Memorandum

DATE: October 12, 2012

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SUBJECT: Fuel Containment Area Water Sampling

1. Introduction

Starfield Resources Inc. (Starfield) constructed and operated a lined embankment secondary containment fuel storage area as part of their Ferguson Lake Project. Rescan Environmental Services Ltd. (Rescan) visited the Project area September 3 - 5, 2012 to assess the quality of the impounded water and to provide recommendations on its management.

The fuel containment area (FCA) is approximately 40 m × 40 m (Plates 1 and 2). The containment area was constructed using local materials for the embankments and a HDPE liner was welded as the impermeable membrane. The liner was keyed in to the top of the embankment and was covered with a non-woven geotextile fabric. A layer of sand and gravel was placed on top of the fabric to form a ramp and a working area within the embankment.

Contact water from snowmelt and rainfall collects seasonally in the containment area. Regular management of this contact water involves filtering the water through a series of 200 L steel open top drums full of filter media (activated carbon) connected in series to a pressure vessel which is also filled with filter media (shredded spill pads; Plate 3). Treated water is then discharged from two points west and north of the FCA (Plate 4).

2. Methodology

Water observed within the fuel containment area during the field visit showed no sign of contact with hydrocarbons. There was no sheen or free product visible on the surface of the water and the water had no odour. Untreated water within the flooded fuel containment area (FCA) and treated water from the oil water separator (OWS) was sampled and tested for hydrocarbons and polycyclic aromatic hydrocarbons (PAHs) during two sampling events.

Plate 1. Aerial view of flooded fuel containment area looking east.

Plate 2. Fuel barrels stored on site at the time of sampling.

Plate 3. Oil water separator used to treat water pumped out of the fuel containment area. Water is pumped through pressurized vessels containing activated carbon.

Plate 4. Western (left) and northern (right) treated water discharge points.

The first sampling event occurred on August 31, 2012. Three untreated water samples were collected from the southern portion of the FCA at the water's surface and three samples were collected at depth, approximately 30 cm above the bottom from the northern portion of the FCA. An additional sample set was collected from the northeast corner of the FCA for analysis of general water quality parameters, including pH, turbidity and nutrients (refer to Appendix A for parameter list). All samples were grab samples, collected by a field technician who entered the FCA and waded to the sampling point.

The second sampling event occurred on September 4, 2012. Untreated water samples were collected from the FCA and samples were collected from treated water being discharged from the OWS. Two untreated samples were collected from the middle of the water column in the FCA 1.25 hours apart (Plate 5). A clean, plastic bucket was used to collect this water for sampling purposes (Plate 6). Treated OWS water was collected at the northern and western discharge sites. At the time of sampling, the discharge rate was 13.3 L/min and 12.0 L/min at the northern and western discharge points respectively. For QA/QC purposes, duplicate samples of untreated and treated water were collected.

Samples were kept cool and immediately sent to ALS Environmental Laboratories in Burnaby for analytical analysis. Grab samples collected from the August 31 sampling event from the FCA were broken and leaked during transit, and the volume remaining was too low for analysis. For this reason, a decision was made to create two composite samples. One composite created from the three samples collected from

the FCA surface, and the second composite created from the samples collected at depth. All analytical results were compared to CCME guidelines for the protection of aquatic life (CCME 2011).

Plate 5. Hose and pump used to collected untreated water sample from the FCA being set up (not yet connected in this photo).

Plate 6. Water collection bucket used for sampling from FCA.

3. Analytical Results and Observations

No PAHs were detected in untreated or treated waters (Appendix B). As a result, parameters were the same for duplicate QA/QC samples collected from the FCA and OWS. Field observations confirmed the analytical results, as field technicians did not observe sheen or odour coming from the water in the FCA during the sampling events.

There are 11 CCME water quality guidelines for PAHs and no CCME guidelines for other hydrocarbons (e.g. EPH10-19). Analytical detection limits, for the most part, were lower than corresponding CCME guidelines. However, detection limits for anthracene and benz(a)anthracene were 4.1 and 2.7 times higher than their respective guidelines, so results for these two parameters are not conclusive.

Hydrocarbons generally fell below detection limits for treated and untreated waters, except detectable levels of hydrocarbons were identified in the composite sample collected from 30 cm above the floor of the FCA. This may be attributed to collection technique. It is likely that fine sediment lining the bottom of the FCA were stirred up by field personnel wading into the FCA. This could have contaminated water samples collected so close to the bottom of the FCA.

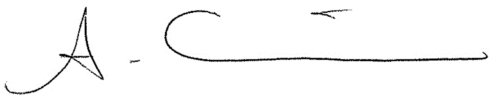
General water chemistry analysis of untreated water revealed no exceedances of CCME guidelines (Appendix A). General parameters such as pH, colour and turbidity were all within an acceptable range for natural waters, and nutrient parameters mostly fell below analytical detection limits.

4. Conclusions

Water before and after treatment was free of detectable PAHs and fell below defined CCME guidelines for the protection of aquatic life (CCME 2011). Detection limits for two PAHs (anthracene and benz(a)anthracene) were higher than CCME guidelines, therefore no definitive statements can be made regarding these two parameters.

The low portion of samples containing hydrocarbons in the contact water suggests that fuel handling practices within the fuel containment area have been good. Recommendations were made to site personnel to review and maintain these practices. In addition for the management of future contact water the recommendation was made to discharge water from the fuel containment area through the oil water separator whenever possible. However, given the lack of observable or detectable hydrocarbons in the treated water, the water meets discharge criteria and can be discharge without treatment provided measures are taken to mitigate other potential impacts from the discharge (e.g., erosion, freezing).

Prepared by:



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References

CCME. 2011. *Canadian water quality guidelines for the protection of aquatic life: Summary table*. Canadian Council of Ministers of the Environment: Winnipeg, MB. http://st-ts.ccme.ca (accessed October 2013).

Appendix A

Table A1. Analytical Results of Untreated Water Collected from the Fuel Containment Area, August 31, 2012

Water type			Untreated Water (FCA)
Sample type			Grab sample
Sample ID			NE CORNER
Date Sampled			31-AUG-12
ALS Sample ID	Units	CCME Guidelines[a]	L1205458-1
Physical Tests			
Colour, True	CU	-	9.7
Conductivity	uS/cm	-	20.7
pH	pH	6.5 to 9.0	6.80
Turbidity	NTU	-	11.5
Anions and Nutrients			
Acidity (as $CaCO_3$)	mg/L	-	6.6
Alkalinity, Total (as $CaCO_3$)	mg/L	-	2.8
Bromide (Br)	mg/L	-	< 0.050
Chloride (Cl)	mg/L	120	0.64
Fluoride (F)	mg/L	0.12	< 0.020
Nitrate (as N)	mg/L	13	< 0.0050
Nitrite (as N)	mg/L	0.197	< 0.0010
Sulfate (SO_4)	mg/L	-	< 0.50

[a] *Canadian water quality guidelines for the protection of freshwater aquatic life, Canadian Council of Ministers of the Environment.*

Appendix B. Analytical results of hydrocarbon and PAH testing on water before and after treatment collected on August 31 and September 04, 2012

Water Type		Untreated Water (FCA)					Treated Water (OWS)		
Sample Type		Grab Sample		Pump Sample			Northern		Western
Sample ID		COMPOSITE 1 TO 3	COMPOSITE 4 TO 6	FCA-01	FCA-01 Duplicate	FCA-02	OWS-01	OWS-01 Duplicate	OWS-02
Date Sampled	CCME Guidelines [a]	31-AUG-12	31-AUG-12	04-SEP-12	04-SEP-12	04-SEP-12	04-SEP-12	04-SEP-12	04-SEP-12
ALS Sample ID	(mg/L)	L1205458-7	L1205458-8	L1205049-1	L1205049-2	L1205049-3	L1205049-4	L1205049-5	L1205049-6
Aggregate Organics (mg/L)									
Oil and Grease	-	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
Hydrocarbons (mg/L)									
EPH10-19	-	0.34	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25
EPH19-32	-	0.55	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25
LEPH	-	0.34	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25
HEPH	-	0.55	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25
PAHs (mg/L)									
Acenaphthene	**0.0058**	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
Acenaphthylene	-	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
Acridine	**0.0044**	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
Anthracene	**0.000012**	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
Benz(a)anthracene	**0.000018**	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
Benzo(a)pyrene	**0.000015**	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010
Benzo(b)fluoranthene	-	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
Benzo(g,h,i)perylene	-	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
Benzo(k)fluoranthene	-	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
Chrysene	-	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
Dibenz(a,h)anthracene	-	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
Fluoranthene	**0.00004**	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
Fluorene	**0.003**	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
Indeno(1,2,3-c,d)pyrene	-	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
Naphthalene	**0.0011**	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
Phenanthrene	**0.0004**	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
Pyrene	**0.000025**	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
Quinoline	**0.0034**	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
Total PAHs	-			<0.00021	<0.00021	<0.00021	<0.00021	<0.00021	<0.00021

[a] *Canadian water quality guidelines for the protection of freshwater aquatic life, Canadian Council of Ministers of the Environment.*