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**Decommissioning of shallow observation wells in the
McCully gas field area, New Brunswick**

V. Tremblay, X. Malet, C. Rivard, D. Lavoie, and G. Bordeleau

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2019

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CONTENTS

1	Introduction	2
2	Location of the study area and observation wells.....	2
3	Geological and hydrogeological contexts.....	5
4	Well decommissioning	7
4.1	In situ decommissioning steps	7
4.2	Estimates for bentonite and sand	8
4.3	Safety and prevention	8
4.4	Estimated quantities of material	9
5	Conclusion.....	22
	References	23
	Acknowledgements	23
	Appendix A Technical Data Sheets	
	Appendix B Photos taken in the field during the observation well Decommissioning work	

LIST OF TABLES

Table 1 - Characteristics of the shallow observation wells located on Corridor pads.....	4
Table 2 - Estimated quantities (in pounds) for each linear meter	8
Table 3 - Quantities of material used to decommission each well.....	9

LIST OF FIGURES

Figure 1 - Observation well locations	3
Figure 2 - Geological cross-section of the study area (Hinds and Parks, 2017)	5
Figure 3 - Bedrock geological map of the study area	6
Figure 4 - Hole dug around the well.....	7
Figure 5 - Cutting of the casing	7
Figure 6 - Pouring of sand in the well	7
Figure 7 - Mix of sand, bentonite and overburden material	7
Figure 8 - Half mask respirator and gloves used while manipulating sand and bentonite	8
Figure 9 - PO-01 decommissioning log.....	10
Figure 10 - PO-02 decommissioning log.....	11
Figure 11 - PO-03 decommissioning log.....	12
Figure 12 - PO-04 decommissioning log.....	13
Figure 13 - PO-05 decommissioning log.....	14
Figure 14 - PO-06 decommissioning log.....	15
Figure 15 - PO-07 decommissioning log.....	16
Figure 16 - PO-08 decommissioning log.....	17
Figure 17 - PO-09 decommissioning log.....	18
Figure 17 - PO-09 decommissioning log (2)	19
Figure 18 - PO-13 decommissioning log.....	20
Figure 19 - PO-14 decommissioning log.....	21

1 INTRODUCTION

The Geological Survey of Canada (GSC) carried out a scientific project on potential impacts of natural gas exploration and production activities on shallow aquifers from 2014 to 2019 in collaboration with many partners, including Corridor Resources. This company accepted to provide access to their well pads located in the McCully gas field and Elgin area (prospect field for condensates) to drill shallow observation wells. These wells were used for different purposes, including water and rock sampling, and geochemical monitoring was carried out over three years. Corridor Resources had specifically required at the beginning that these wells be decommissioned at the end of the project. This report documents the decommissioning in August 2018 of 11 observation wells, whose depth varied from 39 to 80 m.

This report comprises three main sections:

- Location of the study area and observation wells
- Geological and hydrogeological contexts
- Well decommissioning

The different steps followed to decommission the observation wells were based on the New Brunswick *Guidelines for decommissioning (abandonment) of Water Wells* (Government of New Brunswick, 2010).

Additional information is also included in Appendices, such as technical data sheets for the material used to decommission the wells (Appendix A) and photos taken in the field during the decommissioning work at each observation well (Appendix B).

2 LOCATION OF THE STUDY AREA AND OBSERVATION WELLS

The study area was located in southern New Brunswick, near Sussex (Figure 1). It comprised the McCully gas field and the Elgin area. Fourteen (14) observation wells were drilled for this project, of which 11 were drilled on Corridor Resources pads, with two different drill rigs: a rotary-hammer drill and a diamond drill rig. Table 1 presents characteristics of the shallow observation wells drilled on Corridor pads. Coordinates are provided in UTM NAD 83 Zone 20. They were all drilled into bedrock and had a casing only in their upper part, covering the surficial sediment thickness and down 1 to 3 m into the underlying bedrock. Well PO-02 is flowing artesian and PO-01 was shown to have upward flow using borehole geophysical logging.

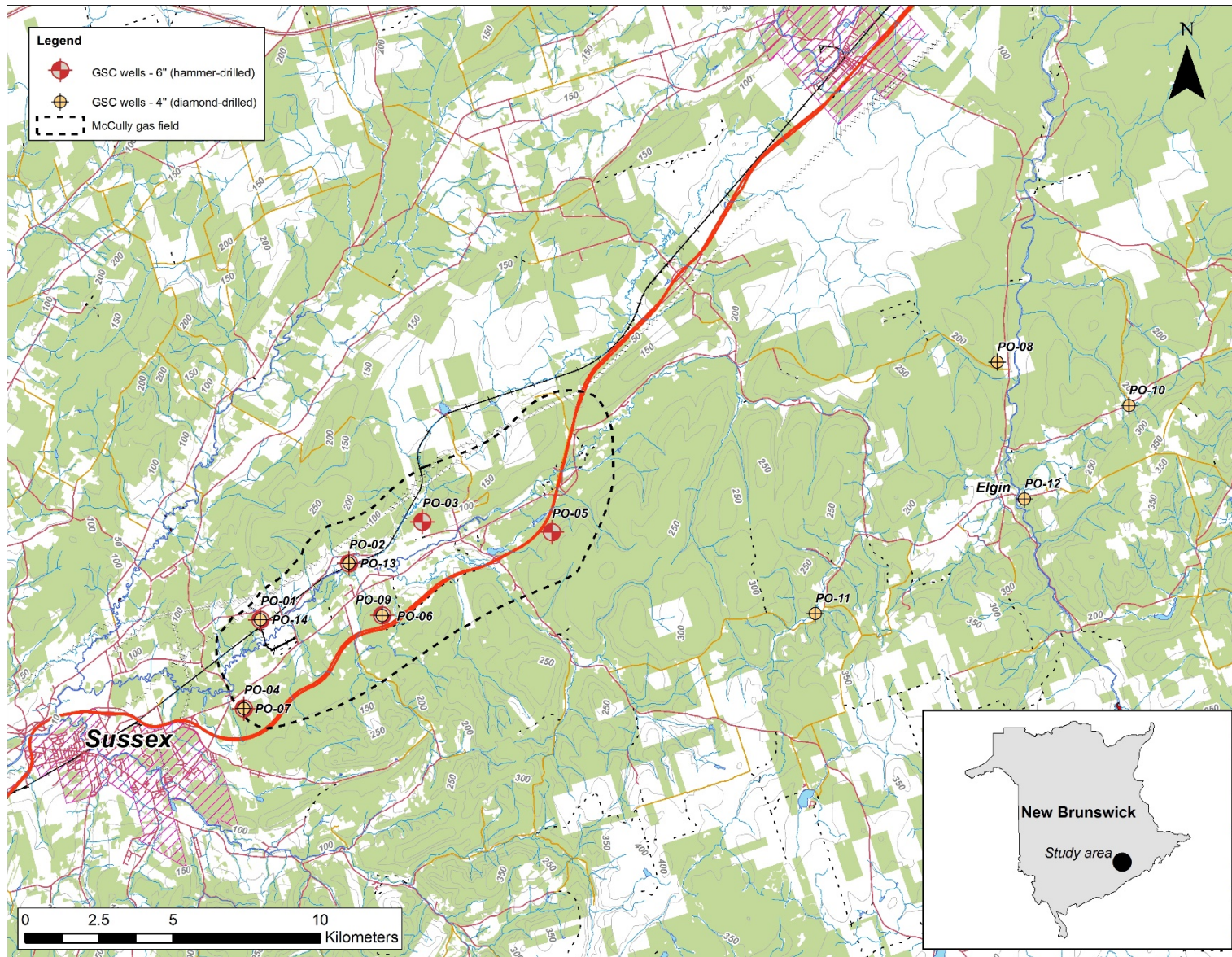


Figure 1 - Observation well locations

Table 1 - Characteristics of the shallow observation wells located on Corridor pads

Well	Corridor pad	Location	Drilled date	Drilling type	X UTM (m)	Y UTM (m)	Elevation (m)	Well depth (m)	Well diameter (mm / in)	Surficial sediments thickness (m)	Casing length (m)	Note
PO-01	O-76	McCully	2015-11-26	Hammer	310 809	5 070 597	18	50.29	152 / 6	9.14	18.29	Artesian well
PO-02	N-57	McCully	2015-11-26	Hammer	313 893	5 072 388	17	50.29	152 / 6	20.12	24.38	
PO-03	G-48	McCully	2015-11-27	Hammer	316 438	5 073 673	52	50.29	152 / 6	10.67	18.29	
PO-04	C-75	McCully	2015-11-27	Hammer	310 110	5 067 616	56	50.29	152 / 6	2.74	9.14	
PO-05	H-28	McCully	2015-11-28	Hammer	320 805	5 073 135	99	50.29	152 / 6	2.74	9.45	
PO-06	P-56	McCully	2015-11-29	Hammer	314 936	5 070 566	72	50.29	152 / 6	14.33	18.29	
PO-07	C-75	McCully	2016-07-05	Diamond	310 116	5 067 610	58	50.29	102 / 4	2.43	6.15	Next to PO-04
PO-08	G-41	Elgin	2016-07-07	Diamond	336 133	5 078 234	136	39.62	102 / 4	0	13.72	
PO-09	P-56	McCully	2016-07-09	Diamond	314 941	5 070 570	71	80.16	102 / 4	9.75	18.20	Next to PO-06
PO-13	N-57	McCully	2018-06-06	Diamond	313 892	5 072 390	18	50.60	102 / 4	19.81	24.08	Next to PO-02
PO-14	O-76	McCully	2018-06-07	Diamond	310 812	5 070 601	21	50.67	102 / 4	9.60	12.80	Next to PO-01

3 GEOLOGICAL AND HYDROGEOLOGICAL CONTEXTS

The study area is located in the Maritimes Carboniferous Basin, and more specifically in the Moncton Sub-basin. A cross-section of the McCully gas field is presented in Figure 2 and a geological map of this region in Figure 3. In the gas field, most of the production is from the tight sandstones of the Hiram Brook Member, but one well drilled into the shale of the Frederick Brook Member is also producing natural gas. The two members belong to the Lower Carboniferous (Tournaisian) Albert Formation of the Horton Group. The sandstones and shales are very tight and economic production can only be achieved through hydraulic fracturing. The Horton Group is overlain by the Sussex, Windsor and Mabou groups. These two target members are typically found at a depth of more than 2 km in the McCully gas field. In the Elgin area, only the Frederick Brook shale is currently targeted.

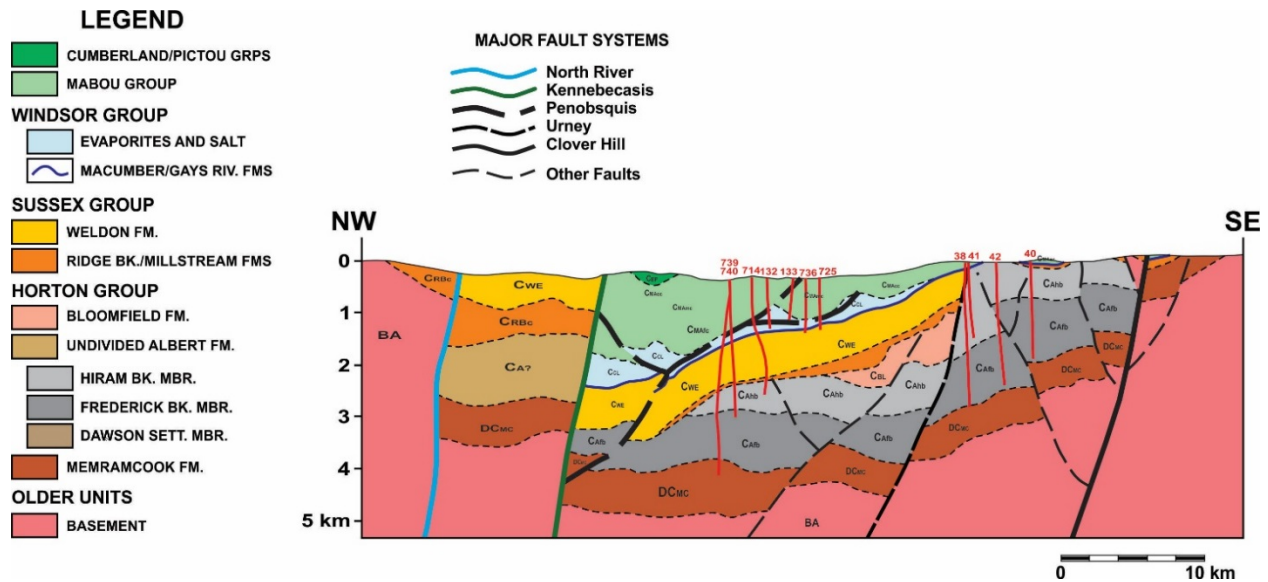


Figure 2 - Geological cross-section of the study area (Hinds and Parks, 2017)

Most shallow observation wells in the McCully gas field were drilled into the Mabou Group, mainly composed of continental and fluvial conglomerates, sandstones and siltstones (PO-01 to PO-09, except for PO-05). Wells PO-05 and PO-08 (located in Elgin) were drilled in the Upper Carboniferous Cumberland Group dominated by continental and fluvial sandstone and siltstone with minor conglomerate. Surficial bedrock is highly fractured, while the matrix porosity measured from core samples is moderate to low, varying between 3 and 11%, with a median of ~6%. The regional bedrock aquifer is typically under unconfined condition and groundwater flow is topographically driven. The water table is usually quite close to the surface (generally less than 5 m from the ground surface, except in topographic highs). The annual recharge rate is in the order of 300 mm (Huchet, 2018).

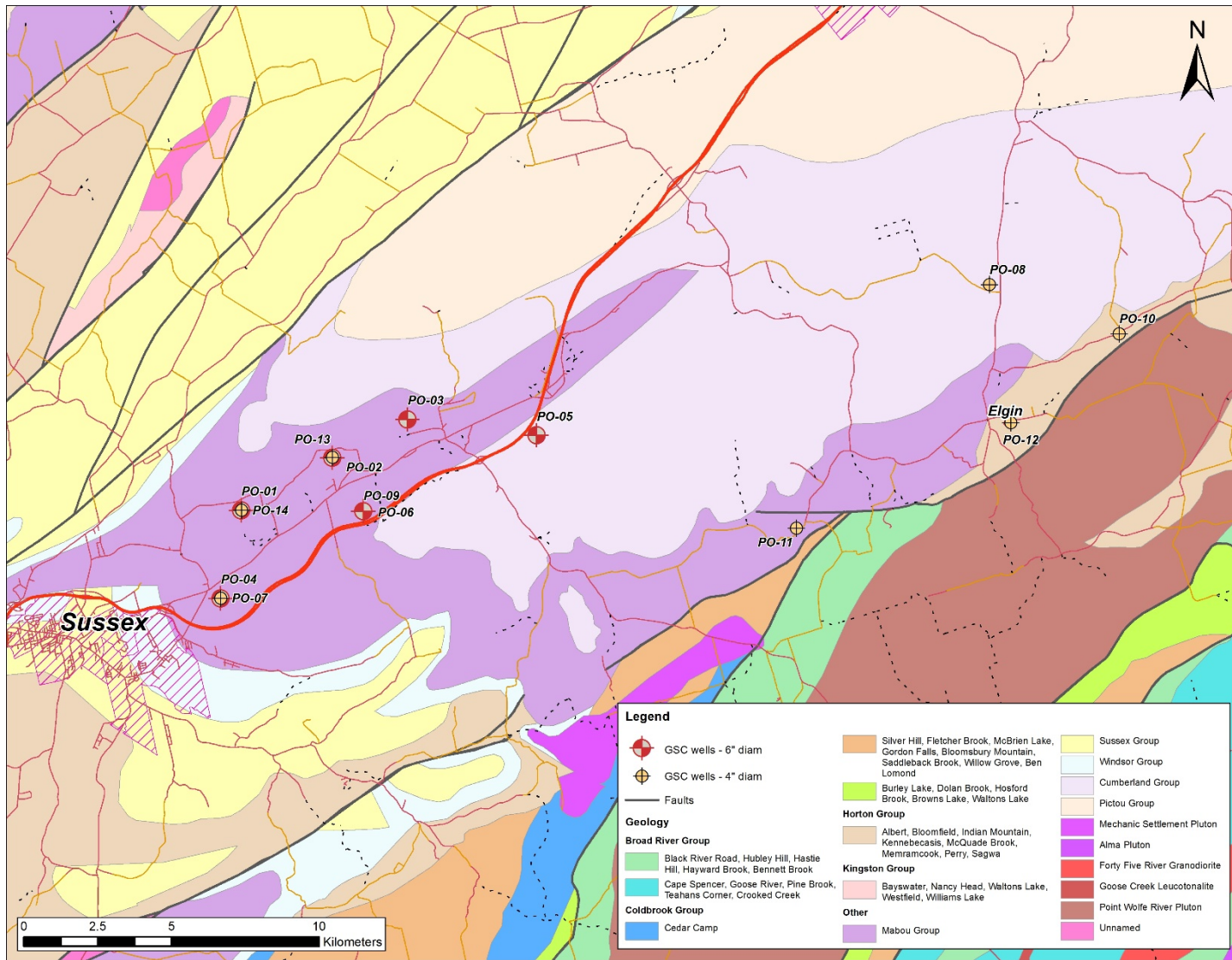


Figure 3 - Bedrock geological map of the study area

4 WELL DECOMMISSIONING

4.1 IN SITU DECOMMISSIONING STEPS

The followings steps were used for decommissioning the wells:

1. A hole was dug around the well to a depth of approximately 0.6 to 0.8 m (Figure 4) according to the guidelines (Government of New Brunswick, 2010);
2. The casing was then cut 0.6 m below the ground surface (Figure 5)
3. After having measured the well depth and casing length, silica sand was poured into the observation well to fill the “open” section (with no casing), up to at least 3 m below the metal casing (Figure 6);
4. The remaining portion of the well was filled with bentonite (clay consisting mostly of montmorillonite) with a high water absorption capacity causing it to expand and swell. This type of material is used to plug the well appropriately, to avoid any contamination from the surface to reach the aquifer through it. Bentonite chips were used in most observation wells, but coated bentonite tablets were used in the case of PO-02 and its twin PO-13 until the water stopped flowing out of the well, to allow bentonite to settle, as this material offers a delay of several minutes before starting to expand. When water had stopped flowing out, bentonite chips were then added, as coated bentonite is very expensive. In some case, when the water level in the well was too low, water was poured on the bentonite at several intervals in order for the bentonite to seal the well properly;
5. At the surface, the hole dug was filled with a mixture of silica sand, bentonite chips and local overburden material (Figure 7).



Figure 4 - Hole dug around the well



Figure 5 - Cutting of the casing



Figure 6 - Pouring of sand in the well



Figure 7 - Mix of silica sand, bentonite chips and overburden material

The three types of material used to fill the wells were the following:

- CETCO bentonite (PUREGOLD Medium Chips),

- CETCO coated bentonite tablets,
- Atlantic Silica sand (0.053 to 4 mm).

Their technical data sheets are provided in Appendix A.

4.2 ESTIMATES FOR BENTONITE AND SAND

For the wells with a 152 mm (6 in) diameter, it was estimated that three bentonite bags of 50 lbs each could fill one linear meter (thus 150 lbs per linear meter). For the wells with a 102 mm (4 in) diameter, we estimated that 1.5 bags of bentonite could fill one linear meter (thus 75 lbs per linear meter). The estimates were similar (in terms of bags) for silica sand, sold in 55 lbs bag, and for coated bentonite tablets sold in 50 lbs plastic pail, based on the technical datasheets.

The estimated quantities, for each type of wells and per linear meter, are provided in Table 2.

Table 2 - Estimated quantities (in pounds) for each linear meter

Material	102 mm (4 in) well	152 mm (6 in) well
CETCO PUREGOLD bentonite (lbs/m)	75	150
CETCO coated bentonite tablets (lbs/m)	75	150
Atlantic Silica sand (lbs/m)	82.5	165

Overall, 34,800 lbs of material (bentonite, sand and coated bentonite tablets) had been estimated, then bought and shipped in New Brunswick for the decommissioning of the 11 observation wells.

4.3 SAFETY AND PREVENTION

Using silica sand and bentonite chips entails some health risks, including silicosis and other respiratory diseases over the long term. To avoid any breathing discomfort or unpleasantness, half mask respirator with multi-contaminant cartridge and P100 filter (for debris and materials that are larger than 0.3 microns or greater) were used when working with these materials. Gloves and security glasses were also used to



Figure 8 - Half mask respirator and gloves used while manipulating silica sand and bentonite

prevent skin irritation and for protection against dust (Figure 8). Cutting the casing using a grinder leads to other risks such as metal dust inhalation and earing discomfort. To prevent this, earmuffs were used in addition to the security glasses (see Figure 5).

4.4 ESTIMATED QUANTITIES OF MATERIAL

Table 3 presents a summary of the estimated material quantities poured in each well during the decommissioning work.


Table 3 - Quantities of material used to decommission each well

Wells	Silica sand (lbs)	Bentonite (lbs)	Coated bentonite tablets (lbs)	Thickness of bentonite below the casing (m)
PO-01	1,598	1,150	-	7.42
PO-02	1,598	850	400	3.62
PO-03	1,378	1,000	-	11.31
PO-04	1,378	1,200	-	18.29
PO-05	276	600	-	3.29
PO-06	1,102	1,500	-	11.41
PO-07	882	400	-	15.32
PO-08	606	450	-	4.28
PO-09	661	550	-	14.41
PO-13	827	250	350	10.42
PO-14	882	450	-	6.99
Total:	11,188	8,400	750	

It is estimated that a total of 11,188 lbs of silica sand, 8,400 lbs of bentonite and 750 lbs of coated bentonite tablets were used to decommission the wells. Well PO-05 required much less material than the other wells, because its walls had collapsed shortly after its drilling and it was completely blocked at 16.4 m below the surface. Borehole walls of well PO-09 had also collapsed, but at a depth of 28 m.

4.5 WELL LOGS

Figures 9 to 19 present the well logs, showing to the left the geological log and to the right, the “decommissioned well log” or “vertical fill cross-section”, i.e., the material used to fill them with associated thickness / length.

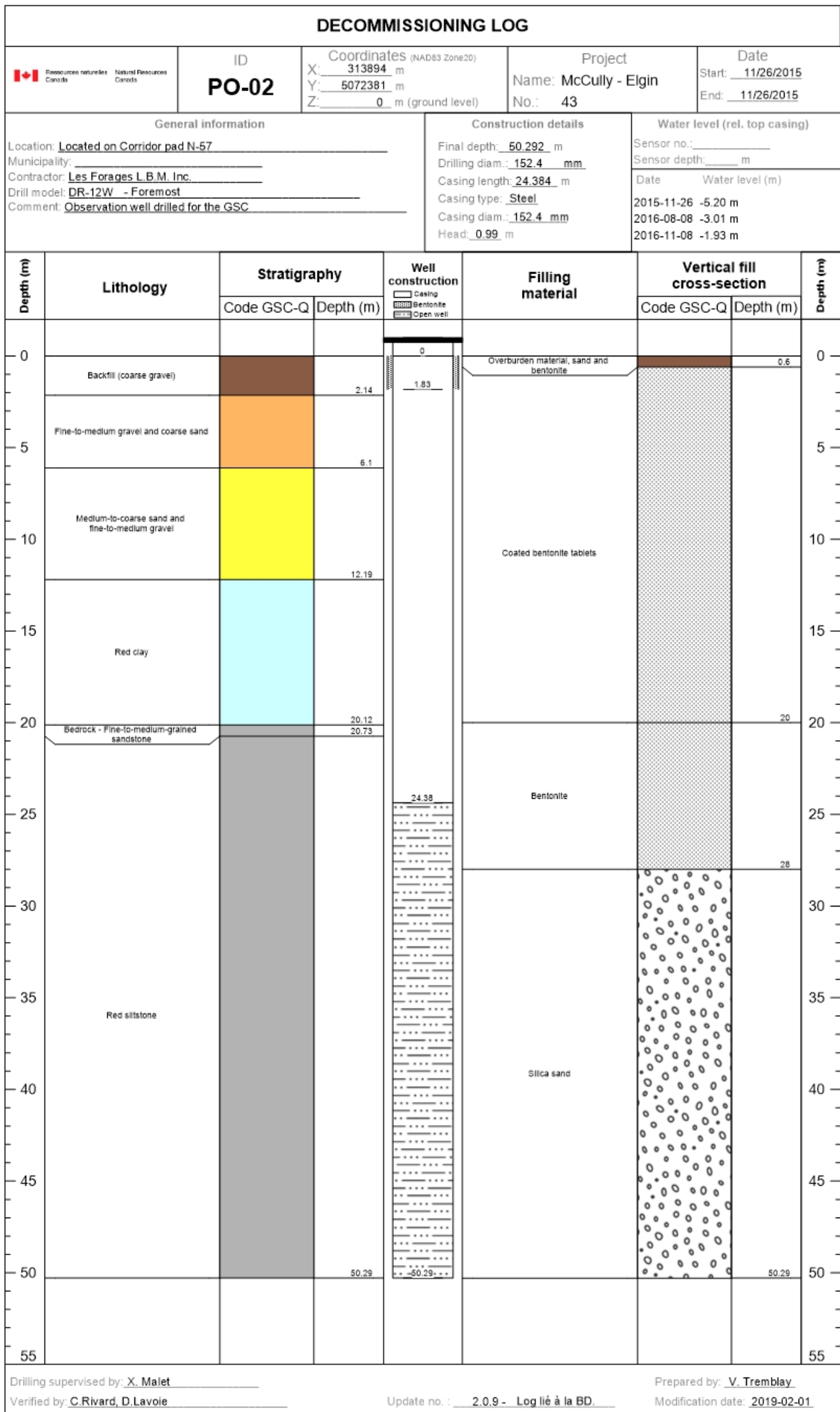
DECOMMISSIONING LOG								
		ID PO-01	Coordinates (NAD83 Zone20) X: <u>310809</u> m Y: <u>5070597</u> m Z: <u>0</u> m (ground level)		Project Name: <u>McCully - Elgin</u> No.: <u>43</u>		Date Start: <u>11/26/2015</u> End: <u>11/26/2015</u>	
General information			Construction details		Water level (rel. top casing)			
Location: <u>Located on Corridor pad O-76</u> Municipality: _____ Contractor: <u>Les Forages L.B.M. Inc.</u> Drill model: <u>DR-12W - Foremost</u> Comment: <u>Observation well drilled by GSC</u>			Final depth: <u>50.292</u> m Drilling diam.: <u>152.4</u> mm Casing length: <u>18.288</u> m Casing type: <u>Steel</u> Casing diam.: <u>152.4</u> mm Head: <u>1.07</u> m		Sensor no.: _____ Sensor depth: _____ m Date Water level (m) 2016-07-29 1.34 m 2016-08-08 1.46 m 2016-11-08 1.40 m			
Depth (m)	Lithology	Stratigraphy		Well construction	Filling material	Vertical fill cross-section		Depth (m)
		Code GSC-Q	Depth (m)			Code GSC-Q	Depth (m)	
0				0				0
	Backfill (gravel)		2.44		Overburden material, sand and bentonite		1.28	
	Sandy-to-very-sandy gravel		5.49	3.05				
	Fine-to-medium sand and medium gravel		9.14					
	Red siltstone		17.37		Bentonite			
	Fine-grained grey sandstone		19.2	18.29				
							25.71	
	Red siltstone		50.29	50.29	Silica sand		50.29	50
55								55

Drilling supervised by: X. Malet
 Verified by: C.Rivard, D.Lavoie

Update no. : 2.0.9 - Log lié à la BD.

Prepared by: V. Tremblay
 Modification date: 2019-02-01

Figure 9 - PO-01 decommissioning log



Drilling supervised by: X. Malet
 Verified by: C.Rivard, D.Lavoie

Update no. : 2.0.9 - Log lié à la BD.

Prepared by: V. Tremblay
 Modification date: 2019-02-01

Figure 10 - PO-02 decommissioning log

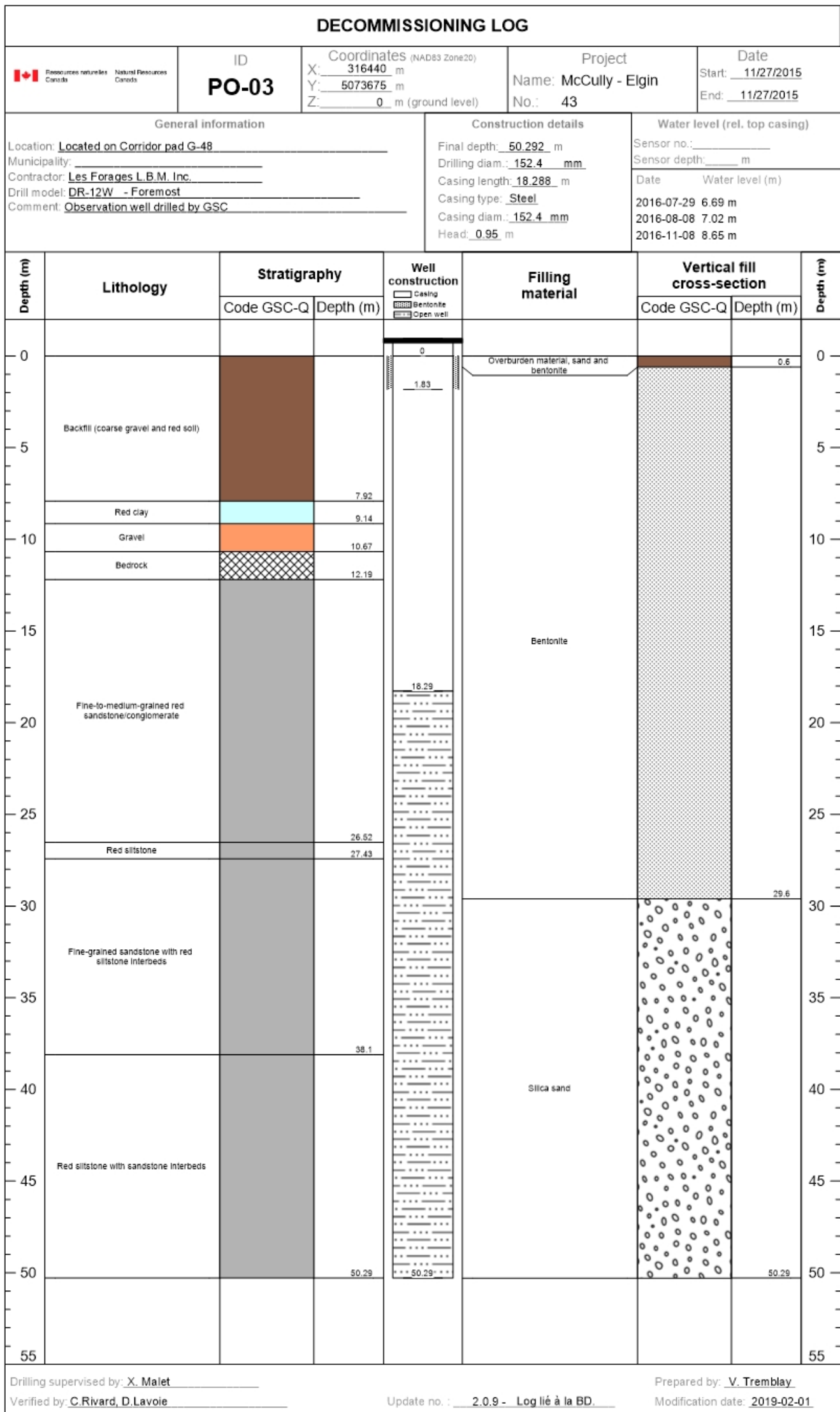


Figure 11 - PO-03 decommissioning log

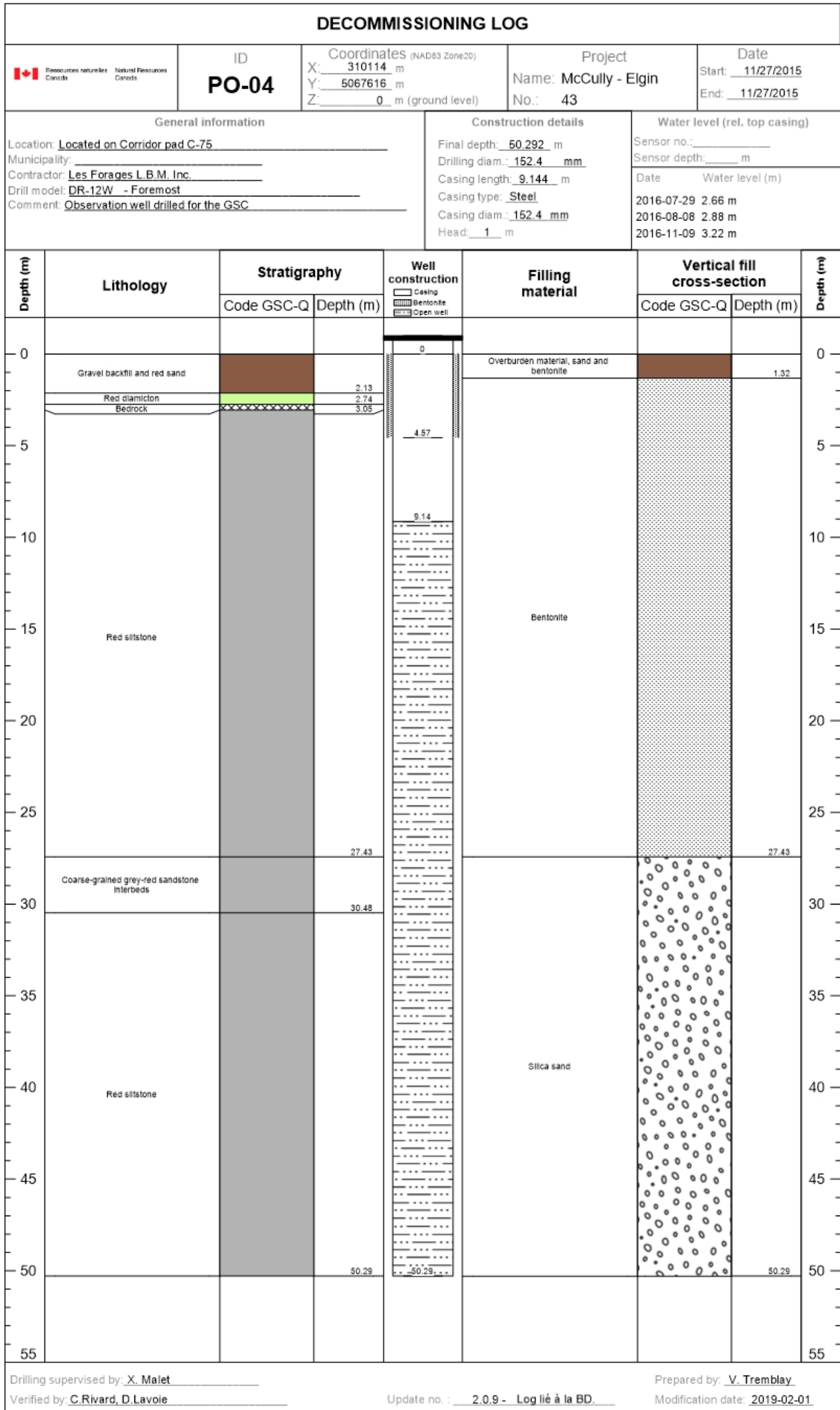
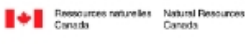


Figure 12 - PO-04 decommissioning log

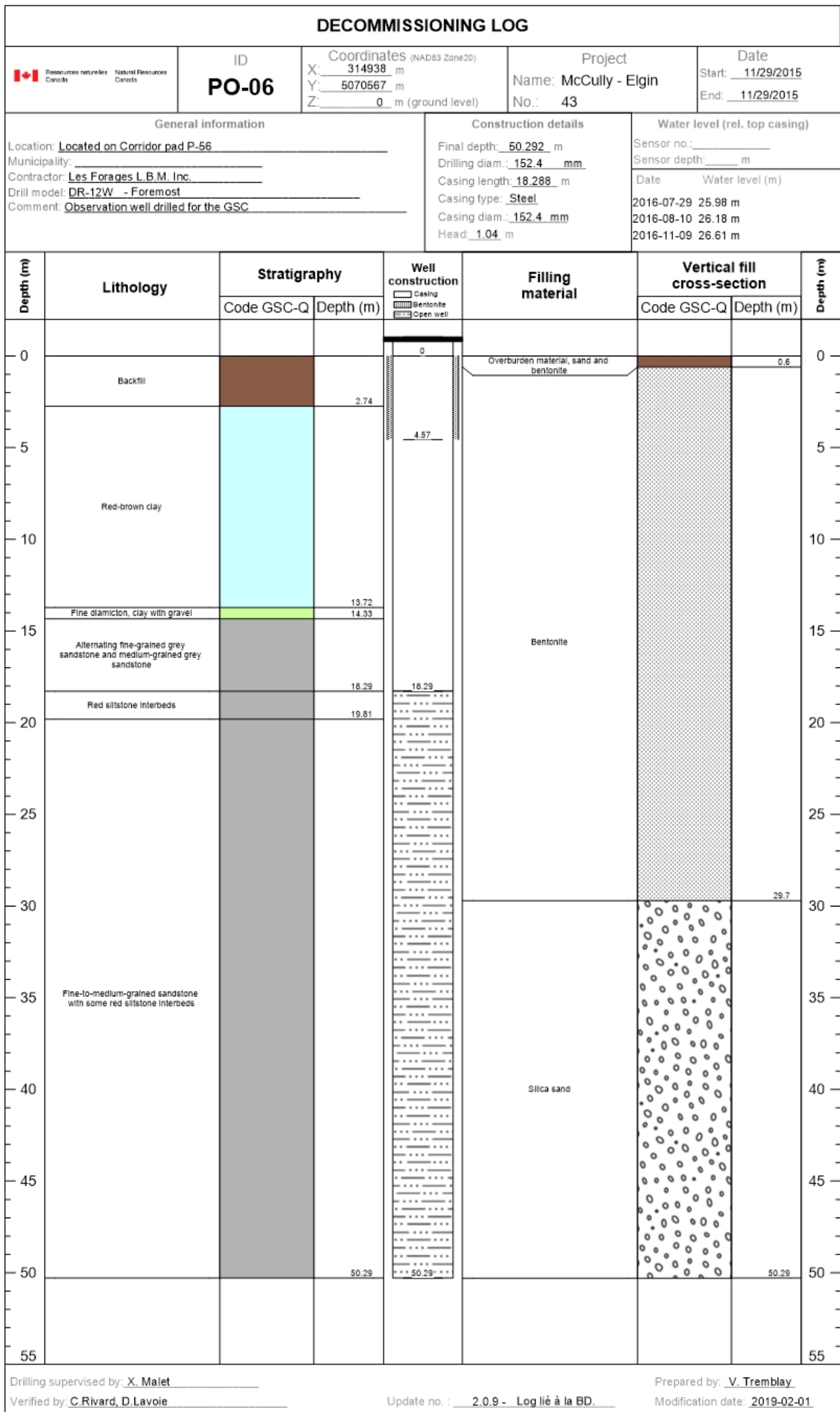
DECOMMISSIONING LOG								
		ID PO-05	Coordinates (NAD83 Zone20) X: 320807 m Y: 5073136 m Z: 0 m (ground level)		Project Name: McCully - Elgin No.: 43		Date Start: 11/28/2015 End: 11/28/2015	
General information			Construction details		Water level (rel. top casing)			
Location: <u>Located on Corridor pad H-28</u> Municipality: _____ Contractor: <u>Les Forages L.B.M. Inc.</u> Drill model: <u>DR-12W - Foremost</u> Comment: <u>Observation well drilled for the GSC</u>			Final depth: <u>50.292</u> m Drilling diam.: <u>152.4</u> mm Casing length: <u>9.4488</u> m Casing type: <u>Steel</u> Casing diam.: <u>152.4</u> mm Head: <u>1.02</u> m		Sensor no.: _____ Sensor depth: _____ m Date Water level (m) 2016-07-29 8.00 m 2016-08-10 8.21 m 2016-11-09 8.93 m			
Depth (m)	Lithology	Stratigraphy		Well construction	Filling material	Vertical fill cross-section		Depth (m)
		Code GSC-Q	Depth (m)			Code GSC-Q	Depth (m)	
0				0	Overburden material, sand and bentonite		0.6	0
2.74	Backfill (sand and gravel)		2.74					
4.57	Red siltstone		4.57					
6.1			6.1		Bentonite			
9.45			9.45					
12.74	Sandstone/mudstone, poorly sorted		12.74					
16.4			16.4		Silica sand			
16.76			16.76					
39.01	Red siltstone with sandstone/mudstone interbeds		39.01					
50.29	Mudstone/sandstone with red siltstone interbeds, poorly sorted		50.29	50.29				50.29
55								55

Drilling supervised by: X. Malet
 Verified by: C.Rivard, D.Lavoie

Update no. : 2.0.9 - Log lié à la BD.

Prepared by: V. Tremblay
 Modification date: 2019-02-01

Figure 13 - PO-05 decommissioning log



Drilling supervised by: X. Malet
 Verified by: C.Rivard, D.Lavoie

Update no. : 2.0.9 - Log lié à la BD.

Prepared by: V. Tremblay
 Modification date: 2019-02-01

Figure 14 - PO-06 decommissioning log

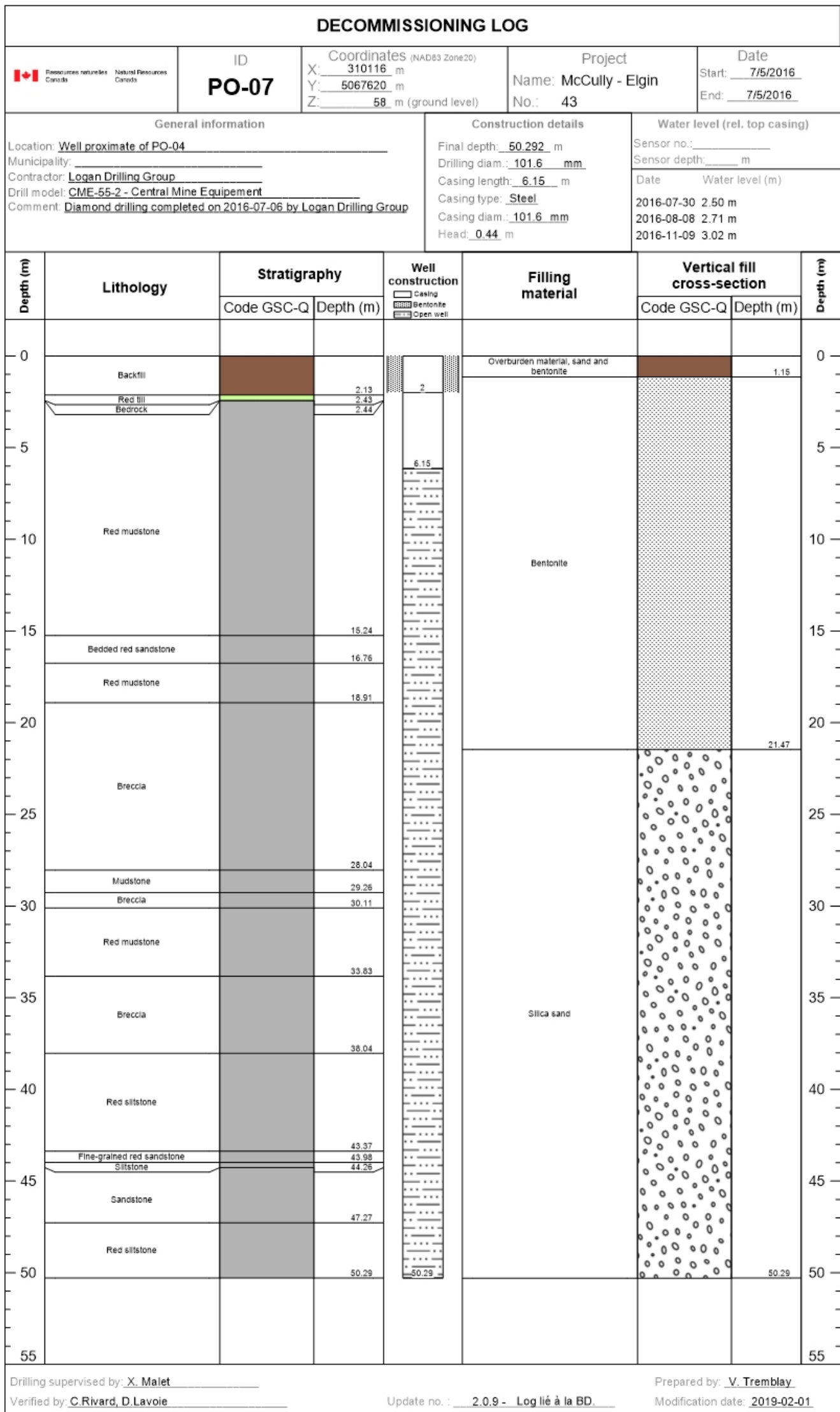



Figure 15 - PO-07 decommissioning log


DECOMMISSIONING LOG								
 Ressources naturelles Canada / Natural Resources Canada		ID PO-08	Coordinates (NAD83 Zone20) X: <u>336133</u> m Y: <u>5078234</u> m Z: <u>136</u> m (ground level)		Project Name: <u>McCully - Elgin</u> No.: <u>43</u>		Date Start: <u>7/7/2016</u> End: <u>7/7/2016</u>	
General information			Construction details		Water level (rel. top casing)			
Location: <u>Located on a Corridor pad</u> Municipality: _____ Contractor: <u>Logan Drilling Group</u> Drill model: <u>CME-55-2 - Central Mine Equipment</u> Comment: <u>Diamond drilling completed on 2016-07-08 by Logan Drilling Group</u>			Final depth: <u>39.624</u> m Drilling diam.: <u>101.6</u> mm Casing length: <u>13.716</u> m Casing type: <u>Steel</u> Casing diam.: <u>101.6</u> mm Head: <u>0.28</u> m		Sensor no.: _____ Sensor depth: _____ m Date Water level (m) 2016-08-10 38.10 m 2016-11-10 32.59 m			
Depth (m)	Lithology	Stratigraphy		Well construction	Filling material	Vertical fill cross-section		Depth (m)
		Code GSC-Q	Depth (m)			Code GSC-Q	Depth (m)	
0					Overburden material, sand and bentonite		0.6	0
	Fine-grained sandstone		1.52					
	Medium-grained brown sandstone, poorly sorted		3.05					
5								5
	Alternating fine-grained grey and brown sandstone				Bentonite			
10								10
			14.53					
15	Medium-grained brown sandstone		16.51					15
	Grey sandstone						18	
20	Alternating grey and brown sandstone		19.66					20
			24.51					
25	Conglomerate and medium-grained sandstone		26.75					25
	Mudstone		27.43					
30	Alternating fine-to-medium-grained grey and brown sandstone				Silica sand			30
35								35
			37.19					
	Fine-grained sandstone and conglomerate		37.49					
	Grey mudstone		37.9					
	Grey conglomerate		38.2					
40	Grey sandstone with some mudstone		39.62				39.62	40
45								45
50								50
55								55

Drilling supervised by: X. Malet
 Verified by: C.Rivard, D.Lavoie

Update no. : 2.0.9 - Log lié à la BD.

Prepared by: V. Tremblay
 Modification date: 2019-02-01

Figure 16 - PO-08 decommissioning log



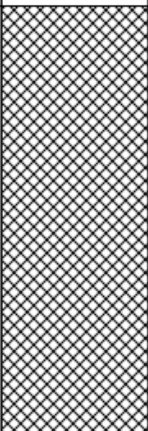
DECOMMISSIONING LOG								
 Resources naturelles Canada	ID PO-09	Coordinates (NAD83 Zone20) X: <u>314941</u> m Y: <u>5070570</u> m Z: <u>71</u> m (ground level)		Project Name: <u>McCully - Elgin</u> No.: <u>43</u>		Date Start: <u>7/9/2016</u> End: <u>7/9/2016</u>		
		General information Location: <u>Located on Corridor pad P-56</u> Municipality: _____ Contractor: <u>Logan Drilling Group</u> Drill model: <u>CME-55-2 - Central Mine Equipment</u> Comment: <u>Diamond drilling completed on 2016-07-10 by Logan Drilling Group</u>			Construction details Final depth: <u>80.1624</u> m Drilling diam.: <u>101.6</u> mm Casing length: <u>18.2</u> m Casing type: <u>Steel</u> Casing diam.: <u>101.6</u> mm Head: <u>0.31</u> m		Water level (rel. top casing) Sensor no.: _____ Sensor depth: _____ m Date Water level (m) 2016-07-30 26.00 m 2016-08-09 26.18 m 2016-11-09 26.60 m	
Depth (m)	Lithology	Stratigraphy		Well construction	Filling material	Vertical fill cross-section		Depth (m)
		Code GSC-Q	Depth (m)			Code GSC-Q	Depth (m)	
0					Overburden material, sand and bentonite		0.6	0
3.05	Backfill							
9.75	Red clay							
10.97	Red silt and red fine sand							
13.41	Till							
13.53	Brown-yellow sandstone							
16.15	Grey conglomerate				Bentonite			
16.25	Green mudstone							
19.81	Fine-to-coarse-grained sandstone, poorly sorted, with some red sandstone interbeds, well sorted							
20.06	Green mudstone							
20.54	Conglomerate							
21.34	Medium-grained grey-green sandstone							
24.38	Alternating grey-green conglomerate and green mudstone							
26.58	Alternating green siltstone and grey sandstone							
31.3	Alternating grey conglomerate and fine-grained sandstone, with some red mudstone							
32.74	Alternating red siltstone and fine-to-medium-grained grey sandstone							
33.53	Medium-grained grey conglomerate							
39.62	Alternating grey and red siltstone and conglomerate							
41.15	Grey-blue mudstone with red siltstone interbeds							
41.45	Grey conglomerate							
43.59	Alternating sandstone and grey-green siltstone							
43.89	Coarse-grained conglomerate							
46.39	Alternating blue siltstone and fine-grained grey sandstone							
50					Collapse			
55	Fine-to-coarse-grained grey-red-brown conglomerate with fine-to-medium-grained sandstone							

Drilling supervised by: X. Malet
Verified by: C.Rivard, D.Lavoie

Update no.: 2.0.9 - Log lié à la BD.

Prepared by: V. Tremblay
Modification date: 2019-02-01

Figure 17 - PO-09 decommissioning


DECOMMISSIONING LOG								
		ID PO-09	Coordinates (NAD83 Zone20) X: <u>314941</u> m Y: <u>5070570</u> m Z: <u>71</u> m (ground level)		Project Name: <u>McCully - Elgin</u> No.: <u>43</u>		Date Start: <u>7/9/2016</u> End: <u>7/9/2016</u>	
General information			Construction details		Water level (rel. top casing)			
Location: <u>Located on Corridor pad P-56</u> Municipality: _____ Contractor: <u>Logan Drilling Group</u> Drill model: <u>CME-55-2 - Central Mine Equipment</u> Comment: <u>Diamond drilling completed on 2016-07-10 by Logan Drilling Group</u>			Final depth: <u>80.1624</u> m Drilling diam.: <u>101.6</u> mm Casing length: <u>18.2</u> m Casing type: <u>Steel</u> Casing diam.: <u>101.6</u> mm Head: <u>0.31</u> m		Sensor no.: _____ Sensor depth: _____ m Date Water level (m) 2016-07-30 26.00 m 2016-08-09 26.18 m 2016-11-09 26.60 m			
Depth (m)	Lithology	Stratigraphy		Well construction	Filling material	Vertical fill cross-section		Depth (m)
		Code GSC-Q	Depth (m)			Code GSC-Q	Depth (m)	
55	Interbeds and some mudstone				Silica sand			55
60			62.58					60
65	Fine-grained grey sandstone and blue-green mudstone Interbeds		67.06					65
70	Blue mudstone with breccia interbeds		70.1					70
75	Alternating grey conglomerate, mudstone and sandstone		73.15					75
	Yellowish conglomerate		74.68					
	Fine-grained sandstone and fine-bedded grey-blue mudstone interbeds		75.07					
	Red conglomerate		76.33					
	Red siltstone		76.64					
80	Red conglomerate		80.16					80.16
85							85	
90							90	
95							95	
100							100	
105							105	
110							110	

Drilling supervised by: X. Malet
 Verified by: C.Rivard, D.Lavoie

Update no. : 2.0.9 - Log lié à la BD.

Prepared by: V. Tremblay
 Modification date: 2019-02-01

Figure 17 - PO-09 decommissioning log (2)


DECOMMISSIONING LOG								
 Ressources naturelles Canada / Natural Resources Canada		ID PO-13	Coordinates (NAD83 Zone20) X: <u>313892</u> m Y: <u>5072390</u> m Z: <u>18</u> m (ground level)		Project Name: <u>McCully - Elgin</u> No.: <u>43</u>	Date Start: _____ End: _____		
General information			Construction details		Water level (rel. top casing)			
Location: <u>Located on Corridor pad N-57</u> Municipality: _____ Contractor: <u>Logan Drilling Group</u> Drill model: <u>CME-55-2 - Central Mine Equipment</u> Comment: <u>Observation well drilled by GSC</u>			Final depth: <u>50.5968</u> m Drilling diam.: <u>101.6</u> mm Casing length: <u>24.0792</u> m Casing type: <u>Steel</u> Casing diam.: <u>101.6</u> mm Head: <u>0.78</u> m		Sensor no.: _____ Sensor depth: _____ m Date _____ Water level (m) _____			
Depth (m)	Lithology	Stratigraphy		Well construction	Filling material	Vertical fill cross-section		Depth (m)
		Code GSC-Q	Depth (m)			Code GSC-Q	Depth (m)	
0				0	Overburden material, sand and bentonite		0.6	0
5	Fine-to-medium sand		7.92	2	Bentonite			5
	Medium sand with fine gravel		9.14					
10	Red clay		19.2				13.8	10
	Sand		19.81					
20	Red conglomerate		21.64					20
	Red siltstone, red conglomerate and fine-grained sandstone		23.16					
	Red siltstone and fine-grained sandstone		24.69	24.08	Coated bentonite tablets			25
25	Fine-grained red sandstone with red siltstone		27.74					
	Red siltstone and fine-to-medium-grained sandstone, well sorted		29.26					
30	Alternating, fine-grained red sandstone, well sorted, and red siltstone interbeds		30.78					30
	Alternating fine-grained red sandstone and fine-grained conglomerate		32.31					
	Alternating red siltstone and fine-grained sandstone		35.36				34.5	35
35	Fine-grained red sandstone with some red siltstone		36.88					
	Alternating fine-grained red sandstone and siltstone		38.4					
40	Red siltstone		39.93					40
	Alternating fine-grained sandstone and red siltstone		41.45		Silica sand			
45	Fine-to-medium-grained sandstone		46.02					45
	Red siltstone		49.07					
50	Alternating fine-grained sandstone and red siltstone		50.6	50.6			50.6	50
55								55

Drilling supervised by: X.Malet, V.Tremblay
 Verified by: C.Rivard, D.Lavoie

Update no.: 2.0.9 - Log lié à la BD.

Prepared by: V. Tremblay
 Modification date: 2019-02-01

Figure 18 - PO-13 decommissioning log

DECOMMISSIONING LOG									
 Ressources naturelles Canada / Natural Resources Canada		ID PO-14		Coordinates (NAD83 Zone20) X: <u>310812</u> m Y: <u>5070601</u> m Z: <u>21</u> m (ground level)		Project Name: <u>McCully - Elgin</u> No.: <u>43</u>		Date Start: _____ End: _____	
General information				Construction details		Water level (rel. top casing)			
Location: <u>Located on Corridor pad O-76</u> Municipality: _____ Contractor: <u>Logan Drilling Group</u> Drill model: <u>CME-55-2 - Central Mine Equipment</u> Comment: <u>Observation well drilled by GSC</u>				Final depth: <u>50.673</u> m Drilling diam.: <u>101.6</u> mm Casing length: <u>12.8016</u> m Casing type: <u>Steel</u> Casing diam.: <u>101.6</u> mm Head: <u>0.65</u> m		Sensor no.: _____ Sensor depth: _____ m Date: _____ Water level (m): _____			
Depth (m)	Lithology	Stratigraphy		Well construction	Filling material	Vertical fill cross-section		Depth (m)	
		Code GSC-Q	Depth (m)			Code GSC-Q	Depth (m)		
0				0	Overburden material, sand and bentonite		0.6	0	
5	Medium-to-coarse sand with gravel		5.49	2	Bentonite	[Pattern]			
	Fine red sand		6.71						
	Sand and gravel		9.14						
	Fine sand		9.6						
10	Red siltstone		11.13						
	Alternating fine-grained sandstone and red siltstone		12.65	12.8					
15	Fine-to-medium-grained red-grey sandstone		17.15						
	Fine-grained red sandstone, poorly sorted, and red siltstone		18.67						
	Red siltstone and fine-grained sandstone		20.19						
20	Alternating fine-grained sandstone and red siltstone		21.72						
	Red siltstone		23.24						
	Alternating red siltstone and fine-grained red sandstone, well sorted		24.77						
25	Alternating fine-to-medium-grained greyish sandstone and red siltstone		26.29						
	Red conglomerate and red siltstone with fine-grained sandstone		27.81						
30	Red siltstone with some fine-grained sandstone		33.91						
35	Fine-grained red sandstone with some red siltstone		41.53						
40	Red siltstone with some fine-grained sandstone		43.05						
45	Alternating fine-to-medium-grained sandstone and red siltstone		46.1						
	Red siltstone and fine-grained sandstone		47.63						
	Alternating fine-grained sandstone and red siltstone		49.15						
50	Alternating fine-to-medium-grained sandstone and red siltstone		50.67	50.67					
55					Silica sand			55	

Drilling supervised by: X. Malet, V. Tremblay
 Verified by: C. Rivard, D. Lavoie

Update no.: 2.0.9 - Log lié à la BD.

Prepared by: V. Tremblay
 Modification date: 2019-02-01

Figure 19 - PO-14 decommissioning log

5 CONCLUSION

The GSC, at the request of Corridor Resources, decommissioned eleven (11) shallow observation wells located on Corridor Resources gas well pads in both the McCully gas field and the Elgin prospect condensate field in August 2018. Initially, a larger quantity of filling material than was actually used had been estimated. Evaluating the quantity of bentonite and sand is difficult since it is largely influenced by the integrity of the bedrock in the open section of the wells and by potential collapsing of the borehole walls.

To prevent any infiltration from the surface into the aquifer, between 3.3 m and 18.3 m of bentonite was put in place below the casing (in the open well section) in addition to that placed in the casing itself, to comply with NB government guidelines. The open section was mainly filled with silica sand.

Well casings were cut at a depth of 0.6 m to 0.8 m, which is the approved method for monitoring wells. For technical reasons, it was found that cutting the casing before filling the well is more practical than cutting it after. It is easier because heavy bags/pails do not need to be lifted as high and it is much easier to cut the casing of an empty well on a dry ground. Experience showed that quickly filling an artesian well with coated bentonite works well.

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APPENDIX A TECHNICAL DATA SHEETS

TECHNICAL DATA

CETCO® COARSE CHIPS PUREGOLD® MEDIUM CHIPS



Certified to
NSF/ANSI 60

HOLE ABANDONMENT MATERIAL

DESCRIPTION

CETCO COARSE CHIPS are natural sodium bentonite screened to 3/8 inch (0.95 cm) to 3/4 inch (1.90 cm) in size. PUREGOLD MEDIUM CHIPS are natural sodium bentonite screened to 1/4 inch (0.64 cm) to 3/8 inch (0.95 cm) in size. CETCO COARSE CHIPS and PUREGOLD MEDIUM CHIPS are certified to NSF/ANSI Standard 60, Drinking Water Treatment Chemicals - Health Effects.

RECOMMENDED USE

Sealing shallow boreholes and seismic shot holes; decommissioning wells; providing an interface between gravel pack and bentonite or cement grout.

CHARACTERISTICS

- ▶ Chemically stable. Results from TCLP Priority Pollutants analysis are below RCRA limits for hazardous constituents
- ▶ Prevent infiltration of surface contamination
- ▶ Provide a high-solids bentonite seal
- ▶ Provide a permanent, flexible seal

MIXING AND APPLICATION

Because chips may develop fines during transporting and handling, bagged material should be screened of fines before placement. Pour chips slowly downhole to prevent bridging or binding. In unsaturated conditions, water should be added at 2 ft intervals to ensure adequate hydration.



CETCO COARSE CHIPS	67.30 lbs/ft ³ (1078.15 kg/m ³)
PUREGOLD MEDIUM CHIPS	69.25 lbs/ft ³ (1109.28 kg/m ³)

BULK DENSITY PACKAGING

50 lb (22.7 kg) bag, 48 per pallet. All pallets are plastic-wrapped.

Hole Diameter (in)	2	4	6	8	10	12	14
Approximate Pounds of Chips per Linear Foot	1.5	6	14	24	37.5	54	73

Hole Diameter (cm)	5	10	15	20	25.5	30.5	35.5
Approximate Kilograms of Chips per Linear Meter	2.2	9	21	36	37.5	80	108

APPLICATION MATRIX

Fieldtech Solutions - 37 Wirraway Dr, Port Melb. VIC. 3207
03 9676 9664; sales@fieldtechsoln.com; www.fieldtechsoln.com



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Figure A.1 - CETCO Bentonite Chips Technical Data

TECHNICAL DATA

CETCO® COATED TABLETS

BENTONITE TABLETS - TIME RELEASED FOR SEALING AND PLUGGING



DESCRIPTION

CETCO COATED TABLETS are coated using an aqueous carrier to apply the coating. The coating allows the tablets to reach a discrete depth within the waterwell, piezometer, monitoring well, or annular space. These untreated organic tablets are compressed into 1/4" (0.64 cm) and 3/8" (0.95 cm) sizes. CETCO COATED TABLETS are certified to NSF/ANSI Standard 60, Drinking Water Treatment Chemicals - Health Effects.

RECOMMENDED USE

CETCO COATED TABLETS are designed to fall through standing water columns of up to 500 vertical feet without bridging. CETCO COATED TABLETS form a chemically resilient, low-permeability, flexible seal.

- ▶ Isolate screen intervals, subsurface instrumentation, and sampling zones
- ▶ Plug abandoned boreholes and cavities
- ▶ Provide a protective barrier between gravel pack and high solids grout
- ▶ Seal or grout plastic or steel casing

Build a stable, permanent below-grade seal in:

- ▶ Caisson holes
- ▶ Mineral exploration holes
- ▶ Monitoring/observation wells
- ▶ Piezometer/water sampling wells
- ▶ Soil/geotechnical sampling holes
- ▶ Waterwells

PACKAGING

50 lb (22.7 kg) plastic pails, 36 per pallet. All pallets are plastic-wrapped.



MIXING AND APPLICATION

1/4" (0.64 cm) CETCO COATED TABLETS REQUIRED FOR SEALING AND PLUGGING APPLICATIONS					
Hole Diameter (in)	Hole Volume ft ³ /ft	Lbs/linear ft	Hole Diameter (cm)	Hole Volume m ³ /m	Kg/linear meter
2	0.02	1.61	5	0.001	0.72
4	0.09	7.26	10	0.003	3.27
6	0.20	16.14	15.2	0.006	7.26
8	0.35	28.25	20.3	0.011	12.7
10	0.55	44.40	25.4	0.017	20.0
12	0.79	63.77	30.5	0.024	28.7
16	1.40	113.01	40.6	0.040	50.9
36	7.07	570.69	91.4	0.212	256.8

3/8" (0.95 cm) CETCO COATED TABLETS REQUIRED FOR SEALING AND PLUGGING APPLICATIONS					
Hole Diameter (in)	Hole Volume ft ³ /ft	Lbs/linear ft	Hole Diameter (cm)	Hole Volume m ³ /m	Kg/linear meter
2	0.02	1.59	5	0.001	0.72
4	0.09	7.15	10	0.003	3.22
6	0.20	15.88	15.2	0.006	7.15
8	0.35	27.80	20.3	0.011	12.5
10	0.55	43.68	25.4	0.017	19.7
12	0.79	62.74	30.5	0.024	28.2
16	1.40	111.19	40.6	0.040	50.0
36	7.07	561.50	91.4	0.212	252.7

GROUTS & SEALANTS

Fieldtech Solutions - 37 Wirraway Dr, Port Melb. VIC. 3207
03 9676 9664; sales@fieldtechsoln.com; www.fieldtechsoln.com



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Figure A.2 - CETCO Coated Tablets Technical Data



www.atlanticsilica.ca

Plant: 4 Osborne Road
 Poodiac, NB, E4E 5K5
 Tel. 506-433-5890
 Fax 506-433-4619

Office: PO Box 10
 Enfield, NS, B2T 1C6
 Tel. 902-883-3020
 Fax. 902-883-8881

Product Sieve analysis as requested.

TYPICAL SIZE ANALYSIS								
US SIEVE SIZE		% RETAINED						
#	mm	#3	#2	#1	#0	#00	#50	#70
4	4.75							
5	4.000	6.7						
6	3.350	20.3						
8	2.360	58.1	4.9					
10	2.000	10.3	46.5					
12	1.700	2.5	42.3	4.7				
14	1.400		4.7	37.1				
16	1.180		0.7	31.3	0.8			
18	1.000		0	17.8	6.7			
20	0.850			7.5	19			
30	0.600			3.1	43.5		5.3	
40	0.425			1.5	25.2	4.5	14.1	
50	0.300				4.5	34.7	52.5	9.2
70	0.212					25.4	14.1	18.2
100	0.150					20.9	12.4	24.9
140	0.106					11.2	4.1	19.3
200	0.075					2.8	0.9	13.8
270	0.053							9
PAN		0.6	0.7	0.4	0.7	0.5	1.9	5.6

Grain Shape	Sub-Angular	Visual
Hardness	7.0 Mohs	
Specific Gravity		2.65g/cm ³
Bulk Density		92-95lb/ft ³

Figure A.3 - Atlantic Silica Inc. Sand Technical Data

**APPENDIX B PHOTOS TAKEN IN THE FIELD DURING THE OBSERVATION WELL
DECOMMISSIONING WORK**



Figure B.1 - Observation well PO-01 before its decommissioning (August 24, 2018)



Figure B.2 - Observation well PO-01 after the casing was cut at 60 cm below the ground surface (step 2) (August 24, 2018)



Figure B.3 - PO-01 during at the final stage (step 5) of the decommissioning (August 24, 2018)



Figure B.4 - Observation well PO-01, after its decommissioning (August 24, 2018)



Figure B.5 - Observation well PO-02 showing artesian condition before its decommissioning (August 26, 2018)



Figure B.6 - Observation well PO-02 during decommissioning (step 3) (August 26, 2018)



Figure B.7 - Observation well PO-02 completely filled (end of step 4) (August 26, 2018)



Figure B.8 - Observation well PO-02 after its decommissioning (August 26, 2018)



Figure B.9 - Observation well PO-04 during its decommissioning (step 3) (August 24, 2018)



Figure B.10 - Observation well PO-05 before its decommissioning (August 25, 2018)



Figure B.11 - Observation well PO-05 during its decommissioning (step 3) (August 25, 2018)



Figure B.12 - Observation well PO-05 after its decommissioning (step 5) (August 25, 2018)



Figure B.13 - Observation well PO-06 before its decommissioning (August 25, 2018)



Figure B.14 - Observation well PO-06 after step 2 (casing cutoff) (August 25, 2018)

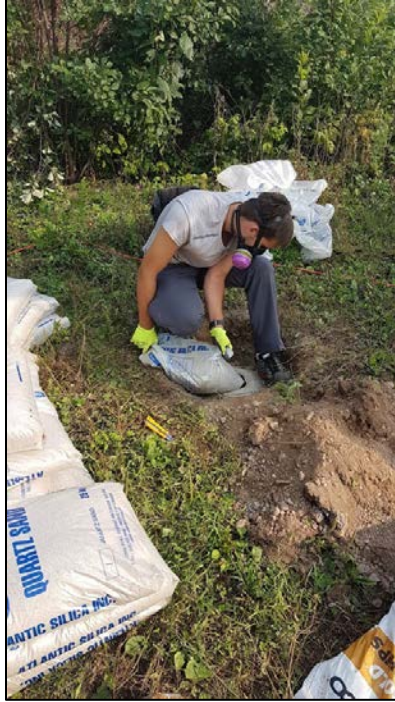


Figure B.15 - Observation well PO-06 during its decommissioning (step 3) (August 25, 2018)



Figure B.16 - Observation well PO-06 after its decommissioning (August 25, 2018)



Figure B.17 - Observation well PO-07 at the final stage of its decommissioning (August 24, 2018)



Figure B.18 - Observation well PO-07 after its decommissioning (August 24, 2018)



Figure B.19 - Observation well PO-08 during its decommissioning (step 2) (August 25, 2018)



Figure B.20 - Observation well PO-08 during its decommissioning (step 5) (August 25, 2018)



Figure B.21 - Observation well PO-08 in the decommissioning final stage (step 5) (August 25, 2018)



Figure B.22 - Observation well PO-09 during its decommissioning (step 1) (August 25, 2018)



Figure B.23 - Observation well PO-09 during its decommissioning (step 4) (August 25, 2018)



Figure B.24 - Observation well PO-09 in the decommissioning final stage (step 5) (August 25, 2018)



Figure B.25 - Observation well PO-09 after its decommissioning (August 25, 2018)



Figure B.26 - Observation well PO-13 before its decommissioning (August 26, 2018)



Figure B.27 - Observation well PO-13 during its decommissioning (step 4) (August 26, 2018)



Figure B.28 - Observation well PO-13 in the final stage (step 5) of its decommissioning (August 26, 2018)



Figure B.29 - Observation well PO-13 after its decommissioning (August 26, 2018)