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REPORT

Influence of Forest Fires on Legacy Seismic Line Regeneration and on Caribou Habitat Restoration Treatment in Wetland Habitats.

Development of Study Design

Submitted to:

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March 21, 2019

Distribution List

1 Electronic Copy - Petroleum Technology Alliance Canada

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Table of Contents

1.0 BACKGROUND 1

2.0 STUDY DESIGN DEVELOPMENT METHODS 1

2.1 Site Identification 1

2.2 Preliminary Scouting Program 2

3.0 RESULTS 6

3.1 Study Design - Sites 6

3.2 Data to be Collected 6

4.0 DISCUSSION 8

5.0 REFERENCES 10

TABLES

Table 1: Data collection variables 7

FIGURES

Figure 1: 2018 Field Scouting Survey Locations and Potential 2019 Monitoring Sites 3

APPENDICES

APPENDIX A
2018 Field Scouting Information and Photos

1.0 BACKGROUND

Golder Associates Ltd. (Golder), in association with the Canadian Forest Service (CFS) of Natural Resources Canada, is looking to investigate fire's influence on the vegetation recovery of legacy seismic lines through transitional wetland and wetland sites, as it relates to caribou habitat restoration treatments. The key question is to understand if the vegetation trajectory of untreated seismic lines has been "reset" as a result of fire, as it relates to restoration. The main aspects to be investigated include the response of treated (i.e., mounded and planted with black spruce) restoration sites to fire, versus untreated burned linear segments, versus treated and unburned linear segments. Early field observations on previously Canadian Natural Resources Ltd. (Canadian Natural) treated sites suggest that mounding, and fire, may influence vegetation species recovery on an expedited trajectory in comparison to burned lines in the absence of mounding. The CFS has also been examining seismic line response to fire, and had similar observations regarding vegetation species recovery, which has led to a collaboration.

CFS has investigated vegetation reestablishment on seismic lines influenced by fire, but not on seismic lines where caribou habitat restoration treatments had been applied or specifically in wetland locations. This collaboration would tie into related studies being conducted by the CFS to model the risk of forest fire to restoration sites (COSIA) with an ecosystem approach (e.g., soil biota/community) to what happens after fires and restoration site preparation. Study sites are in northeastern Alberta, from the Cold Lake Air Weapon Range (CLAWR), north and west where in-situ oil sands development occurs.

Phase I of the study involved the development of a scientifically-defensible and statistically-sound study design which is the focus of the 2018-19 funding cycle. Phase II of the study would involve implementing the study design, collecting field data, and analyzing and reporting on the results. Phase II has been submitted as a letter of intent to the Alberta Upstream Petroleum Research Fund (AUPRF) of Petroleum Technology Alliance of Canada (PTAC) to continue work begun in 2018 through the 2019-2020 funding cycle. This report focuses on the Phase I study design aspect of the overall project.

2.0 STUDY DESIGN DEVELOPMENT METHODS

Golder and CFS initiated the study design process in August 2018, through a kick-off meeting to discuss previously collected data by both organizations, and to determine the next steps forward. Through this discussion, CFS identified 2018 data that had been collected within Canadian Natural Resources Limited (CNRL) Kirby's lease, on mounded and untreated sites, mainly in wetlands (5 treated and 5 untreated plots). Additionally, Golder presented linear restoration programs and monitoring sites within the Canadian Natural CLAWR site, which included 2011 – 2014 treatments, 2011 – 2013 summer planting, 2014 winter planting and 21 monitoring plots established along treated lines. The steps forward included identification of potential sampling sites, coordination on a preliminary scouting design and development of the study design, in both sampling site locations and site and vegetation data variables to be collected.

2.1 Site Identification

The initial site selection process completed in a GIS system using available data, by:

- Itemizing treated lines with associated/adjacent ecosite phase calls
- Eliminating upland areas and focusing only on wetland line segments
- Identifying treated segments within the Alberta Agriculture and Forestry spatial wildfire data (AAF 2018)

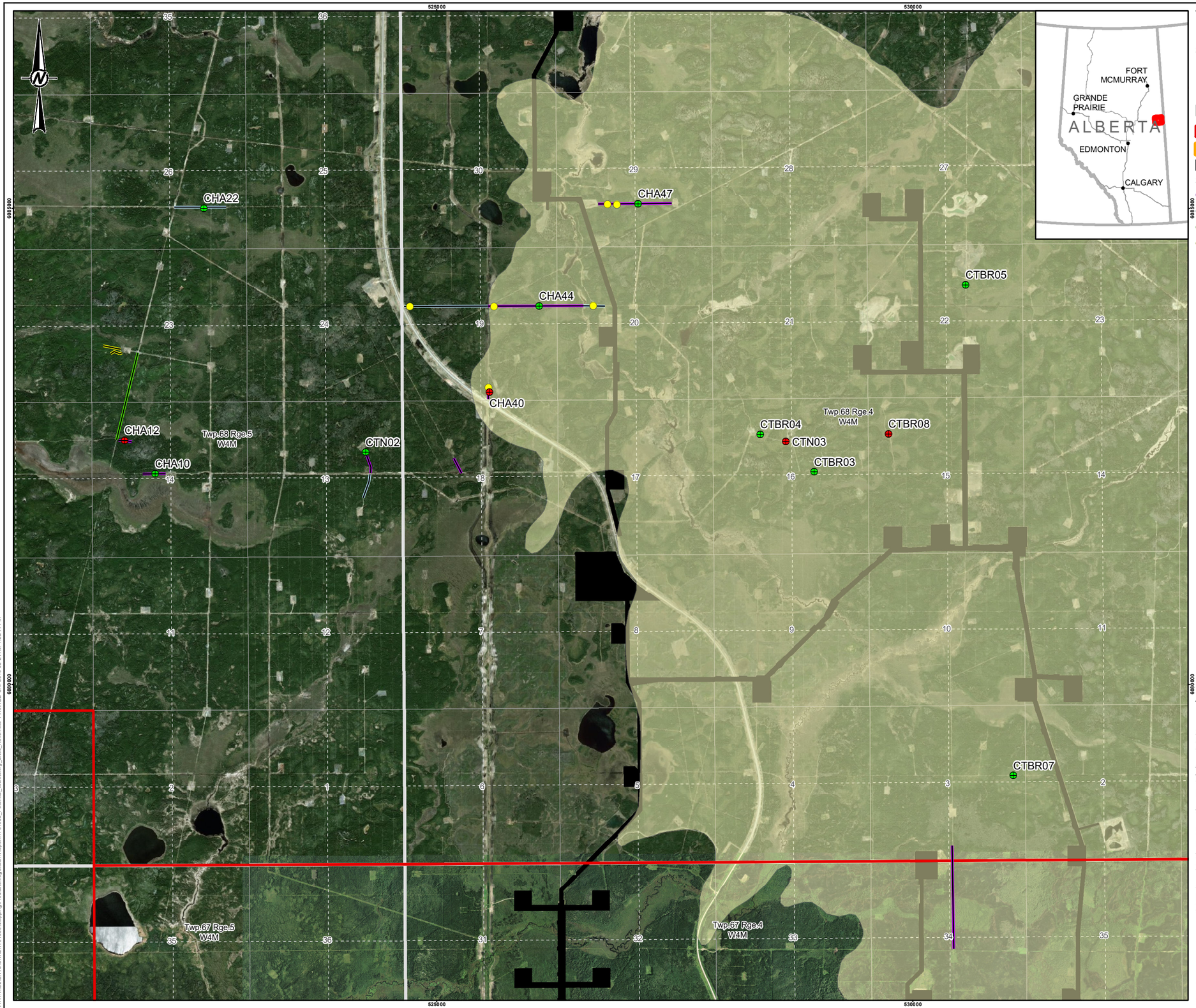
Potential sites to be scouted during the field program would be visited to identify appropriate plot locations for treated/burned, untreated/burned, treated/unburned and untreated/unburned data collection with sufficient replication. Monitoring plot data, linear treatment data and spatial map data (i.e., ecosite phase mapping, linear treatment/monitoring plot locations, fire boundary) were shared with CFS and uploaded to an iPad to assist with field scouting.

2.2 Preliminary Scouting Program

The field scouting program occurred on October 4 to October 6, 2018 and was completed by Caitlin Parker, a Golder biologist, and Dr. Jaime Pinzon a CFS research scientist. Prior to completing any field work, the crew eliminated any sites that were upland and/or if treatment involved tree felling or solely planting. This, in addition to the initial site selection process, allowed the team to identify approximately 30 sites to be visited. The sites to visit were targeted to evaluate their accessibility and suitability for establishing a monitoring plot location for future data collection.

Data collected in the preliminary scouting included:

- location coordinates (UTMs);
- confirmation of forest fire/burn;
- determining burn intensity;
- confirmation of restoration treatment;
- observation of dominant species composition (including tree species present and understorey species as identifiable in fall); and
- photos and general notes (e.g., game trails).



LEGEND

- 2014 - 2015 MONITORING PLOT

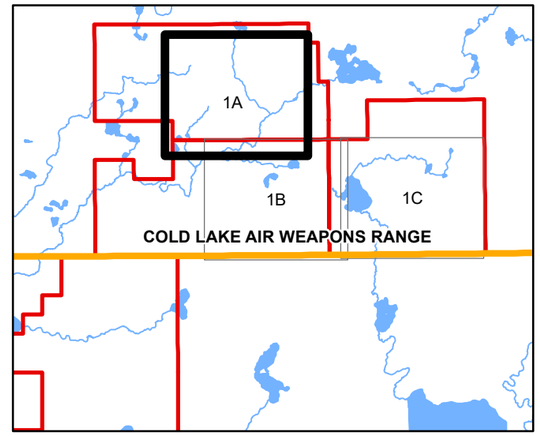
2018 FIELD LOCATIONS

POTENTIAL MONITORING SITE

- NO
- YES
- 2015 WILDFIRE BOUNDARY
- CANADIAN NATURAL PRIMROSE AND WOLF LAKE LEASE BOUNDARY
- COLD LAKE AIR WEAPONS RANGE
- PRIMROSE AND WOLF LAKE PROJECT DISPOSITION

2014 TREATMENT TYPE

- MOUNDING AND PLANTING
- MOUNDING, TREE BENDING, TREE FELLING AND PLANTING
- PLANTING
- SLASH ROLL BACK



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CLIENT

PETROLEUM TECHNOLOGY ALLIANCE CANADA (PTAC)

PROJECT

STUDY DESIGN TO INVESTIGATE INFLUENCE OF FOREST FIRES ON LEGACY SEISMIC LINE REVEGETATION IN AREAS WITH CARIBOU HABITAT RESTORATION TREATMENTS

TITLE

2018 FIELD SCOUTING SURVEY LOCATIONS AND POTENTIAL MONITORING SITES

CONSULTANT

GOLDER

YYYY-MM-DD	2019-02-06
DESIGNED	VC
PREPARED	PS
REVIEWED	VC
APPROVED	CD

PROJECT NO.	CONTROL	REV.	FIGURE
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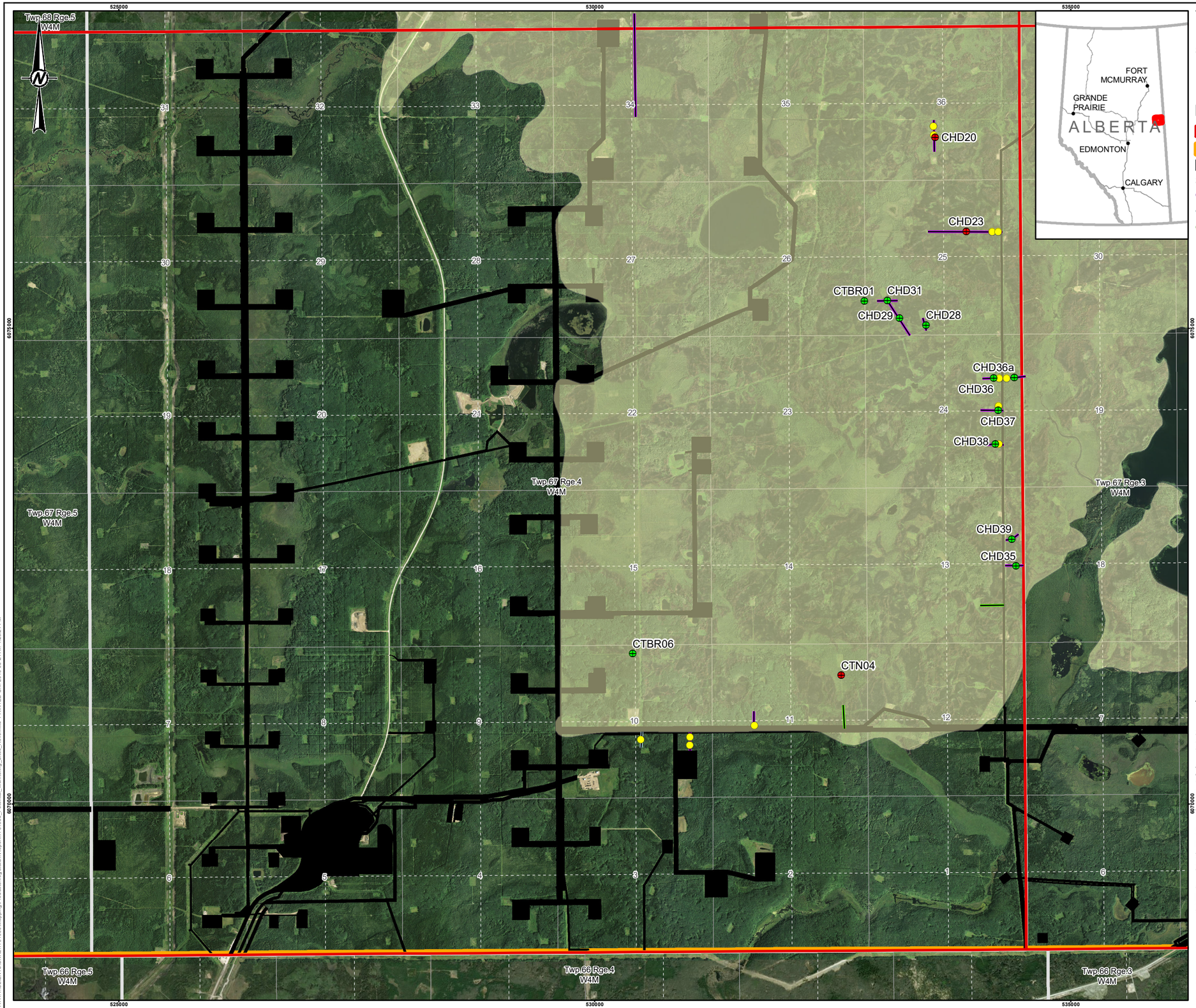

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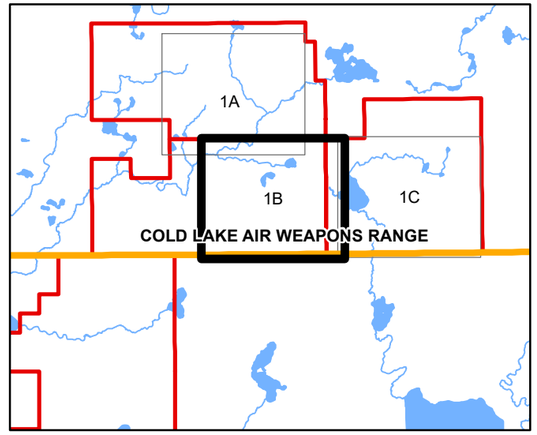
2014 TREATMENT TYPE

- MOUNDING AND PLANTING
- MOUNDING, TREE BENDING, TREE FELLING AND PLANTING
- PLANTING



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PETROLEUM TECHNOLOGY ALLIANCE CANADA (PTAC)

PTAC PETROLEUM TECHNOLOGY ALLIANCE CANADA

PROJECT

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APPROVED	CD

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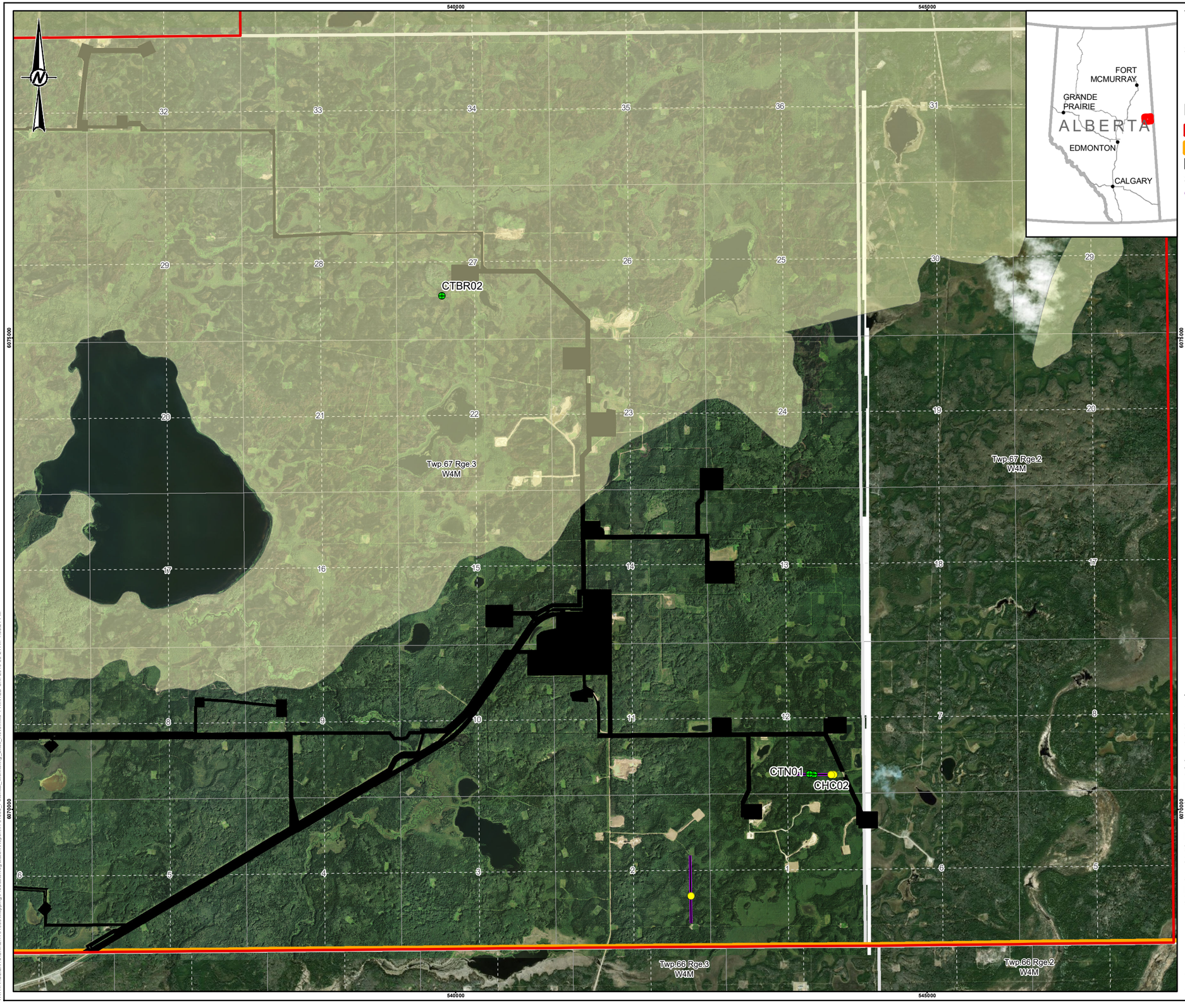

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REVIEWED	VC
APPROVED	CD

PROJECT NO.	CONTROL	REV.	FIGURE
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3.0 RESULTS

3.1 Study Design - Sites

Based on initial observations, the field scouting program was able to identify a number of potentially suitable monitoring locations and helped eliminate a number of unsuitable sites. Basic information from all sites visited in the 2018 field scouting program and representative photos from selected sites are provided in Appendix A.

The preliminary scouting program identified:

- 10 treated/burned sites;
- 7 no treatment/burned sites;
- 4 treated/no burn sites; and
- 2 no treatment/no burn sites.

The treated/no burn and no treatment/no burn do not have sufficient replicate numbers for a balanced sample design based on sites identified during the October 2018 field program. One of the four treated/no burn sites may yet need to be removed as a candidate, as the mounds have subsided and are no longer distinguishable. Data collected by CFS teams at the CNRL Kirby site may need to be used for comparison purposes. Treatment lines were the focus of the October 2018 field crew followed by no treatment/burned. Additional no treatment/no burn sites may be located during the initiation of the proposed 2019 field program, or 2018 data collected by CFS at the CNRL Kirby site may be used.

Sites were generally considered unsuitable for this study purpose when the intensity of the forest fire/burn resulted in patchy area with residual unburned vegetation (i.e., they were not fully burned or unburned), if they were confirmed to be upland sites, if the treated segment was too short (<25 m wetland), or if the ecosite did not have a similar canopy cover. As such, six wetland treated lines visited in October 2018 could not be considered as candidate sites due to unsuitability due to one of these described conditions.

3.2 Data to be Collected

Data to be collected in the proposed 2019-2020 scope of work will include environmental site data, basic soil data and vegetation data, including both off and on treatment mounds, and on and off seismic lines. Table 1 summarizes the key variables to be collected at each site.

Table 1: Data collection variables.

Data Type	Variable to Collect	Notes
Environmental Data	Volumetric moisture	Measured at 12 cm below ground surface with Time Domain Reflectometer (TDR) device
	Temperature	Measured at 12 cm below ground surface, at ground surface, ambient air
	pH	Substrate
	Coarse woody material volume	Using methods based on either a transect/intercept method or a plot-based inventory method.
	Mound characteristics	Height, diameter/radius, etc., as applicable
	Depth to water table	As ground disturbance protocol allows
	Burn intensity	Relative scale/ranking
	Microtopography	Measured using terrestrial 3-D laser scanner/mapper tool (as CFS budget allows)
	Light level/exposure	Relative scale/ranking
Vegetation Data	Percent cover by species for vascular plants	Trees, shrubs, forbs, graminoids
	Percent cover by genus for non-vascular plants	Moss, liverwort and lichens
	Percent surface cover	Groundcover (e.g., water, exposed/bare soil, rock, litter, etc.)
	Percent cover by strata	Total percent cover for trees, shrubs, forbs, graminoids, bryophytes, lichens
	Planted seedling information by species	Height, growth, health
	Ingress seedling information by species	Number/count, height

Data will be collected such that the following factors of interest can be compared:

- Burned versus unburned sites
- Mounded/treated seismic lines versus untreated seismic lines versus surrounding forest
- Seismic lines versus surrounding forest
- Mounded/treated versus off-mound but treated

Based on the selection of sites and data to be collected, this would allow for the analysis of several sets of samples with the following potential lines of investigation:

1) M1 – Lines only -> Fire + Treatment (Mounding and seedling planting)
2) M2 – Treated lines and adjacent forest -> Fire + Treatment
3) M3 – Treated lines only -> Fire + Off/On Mound

4.0 DISCUSSION

Based on the development of the study design, 2019 work proposes to continue the collaboration with the CFS in the collection of relevant vegetation and environmental site data from the selected research sites. Data collected will then be entered digitally, a database will be developed and will form the basis for the statistical analysis and reporting to meet the overall study objectives. The intent of the analysis is to address the key question, which is if the vegetation trajectory of untreated seismic lines have been "reset" as a result of fire, as it relates to restoration. Analysis of the data would look to identify the response of treated (i.e., mounded and planted with black spruce) restoration sites to fire versus untreated burned linear segments, versus treated and unburned linear segments within wetland sites.

Golder has submitted a letter of intent (Stage II) to the AUPRF PTAC to continue work begun in 2018 through the 2019-2020 funding cycle. Pending approval of the funding, the field program of Phase II is anticipated to begin in July 2019. Field data collation, analysis and reporting would be completed between August 2019 and March 2020.

Signature Page

We trust this meets your needs and requirements. The report was authored by Golder, with study design development, input and review provided by Drs. Anna Dabros and Jaime Pinzon with Natural Resources Canada, Canadian Forest Service.

Golder Associates Ltd.

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Senior Terrestrial Ecologist

Corey De La Mare, P.Biol.
Principal, Senior Senior Biologist

VC/PB/pls

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APPENDIX A

2018 Field Scouting Information and Photos

Site ID	Burned	Treated	Monitoring Site	Lat	Long	Fire on line	Dominant veg. on line	Tree species at line	Fire Severity	Forest burned	Dominant veg. forest
CHD20	Yes	Yes	No	54.839067°	-110.477240°	No	not a good line, very few burned trees and quite patchy				
CHD23	Yes	Yes	No	54.830125°	-110.472216°	No	not a good line, quite dry with patches of pine, short distance to wetland and too close to the main pipeline				
CHD28	Yes	Yes	Yes	54.821344°	-110.478959°	Little	willows, sedges/grass	black spruce, pine	Medium	Yes	sedges, bog birch, poplars, black spruce, pine
CHD29	Yes	Yes	Yes	54.822002°	-110.483232°	Little	willows, labrador tea, sedges/grass	birch, poplars, black spruce, larch, pine	Medium	Yes	willows, labrador tea, sedges/grass
CHD31	Yes	Yes	Yes	54.823665°	-110.485212°	Little	labrador tea, sedges/grass	pine, black spruce, poplars	Medium	Yes	labrador tea, willows, sedges/grass
CHD36	Yes	Yes	Yes	54.816255°	-110.467924°	No	willows	black spruce, poplars, larch	No	No	larch
CHD36A	Yes	Yes	Yes	54.816306°	-110.464543°	No	willows	black spruce, poplars, larch	No	No	larch
CHD37	Yes	Yes	Yes	54.813200°	-110.467241°	No	sedges/grass, willows	black spruce, pine, larch, poplars	Low-Medium	Partly	willows, sedges/grass
CHD38	Yes	Yes	Yes	54.810043°	-110.467775°	Little	willows, aspen, sedges/grass	black spruce, pine, larch	Medium	Yes	black spruce, poplars, sedges/grass
CHD39	Yes	Yes	Yes	54.801021°	-110.465192°	Little	willows, sedges/grass	black spruce	Low	Yes	Black spruce, pine, labrador tea
CHA40	Yes	Yes	No	54.894004°	-110.601575°	No	not a good line, mostly dry (wet portion too short), too close to road and pipe line				
CHA44	Yes	Yes	Yes	54.902130°	-110.593378°	No	sedges/grass, bogbirch, willows	larch, black spruce, pine	Medium	Yes	bogbirch, labrador tea, little regen (poplars, spruce, pine)
CHA47	Yes	Yes	Yes	54.911736°	-110.577072°	Little	labrador tea, sedges/grass, willows	pine, black spruce, poplars	Medium	Yes	labrador tea, pine
CTBR01	Yes	No	Yes	54.823642°	-110.488980°	No	sedges/grass, bogbirch, willows, labrador tea	black spruce, pine, poplars	Medium	Yes	black spruce, larch, pine
CTBR02	Yes	No	Yes	54.824548°	-110.379668°	No	sedges/grass, willows	no regen	Medium	Yes	bogbirch, sedges/grass, labrador tea, willows, black spruce
CTBR03	Yes	No	Yes	54.886308°	-110.548474°	Little	sedges/grass, bogbirch, willows	no regen	Medium	Yes	bogbirch, willows, labrador tea, poplars, black spruce, pine
CTBR04	Yes	No	Yes	54.889861°	-110.557284°	No	sedges/grass, bogbirch, willows	no regen	Low	Yes	sedges/grass, black spruce, pine, bogbirch, labrador tea
CTBR05	Yes	No	Yes	54.903882°	-110.523475°	No	sedges/grass, willows	black spruce, pine, poplars	Low	Yes	labrador tea, willows, bogbirch, pine, black spruce
CTBR06	Yes	No	Yes	54.790492°	-110.527254°	No	bogbirch, willows, sedges/grass, labrador tea	pine, black spruce	Low	Yes	willows, bogbirch, labrador tea, pine, black spruce, larch. Short open forest

Site ID	Burned	Treated	Monitoring Site	Lat	Long	Fire on line	Dominant veg. on line	Tree species at line	Fire Severity	Forest burned	Dominant veg. forest
CTBR07	Yes	No	Yes	54.857521°	-110.516239°	No	few veg (sedges/grass, labrador tea, bogbirch, willows)	black spruce, pine	Low	Yes	labrador tea, bogbirch, willows, black spruce, pine
CTBR08	Yes	No	No	54.889859°	-110.536269°	No	not ideal site, poorly burned, low severity				
CHC02	No	Yes	Yes	54.778624°	-110.319058°	na	sedges/grass, willows	black spruce, larch	na	na	larch, black spruce
CHA10	No	Yes	Yes	54.886471°	-110.656412°	na	sedges/grass, willows (mounds not evident)	larch, black spruce	na	na	larch, black spruce, bogbirch, labrador tea
CHA12	No	Yes	No	54.889653°	-110.661413°	na	not a good line, mostly upland and very different from all other sites				
CHA22	No	Yes	Yes	54.911537°	-110.648219°	na	sedges/grass, willows	pine, black spruce	na	na	larch, spruce, willows, bogbirch, labrador tea
CHD35	No	Yes	Yes	54.798517°	-110.464541°	na	sedges/grass (very wet)	most planted trees gone	na	na	sedges/grass, larch, black spruce, bogbirch, (spruce and larch seedlings)
CTN01	No	No	Yes	54.778676°	-110.319763°	na	sedges/grass, willows	no regen	na	na	larch, black spruce, labrador tea, sedges/grass
CTN02	No	No	Yes	54.888415°	-110.621908°	na	willows, bogbirch, sedges/grass, labrador tea	black spruce, larch	na	na	labrador tea, larch, black spruce
CTN03	No	No	No	54.889186°	-110.553119°	na	potential site, small patch of unbuned forest				
CTN04	No	No	No	54.788296°	-110.493207°	na	potential site, unburned within fire perimeter, fire ~150 m. Larch dominated with some spruce				

Photo 1. *CHD28 potential monitoring location (burned/treated).*

Photo 2*. CHD29 potential monitoring location (burned/treated).*

Photo 3. *CHD31 potential monitoring location (burned/treated).*

Photo 4. *CHD36A potential monitoring location (burned/treated). Within fire polygon but minimally burned.*

Photo 5. *CHD37 potential monitoring location (burned/treated).*

Photo 6. *CHD38 potential monitoring location (burned/treated).*

Photo 7. *CHD39 potential monitoring location (burned/treated).*

Photo 8*. CHD44 potential monitoring location (burned/treated).*

Photo 9. *CHD47 potential monitoring location (burned/treated).*

Photo 10. *CTBR01 potential monitoring location (burned/untreated).*

Photo 11. *CTBR02 potential monitoring location (burned/untreated).*

Photo 12. *CTBR03 potential monitoring location (burned/untreated).*

Photo 13. *CTBR04 potential monitoring location (burned/untreated).*

Photo 14*. CTBR05 potential monitoring location (burned/untreated).*

Photo 15. *CTBR06 potential monitoring location (burned/untreated).*

Photo 16. *CTBR07 potential monitoring location (burned/untreated).*

Photo 17. *CHC02 potential monitoring location (unburned/treated).*

Photo 18. *CHA10 potential monitoring location (unburned/treated).*

Photo 19. *CHA22 potential monitoring location (unburned/treated).*

Photo 20*. CTN01 potential monitoring location (unburned/untreated).*

Photo 21. *CTN02 potential monitoring location (unburned/untreated).*

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