

# BULLMOOSE AREA MINE SITES NWT UPDATED REMEDIAL ACTION PLAN

## Executive Summary

Public Works and Government Services Canada (PWGSC) is assisting in the compilation and contracting requirements for the Bullmoose Area Mine Sites project on behalf of Aboriginal Affairs and Northern Development Canada (AANDC). During the 2012/13 Fiscal Year, EBA Engineering Consultants Ltd. (EBA) finalized a Remedial Action Plan (RAP) for a cluster of 7 mine/exploration sites located north of Great Slave Lake. The seven sites are: 1) Ruth Mine, 2) Bullmoose Mine, 3) Beaulieu Mine, 4) Spectrum Mine, 5) Chipp Mine, 6) Joon Mine, and 7) Storm Mine. The cluster of sites has been referred to as the Bullmoose Area Mine Sites. The project area consists of seven abandoned mine sites within a 20 km radius, in the Taiga Shield region of the Northwest Territories (NT). The individual mine sites are between 60 and 90 km east of Yellowknife, NT.

Stantec completed risk assessment peer reviews and conducted a technical review of the RAP as part of a third party review (Review), and completed an initial costing of the EBA RAP. A Terms of Reference (TOR) document was issued on November 18, 2013, by the Northern Contaminated Site Group, Public Works and Government Services Canada, to Stantec Consulting Ltd. (Stantec) to prepare an update report to the EBA RAP (Updated RAP) to address the items identified in the Review. The major items cited in the Review needing to be addressed were:

- Risks are not fully described for the option of covering waste rock and leaving it in place, as part of the evaluation of Acid Rock Drainage (ARD) potential, and should be revisited.
- The potential for on-site phytoremediation to address soil impacts (both co-contaminated [metals plus PHCs] as well as PHCs only) should be considered.
- Potential for a wetland approach to mitigate runoff/transport of metals should be considered for Areas of Environmental Concern (AECs) with identified impacts proposed to be left in place and monitored, and for AECs with residual risks after removal of impacts.

Subsequently, Stantec undertook completion new Preliminary Quantitative Risk Assessments (PQRAs) for the Bullmoose, Ruth, Spectrum and Beaulieu Mine sites, the results of which have been included in this report. The TOR for the Updated RAP had one amendment issued, on October 8, 2014, calling for this Updated RAP report to be able to serve as a stand-alone document by summarizing all remedial options analyzed and recommended. In addition, a field reconnaissance was undertaken in September, 2014, to ascertain the extent of recent fire damage to the Sites. The PQRA results have been reflected in the remedial options analysis (ROA) updated for the seven Sites waste streams, resulting in the recommendation to not remediate impacted sediment areas and instead monitor, except where sediments are co-located with impacted soils recommended for removal. In addition, site-specific target levels (SSTLs) have been defined for the contaminants of concern (COCs) for Ruth Mine [As: 75 mg/kg], Bullmoose Mine [As: 90 mg/kg, Ni 95 mg/kg], and Beaulieu Mine [As: 82.5 mg/kg, Hg 12 mg/kg]. Lastly, remedial options were worked out with the Yellowknives Dene First Nation (YKDFN) in February, 2015.

The recommended remedial options for the seven Sites waste streams are as follows:

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**Bullmoose Area Mine Sites Recommended Remedial Options**

Waste Stream	Recommended Remedial Options <sup>(1)</sup>						
	Ruth	Bullmoose	Beaulieu	Spectrum	Chipp	Storm	Joon
<b>Physical Hazards (PH):</b>							
PH-Shafts	E1	E1	E1	E1	E1	-	-
PH-Vents	-	E1	-	-	-	-	-
PH-Portals	-	D2	-	-	-	-	-
PH-Trenches	D2	D2	D2	D1/D2	D1	D1	D1
PH-Buildings	B2	B2	B2	B2	B2	B2	B2
<b>Non-hazardous Waste (NhW):</b>							
NhW-Wood	C1	C1	C1	C1	C1	C1	C1
NhW-Other	B2	B2	B2	B2	B2	B2	B2
<b>Hazardous Waste (HW):</b>							
HW-Asbestos	A1	A1	-	A1	-	-	-
HW-Organic liquids	A1	-	A1	A1	-	-	A1
HW-Leach. lead paint	A1	-	-	A1	A1	A1	A1
HW-Press. Cylinders	B1	-	-	B1	-	-	B1
HW-Other	-	A1	A1	A1	-	A1	A1
Sediments <sup>(2)</sup>	F1	F1/B3/F2	-	F1	-	-	F1
Tailings <sup>(3)</sup>	B3	B3+E2/F1	B3	B3	-	-	-
Waste Rock <sup>(4)</sup>	B3	B3/C3	B4	B4	B4	B4	B4
<b>Soils:</b>							
Soils-Metals & PHCs <sup>(5)</sup>	B3	B3	B3	B3	G	G	B3
Soils- PHCs <sup>(5)</sup>	-	C3	C3	C3	-	-	C3
Water <sup>(6)</sup>	-	F1/C4	-	C4	C4	-	-

Notes 1. Remedial Option codes are as follows:

A1	HW-Off-site disposal	B4	Waste Rock-As backfill & leave rest	D1	Backfill: proximal material
A2	NhW-Off-site disposal	B5	Waste Rock-landfill on-site	D2	Backfill: site waste rock
A3	Soil/Sediment/Tailings-Off-site disposal	B6	Waste Rock-Leave on-site and Monitor	E1	Engineered cap & fill
A4	Water-Off-site disposal	C1	Wood-On-site burn	E2	Engineered cover
B1	HW-On-site disposal	C2	Organic Liquids-On-site incineration	F1	Annual-5-yr-monitoring
B2	NhW-On-site disposal	C3	PHC Soil-On-site treatment	F2	Specific monitoring
B3	Soil/Sediment/Tailings -On-site disposal	C4	Water-On-site treatment		

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2. Details by site AEC/APEC for sediments (refer to Figures at Appendix E for numbering of reference locations of AECs/APECs):

Site	AEC/ APEC	Description	Remedial Option
Ruth	14	Tam Lake New Camp and Old Camp: from overland transport of tailings and/or atmospheric deposition of tailings dust. Depth unknown.	F1 – Annual 5-yr monitoring for Hg and As.
Bullmoose	13	(a) Bullmoose Lake: Sediment and precipitating metals originating from Bullmoose portal wetland. (b) Bullmoose Alpha Lake: Unknown source, may be natural elevated Hg conditions from regional deposition. (c) Bullmoose Doodad Lake: Unknown source, may be natural elevated Hg conditions from regional deposition. (d) Bullmoose Budd Lake: Unknown source, may be natural elevated Hg conditions from regional deposition.	F1 – Annual-5-yr-monitoring. (a) Bullmoose Lake COC: As; Approx. area = 1,800 m <sup>2</sup> ; Approx. volume = 270 m <sup>3</sup> . (b) Bullmoose Alpha Lake: COCs: Hg, pH; Approx. area = 8,500 m <sup>2</sup> ; Approx. volume = 3,500 m <sup>3</sup> . (c) Bullmoose Doodad Lake: COC: Hg; Approx. area = 7,000 m <sup>2</sup> ; Approx. volume = unknown. (d) Bullmoose Budd Lake: COC: Hg; Approx. area = unknown; Approx. volume = unknown.
	14	Bullmoose Creek: Seepage from portal contributes to arsenic levels, waste rock in creek bed, runoff from waste rock next to creek.	B3 – Sediments on-site landfill disposal. COCs: As, Hg, Zn, F2, F3; Approx. area = 315 m <sup>2</sup> ; Approx. volume = 63 m <sup>3</sup> .
	7	Bullmoose Portal Wetland: Precipitation of metals-impacted water flowing from portal entrance.	F2 – Specific monitoring. COCs: As, Fe, Mn; Approx. area = 302 m <sup>2</sup> ; Approx. volume = 176 m <sup>3</sup> .
	9	Bullmoose Sewage Lagoon: Unknown source, possible from mining related activities.	B3 – Sediments on-site landfill disposal. COCs: As, Hg; Approx. area = 1,600 m <sup>2</sup> ; Approx. volume = 500 m <sup>3</sup> .
Spectrum	Lake	Sediments: Arsenic and mercury related to historic mining activities (tailings possibly).	F1 – Annual 5-yr monitoring for Hg and As. Approx. area = 5,200 m <sup>2</sup> , Approx. volume = 1,300 m <sup>3</sup> .
Joon	Unm.	Sediments: Lead possibly from mining related activities.	F1 – Annual 5-yr monitoring for Pb. Approx. area = 100 m <sup>2</sup> , Approx. volume = unknown.

3. Details by site AEC/APEC for tailings (refer to Figures at Appendix E for numbering of reference locations of AECs/APECs):

Site	AEC/ APEC	Description	Remedial Option
Ruth	10	Small tailings area south of assay building.	B3 – Tailings on-site landfill disposal; full volume of 160 m <sup>3</sup> included with co-impacted soils.
	11	Tailings area and surrounding dispersed tailings.	B3 – Tailings on-site landfill disposal; full volume of 1,500 m <sup>3</sup> included with co-impacted soils.
Bullmoose	23	Beta Lake Impoundment, exposed tailings: Exposed tailings covered with waste rock, precipitated sulphur salts accumulating at surface.	B3+E2 – Engineered cover after excavation and landfill disposal of upper 0.3m. COCs: Cr, S (salts); Approx. area = 1,050 m <sup>2</sup> , Approx. volume = 315 m <sup>3</sup> .
	23	Beta Lake Impoundment, submerged tailings.	F1 – Annual-5-yr-monitoring. COC: Cr, Cu, Cd, (in top 5 cm only); Approx. area = 6,900 m <sup>2</sup> , Approx. volume = unknown.
	10	Skeeter Lake, submerged tailings.	F1 – Annual-5-yr-monitoring. COC: Cr; Approx. area = 48,500 m <sup>2</sup> , Approx. volume = unknown.
Beaulieu	5	Tailings.	B3 – On-site disposal at Bullmoose. COCs: As, Cr, Cu, Hg; Approx. area = 4,000 m <sup>2</sup> , Approx. volume = 1,600 m <sup>3</sup> .
Spectrum	1	Tailings.	B3 – On-site disposal at Bullmoose. COCs: Cr, Cu, Hg; Approx. area = 1,250 m <sup>2</sup> , Approx. volume = 250 m <sup>3</sup> .

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4. Details by site AEC/APEC for waste rock (refer to Figures at Appendix E for numbering of reference locations of AECs/APECs):

Site	AEC/ APEC	Description	Remedial Option
Ruth	Var.	Moderate potential for leaching of metals.	B3 – On-site disposal. Of the estimated 805 m <sup>3</sup> of waste rock, 640 m <sup>3</sup> is included with co-impacted soil volumes. For the remaining 165 m <sup>3</sup> , remedial option E2 Engineered Cover, risk-based, i.e., in areas with proximity to surface water drainage, applies.
Bullmoose	18	Waste rock used as a source of cover during the 1988 site remediation is known to have metal leaching potential for a number of contaminants, including As and Cr - classified as non-acid generating. Used throughout site.	E2 – Engineered cover, risk-based, i.e., in areas with proximity to surface water drainage.
	18	Waste rock located in three areas: Bullmoose Portal Area (mixed with sediment), Bullmoose Creek Area (mixed with sediment), Bullmoose Lake Area.	G – No action. Waste rock co-located with co-impacted soils in the Creek to be addressed through soil removal. Waste rock in Portal and Lake to be left in place.
Beaulieu	1	Waste Rock: potential to produce acid rock drainage or metal-rich effluent; however limited volume and located away from surface water and/or sensitive receptors.	B4 – Waste rock-as backfill and leave rest in place. Approx. area = 1,095 m <sup>2</sup> , Approx. volume = 2,036 m <sup>3</sup> .
Spectrum	Var.	Waste Rock: potential to produce acid rock drainage or metal-rich effluent; however limited volume and located away from surface water bodies and/or sensitive receptors.	B4 – Waste rock-as backfill. Approx. area = 223 m <sup>2</sup> , Approx. volume = 46 m <sup>3</sup> .
Chipp	Var.	Waste Rock: Potential to produce acid rock drainage or metal-rich effluent; however limited volume and located away from surface water bodies and/or sensitive receptors.	B4 – Waste rock-as backfill. Approx. area = 138 m <sup>2</sup> , Approx. volume = 69 m <sup>3</sup> .
Storm	Var.		B4 – Waste rock-as backfill. This accounts for 33 m <sup>3</sup> of the estimated 81 m <sup>3</sup> of material. For the remainder, E2 – Engineered cover, risk-based, i.e., in areas with proximity to surface water drainage.
Joon	Var.		B4 – Waste rock-as backfill. 275 m <sup>2</sup> area.

5. Details by site AEC/APEC for soils (refer to Figures at Appendix E for numbering of reference locations of AECs/APECs):

Site	AEC/ APEC	Description	Remedial Option
Ruth	1-9/ 17/ 20- 22/ 25	Soil Impacts - Co-contaminated (metals + PHCs): Throughout Site (4 locations)	B3 – On-site disposal. Estimated 5985 m <sup>3</sup> of material.
Bullmoose	Var.	Soil Impacts - Co-contaminated (metals + PHCs): Mill Area, Warehouse Area (3 soil locations); Lay Down Area (6 soil locations); Fuel Storage Area (2 soil locations); Former Maintenance Area (7 soil locations).	B3 – On-site disposal. Mill Area (COCs: F2-F4, As, Cr, Co, Pb, Mo, Se): approx. volume = 237 m <sup>3</sup> ; Warehouse Area (3 soil locations; COCs: F3, F4, As, Cr, Ni): approx. volume = 427 m <sup>3</sup> ; Lay Down Area (6 soil locations; COCs: F3, F4, As, Cr, Co, Ni, Mo, Pb, Se): approx. volume = 30 m <sup>3</sup> ; Fuel Storage Area (2 soil locations; COCs: F3, F4, As, Cr, Ni): approx. volume =

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			10 m <sup>3</sup> ; Former Maintenance Area (7 soil locations; COCs: F2, F3, As, Cr, Cu, Ni): approx. volume = 97 m <sup>3</sup> .
	Var.	Soil Impacts - PHCs only: Former Tank Farm Area; Fuel Storage Area (5 soil locations); Former Maintenance Area; New Camp.	C3 – PHC Soil-On-site treatment. Former Tank Farm Area (COCs: F2, F3): approx. volume = 558 m <sup>3</sup> ; Fuel Storage Area (5 soil locations; COCs: F2-F4): approx. volume = 560 m <sup>3</sup> ; Former Maintenance Area (1 soil location; COCs: F2, F3): approx. volume = 249 m <sup>3</sup> ; New Camp (COCs: F3, F4): approx. volume = 5 m <sup>3</sup> .
Beaulieu	Var.	Soil Impacts - Co-contaminated (metals + PHCs): Throughout site (8 metal soil locations).	B3 – On-site disposal at Bullmoose. COCs: F3, F4, As, Cr, Hg, Ni, Zn): approx. volume = 195 m <sup>3</sup> .
	Var.	Soil Impacts - PHCs only: Central and south of site (3 soil locations; Southeast of site (2 soil locations).	C3 – PHC Soil-on-site treatment at Bullmoose. Central and south of site; COCs: F2, F3, F4: approx. volume = 4 m <sup>3</sup> ; Southeast of site; COCs: F2, F3, F4, benzene; approx. volume = 25 m <sup>3</sup> .
Spectrum	Var.	Soil Impacts - Co-contaminated (metals + PHCs): Throughout site (19 soil locations). East of shaft and area with 12 drums (2 soil locations).	B3 – On-site disposal at Bullmoose. Throughout; COCs: As, Cr, Hg, Cu, Ni, Pb, Zn; approx. volume = 20 m <sup>3</sup> . East of shaft and area with 12 drums; COCs: F1-F3, Ni, Ba; approx. volume = 6 m <sup>3</sup> .
	Var.	Soil Impacts - PHCs only: East of trench (1 soil location).	C3 – PHC Soil-On-site treatment at Bullmoose. East of trench; COCs: F1-F3): approx. volume = 1 m <sup>3</sup> .
Chipp	1B, 1D, 1F	Soil Impacts - Co-contaminated (metals + PHCs): By Trenches and Waste Rock (3 soil locations).	G – No action. COCs: Cu, Ni, Se: approx. volume = 3 m <sup>3</sup> .
Storm	1B, 1C, 2	Soil Impacts - Co-contaminated (metals + PHCs): Throughout the site (3 soil locations).	G – No action. COCs: Cr, Cu, Ni: approx. volume = 5 m <sup>3</sup> .
Joon	1A, 6D, 7A, 7E	Soil Impacts - Co-contaminated (metals + PHCs): Throughout Site by Strike Lake; By Unnamed Lake (2 soil locations).	B3 – On-site disposal at Ruth. Throughout Site by Strike Lake (COCs: As, Cu, Ni): approx. volume = 11 m <sup>3</sup> ; By Unnamed Lake (COCs: Cu, Ni): approx. volume = 2 m <sup>3</sup> .
		Soil Impacts - PHCs only: Trenches and Strike Lake.	C3 – PHC Soil-on-site treatment at Bullmoose. Trenches and Strike Lake (COC: F2): approx. volume = 1 m <sup>3</sup> .

6. Details by site AEC/APEC for water (refer to Figures at Appendix E for numbering of reference locations of AECs/APECs):

Site	AEC/APEC	Description	Remedial Option
Bullmoose	7	Portal Seep.	F2 – Specific monitoring requiring design.
	14	Metals - Impacted Water: Bullmoose Creek.	C4 – Water-On-site treatment. COCs: Al, As, Cd, Cr, Cu, Fe, Pb, Zn; Approx. volume unknown.
Spectrum	Var.	Metals - Impacted Water: Mine shaft and trench.	C4 – Water-On-site treatment. COCs: Al, As, Cd, Cr, Cu, Fe, Pb, Hg, Ni, Se, Zn; Mine shaft: approx. volume = 12 m <sup>3</sup> , Trenches: approx. volume = 20 m <sup>3</sup> .
Chipp	1A, 1F	Metals - Impacted Water: Mine shaft and trenches.	C4 – Water-On-site treatment. COCs: Al, As, Cd, Cu, Fe, Pb, Hg, Ag; Mine shaft: approx. volume = 10 m <sup>3</sup> , Trenches: approx. volume = 10 m <sup>3</sup> .

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Updates to site impacts, remedial options analysis, recommended remedial options, and remedial actions have been tabulated in a series of Excel worksheets, which form tables in Appendix A of the report. In addition, uncertainties in the estimates of impacted material volumes were produced, on the basis of the relative spatial density of sample result information – this information has been listed along with updated impacted material volumes, and has been used to inform the cost estimate prepared for the RAP (reported separately).

Environmental protection measures, geotechnical considerations, a verification program, and short- and long-term monitoring program recommendations round out the RAP.