NS	NS	NS	NS	mg/L	33	71	88	5.66	39	7	57	7.58	32.1	16.	7.93	10.8	3.86	3.93	2	3.98	51	5.36	0.195	1. 1	1.22
Rubidium	NS	NS	NS	NS	mg/L	0.00223	0.00255	0.00293	0.00569	0.00182	0.00168	0.0016	0.00 73	0.0332	0.02 9	0.00 0	0.00911	0.00199	0.00199	0	0.0021	0.00167	0.00195	< 0.0002	0.00058	0.0006
Selenium	0.001	0.001	NS	NS	mg/L	< 0.00005	< 0.00005	< 0.00005	0.000066	< 0.00005	< 0.00005	< 0.00005	< 0.00005	0.000912	0.000096	< 0.00005	0.000101	< 0.00005	< 0.00005	NC	0.00023	< 0.00005	< 0.00005	< 0.00005	< 0.00005	< 0.00005
Sil con	NS	NS	NS	NS	mg/L	7 9	7. 6	6.71	7.11	7.0	7.15	7.19	5.19	5.13	5.5	-	3.8	73	61	3	7	7.7	8.01	7.01	6.58	6. 9
Silver	NS	0.00025	NS	NS	mg/L	< 0.00001	< 0.00001	< 0.00001	< 0.00001	< 0.00001	< 0.00001	< 0.00001	< 0.00001	< 0.00001	<0.000010	< 0.00001	< 0.00001	< 0.00001	< 0.00001	NC	< 0.00001	< 0.00001	< 0.00001	< 0.00001	< 0.00001	0.000018
Sodium	NS	NS	NS	NS	mg/L	1 2	1 7	17	18.6	19.	22.8	25.5	19.1	72.7	31.3	82.	87.1	1.	1.8	0	3.3	3.3	1 2	16.	135.	13.
Strontium	NS	NS	NS	NS	mg/L	0.325	0.318	0.321	0.33	0.258	0.25	0.2 6	0.30	0.208	0.336	0.179	0.178	0.139	0.132	5	0.1 8	0.311	0.309	0.001	0.000 8	0.00039
Sulfur, e emental	NS	NS	NS	NS	mg/L	1.35	1.29	2.2	3.11	1.88	2.07	2.29	2 2	1 3	3.	11.	11.8	78	36	9	8.	1.09	1.09	1.5	3.28	3.21
Tellurium	NS	NS	NS	NS	mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	<0.00020	< 0.0002	< 0.0002	< 0.0002	< 0.0002	NC	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Thal um	0.0008	0.0008	NS	NS	mg/L	< 0.00001	< 0.00001	< 0.00001	< 0.00001	< 0.00001	< 0.00001	< 0.00001	< 0.00001	0.000035	<0.000010	< 0.00001	< 0.00001	< 0.00001	< 0.00001	NC	< 0.00001	< 0.00001	< 0.00001	< 0.00001	< 0.00001	< 0.00001
Thorium	NS	NS	NS	NS	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	<0.00010	< 0.0001	< 0.0001	< 0.0001	< 0.0001	NC	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Tin	NS	NS	NS	NS	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	0.00021	< 0.0001	< 0.0001	< 0.0001	< 0.0001	NC	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Titanium	NS	NS	NS	NS	mg/L	< 0.0003	< 0.0003	< 0.0003	< 0.0003	< 0.0003	< 0.0003	< 0.0003	< 0.0003	< 0.0003	<0.00030	0.000 5	< 0.0003	< 0.0003	< 0.0003	NC	< 0.0003	< 0.0003	< 0.0003	< 0.0003	< 0.0003	< 0.0003
Tungsten	NS	NS	NS	NS	mg/L	< 0.0001	< 0.0001	0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	0.00093	0.00053	< 0.0001	0.000 3	< 0.0001	< 0.0001	NC	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Uranium	0.033	0.015	NS	NS	mg/L	0.0001	0.000058	0.000308	0.000208	0.000083	0.000028	0.00003	0.00062	0.00121	0.0005 2	0.000391	0.000992	0.000069	0.000071	3	0.000135	0.000062	0.000068	0.000019	0.00009	0.000105
Vanadium	NS	NS	NS	NS	mg/L	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	0.00103	<0.00050	< 0.0005	< 0.0005	< 0.0005	< 0.0005	NC	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005
Zinc	0.075 - 0.209[j]	0.007 - 0.036[k]	0.127 - 0.286[e]	0.128 - 0.288 [e]	mg/L	< 0.001	0.0023	0.009	0.0197	0.0106	0.0013	0.003	< 0.001	< 0.001	0.00	0.0023	0.0035	< 0.001	< 0.001	NC	0.0011	< 0.001	0.0011	**0.0075**	< 0.001	0.001
Zirconium	NS	NS	NS	NS	mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	<0.00020	< 0.0002	< 0.0002	< 0.0002	< 0.0002	NC	< 0.0002	< 0.0002	< 0.0002	0.00038	< 0.0002	< 0.0002
PAHs																				NC						
Acenaphthene	0.0058	0.0058	NS	NS	mg/L	-	-	-	-	< 0.00002	-	< 0.00002	-	-	-	-	-	-	-	NC	-	-	-	-	-	-
Acenaphthylene	NS	NS	NS	NS	mg/L	-	-	-	-	< 0.00002	-	< 0.00002	-	-	-	-	-	-	-	NC	-	-	-	-	-	-
Acridine	0.00	0.00	NS	NS	mg/L	-	-	-	-	< 0.00002	-	< 0.00002	-	-	-	-	-	-	-	NC	-	-	-	-	-	-
Anthracene	0.000012	0.000012	NS	NS	mg/L	-	-	-	-	< 0.00001	-	< 0.00001	-	-	-	-	-	-	-	NC	-	-	-	-	-	-
Fluorene	0.003	0.003	NS	NS	mg/L	-	-	-	-	< 0.00002	-	< 0.00002	-	-	-	-	-	-	-	NC	-	-	-	-	-	-
Naphthalene	0.0011	0.0011	NS	NS	mg/L	-	-	-	-	< 0.00005	-	< 0.00005	-	-	-	-	-	-	-	NC	-	-	-	-	-	-
Phenanthrene	0.000	0.000	NS	NS	mg/L	-	-	-	-	< 0.00005	-	< 0.00005	-	-	-	-	-	-	-	NC	-	-	-	-	-	-
Benz[a]anthracene	0.000018	0.000018	NS	NS	mg/L	-	-	-	-	< 0.00001	-	< 0.00001	-	-	-	-	-	-	-	NC	-	-	-	-	-	-
Benzo[a]pyrene	0.000015	0.000015	NS	NS	mg/L	-	-	-	-	< 0.000005	-	< 0.000005	-	-	-	-	-	-	-	NC	-	-	-	-	-	-
Benzo[b, j] luoranthene	NS	NS	NS	NS	mg/L	-	-	-	-	< 0.00001	-	< 0.00001	-	-	-	-	-	-	-	NC	-	-	-	-	-	-
Benzo[g,h,i]perylene	NS	NS	NS	NS	mg/L	-	-	-	-	< 0.00002	-	< 0.00002	-	-	-	-	-	-	-	NC	-	-	-	-	-	-
Benzo[k]fluoranthene	NS	NS	NS	NS	mg/L	-	-	-	-	< 0.00001	-	< 0.00001	-	-	-	-	-	-	-	NC	-	-	-	-	-	-
Chrysene	NS	NS	NS	NS	mg/L	-	-	-	-	< 0.00002	-	< 0.00002	-	-	-	-	-	-	-	NC	-	-	-	-	-	-
Dibenz(a,h)anthracene	NS	NS	NS	NS	mg/L	-	-	-	-	< 0.000005	-	< 0.000005	-	-	-	-	-	-	-	NC	-	-	-	-	-	-
Fluoranthene	0.0000	0.0000	NS	NS	mg/L	-	-	-	-	< 0.00002	-	< 0.00002	-	-	-	-	-	-	-	NC	-	-	-	-	-	-
Indeno(1,2,3-c,d)pyrene	NS	NS	NS	NS	mg/L	-	-	-	-	< 0.00001	-	< 0.00001	-	-	-	-	-	-	-	NC	-	-	-	-	-	-
Methylnaphthalene, 1-	NS	NS	NS	NS	mg/L	-	-	-	-	< 0.00002	-	< 0.00002	-	-	-	-	-	-	-	NC	-	-	-	-	-	-
Methylnaphthalene, 2-	NS	NS	NS	NS	mg/L	-	-	-	-	< 0.00002	-	< 0.00002	-	-	-	-	-	-	-	NC	-	-	-	-	-	-
Pyrene	0.000025	0.000025	NS	NS	mg/L	-	-	-	-	< 0.00001	-	< 0.00001	-	-	-	-	-	-	-	NC	-	-	-	-	-	-
Quinoline	0.003	0.003	NS	NS	mg/L	-	-	-	-	< 0.00002	-	< 0.00002	-	-	-	-	-	-	-	NC	-	-	-	-	-	-
Phenols and PHC															-					NC						
Pheno s (Phenolics)	0.00	0.00	NS	NS	mg/L	-	-	-	-	< 0.001	-	< 0.001	< 0.001	-	-	-	-	-	-	NC	-	-	-	-	-	-
Benzene	0.37	0.37	NS	NS	mg/L	-	-	-	-	< 0.0005	-	< 0.0005	-	-	-	-	-	-	-	NC	-	-	-	-	-	-
Toluene	0.002	0.002	NS	NS	mg/L	-	-	-	-	< 0.001	-	< 0.001	-	-	-	-	-	-	-	NC	-	-	-	-	-	-
Ethylbenzene	0.09	0.09	NS	NS	mg/L	-	-	-	-	< 0 0005	-	< 0.0005	-	-	-	-	-	-	-	NC	-	-	-	-	-	-
Xylene, O-	NS	NS	NS	NS	mg/L	-	-	-	-	< 0 0005	-	< 0.0005	-	-	-	-	-	-	-	NC	-	-	-	-	-	-
Xylene, p m-	NS	NS	NS	NS	mg/L	-	-	-	-	< 0 000	-	< 0.000	-	-	-	-	-	-	-	NC	-	-	-	-	-	-
Xylenes, Total	NS	NS	NS	NS	mg/L	-	-	-	-	< 0.0006	-	< 0.0006	-	-	-	-	-	-	-	NC	-	-	-	-	-	-

Notes

CCME FAL, Guide ines to protect freshwater aquatic life

Chronic: Guidel nes to protect freshwater aquatic l fe, (30-day average guidel nes)

Acute: Guide ines to protect freshwater aquatic life, (Max mum allowable concentration [MAC] guidelines)

MWQSOG FAL: Man toba Water Qua ity Standards, Objectives, and Guidelines (Tier II) - Protection of Aquatic L fe and Wildl fe

Chronic: Guidel nes to protect freshwater aquatic l fe, (30-day or 4-day average guidel nes)

*Acute: Guide ines to protect freshwater aquatic life, (one-hour Max mum guidel nes)

Table 4-9. Summary of Water Quality Exceedances

Well ID	Pre/Post Pumping Test	Sample Date	Hydrostratigraphic Unit	Drinking Water		Agricultual/Irrigation			Livestock		Aquatic Life	
				CDWQ	MWQSOG	CCME	FIGQG	MWQSOG	CCME	MWQSOG	CCME (Acute)	MWQSOG (Acute)
BRU 95-5	Pre-test	2020-Nov-15	Red River Carbonate	Turbidity (MAC); Fe (AO)	Turbidity (MAC); Fe (AO)	-	F; S(as H2S); Fe	-	-	-	F; Fe	-
	Post-test	2020-Dec-02	Red River Carbonate/ Winnipeg Shale	Turbidity (MAC); Fe (AO)	Turbidity (MAC); Fe (AO)	-	F; Fe	-	-	-	F; Fe	-
BRU 95-6	Pre-test	2020-Nov-15	Winnipeg Sandstone	Turbidity (MAC); Mn (AO)	Turbidity (MAC)	-	F	-	-	-	F	-
	Post-test	2020-Dec-02	Winnipeg Sandstone	Mn (AO)	-	-	F; Zn	-	-	-	F	-
BRU 95-7	Pre-test	2020-Nov-25	Winnipeg Sandstone	Turbidity (MAC); Mn (AO)	Turbidity (MAC)	-	F; S (as H2S); Zn	-	-	-	F	-
	Mid-test	2020-Nov-29	Winnipeg Sandstone	Turbidity (MAC)	Turbidity (MAC)	-	F	-	-	-	F	-
	Post-test	2020-Dec-01	Winnipeg Sandstone	Turbidity (MAC); Fe (AO)	Turbidity (MAC); Fe (AO)	-	F; S(as H2S); Fe	-	-	-	F; Fe	-
BRU 95-9	Pre-test	2020-Nov-24	Winnipeg Shale	Fe (AO)	Fe (AO)	-	F; Fe	-	-	-	F; Fe	-
	Post-test	2020-Dec-02	Winnipeg Shale	-	-	Mo	F	Mo	-	-	F	-
	NA	2021-Feb-04	Winnipeg Shale	Turbidity (MAC)	Turbidity (MAC)	-	F, Cd	-	-	-	F	
BRU-96-1	Pre-test	2020-Nov-13	Winnipeg Sandstone	Turbidity (MAC)	Turbidity (MAC)	B	B	B	-	-	F	-
	Post-test	2020-Dec-02	Winnipeg Sandstone	Mn (AO)	-	B	-	B	-	-	F	-
BRU 96-2	Pre-test	2020-Nov-14	Red River Carbonate	Turbidity (MAC)	Turbidity (MAC)	-	F	-	-	-	F	-
	Post-test	2020-Dec-02	Red River Carbonate	Turbidity (MAC)	Turbidity (MAC)	-	F	-	-	-	F	-
Unknow n[a]	Pre-test	2020-Nov-15	Winnipeg Sandstone	Turbidity (MAC), Fe (AO)	Turbidity (MAC)	-	F; Fe	-	-	-	F; Fe	-
	Post-test	2020-Dec-02	Winnipeg Sandstone	-	-	-	F; S(as H2S)	-	-	-	F	-
66124[a]	Pre-test	2020-Nov-15	Red River Carbonate/ Winnipeg Shale	-	-	-	F	-	-	-	F; Cu; Zn	-
23901[a]	Pre-test	2020-Nov-18	Red River Carbonate	Turbidity (MAC)	Turbidity (MAC)	-	F; S(as H2S)	-	-	-	F	-
	Post-test	2020-Dec-02	Red River Carbonate	-	-	-	F; S(as H2S)	-	-	-	F	-

Notes:

a: Private domestic wells

CDWQ MAC: Canadian Drinking Water Quality Maximum Acceptable Concentration Guidelines (Updated in September 2020 version)

CDWQ Other: Canadian Drinking Water Quality (CDWQ) Aesthetic Objective (AO) (Updated in September 2020 Version)

CCME Irrigation: Canadian Council of Ministers of the Environment Water Quality Guidelines for the Protection of Agricultural Water - Irrigation Water Use

CCME Livestock: Canadian Council of Ministers of the Environment Water Quality Guidelines for the Protection of Agricultural Water - Livestock Water Use

FIGQG Agricultural: Federal Interim Groundwater Quality Guidelines - Groundwater Quality Guidelines for Federal Contaminated Sites - Agricultural Land Use - Tables 1.1-1.7 (coarse grain size)

MWQSOG MAC: Manitoba Water Quality Standards, Objectives, and Guidelines (Tier III) - Protection of Drinking Water Use - Maximum Acceptable Concentration

MWQSOG AO: Manitoba Water Quality Standards, Objectives, and Guidelines (Tier III) - Protection of Drinking Water Use - Aesthetic Objectives

MWQSOG Irrigation: Manitoba Water Quality Standards, Objectives, and Guidelines (Tier III) - Protection of Irrigation Water Use

MWQSOG Livestock: Manitoba Water Quality Standards, Objectives, and Guidelines (Tier III) - Protection of Livestock Water Use

NA - not avaliable

Table 4-10. Comparison of Water Quality Before and After Pumping Test

Hydrogeostratigraphic Unit	Red River Carbonate								Winnipeg Sandstone												Winnipeg Shale			
Parameters	BRU 95-5		Magnitude of Change	RPD (%)	BRU 96-2		Magnitude of Change	RPD (%)	BRU 95-6		Magnitude of Change	RPD (%)	BRU 95-7		Magnitude of Change	RPD (%)	BRU 96-1		Magnitude of Change	RPD (%)	BRU 95-9		Magnitude of Change	RPD (%)
	Pre	Post			Pre	Post			Pre	Post			Pre	Post			Pre	Post			Pre	Post		
pH	8.33	8.16	-0.17	-2%	8.39	8.18	-0.21	-3%	8.35	8.12	-0.23	-3%	8.11	8.36	0.25	3%	8.44	8.49	0.05	1%	8.09	8.35	0.26	3%
Conductivity	535	525	-10	-2%	383	415.5	32.5	8%	483	594	111	21%	439.8	444.2	4.4	1%	581	569	-12	-2%	482.1	502	19.9	4%
TDS	277	258	-19	-7%	224	217	-7	-3%	264	292	28	10%	239	245	6	2%	358	340	-18	-5%	269	489	220	58%
Hardness (as CaCO3)	268	265	-3	-1%	112	125	13	11%	238	-		NC	196	197	1	1%	116	110	-6	-5%	211	-		NC
Alkalinity, Total (As CaCO3)	302	299	-3	-1%	197	212	15	7%	273	302	29	10%	246	244	-2	-1%	260	271	11	4%	276	1010	734	114%
Bicarbonate (as CaCO3)	358	365	7	2%	231	258	27	11%	322	369	47	14%	300	287	-13	-4%	304	313	9	3%	337	1230	893	114%
Dissolved Organic Carbon (DOC)	1.74	2.01	0.27	14%	1.45	3.65	2.2	86%	0.87	2.12	1.25	84%	1.55	1.58	0.03	2%	0.5	1.66	1.16	107%	1.75	16.9	15.15	162%
Ammonia-N	0.41	0.202	-0.208	-68%	0.322	0.288	-0.034	-11%	0.415	0.389	-0.026	-6%	0.498	0.59	0.092	17%	0.415	0.38	-0.035	-9%	0.446	0.81	0.364	58%
Boron	0.156	0.155	-0.001	-1%	0.302	0.266	-0.036	-13%	0.251	0.339	0.088	30%	0.214	0.212	-0.002	-1%	0.692	0.605	-0.087	-13%	0.334	0.299	-0.035	-11%
Fluoride	0.325	0.331	0.006	2%	0.549	0.499	-0.05	-10%	0.383	0.382	-0.001	0%	0.406	0.411	0.005	1%	0.882	0.876	-0.006	-1%	0.302	0.481	0.179	46%
Calcium	50.7	48.5	-2.2	-4%	24.7	27.1	2.4	9%	45.1	45.1	0	0%	36.4	35.2	-1.2	-3%	26.4	22.9	-3.5	-14%	43.1	22.1	-21	-64%
Magnesium	34.4	35	0.6	2%	12.4	13.9	1.5	11%	30.4	32.8	2.4	8%	25.5	26.4	0.9	3%	12.2	12.8	0.6	5%	25.2	19	-6.2	-28%
Potassium	4.33	4.71	0.38	8%	3.86	3.98	0.12	3%	4.88	5.66	0.78	15%	4.39	4.57	0.18	4%	7.93	10.8	2.87	31%	7.58	32.1	24.52	124%
Sodium	14.2	14.7	0.5	3%	41.4	43.3	1.9	4%	17	18.6	1.6	9%	19.4	25.5	6.1	27%	82.4	87.1	4.7	6%	19.1	72.7	53.6	117%
Chloride	1.78	1.01	-0.77	-55%	2.56	2.76	0.2	8%	1.48	1.63	0.15	10%	1.04	1.52	0.48	38%	22.9	22.4	-0.5	-2%	1.87	37.4	35.53	181%
Sulphide	< 0.018	0.078		NC	< 0.018	< 0.018		NC	< 0.018	< 0.018		NC	0.023	0.02	-0.003	-14%	< 0.018	< 0.018		NC	< 0.18	< 1.8		NC
Sulphide (as H2S)	< 0.019	0.083		NC	< 0.019	< 0.019		NC	< 0.019	< 0.019		NC	0.024	0.021	-0.003	-13%	< 0.019	< 0.019		NC	< 0.19	< 1.9		NC
Sulphate	4.6	3.22	-1.38	-35%	14.4	13.4	-1	-7%	6.92	8.01	1.09	15%	5.23	5.83	0.6	11%	33.5	32.1	-1.4	-4%	6.84	37.2	30.36	138%
Iron	0.609	0.845	0.236	32%	0.259	0.199	-0.06	-26%	0.054	< 0.01		NC	0.198	0.474	0.276	82%	< 0.01	< 0.01		NC	0.623	< 0.01		NC
Manganese	0.00903	0.00932	0.00029	3%	0.00306	0.00297	-9E-05	-3%	0.0279	0.0454	0.0175	48%	0.0256	0.0168	-0.0088	-42%	0.0107	0.0313	0.0206	98%	0.0146	0.00464	-0.00996	-104%
Molybdenum	0.00215	0.00146	-0.00069	-38%	0.0084	0.0076	-0.0008	-10%	0.00205	0.00392	0.00187	63%	0.00224	0.00193	-0.00031	-15%	0.00332	0.00534	0.00202	47%	0.00154	0.0344	0.03286	183%
Zinc	< 0.001	0.0023		NC	< 0.001	0.0011		NC	0.009	0.0197	0.0107	75%	0.0106	0.0034	-0.0072	-103%	0.0023	0.0035	0.0012	41%	< 0.001	< 0.001		NC

Note:

All concentration data presented in mg/L.

NC: Not Calculated (Results <5x laboratory detection limit)

RPD = Relative Percent Difference. Positive RPD indicates "post" concentration is greater than "pre" value. Negative RPD indicates "post" concentration is lower than "pre" value

Calculated RPD in excess of 30%.

Table 4-11. Simulated Groundwater Quality in Response to Changing Redox Conditions

Hydrogeostratigraphic Unit	Red River Carbonate			Winnipeg Sandstone			Winnipeg Shale		
	BRU 95-5			BRU 95-7			BRU 95-9		
Parameters	**Exisiting**	**Operations**	**RPD (%)**	**Exisiting**	**Operations**	**RPD (%)**	**Exisiting**	**Operations**	**RPD (%)**
pH	7.54	8.7	14%	7.84	8.8	12%	7.56	8.8	16%
Pe	2.68	13.8	135%	3.2	13.5	123%	2.44	13.6	139%
Hardness (as CaCO3)	268	154	-54%	196	196	0%	211	211	0%
Alkalinity, Total (As CaCO3)	302	184	-48%	246	242	-2%	276	272	-2%
Ammonia-N	0.41	0	-200%	0.50	0	-200%	0.45	0	-200%
Chloride	1.78	1.78	0%	1.04	1.04	0%	1.9	1.9	0%
Sulphate	4.6	4.6	0%	5.2	5.2	0%	6.8	6.8	0%
Calcium	50.7	5.19	-163%	36.4	36.4	0%	43.1	43.1	0%
Magnesium	34.4	34.4	0%	25.5	25.5	0%	25.2	25.2	0%
Fluoride	0.325	0.325	0%	0.406	0.406	0%	0.302	0.302	0%
Sodium	14.2	14.2	0%	19.4	19.4	0%	19.1	19.1	0%
Potassium	4.33	4.33	0%	4.39	4.39	0%	7.58	7.58	0%
Aluminum	0.001	0.0002	-133%	0.001	0.0004	-80%	0.001	0.0004	-87%
Arsenic	0.00155	0.00155	0%	0.0003	0.0003	0%	0.0009	0.0009	0%
Iron	0.60924	0.00016	-200%	0.1981	0.0002	-200%	0.6232	0.0002	-200%
Manganese	0.00903	0.00903	0%	0.0256	0.0256	0%	0.0146	0.0146	0%
Molybdenum	0.00215	0.00215	0%	0.0022	0.0022	0%	0.0015	0.0015	0%
Uranium	0.0001	0.0001	0%	0.0001	0.0001	0%	0.0001	0.0001	0%
Strontium	0.32514	0.32513	0%	0.2581	0.2581	0%	0.3041	0.3041	0%
Zinc	<0.001	0.001	NC	0.0106	0.0106	0%	<0.001	0.0010	NC
Saturated Indices									
Calcite (CaCO3)	0.04	0.00	-	0.16	1.06	-	-0.02	1.19	-
Diaspore (AlOOH)	0.98	0.00	-	0.98	0.00	-	1.10	0.00	-
Ferrihydrite (FeOOH)	2.29	0.00	-	2.77	0.00	-	2.23	0.00	-
Gypsum (CaSO4.2H2O)	-3.02	-3.93	-	-3.07	-3.08	-	-2.89	-2.91	-
Manganite (MnOOH)	-7.04	7.37	-	-5.14	7.61	-	-7.38	7.53	-
Rhodochrosite (MnCO3)	-1.69	-0.91	-	-0.98	-0.47	-	-1.48	-0.67	-
Siderite (FeCO3)	-0.48	-16.40	-	-1.33	-16.34	-	-0.43	-16.38	-
Strontianite (SrCO3)	-1.59	-0.64	-	-1.44	-0.52	-	-1.61	-0.39	-

Table 4-12. Simulated Groundwater Quality in Red River Carbonate in Response to Upward Mixing

Parameters	CDWQ MAC	CDWQ AO	Fraction of Water from Red River Carbonate									
			100%	90%	80%	70%	60%	50%	40%	30%	20%	10%
pH	NS	7.0-10.5	7.54	7.53	7.54	7.56	7.58	7.60	7.62	7.64	7.67	7.69
Pe	NS	NS	2.68	2.75	2.77	2.79	2.81	2.84	2.88	2.94	3.03	3.17
Hardness (as CaCO3)	NS	NS	268	258	250	243	235	228	220	213	205	197
Alkalinity, Total (As CaCO3)	NS	NS	302	293	287	282	276	270	264	258	252	246
Ammonia-N	NS	NS	0.41	0.42	0.43	0.44	0.45	0.45	0.46	0.47	0.48	0.49
Chloride	NS	250	1.78	1.71	1.63	1.56	1.48	1.41	1.34	1.26	1.19	1.11
Sulphate	NS	500	4.6	4.66	4.73	4.79	4.85	4.92	4.98	5.04	5.10	5.17
Calcium	NS	NS	50.7	48.0	46.6	45.1	43.6	42.0	40.4	38.8	37.2	35.6
Magnesium	NS	NS	34.4	33.5	32.6	31.7	30.9	30.0	29.1	28.2	27.3	26.4
Fluoride	1.5	NS	0.325	0.333	0.341	0.349	0.358	0.366	0.374	0.382	0.390	0.398
Sodium	NS	200	14.2	14.726	15.246	15.766	16.286	16.807	17.327	17.847	18.367	18.887
Potassium	NS	NS	4.33	4.3369	4.3428	4.3488	4.3548	4.3607	4.3667	4.3727	4.3787	4.3846
Aluminum	NS	NS	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Arsenic	0.01	NS	0.00155	0.0014	0.0013	0.0012	0.0011	0.0009	0.0008	0.0007	0.0006	0.0004
Iron	NS	0.3	0.609	0.568	0.527	0.486	0.445	0.404	0.363	0.321	0.280	0.239
Manganese	0.12	0.02	0.0090	0.0107	0.0123	0.0140	0.0157	0.0173	0.0190	0.0206	0.0223	0.0240
Molybdenum	NS	NS	0.00215	0.00216	0.00217	0.00218	0.00219	0.00220	0.00221	0.00221	0.00222	0.00223
Uranium	0.02	NS	0.0001	0.000098	0.000097	0.000095	0.000093	0.000092	0.000090	0.000088	0.000086	0.000085
Strontium	7.0	NS	0.325	0.318	0.312	0.305	0.298	0.292	0.285	0.278	0.272	0.265
Zinc	NS	5	<0.001	0.0020	0.003	0.004	0.005	0.006	0.007	0.008	0.009	0.010

Notes:

CDWQ MAC: Canadian Drinking Water Quality Maximum Acceptable Concentration Guidelines (Updated in September 2020 version)

CDWQ Other: Canadian Drinking Water Quality (CDWQ) Aesthetic Objective (AO) (Updated in September 2020 Version)

Red Exceeds applicable CDWQ guideline for protection of drinking w ater (MAC)

Yellow Exceeds applicable CDWQ guideline for protection of drinking w ater (AO)

AECOM

Table 4-13. Simulated Groundwater Quality in Winnipeg Sandstone in Response to Downward Mixing

Parameters	CDWQ MAC	CDWQ AO	Fraction of Water from Winnipeg Sandstone									
			100%	90%	80%	70%	60%	50%	40%	30%	20%	10%
pH	NS	7.0-10.5	7.84	7.79	7.75	7.71	7.68	7.65	7.62	7.60	7.58	7.56
Pe	NS	NS	3.2	2.95	2.85	2.79	2.76	2.74	2.72	2.71	2.70	2.69
Hardness (as CaCO3)	NS	NS	196	203	210	217	225	232	239	246	253	261
Alkalinity, Total (As CaCO3)	NS	NS	246	251	257	263	268	274	279	285	291	296
Ammonia-N	NS	NS	0.50	0.49	0.48	0.47	0.46	0.45	0.45	0.44	0.43	0.42
Chloride	NS	250	1.04	1.11	1.19	1.26	1.34	1.41	1.48	1.56	1.63	1.71
Sulphate	NS	500	5.2	5.2	5.1	5.0	5.0	4.9	4.9	4.8	4.7	4.7
Calcium	NS	NS	36.4	37.8	39.3	40.7	42.1	43.6	45.0	46.4	47.9	49.3
Magnesium	NS	NS	25.5	26.4	27.3	28.2	29.1	30.0	30.9	31.7	32.6	33.5
Fluoride	1.5	NS	0.406	0.398	0.390	0.382	0.374	0.366	0.358	0.349	0.341	0.333
Sodium	NS	200	19.4	18.9	18.4	17.8	17.3	16.8	16.3	15.8	15.2	14.7
Potassium	NS	NS	4.39	4.3846	4.3787	4.3727	4.3667	4.3607	4.3548	4.3488	4.3428	4.3369
Aluminum	NS	NS	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Arsenic	0.01	NS	0.0003	0.0004	0.0006	0.0007	0.0008	0.0009	0.0011	0.0012	0.0013	0.0014
Iron	NS	0.3	0.198	0.239	0.280	0.321	0.363	0.404	0.445	0.486	0.527	0.568
Manganese	0.12	0.02	0.0256	0.0240	0.0223	0.0206	0.0190	0.0173	0.0157	0.0140	0.0123	0.0107
Molybdenum	NS	NS	0.0022	0.0022	0.0022	0.0022	0.0022	0.0022	0.0022	0.0022	0.0022	0.0022
Uranium	0.02	NS	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
Strontium	7.0	NS	0.2581	0.2648	0.2715	0.2782	0.2849	0.2916	0.2983	0.3050	0.3117	0.3184
Zinc	NS	5	0.0106	0.0096	0.0087	0.0077	0.0068	0.0058	0.0048	0.0039	0.0029	0.0020

Notes:

CDWQ MAC: Canadian Drinking Water Quality Maximum Acceptable Concentration Guidelines (Updated in September 2020 version)

CDWQ Other: Canadian Drinking Water Quality (CDWQ) Aesthetic Objective (AO) (Updated in September 2020 Version)

Red Exceeds applicable CDWQ guideline for protection of drinking w ater (MAC)

Yellow Exceeds applicable CDWQ guideline for protection of drinking w ater (AO)

Table 5-1. Summary of Aquifer Properties

Hydrostratigraphic Unit	Hydraulic Conductivity (m/s)			Transmissivity (US gallons/day/ft)		Storativity (-)		Comments	Study Location	Source
	Minimum	Maximum	Geometric Mean	Minimum	Maximum	Minimum	Maximum			
Quaternary Sediments	1×10^{-12}	1						Glacial till to gravel	Literature	Freeze and Cherry (1979)
	8.2×10^{-6}	2.4×10^{-4}						Multiple slug tests (sand)	SE Manitoba (Sandilands Area)	Cherry (2000)
	8.3×10^{-9}	6.8×10^{-6}						Multiple slug tests (till)	SE Manitoba (Sandilands Area)	Cherry (2000)
	1.5×10^{-5}	1.3×10^{-4}						Multiple permeameter tests	SE Manitoba (Sandilands Area)	Ferguson (2004)
			2.5×10^{-3}	430,000				Sand and gravel	Moosenose Ridge Deposit	Woodbury (1995)
Red River Carbonate	1.0×10^{-9}	5.0×10^{-6}						Limestone and Dolomite	Literature	Freeze and Cherry (1979)
	1.7×10^{-5}	*5.0×10^{-4}*		5,000	150,000	1.0×10^{-6}	1.0×10^{-3}		SE Manitoba	Render (1970)
						2.0×10^{-5}	3.0×10^{-4}		SE Manitoba	Kennedy (2002)
			8.0×10^{-4}					76 short term pumping tests	SE Manitoba	Wang et al. (2008)
			2.5×10^{-4}	75,000					SE Manitoba (Steinbach)	Bell (2009)
	1.5×10^{-5}	3.9×10^{-4}	7.7×10^{-5}					2 slug tests	SE Manitoba (Project Site)	AECOM (this study)
Winnipeg Shale	1.0×10^{-13}	1.0×10^{-9}							Literature	Freeze and Cherry (1979)
			2.8×10^{-8}					1 slug test	SE Manitoba (Project Site)	AECOM (this study)
Winnipeg Sandstone	1.0×10^{-10}	1.0×10^{-6}							Literature	Freeze and Cherry (1979)
	1.0×10^{-6}	1.0×10^{-3}							SE Manitoba	Betcher (1986) cited in jeff bell
	2.2×10^{-5}	4.4×10^{-5}	2.4×10^{-5}	5,000	10,000			11 short term pumping tests	SE Manitoba	Wang et al. (2008)
	3.6×10^{-6}	1.1×10^{-3}						16 of 20 tests between 10^{-4} and 10^{-6} m/s	Southern Manitoba	Ferguson et al. (2007)
	7.9×10^{-5}		8.0×10^{-5}	10,000		2.0×10^{-5}	6.0×10^{-5}	24-hour pumping test (3,000 m^3/day; s = 58m)	SE Manitoba (Dougald and Oakbank)	Friesen (2019a)
			3.0×10^{-5}			2.0×10^{-5}	6.0×10^{-5}	24-hour pumping test	SE Manitoba (RM Springfield)	Friesen (2019b)
			5.2×10^{-5}	12,000		1.0×10^{-5}		60-hour pumping test (2,400 m^3/day; s = 24.4m)	SE Manitoba (Park Road)	Friesen (2015)
			3.9×10^{-5}	9,000					SE Manitoba (Granny's Poultry)	Friesen (2014)
						2.0×10^{-5}	1.0×10^{-4}		SE Manitoba	Kennedy (2002)
	5.2×10^{-5}	6.2×10^{-5}	5.7×10^{-5}					2 slug tests	SE Manitoba (Project Site)	AECOM (this study)
	4.8×10^{-5}	1.1×10^{-4}	9.5×10^{-5}			1.2×10^{-4}	1.7×10^{-4}	62-hour pumping test (2,295 m^3/day; s = 36m)	SE Manitoba (Project Site)	AECOM (this study)
Precambrian Bedrock	5.0×10^{-9}	1.0×10^{-4}							Literature	Freeze and Cherry (1979)

Notes:

Italics: Calculated from reported transmissivity values.

Table 6-1. Scenario Testing Results

Observation Point Name	30-10-8E1	29-10-8E1	31-10-8E1	32-10-8E1	36-10-7E1	20-10-8E1	G05SA015	33-10-8E1	3-11-7E1	G05OJ175
Distance to Production Well (m)	146	1504	1537	2186	2223	2313	2916	3515	4416	7462
Scenario	**Simulated Groundwater Elevation (m) in Red River Carbonate**									
1) 0% Re-injection	262.9	269.1	268.2	270.2	266.6	269.2	269.8	270.1	263.1	259.4
2) 50% Re-injection	266.7	270.3	269.3	270.9	267.3	269.8	270.2	270.3	263.1	259.4
3) No Shale Degradation	266.2	269.1	268.2	270.2	266.6	269.3	269.8	270.1	263.1	259.4
Scenario	**Simulated Drawdown (m) in Red River Carbonate**									
1) 0% Re-injection	7.5	2.1	2.2	1.3	1.3	0.9	0.8	0.4	0.1	0.0
2) 50% Re-injection	3.6	0.9	1.1	0.6	0.6	0.4	0.3	0.1	0.0	0.0
3) No Shale Degradation	4.2	2.0	2.1	1.3	1.3	0.9	0.7	0.4	0.1	0.0
Observation Point Name	30-10-8E1	29-10-8E1	31-10-8E1	32-10-8E1	36-10-7E1	20-10-8E1	G05SA014	33-10-8E1	3-11-7E1	G05OJ163
Distance to Production Well (m)	146	1504	1537	2186	2223	2313	2916	3515	4416	7462
Scenario	**Simulated Groundwater Elevation (m) in Winnipeg Sandstone**									
1) 0% Re-injection	262.9	269.1	267.9	269.7	266.4	269.2	269.4	269.8	263.2	259.1
2) 50% Re-injection	266.7	270.2	269.0	270.4	267.1	269.8	269.9	270.1	263.3	259.2
3) No Shale Degradation	254.6	268.5	267.7	269.6	266.4	268.9	269.3	269.8	263.2	259.1
Scenario	**Simulated Drawdown (m) Winnipeg Sandstone**									
1) 0% Re-injection	7.5	2.1	2.2	1.4	1.2	0.9	0.8	0.4	0.2	0.0
2) 50% Re-injection	3.6	0.9	1.1	0.6	0.6	0.4	0.4	0.1	0.1	0.0
3) No Shale Degradation	15.7	2.6	2.4	1.5	1.3	1.2	0.9	0.4	0.2	0.0

Table 6-2. Sensitivity Analysis Results

Observation Point Name	30-10-8E1	29-10-8E1	31-10-8E1	32-10-8E1	36-10-7E1	20-10-8E1	G05SA015	33-10-8E1	3-11-7E1	G05OJ175
Distance to Production Well (m)	146	1,504	1,537	2,186	2,223	2,313	2,916	3,515	4,416	7,462
Sensitivity Analysis	**Simulated Groundwater Elevation (m) in Red River Carbonate**									
Base Case (Scenario 1)	262.9	269.1	268.2	270.2	266.6	269.2	269.8	270.1	263.1	259.4
Recharge - 20%	262.0	268.2	267.3	269.3	266.0	268.7	269.2	269.5	262.9	259.0
Recharge + 20%	263.5	269.6	269.0	270.9	267.1	269.5	270.2	270.4	263.2	259.6
Carbonate K = Min (1.5 x 10^{-5})	257.5	269.4	269.3	271.6	267.6	269.5	271.0	270.8	263.4	260.1
Carbonate K = Max (8.25 x 10^{-4})	256.6	258.8	256.4	258.3	255.1	259.6	259.3	259.8	252.2	250.2
Shale K ÷ 10	262.5	268.8	268.2	270.5	266.6	269.1	269.8	270.2	263.0	259.4
Shale K x 10	262.6	268.8	267.9	269.8	266.4	269.1	269.6	269.9	263.1	259.3
Sandstone K = Min (1.0 x 10^{-6})	260.7	269.1	268.6	270.9	266.9	269.3	270.0	270.4	263.1	259.5
Sandstone K = Max (1.0 x 10^{-4})	264.6	268.7	267.7	269.4	266.1	268.9	269.4	269.6	262.8	259.1
Sensitivity Analysis	**Simulated Drawdown (m) in Red River Carbonate**									
Base Case (Scenario 1)	7.5	2.1	2.2	1.3	1.3	0.9	0.8	0.4	0.1	0.0
Recharge - 20%	7.9	2.4	2.4	1.5	1.6	1.3	1.1	0.6	0.2	0.0
Recharge + 20%	7.2	2.0	1.8	1.1	1.0	0.9	0.6	0.3	0.1	0.0
Carbonate K = Min (1.5 x 10^{-5})	14.4	3.5	2.7	1.8	1.2	1.2	0.6	0.3	0.0	0.0
Carbonate K = Max (8.25 x 10^{-4})	1.5	0.8	0.8	0.7	0.7	0.7	0.6	0.6	0.4	0.2
Shale K ÷ 10	7.6	2.2	2.1	1.2	1.3	1.0	0.8	0.4	0.1	0.0
Shale K x 10	7.8	2.4	2.4	1.6	1.4	1.1	0.9	0.5	0.1	0.0
Sandstone K = Min (1.0 x 10^{-6})	10.3	2.9	2.5	1.5	1.3	1.1	0.8	0.4	0.1	0.0
Sandstone K = Max (1.0 x 10^{-4})	4.5	0.9	1.4	0.6	1.0	0.5	0.6	-0.1	0.2	0.0
Observation Point Name	30-10-8E1	29-10-8E1	31-10-8E1	32-10-8E1	36-10-7E1	20-10-8E1	G05SA014	33-10-8E1	3-11-7E1	G05OJ163
Distance to Production Well (m)	146	1,504	1,537	2,186	2,223	2,313	2,916	3,515	4,416	7,462
Sensitivity Analysis	**Simulated Groundwater Elevation (m) in Winnipeg Sandstone**									
Base Case (Scenario 1)	262.9	269.1	267.9	269.7	266.4	269.2	269.4	269.8	263.2	259.1
Recharge - 20%	262.0	268.2	267.1	268.9	265.8	268.7	268.9	269.3	262.9	258.8
Recharge + 20%	263.6	269.6	268.6	270.3	266.9	269.5	269.8	270.1	263.4	259.4
Carbonate K = Min (1.5 x 10^{-5})	257.5	269.4	268.6	270.8	267.2	269.5	270.1	270.5	263.6	260.0
Carbonate K = Max (8.25 x 10^{-4})	256.6	258.8	256.4	258.2	255.0	259.6	259.3	259.7	252.4	250.2
Shale K ÷ 10	262.5	268.8	266.7	268.3	265.1	269.1	268.8	268.4	262.3	258.1
Shale K x 10	262.6	268.8	267.8	269.7	266.4	269.1	269.6	269.9	263.1	259.3
Sandstone K = Min (1.0 x 10^{-6})	260.2	269.1	268.6	270.8	266.9	269.3	270.0	270.3	263.1	259.5
Sandstone K = Max (1.0 x 10^{-4})	264.6	268.7	267.1	268.6	265.6	268.9	268.8	268.9	262.7	258.6
Sensitivity Analysis	**Simulated Drawdown (m) in Winnipeg Sandstone**									
Base Case (Scenario 1)	7.5	2.1	2.2	1.4	1.2	0.9	0.8	0.4	0.2	0.0
Recharge - 20%	7.9	2.4	2.5	1.7	1.5	1.3	1.1	0.6	0.3	0.1
Recharge + 20%	7.2	2.0	1.8	1.2	1.0	0.9	0.6	0.4	0.1	0.0
Carbonate K = Min (1.5 x 10^{-5})	14.3	3.5	2.9	1.9	1.3	1.2	0.8	0.4	0.1	0.0
Carbonate K = Max (8.25 x 10^{-4})	1.5	0.8	0.8	0.7	0.7	0.7	0.6	0.6	0.4	0.2
Shale K ÷ 10	7.6	2.2	2.5	1.7	1.6	1.0	0.9	0.6	0.6	0.2
Shale K x 10	7.8	2.4	2.4	1.6	1.4	1.1	0.9	0.5	0.1	0.0
Sandstone K = Min (1.0 x 10^{-6})	10.7	2.9	2.5	1.5	1.3	1.1	0.8	0.4	0.1	0.0
Sandstone K = Max (1.0 x 10^{-4})	4.5	0.9	1.4	0.7	0.9	0.5	0.6	-0.1	0.3	0.1

Appendix A. Groundwater Exploration Permit

Manitoba
Conservation and Climate

Drainage and Water Rights Licensing Branch
Box 16, 200 Saulteaux Crescent,
Winnipeg, Manitoba, Canada R3J 3W3
T 204-945-3983 **F** 204-948-2357 **E:** *wateruse@gov.mb.ca*
www.manitoba.ca

November 5, 2020

File: HD Minerals Ltd. (-13)

Laura Weeden, P.Eng.
Vice President, Operations
HD Minerals Ltd./CanWhite Sands Corp.
Suite 2650, 645 - 7th Ave. SW
Calgary, AB T2P 4G8

Dear Ms. Weeden:

Re: Authorization for HD Minerals Ltd. to Divert and Use Groundwater for Testing and Analysis as Part of the Company's Hydrogeological Study in Connection with the Plan Submission of the Environmental Act Proposal for Sand Extraction Project to the Environmental Approvals Branch of Manitoba and to the RM of Springfield for Review.

This letter is in response to an application registered on October 29, 2020 for authorization to HD Minerals Ltd. to divert and use groundwater for testing and analysis as described above.

As Acting Head of Groundwater Licensing, Drainage and Water Rights Licensing Branch, I have the delegated authority on behalf of the Minister of Conservation and Climate, for administration of *The Water Rights Act*, which includes the issuance of authorizations, permits, and licences. Therefore, HD Minerals Ltd. may consider this letter to be authorization under *The Water Rights Act* to withdraw and divert groundwater from six (6) new wells to be drilled in SE 32-10-8 EPM, SW 32-10-8 EPM, and SW 33-10-8 EPM, in the RM Springfield, Manitoba, subject to the following conditions:

1. This authorization is issued upon the express condition that it shall be subject to the provisions of *The Water Rights Act* and Regulations and all amendments thereto.

2. The total amount of water that may be pumped from the well for testing and analysis is not to exceed 16,500 cubic metres (16,500,000 litres).

3. The rate at which water may be diverted shall not exceed 500 gallons per minute.

4. This authorization shall expire on April 30, 2021.

5. HD Minerals Ltd., shall prior to the diversion of water, acquire the necessary approvals from other relevant municipal, provincial, and federal agencies.

6. HD Minerals Ltd. shall comply with all regulations concerning cleaning, fueling, and servicing of equipment used in the procedure.

7. HD Minerals Ltd. shall assume any liability that may ensue as a result of diversion of water as authorized by this letter.

8. The Minister or Minister's agents may, under certain conditions, instruct HD Minerals Ltd. to reduce or terminate withdrawal of water from the aquifer to accommodate existing senior licensed water users, domestic users, and environmental needs, if applicable.

9. HD Minerals Ltd. is responsible to correct any water supply problems or provide temporary water supply to anyone whose well(s) are negatively impacted as a result of pumping.

Please contact Ronaldo Miranda at (204) 945-6475 if you have any questions concerning this Temporary Authorization.

Yours truly,

[redacted]

Kylene Wiseman, P.Geo.
A/Head of Groundwater Licensing
Drainage and Water Rights Licensing Branch

cc: Colleen Draper, CAO, RM of Springfield
Sirena Ketchen, Mines Branch
Ronaldo Miranda, (CC)

Appendix B. Borehole Logs

PROJECT: Vivian Sand Facility Project	CLIENT: CanWhite Sands Corp.	TESTHOLE NO: **Bru 95-6**
LOCATION: Vivian, MB N 5,527,624.0 E 682,199.0		PROJECT NO.: 60640258
CONTRACTOR: Friesen Drillers Ltd.	METHOD: Mud Rotary	ELEVATION (m): 275.041

SAMPLE TYPE: GRAB | SHELBY TUBE | SPLIT SPOON | BULK | NO RECOVERY | CORE

BACKFILL TYPE: BENTONITE | GRAVEL | SLOUGH | GROUT | CUTTINGS | SAND

DEPTH (m)	SOIL SYMBOL	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE #	VAPOUR READINGS	COMMENTS	ELEVATION (m)
0		SAND, fine grained with minor (15%) medium sand -White -Loose -Non-cohesive, non-plastic					
1							274
2							273
3							272
4							271
5							270
6							269
7		SILTY CLAY with fine sand (20%), trace gravel and cobbles (5%) -Brown -Medium dense -Cohesive, medium to high plasticity					268
8							267
9							266
10							

AECOM

LOGGED BY: Stephen Dickin	COMPLETION DEPTH: 57.00 m
REVIEWED BY: Reuben Dandurand	COMPLETION DATE: 11/13/20
PROJECT ENGINEER: Ryan Mills	Page 1 of 7

PROJECT: Vivian Sand Facility Project	CLIENT: CanWhite Sands Corp.	TESTHOLE NO: **Bru 95-6**
LOCATION: Vivian, MB N 5,527,624.0 E 682,199.0		PROJECT NO.: 60640258
CONTRACTOR: Friesen Drillers Ltd.	METHOD: Mud Rotary	ELEVATION (m): 275.041

SAMPLE TYPE: GRAB | SHELBY TUBE | SPLIT SPOON | BULK | NO RECOVERY | CORE

BACKFILL TYPE: BENTONITE | GRAVEL | SLOUGH | GROUT | CUTTINGS | SAND

DEPTH (m)	SOIL SYMBOL	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE #	VAPOUR READINGS	COMMENTS	ELEVATION (m)
10							
11							264
12							263
13							262
14							261
15							260
		SILTY MEDIUM TO COARSE SAND, -Brown -Medium dense -Cohesive, low plasticity					
16							259
17							258
18							257
		SILTY CLAY with sand (20%) and trace gravel/cobbles (5%) -Brown -Dense -Cohesive, medium to high plasticity					
19							256
20							

AECOM

LOGGED BY: Stephen Dickin	COMPLETION DEPTH: 57.00 m
REVIEWED BY: Reuben Dandurand	COMPLETION DATE: 11/13/20
PROJECT ENGINEER: Ryan Mills	Page 2 of 7

PROJECT: Vivian Sand Facility Project	CLIENT: CanWhite Sands Corp.	TESTHOLE NO: **Bru 95-6**
LOCATION: Vivian, MB N 5,527,624.0 E 682,199.0		PROJECT NO.: 60640258
CONTRACTOR: Friesen Drillers Ltd.	METHOD: Mud Rotary	ELEVATION (m): 275.041

SAMPLE TYPE: GRAB | SHELBY TUBE | SPLIT SPOON | BULK | NO RECOVERY | CORE

BACKFILL TYPE: BENTONITE | GRAVEL | SLOUGH | GROUT | CUTTINGS | SAND

DEPTH (m)	SOIL SYMBOL	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE #	VAPOUR READINGS	COMMENTS	ELEVATION (m)
20							
21							254
22							253
23							252
24							251
		COARSE SAND AND GRAVEL -Brown -Loose -Non-cohesive, non-plastic					
25							250
26							249
27							248
28							247
29							246
30							

AECOM

LOGGED BY: Stephen Dickin	COMPLETION DEPTH: 57.00 m
REVIEWED BY: Reuben Dandurand	COMPLETION DATE: 11/13/20
PROJECT ENGINEER: Ryan Mills	Page 3 of 7

PROJECT: Vivian Sand Facility Project	CLIENT: CanWhite Sands Corp.	TESTHOLE NO: **Bru 95-6**
LOCATION: Vivian, MB N 5,527,624.0 E 682,199.0		PROJECT NO.: 60640258
CONTRACTOR: Friesen Drillers Ltd.	METHOD: Mud Rotary	ELEVATION (m): 275.041

SAMPLE TYPE: GRAB | SHELBY TUBE | SPLIT SPOON | BULK | NO RECOVERY | CORE

BACKFILL TYPE: BENTONITE | GRAVEL | SLOUGH | GROUT | CUTTINGS | SAND

DEPTH (m)	SOIL SYMBOL	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE #	VAPOUR READINGS	COMMENTS	ELEVATION (m)
30							
31							244
32							243
33							242
34							241
35							240
36							239
37		LIMESTONE -Beige -Minor weathering -Competent rock					238
38							237
39							236
40							

AECOM

LOGGED BY: Stephen Dickin	COMPLETION DEPTH: 57.00 m
REVIEWED BY: Reuben Dandurand	COMPLETION DATE: 11/13/20
PROJECT ENGINEER: Ryan Mills	Page 4 of 7

PROJECT: Vivian Sand Facility Project	CLIENT: CanWhite Sands Corp.	TESTHOLE NO: **Bru 95-6**
LOCATION: Vivian, MB N 5,527,624.0 E 682,199.0		PROJECT NO.: 60640258
CONTRACTOR: Friesen Drillers Ltd.	METHOD: Mud Rotary	ELEVATION (m): 275.041

SAMPLE TYPE: GRAB | SHELBY TUBE | SPLIT SPOON | BULK | NO RECOVERY | CORE

BACKFILL TYPE: BENTONITE | GRAVEL | SLOUGH | GROUT | CUTTINGS | SAND

DEPTH (m)	SOIL SYMBOL	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE #	VAPOUR READINGS	COMMENTS	ELEVATION (m)
40							
41							234
42							233
43							232
44							231
45							230
46							229
47		SHALE -Reddish brown -Highly weathered, can be shaped/peeled with a knife -Cuttings are cohesive and exhibit high plasticity					228
48		-Becomes greenish brown					227
49		SANDSTONE -White -Fine grained -Well sorted -Weakly cemented, low strength					226
50							

AECOM

LOGGED BY: Stephen Dickin	COMPLETION DEPTH: 57.00 m
REVIEWED BY: Reuben Dandurand	COMPLETION DATE: 11/13/20
PROJECT ENGINEER: Ryan Mills	Page 5 of 7

PROJECT: Vivian Sand Facility Project	CLIENT: CanWhite Sands Corp.	TESTHOLE NO: **Bru 95-6**
LOCATION: Vivian, MB N 5,527,624.0 E 682,199.0		PROJECT NO.: 60640258
CONTRACTOR: Friesen Drillers Ltd.	METHOD: Mud Rotary	ELEVATION (m): 275.041

SAMPLE TYPE: GRAB | SHELBY TUBE | SPLIT SPOON | BULK | NO RECOVERY | CORE

BACKFILL TYPE: BENTONITE | GRAVEL | SLOUGH | GROUT | CUTTINGS | SAND

DEPTH (m)	SOIL SYMBOL	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE #	VAPOUR READINGS	COMMENTS	ELEVATION (m)
50							
51							224
52							223
53							222
54							221
55							220
56							219
57		-Hole not daylighted and no utility locates completed -UTM coordinate and elevation data surveyed by David Atkinson (AECOM) -Bru 95-6 Water Well Tag Number: 4506 -0.13m (5") diameter surface casing was installed from surface to 0 91m below the top of the limestone contact. The annulus between the surface casing and the borehole wall was sealed with bentonite-cement grout. -Drilling through overburden was conducted using a 7 7/8th inch outer diameter tricone drill bit. A 6 1/4 inch (OD) tricone bit was using to advance the hole 0.91m into the limestone unit to create a "socket" for the bottom of the 5" PVC casing to rest in. The remainder of the hole was drilled using a 4 3/4 inch (OD) PDC cutting drag bit. -Grab samples of cuttings were collected for logging purposes only.					218
58							217
59		Monitoring well completion details: Well Stick-up: 0.802 m AGS 2" Diameter PVC well pipe, Schedule 40, 10-slot screen Bentonite-cement grout: 0 - 50 29 m BGS Sand: 50.29 - 57.00 m BGS Screen: 52.45 - 55.50 m BGS End of Bore: 57.00 m BGS					216
60							

AECOM

LOGGED BY: Stephen Dickin	COMPLETION DEPTH: 57.00 m
REVIEWED BY: Reuben Dandurand	COMPLETION DATE: 11/13/20
PROJECT ENGINEER: Ryan Mills	Page 6 of 7

PROJECT: Vivian Sand Facility Project	CLIENT: CanWhite Sands Corp.	TESTHOLE NO: **Bru 95-6**
LOCATION: Vivian, MB N 5,527,624.0 E 682,199.0		PROJECT NO.: 60640258
CONTRACTOR: Friesen Drillers Ltd.	METHOD: Mud Rotary	ELEVATION (m): 275.041

SAMPLE TYPE: GRAB | SHELBY TUBE | SPLIT SPOON | BULK | NO RECOVERY | CORE

BACKFILL TYPE: BENTONITE | GRAVEL | SLOUGH | GROUT | CUTTINGS | SAND

DEPTH (m)	SOIL SYMBOL	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE #	VAPOUR READINGS	COMMENTS	ELEVATION (m)
60		Depth to water: 8.42 m BGS on Nov 15, 2020 2:20 PM Top of Pipe Elevation: 275.843 m ASL					
61							214
62							213
63							212
64							211
65							210
66							209
67							208
68							207
69							206
70							

AECOM

LOGGED BY: Stephen Dickin	COMPLETION DEPTH: 57.00 m
REVIEWED BY: Reuben Dandurand	COMPLETION DATE: 11/13/20
PROJECT ENGINEER: Ryan Mills	Page 7 of 7

PROJECT: Vivian Sand Facility Project	CLIENT: CanWhite Sands Corp.	TESTHOLE NO: **Bru 95-7**
LOCATION: Vivian, MB N 5,527,612.0 E 681,865.0		PROJECT NO.: 60640258
CONTRACTOR: Friesen Drillers Ltd.	METHOD: Dual Rotary	ELEVATION (m): 277.12

SAMPLE TYPE: GRAB | SHELBY TUBE | SPLIT SPOON | BULK | NO RECOVERY | CORE

BACKFILL TYPE: BENTONITE | GRAVEL | SLOUGH | GROUT | CUTTINGS | SAND

DEPTH (m)	SOIL SYMBOL	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE #	VAPOUR READINGS	COMMENTS	ELEVATION (m)
0		SAND & GRAVEL -Brown -Non-cohesive, non-plastic					277
1							276
2							275
3							274
4							273
5							272
6							271
7		SILTY SAND -Grey					270
8							269
9		CLAY -Grey					268
10							

AECOM

LOGGED BY: Reuben Dandurand	COMPLETION DEPTH: 74.98 m
REVIEWED BY: Reuben Dandurand	COMPLETION DATE: 11/23/20
PROJECT ENGINEER: Ryan Mills	Page 1 of 8

PROJECT: Vivian Sand Facility Project	CLIENT: CanWhite Sands Corp.	TESTHOLE NO: **Bru 95-7**
LOCATION: Vivian, MB N 5,527,612.0 E 681,865.0		PROJECT NO.: 60640258
CONTRACTOR: Friesen Drillers Ltd.	METHOD: Dual Rotary	ELEVATION (m): 277.12

SAMPLE TYPE: GRAB | SHELBY TUBE | SPLIT SPOON | BULK | NO RECOVERY | CORE

BACKFILL TYPE: BENTONITE | GRAVEL | SLOUGH | GROUT | CUTTINGS | SAND

DEPTH (m)	SOIL SYMBOL	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE #	VAPOUR READINGS	COMMENTS	ELEVATION (m)
10							267
11							266
12							265
13							264
14							263
15							262
		SILTY SAND with gravel -Grey					
16							261
17							260
18							259
19							258
20							

AECOM

LOGGED BY: Reuben Dandurand	COMPLETION DEPTH: 74.98 m
REVIEWED BY: Reuben Dandurand	COMPLETION DATE: 11/23/20
PROJECT ENGINEER: Ryan Mills	Page 2 of 8

PROJECT: Vivian Sand Facility Project	CLIENT: CanWhite Sands Corp.	TESTHOLE NO: **Bru 95-7**
LOCATION: Vivian, MB N 5,527,612.0 E 681,865.0		PROJECT NO.: 60640258
CONTRACTOR: Friesen Drillers Ltd.	METHOD: Dual Rotary	ELEVATION (m): 277.12

SAMPLE TYPE: GRAB | SHELBY TUBE | SPLIT SPOON | BULK | NO RECOVERY | CORE

BACKFILL TYPE: BENTONITE | GRAVEL | SLOUGH | GROUT | CUTTINGS | SAND

DEPTH (m)	SOIL SYMBOL	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE #	VAPOUR READINGS	COMMENTS	ELEVATION (m)
20							257
21							256
22							255
23		SILTY SAND with gravel and boulders -Grey					254
24							253
25							252
26							251
27							250
28							249
29							248
30							

AECOM

LOGGED BY: Reuben Dandurand	COMPLETION DEPTH: 74.98 m
REVIEWED BY: Reuben Dandurand	COMPLETION DATE: 11/23/20
PROJECT ENGINEER: Ryan Mills	Page 3 of 8

PROJECT: Vivian Sand Facility Project	CLIENT: CanWhite Sands Corp.	TESTHOLE NO: **Bru 95-7**
LOCATION: Vivian, MB N 5,527,612.0 E 681,865.0		PROJECT NO.: 60640258
CONTRACTOR: Friesen Drillers Ltd.	METHOD: Dual Rotary	ELEVATION (m): 277.12

SAMPLE TYPE: GRAB | SHELBY TUBE | SPLIT SPOON | BULK | NO RECOVERY | CORE

BACKFILL TYPE: BENTONITE | GRAVEL | SLOUGH | GROUT | CUTTINGS | SAND

DEPTH (m)	SOIL SYMBOL	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE #	VAPOUR READINGS	COMMENTS	ELEVATION (m)
30							247
31							246
32							245
33							244
34							243
35							242
36		LIMESTONE -Beige -Minor weathering -Competent rock					241
37							240
38							239
39							238
40							

AECOM

LOGGED BY: Reuben Dandurand	COMPLETION DEPTH: 74.98 m
REVIEWED BY: Reuben Dandurand	COMPLETION DATE: 11/23/20
PROJECT ENGINEER: Ryan Mills	Page 4 of 8

PROJECT: Vivian Sand Facility Project	CLIENT: CanWhite Sands Corp.	TESTHOLE NO: **Bru 95-7**
LOCATION: Vivian, MB N 5,527,612.0 E 681,865.0		PROJECT NO.: 60640258
CONTRACTOR: Friesen Drillers Ltd.	METHOD: Dual Rotary	ELEVATION (m): 277.12

SAMPLE TYPE: GRAB | SHELBY TUBE | SPLIT SPOON | BULK | NO RECOVERY | CORE

BACKFILL TYPE: BENTONITE | GRAVEL | SLOUGH | GROUT | CUTTINGS | SAND

DEPTH (m)	SOIL SYMBOL	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE #	VAPOUR READINGS	COMMENTS	ELEVATION (m)
40							237
41							236
42							235
43							234
44							233
45							232
46							231
47							230
48							229
49		SHALE -Reddish brown -Highly weathered, can be shaped/peeled with a knife -Cuttings are cohesive and exhibit high plasticity					228
50							

AECOM

LOGGED BY: Reuben Dandurand	COMPLETION DEPTH: 74.98 m
REVIEWED BY: Reuben Dandurand	COMPLETION DATE: 11/23/20
PROJECT ENGINEER: Ryan Mills	Page 5 of 8

PROJECT: Vivian Sand Facility Project	CLIENT: CanWhite Sands Corp.	TESTHOLE NO: **Bru 95-7**
LOCATION: Vivian, MB N 5,527,612.0 E 681,865.0		PROJECT NO.: 60640258
CONTRACTOR: Friesen Drillers Ltd.	METHOD: Dual Rotary	ELEVATION (m): 277.12

SAMPLE TYPE: GRAB | SHELBY TUBE | SPLIT SPOON | BULK | NO RECOVERY | CORE

BACKFILL TYPE: BENTONITE | GRAVEL | SLOUGH | GROUT | CUTTINGS | SAND

DEPTH (m)	SOIL SYMBOL	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE #	VAPOUR READINGS	COMMENTS	ELEVATION (m)
50							227
51							226
52		SANDSTONE -White -Fine grained -Well sorted -Weakly cemented, low strength					225
53							224
54							223
55							222
56							221
57							220
58							219
59							218
60							

AECOM

LOGGED BY: Reuben Dandurand	COMPLETION DEPTH: 74.98 m
REVIEWED BY: Reuben Dandurand	COMPLETION DATE: 11/23/20
PROJECT ENGINEER: Ryan Mills	Page 6 of 8

PROJECT: Vivian Sand Facility Project	CLIENT: CanWhite Sands Corp.	TESTHOLE NO: **Bru 95-7**
LOCATION: Vivian, MB N 5,527,612.0 E 681,865.0		PROJECT NO.: 60640258
CONTRACTOR: Friesen Drillers Ltd.	METHOD: Dual Rotary	ELEVATION (m): 277.12

SAMPLE TYPE: GRAB | SHELBY TUBE | SPLIT SPOON | BULK | NO RECOVERY | CORE

BACKFILL TYPE: BENTONITE | GRAVEL | SLOUGH | GROUT | CUTTINGS | SAND

DEPTH (m)	SOIL SYMBOL	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE #	VAPOUR READINGS	COMMENTS	ELEVATION (m)
60							217
61							216
62							215
63							214
64							213
65							212
66							211
67							210
68							209
69							208
70							

AECOM

LOGGED BY: Reuben Dandurand	COMPLETION DEPTH: 74.98 m
REVIEWED BY: Reuben Dandurand	COMPLETION DATE: 11/23/20
PROJECT ENGINEER: Ryan Mills	Page 7 of 8

PROJECT: Vivian Sand Facility Project	CLIENT: CanWhite Sands Corp.	TESTHOLE NO: **Bru 95-7**
LOCATION: Vivian, MB N 5,527,612.0 E 681,865.0		PROJECT NO.: 60640258
CONTRACTOR: Friesen Drillers Ltd.	METHOD: Dual Rotary	ELEVATION (m): 277.12

SAMPLE TYPE: GRAB | SHELBY TUBE | SPLIT SPOON | BULK | NO RECOVERY | CORE

BACKFILL TYPE: BENTONITE | GRAVEL | SLOUGH | GROUT | CUTTINGS | SAND

DEPTH (m)	SOIL SYMBOL	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE #	VAPOUR READINGS	COMMENTS	ELEVATION (m)
70							207
71							206
72							205
		- The presence of several thin shale interbeds were noted between 72.24 m and 74.68. the thickness of the shale interbeds increased with depth					
73							204
74							203
		SHALE					
75		-Hole not daylighted and no utility locates completed -UTM coordinate and elevation data surveyed by David Atkinson (AECOM) -Bru 95-7 Water Well Tag Number: 4560 - A surface seal was completed to a depth of 7.62 m (25ft) BGS using 0.51 m (20") diameter tricone drill bit and bentonite-cement grout. -Casing diameter (i.e. borehole diameter): 0.41 m (16") -Grab samples of cuttings were collected for logging purposes only. -Well development was completed using airlift and cable tool methods					202
76							201
77		Water supply well completion details: Well Stick-up: 0.807 m AGS 0.305 m (12") Diameter steel well pipe 0.305 m (12") Diameter stainless Steel Wirewound Screen, 15 slot Bentonite-cement grout: 0 - 52.43 m BGS Silica sand (0.55): 52.43 - 74.98 m BGS Screen: 53 95 - 72.24 m BGS End of Bore: 74.98 m BGS					200
78		Depth to water: 10.958 m BGS on Nov 25, 2020 12:55 PM Top of Pipe Elevation: 277.927 m ASL					199
79							198
80							

AECOM

LOGGED BY: Reuben Dandurand	COMPLETION DEPTH: 74.98 m
REVIEWED BY: Reuben Dandurand	COMPLETION DATE: 11/23/20
PROJECT ENGINEER: Ryan Mills	Page 8 of 8

Project: Vivian Sand Facility Project
Project Location: Vivian, MB
Project Number: 60640258

Log of Bru 95-8

Date(s) Drilled	**Nov 16 to 19, 2020**	Logged By	**Reuben Dandurand**	Checked By	**Stephen Dickin**
Drilling Method	**Rotary**	Drill Bit Size/Type	**See notes at bottom**	Total Depth Drilled (meters)	**55.1**
Drill Rig Type	**Acker MP8**	Drilling Contractor	**Paddock Drilling Ltd.**	Approximate Surface Elevation	**277.3 m**
Groundwater Level		Borehole Backfill	**Bentonite-Cement Grout**	Inclination from Horizontal/Bearing	**Vertical**
Location	**681953 E 5527630 N**			Hammer Data	**N/A**

Elevation, meters	Depth, meters	ROCK CORE: Run No.	Recovery, %	RQD, %	Fractures/Run	Strength Index	Weathering Index	Lithology	MATERIAL DESCRIPTION	Discontinuity Description: Type	Alpha, °	Surface Shape	Surface Roughness	Infill Type	Thickness Rating	Openess Rating	Jr	Ja	Jn	Jcon	REMARKS AND OTHER TESTS
277.3	0								SAND & GRAVEL -Brown -Non-cohesive, non-plastic												
278.3	1																				
279.3	2																				
280.3	3																				
281.3	4																				
282.3	5																				

GEO CORE BURNABY BRE C:\USERS\REUBEN DANDURAND\DOCUMENTS\GINT\60640258 CANWHITE BRU 95-8.GPJ URSSEA3.GLB BRE TINNEL FS.GDT 1/21/21

Project: Vivian Sand Facility Project
Project Location: Vivian, MB
Project Number: 60640258

Log of Bru 95-8

Elevation, meters	Depth, meters	ROCK CORE: Run No.	Recovery, %	RQD, %	Fractures/Run	Strength Index	Weathering Index	Lithology	MATERIAL DESCRIPTION	Discontinuity Description: Type	Alpha, °	Surface Shape	Surface Roughness	Infill Type	Thickness Rating	Openess Rating	Jr	Ja	Jn	Jcon	REMARKS AND OTHER TESTS
282.3	5																				
283.3	6																				
									SILTY SAND -Grey												
284.3	7																				
285.3	8																				
									CLAY -Grey												
286.3	9																				
287.3	10																				
288.3	11																				

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Project: Vivian Sand Facility Project
Project Location: Vivian, MB
Project Number: 60640258

Log of Bru 95-8

Elevation, meters	Depth, meters	ROCK CORE: Run No.	Recovery, %	RQD, %	Fractures/Run	Strength Index	Weathering Index	Lithology	MATERIAL DESCRIPTION	Discontinuity Description: Type	Alpha, °	Surface Shape	Surface Roughness	Infill Type	Thickness Rating	Openess Rating	Jr	Ja	Jn	Jcon	REMARKS AND OTHER TESTS
289.3	12																				
290.3	13																				
291.3	14	R12	0	0		-	-														
		R13	0	0		-	-														
292.3	15																				
									SILTY SAND with gravel -Grey												
293.3	16																				
294.3	17																				

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Project: Vivian Sand Facility Project
Project Location: Vivian, MB
Project Number: 60640258

Log of Bru 95-8

Elevation, meters	Depth, meters	ROCK CORE: Run No.	Recovery, %	RQD, %	Fractures/Run	Strength Index	Weathering Index	Lithology	MATERIAL DESCRIPTION	Discontinuity Description: Type	Alpha, °	Surface Shape	Surface Roughness	Infill Type	Thickness Rating	Openess Rating	Jr	Ja	Jn	Jcon	REMARKS AND OTHER TESTS
295.3	18																				
296.3	19																				
297.3	20																				
298.3	21																				
299.3	22																				
300.3	23								SILTY SAND with gravel and boulders -Grey												

GEO_CORE BURNABY BRE C:\USERS\REUBEN DANDURAND\DOCUMENTS\GINT\60640258 CANWHITE BRU 95-8.GPJ URSSEA3.GLB BRE TINNEL FS.GDT 1/21/21

Project: Vivian Sand Facility Project
Project Location: Vivian, MB
Project Number: 60640258

Log of Bru 95-8

Elevation, meters	Depth, meters	ROCK CORE: Run No.	Recovery, %	RQD, %	Fractures/Run	Strength Index	Weathering Index	Lithology	MATERIAL DESCRIPTION	Discontinuity Description: Type	Alpha, °	Surface Shape	Surface Roughness	Infill Type	Thickness Rating	Openess Rating	Jr	Ja	Jn	Jcon	REMARKS AND OTHER TESTS
301.3	24																				
302.3	25																				
303.3	26																				
304.3	27																				
305.3	28																				
306.3	29																				
307.3	30																				

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Project: Vivian Sand Facility Project
Project Location: Vivian, MB
Project Number: 60640258

Log of Bru 95-8

Elevation, meters	Depth, meters	ROCK CORE: Run No.	Recovery, %	RQD, %	Fractures/Run	Strength Index	Weathering Index	Lithology	MATERIAL DESCRIPTION	Discontinuity Description: Type	Alpha, °	Surface Shape	Surface Roughness	Infill Type	Thickness Rating	Openess Rating	Jr	Ja	Jn	Jcon	REMARKS AND OTHER TESTS
307.3	30																				
308.3	31																				
309.3	32																				
									WEATHERED / INCOMPETENT BEDROCK												
310.3	33																				
311.3	34																				
312.3	35																				
		R1	68	48		R4	W2			JN	65	U	R	Cm St Ox	T2	A2	3	8	3	25	35.94 m BGS
313.3	36				3					JN	50	U	R	-	T0	A1	3	8	3	25	36.19 m BGS

GEO CORE BURNABY BRE C:\USERS\REUBEN DANDURAND\DOCUMENTS\GINT\60640258 CANWHITE BRU 95-8.GPJ URSSEA3.GLB BRE TINNEL FS.GDT 1/21/21

Project: Vivian Sand Facility Project
Project Location: Vivian, MB
Project Number: 60640258

Log of Bru 95-8

Elevation, meters	Depth, meters	ROCK CORE: Run No.	Recovery, %	RQD, %	Fractures/Run	Strength Index	Weathering Index	Lithology	MATERIAL DESCRIPTION	Discontinuity Description: Type	Alpha, °	Surface Shape	Surface Roughness	Infill Type	Thickness Rating	Openess Rating	Jr	Ja	Jn	Jcon	REMARKS AND OTHER TESTS
		R1	68	48		R4	W2		LIMESTONE -Beige -Minor weathering -Competent rock	FRZ	90	U	R	Cm St	T4	A4	3	10	3	0	36.49 m BGS
										JN	90	P	R	Ox	T0	A3	1.5	4	3	10	36.97 m BGS
314.3	37																				
										JN	90	U	R	-	T0	A2	3	0	3	10	37.35 m BGS
										JN	60	U	R	-	T0	A3	3	0	3	10	37.44 m BGS
										JN	90	U	R	-	T0	A2	3	0	3	10	37.55 m BGS
		R2	100	83	6	R4	W2		Small vugs (<2mm)	JN	90	U	R	-	T0	A3	3	0	3	10	37.79 m BGS
315.3	38									JN	90	U	R	-	T0	A2	3	0	3	10	38.15 m BGS
										JN	88	U	R	Cm	T1	A2	3	4	2	10	38.47 m BGS
										JN	90	U	R	Ox	T1	A1	3	1	2	25	38.71 m BGS
					5					JN	90	U	R	Cm Ox	T2	A2	3	4	2	10	38.84 m BGS
									Clay rich beds 5 cm thick	JN	90	U	S	Cm	T1	A2	3	4	2	10	38.93 m BGS
316.3	39	R3	100	94		R4	W2														
										JN	90	U	S	Ox	T1	A2	3	1	2	10	39.8 m BGS
317.3	40									JN	90	U	S	Cm Ox	T1	A2	3	4	2	10	40.16 m BGS
										JN	90	P	S	Cm	T1	A2	1	4	2	10	40.63 m BGS
		R4	100	100	4	R3	W2														
										JN	90	P	S	Ox	T1	A2	1	1	2	10	41.03 m BGS
318.3	41								Bedding is horizontal/planar, fractures align with bedding												
										JN	88	U	VR	Ox	T1	A2	3	0.75	2	10	41.26 m BGS
										JN	90	P	S	-	T0	A1	1	0	2	25	41.55 m BGS
319.3	42	R5	100	93		R4	W2			JN	90	P	P	-	T0	A1	.5	0	2	5	42.01 m BGS
										JN	85	U	R	-	T0	A2	3	0	2	10	42.41 m BGS
										JN	90	P	K	Ox Cm	T2	A2	0.5	4	2	5	42.45 m BGS
																					42.51 m BGS

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Project: Vivian Sand Facility Project
Project Location: Vivian, MB
Project Number: 60640258

Log of Bru 95-8

Elevation, meters	Depth, meters	Run No.	Recovery, %	RQD, %	Fractures/Run	Strength Index	Weathering Index	Lithology	MATERIAL DESCRIPTION	Type	Alpha, °	Surface Shape	Surface Roughness	Infill Type	Thickness Rating	Openess Rating	Jr	Ja	Jn	Jcon	REMARKS AND OTHER TESTS
					5					JN	88	P	S	-	T0	A2	1	0	2	10	
		R5	100	93		R4	W2														
320.3	43																				
										JN	83	P	S	Cm	T1	A2	1	4	2	10	43.18 m BGS
										JN	90	U	R	Ox	T1	A3	3	4	2	10	43.23 m BGS
					6					JN	90	P	P	-	T0	A1	0.5	0	2	5	43.25 m BGS
		R6	100	91		R4	W2			JN	90	P	S	-	T0	A2	1	0	2	10	43.82 m BGS
										JN	90	P	S	Cm Ox	T1	A3	1	4	2	10	43.9 m BGS
321.3	44									JN	90	P	S	Cm Ox	T1	A2	1	4	2	25	44.02 m BGS
										JN	90	U	S	Cm Ox	T5	A5	2	14	2	0	44.8 m BGS
322.3	45																				
		R7	100	90		R3	W2														
										JN	90	P	S	Cm Ox	T1	A1	1	4	2	10	45.54 m BGS
										JN	90	P	K	Cm	T2	A1	0.5	4	2	5	45.65 m BGS
					4					JN	90	P	S	Cm	T2	A1	1	4	2	10	45.8 m BGS
323.3	46																				
										JN	80	P	R	-	T0	A2	1.5	0	2	10	46.39 m BGS
										JN	90	P	P	Cm Ox	T1	A1	0.5	4	2	5	46.72 m BGS
										JN	90	P	S	Cm	T2	A2	1	8	2	10	46.77 m BGS
		R8	100	97	4	R4	W2		Shale Bed 5 cm thick	JN	90	P	S	Cm	T1	A1	1	4	2	10	46.89 m BGS
324.3	47																				
										JN	90	P	S	Cm Ox	T2	A2	1	8	2	10	47.76 m BGS
325.3	48									JN	90	P	P	Cm	T1	A1	0.5	4	2	5	48.13 m BGS
		R9	87	81	3	R3	W2		INTERBEDDED LIMESTONE & SHALE												
									Trace sulphides noted along joint plane												
										JN	90	P	R	Cm Ox	T3	A3	1.5	12	2	5	48.79 m BGS

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Project: Vivian Sand Facility Project
Project Location: Vivian, MB
Project Number: 60640258

Log of Bru 95-8

Elevation, meters	Depth, meters	Run No.	Recovery, %	RQD, %	Fractures/Run	Strength Index	Weathering Index	Lithology	MATERIAL DESCRIPTION	Type	Alpha, °	Surface Shape	Surface Roughness	Infill Type	Thickness Rating	Openess Rating	Jr	Ja	Jn	Jcon	REMARKS AND OTHER TESTS
									SHALE -Reddish brown -Highly weathered, can be shaped/peeled with a knife -Cuttings are cohesive and exhibit high plasticity												
326.3	49	R9	87	81		R3	W2														
										JN	30	P	S	Cm	T1	A1	1	4	3	10	49.57 m BGS
										JN	90	P	R	Cm Ox	T2	A2	1.5	8	3	10	49.64 m BGS
					3																
		R10	100	98		R1	W4														
327.3	50									JN	90	P	K	Cm Ox	T2	A2	0.5	8	3	5	50.04 m BGS
									Sand bed 10 cm thick Blue and very clayey below sand bed												
328.3	51																				
		R11	95	83		R1	W3														
										FR	85	U	S	Ox	T1	A2	2	4	2	10	51.83 m BGS
										FR	90	U	S	Ox	T2	A2	2	8	2	10	51.86 m BGS
										FR	90	U	S	Ox	T1	A2	2	4	2	10	51.88 m BGS
329.3	52				3																
									SANDSTONE -White -Fine grained -Well sorted -Weakly cemented, low strength												
330.3	53								borehole will not stay open without drill mud												
331.3	54																				
332.3	55																				

GEO_CORE BURNABY BRE C:\USERS\REUBEN.DANDURAND\DOCUMENTS\GINT\60640258 CANWHITE BRU 95-8.GPJ URSSEA3.GLB BRE TINNEL FS.GDT 1/21/21

Project: Vivian Sand Facility Project
Project Location: Vivian, MB
Project Number: 60640258

Log of Bru 95-8

Elevation, meters	Depth, meters	ROCK CORE: Run No.	Recovery, %	RQD, %	Fractures/Run	Strength Index	Weathering Index	Lithology	MATERIAL DESCRIPTION	Discontinuity Description: Type	Alpha, °	Surface Shape	Surface Roughness	Infill Type	Thickness Rating	Openess Rating	Jr	Ja	Jn	Jcon	REMARKS AND OTHER TESTS
332.3	55																				
333.3	56																				
334.3	57																				
335.3	58																				
336.3	59																				
337.3	60																				
338.3	61																				

Hole not daylighted and no utility locates completed
UTM coordinate and elevation data surveyed by David
A kinson (AECOM)
-Tricone bit and HWT casing shoe (11.7cm OD) to advance HW casing into limestone, Then HQ bit to bottom of hole (9.58cm OD)
-HW casing was advanced through the overburden and set in a limestone boulder at 34.29m BGS.
-Tripletube HQ drilling occurred through the limestone, shale, and into the top of the sandstone unit. Due to poor recovery in the sandstone unit, HQ drilling ceased and NW casing was used to advance the borehole to the target depth. The NW casing was temporarily left in place during he VWP installation to prevent borehole wall collapse in the sandstone. The NW casing was removed simultaneously with borehole backfilling (grouting). HW casing could not be removed and was left in place.

Completion details:
Instrument Casing Stick-up: 1.116 m AGS (top of steel box)
A five channel datalogger was installed at surface, and is located within he instrument casing box
Four vibra ing wire piezometers were installed at the following depths:
VW1: 40.762 m BGS (limestone)
VW2: 43.759 m BGS (limestone)
VW3: 50.832 m BGS (shale)
VW4: 54.689 m BGS (sandstone)
-The VWs were affixed to 1 inch PVC tremmie pipe, which was lowered to the bottom of the borehole.
-Bentonite-cement grout was injected down the tremmie pipe and was used to backfill the hole from 0 to 55.09 m BGS
End of Bore: 55.09 m BGS

Top of Box Elevation: 278.387 m ASL
Ground elevation: 277.271 m ASL

GEO CORE BURNABY BRE C:\USERS\REUBEN DANDURAND\DOCUMENTS\GINT\60640258 CANWHITE BRU 95-8.GPJ URSSEA3.GLB BRE TINNEL FS.GDT 1/21/21

PROJECT: Vivian Sand Facility Project	CLIENT: CanWhite Sands Corp.	TESTHOLE NO: **Bru 95-9**
LOCATION: Vivian, MB N 5,527,621.0 E 682,203.0		PROJECT NO.: 60640258
CONTRACTOR: Friesen Drillers Ltd.	METHOD: Mud Rotary	ELEVATION (m): 275.191

SAMPLE TYPE: GRAB | SHELBY TUBE | SPLIT SPOON | BULK | NO RECOVERY | CORE

BACKFILL TYPE: BENTONITE | GRAVEL | SLOUGH | GROUT | CUTTINGS | SAND

DEPTH (m)	SOIL SYMBOL	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE #	VAPOUR READINGS	COMMENTS	ELEVATION (m)
0		SAND, fine grained with minor (15%) medium sand -White -Loose -Non-cohesive, non-plastic					275
1							274
2							273
3			■				272
4							271
5							270
6			■				269
7		SILTY CLAY with fine sand (20%), trace gravel and cobbles (5%) -Brown -Medium dense -Cohesive, medium to high plasticity					268
8							267
9			■				266
10							

AECOM

LOGGED BY: Reuben Dandurand	COMPLETION DEPTH: 48.16 m
REVIEWED BY: Stephen Dickin	COMPLETION DATE: 11/23/20
PROJECT ENGINEER: Ryan Mills	Page 1 of 6

PROJECT: Vivian Sand Facility Project	CLIENT: CanWhite Sands Corp.	TESTHOLE NO: **Bru 95-9**
LOCATION: Vivian, MB N 5,527,621.0 E 682,203.0		PROJECT NO.: 60640258
CONTRACTOR: Friesen Drillers Ltd.	METHOD: Mud Rotary	ELEVATION (m): 275.191

SAMPLE TYPE: GRAB | SHELBY TUBE | SPLIT SPOON | BULK | NO RECOVERY | CORE

BACKFILL TYPE: BENTONITE | GRAVEL | SLOUGH | GROUT | CUTTINGS | SAND

DEPTH (m)	SOIL SYMBOL	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE #	VAPOUR READINGS	COMMENTS	ELEVATION (m)
10							265
11							264
12							263
13							262
14							261
15							260
		SILTY MEDIUM TO COARSE SAND, -Brown -Medium dense -Slightly plastic, cohesive					
16							259
17							258
18							257
		SILTY CLAY with sand (20%) and trace gravel/cobbles (5%) -Brown -Dense -Plastic, cohesive					
19							256
20							

AECOM

LOGGED BY: Reuben Dandurand	COMPLETION DEPTH: 48.16 m
REVIEWED BY: Stephen Dickin	COMPLETION DATE: 11/23/20
PROJECT ENGINEER: Ryan Mills	Page 2 of 6

PROJECT: Vivian Sand Facility Project	CLIENT: CanWhite Sands Corp.	TESTHOLE NO: **Bru 95-9**
LOCATION: Vivian, MB N 5,527,621.0 E 682,203.0		PROJECT NO.: 60640258
CONTRACTOR: Friesen Drillers Ltd.	METHOD: Mud Rotary	ELEVATION (m): 275.191

SAMPLE TYPE: GRAB | SHELBY TUBE | SPLIT SPOON | BULK | NO RECOVERY | CORE

BACKFILL TYPE: BENTONITE | GRAVEL | SLOUGH | GROUT | CUTTINGS | SAND

DEPTH (m)	SOIL SYMBOL	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE #	VAPOUR READINGS	COMMENTS	ELEVATION (m)
20							255
21							254
22							253
23							252
24							251
		COARSE SAND AND GRAVEL -Brown -Loose -Non-plastic, non-cohesive					
25							250
26							249
27							248
28							247
29							246
30							

AECOM

LOGGED BY: Reuben Dandurand	COMPLETION DEPTH: 48.16 m
REVIEWED BY: Stephen Dickin	COMPLETION DATE: 11/23/20
PROJECT ENGINEER: Ryan Mills	Page 3 of 6

PROJECT: Vivian Sand Facility Project	CLIENT: CanWhite Sands Corp.	TESTHOLE NO: **Bru 95-9**
LOCATION: Vivian, MB N 5,527,621.0 E 682,203.0		PROJECT NO.: 60640258
CONTRACTOR: Friesen Drillers Ltd.	METHOD: Mud Rotary	ELEVATION (m): 275.191

SAMPLE TYPE: GRAB | SHELBY TUBE | SPLIT SPOON | BULK | NO RECOVERY | CORE

BACKFILL TYPE: BENTONITE | GRAVEL | SLOUGH | GROUT | CUTTINGS | SAND

DEPTH (m)	SOIL SYMBOL	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE #	VAPOUR READINGS	COMMENTS	ELEVATION (m)
30							245
31							244
32							243
33							242
34							241
35		LIMESTONE -Beige -Minor weathering -Competent rock					240
36							239
37							238
38							237
39							236
40							

AECOM

LOGGED BY: Reuben Dandurand
REVIEWED BY: Stephen Dickin
PROJECT ENGINEER: Ryan Mills

COMPLETION DEPTH: 48.16 m
COMPLETION DATE: 11/23/20

ENV RO (VAPOUR/F2/F3) 60640258 CANWHITE MW.GPJ UMA.GDT 2/7/21

PROJECT: Vivian Sand Facility Project	CLIENT: CanWhite Sands Corp.	TESTHOLE NO: **Bru 95-9**
LOCATION: Vivian, MB N 5,527,621.0 E 682,203.0		PROJECT NO.: 60640258
CONTRACTOR: Friesen Drillers Ltd.	METHOD: Mud Rotary	ELEVATION (m): 275.191

SAMPLE TYPE: GRAB | SHELBY TUBE | SPLIT SPOON | BULK | NO RECOVERY | CORE

BACKFILL TYPE: BENTONITE | GRAVEL | SLOUGH | GROUT | CUTTINGS | SAND

DEPTH (m)	SOIL SYMBOL	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE #	VAPOUR READINGS	COMMENTS	ELEVATION (m)
40							235
41							234
42							233
43							232
44							231
45							230
46							229
47		SHALE -Redish brown -Soft -Highly plastic -Wet					228
48							227
49		Hole not daylighted and no utility locates completed -UTM coordinate and elevation data surveyed by David Atkinson (AECOM) -Bru 95-9 Water Well Tag Number: 4544 -Bru 95-9 is located adjacent to deeper well Bru 95-6 -0.13m (5") diameter surface casing was installed from surface to 0 91m below the top of the limestone contact. The annulus between the surface casing and the borehole wall was sealed with bentonite-cement grout. -Drilling through overburden was conducted using a 7 7/8th inch outer diameter tricone drill bit. A 6 1/4 inch (OD) tricone bit was used to advance the hole 0.91m into the limestone unit to create a "socket" for the bottom of the 0.13m (5") PVC casing to rest in. The remainder of the hole was drilled using a 4 3/4 inch (OD) PDC cutting drag bit.					226
50							

AECOM

LOGGED BY: Reuben Dandurand	COMPLETION DEPTH: 48.16 m
REVIEWED BY: Stephen Dickin	COMPLETION DATE: 11/23/20
PROJECT ENGINEER: Ryan Mills	Page 5 of 6

PROJECT: Vivian Sand Facility Project	CLIENT: CanWhite Sands Corp.	TESTHOLE NO: **Bru 95-9**
LOCATION: Vivian, MB N 5,527,621.0 E 682,203.0		PROJECT NO.: 60640258
CONTRACTOR: Friesen Drillers Ltd.	METHOD: Mud Rotary	ELEVATION (m): 275.191

SAMPLE TYPE: GRAB | SHELBY TUBE | SPLIT SPOON | BULK | NO RECOVERY | CORE

BACKFILL TYPE: BENTONITE | GRAVEL | SLOUGH | GROUT | CUTTINGS | SAND

DEPTH (m)	SOIL SYMBOL	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE #	VAPOUR READINGS	COMMENTS	ELEVATION (m)
50		-Grab samples of cuttings were collected for logging purposes only.					225
		Monitoring well completion details: Well Stick-up: 0.653 m AGS 2" Diameter PVC well pipe, Schedule 40, 10 slot Bentonite-cement grout: 0 - 47.24 m BGS Sand: 47.24 - 48.16 m BGS Screen: 47.85 - 48.16 m BGS End of Bore: 48.16 m BGS Depth to water: 11.478 m BGS on Nov 25, 2020 10:37 AM Top of Pipe Elevation: 275.844 m ASL					
51							224
52							223
53							222
54							221
55							220
56							219
57							218
58							217
59							216
60							

AECOM

LOGGED BY: Reuben Dandurand	COMPLETION DEPTH: 48.16 m
REVIEWED BY: Stephen Dickin	COMPLETION DATE: 11/23/20
PROJECT ENGINEER: Ryan Mills	Page 6 of 6

PROJECT: Vivian Sand Facility Project	CLIENT: CanWhite Sands Corp.	TESTHOLE NO: **Bru 96-1**
LOCATION: Vivian, MB N 5,527,787.0 E 683,064.0		PROJECT NO.: 60640258
CONTRACTOR: Friesen Drillers Ltd.	METHOD: Mud Rotary	ELEVATION (m): 273.215

SAMPLE TYPE: GRAB | SHELBY TUBE | SPLIT SPOON | BULK | NO RECOVERY | CORE

BACKFILL TYPE: BENTONITE | GRAVEL | SLOUGH | GROUT | CUTTINGS | SAND

DEPTH (m)	SOIL SYMBOL	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE #	VAPOUR READINGS	COMMENTS	ELEVATION (m)
0		SAND, fine grained with minor (15%) medium sand -White -Loose -Non-cohesive, non-plastic					273
1							272
2							
		SILTY COARSE SAND with some gravel (20%) and trace clay (5%) -Grey -Medium dense -Cohesive, low plasticity					271
3							
		SILTY MEDIUM TO COARSE SAND, with trace gravel (10%) -Brown -Medium dense -Non-cohesive, non-plastic					270
4							269
5							268
6							267
7							266
8							265
9							
		SILTY SAND with trace clay (8%) gravel and cobbles (5%) -Grey -Dense -Cohesive, low plasticity					264
10							

AECOM

LOGGED BY: Stephen Dickin | COMPLETION DEPTH: 53.34 m

REVIEWED BY: Reuben Dandurand | COMPLETION DATE: 11/10/20

PROJECT ENGINEER: Ryan Mills

ENV RO (VAPOUR/F2/F3) 60640258 CANWHITE MW.GPJ UMA.GDT 2/7/21

PROJECT: Vivian Sand Facility Project	CLIENT: CanWhite Sands Corp.	TESTHOLE NO: **Bru 96-1**
LOCATION: Vivian, MB N 5,527,787.0 E 683,064.0		PROJECT NO.: 60640258
CONTRACTOR: Friesen Drillers Ltd.	METHOD: Mud Rotary	ELEVATION (m): 273.215

SAMPLE TYPE: GRAB | SHELBY TUBE | SPLIT SPOON | BULK | NO RECOVERY | CORE

BACKFILL TYPE: BENTONITE | GRAVEL | SLOUGH | GROUT | CUTTINGS | SAND

DEPTH (m)	SOIL SYMBOL	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE #	VAPOUR READINGS	COMMENTS	ELEVATION (m)
10							263
11							262
12			■				261
13							260
14							259
15			■				258
16							257
17							256
18			■				255
19							254
20							

AECOM

LOGGED BY: Stephen Dickin	COMPLETION DEPTH: 53.34 m
REVIEWED BY: Reuben Dandurand	COMPLETION DATE: 11/10/20
PROJECT ENGINEER: Ryan Mills	Page 2 of 6

PROJECT: Vivian Sand Facility Project	CLIENT: CanWhite Sands Corp.	TESTHOLE NO: **Bru 96-1**
LOCATION: Vivian, MB N 5,527,787.0 E 683,064.0		PROJECT NO.: 60640258
CONTRACTOR: Friesen Drillers Ltd.	METHOD: Mud Rotary	ELEVATION (m): 273.215

SAMPLE TYPE: GRAB | SHELBY TUBE | SPLIT SPOON | BULK | NO RECOVERY | CORE

BACKFILL TYPE: BENTONITE | GRAVEL | SLOUGH | GROUT | CUTTINGS | SAND

DEPTH (m)	SOIL SYMBOL	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE #	VAPOUR READINGS	COMMENTS	ELEVATION (m)
20							253
21							252
		COARSE SAND AND GRAVEL -Brown -Loose -Non-cohesive, non-plastic					
22							251
23							250
24							249
25							248
26							247
27							246
28							245
29							244
30							

AECOM

LOGGED BY: Stephen Dickin	COMPLETION DEPTH: 53.34 m
REVIEWED BY: Reuben Dandurand	COMPLETION DATE: 11/10/20
PROJECT ENGINEER: Ryan Mills	Page 3 of 6

PROJECT: Vivian Sand Facility Project	CLIENT: CanWhite Sands Corp.	TESTHOLE NO: **Bru 96-1**
LOCATION: Vivian, MB N 5,527,787.0 E 683,064.0		PROJECT NO.: 60640258
CONTRACTOR: Friesen Drillers Ltd.	METHOD: Mud Rotary	ELEVATION (m): 273.215

SAMPLE TYPE: GRAB, SHELBY TUBE, SPLIT SPOON, BULK, NO RECOVERY, CORE

BACKFILL TYPE: BENTONITE, GRAVEL, SLOUGH, GROUT, CUTTINGS, SAND

DEPTH (m)	SOIL SYMBOL	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE #	VAPOUR READINGS	COMMENTS	ELEVATION (m)
30							243
31							242
32							241
33							240
34							239
35		LIMESTONE -Beige with purple laminations -Minor weathering -Competent rock					238
36							237
37							236
38							235
39							234
40							

AECOM

LOGGED BY: Stephen Dickin	COMPLETION DEPTH: 53.34 m
REVIEWED BY: Reuben Dandurand	COMPLETION DATE: 11/10/20
PROJECT ENGINEER: Ryan Mills	Page 4 of 6

PROJECT: Vivian Sand Facility Project	CLIENT: CanWhite Sands Corp.	TESTHOLE NO: **Bru 96-1**
LOCATION: Vivian, MB N 5,527,787.0 E 683,064.0		PROJECT NO.: 60640258
CONTRACTOR: Friesen Drillers Ltd.	METHOD: Mud Rotary	ELEVATION (m): 273.215

SAMPLE TYPE: GRAB | SHELBY TUBE | SPLIT SPOON | BULK | NO RECOVERY | CORE

BACKFILL TYPE: BENTONITE | GRAVEL | SLOUGH | GROUT | CUTTINGS | SAND

DEPTH (m)	SOIL SYMBOL	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE #	VAPOUR READINGS	COMMENTS	ELEVATION (m)
40							233
41							232
42							231
43							230
		SHALE -Reddish brown -Highly weathered, can be shaped/peeled with a knife -Cuttings are cohesive and exhibit high plasticity					
44							229
45							228
46		SANDSTONE -White -Fine grained -Well sorted -Weakly cemented, low strength					227
47							226
48							225
49							224
50							

AECOM

LOGGED BY: Stephen Dickin	COMPLETION DEPTH: 53.34 m
REVIEWED BY: Reuben Dandurand	COMPLETION DATE: 11/10/20
PROJECT ENGINEER: Ryan Mills	Page 5 of 6

PROJECT: Vivian Sand Facility Project	CLIENT: CanWhite Sands Corp.	TESTHOLE NO: **Bru 96-1**
LOCATION: Vivian, MB N 5,527,787.0 E 683,064.0		PROJECT NO.: 60640258
CONTRACTOR: Friesen Drillers Ltd.	METHOD: Mud Rotary	ELEVATION (m): 273.215

SAMPLE TYPE: GRAB | SHELBY TUBE | SPLIT SPOON | BULK | NO RECOVERY | CORE

BACKFILL TYPE: BENTONITE | GRAVEL | SLOUGH | GROUT | CUTTINGS | SAND

DEPTH (m)	SOIL SYMBOL	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE #	VAPOUR READINGS	COMMENTS	ELEVATION (m)
50							223
51							222
52							221
53							220
54		Hole not daylighted and no utility locates completed -UTM coordinate and elevation data surveyed by David Atkinson (AECOM) -Bru 96-1 Water Well Tag Number: 4558 -0.13m (5") diameter surface casing was installed from surface to 0 91m below the top of the limestone contact. The annulus between the surface casing and the borehole wall was sealed with bentonite-cement grout. -Drilling through overburden was conducted using a 7 7/8th inch outer diameter tricone drill bit. A 6 1/4 inch (OD) tricone bit was using to advance the hole 0.91m into the limestone unit to create a "socket" for the bottom of the 0.13m (5") PVC casing to rest in. The remainder of the hole was drilled using a 4 3/4 inch (OD) PDC cutting drag bit. -Grab samples of cuttings were collected for logging purposes only.					219
55							218
56		Monitoring well completion details: Well Stick-up: 0.584 m AGS 2" Diameter PVC well pipe, Schedule 40, 10-slot screen Bentonite-cement grout: 0 - 45.72 m BGS Sand: 45.72 - 53.34 m BGS Screen: 49 23 - 52.28 m BGS End of Bore: 53.34 m BGS Depth to water: 6.838 m BGS on Nov 10, 2020 3:30 PM Top of Pipe Elevation: 273.799 m ASL					217
57							216
58							215
59							214
60							

AECOM

LOGGED BY: Stephen Dickin	COMPLETION DEPTH: 53.34 m
REVIEWED BY: Reuben Dandurand	COMPLETION DATE: 11/10/20
PROJECT ENGINEER: Ryan Mills	Page 6 of 6

PROJECT: Vivian Sand Facility Project	CLIENT: CanWhite Sands Corp.	TESTHOLE NO: **Bru 96-2**
LOCATION: Vivian, MB N 5,527,791.0 E 683,062.0		PROJECT NO.: 60640258
CONTRACTOR: Friesen Drillers Ltd.	METHOD: Mud Rotary	ELEVATION (m): 273.304

SAMPLE TYPE: GRAB | SHELBY TUBE | SPLIT SPOON | BULK | NO RECOVERY | CORE

BACKFILL TYPE: BENTONITE | GRAVEL | SLOUGH | GROUT | CUTTINGS | SAND

DEPTH (m)	SLOTTED PIEZOMETER	SOIL SYMBOL	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE #	VAPOUR READINGS	COMMENTS	ELEVATION (m)
0			SAND, fine grained with minor (15%) medium sand -White -Loose -Non-cohesive, non-plastic					273
1								272
2			SILTY COARSE SAND with some gravel (20%) and trace clay (5%) -Grey -Medium dense -Cohesive, low plasticity					271
3			SILTY MEDIUM TO COARSE SAND, with trace gravel (10%) -Brown -Medium dense -Non-cohesive, non-plastic					270
4								269
5								268
6								267
7								266
8								265
9			SILTY SAND with trace clay (8%) gravel and cobbles (5%) -Grey -Dense -Cohesive, low plasticity					264
10								

AECOM

LOGGED BY: Stephen Dickin	COMPLETION DEPTH: 41.76 m
REVIEWED BY: Reuben Dandurand	COMPLETION DATE: 11/10/20
PROJECT ENGINEER: Ryan Mills	Page 1 of 5

PROJECT: Vivian Sand Facility Project	CLIENT: CanWhite Sands Corp.	TESTHOLE NO: **Bru 96-2**
LOCATION: Vivian, MB N 5,527,791.0 E 683,062.0		PROJECT NO.: 60640258
CONTRACTOR: Friesen Drillers Ltd.	METHOD: Mud Rotary	ELEVATION (m): 273.304

SAMPLE TYPE: GRAB | SHELBY TUBE | SPLIT SPOON | BULK | NO RECOVERY | CORE

BACKFILL TYPE: BENTONITE | GRAVEL | SLOUGH | GROUT | CUTTINGS | SAND

DEPTH (m)	SLOTTED PIEZOMETER	SOIL SYMBOL	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE #	VAPOUR READINGS	COMMENTS	ELEVATION (m)
10								263
11								262
12								261
13								260
14								259
15								258
16								257
17								256
18								255
19								254
20								

AECOM

LOGGED BY: Stephen Dickin	COMPLETION DEPTH: 41.76 m
REVIEWED BY: Reuben Dandurand	COMPLETION DATE: 11/10/20
PROJECT ENGINEER: Ryan Mills	Page 2 of 5

PROJECT: Vivian Sand Facility Project	CLIENT: CanWhite Sands Corp.	TESTHOLE NO: **Bru 96-2**
LOCATION: Vivian, MB N 5,527,791.0 E 683,062.0		PROJECT NO.: 60640258
CONTRACTOR: Friesen Drillers Ltd.	METHOD: Mud Rotary	ELEVATION (m): 273.304

SAMPLE TYPE: GRAB | SHELBY TUBE | SPLIT SPOON | BULK | NO RECOVERY | CORE

BACKFILL TYPE: BENTONITE | GRAVEL | SLOUGH | GROUT | CUTTINGS | SAND

DEPTH (m)	SLOTTED PIEZOMETER	SOIL SYMBOL	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE #	VAPOUR READINGS	COMMENTS	ELEVATION (m)
20								253
21								252
			COARSE SAND AND GRAVEL -Brown -Loose -Non-cohesive, non-plastic					
22								251
23								250
24								249
25								248
26								247
27								246
28								245
29								244
30								

AECOM

LOGGED BY: Stephen Dickin	COMPLETION DEPTH: 41.76 m
REVIEWED BY: Reuben Dandurand	COMPLETION DATE: 11/10/20
PROJECT ENGINEER: Ryan Mills	Page 3 of 5

PROJECT: Vivian Sand Facility Project	CLIENT: CanWhite Sands Corp.	TESTHOLE NO: **Bru 96-2**
LOCATION: Vivian, MB N 5,527,791.0 E 683,062.0		PROJECT NO.: 60640258
CONTRACTOR: Friesen Drillers Ltd.	METHOD: Mud Rotary	ELEVATION (m): 273.304

SAMPLE TYPE: GRAB | SHELBY TUBE | SPLIT SPOON | BULK | NO RECOVERY | CORE

BACKFILL TYPE: BENTONITE | GRAVEL | SLOUGH | GROUT | CUTTINGS | SAND

DEPTH (m)	SLOTTED PIEZOMETER	SOIL SYMBOL	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE #	VAPOUR READINGS	COMMENTS	ELEVATION (m)
30								243
31								242
32								241
33								240
34								239
35			LIMESTONE -Beige with purple laminations -Minor weathering -Competent rock					238
36								237
37								236
38								235
39								234
40								

AECOM

LOGGED BY: Stephen Dickin	COMPLETION DEPTH: 41.76 m
REVIEWED BY: Reuben Dandurand	COMPLETION DATE: 11/10/20
PROJECT ENGINEER: Ryan Mills	Page 4 of 5

PROJECT: Vivian Sand Facility Project	CLIENT: CanWhite Sands Corp.	TESTHOLE NO: **Bru 96-2**
LOCATION: Vivian, MB N 5,527,791.0 E 683,062.0		PROJECT NO.: 60640258
CONTRACTOR: Friesen Drillers Ltd.	METHOD: Mud Rotary	ELEVATION (m): 273.304

SAMPLE TYPE: GRAB | SHELBY TUBE | SPLIT SPOON | BULK | NO RECOVERY | CORE

BACKFILL TYPE: BENTONITE | GRAVEL | SLOUGH | GROUT | CUTTINGS | SAND

DEPTH (m)	SLOTTED PIEZOMETER	SOIL SYMBOL	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE #	VAPOUR READINGS	COMMENTS	ELEVATION (m)
40								233
41								232
42			Hole not daylighted and no utility locates completed -UTM coordinate and elevation data surveyed by David Atkinson (AECOM) -Bru 96-2 Water Well Tag Number: 4559 -Located in a borehole adjacent to Bru 96-1 -0.13m (5") diameter surface casing was installed from surface to 0 91m below the top of the limestone contact. The annulus between the surface casing and the borehole wall was sealed with bentonite-cement grout. -Drilling through overburden was conducted using a 7 7/8th inch outer diameter tricone drill bit. A 6 1/4 inch (OD) tricone bit was using to advance the hole 0.91m into the limestone unit to create a "socket" for the bottom of the 0.13m (5") PVC casing to rest in. The remainder of the hole was drilled using a 4 3/4 inch (OD) PDC cutting drag bit. - A 0.13m (5") OD 8mm thick rubber shale trap was affixed to the bottom and outside of the 2" PVC well standpipe and was lowered to 35.97m BGS, which was immediately below the bottom of the socket and 0.13m (5") surface casing. -Grab samples of cuttings were collected for logging purposes only. Monitoring well completion details: Well Stick-up: 0.701 m AGS 2" Diameter PVC well pipe, Schedule 40 open at bottom (35 97 m BGS) Screen: No screen. Exposed borehole wall between: 35 97 - 41.76 m BGS Bentonite-cement grout: 0 - 35 97 m BGS End of Bore: 41.76 m BGS Depth to water: 6.919 m BGS on Nov 10, 2020 3:30 PM Top of Pipe Elevation: 274.005 m ASL					231
43								230
44								229
45								228
46								227
47								226
48								225
49								224
50								

AECOM

LOGGED BY: Stephen Dickin	COMPLETION DEPTH: 41.76 m
REVIEWED BY: Reuben Dandurand	COMPLETION DATE: 11/10/20
PROJECT ENGINEER: Ryan Mills	Page 5 of 5

Appendix C. Photographic Logs

Appendix C.1. Bedrock Core Photos

AECOM

Core Photo Log – Bru 95-8

Bru95-8 - Box 1 and 2 of 7 - 30.78 to 38.40 mBGS

AECOM

Core Photo Log – Bru 95-8

Bru95-8 - Box 3 and 4 of 7 - 38.40 to 43.90 mBGS

AECOM

Core Photo Log – Bru 95-8

Bru95-8 - Box 5, 6 and 7 of 7 - 43.90 to 50.60 mBGS

Appendix C.2. Chip Tray Photos

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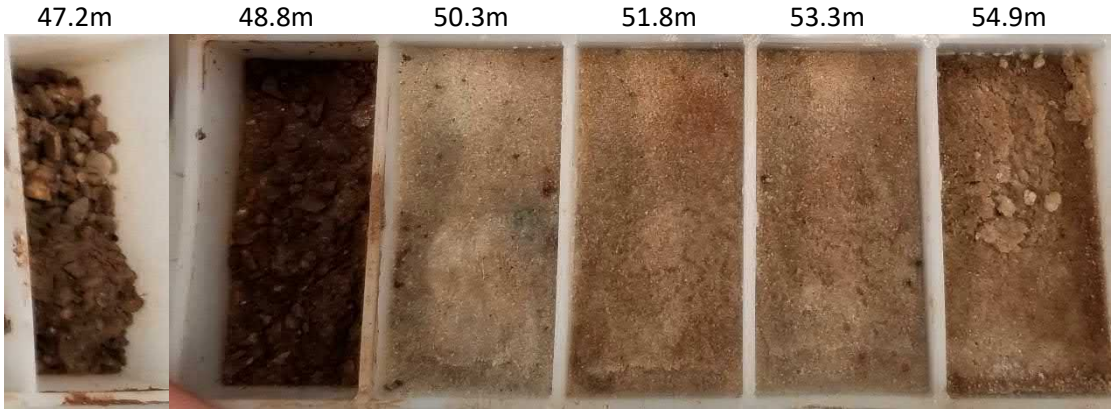
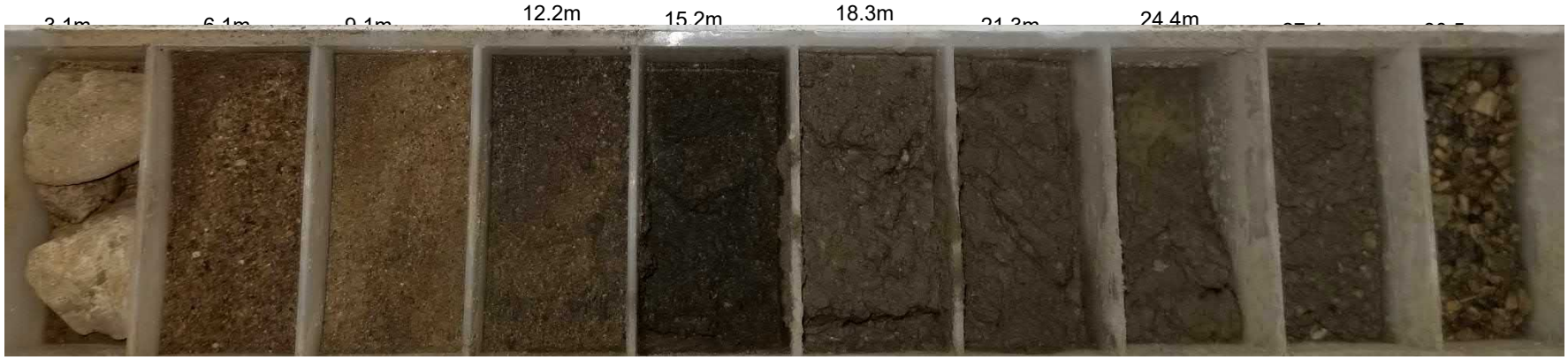
Chip Tray Photo Log

Bru 95-6 (adjacent to Bru 95-5 and Bru 95-9)



AECOM

Chip Tray Photo Log

Bru 95-7 (Water Well)