BACK RIVER PROJECT

2019 Annual Report for

Water Licence 2AM-BRP1831

Prepared by
Sabina Gold and Silver Corp.

Prepared for
Nunavut Water Board

April 2020

BACK RIVER PROJECT

2019 2AM-BRP1831 Annual Report

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Acronyms

CIRNAC	Crown-Indigenous Relations and Northern Affairs Canada
Inspector	CIRNAC Inspector
KIA	Kitikmeot Inuit Association
The Licence	Water Licence 2BC-BRP1819
MLA	Marine Laydown Area
NIRB	Nunavut Impact Review Board
NU	Nunavut
NWB	Nunavut Water Board
The Project	Back River Project
Sabina	Sabina Gold & Silver Corp.

Executive Summary - English

Sabina Gold & Silver Corp. (Sabina) has filed its Annual Report on its activities during 2019 under Water Licence No. 2AM-BRP1831 (the Licence) issued by the Nunavut Water Board. As set out in Part B Item 2 and Schedule B of the Licence, the report includes information on the following topics:

- Information related to the dikes, dams and structures constructed to withhold water or waste;
- A summary report of Water use, Winter Ice Road activities, dewatering activities, and any updates to the Water and Load Balance results;
- Summaries of geochemical monitoring results, ore stockpile quantities, seepage and runoff monitoring, and waste disposal;
- A list of unauthorized discharges and a summary of follow-up actions taken;
- A summary of Modifications and/or major maintenance work carried out on all Water and Waste-related structures and facilities;
- Monitoring program results and interpretation;
- A summary of any progressive Closure and Reclamation work undertaken;
- An updated estimate of the current restoration liability;
- A summary of any studies requested by the Board that relate to Water use, Waste disposal or Reclamation, and a brief description of any future studies planned
- Any revisions to Management Plans, reports or manuals;
- A summary of actions taken to address concerns or deficiencies listed in the inspection reports and/or compliance reports filed by an Inspector;
- A summary of public consultation/participation, describing consultation with local organizations and residents of the nearby communities, if any were conducted;
- Any other details on Water use requested by the Board by the 1st November of the year being reported.

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ᓴᐲᓇ ᒨᓗ ᐊᒻᒪᓗ ᓴᕕᓕᕆᔨᒃᑯᑦ (ᓴᐲᓇ) ᐊᕐᕌᒍᑕᒫᖅ ᐅᓂᑳᖕᒐᓐᓂᒃ ᑐᓂᓯᓚᐅᖅᑐᑦ ᖃᓄᐃᓕᐅᕐᓂᕆᔭᖏᑦᑕ ᒥᒃᓵᓄᑦ 2019-ᒥᑦ ᒪᓕᒃᓱᒍ ᐃᒪᕐᒧᑦ ᓚᐃᓴᓐᓯ ᓈᓴᐅᑎᖓ 2AM-BRP1831 (ᓚᐃᓴᓐᓯ) ᑐᓂᔭᐅᔪᖅ ᓄᓇᕗᒻᒥ ᐃᒪᓕᕆᔨᒃᑯᑦ ᑲᑎᒪᔨᖏᑦ. ᐅᖃᖅᓯᒪᓂᖓᑐᑦ ᐃᓚᖓᓂᑦ B-ᒥᑦ ᑎᑎᖅᑲᖅ 2 ᐊᒻᒪ ᐃᓚᖓᓂ B–ᒥ ᓚᐃᓴᓐᓯᒥᑦ, ᐅᓂᒃᑳᒥᑦ ᐃᓚᐅᔪᑦ ᑐᑭᓯᐅᒪᔾᔪᑏᑦ ᐱᔾᔪᑎᖃᖅᑐᑦ ᐅᑯᓂᖕᖓᑦ:

- ᑐᑭᓯᒋᐊᕈᑎᒃᓴᑦ ᐅᑯᓄᖓ ᓯᒥᒃᑐᖅᓯᒪᔪᑦ, ᐊᕙᓗᓕᐊᖑᓯᒪᔪᑦ ᐊᒻᒪ ᓴᓇᓯᒪᔪᑦ ᐃᒪᕐᒥᑦ ᐅᕙᓗᓐᓂᑦ ᑯᕕᖅᑕᑯᒥᑦ ᐊᑐᖅᑕᐅᔪᒃᓴᑦ;
- ᑐᑭᓯᒋᐊᕈᑎᒃᓴᑦ ᑐᓴᕈᑎᒃᓴᓕᐊᖅ ᐃᒪᕐᒥᑦ ᐊᑐᓚᐅᕐᓂᕐᒧᑦ, ᐅᑭᐅᒃᑯᑦ ᓯᑯᒃᑯᑦ ᐊᕝᕐᑯᑎᓴᖅ ᐱᓕᕆᐊᑦ, ᐃᒪᐃᔭᐃᓂᕐᒧᑦ ᐱᓕᕆᐊᑦ, ᐊᒻᒪ ᑐᓴᕈᑎᒃᓴᑦ ᐃᒪᕐᒧᓪᓗ ᐅᓯᖃᑦᑕᕐᓂᕐᒧᓪᓗ ᐱᐊᓂᒃᑐᑦ;
- ᓇᐃᓇᖅᓯᒪᔪᑦ ᐅᔭᕋᕐᓂᐊᓂᕐᒧᑦ, ᐅᔭᕋᕐᓂᐊᒐᒃᓴᖅ ᓇᕕᑕᐅᓯᒪᔪᖅ; ᓯᒥᒃᑐᖅᓯᒪᔪᖅ ᓯᒥᒃᑐᖅᓯᒪᑦᑎᐊᕋᓗᐊᒪᖓᑦ ᖃᐅᔨᓴᖅᐸᖕᓂᖅ ᐊᒻᒪ ᕿᕕᖅᑕᖅᕕᒃ;
- ᑎᑎᕋᖅᓯᒪᔪᑦ ᐱᔪᓇᖅᑎᑕᐅᓯᒪᙱᕋᓱᑎᒃ ᑯᕕᓯᓃᑦ ᐊᒻᒪᓗ ᓇᐃᓈᖅᓯᒪᔪᖅ ᖃᐅᔨᒋᐊᒃᑲᓂᕐᓂᐅᔪᑦ;
- ᓇᐃᓇᖅᓯᒪᔪᑦ ᐊᓯᐊᖑᐊᖅᔪᒃᓱᒍ ᐊᒻᒪ/ᐅᖓᕙᓘᓐᓃᑦ ᐊᖏᔪᒻᒪᕆᒃ ᐱᓕᕆᐊᖅ ᑲᒪᒋᔭᐅᔭᕆᐊᖃᓚᐅᖅᑐᖅ ᐃᒪᕐᒧᑦ ᐊᒻᒪ ᑯᕕᖅᑕᖅᕕᒧᑦ ᐱᑉᓱᒍ ᐊᒻᒪ ᐃᓂᖃᖅᕕᐅᔪᑦ;
- ᖃᐅᔨᒋᐊᖃᑦᑕᕐᓂᕐᒥᑦ ᖃᓄᐃᓕᖓᓕᕐᓂᖓ ᐊᒻᒪ ᑐᑭᓕᐅᖅᓯᒪᔪᑦ;
- ᓇᐃᓴᖅᓯᒪᔪᖅ ᖃᓄᐃᓕᐅᕐᓂᐅᔪᖅ ᕿᒪᐃᓂᐊᕐᓂᕐᒧᑦ ᐊᒻᒪ ᓄᓇᒥᒃ ᓴᓗᒪᖅᓴᐃᓂᖅ;
- ᖃᓂᕐᑯᓯᒪᑉᓱᒍ ᐅᒃᑐᕋᐅᓯᖅ ᒪᓐᓇᐅᔪᖅ ᐊᑭᓕᒃᓴᐅᓇᔭᖅᑐᖅ ᓱᕈᖅᓯᒪᔪᒧᑦ;
- ᓇᐃᓇᖅᓯᒪᔪᑦ ᑐᑭᓯᒋᐊᕈᑎᒃᓴᑦ ᑲᑎᒪᔩᑦ ᑐᒃᓯᕋᖅᓯᒪᔭᖏᑦ ᐃᒪᖅ ᐊᑐᖅᑕᐅᕙᓂᖓᓄᑦ; ᐊᒃᑕᑯᕈᓯᖅ ᐅᕙᓘᓐᓃᑦ ᓄᓇᒥᒃ ᓴᓗᒻᒪᖅᓴᐃᓂᖅ ᓇᐃᓇᖅᓯᒪᓗᒍ ᖃᐅᔨᓴᕐᓂᐊᕐᓂᖅ ᓯᕗᓂᒃᓴᒥ ᖃᓄᐃᓕᐅᕈᑕᐅᓂᐊᕐᓂᖓ
- ᐊᓯᐊᖑᐃᓂᖅ ᐊᐅᓚᑦᑎᓂᕐᒧᑦ ᐸᕐᓇᐅᑏᑦ, ᐅᕙᓗᓐᓂᑦ ᒪᓕᒃᑕᐅᔪᒃᓴᑦ;
- ᑎᑎᕋᖅᓯᒪᔪᑦ ᖃᓄᐃᓕᐅᕐᓂᑯᑦ ᑲᒪᒋᕐᑯᔭᐅᔪᑦ ᐱᑉᓗᒋᑦ ᐅᖓᕙᓘᓐᓃᑦ ᐱᐊᓂᒃᓯᒪᕆᑦᑐᑦ ᖃᐅᔨᓴᐃᓂᒃᑯᑦ ᑐᓴᕈᑎᒥ ᐊᒻᒪ/ᐅᖓᕙᓘᓐᓃᑦ ᖃᐅᔨᓴᖅᑎᐅᑉ ᐱᐊᓂᒃᓯᒪᓂᕋᖅᑕᕆᑦ;
- ᓇᐃᓈᖅᓯᒪᔪᑦ ᐃᓄᓗᒃᑖᓂᒃ ᐅᖃᖅᑎᖃᕐᓃᑦ/ᐃᓚᐅᖃᑕᐅᑎᑦᑎᓃᑦ, ᐅᖃᐅᓯᖃᕐᓗᓂ ᐅᖃᖅᑎᖃᕐᓂᐅᓚᐅᖅᑐᓂᒃ ᓄᓇᓕᖕᒥᑦ ᑲᑐᔾᔨᖃᑎᒌᓂᒃ ᐊᒻᒪᓗ ᐃᓄᖕᒋᓐᓂᒃ ᖃᓂᑦᑐᓂᒃ ᓄᓇᓕᖕᒥᐅᓂᑦ, ᐅᖃᖅᑎᖃᓚᐅᖅᐸᑕᔭ;
- ᓱᓇᑐᐃᓐᓇᐃᑦ ᐊᓯᖏᑦ ᓇᓗᓇᐃᔭᖅᓯᒪᔪᑦ ᐃᒪᕐᒥᒃ ᐊᑐᕐᓂᕐᒧᑦ ᑐᒃᓯᕋᖅᑕᐅᔪᖅ ᑲᑎᒪᔨᓄᑦ ᓄᕕᐱᕆ 1-ᒥᑦ ᐅᑭᐅᕐᒥᑦ ᐅᓂᒃᑳᓕᐊᖑᖕᒪᑦ.

Aulapkaiyini Naittuq – Inuinnaqtun

Sabina Guulit Silverlu Kuapurisan (Sabina) tuniyat Ukiumun Tuhaqhitaut huliniqnut atuqtitlugu 2019 malikhugu Imaqmun Laisa Nappaa 2AM-BRP1831 (tamna Laisa) tuniyat tapkuat Nunavut Imaligiyit Katimayit. Taima ihuaqhihimaniagut talvani Ilanga B Titiraq 2 tamnalu Atugakhaliaq B talvani Laisami, tamna tuhaqhitaut ilalik tuhagakhat tahapkununga pityutinut:

- Tuhagakhat turangayut haputinut, hapuhiugaqnut hanahimayutlu hanaugat imaqaqviuyukhat uvaluniit iqakunut;
- Nainaqhimayuq tuhaqhitaut Immap atuqnianut, Ukiumi Hikukkuk Apqutit huliniit, imaiyainiqmun huliniit, kitutluliqak nutanguqnit tapkununga Immap Hunaqaqninutlu Ihuaqhihimani qanuritnit;
- Nainaqhimani nunaliqutit qanuritnit munarini, havikhat qaliriktitaqnit aktilangit, maqinit kuukviunitlu munarinit, tapkuatlu iqakut iqaqnit;
- Titiqat pilaqtitauhimaittut kuvititnit nainaqhimayutlu kinguagut huliniit piyauni;
- Nainaqhimayut Ihuaqhigiarutit tamnalu/uvaluniit angiyut hanayauni havariyaunit tamaitnut Immap Iqakutlu-turangayut hanahimayut havagutailu;
- Munarini havagutt qanuritnit tukiliurutailu;
- Nainaqhimayut kitutliqak pivalianit Umiktirnianut Halumaqtiqnianutlu havariyauyut;
- Nutanguqhimayut mikhautnit tatya ilitquhiraluanganut utiqtitnahuaqni akiliqtutaulat;
- Nainaqhimayut kitutliqak naunaiyautit atuquyai tapkuat Katimayit turangayut Immap atuqnianut, Iqakut iqaqni uvaluniit Halumaqtiqninut, nainaqhimayuqlu unniqtut kitunutliqak hivunikhami naunaiyaqni parnaktauyut
- Kitutliqak nutanguqni tapkuat Aulatauni Parnautit, tuhaqhitautit makpiraliugatlu;
- Nainaqhimani hulinit atuqtauyut hugiaqninut ihumaalutit uvaluniit iniqhimaittut titiqni qauyihainiqmun tuhaqhitautit tamnalu/uvaluniit malikhaqni tuhaqhitautit tuniya taphuma Qauyihaiyip;
- Nainaqhimayuq inungnut uqaqaqtigiknit/piqataunit, unnirtuqni uqaqatigikni nunalikni timiuyut nunaliuyutlu haniani nunaliuyut, atuqtauhimaniqata;
- Kitutluliqak ahii unniqtuttiaqni Immap atuqni pitquyauyut Katimayinit qangiqtitnagu Nuvipa 1 ukiunganut tuhaqhitautauyumun.

1. Introduction

This report to the Nunavut Water Board (NWB) summarizes activities and monitoring undertaken at the Sabina Gold and Silver Corp. (Sabina) Back River Project (BRP; the Project) Marine Laydown Area (MLA) and Goose Lake project areas in accordance with Part B, Item 2 of 2AM-BRP1831 (the Licence). This License was issued on September 21, 2018 and will expire on December 31, 2031. The NWB Annual Report Form can be found in Appendix A of this report.

Sabina's Back River Project is located within the West Kitikmeot region of southwestern Nunavut. It is situated approximately 400 km southwest of Cambridge Bay, 95 km southeast of the southern end of Bathurst Inlet (Kingaok), and 520 km northeast of Yellowknife, Northwest Territories. The Project is located predominantly within the Queen Maud Gulf Watershed.

The Project is comprised of two main areas; the MLA situated along the western shore of southern Bathurst Inlet and the Goose Lake Area south of the MLA where the gold deposits are located. These areas are connected seasonally by an approximately 160 km long winter ice road. The majority of annual resupply is brought in by water to the MLA and necessary materials are transferred via winter ice road to the Goose Lake property.

Project initial development works began in 2018 and included the development of pads, all-weather access roads and an airstrip at the MLA, as well as the erection of a tent camp and barge off-loading area for the receipt, storage and transfer of materials necessary to support construction activities (see the 2018 Annual Report for Water Licence 2BC-BRP1819 (Sabina 2019)).

In 2019, Sabina completed several key additional Pre-Development activities at the Back River Project focused on advancing and de-risking future development, including:

- Construction and operation of Sabina's inaugural WIR which included successful delivery of equipment, supplies, and other goods to the Goose Property necessary for construction of the Back River Project
- Completion of a cargo sealift
- Preliminary construction of a bulk fuel storage tank at the MLA
- Continued gold exploration and resource definition at the Goose Property

Sabina has yet to make a full construction decision due to the lack of a financing decision. Sabina is actively seeking additional financing for both Exploration and Pre-Development activities for 2020.

2. Annual Report per Part B, Item 2

This section of the report has been constructed to address the requirements Part B, Item 2 and Schedule B of the Licence. For ease of comparison, each subheading within this section corresponds directly with the identically numbered subheading of Schedule B of Water Licence 2AM-BRP1831.

CONSTRUCTION

2.1 FOR THE DIKES, DAMS AND STRUCTURES CONSTRUCTED TO WITHHOLD WATER OR WASTE

At this time, no dikes, dams or structures to withhold water or waste have been constructed.

WATER

2.2 MONTHLY AND ANNUAL VOLUME OF FRESH WATER OBTAINED FROM ALL SOURCES

Monthly and Annual volumes of freshwater withdrawn under this Licence for WIR development and maintenance are provided, by source, in Table 2.2-1. In total, 56,340 m3 of fresh water was withdrawn under this Licence between February and May 2019 in support of ice road construction maintenance and use. MLA water usage is provided, by freshwater source, in Table 2.2-2. A total of 127 m3 of water was used at the MLA in 2019. No other fresh water was withdrawn under this Licence in 2019. Water withdrawal amounts were within limits established in the Licence.

Table 2.2-1 Monthly and Annual WIR Water Withdrawal by Lake

Lake	Feb	Mar	Apr	May	Lake Total Water Withdrawal (m3)	Lake-specific withdrawal limit (m3)
Lake 40 UTM N 7378706 E 385690	0	0	0	165	**165**	**8,643**
Lake 39 UTM N 7373635 E 387680	0	0	0	0	**0**	**868,067**
Lake 38 UTM N 7367973 E 3900840	0	0	0	0	**0**	**5,185**
Lake 37 UTM N 7367584 E 391134	0	0	0	0	**0**	**1,604**
Lake 36 UTM N 7364930 E 391683	0	0	0	0	**0**	**293,621**
Lake 34 UTM N 7351852 E 400718	4,838	1,335	615	30	**6,818**	**17,010,361**
Lake 33 UTM N 7343073 E 403581	478	0	0	0	**478**	**2,859**
Lake 32 UTM N 7340003 E 404631	2,778	120	150	270	**3,318**	**56,674**
Lake 31 UTM N 7336793 E 403071	83	0	0	0	**83**	**5,334**
Lake 30 UTM N 7334245 E 403433	615	105	300	60	**1,080**	**211,044**
Lake 29 UTM N 7332392 E 403397	2,850	870	105	0	**3,825**	**23,951**
Lake 28 UTM N 7329276 E 401911	0	745	90	0	**835**	**1,512**
Lake 27 UTM N 7328257 E 401915	0	0	0	0	**0**	**6,992**
Lake 26 UTM N 7327338 E 401382	0	0	15	0	**15**	**683**
Lake 25 UTM N 7326281 E 400452	0	3,708	360	165	**4,233**	**80,746**
Lake 24 UTM N 7325353 E 400617	0	0	0	0	**0**	**7,597**
Lake 23 UTM N 7323246 E 400275	0	975	570	0	**1,545**	**6,103**
Lake 22 UTM N 7231054 E 402904	0	423	0	0	**423**	**59,995**
Lake 21 UTM N 7318800 E 403392	0	945	45	0	**990**	**39,637**

Lake 20 UTM N7314226 E 404075	0	2,000	180	0	**2,180**	**1,060,454**
Lake 19 UTM N 7311911 E 401691	0	2,555	90	0	**2,645**	**9,827**
Lake 18 UTM N 7309759 E 402495	0	0	60	218	**278**	**7,174**
Lake 17 UTM N 731007 E 401912	0	570	75	105	**750**	**15,059**
Lake 16 UTM N 7308843 E 401524	0	2,935	600	36	**3,571**	**128,478**
Lake 15 UTM N 7305916 E 402441	0	1,160	270	158	**1,588**	**1,239,167**
Lake 14 UTM N7303281 E 399696	0	1,853	520	143	**2,515**	**447,685**
Lake 13 UTM N 7298909 E 399919	0	2,520	628	203	**3,350**	**237,327**
Lake 12 UTM N7293431 E 401036	0	525	555	128	**1,208**	**88,191**
Lake 11 UTM N7287885 E 404204	0	375	585	195	**1,155**	**359,780**
Lake 10 UTM N7284074 E 407857	0	23	1,991	0	**2,014**	**15,112**
Lake 9 UTM N 7280643 E411983	0	0	3,821	60	**3,881**	**98,188**
Lake 8 UTM N7277741 E 418218	0	0	1,073	0	**1,073**	**53,703**
Lake 7 UTM N7276631 E 418218	0	0	1,140	45	**1,185**	**113,798**
Lake 6 UTM N 7277136 E 419314	0	0	540	60	**600**	**424,972**
Lake 5 UTM N 7277346 E 421197	0	0	353	0	**353**	**25,362**
Lake 4 UTM N 7275521 E 422778	0	0	0	30	**30**	**19,379**
Lake 3 UTM N 7273459 E 425284	0	0	1,185	30	**1,215**	**79,375**
Lake 2 UTM N 7273318 E 427649	0	0	855	0	**855**	**53,507**
Lake 1 UTM N7272263 E 428691	0	0	2,093	0	**2,093**	**39,603**
Total Monthly Usage (m3)	**11,640**	**23,740**	**18,862**	**2,099**	**56,340**	

Table 2.2-2 Monthly and Annual MLA Water Withdrawal by Lake

Lake	**Jan**	**Feb**	**Lake Total Water Withdrawal (L)**
MLA Pond S1 UTM N7272263 E 428691	10,001	0	10,001
Lake 3 UTM N 7273459 E 425284	75,238	32,277	117,514
			127,515

2.3 SUMMARY OF INTERCONNECTION WINTER ICE ROAD PLANS IMPLEMENTED IN ACCORDANCE WITH PART E, ITEM 13

Sabina’s notification and summary of Interconnection Winter Ice Road plans provided to the NWB is also attached here as Appendix B. Appendix C provides the final WIR route for 2019.

2.4 SUMMARY OF DEWATERING PLANS IMPLEMENTED IN ACCORDANCE WITH PART E, ITEM 14

No dewatering activities have occurred to date. A dewatering Plan will be provided to the NWB 60 days prior to initiation of dewatering in accordance with Part E Item 14 of the Licence.

2.5 SUMMARY UPDATE TO THE WATER AND LOAD BALANCE RESULTS, IF ANY

No updates to the Water and Load balance were made in 2019.

WASTE

2.6 GEOCHEMICAL MONITORING RESULTS

a. Operational acid/base accounting and associated test work used for Waste Rock designation (PAG and NPAG rock);

No waste rock has been generated to date.

b. As-built volumes of Waste Rock used in construction and placed in the Waste Rock Storage Areas with estimated balance of acid generation to acid neutralization capacity in a given sample as well as metal toxicity;

No waste rock has been generated to date.

c. All monitoring data with respect to geochemical analyses on site and related to roads and quarries;

No geochemical analyses were undertaken in 2019.

d. Any Leaching observations and tests collected on pit slope and dike exposure;

This infrastructure has not yet been constructed.

e. Any geochemical outcomes or observations that could imply or lead to environmental impact.

No observations of potential geochemical environmental impact were made in 2019.

2.7 VOLUMES OF ORE STOCKPILED.

No ore has been mined at the Project to date.

2.8 SUMMARY OF QUANTITIES AND ANALYSIS OF SEEPAGE AND RUNOFF MONITORING FROM THE TAILINGS STORAGE FACILITY, WASTE ROCK STORAGE AREAS, LANDFILL(S) AND ASSOCIATED DIKES/BERMS.

The Tailings Storage Facility, Waste Rock Storage Areas, Landfill and associated dikes/berms have not yet been constructed.

2.9 A SUMMARY REPORT OF ALL GENERAL WASTE DISPOSAL ACTIVITIES INCLUDING MONTHLY AND ANNUAL QUANTITIES IN CUBIC METRES OF WASTE GENERATED AND LOCATION OF DISPOSAL.

Information on waste disposal is provided in Appendix D and includes quantities and types of wastes incinerated (Appendix D Table 1) as well as wastes backhauled to KBL Environmental in Yellowknife (Appendix D Table 2). Wastes backhauled included incinerator ash as well as wastes from the Goose and George Properties. KBL Environmental provides waste management services, including transfer of Project wastes to approved disposal facilities outside of Nunavut. No waste is currently landfilled on site.

2.10 REPORTING OF INCINERATOR TEST RESULTS INCLUDING THE MATERIALS BURNED AND THE EFFICIENCY OF THE INCINERATOR IN RELATION TO EFFECTS ON WATER AND THE POTENTIAL DEPOSIT OF WASTE INTO WATER.

No incinerator testing was conducted in 2019. Materials burned are itemized in Appendix D Table 1 of this report.

SPILLS

2.11 A LIST AND DESCRIPTION OF ALL UNAUTHORIZED DISCHARGES INCLUDING VOLUMES, SPILL REPORT LINE IDENTIFICATION NUMBER AND SUMMARIES OF FOLLOW-UP ACTION TAKEN

All spills, regardless of size are recorded for adaptive management purposes at the Back River Project.

Sabina confirms two (2) spills were reported to the NT-NU 24 Hour Spill Report Line in 2019.

Sabina Spill No.	Date of Occurrence	Quantity	Material Spilled	Location	NT-NU Spill
Goose Property					
2019-15	4/19/2019	400L	Drilling Brine	Goose Property	✓
Winter Ice Road					
2019-17	5/9/2019	1L	Hydraulic Oil	WIR	✓

- 2019-05: A cable caught while lifting a containment tub of drilling water (approximately 10% CaCl salt), resulting in approximately 400L of the solution to spill. The containment tub was immediately stabilized, stopping further loss, and a berm was immediately built around the spill area to stop any further migration of product. Contaminated snow was scraped to surface and loaded into a 200 Gallon Water Tub, and transported back to site and placed in the drill cutting containment area.
- 2019-17: A hydraulic hose line on Winter Ice Road maintenance equipment broke leading to the spill of approximately 1L of hydraulic oil. The majority of the spill was captured within a small yellow berm. A smaller volume landed on the ice. The snow/slush that was in the small yellow berm was bagged it along with any product on the ice. The water that was in the small yellow berm was carefully lifted into an impermeable fiberglass sleigh and covered for transport. The bag of snow/slush and the water was delivered to the incinerator. Sabina notes this 1L spill was reported to the NT-NU Spill Report Line due to a direct request from CIRNAC to do so.

MODIFICATIONS

2.12 A SUMMARY OF MODIFICATIONS AND/OR MAJOR MAINTENANCE WORK CARRIED OUT ON ALL WATER AND WASTE-RELATED STRUCTURES AND FACILITIES.

No modifications or major maintenance work was carried out in 2019. In 2020, Sabina is submitting a Modification Package to the NIRB describing proposed modifications to the originally proposed Project and will subsequently provide this package to the NWB for the purposes of amending the Water Licence.

MONITORING

2.13 THE RESULTS AND INTERPRETATION OF THE MONITORING PROGRAM IN ACCORDANCE WITH PART I AND SCHEDULE I.

A monitoring summary outlining activity related to each monitoring station indicated in Part I and Schedule I of the Licence is provided in Appendix E. Approximately 24.75 m^3 of water was discharged from the temporary MLA berms in 2019. No berm water was discharged at the Goose Property in 2019 due to snow clearing within the berms and evaporative loss of summer rainfall. Berm water quality results and discharge criteria are summarized in Table 2.13-1 and discharge locations and quantities are summarized in Table 2.13-2. Water was discharged >31 m from any waterbodies and in a manner so as to prevent erosion and direct connectivity with waterbodies.

Table 2.13-1 Berm Discharge Water Quality Results

	Benzene (mg/L)	Ethylbenzene (mg/L)	Toluene (mg/L)	Lead (mg/L)	Oil and Grease (mg/L)	TSS (mg/L)	pH
Max Avg. Concentration	0.37	0.09	0.002	0.1	5 and no visible sheen	15	Between 6.0 and 9.5
MLA Berm 1	<0.00050	<0.00050	<0.00045	0.000134	<5.0 no	5.2	6.17
MLA Berm 2	<0.00050	<0.00050	<0.00045	0.000224	<5.0 no	7.4	6.36
MLA Berm 4	<0.00050	<0.00070	<0.00045	0.000093	<5.0 no	4.0	6.51
MLA Berm 7	<0.00050	<0.00050	<0.00045	0.000140	<5.0 no	7.4	6.69
Windsock Berm	<0.00050	<0.00050	<0.00045	0.000075	<5.0	7.0	6.92
MLA Berm 8	<0.00050	<0.00050	<0.00045	0.000100	<5.0 no	<3.0	8.72

Table 2.13-2 Discharge Locations and Quantities

Berm	Discharge Location	Discharge Quantity (m3)
MLA Berm 1	UTM NAD83 ZONE 13 N; N 7394413 E 381001	5.5
MLA Berm 2	UTM NAD83 ZONE 13 N; N 7394420 E 381015	6.25
MLA Berm 4	UTM NAD83 ZONE 13 N; N 7394395 E 381003	4.0
MLA Berm 7	UTM NAD83 ZONE 13 N; N 7394370 E 381016	4.0
Windsock Berm	UTM NAD83 ZONE 13 W; N 7394206 E 381198	1.0
MLA Berm 8	UTM NAD83 ZONE 13 N; N 7394370 E 381016	4.0
Total		**24.75**

Personnel were on site at the Goose Property from June 19 through 21 to assess site conditions and did not observe any seepage form any facilities. Personnel were similarly on site at the MLA from June 19th through to the MLA closure in September and did not observe any seepage or runoff with the potential to enter a freshwater waterbody. However, runoff was noted from the MLA Quarry, and although there was no potential for the water to enter a freshwater waterbody, runoff was sampled and compared to the criteria for station BRP-G (See Table 2.13-3); no exceedances were noted.

Table 2.13-3 MLA Quarry Runoff Water Quality Results

	Oil and Grease (mg/L)	TSS (mg/L)	pH
Max Avg. Concentration	no visible sheen	50	Between 6.0 and 9.5
Max Concentration of Any Grab Sample	no visible sheen	100	Between 6.0 and 9.5

MLA Quarry	no visible sheen	48	7.47

Greywater discharge at the MLA occurred under Water Licence 2BE-GEO2025 (previously Licence 2BE-GEO1520) in 2019. In 2020 MLA greywater discharge water will be monitored and reported under Water Licence 2AM-BRP1831 per the revised sampling requirements related to station BRP-42.

No construction took place at the Goose Property in 2019. Goose Property exploration-related activities, including water uses, are reported in the 2BE-GOO2028 (previously Licence 2BE-GOO1520) annual report.

Full laboratory results of all water quality samples collected are provided in Appendix F.

2.14 THE RESULTS OF MONITORING RELATED TO THE GENERAL AND AQUATIC EFFECTS MONITORING PROGRAM IN ACCORDANCE WITH PART I ITEM 1.

Aquatic effects monitoring has not yet commenced at the Back River Project. This monitoring will be initiated once the Project enters the Construction phase.

CLOSURE

2.15 A SUMMARY OF ANY PROGRESSIVE CLOSURE AND RECLAMATION WORK UNDERTAKEN, INCLUDING PHOTOGRAPHIC RECORDS OF SITE CONDITIONS BEFORE AND AFTER COMPLETION OF OPERATIONS, AND AN OUTLINE OF ANY WORK ANTICIPATED FOR THE NEXT YEAR, INCLUDING ANY CHANGES TO IMPLEMENTATION AND SCHEDULING

As the Project has not yet entered the Construction phase, no progressive reclamation activities have been undertaken to date. Sabina anticipates that these activities will commence once areas are determined to be no longer in use. Photographic records of pre-construction site conditions are maintained by Sabina for comparison with photos to be taken after completion of Operations.

2.16 AN UPDATED ESTIMATE OF THE CURRENT RECLAMATION LIABILITY BASED ON PROJECT DEVELOPMENT MONITORING, RESULTS OF RESTORATION RESEARCH AND ANY CHANGES OR MODIFICATIONS TO THE APPURTENANT UNDERTAKING

No changes are proposed to the current reclamation liability at this time.

PLANS/REPORTS/STUDIES

2.17 A SUMMARY OF ANY STUDIES REQUESTED BY THE BOARD THAT RELATE TO WATER USE, WASTE DISPOSAL OR RECLAMATION, AND A BRIEF DESCRIPTION OF ANY FUTURE STUDIES PLANNED

No studies have been requested by the Board and no studies have been identified as necessary for 2020.

2.18 WHERE APPLICABLE, REVISIONS AS ADDENDA, WITH AN INDICATION OF WHERE CHANGES HAVE BEEN MADE, FOR PLANS, REPORTS, AND MANUALS

The Incinerator Management Plan has been updated and is attached as Appendix G of this report. No other revisions have been made to any Plans, Reports, or Manuals in 2019.

2.19 AN EXECUTIVE SUMMARY IN ENGLISH, INUKTITUT, AND INUINNAQTUN OF ALL PLANS, REPORTS, OR STUDIES CONDUCTED UNDER THIS LICENCE.

An executive summary of this report is provided in both English and Inuktitut at the start of this report.

GENERAL

2.20 A SUMMARY OF ACTIONS TAKEN TO ADDRESS CONCERNS OR DEFICIENCIES LISTED IN THE INSPECTION REPORTS AND/OR COMPLIANCE REPORTS FILED BY AN INSPECTOR

A summary of agency inspections and site visits for the calendar year being reported is provided below.

1. January 30: CIRNAC Water Licence Inspection
2. May 9: KIA Back River Project Winter Ice Road Site Visit
3. May 9: CIRNAC Land Use Inspection
4. July 24: KIA Back River Project Inspection

Inspection results were conveyed during close-out meetings and are documented in Inspection Reports subsequently distributed to Sabina and relevant stakeholders. Sabina responded to any requests in the inspections to provide additional information and/or address the identified concerns.

OTHER

2.21 A SUMMARY OF PUBLIC CONSULTATION AND PARTICIPATION WITH LOCAL ORGANIZATIONS AND THE RESIDENTS OF THE NEARBY COMMUNITIES, INCLUDING A SCHEDULE OF UPCOMING COMMUNITY EVENTS AND INFORMATION SESSIONS

Sabina’s BRP engagement record is provided in Appendix H.

2.22 ANY OTHER DETAILS ON WATER USE OR WASTE DISPOSAL REQUESTED BY THE BOARD BY NOVEMBER 1ST OF THE YEAR BEING REPORTED.

No additional sampling or details on water use or waste disposal activities related to this Licence was requested by the Board or Inspector in 2019.

Appendix A NWB Annual Report Form

NWB Annual Report **Year being reported:** Select 2019

License No: 2AM-BRP1831 **Issued Date:** September 21, 2018
Expiry Date: December 31, 2031

Project Name: BACK RIVER PROJECT

Licensee: SABINA GOLD AND SILVER CORP

Mailing Address: #1800-555 Burrard St, Box 220, Vancouver, BC, V7X 1M9

Name of Company filing Annual Report (if different from Name of Licensee please clarify relationship between the two entities, if applicable):

SABINA GOLD AND SILVER CORP

General Background Information on the Project (*optional):

See Section 1 of attached report

Licence Requirements: the licensee must provide the following information in accodance with

Part B Select **2**

A summary report of water use and waste disposal activities, including, but not limited to: methods of obtaining water; sewage and greywater management; drill waste management; solid and hazardous waste management.

Water Source(s): Goose Lake, MLA Pond S1, MLA Pond S2

Water Quantity:

Allowed:		Actually Used:
578,000 cu.m.	Annually	127 cu.m.
1,400,000 cu.m.	Annually for dewatering	0 cu.m.
675 cu.m./km	for the WIR	352 cu.m./km WIR

Waste Management and/or Disposal

- ☑ Solid Waste Disposal
- ☑ Sewage
- ☐ Drill Waste
- ☐ Greywater
- ☑ Hazardous
- ☐ Other:

Additional Details:

See Section 2.9 of this report for wastes disposed of in 2019.

A list of unauthorized discharges and a summary of follow-up actions taken.

Spill No.: (as reported to the Spill Hot-line)
Date of Spill:
Date of Notification to an Inspector:
Additional Details: (impacts to water, mitigation measures, short/long term monitoring, etc)

Please see Section 2.11 of Annual Report.

Please see Section 2.11 of Annual Report.

Revisions to the Spill Contingency Plan

No Spill Contingency Plan (SCP) submitted or approved

Additional Details:

No revisions to the SCP were made in 2019

Revisions to the Abandonment and Restoration Plan

No Abandonment and Restoration (AR) Plan submitted or approved

Additional Details:

No revisions to the ARP were made in 2019

Progressive Reclamation Work Undertaken

Additional Details (i.e., work completed and future works proposed)

Please see Section 2.15 of Annual Report.

Results of the Monitoring Program including:

The GPS Co-ordinates (in degrees, minutes and seconds of latitude and longitude) of each location where sources of water are utilized;

Details attached

Additional Details:

Please see Section 2.15 of Annual Report.

The GPS Co-ordinates (in degrees, minutes and seconds of latitude and longitude) of each location where wastes associated with the licence are deposited;

Details attached

Additional Details:

See Section 2.9 of this report for wastes disposed of in 2019.
Waste water discharge infomation (includign discharge locatiosn) are provided in Section 2.13 of the Annual Report.

Results of any additional sampling and/or analysis that was requested by an Inspector

No additional sampling requested by an Inspector or the Board

Additional Details: (date of request, analysis of results, data attached, etc)

See Section 2.20 of this report

Any other details on water use or waste disposal requested by the Board by November 1 of the year being reported.

No additional sampling requested by an Inspector or the Board

Additional Details: (Attached or provided below)

See Section 2.17 of this report

Any responses or follow-up actions on inspection/compliance reports

Inspection Report received by the Licensee (Date):

Additional Details: (Dates of Report, Follow-up by the Licensee)

Please see Section 2.20 of Annual Report.

Any additional comments or information for the Board to consider

Date Submitted:	March 31 2020	
Submitted/Prepared by:	Merele Keefe/Katsky Venter	
Contact Information:	**Tel:**	
	Fax:	
	email:	mkeefe@sabinagoldsilver.com

Appendix B Proposed Ice Road Development Plan

BACK RIVER PROJECT
2019 Winter Ice Road Technical Memorandum

December 2018

1. INTRODUCTION

The Back River Project (the Project) is a proposed gold project owned by Sabina Gold & Silver Corp. (Sabina) within the West Kitikmeot region of southwestern Nunavut. The Project is comprised of two main areas with interconnecting winter ice roads (WIR) between the Goose Site and the Marine Laydown Area (MLA) situated along the western shore of southern Bathurst Inlet. The majority of annual resupply will be completed using the MLA via sealift, and an approximately 160-km long WIR will interconnect these two sites.

The 2019 Winter Ice Road Technical Memo outlines the approach for construction, operations, and closure of the WIR for the 2019 season. This memo has been written to meet the requirements of Sabina's Project Certificate (No. 007), Sabina's Type A Water Licence (2AM-BRP1831), and Sabina's KIA Commercial Lease (KTCL-18D003). The information presented herein is current as of December 2018.

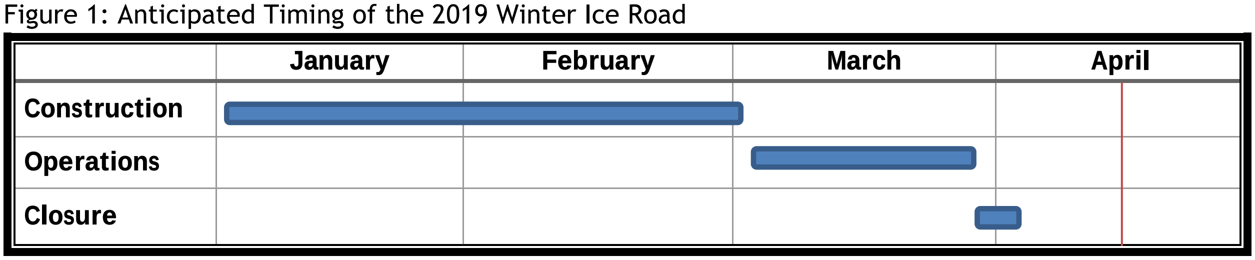
2. WINTER ICE ROAD ALIGNMENT

The approximate routing of the 2019 Winter Ice Road is included in Appendix A. The WIR between the MLA and Goose Site will be approximately 160 km long, travelling over approximately 60-70% water and 30-40% land depending on the final route constructed. Sabina anticipates slight variations in routing to occur should construction or operational challenges exist.

3. WINTER ICE ROAD SCHEDULE

The 2019 Winter Ice Road construction is expected to take 45 to 60 days, beginning in early January and completing in late February or early March 2019. Once WIR construction is completed, the WIR route will be maintained during WIR operation as materials are hauled via tractor trailers from the MLA south to Goose site. Some material may also be backhauled to the MLA for shipments south (i.e. hazardous waste). Hauling on the 2019 WIR is expected to take 15 to 20 days and is estimated to be completed by late March. Sabina anticipates approximately 90 loads to be transported from the MLA to the Goose Site. Once hauling is complete, Sabina will commence closure of this seasonal route which will take only a few days. Sabina intends to close the 2019 WIR by early April and does not intend to exceed the April 15 cut-off in recognition of the commitment made in Sabina's Back River Project Wildlife Mitigation and Management Plan and in our KIA Commercial Lease. Should any delays in construction or operations result in Sabina extending past the April 15 cut-off date, Sabina will provide written notice to the Kitikmeot Inuit Association and the Government of Nunavut.

Figure 1: Anticipated Timing of the 2019 Winter Ice Road



To support the above schedule, the MLA camp will be opened in mid-December 2018 or early January 2019 to support the mobilization and start up of WIR equipment in advance of the construction season.

The Goose camp will be opened as needed to support the 2019 WIR activities; timing will depend on construction progression and other Project requirements for this camp.

Due to a failed sealift in late 2018 Sabina anticipates that an airlift program will be required to support the start up of the 2019 WIR construction efforts. To that end, Sabina requires an ice airstrip at the MLA to support the 2019 WIR season; this effort could begin as early as late December 2018.

4. WINTER ICE ROAD CONSTRUCTION

Sabina intends to start the 2019 WIR construction from the MLA and progress as a single work front towards Goose Site. Sabina has assessed ice conditions at the MLA in late November 2018 and Bathurst Inlet ice conditions are favourable to support the airlift program required to start up of the 2019 WIR construction efforts.

The WIR is anticipated to commence construction in early January 2019 when the subgrade is frozen to a sufficient depth and the ice can support light tracked vehicles. Construction of the WIR will take approximately 45 to 60 days depending on weather, ice and snow conditions at the time.

Sabina will adhere to the "Guidelines for Safe Ice Construction" published by the Northwest Territories Department of Transportation (2015), as well as the Land Use Guidelines published for Government of Northwest Territories and Nunavut (INAC 2010), which will guide the construction and maintenance requirements of the WIR. These guidelines are outlined in the Road Management Plan (Appendix B).

Accommodations to support the 2019 WIR construction will utilize a combination of the MLA, a mobile Forward Camp, and the Goose Site. The 2019 WIR efforts will be supported by a mobile Forward Camp on sleighs that will progressively advance with the construction front to increase efficiencies and provide safety support along the 160-km WIR alignment. This Forward Camp will spend approximately 1 week at each location as the WIR construction front advances. Sabina anticipates placing this Forward Camp on Inuit Owned Land under the KIA Commercial Lease. This Forward Camp will house approximately 12 people at any one time and will utilize fresh water under the Type A Water License. Waste management practices at the Forward Camp will adhere to Sabina's Waste Management Plan. The Forward Camp will utilize a Pacto waste systems for human waste which will be removed and incinerated at either the MLA or Goose Site. Similarly, all combustible, non-hazardous waste will be backhauled to either the MLA or Goose Site for incineration. All other waste materials, including hazardous waste, waste oil and non-combustible waste, will be backhauled to the MLA or Goose Site for storage prior to being shipped off site to an approved waste management facility for disposal. Greywater from the kitchen and shower facilities will be disposed of in accordance with the Conditions for the Use of Waters and/or the Deposit of Waste Without A Licence (NWB 2017). Greywater disposal will be located in a sump or natural depression a minimum distance of thirty-one (31) metres from the ordinary high-water mark of any waterbody. Sabina will provide GPS co-ordinates of all locations where greywater waste associated with the Forward Camp are deposited in the NWB and KIA Annual Reports.

5. WINTER ICE ROAD OPERATIONS

Hauling operations on the 2019 WIR is expected to take 15-20 days in March 2019. Sabina anticipates up to 90 loads of materials, equipment, and consumables to be transferred down the WIR in this period. Freight hauling is expected to average 25 tonnes per load including double or triple-axle flat-deck trailers.

Sabina currently does not intend to haul fuel along the WIR in 2019 except to support construction and maintenance activities; however, if this effort is required, Sabina will utilize the onsite fuel truck or fuel cubes. Any vessel used would be certified for this purpose and have an estimated capacity of 20,000 L per load.

Based on the ice thickness measured, load calculations will be conducted to verify that the ice will support the weight of operations equipment. Regular ice profiling will be conducted throughout the WIR operations to monitor ice growth and to maximize the safe loading capacity of the ice.

6. WINTER ICE ROAD CLOSURE

Decommissioning of the Winter Ice Road will involve restoring natural drainage by removing potential obstructions to drainage paths in advance of the spring melt. Closure will also include recovery of any sand along the alignment that may have been transferred by hauling equipment to frozen lakes from adjacent portages; this sand would only be placed on portages if additional traction was required for hauling vehicles.

Any materials or temporary supplies along the WIR route will be removed to the MLA or Goose site for the off season. Refer to the Interim Closure and Reclamation Plan for additional details on the closure of the Winter Ice Road.

7. WINTER ICE ROAD WATER USE

Water will be required for construction of overland sections, construction of ramps, and for maintenance of over-ice sections. All lakes and water sources along the route will be identified as suitable or not-suitable for water withdrawal, based on DFO water withdrawal limits and other environmental protocols.

Sabina has attached the Winter Ice Road Water Withdrawal Evaluation Memorandum (Appendix B). This attachment includes approximate 2019 projected routing, bathymetry, depth, potential water withdrawal locations, proposed extraction volumes, and anticipated water level decreases.

During WIR construction, Sabina will confirm lake water availability using ice augers; this information will confirm the necessary water depth below frozen ice layers which verifies the actual maximum water volume that can be withdrawn. The amounts of water withdrawn from approved sources will be monitored in accordance with Schedule I, Table 2 of the Type A Water Licence. Sabina is confident that, based on the current water withdrawal projections, sufficient water is available for the WIR construction while remaining within these the appropriate limits.

8. SUPPORTING DOCUMENTATION

Appended to this memo are supporting documents that provide additional information on Sabina's management of the 2019 Winter Ice Road, specifically:

- Appendix A: Winter Ice Road Route Overview 2019
- Appendix B: Winter Ice Road Water Withdrawal Evaluation – Back River Project (Golder 2017)
- Appendix C: Road Management Plan (October 2017);

9. REFERENCES

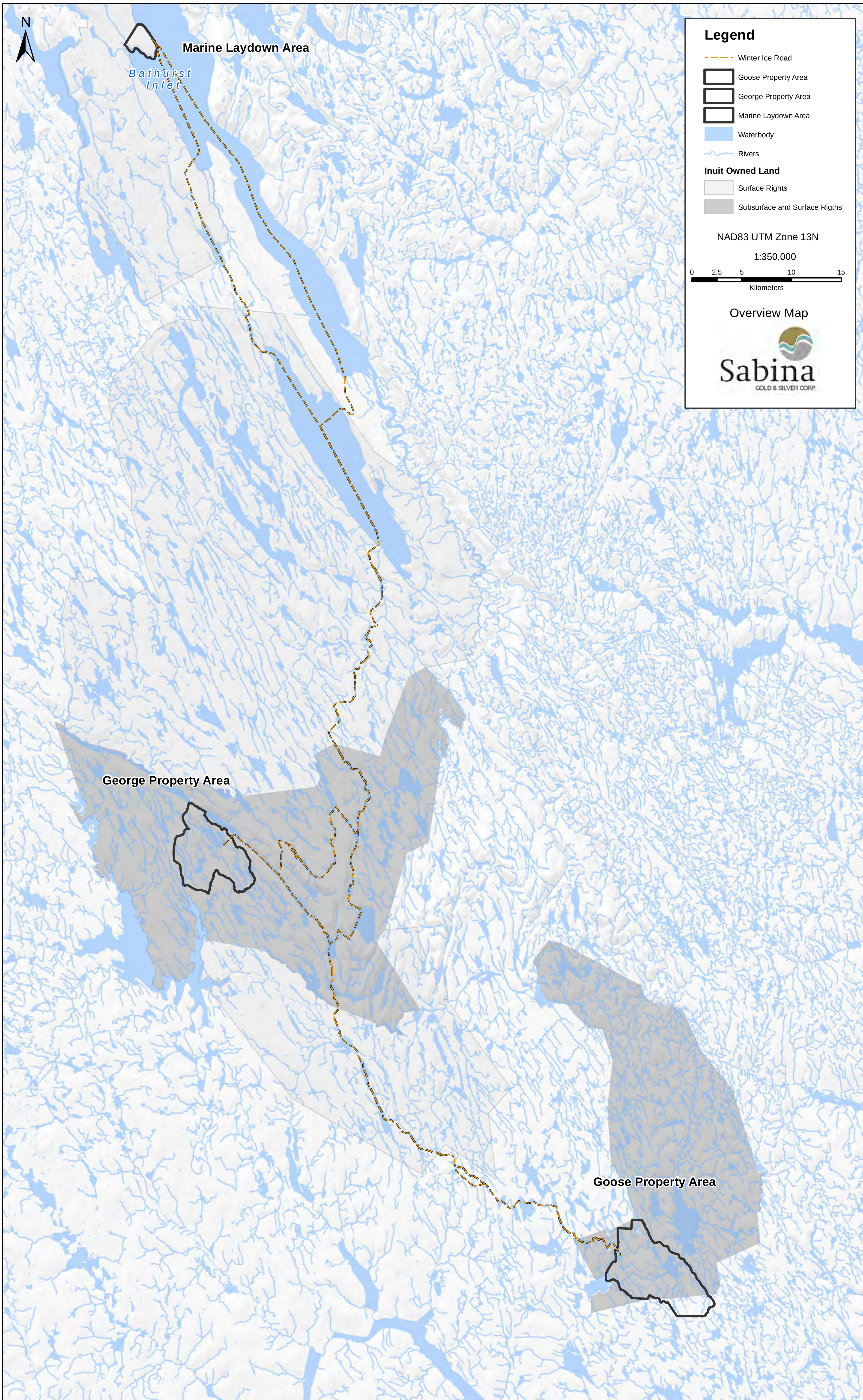
GNWT DoT. 2015. Guidelines for Safe Ice Construction. February 2015.

INAC (Indigenous and Northern Affairs Canada). 2010. Northern Land Use Guidelines – Access: Roads and Trails. January 2010. ISBN: 978-1100-14743-7. Link.

NWB (Nunavut Water Board). 2017. Guide 9. Guide to the Approval for the Use of Water or Deposit of Waste Without a Licence. March 2017.

Appendix A

Winter Ice Road Route Overview 2019


N
Marine Laydown Area
Bathurst Inlet
George Property Area
Goose Property Area
Legend
Winter Ice Road
Goose Property Area
George Property Area
Marine Laydown Area
Waterbody
Rivers
Inuit Owned Land
Surface Rights
Subsurface and Surface Rigths
NAD83 UTM Zone 13N
1:350,000
0 2.5 5 10 15
Kilometers
Overview Map
Sabina
GOLD & SILVER CORP.

Appendix B

Winter Ice Road Water Withdrawal Evaluation Memo

TECHNICAL MEMORANDUM

DATE November 8, 2018 **REFERENCE No.** 1776921_021_MEM_Rev0

TO Merle Keefe
Sabina Gold & Silver Corp.

CC Matthew Pickard, Dionne Filiatrault

FROM Cam Stevens **EMAIL** cameron_stevens@golder.com

WINTER ICE ROAD WATER WITHDRAWAL EVALUATION – BACK RIVER PROJECT

Golder Associates Ltd. (Golder) was retained by Sabina Gold & Silver Corp. (Sabina) to provide an evaluation of potential water sources for winter ice road construction along the proposed 160 km-long winter road corridor from the Goose Property at Goose Lake to the Marine Laydown Area at Bathurst Inlet. Potential water sources are waterbodies deeper than 3.5 m (i.e., lakes) and available water volumes in those waterbodies are no more than 10% of the under ice volume, as per the Fisheries and Oceans Canada (DFO) protocol for mitigating water withdrawal effects on fish in ice-covered waterbodies in the North (DFO 2010).

The information provided in this technical memorandum (memo) fulfills commitments made during the environmental review of the Back River Project (the Project) (see Addendum Appendix V6-6G in Sabina [2017]), and provides Sabina with the necessary information to minimize, if not eliminate, any potential effects to overwintering fish and fish habitat, including spawning shoal habitat, during the construction of the winter ice road. The current plan for the winter ice road requires 108,000 m^3 of water per season (675 m^3 per km) to maintain ice thickness as per the Project Description (Volume 2 in Sabina [2017]).

The following sections of the memo provide methods and results for the available under-ice water volumes, the volumes representing 10% of available under-ice water, and the reduction in water depth associated with withdrawals of 10% of the available under-ice water per each lake in the winter road corridor. The memo also evaluates changes in water depths in terms of risk to spawning shoal habitat loss in lakes as per methods outlined in Addendum Appendix V6-6G in Sabina (2017). Based on that evaluation, recommended volumes for water withdrawal that present negligible risk of habitat loss are provided.

1.0 METHODS

Bathymetric digital elevation models were generated by Aeroquest Mapcon (Aeroquest) for 118 waterbodies within the winter road corridor using stereo-photogrammetric interpretation methods of stereo, 8 band, 50 cm satellite imagery; imagery was collected in August 2017 by DigitalGlobe's Worldview-2 satellite (Legleiter et al. 2014; Dörnhöfer and Oppelt 2016). For each waterbody, surrounding terrain characteristics were used to interpret slopes entering the waterbody at the shorelines, where the slopes were then extrapolated into the waterbody to connect with the lake bottom topography visualized through 'coastal blue', 'blue' and 'green' (spectral) bands in the imagery in a Geographic Information System (GIS). These spectral bands allow the identification of detailed lakebed topography to a depth of 30 m.

Bathymetric models of each waterbody were provided to Golder in raster format for analyses of volume and area per depth in a GIS platform for each waterbody deeper than 3.5 m. Tables produced from the raster analysis (see Appendix A) were used to estimate available under-ice water volumes for ice road construction for each source lake (i.e., 10% of under ice volume); where it was assumed that the maximum ice thickness is 2 m (DFO 2010). Changes in water levels from water withdrawals were also estimated. As it was assumed that all waterbodies deeper than 3.5 m support large-bodied fish, predicted changes in water levels were assigned a level of risk for spawning habitat loss as per Addendum Appendix V6-6G in Sabina (2017) (Table 1). Waterbodies with a potential risk of spawning habitat loss from a 10% under-ice volume reduction were identified as sources where water withdrawals should be reduced, particularly during below-average precipitation years. Recommended volumes for water withdrawal that present negligible risk of habitat loss were then calculated for these waterbodies.

Table 1: Water Withdrawal Risk Level Framework for Spawning Shoal Habitat for Fall-Spawning Fish[(a)]

Risk of Spawning Habitat Loss	Change in Water Elevation Under Ice (m)	Rationale
Nil or negligible	Less than 0.22	The reduction in water level lies within the average change in ice thickness (i.e., within normal variation)
Low	0.22 to less than 0.42	The reduction in water level remains within 1 SD of the average
Medium	0.42 to 0.8	The reduction in water level remains between 1 and 2 SD of the average
High	Greater than 0.8	The reduction in water level is beyond 2 SD of average and there is less than a 5% chance for this occurring naturally

a) includes coregonid species, such as Lake Whitefish (*Coregonus clupeaformis*), and Lake Trout (*Salvelinus namaycush*); SD = standard deviation

A characterization of whether bathymetric data are representative of below-average, average, or above-average water level conditions was provided using precipitation statistics for the region. Statistics were derived for both 2017 and 30-year (1981-2010) ‘normal’ data, obtained from a representative monitoring station in west-central Nunavut (station name: Kugluktuk A; see Government of Canada 2017).

The evaluation of satellite imagery results (volumes) also included a comparison with results generated by bathymetric (sonar) surveys previously performed in the field for a subset of seven lakes (Appendix V6-3A in Sabina [2017]; Rescan 2014). The lakes with existing bathymetric data included five lakes surveyed in early July 2014 (Fold Lake, Winter Road Lake 01, Winter Road Lake 02, Winter Road Lake 05, and Winter Road Lake 06) and two lakes surveyed in August 2010 (Llama Lake and Chair Lake). All lakes were less than 30 m depth, the extent to which accurate detection of the spectral bands in the satellite imagery is known to be effective. It was assumed that the previously conducted surveys of each lake were performed consistent with methods described by DFO (2010), and included one longitudinal transect (connecting the two farthest shorelines) and a minimum of two perpendicular transects evenly spaced on the longitudinal transect at maximum intervals of 500 m. Project lakes with existing bathymetric data that were excluded from the comparison were either outside the boundary of the winter road corridor, or had insufficient data to provide a reliable volume estimate.

2.0 RESULTS AND DISCUSSION

Of the 118 waterbodies examined for use for winter ice road construction, 55 lakes were identified as being deep enough (greater than 3.5 m) for under-ice water withdrawal (Table 2; Figure 1; Appendix B). Overall, source lakes were determined to provide a median capacity of 39,637 m^3 of water per lake for winter ice road construction, where available 10% under-ice volumes may range from 683 m^3 for Lake 996 to 301,075,442 m^3 for Lake 34-0 (i.e., lower Bathurst Inlet). The provided volume statistics for lakes in the winter road corridor are expected to represent average lake level conditions, given that cumulative precipitation levels in August 2017 totalled 208.4 mm, just 1 mm below normal totals for that time of the year when the imagery was acquired (Figure 2). It is expected that available water volumes for winter ice road construction is lower during below-average precipitation years and higher during above-average precipitation years.

Table 2: Water Sources, Bathymetry Statistics, and Available Volumes for Winter-Ice Road Construction for the Back River Project

Waterbody ID	North. UTM	East. UTM	Surface Area (SA) (m^2)	Volume (V) (m^3)	V:SA ratio (m)	Under Ice Volume Below 2 m Depth (m^3)	10% Volume Below 2 m Depth (m^3)	Predicted Water Level Change (m)	Risk of Habitat Loss For 10% Guideline	Calculated Volume for Nil Risk (m^3)
Lake 1-0	7272263	428691	348,021	951,009	2.7	396,025	39,603	0.19	Nil	39,603
Lake 2-0	7273318	427649	598,077	1,487,839	2.5	535,068	53,507	0.17	Nil	53,507
Lake 3-0	7273459	425284	557,865	1,738,708	3.1	793,748	79,375	0.21	Nil	79,375
Lake 4-0	7275521	422778	349,596	705,486	2.0	193,786	19,379	0.13	Nil	19,379
Lake 8-0	7276631	418218	765,711	2,427,790	3.2	1,137,977	113,798	0.20	Nil	113,798
Lake 7-0	7277136	419314	2,211,876	8,325,456	3.8	4,336,453	433,645	0.22	Low	424,972
Lake 6-0	7277346	421197	224,514	614,579	2.7	253,622	25,362	0.19	Nil	25,362
Lake 9-0	7277741	416761	620,172	1,581,371	2.5	537,030	53,703	0.14	Nil	53,703
Lake 11-0	7280643	411983	885,771	2,406,329	2.7	981,876	98,188	0.19	Nil	98,188
Lake 13-0a	7284074	407857	290,376	597,123	2.1	151,117	15,112	0.12	Nil	15,112
Lake 14-0a	7287885	404204	3,942,630	10,415,812	2.6	3,597,800	359,780	0.16	Nil	359,780
Lake 14-1	7293431	401036	2,221,497	4,779,159	2.2	881,912	88,191	0.08	Nil	88,191
Lake 15-0	7298909	399919	1,441,269	5,027,754	3.5	2,373,270	237,327	0.19	Nil	237,327
Lake 16-0	7303281	399696	2,068,272	12,016,309	5.8	8,139,725	813,973	0.40	Low	447,685
Lake 17-0	7305916	402441	5,913,261	61,932,318	10.5	50,372,624	5,037,262	0.90	High	1,239,167
Lake 16-1	7306279	398021	319,815	812,512	2.5	260,311	26,031	0.14	Nil	26,031
Lake LA17-0	7308172	395986	3,193,056	18,907,975	5.9	12,865,851	1,286,585	0.43	Med.	643,293
Lake 18-0	7308843	401524	635,085	2,886,128	4.5	1,690,494	169,049	0.28	Low	128,478
Lake 984	7309759	402495	153,108	296,424	1.9	71,739	7,174	0.17	Nil	7,174
Lake 18-1	7310007	401912	161,253	426,414	2.6	150,589	15,059	0.15	Nil	15,059
Lake LA18-0a	7311590	396960	714,708	4,368,027	6.1	3,006,955	300,695	0.36	Low	128,478
Lake 19-0	7311911	401691	160,065	360,221	2.3	98,274	9,827	0.12	Nil	9,827
Lake 985	7312109	395983	40,914	106,234	2.6	35,130	3,513	0.13	Nil	3,513
Lake 986	7312574	392342	16,299	37,926	2.3	12,753	1,275	0.14	Nil	1,275
Lake 989	7313114	391719	29,322	62,690	2.1	17,580	1,758	0.13	Nil	1,758
Lake 987	7313141	398133	206,199	760,584	3.7	393,753	39,375	0.21	Nil	39,375
Lake 991	7313599	391191	36,702	76,595	2.1	21,030	2,103	0.13	Nil	2,103

Waterbody ID	North. UTM	East. UTM	Surface Area (SA) (m^2)	Volume (V) (m^3)	V:SA ratio (m)	Under Ice Volume Below 2 m Depth (m^3)	10% Volume Below 2 m Depth (m^3)	Predicted Water Level Change (m)	Risk of Habitat Loss For 10% Guideline	Calculated Volume for Nil Risk (m^3)
Lake LA20-0	7313887	399363	324,144	940,089	2.9	389,431	38,943	0.18	Nil	38,943
Lake 990	7314076	388751	761,706	3,456,788	4.5	2,130,011	213,001	0.41	Low	115,021
Lake 20-0	7314226	404075	5,757,903	24,053,493	4.2	14,139,389	1,413,939	0.29	Low	1,060,454
Lake 992	7314853	389975	893,646	3,525,249	3.9	1,938,558	193,856	0.24	Low	178,347
Lake LA21-0	7315592	399777	256,878	761,896	3.0	309,761	30,976	0.18	Nil	30,976
Lake LA23-0	7315882	401330	265,968	1,013,844	3.8	524,720	52,472	0.23	Low	51,947
Lake LA21-1	7316914	399454	204,606	406,055	2.0	129,313	12,931	0.16	Nil	12,931
Lake LA22-0	7317386	399995	2,393,802	5,635,137	2.4	1,697,105	169,711	0.16	Nil	169,711
Lake 23-0	7318800	403392	498,888	1,218,007	2.4	396,365	39,637	0.14	Nil	39,637
Lake 24-0	7321054	402094	876,762	2,011,377	2.3	599,951	59,995	0.13	Nil	59,995
Lake 994	7323246	400275	136,197	276,346	2.0	61,034	6,103	0.11	Nil	6,103
Lake 995	7325353	400617	103,959	233,491	2.2	75,975	7,597	0.17	Nil	7,597
Lake 25-0	7326281	400452	483,390	1,713,886	3.5	868,241	86,824	0.23	Low	80,746
Lake 996	7327338	401382	26,253	43,840	1.7	6,832	683	0.09	Nil	683
Lake 26-0	7328257	401915	59,454	181,351	3.1	97,110	9,711	0.30	Low	6,992
Lake 997	7329276	401911	17,280	41,763	2.4	15,122	1,512	0.17	Nil	1,512
Lake 28-0	7332392	403397	265,680	653,963	2.5	239,515	23,951	0.18	Nil	23,951
Lake 29-0	7334245	403433	1,174,887	5,393,491	4.6	3,246,825	324,682	0.34	Low	211,044
Lake 998	7336793	403071	46,809	125,763	2.7	53,343	5,334	0.20	Nil	5,334
Lake 30-0	7340003	404631	927,360	1,683,771	1.8	566,741	56,674	0.21	Nil	56,674
Lake 30-4	7343073	403851	48,825	101,926	2.1	28,590	2,859	0.15	Nil	2,859
Lake 31-0	7351852	400718	82,758,231	2,779,474,304	33.6	2,616,978,541	261,697,854	3.39	High	17,010,361
Lake 999	7364930	391663	1,645,029	13,130,162	8.0	10,124,845	1,012,485	0.76	Med.	293,621
Lake 31-1	7367584	391134	34,803	70,470	2.0	16,035	1,604	0.12	Nil	1,604
Lake 31-2	7367973	390840	55,377	137,368	2.5	52,909	5,291	0.22	Low	5,185
Lake 32-0	7373635	387860	3,747,375	21,976,529	5.9	14,966,675	1,496,668	0.37	Low	868,067
Lake 33-0	7378706	385690	124,371	270,935	2.2	86,426	8,643	0.17	Nil	8,643
Lake 34-0	7380542	390639	157,216,248	3,320,662,011	21.1	3,010,754,419	301,075,442	2.03	High	32,516,148

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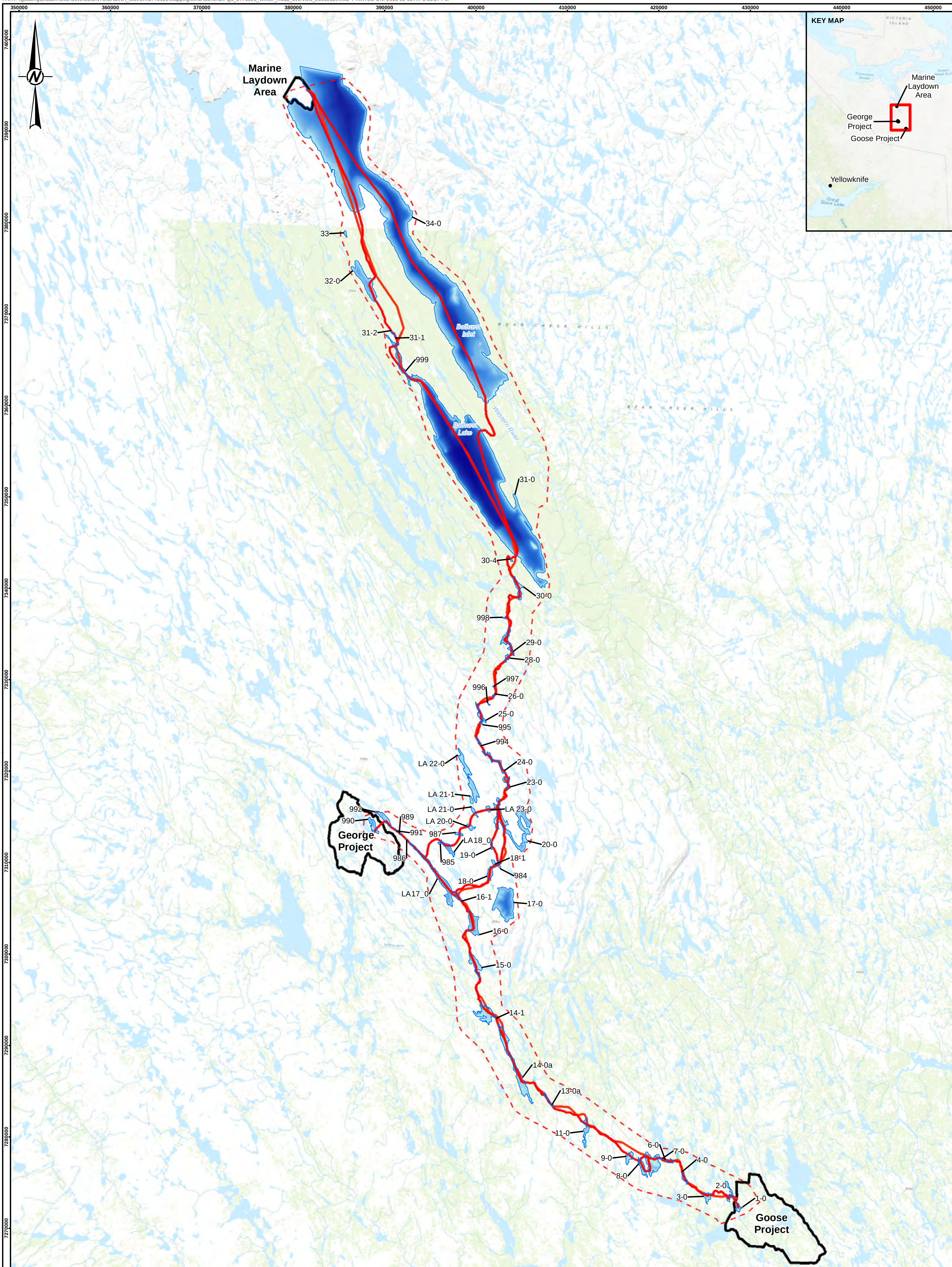

LEGEND

- WINTER ROAD
- PROJECT AREA
- LAKE EXTENT (DEPTH > 3.5M)
- PROJECT BOUNDARY

BATHYMETRY (1 M INTERVAL)

0
-13
-26
-39
-52
-65

0 10 20

1:400,000 KILOMETRES

REFERENCE(S)

SERVICE LAYER CREDITS: SOURCES: ESRI, HERE, DELORME, INTERMAP, INCREMENT P CORP., GEBCO, USGS, FAO, NPS, NRCAN, GEOBASE, IGN, KADASTER NL, ORDNANCE SURVEY, ESRI JAPAN, METI, ESRI CHINA (HONG KONG), SWISSTOPO, MAPMYINDIA, © OPENSTREETMAP CONTRIBUTORS, AND THE GIS USER COMMUNITY

PROJECTION: UTM ZONE 13 DATUM: NAD 83

CLIENT

SABINA GOLD & SILVER CORP.

PROJECT

BACK RIVER PROJECT

TITLE

OVERVIEW OF WATER SOURCES FOR WINTER ICE ROAD CONSTRUCTION FOR THE BACK RIVER PROJECT

CONSULTANT

Golder Associates

YYYY-MM-DD	2018-02-05
DESIGNED	BW
PREPARED	JG
REVIEWED	
APPROVED	

PROJECT NO.	CONTROL	REV.	FIGURE
1776921	1300/1320	A	1

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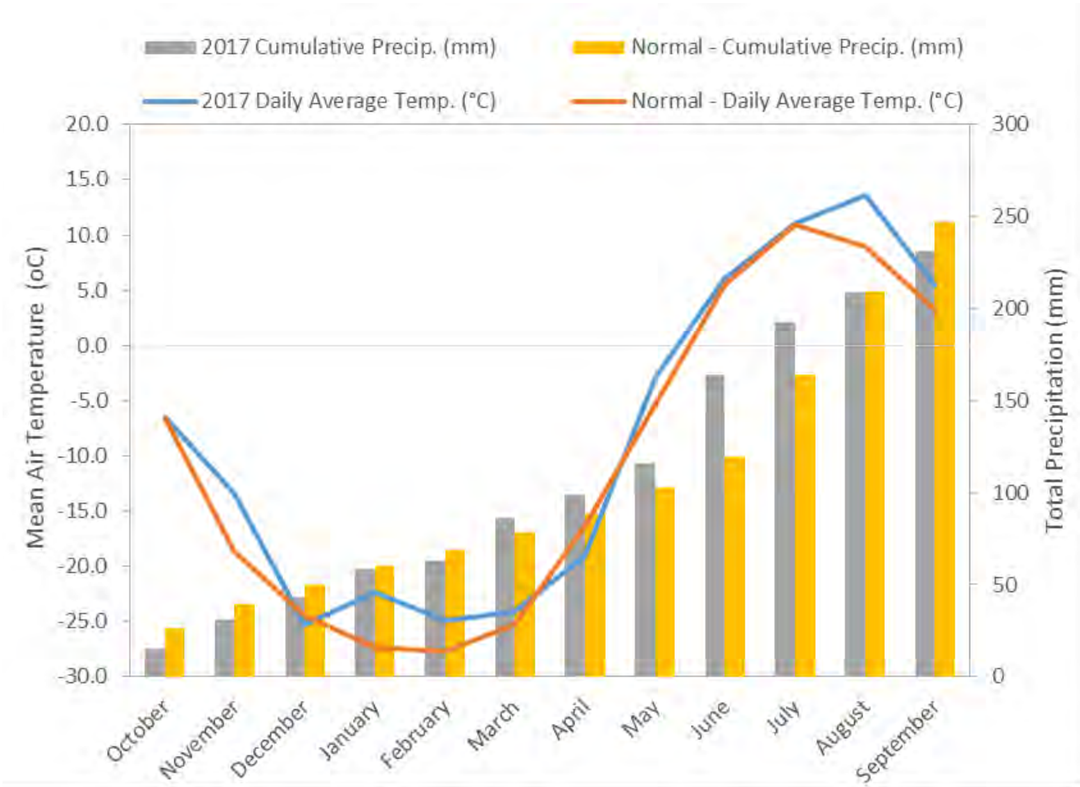

Figure 2: A Comparison of Monthly Total Precipitation and Mean Air Temperature for 2017 versus 'Normals' (1981-2010)

No measurable effects are predicted for fish and fish habitat for most of the identified source lakes if using the 10% under-ice volume guideline for water withdrawal (Table 2). However, potential effects to fish and fish habitat may result for some lakes with large volumes of water relative to the surface area of the lake (i.e., lakebeds profiled as a deep 'bathtub' or 'bowl' shape). For example, minor effects to fish habitat may result in Lake LA17-0 and Lake 999 where predicted water levels may be reduced by 0.43 m, and 0.76 m, respectively, during water withdrawal. To avoid effects to fish and fish habitat (e.g., exposing incubating eggs on shoals) in these two lakes, it is recommended that volumes less than the 10% under ice volume be withdrawn (e.g., approximately 5% for Lake LA17-0, and 3% for Lake 999). A similar recommendation is made for Lake 31-0 (Bathurst Lake) where moderate to major effects to fish habitat may result from water withdrawals unless reduced below the DFO guideline. Given that predicted water levels may drop by 3.39 m if extracted volumes are 10% the under-ice volume, it is recommended that approximately 1% of the under ice volume be withdrawn from Lake 31-0 for road construction. Although the available under ice volume for Lake 34-0 (i.e., lower Bathurst Inlet) for winter ice road construction may be larger than that reported in Table 2 because of receiving under-ice flows from the Western River, the reported under ice volume is recommended without additional hydrological study as a protective measure for fish and fish habitat.

The lake volume statistics generated by the satellite imagery interpretation method were similar to those generated from a field-based sonar survey of lakes. Lake volumes generated by the satellite imagery interpretation method were only marginally higher (by 9.2%) than the previously estimated volumes (Table 3). Differences may be a result of annual or seasonal changes in lake conditions, and also a result of differences underlying the two methods. Although a field-based sonar survey can collect accurate elevation details using a depth sounder, coverage is often limited in spatial extent due to time or logistical constraints. Furthermore, DFO's protocol recommends only one longitudinal transect (connecting the two farthest shorelines) and a minimum of two perpendicular transects evenly spaced on the longitudinal transect at maximum intervals of 500 m (DFO 2010). The spatial extent of topographic detail collected in the field can clearly be much less than what can be provided by satellite imagery, and recent studies suggest that accurate elevation data (within 0.2 m) can be achieved using high-quality imagery and stereo-photogrammetry interpretation methods (Ehses and Rooney 2015; Mohamed et al. 2016).

Table 3: Comparison of Volume Estimates for Field Survey-Derived Bathymetry versus Satellite Imagery-Derived Bathymetry

Analysis ID	Existing ID	Maximum Depth (m)	Field-Derived Volume (m^3)	Satellite-Derived Volume (m^3)	Volume % Difference
Lake 990	Fold Lake	15.4	2,970,486[(a)]	3,456,788	16.4
Lake 4-0	Winter Road Lake 01	8.5	664,318[(a)]	705,486	6.2
Lake 13-0a	Winter Road Lake 02	5.4	435,046[(a)]	597,123	37.3
Lake 25-0	Winter Road Lake 05	11.3	1,482,102[(a)]	1,713,886	15.6
Lake 26-0	Winter Road Lake 06	10.5	190,557[(a)]	181,351	-4.8
Lake 1-0	Llama Lake	13.6	1,130,613[(b)]	951,009	-15.9
Lake 2-0	Chair Lake	10.3	1,355,660[(b)]	1,487,839	9.8
				Mean Difference	9.2

a) Rescan (2014)
b) Appendix V6-3A in Sabina (2017)

In summary, the recommended (negligible risk to fish habitat) under-ice water volumes to be withdrawn for the construction of the winter ice road (in Table 2) are expected to be more protective of fish and fish habitat than the DFO 10% under-ice volume guideline. Furthermore, actual volumes of water to be withdrawn from each lake during construction are expected to be much less than the recommended volumes. The current plan for the winter ice road requires only 108,000 m^3 of water in total, which is lower than the recommend volume for some of the individual source lakes and is considerably lower than the combined recommended volumes in Table 2-1. However, water withdrawal targets should be re-evaluated annually for lakes if and when climate-related changes influence lake conditions beyond the baseline characterization described in this memo.

3.0 CLOSURE

We trust the above meets your needs, if you have any questions or concerns, please do not hesitate to contact the undersigned.

Sincerely,

Cam Stevens
Associate, Fisheries Biologist

Nathan Schmidt
Principal, Senior Water Resources Engineer

CS/NS/jr

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APPENDIX A
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Table 1: Lake 1-0 (Llama Lake)

Lake Volume and Surface Area Per Depth		
Elevation (m)	**Cumulative Volume (m^3)**	**Cumulative Area (m^2)**
0	951,009	348,021
-0.5	786,774	311,913
-1	638,670	270,801
-1.5	510,448	242,370
-2	396,025	214,992
-2.5	295,643	186,885
-3	208,840	155,556
-3.5	138,458	126,351
-4	82,119	96,138
-4.5	39,609	74,187
-5	7,540	11,493
-5.5	2,876	7,317

Table 2: Lake 2-0

Lake Volume and Surface Area Per Depth		
Elevation (m)	**Cumulative Volume (m^3)**	**Cumulative Area (m^2)**
0	1,487,839	598,077
-0.5	1,206,147	536,076
-1	950,662	482,616
-1.5	726,548	414,567
-2	535,068	343,089
-2.5	378,487	284,283
-3	250,032	213,183
-3.5	156,529	162,261
-4	86,311	83,394
-4.5	49,066	65,880
-5	20,279	29,286
-5.5	8,028	20,043

Table 3: Lake 3-0

Lake Volume and Surface Area Per Depth		
Elevation (m)	**Cumulative Volume (m^3)**	**Cumulative Area (m^2)**
0	1,738,708	557,865
-0.5	1,471,400	515,466
-1	1,222,799	476,883
-1.5	996,480	428,517
-2	793,748	372,249
-2.5	618,754	328,077
-3	465,410	282,915
-3.5	334,237	242,181
-4	222,877	186,147
-4.5	139,473	148,266
-5	73,867	108,693
-5.5	28,801	72,639

Table 4: Lake 4-0 (Winter Road Lake 01)

Lake Volume and Surface Area Per Depth		
Elevation (m)	**Cumulative Volume (m^3)**	**Cumulative Area (m^2)**
0	705,486	349,596
-0.5	543,299	302,454
-1	402,231	248,976
-1.5	288,067	208,080
-2	193,786	155,061
-2.5	123,756	125,640
-3	67,658	90,612
-3.5	28,424	66,951

Table 5: Lake 8-0

Lake Volume and Surface Area Per Depth		
Elevation (m)	**Cumulative Volume (m^3)**	**Cumulative Area (m^2)**
0	2,427,790	765,711
-0.5	2,062,180	704,376
-1	1,722,511	639,504
-1.5	1,416,714	584,028
-2	1,137,977	505,422
-2.5	896,624	460,161
-3	677,996	390,681
-3.5	498,982	325,350
-4	352,629	232,290
-4.5	247,406	188,874
-5	163,374	136,503
-5.5	102,089	109,107
-6	53,617	70,497
-6.5	22,787	53,226

Table 6: Lake 7-0

Lake Volume and Surface Area Per Depth		
Elevation (m)	**Cumulative Volume (m^3)**	**Cumulative Area (m^2)**
0	8,325,456	2,211,876
-0.5	7,247,255	2,110,995
-1	6,213,087	2,021,373
-1.5	5,238,844	1,876,698
-2	4,336,453	1,730,376
-2.5	3,503,990	1,599,210
-3	2,737,090	1,432,809
-3.5	2,067,760	1,242,540
-4	1,496,684	974,259
-4.5	1,053,454	800,208
-5	694,516	599,229
-5.5	427,598	469,224
-6	224,290	284,922
-6.5	101,840	206,397
-7	15,882	24,579
-7.5	5,966	15,507

Table 7: Lake 6-0

Lake Volume and Surface Area Per Depth		
Elevation (m)	Cumulative Volume (m^3)	Cumulative Area (m^2)
0	614,579	224,514
-0.5	508,726	201,150
-1	413,116	181,332
-1.5	327,974	159,327
-2	253,622	137,583
-2.5	189,913	117,333
-3	136,266	94,599
-3.5	93,626	76,032
-4	60,191	56,196
-4.5	35,098	44,199
-5	15,937	25,083
-5.5	5,842	15,588

Table 8: Lake 9-0

Lake Volume and Surface Area Per Depth		
Elevation (m)	Cumulative Volume (m^3)	Cumulative Area (m^2)
0	1,581,371	620,172
-0.5	1,283,776	574,164
-1	1,006,749	525,564
-1.5	757,986	469,674
-2	537,030	405,927
-2.5	348,525	348,795
-3	187,488	260,631
-3.5	77,135	184,167

Table 9: Lake 11-0

Lake Volume and Surface Area Per Depth		
Elevation (m)	**Cumulative Volume (m^3)**	**Cumulative Area (m^2)**
0	2,406,329	885,771
-0.5	1,986,081	803,664
-1	1,602,079	709,965
-1.5	1,270,068	619,065
-2	981,876	521,703
-2.5	738,637	452,313
-3	528,555	382,608
-3.5	353,075	319,824
-4	208,294	199,395
-4.5	120,846	151,551
-5	55,599	80,262
-5.5	22,085	54,639

Table 10: Lake 13-0a (Winter Road Lake 02)

Lake Volume and Surface Area Per Depth		
Elevation (m)	**Cumulative Volume (m^3)**	**Cumulative Area (m^2)**
0	597,123	290,376
-0.5	462,061	254,862
-1	342,054	215,253
-1.5	240,406	191,115
-2	151,117	156,141
-2.5	81,631	122,094
-3	28,802	37,107
-3.5	13,126	26,073
-4	2,450	3,024
-4.5	1,081	2,412

Table 11: Lake 14-0a

Lake Volume and Surface Area Per Depth		
Elevation (m)	**Cumulative Volume (m^3)**	**Cumulative Area (m^2)**
0	10,415,812	3,942,630
-0.5	8,508,701	3,706,839
-1	6,707,236	3,413,583
-1.5	5,076,385	3,109,680
-2	3,597,800	2,447,298
-2.5	2,465,903	2,080,647
-3	1,517,173	1,296,630
-3.5	925,510	1,073,889
-4	439,353	581,913
-4.5	186,010	435,573

Table 12: Lake 14-1 (Winter Road Lake 03)

Lake Volume and Surface Area Per Depth		
Elevation (m)	**Cumulative Volume (m^3)**	**Cumulative Area (m^2)**
0	4,779,159	2,221,497
-0.5	3,696,902	2,121,723
-1	2,656,345	1,995,939
-1.5	1,713,762	1,775,016
-2	881,912	1,167,093
-2.5	391,958	793,134
-3	87,827	148,545
-3.5	30,358	84,393

Table 13: Lake 15-0

Lake Volume and Surface Area Per Depth		
Elevation (m)	**Cumulative Volume (m^3)**	**Cumulative Area (m^2)**
0	5,027,754	1,441,269
-0.5	4,320,561	1,395,918
-1	3,631,480	1,355,472
-1.5	2,978,026	1,258,470
-2	2,373,270	1,149,336
-2.5	1,834,521	1,003,284
-3	1,372,339	795,123
-3.5	1,001,136	690,291
-4	681,553	501,993
-4.5	452,038	416,331
-5	265,208	302,211
-5.5	132,056	231,246
-6	33,062	53,973
-6.5	11,835	32,049

Table 14: Lake 16-0

Lake Volume and Surface Area Per Depth		
Elevation (m)	**Cumulative Volume (m^3)**	**Cumulative Area (m^2)**
0	12,016,309	2,068,272
-0.5	10,997,464	2,014,488
-1	10,001,007	1,967,616
-1.5	9,044,365	1,860,210
-2	8,139,725	1,742,535
-2.5	7,289,399	1,658,664
-3	6,480,762	1,575,414
-3.5	5,717,933	1,476,243
-4	5,004,215	1,375,101
-4.5	4,341,201	1,277,172
-5	3,726,880	1,167,093
-5.5	3,169,045	1,065,015
-6	2,661,580	959,958
-6.5	2,202,731	875,907
-7	1,785,082	786,681
-7.5	1,413,523	700,362
-8	1,084,083	605,790
-8.5	799,103	534,645
-9	548,721	457,002
-9.5	345,505	357,075
-10	190,492	247,329
-10.5	81,526	189,459

Table 15: Lake 17-0

Lake Volume and Surface Area Per Depth		
Elevation (m)	**Cumulative Volume (m^3)**	**Cumulative Area (m^2)**
0	61,932,318	5,913,261
-0.5	58,988,355	5,863,014
-1	56,069,074	5,813,217
-1.5	53,191,478	5,696,244
-2	50,372,624	5,540,463
-2.5	47,635,707	5,406,192
-3	44,967,408	5,241,510
-3.5	42,391,708	5,060,475
-4	39,906,981	4,851,423
-4.5	37,526,172	4,672,242
-5	35,233,773	4,421,880
-5.5	33,077,330	4,204,242
-6	31,029,091	3,975,948
-6.5	29,091,298	3,775,158
-7	27,253,008	3,540,456
-7.5	25,520,934	3,388,428
-8	23,863,695	3,223,233
-8.5	22,287,815	3,080,664
-9	20,782,317	2,938,743
-9.5	19,345,963	2,806,947
-10	17,974,529	2,677,734
-10.5	16,665,221	2,559,897
-11	15,413,919	2,444,607
-11.5	14,219,600	2,332,719
-12	13,080,745	2,222,280
-12.5	11,997,651	2,110,113
-13	10,970,236	1,999,755
-13.5	9,998,631	1,886,976
-14	9,082,514	1,775,952
-14.5	8,221,505	1,668,375
-15	7,413,747	1,562,508
-15.5	6,656,587	1,466,451
-16	5,946,799	1,372,005
-16.5	5,284,027	1,279,431
-17	4,666,741	1,189,449
-17.5	4,093,761	1,102,932
-18	3,563,254	1,017,972
-18.5	3,075,495	933,507
-19	2,629,259	848,709
-19.5	2,225,377	767,574
-20	1,861,215	682,425

Table 15: Lake 17-0 (continued)

Lake Volume and Surface Area Per Depth		
Elevation (m)	**Cumulative Volume (m^3)**	**Cumulative Area (m^2)**
-20.5	1,538,744	607,680
-21	1,252,962	524,637
-21.5	1,005,985	463,815
-22	788,650	398,403
-22.5	603,012	344,385
-23	443,520	277,704
-23.5	316,488	231,093
-24	211,662	181,017
-24.5	131,801	138,987
-25	71,788	97,299
-25.5	29,713	71,325

Table 16: Lake 16-1

Lake Volume and Surface Area Per Depth		
Elevation (m)	**Cumulative Volume (m^3)**	**Cumulative Area (m^2)**
0	812,512	319,815
-0.5	656,628	303,615
-1	508,692	286,110
-1.5	375,239	248,013
-2	260,311	207,252
-2.5	165,049	174,015
-3	86,367	90,900
-3.5	46,432	69,156
-4	16,902	25,299
-4.5	6,517	16,578

Table 17: Lake LA17-0

Lake Volume and Surface Area Per Depth		
Elevation (m)	**Cumulative Volume (m^3)**	**Cumulative Area (m^2)**
0	18,907,975	3,193,056
-0.5	17,331,869	3,111,678
-1	15,795,680	3,029,634
-1.5	14,305,839	2,929,986
-2	12,865,851	2,812,185
-2.5	11,491,012	2,686,905
-3	10,179,056	2,553,057
-3.5	8,937,258	2,414,124
-4	7,764,886	2,272,824
-4.5	6,660,229	2,145,879
-5	5,618,749	2,013,453
-5.5	4,657,451	1,832,022
-6	3,786,398	1,600,722
-6.5	3,030,687	1,422,720
-7	2,363,514	1,175,598
-7.5	1,816,893	1,011,708
-8	1,351,204	752,112
-8.5	1,004,902	634,284
-9	715,587	488,862
-9.5	494,721	395,442
-10	319,267	258,894
-10.5	204,715	200,232
-11	118,230	119,160
-11.5	67,019	86,382
-12	31,037	44,217
-12.5	12,445	30,618

Table 18: Lake 18-0

Lake Volume and Surface Area Per Depth		
Elevation (m)	**Cumulative Volume (m³)**	**Cumulative Area (m²)**
0	2,886,128	635,085
-0.5	2,571,908	622,143
-1	2,263,916	608,175
-1.5	1,968,603	573,255
-2	1,690,494	537,786
-2.5	1,432,519	494,226
-3	1,196,240	445,176
-3.5	983,789	404,523
-4	792,166	352,332
-4.5	627,040	308,979
-5	482,366	266,328
-5.5	357,855	232,326
-6	249,488	196,920
-6.5	160,328	160,461
-7	88,190	123,966
-7.5	35,648	87,174

Table 19: Lake 984

Lake Volume and Surface Area Per Depth		
Elevation (m)	**Cumulative Volume (m³)**	**Cumulative Area (m²)**
0	296,424	153,108
-0.5	222,837	141,282
-1	154,983	116,604
-1.5	105,469	82,350
-2	71,739	46,314
-2.5	50,654	38,205
-3	33,417	29,034
-3.5	20,565	22,446
-4	10,796	15,111
-4.5	4,391	10,665

Table 20: Lake 18-1

Lake Volume and Surface Area Per Depth		
Elevation (m)	**Cumulative Volume (m^3)**	**Cumulative Area (m^2)**
0	426,414	161,253
-0.5	347,889	152,856
-1	273,423	144,927
-1.5	206,642	122,508
-2	150,589	101,844
-2.5	103,121	88,371
-3	62,127	74,511
-3.5	28,085	61,884

Table 21: Lake LA18-0a

Lake Volume and Surface Area Per Depth		
Elevation (m)	**Cumulative Volume (m^3)**	**Cumulative Area (m^2)**
0	4,368,027	714,708
-0.5	4,014,611	699,075
-1	3,668,821	682,677
-1.5	3,332,711	661,842
-2	3,006,955	640,116
-2.5	2,693,523	613,575
-3	2,393,308	579,033
-3.5	2,112,672	543,897
-4	1,849,433	507,033
-4.5	1,606,085	466,578
-5	1,382,725	425,655
-5.5	1,179,964	385,632
-6	996,976	336,573
-6.5	835,437	309,663
-7	687,154	277,686
-7.5	556,205	246,411
-8	440,264	209,835
-8.5	341,992	183,456
-9	256,581	156,249
-9.5	184,461	132,399
-10	123,961	107,064
-10.5	75,973	85,185
-11	38,628	51,327
-11.5	16,249	38,412

Table 22: Lake 19-0

Lake Volume and Surface Area Per Depth		
Elevation (m)	**Cumulative Volume (m^3)**	**Cumulative Area (m^2)**
0	360,221	160,065
-0.5	283,395	147,330
-1	212,794	133,866
-1.5	150,823	114,210
-2	98,274	94,680
-2.5	55,599	76,140
-3	21,703	31,635
-3.5	8,554	21,276

Table 23: Lake 985

Lake Volume and Surface Area Per Depth		
Elevation (m)	**Cumulative Volume (m^3)**	**Cumulative Area (m^2)**
0	106,234	40,914
-0.5	86,360	38,592
-1	67,644	36,297
-1.5	50,480	32,436
-2	35,130	28,764
-2.5	22,038	23,598
-3	11,445	17,559
-3.5	4,342	11,160

Table 24: Lake 986

Lake Volume and Surface Area Per Depth		
Elevation (m)	**Cumulative Volume (m^3)**	**Cumulative Area (m^2)**
0	37,926	16,299
-0.5	30,295	14,220
-1	23,650	12,348
-1.5	17,841	10,917
-2	12,753	9,513
-2.5	8,385	8,046
-3	4,704	6,048
-3.5	2,032	4,653

Table 25: Lake 989

Lake Volume and Surface Area Per Depth		
Elevation (m)	**Cumulative Volume (m^3)**	**Cumulative Area (m^2)**
0	62,690	29,322
-0.5	48,842	26,073
-1	36,561	22,338
-1.5	26,256	18,891
-2	17,580	14,976
-2.5	10,895	11,817
-3	5,699	8,595
-3.5	2,181	5,616

Table 26: Lake 987

Lake Volume and Surface Area Per Depth		
Elevation (m)	**Cumulative Volume (m^3)**	**Cumulative Area (m^2)**
0	760,584	206,199
-0.5	660,430	194,562
-1	565,753	183,537
-1.5	476,918	171,882
-2	393,753	160,596
-2.5	318,065	142,254
-3	251,463	116,433
-3.5	197,446	100,071
-4	150,792	83,763
-4.5	112,205	70,776
-5	79,776	58,113
-5.5	53,942	45,423
-6	34,115	32,454
-6.5	20,002	24,156
-7	9,785	14,814
-7.5	3,695	9,630

Table 27: Lake 991

Lake Volume and Surface Area Per Depth		
Elevation (m)	**Cumulative Volume (m^3)**	**Cumulative Area (m^2)**
0	76,595	36,702
-0.5	59,409	32,085
-1	44,450	27,594
-1.5	31,736	23,274
-2	21,030	19,152
-2.5	12,573	14,697
-3	6,223	9,414
-3.5	2,372	6,093

Table 28: Lake LA20-0

Lake Volume and Surface Area Per Depth		
Elevation (m)	**Cumulative Volume (m^3)**	**Cumulative Area (m^2)**
0	940,089	324,144
-0.5	783,490	302,679
-1	637,283	271,242
-1.5	507,698	247,482
-2	389,431	222,093
-2.5	284,596	197,334
-3	192,027	157,527
-3.5	120,826	127,575
-4	64,244	90,423
-4.5	25,810	63,693

Table 29: Lake 990 (Fold Lake)

Lake Volume and Surface Area Per Depth		
Elevation (m)	Cumulative Volume (m^3)	Cumulative Area (m^2)
0	3,456,788	761,706
-0.5	3,087,385	716,427
-1	2,739,717	656,919
-1.5	2,423,106	609,525
-2	2,130,011	545,661
-2.5	1,870,827	491,571
-3	1,638,121	400,167
-3.5	1,453,581	339,399
-4	1,297,348	285,903
-4.5	1,158,719	268,677
-5	1,028,661	251,361
-5.5	907,323	233,991
-6	794,532	216,981
-6.5	689,551	202,869
-7	591,575	188,604
-7.5	500,912	173,979
-8	417,561	159,345
-8.5	341,565	144,666
-9	272,818	129,204
-9.5	213,107	109,845
-10	162,911	87,579
-10.5	122,816	72,927
-11	89,990	56,997
-11.5	64,197	46,296
-12	43,700	33,516
-12.5	28,675	26,550
-13	17,063	17,811
-13.5	9,378	13,059
-14	3,909	6,435
-14.5	1,383	3,843

Table 30: Lake 20-0

Lake Volume and Surface Area Per Depth		
Elevation (m)	**Cumulative Volume (m^3)**	**Cumulative Area (m^2)**
0	24,053,493	5,757,903
-0.5	21,274,098	5,359,257
-1	18,694,202	4,914,081
-1.5	16,327,151	4,554,369
-2	14,139,389	4,160,286
-2.5	12,143,103	3,824,901
-3	10,313,817	3,444,399
-3.5	8,671,863	3,124,656
-4	7,188,577	2,734,920
-4.5	5,892,489	2,450,403
-5	4,736,646	2,011,113
-5.5	3,800,296	1,737,054
-6	2,996,722	1,430,307
-6.5	2,332,005	1,230,615
-7	1,764,101	958,626
-7.5	1,324,398	802,566
-8	958,983	612,387
-8.5	682,383	495,297
-9	462,115	355,122
-9.5	303,961	279,081
-10	181,373	194,058
-10.5	96,468	146,736
-11	33,608	44,649
-11.5	14,164	33,363

Table 31: Lake 992 (Lower Long Lake)

Lake Volume and Surface Area Per Depth		
Elevation (m)	**Cumulative Volume (m^3)**	**Cumulative Area (m^2)**
0	3,525,249	893,646
-0.5	3,090,884	843,894
-1	2,681,132	794,889
-1.5	2,296,727	742,455
-2	1,938,558	684,441
-2.5	1,609,868	630,351
-3	1,308,061	570,294
-3.5	1,037,696	511,290
-4	796,388	428,427
-4.5	600,504	355,113
-5	441,327	242,514
-5.5	331,443	197,631
-6	243,202	131,913
-6.5	183,033	109,143
-7	133,905	84,798
-7.5	95,742	68,004
-8	65,674	49,887
-8.5	43,530	38,835
-9	26,637	26,559
-9.5	14,968	20,178
-10	6,340	9,612
-10.5	2,417	6,255

Note: results represent approximately half of the lake

Table 32: Lake LA21-0

Lake Volume and Surface Area Per Depth		
Elevation (m)	**Cumulative Volume (m^3)**	**Cumulative Area (m^2)**
0	761,896	256,878
-0.5	636,798	243,540
-1	518,164	230,571
-1.5	408,466	208,323
-2	309,761	184,896
-2.5	223,571	160,011
-3	149,502	131,949
-3.5	90,275	105,246
-4	43,945	61,821
-4.5	17,741	43,488

Table 33: Lake LA23-0

Lake Volume and Surface Area Per Depth		
Elevation (m)	**Cumulative Volume (m^3)**	**Cumulative Area (m^2)**
0	1,013,844	265,968
-0.5	883,593	255,177
-1	758,619	244,926
-1.5	638,981	233,838
-2	524,720	223,182
-2.5	417,547	205,551
-3	319,059	188,469
-3.5	231,584	161,847
-4	156,958	135,342
-4.5	97,169	104,409
-5	51,964	72,063
-5.5	21,204	51,399

Table 34: Lake LA21-1

Lake Volume and Surface Area Per Depth		
Elevation (m)	**Cumulative Volume (m^3)**	**Cumulative Area (m^2)**
0	406,055	204,606
-0.5	313,083	167,463
-1	238,330	125,316
-1.5	179,826	108,810
-2	129,313	92,871
-2.5	87,933	72,837
-3	56,168	50,058
-3.5	33,938	39,006
-4	17,084	25,722
-4.5	6,464	16,857

Table 35: Lake LA22-0

Lake Volume and Surface Area Per Depth		
Elevation (m)	**Cumulative Volume (m^3)**	**Cumulative Area (m^2)**
0	5,635,137	2,393,802
-0.5	4,482,867	2,216,070
-1	3,417,646	2,004,201
-1.5	2,486,972	1,719,324
-2	1,697,105	1,305,063
-2.5	1,119,971	1,006,281
-3	687,345	499,131
-3.5	461,891	403,263
-4	283,219	234,945
-4.5	178,423	184,986
-5	97,282	137,520
-5.5	38,910	96,624

Table 36: Lake 23-0

Lake Volume and Surface Area Per Depth		
Elevation (m)	**Cumulative Volume (m^3)**	**Cumulative Area (m^2)**
0	1,218,007	498,888
-0.5	978,980	457,965
-1	759,688	413,127
-1.5	565,653	363,042
-2	396,365	304,857
-2.5	255,928	256,743
-3	139,356	190,107
-3.5	57,778	137,799

Table 37: Lake 24-0

Lake Volume and Surface Area Per Depth		
Elevation (m)	Cumulative Volume (m^3)	Cumulative Area (m^2)
0	2,011,377	876,762
-0.5	1,593,705	794,241
-1	1,216,306	707,499
-1.5	885,350	616,248
-2	599,951	502,839
-2.5	370,232	417,114
-3	182,194	251,559
-3.5	74,529	180,648

Table 38: Lake 994

Lake Volume and Surface Area Per Depth		
Elevation (m)	**Cumulative Volume (m^3)**	**Cumulative Area (m^2)**
0	276,346	136,197
-0.5	211,157	124,704
-1	151,661	108,810
-1.5	101,855	90,432
-2	61,034	64,206
-2.5	33,180	47,628
-3	13,069	19,656
-3.5	4,999	12,825

Table 39: Lake 995

Lake Volume and Surface Area Per Depth		
Elevation (m)	**Cumulative Volume (m^3)**	**Cumulative Area (m^2)**
0	233,491	103,959
-0.5	184,607	91,971
-1	141,616	80,118
-1.5	105,172	65,538
-2	75,975	49,248
-2.5	53,340	41,301
-3	34,509	32,976
-3.5	19,729	26,199
-4	8,207	12,276
-4.5	3,137	8,127

Table 40: Lake 25-0 (Winter Road Lake 05)

Lake Volume and Surface Area Per Depth

Elevation (m)	Cumulative Volume (m^3)	Cumulative Area (m^2)
0	1,713,886	483,390
-0.5	1,479,292	454,887
-1	1,258,717	423,630
-1.5	1,055,229	390,429
-2	868,241	330,912
-2.5	712,176	293,499
-3	574,202	257,418
-3.5	451,816	232,380
-4	341,796	204,354
-4.5	246,870	175,221
-5	166,488	126,810
-5.5	109,103	103,149
-6	63,042	61,848
-6.5	36,204	45,756
-7	16,933	11,070
-7.5	12,052	8,469
-8	8,414	6,066
-8.5	5,663	4,896
-9	3,483	3,753
-9.5	1,874	2,709
-10	757	1,224
-10.5	278	765

Table 41: Lake 996

Lake Volume and Surface Area Per Depth

Elevation (m)	Cumulative Volume (m^3)	Cumulative Area (m^2)
0	43,840	26,253
-0.5	31,678	22,446
-1	21,286	18,900
-1.5	12,971	14,409
-2	6,832	8,010
-2.5	3,481	5,508
-3	1,240	2,079
-3.5	436	1,233

Table 42: Lake 26-0 (Winter Road Lake 06)

Lake Volume and Surface Area Per Depth		
Elevation (m)	**Cumulative Volume (m^3)**	**Cumulative Area (m^2)**
0	181,351	59,454
-0.5	154,336	48,852
-1	132,265	39,654
-1.5	113,597	35,064
-2	97,110	30,897
-2.5	82,370	28,089
-3	69,005	25,425
-3.5	57,094	22,320
-4	46,686	19,287
-4.5	37,659	16,812
-5	29,834	14,472
-5.5	23,043	12,771
-6	17,092	10,998
-6.5	12,014	9,297
-7	7,753	5,436
-7.5	5,320	4,320
-8	3,393	3,141
-8.5	2,024	2,358
-9	1,010	1,593
-9.5	372	1,017

Table 43: Lake 997

Lake Volume and Surface Area Per Depth		
Elevation (m)	**Cumulative Volume (m^3)**	**Cumulative Area (m^2)**
0	41,763	17,280
-0.5	33,611	15,246
-1	26,461	13,284
-1.5	20,335	11,277
-2	15,122	9,513
-2.5	10,772	7,875
-3	7,193	6,390
-3.5	4,381	4,842
-4	2,264	3,240
-4.5	911	2,214

Table 44: Lake 28-0

Lake Volume and Surface Area Per Depth		
Elevation (m)	**Cumulative Volume (m^3)**	**Cumulative Area (m^2)**
0	653,963	265,680
-0.5	528,349	236,736
-1	417,104	207,198
-1.5	321,078	177,165
-2	239,515	140,265
-2.5	174,734	119,358
-3	119,751	93,681
-3.5	77,451	75,375
-4	44,548	49,707
-4.5	23,042	36,387
-5	8,010	11,835
-5.5	3,093	7,965

Table 45: Lake 29-0

Lake Volume and Surface Area Per Depth		
Elevation (m)	**Cumulative Volume (m^3)**	**Cumulative Area (m^2)**
0	5,393,491	1,174,887
-0.5	4,817,050	1,131,201
-1	4,262,173	1,080,720
-1.5	3,737,917	1,015,686
-2	3,246,825	921,393
-2.5	2,804,519	847,629
-3	2,399,386	757,305
-3.5	2,039,176	683,649
-4	1,715,040	594,387
-4.5	1,432,061	537,903
-5	1,176,592	472,086
-5.5	955,205	414,081
-6	761,770	348,588
-6.5	600,293	298,143
-7	462,858	233,271
-7.5	355,325	197,280
-8	264,767	151,047
-8.5	195,440	126,801
-9	137,826	102,753
-9.5	92,119	80,523
-10	56,906	52,065
-10.5	34,308	38,700
-11	17,925	26,217
-11.5	7,001	17,721

Table 46: Lake 998

Lake Volume and Surface Area Per Depth		
Elevation (m)	**Cumulative Volume (m^3)**	**Cumulative Area (m^2)**
0	125,763	46,809
-0.5	103,848	40,851
-1	84,747	35,496
-1.5	68,045	31,401
-2	53,343	27,126
-2.5	40,766	23,247
-3	30,037	19,116
-3.5	21,351	15,615
-4	14,376	12,312
-4.5	8,942	9,630
-5	4,748	6,426
-5.5	1,948	4,725

Table 47: Lake 30-0

Lake Volume and Surface Area Per Depth		
Elevation (m)	**Cumulative Volume (m^3)**	**Cumulative Area (m^2)**
0	1,683,771	927,360
-0.5	1,258,362	778,509
-1	900,580	370,440
-1.5	724,696	333,720
-2	566,741	294,957
-2.5	429,027	256,815
-3	309,111	201,456
-3.5	216,433	169,920
-4	138,546	127,656
-4.5	81,453	101,151
-5	36,825	50,634
-5.5	15,061	36,639

Table 48: Lake 30-4

Lake Volume and Surface Area Per Depth		
Elevation (m)	**Cumulative Volume (m^3)**	**Cumulative Area (m^2)**
0	101,926	48,825
-0.5	79,011	42,921
-1	58,908	37,179
-1.5	42,092	30,240
-2	28,590	23,796
-2.5	18,087	18,225
-3	10,211	10,035
-3.5	5,873	7,398
-4	2,787	4,374
-4.5	1,021	2,718

Table 49: Lake 31-0

Lake Volume and Surface Area Per Depth		
Elevation (m)	**Cumulative Volume (m^3)**	**Cumulative Area (m^2)**
0	2,779,474,304	82,758,231
-0.5	2,738,286,322	81,993,276
-1	2,697,479,161	81,173,871
-1.5	2,657,060,478	80,500,122
-2	2,616,978,541	79,766,712
-2.5	2,577,275,942	79,043,760
-3	2,537,934,427	78,270,867
-3.5	2,498,976,729	77,559,606
-4	2,460,374,524	76,781,853
-4.5	2,422,167,580	76,045,545
-5	2,384,328,503	75,273,336
-5.5	2,346,852,319	74,632,995
-6	2,309,694,851	73,976,832
-6.5	2,272,843,941	73,428,219
-7	2,236,266,110	72,845,262
-7.5	2,199,978,270	72,306,963
-8	2,163,957,904	71,748,549
-8.5	2,128,208,323	71,249,652
-9	2,092,707,373	70,744,662
-9.5	2,057,462,312	70,235,793
-10	2,022,471,385	69,723,927
-10.5	1,987,739,440	69,204,159
-11	1,953,266,573	68,684,013
-11.5	1,919,046,272	68,198,400
-12	1,885,068,199	67,705,983
-12.5	1,851,334,569	67,228,920

Table 49: Lake 31-0 (continued)

Lake Volume and Surface Area Per Depth		
-13	1,817,838,881	66,697,659
-13.5	1,784,611,758	66,210,417
-14	1,751,627,867	65,717,829
-14.5	1,718,882,776	65,263,140
-15	1,686,364,164	64,808,766
-15.5	1,654,084,897	64,309,302
-16	1,622,054,442	63,761,085
-16.5	1,590,297,568	63,265,374
-17	1,558,788,025	62,746,614
-17.5	1,527,535,319	62,264,043
-18	1,496,522,874	61,762,707
-18.5	1,465,765,321	61,268,445
-19	1,435,253,763	60,769,143
-19.5	1,404,995,684	60,263,793
-20	1,374,989,744	59,751,288
-20.5	1,345,249,489	59,210,694
-21	1,315,778,729	58,660,461
-21.5	1,286,584,459	58,117,185
-22	1,257,661,383	57,566,655
-22.5	1,229,012,381	57,030,012
-23	1,200,631,288	56,477,808
-23.5	1,172,533,740	55,912,635
-24	1,144,717,715	55,346,733
-24.5	1,117,200,617	54,721,701
-25	1,089,995,211	54,093,960
-25.5	1,063,111,477	53,442,306
-26	1,036,552,135	52,792,983
-26.5	1,010,316,014	52,152,156
-27	984,399,486	51,509,538
-27.5	958,815,565	50,828,094
-28	933,570,502	50,145,750
-28.5	908,670,006	49,457,457
-29	884,111,981	48,772,368
-29.5	859,900,511	48,074,625
-30	836,036,328	47,279,367
-30.5	812,565,571	46,607,166
-31	789,426,176	45,925,938
-31.5	766,625,128	45,280,584
-32	744,143,346	44,571,042
-32.5	722,006,980	43,975,332
-33	700,167,379	43,382,241
-33.5	678,627,297	42,778,629

Table 49: Lake 31-0 (continued)

Lake Volume and Surface Area Per Depth		
-34	657,388,064	42,176,700
-34.5	636,455,412	41,554,566
-35	615,832,872	40,931,937
-35.5	595,521,309	40,315,581
-36	575,516,794	39,702,060
-36.5	555,810,028	39,125,016
-37	536,390,699	38,547,693
-37.5	517,270,174	37,934,649
-38	498,455,270	37,322,379
-38.5	479,949,509	36,701,775
-39	461,752,823	36,082,944
-39.5	443,862,015	35,480,250
-40	426,271,732	34,876,053
-40.5	408,991,697	34,243,875
-41	392,027,236	33,613,353
-41.5	375,357,554	33,065,784
-42	358,961,388	32,516,379
-42.5	342,841,389	31,964,148
-43	326,996,676	31,414,347
-43.5	311,425,290	30,871,422
-44	296,124,835	30,327,417
-44.5	281,090,826	29,809,215
-45	266,315,475	29,291,625
-45.5	251,799,364	28,772,748
-46	237,542,200	28,252,341
-46.5	223,568,690	27,641,682
-47	209,899,524	27,030,564
-47.5	196,562,608	26,317,629
-48	183,580,647	25,575,021
-48.5	171,007,519	24,720,444
-49	158,858,197	23,844,411
-49.5	147,142,961	23,019,183
-50	135,836,868	22,053,330
-50.5	125,044,753	21,117,474
-51	114,717,209	20,171,889
-51.5	104,882,606	19,168,425
-52	95,546,830	18,123,930
-52.5	86,725,970	17,161,929
-53	78,382,597	16,124,526
-53.5	70,550,222	15,209,154
-54	63,168,664	14,290,947
-54.5	56,242,766	13,416,732

Table 49: Lake 31-0 (continued)

Lake Volume and Surface Area Per Depth		
-55	49,748,780	12,454,083
-55.5	43,766,641	11,480,868
-56	38,262,036	9,984,519
-56.5	33,494,892	9,088,650
-57	29,168,416	8,002,602
-57.5	25,342,406	7,304,724
-58	21,860,302	6,573,060
-58.5	18,694,822	6,091,542
-59	15,766,101	5,604,417
-59.5	13,077,313	5,153,346
-60	10,610,749	4,659,732
-60.5	8,406,393	4,161,825
-61	6,444,473	3,645,792
-61.5	4,756,378	3,111,633
-62	3,327,705	2,489,598
-62.5	2,211,484	1,981,539
-63	1,340,252	1,264,635
-63.5	787,502	952,182
-64	382,210	551,313
-64.5	151,366	377,046

Table 50: Lake 999

Lake Volume and Surface Area Per Depth		
Elevation (m)	**Cumulative Volume (m^3)**	**Cumulative Area (m^2)**
0	13,130,162	1,645,029
-0.5	12,324,390	1,578,249
-1	11,551,678	1,504,566
-1.5	10,819,036	1,426,212
-2	10,124,845	1,342,953
-2.5	9,471,923	1,269,396
-3	8,855,337	1,192,131
-3.5	8,273,597	1,134,972
-4	7,720,226	1,074,447
-4.5	7,196,013	1,022,535
-5	6,697,821	965,898
-5.5	6,227,583	914,967
-6	5,782,681	855,180
-6.5	5,366,913	807,948
-7	4,974,531	749,808
-7.5	4,608,981	712,206
-8	4,261,919	667,332
-8.5	3,936,614	633,996
-9	3,627,776	599,787
-9.5	3,336,031	567,324
-10	3,060,269	515,619
-10.5	2,809,077	489,231
-11	2,571,030	460,863
-11.5	2,346,590	437,148
-12	2,133,688	397,755
-12.5	1,939,590	378,657
-13	1,754,894	358,821
-13.5	1,580,047	340,425
-14	1,414,333	322,128
-14.5	1,257,609	304,803
-15	1,109,556	287,262
-15.5	969,988	271,035
-16	838,528	254,754
-16.5	715,437	237,744
-17	600,816	219,321
-17.5	494,990	203,760
-18	396,851	188,118
-18.5	306,567	173,007
-19	223,659	112,086
-19.5	170,397	100,881
-20	122,628	81,927

Table 50: Lake 999 (continued)

Lake Volume and Surface Area Per Depth		
Elevation (m)	**Cumulative Volume (m^3)**	**Cumulative Area (m^2)**
-20.5	84,113	72,216
-21	50,359	62,487
-21.5	22,284	50,175

Table 51: Lake 31-1

Lake Volume and Surface Area Per Depth		
Elevation (m)	**Cumulative Volume (m^3)**	**Cumulative Area (m^2)**
0	70,470	34,803
-0.5	53,923	31,437
-1	39,034	28,197
-1.5	26,274	22,941
-2	16,035	14,895
-2.5	9,540	11,124
-3	4,806	6,885
-3.5	1,913	4,752

Table 52: Lake 31-2

Lake Volume and Surface Area Per Depth		
Elevation (m)	**Cumulative Volume (m^3)**	**Cumulative Area (m^2)**
0	137,368	55,377
-0.5	111,092	49,734
-1	87,524	43,290
-1.5	68,169	34,299
-2	52,909	22,995
-2.5	42,007	20,646
-3	32,218	18,522
-3.5	23,705	15,561
-4	16,557	12,969
-4.5	10,708	10,467
-5	6,040	8,172
-5.5	2,505	5,985

Table 53: Lake 32-0

Lake Volume and Surface Area Per Depth		
Elevation (m)	**Cumulative Volume (m^3)**	**Cumulative Area (m^2)**
0	21,976,529	3,747,375
-0.5	20,130,753	3,636,045
-1	18,339,977	3,518,766
-1.5	16,617,299	3,372,615
-2	14,966,675	3,218,004
-2.5	13,385,314	3,107,889
-3	11,858,153	2,995,722
-3.5	10,405,325	2,816,910
-4	9,039,923	2,641,860
-4.5	7,770,292	2,437,587
-5	6,601,351	2,226,348
-5.5	5,542,465	2,010,033
-6	4,590,286	1,790,037
-6.5	3,742,287	1,602,801
-7	2,986,697	1,408,995
-7.5	2,329,723	1,219,779
-8	1,766,071	1,032,291
-8.5	1,282,680	901,386
-9	864,349	742,716
-9.5	533,637	582,318
-10	280,019	383,598
-10.5	114,906	278,631

Table 54: Lake 33-0

Lake Volume and Surface Area Per Depth		
Elevation (m)	**Cumulative Volume (m^3)**	**Cumulative Area (m^2)**
0	270,935	124,371
-0.5	212,600	108,945
-1	161,855	87,570
-1.5	121,111	75,402
-2	86,426	58,716
-2.5	59,865	47,709
-3	38,572	36,459
-3.5	22,604	27,396
-4	11,012	15,255
-4.5	4,521	10,881

Table 55: Lake 34-0 (Lower Bathurst Inlet)

Lake Volume and Surface Area Per Depth		
Elevation (m)	**Cumulative Volume (m^3)**	**Cumulative Area (m^2)**
0	3,320,662,011	157,216,248
-0.5	3,242,285,412	156,296,529
-1	3,164,357,277	155,139,363
-1.5	3,087,175,952	153,595,260
-2	3,010,754,419	152,013,132
-2.5	2,935,337,834	149,661,963
-3	2,861,083,384	147,317,517
-3.5	2,787,866,353	145,558,773
-4	2,715,516,461	143,831,412
-4.5	2,644,168,880	141,559,281
-5	2,573,955,889	138,770,010
-5.5	2,505,117,971	136,589,616
-6	2,437,357,360	134,425,800
-6.5	2,370,739,815	132,051,222
-7	2,305,297,954	129,707,748
-7.5	2,241,084,611	127,158,525
-8	2,178,127,683	124,601,346
-8.5	2,116,626,591	121,407,669
-9	2,056,715,484	117,836,145
-9.5	1,998,611,273	114,569,469
-10	1,942,156,521	111,006,765
-10.5	1,887,443,003	107,868,915
-11	1,834,265,954	104,774,184
-11.5	1,782,515,939	102,239,658
-12	1,732,011,025	99,746,091
-12.5	1,682,747,632	97,322,355
-13	1,634,673,468	94,934,628
-13.5	1,587,841,099	92,418,390
-14	1,542,232,067	89,901,333
-14.5	1,497,855,760	87,615,594
-15	1,454,603,280	85,344,021
-15.5	1,412,437,213	83,337,822
-16	1,371,248,955	81,401,391
-16.5	1,330,951,001	79,797,096
-17	1,291,444,162	78,208,425
-17.5	1,252,743,067	76,603,950
-18	1,214,832,755	75,027,555
-18.5	1,177,719,168	73,436,157
-19	1,141,389,022	71,869,878
-19.5	1,105,835,767	70,359,318
-20	1,071,012,696	68,925,483

Table 55: Lake 34-0 (Lower Bathurst Inlet) (continued)

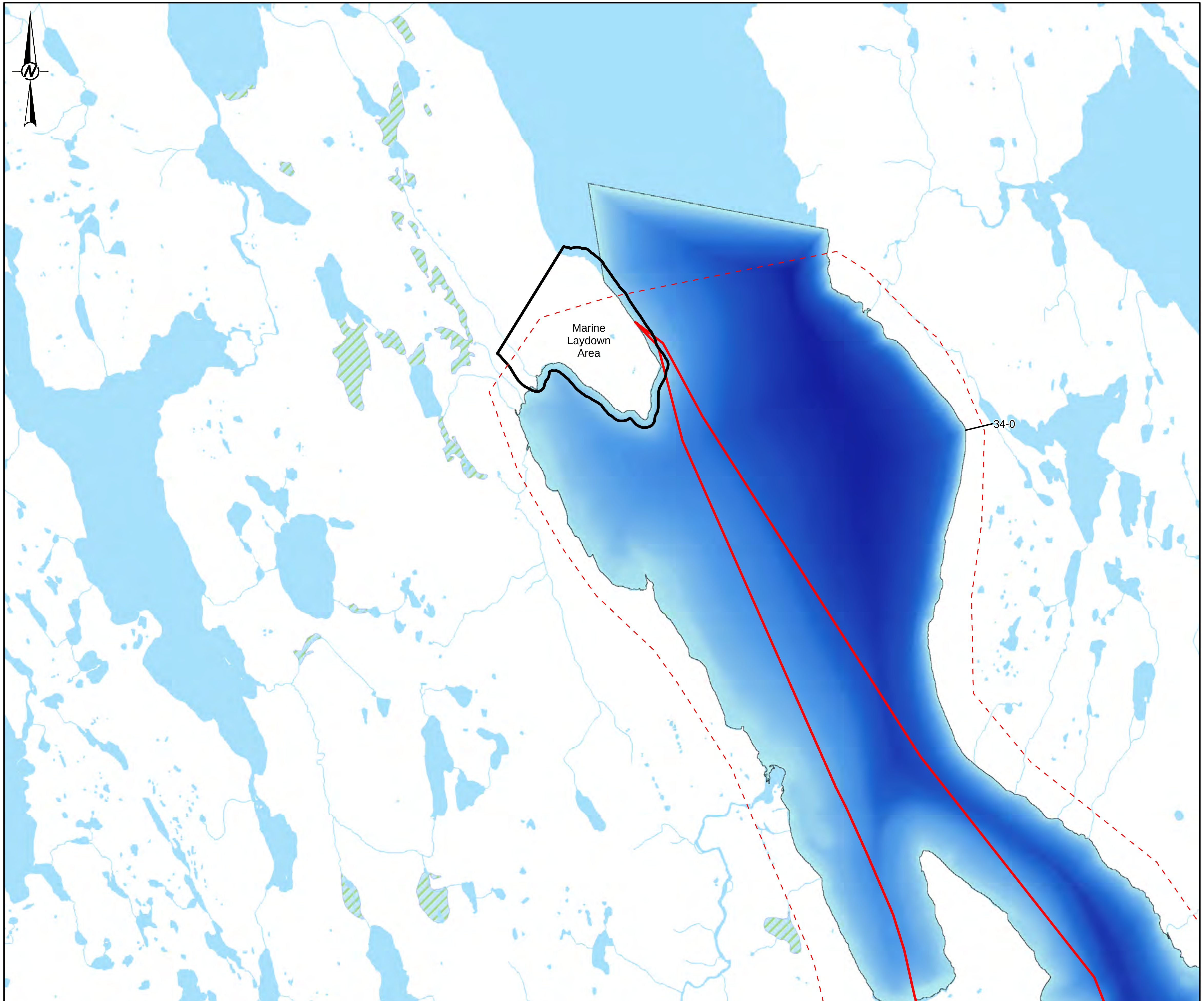
Lake Volume and Surface Area Per Depth		
Elevation (m)	**Cumulative Volume (m^3)**	**Cumulative Area (m^2)**
-20.5	1,036,903,801	67,520,178
-21	1,003,484,304	66,104,001
-21.5	970,767,886	64,767,087
-22	938,711,950	63,413,928
-22.5	907,299,980	62,239,320
-23	876,467,854	61,008,156
-23.5	846,253,173	59,857,542
-24	816,602,873	58,743,063
-24.5	787,524,687	57,575,763
-25	759,021,754	56,434,914
-25.5	731,092,489	55,285,002
-26	703,733,181	54,154,953
-26.5	676,913,254	53,126,199
-27	650,604,821	52,108,326
-27.5	624,783,781	51,175,593
-28	599,428,816	50,244,048
-28.5	574,533,210	49,339,089
-29	550,088,651	48,440,565
-29.5	526,087,209	47,566,152
-30	502,521,118	46,698,912
-30.5	479,422,657	45,698,769
-31	456,818,707	44,721,144
-31.5	434,722,343	43,668,513
-32	413,149,392	42,626,592
-32.5	392,102,798	41,562,108
-33	371,585,866	40,507,344
-33.5	351,609,916	39,399,894
-34	332,180,732	38,242,395
-34.5	313,348,528	37,089,666
-35	295,088,704	35,925,381
-35.5	277,429,392	34,716,213
-36	260,368,854	33,488,091
-36.5	243,935,626	32,248,809
-37	228,116,039	31,007,007
-37.5	212,876,735	29,953,134
-38	198,160,274	28,905,912
-38.5	183,963,137	27,884,169
-39	170,275,692	26,857,386
-39.5	157,100,529	25,846,137
-40	144,428,510	24,823,413
-40.5	132,289,859	23,734,530

Table 55: Lake 34-0 (Lower Bathurst Inlet) (continued)

Lake Volume and Surface Area Per Depth		
Elevation (m)	Cumulative Volume (m^3)	Cumulative Area (m^2)
-41	120,690,883	22,664,268
-41.5	109,614,224	21,645,522
-42	99,042,791	20,349,549
-42.5	89,120,186	19,343,151
-43	79,696,709	18,260,478
-43.5	70,870,760	17,047,413
-44	62,645,297	15,560,451
-44.5	55,193,891	14,252,175
-45	48,387,157	12,141,720
-45.5	42,569,731	11,134,899
-46	37,245,670	9,563,436
-46.5	32,665,660	8,762,805
-47	28,476,533	7,786,719
-47.5	24,748,249	7,133,058
-48	21,336,650	6,211,449
-48.5	18,354,386	5,719,374
-49	15,616,131	5,217,471
-49.5	13,113,823	4,793,148
-50	10,821,496	4,370,733
-50.5	8,744,070	3,940,920
-51	6,878,964	3,476,700
-51.5	5,234,537	3,103,515
-52	3,772,989	2,650,050
-52.5	2,559,532	2,208,681
-53	1,559,990	1,605,843
-53.5	840,334	1,277,856
-54	276,818	410,859
-54.5	107,940	270,522

APPENDIX B

Map of Water Sources for Ice Road Construction

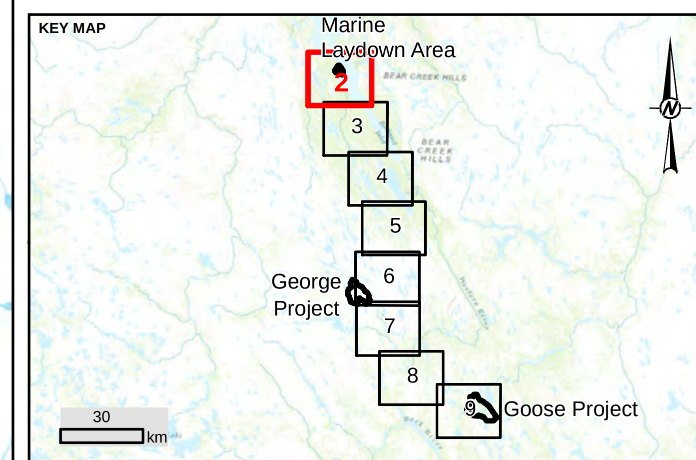


LEGEND

- MARINE LAYDOWN AREA
- WINTER ROAD
- WATERCOURSE
- LAKE EXTENT (DEPTH > 3.5M)
- PROJECT BOUNDARY
- WATERBODY
- WETLAND

BATHYMETRY (1 M INTERVAL)
0
-13
-26
-39
-52
-65

KEY MAP



0 1.5 3
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NOTE(S)
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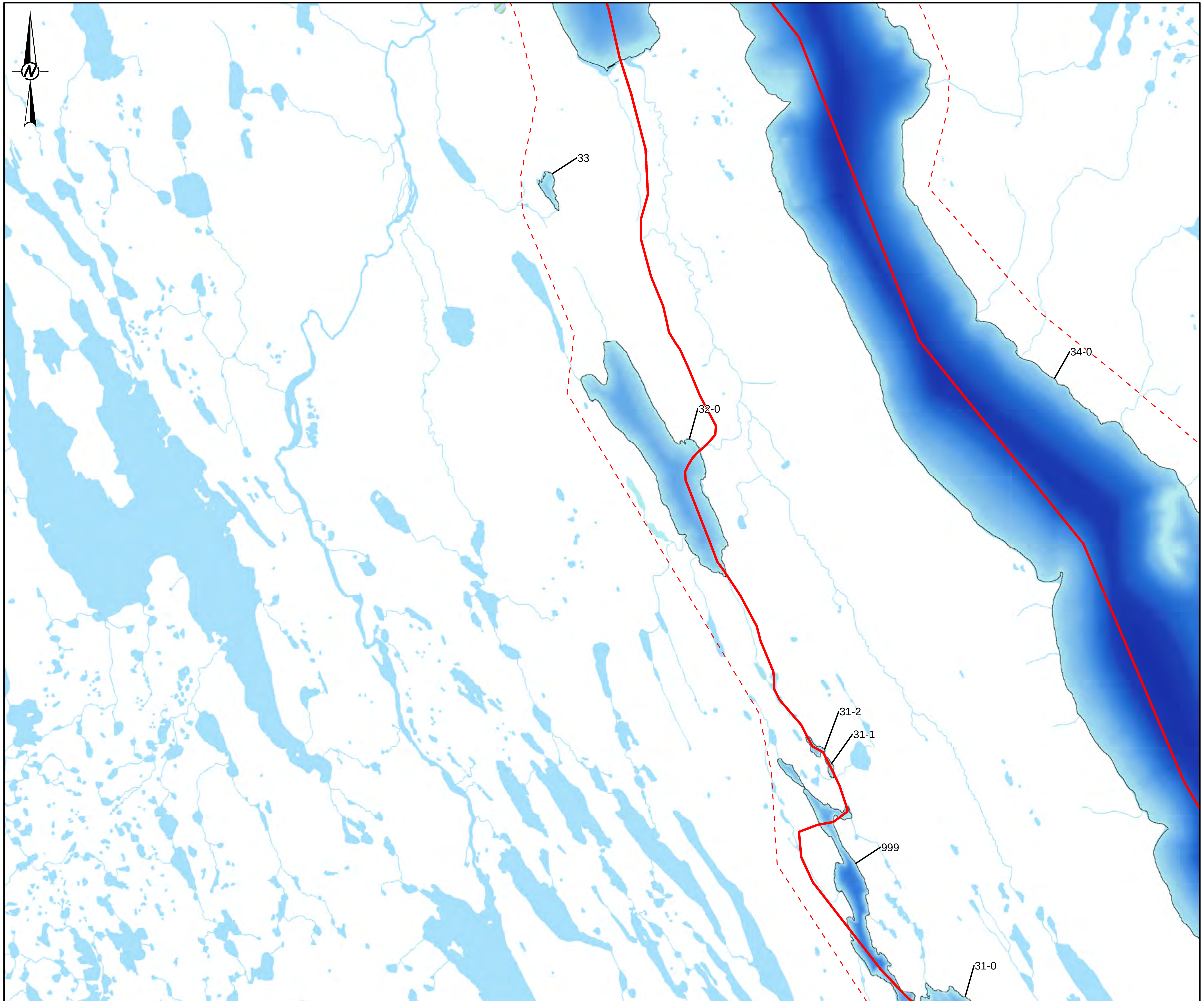
Golder Associates

PROJECT
BACK RIVER PROJECT

TITLE
WATER SOURCES FOR WINTER ICE ROAD CONSTRUCTION FOR THE BACK RIVER PROJECT

PROJECT NO.	FIGURE	REV.
1776921/1300/1320	B2	A

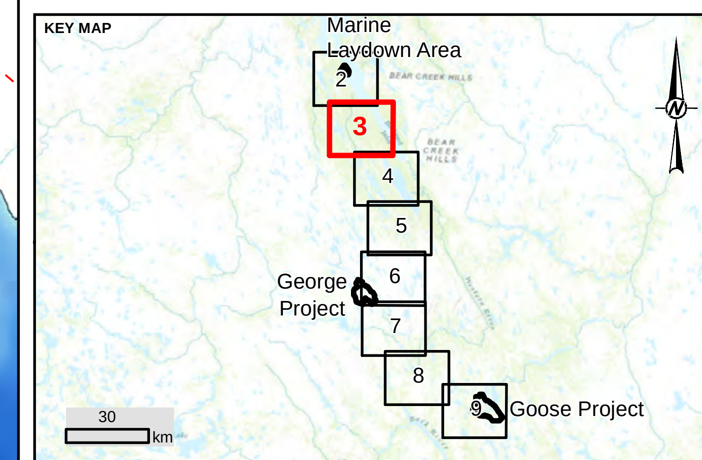


LEGEND

- WINTER ROAD
- WATERCOURSE
- LAKE EXTENT (DEPTH > 3.5M)
- PROJECT BOUNDARY
- WATERBODY
- WETLAND

BATHYMETRY (1 M INTERVAL)
0
-13
-26
-39
-52
-65

KEY MAP



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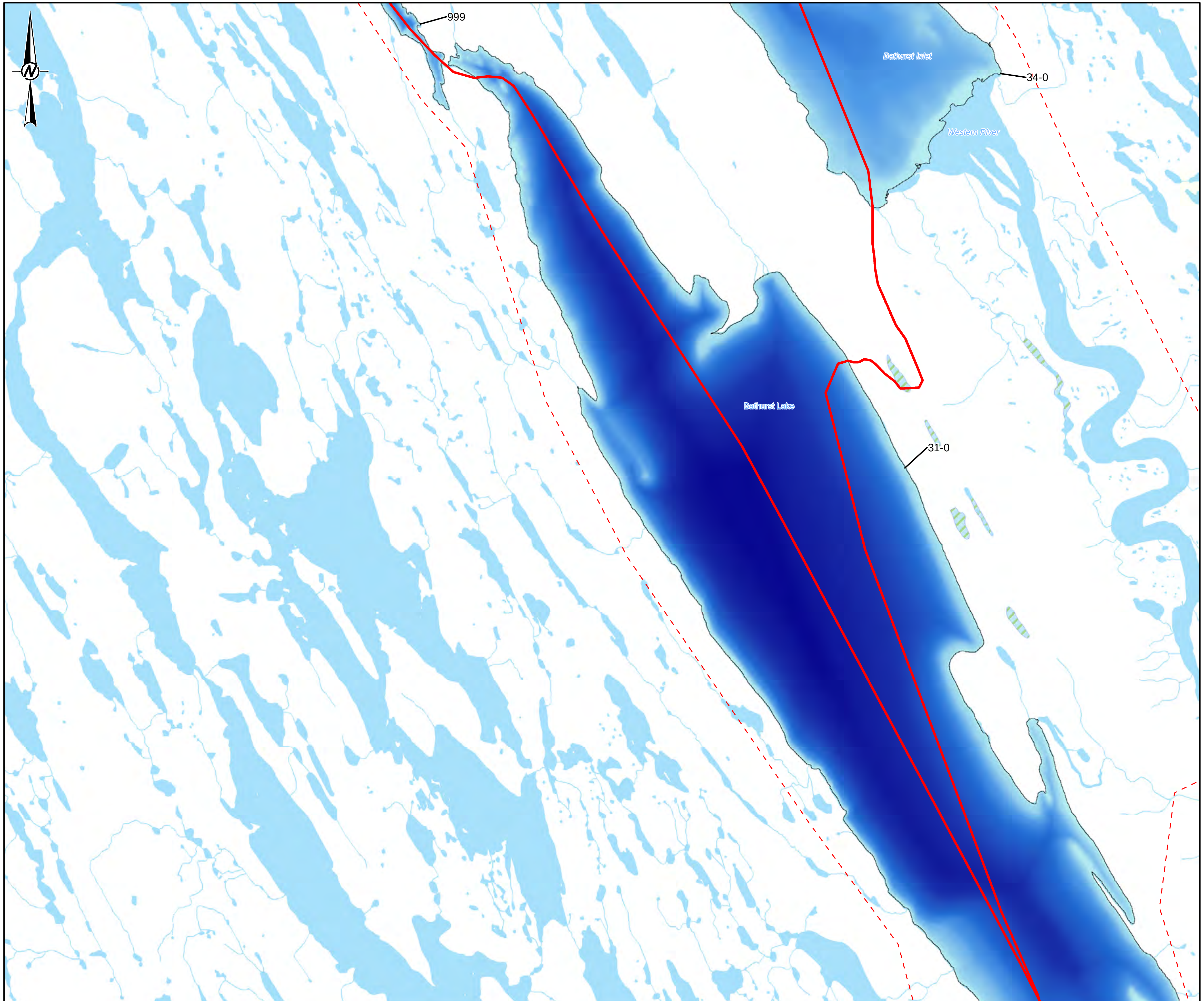
PROJECT NO.	FIGURE	REV.
1776921/1300/1320	B3	A

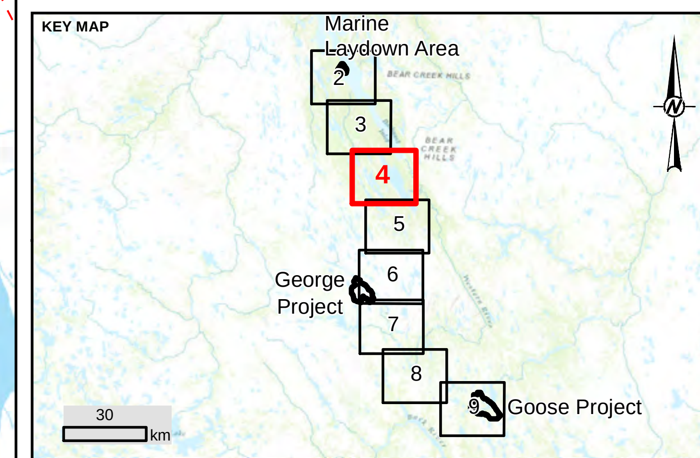


LEGEND

- WINTER ROAD
- WATERCOURSE
- LAKE EXTENT (DEPTH > 3.5M)
- PROJECT BOUNDARY
- WATERBODY
- WETLAND

BATHYMETRY (1 M INTERVAL)
0
-13
-26
-39
-52
-65

KEY MAP



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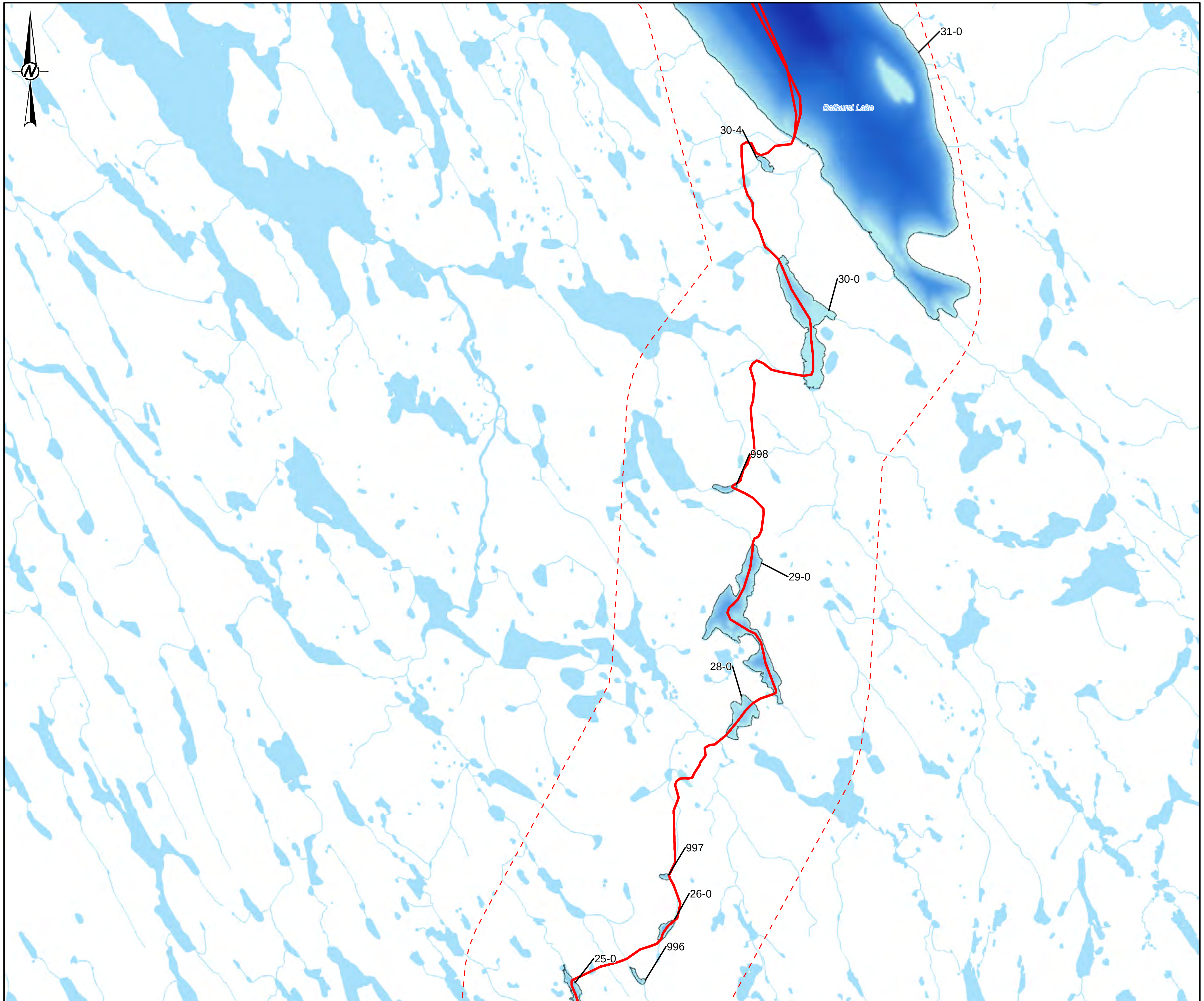
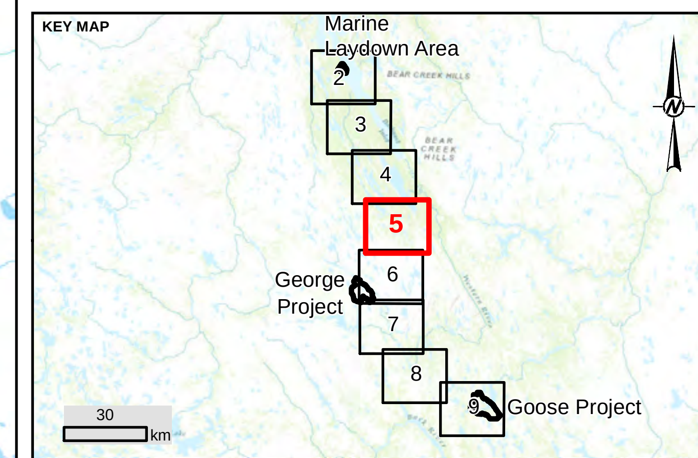


LEGEND

- WINTER ROAD
- WATERCOURSE
- LAKE EXTENT (DEPTH > 3.5M)
- PROJECT BOUNDARY
- WATERBODY
- WETLAND

BATHYMETRY (1 M INTERVAL)
0
-13
-26
-39
-52
-65

KEY MAP



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PROJECT NO.	FIGURE	REV.
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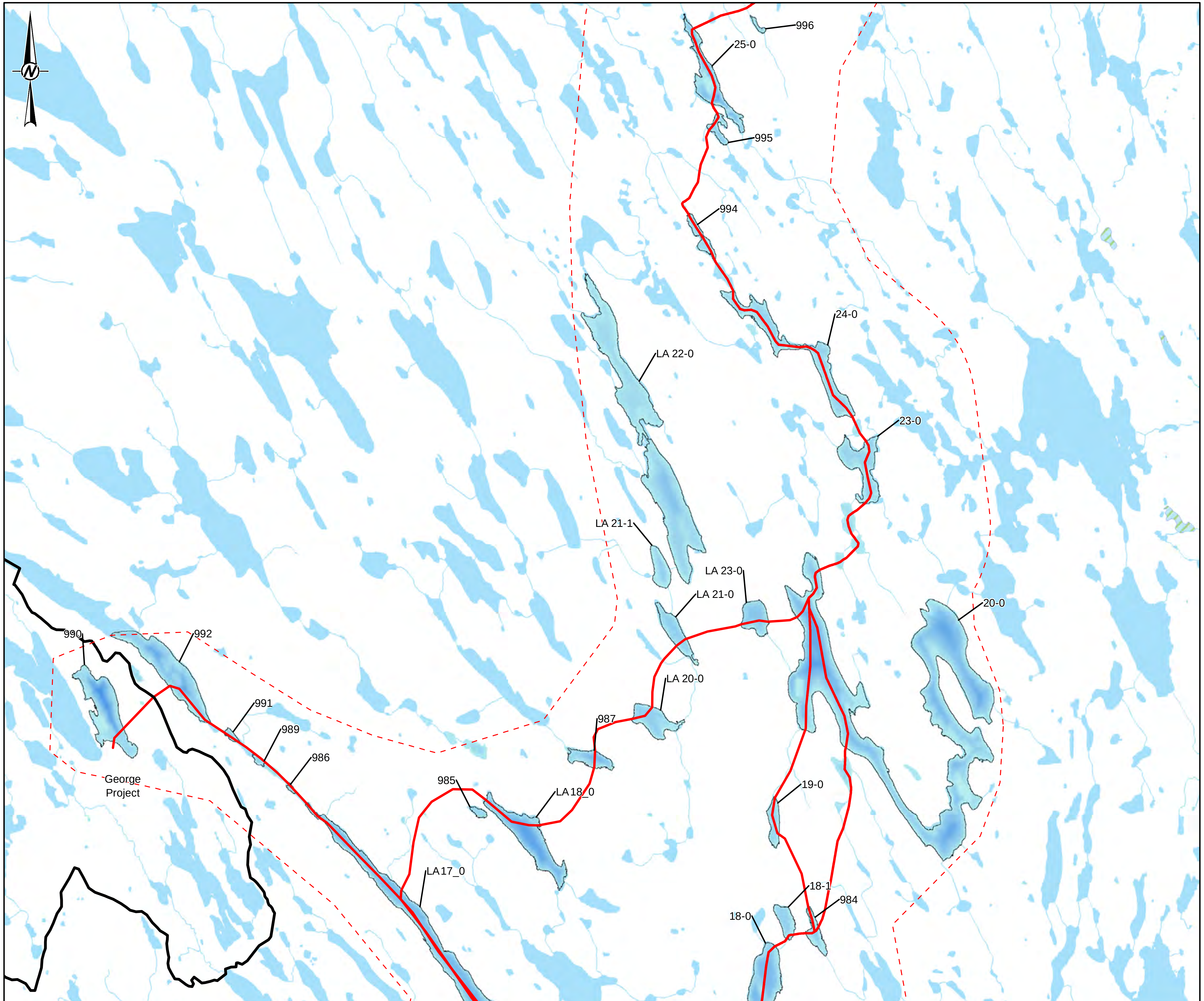
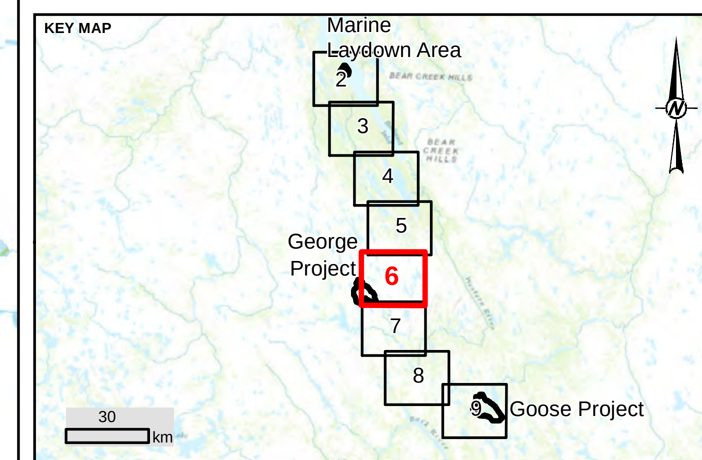


LEGEND

- GEORGE PROPERTY AREA
- WINTER ROAD
- WATERCOURSE
- LAKE EXTENT (DEPTH > 3.5M)
- PROJECT BOUNDARY
- WATERBODY
- WETLAND

BATHYMETRY (1 M INTERVAL)

0
-13
-26
-39
-52
-65



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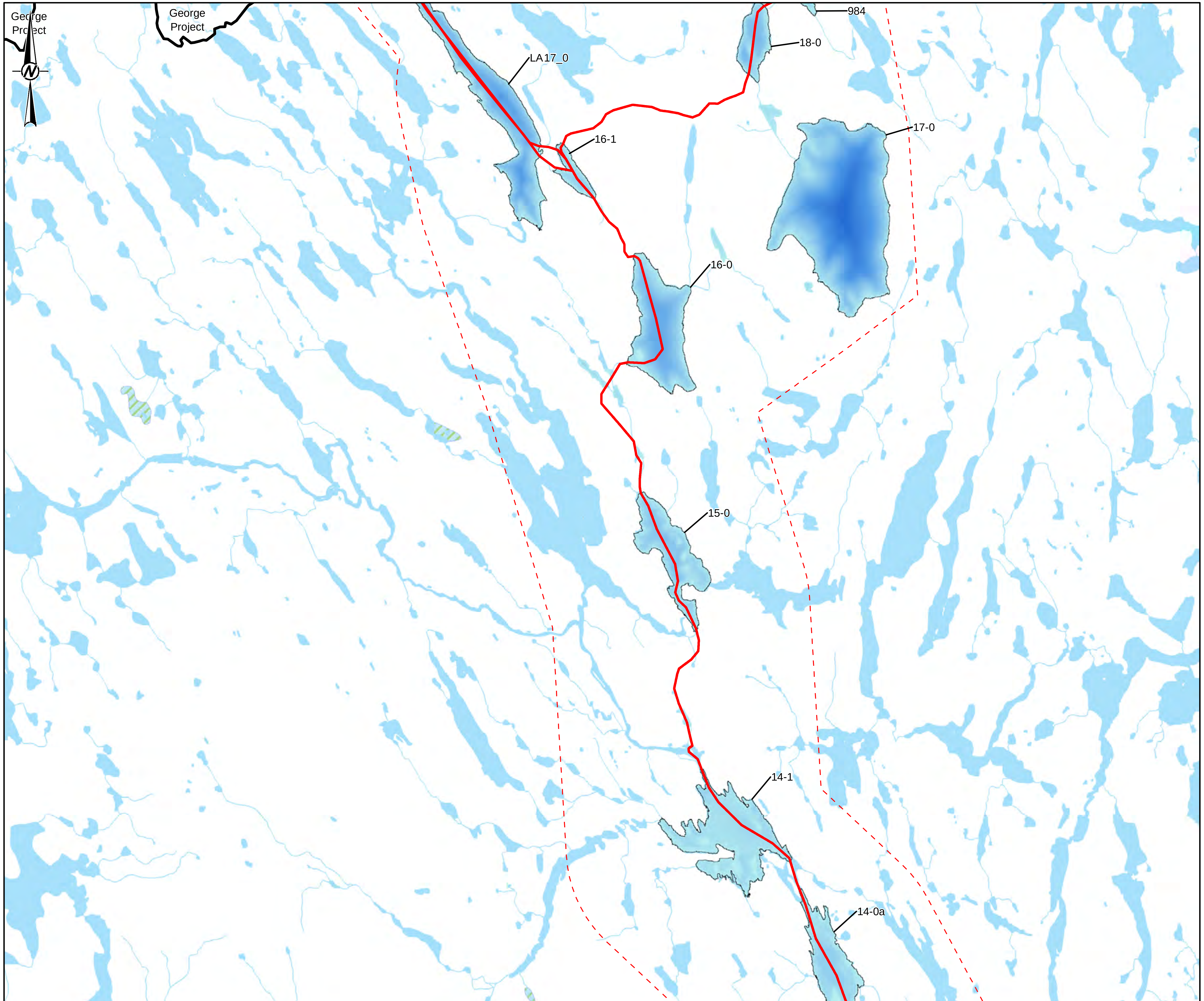
PROJECT NO.	FIGURE	REV.
1776921/1300/1320	B6	A



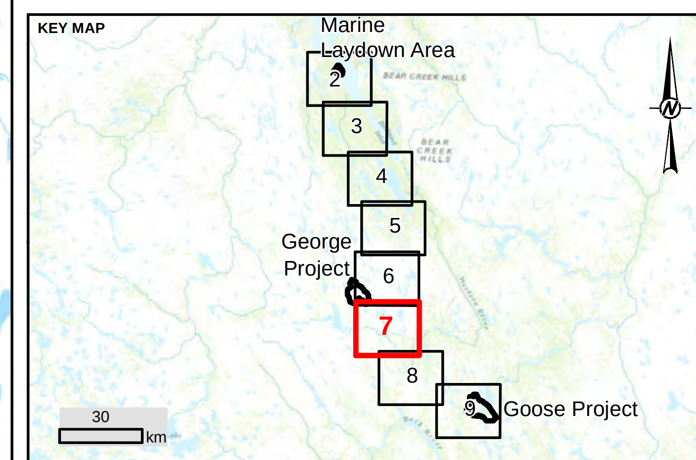
LEGEND

- GEORGE PROPERTY AREA
- WINTER ROAD
- WATERCOURSE
- LAKE EXTENT (DEPTH > 3.5M)
- PROJECT BOUNDARY
- WATERBODY
- WETLAND

BATHYMETRY (1 M INTERVAL)

0
-13
-26
-39
-52
-65

KEY MAP



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1:75,000 KILOMETRES

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TITLE
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PROJECT NO.	FIGURE	REV.
1776921/1300/1320	B7	A

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IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI B

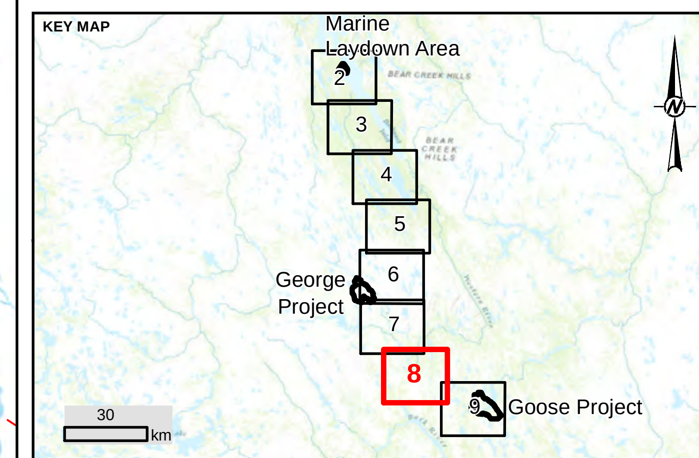
25mm

LEGEND

- WINTER ROAD
- WATERCOURSE
- LAKE EXTENT (DEPTH > 3.5M)
- PROJECT BOUNDARY
- WATERBODY
- WETLAND

BATHYMETRY (1 M INTERVAL)
0
-13
-26
-39
-52
-65

KEY MAP



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1:75,000 KILOMETRES

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TITLE
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PROJECT NO.	FIGURE	REV.
1776921/1300/1320	B8	A

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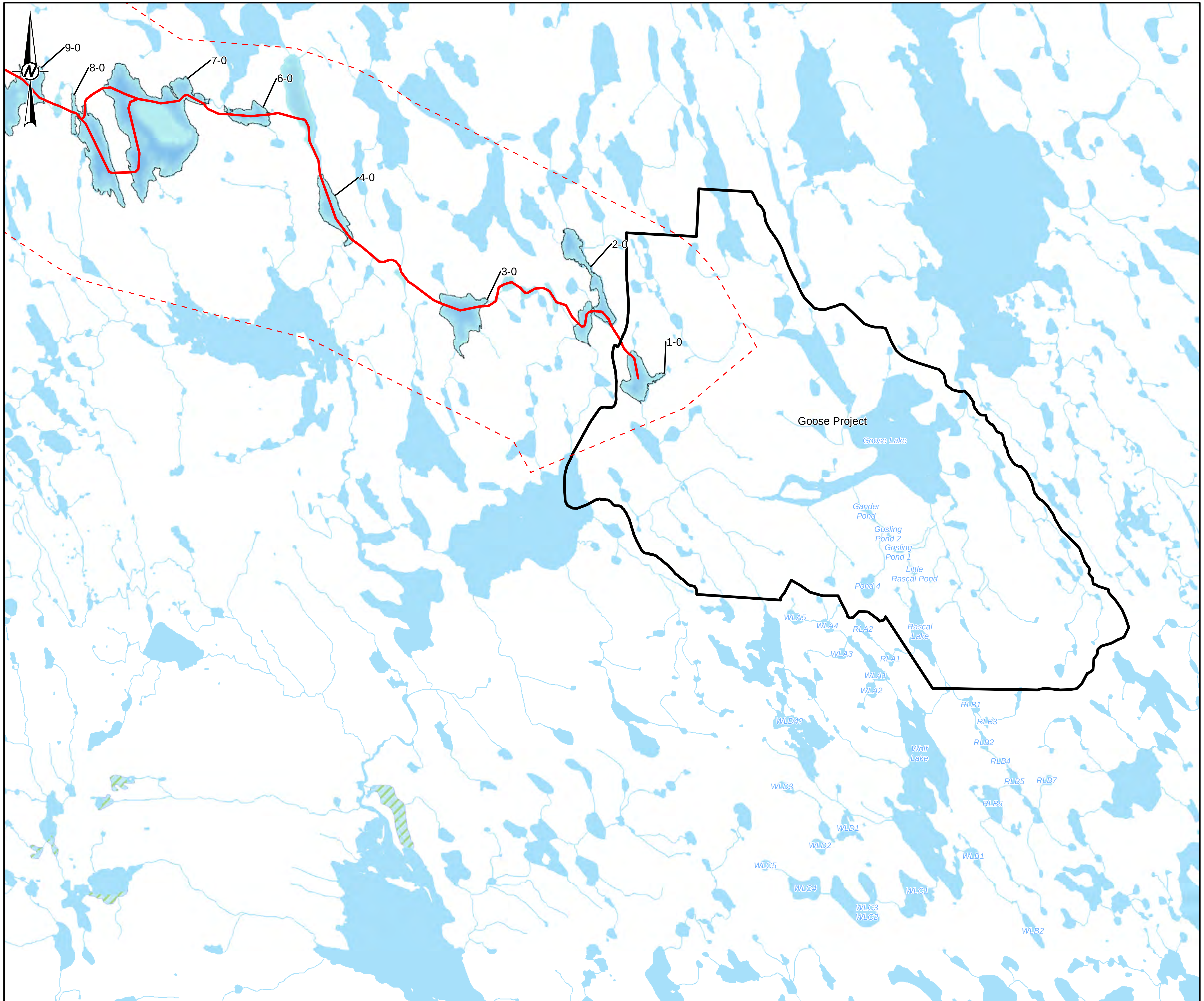


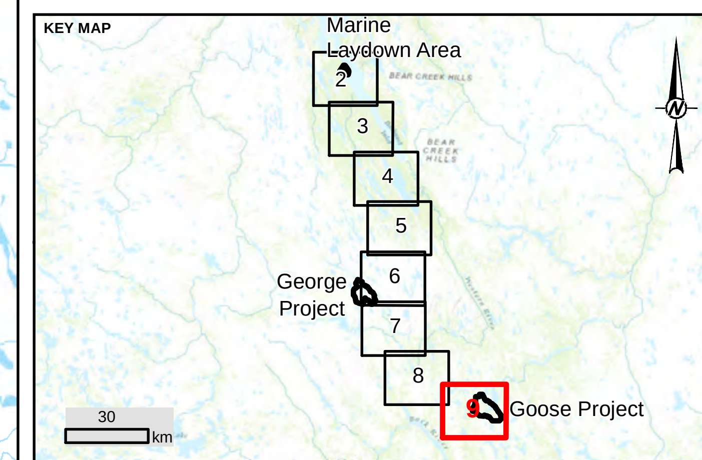
LEGEND

- GOOD PROPERTY AREA
- WINTER ROAD
- WATERCOURSE
- LAKE EXTENT (DEPTH > 3.5M)
- PROJECT BOUNDARY
- WATERBODY
- WETLAND

BATHYMETRY (1 M INTERVAL)

0
-13
-26
-39
-52
-65

KEY MAP



0 1.5 3

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NOTE(S)

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REFERENCE(S)

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TITLE

WATER SOURCES FOR WINTER ICE ROAD CONSTRUCTION FOR THE BACK RIVER PROJECT

PROJECT NO.	FIGURE	REV.
1776921/1300/1320	B9	A

Appendix C

Road Management Plan

BACK RIVER PROJECT
Road Management Plan

October 2017

BACK RIVER PROJECT
ROAD MANAGEMENT PLAN

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Appendix A. Applicable Legislation

Revision Log

Version	Date	Section	Page	Revision
1	October 2017	All	All	Supporting Document for Type A Water Licence Application, submitted to Nunavut Water Board for review and approval

Acronyms

DFO	Fisheries and Oceans Canada
FEIS	Final Environmental Impact Statement
GNWT	Government of Northwest Territories
GPR	Ground Penetrating Radar
INAC	Indigenous and Northern Affairs Canada
KIA	Kitikmeot Inuit Association
MAD	Main Application Document
MLA	Marine Laydown Area
NWB	Nunavut Water Board
Project	Back River Project
RMP or Plan	Road Management Plan
Sabina	Sabina Gold & Silver Corp.
WIR	Winter Ice Road

1. Introduction

The Back River Project (the Project) is a proposed gold project owned by Sabina Gold & Silver Corp. (Sabina) within the West Kitikmeot region of southwestern Nunavut. It is situated approximately 400 kilometres (km) southwest of Cambridge Bay, 95 km southeast of the southern end of Bathurst Inlet (Kingaok), and 520 km northeast of Yellowknife, Northwest Territories. The Project is located predominantly within the Queen Maud Gulf Watershed (Nunavut Water Regulations, Schedule 4).

The Project is comprised of two main areas with interconnecting winter ice roads (WIR) (Main Application Document [MAD] Appendix A, base Figure 2): Goose Property (MAD Appendix A, base Figure 3) and the Marine Laydown Area (MLA) (MAD Appendix A, base Figure 4) situated along the western shore of southern Bathurst Inlet. The majority of annual resupply will be completed using the MLA, and an approximately 160 km long WIR will interconnect these sites. Refer to the MAD Appendix A, base Figures 1 to 5 for general site layout and locations. A detailed Project description is provided in the MAD.

The Road Management Plan (RMP or Plan) outlines the approach for construction, operations, and reclamation of transportation infrastructure, such as all-weather roads, WIRs, and airstrips. This plan includes provisions for the MLA in southern Bathurst Inlet and the Goose Property. The RMP and other management plans are intended to support the Type A Water Licence Application for the Project.

The Plan was prepared following the requirements of the Supplementary Information Guidelines (SIG) for Mining and Milling MM3 and Water Works M1, issued by Nunavut Water Board (NWB 2010 a, b), the Environmental Impact Statement Guidelines issued by the Nunavut Impact Review Board to Sabina (NIRB 2013), and in conformance with current Federal and Territorial statutory requirements.

This is a living document to be updated upon changes in related regulatory requirements, management reviews, changes to facility operation or maintenance, and environmental monitoring results, best practice updates or other Project specific protocols once Construction starts through to Project closure activities. Any updates will be filed with the Annual Report submitted under the Type A Water Licence.

The information presented herein is current as of September 2017. At this stage, certain aspects of the Plan remain conceptual. The next update will likely be based on detailed engineering design prior to the start of Construction. The RMP will be reviewed as needed for changes in operation and technology and as directed by the Nunavut Water Board (NWB) in the Type A Water Licence or other regulatory authorization where appropriate. Completion of the updated Plan will be documented through signatures of the personnel responsible for reviewing, updating, and approving the Plan.

A record will document all significant changes that have been incorporated in the Road Management Plan subsequent to the latest review. The record will include the names of the persons who made and approved the change, as well as the date of the approval.

Sabina will maintain a distribution list providing contact details for all parties to receive the Plan including key personnel, contractors, organizations, and external agencies.

2. Scope and Objectives

The Plan is one of the documents that forms part of Sabina's overall Infrastructure and Access Management Program for the Project. This plan has been written to meet requirements of a Type A Water Licence and applies to all Sabina projects in the Kitikmeot region.

This plan is divided into the following components:

- Applicable Legislation and Guidelines (Section 3);
- Planning and Implementation (Section 4);
- Roles and Responsibilities (Section 5);
- Traffic Management and Road Safety (Section 6);
- Inspection, Maintenance, and Monitoring of Roads (Section 7);
- Wildlife Protection Measures (Section 8);
- Adaptive Management (Section 9); and
- Reclamation (Section 10).

The Plan outlines construction, operation, and management of access and terrestrial transportation for the Project including construction, operations, and closure of an all-weather airstrip, connecting WIRs, and associated borrow pit/quarries.

Winter ice roads, and all-weather haul and service roads are needed during operation of the Project. All Project roads will be private for the exclusive use of Sabina's operations. The road network required for the Project is presented in base Figures 1 to 3 (Appendix A of the MAD) and in Figure 4.1-1.

The measures identified in this plan are intended to protect the targeted valued ecosystem components and valued socio-economic components including, water quality, fish habitat, terrestrial wildlife, health and safety of employees, and cultural resources and heritage.

This plan provides construction and operating maintenance methods and best management practices that will be used for the Project. The purpose of this plan is to ensure sound management of water and waste deposited to minimize the impacts to the local environment during construction, operations, and closure of the transportation corridors.

Implementing best management practices and working responsibly will ensure the protection of the environment and personnel safety. The goal of any management plan is to reduce and prevent impacts to the environment while ensuring personnel safety and appropriate fiscal considerations during mineral exploration activities.

2.1 RELATED PLANS AND STUDIES

Documents within the Application for the Type A Water Licence, which support this plan include the following:

- Spill Contingency Plan (Supporting Document [SD]-17);
- Hazardous Materials Management Plan (SD-13);
- Environmental Management and Protection Plan (SD-20);
- Water Management Plan (SD-05);
- Borrow Pits and Quarry Management Plan (SD-03);
- Interim Closure and Reclamation Plan (SD-26);
- Aquatic Effects Management Plan (SD-21);
- Risk Management and Emergency Response Plan (SD-15);
- Air Quality Monitoring and Management Plan (Final Environmental Impact Statement [FEIS] Volume 10, Chapter 17); and
- Wildlife Mitigation and Monitoring Plan (Version 7; submitted with FEIS Addendum February 2017).

In addition, the following documents have also been used to inform the design and management decisions presented in the Road Management Plan:

- Alternatives Assessment (MAD Section 5.1.3);
- Site-Wide Geotechnical Properties Report (MAD Appendix F-2);
- Water and Load Balance Report (MAD Appendix E-2);
- Geochemical Characterization Report (MAD Appendix E-3);
- Geophysical Survey of Waterbodies (FEIS Volume 6, Appendix V6-3E); and
- Climate and Meteorology (FEIS Volume 4, Chapter 3).

3. Applicable Legislation and Guidelines

The RMP has been prepared to comply with existing regulations and follow the available guidelines provided by the federal government and the government of Nunavut. The applicable regulations are provided in Appendix A.

Water use and waste disposal in Nunavut is regulated by the NWB through the water licensing process.

In addition, the following guidance documents have also been used to inform the design and management decisions presented in the Plan:

- Northern Land Use Guidelines Access: Roads and Trails (INAC 2010);
- Aerodrome Standards and Recommended Practices (Transport Canada 2005);
- Geometric Guidelines (Roads and Transportation 1986);
- Protocol for Winter Water Withdrawal from Ice-Covered Waterbodies in the Northwest Territories and Nunavut (DFO 2010);
- Environmental Guidelines for the Construction, Maintenance and Closure of Winter Roads in the Northwest Territories (GNWT DoT 1993); and
- Guidelines for Safe Ice Construction (GNWT DoT 2015).

3.1 LAND TENURE

The majority of all-weather roads and the WIR will be located on Inuit Owned Lands administered by the Kitikmeot Inuit Association (KIA). The surface ownership of the land encompassing the roads rights-of-way was transferred to the KIA when the Nunavut Land Claims Agreement came into effect. Land and environmental management in this area are governed by the provisions of the Nunavut Land Claims Agreement.

Smaller portions of the all-weather road (i.e., access to the Tailings Storage Facility) and small portions of the WIR will be on crown land, administered by the Department of Indigenous and Northern Affairs Canada (INAC).

Refer to base Figures 1 to 3 (Appendix A of the MAD) for clarification of land tenure status.

3.2 PERMITTING REGIME

Table 3.2-1 outlines the current licenses and permits held by Sabina in relation to the Exploration Phase of the Project.

A list of anticipated approvals and authorizations required for construction of all-weather haul and service roads, as well as the WIR are shown in Table 3.2-2.

Table 3.2-1. Current Authorizations and Permits (as of July 2017)

Permit	Expiry (year-mo-day)	Agency	Description
KTL204C012	2017-12-12	KIA	Boulder: Staking/prospecting, exploration (ground/air geophysics), geophysical survey, gridding and drilling.
KTL204C020	2017-12-12	KIA	Boot: Exploration (air/ground geophysics), staking, prospecting, fly/survival camp and drilling.
KTL304C017	2017-12-12	KIA	Goose: Staking/prospecting, exploration (ground/air geophysics), drilling, bulk sampling, bulk fuel storage, camp, winter road, all-weather airstrip and connecting road.
KTL304C018	2017-12-12	KIA	George: Staking/prospecting, exploration (ground/air geophysics), drilling, bulk sampling, bulk fuel storage, camp, winter road, all-weather airstrip.
KTL312C004	2017-12-12	KIA	Wishbone/Malley: Exploration (air/ground geophysics), staking, prospecting, fly/survival camp and drilling
KTL304F049	2017-12-12	KIA	Winter road connecting Bathurst Inlet - Goose and George.
KTP11Q001	2017-12-12	KIA	Goose rock quarry.
KTP12Q001	2017-12-12	KIA	Goose Airstrip borrow area.
KTP12Q002	2017-12-12	KIA	George borrow quarry.
N2011F0029	2018-12-13	INAC	Winter Road connecting George-Goose.
N2017F0016	2022-07-20	INAC	Winter Road connecting Bathurst Inlet - Back River Project.
N2012C0003	2019-02-06	INAC	Wishbone-Malley Mineral Exploration activities on Crown Land
N2016C0011	2021-10-26	INAC	Back River Exploration activities.
2BE-GOO1520	2020-02-18	NWB	Goose water licence.
2BE-GEO1520	2020-05-29	NWB	George water licence.
2BE-MLL1217	2022-06-29	NWB	Wishbone-Malley water licence.

Table 3.2-2. Approvals and Authorizations for All Roads

Authorization	Authority	Basis
Article 12, Part 5 Environmental Assessment	NIRB	allows Project to proceed to authorizations to build and operate roads
Type A Water Licence	NWB	allows for construction of the proposed mine and related roads
Navigation Protection Act evaluation	Transport Canada	Sabina will request a navigability determination and minor works variance from Transport Canada
Inuit Impact and Benefits Agreement	KIA	impacts are compensated and benefits provided to Inuit
Water Compensation Agreement	KIA	compensation for Inuit Water Rights under Nunavut Agreement Section 20
Quarry Permit	KIA	various quarry and borrow pit sites on Inuit Owned Land along the right-of-way for building roads and infrastructure pads.
Explosive Magazine Permit Renewal	Workers' Safety and Compensation Commission	permits an explosive magazine on-site and at other approved locations
Class 2 Permit for Heritage Sites (obtained by qualified professional archaeologist)	Department of Culture, Language, Elders and Youth	unavoidable impacts of roads on heritage sites must be mitigated

4. Planning and Implementation

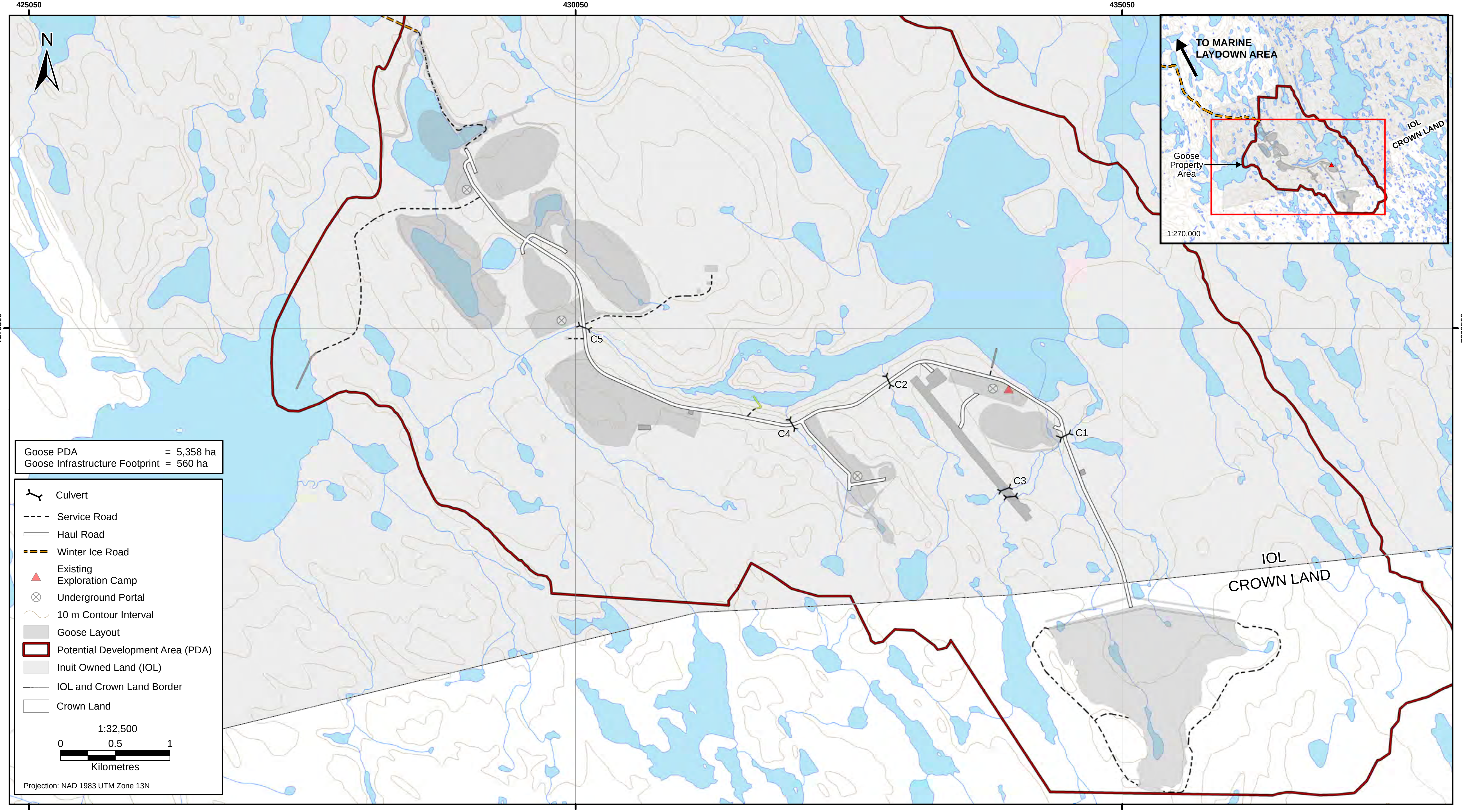
4.1 ALL-WEATHER ROADS

The MLA and Goose Property will require all-weather roads to operate year-round. All-weather roads consist of haul roads and service roads. Goose Property will have 4 km of service roads and 9 km of haul roads (Figure 4.1-1). The MLA will have less than 2 km of service roads and no haul roads. These roads will be constructed in a permafrost environment. In non-permafrost areas, it is common for road designs to incorporate both cuts and fills to establish the final grade along the alignment. However, in permafrost areas, disturbing sensitive overburden soils and surface vegetation can result in thaw degradation and the creation of unstable ground. Consequently, the design for the Project calls for limited cuts in overburden soils and focuses mainly on embankment construction. The embankment material will come from rock quarry sources near to the existing road alignment.

The roads will cross a number of ephemeral streams. While the streams will be dry most of the year, there may be considerable flow during freshet. All culverts and bridges will be designed to handle a 1-in-100-year event. Surface gravel will be used on all service roads. Where there is combined haul and service traffic on a road, surfacing gravel will be used.

Due to site constraints, a portion of the haul roads at Goose Property will share the road with service vehicles. Strict traffic controls will be implemented to ensure safe operating conditions.

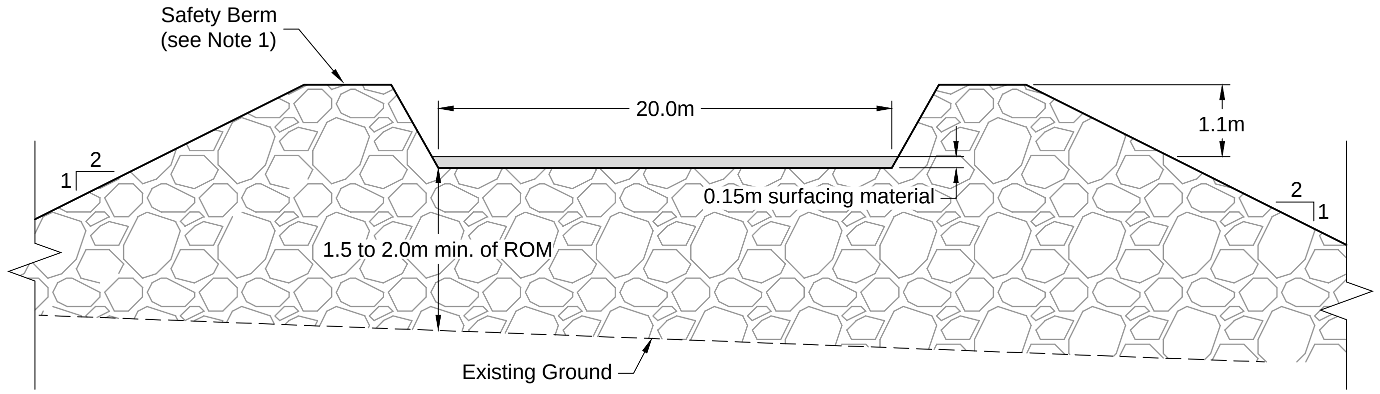
Further studies, reports, and plans relevant to the design of all-weather road infrastructure are presented in Section 2.1. Preliminary typical cross-sections of all-weather roads and watercourse crossings are shown in Figure 4.1-2. Detailed design drawings will be provided at least sixty (60) days prior to construction.



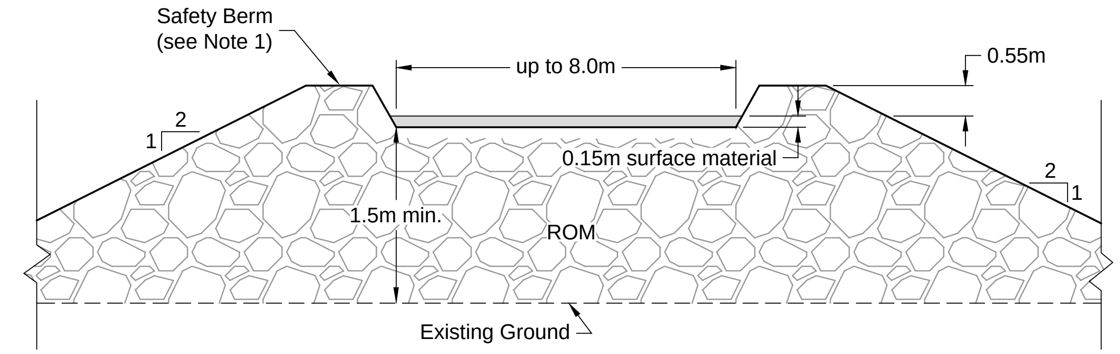
Sabina
GOLD & SILVER CORP.

Goose Property Area
Road Infrastructure
Type A Water Licence

Figure 4.1-1



Typical Cross Section of Haul Road



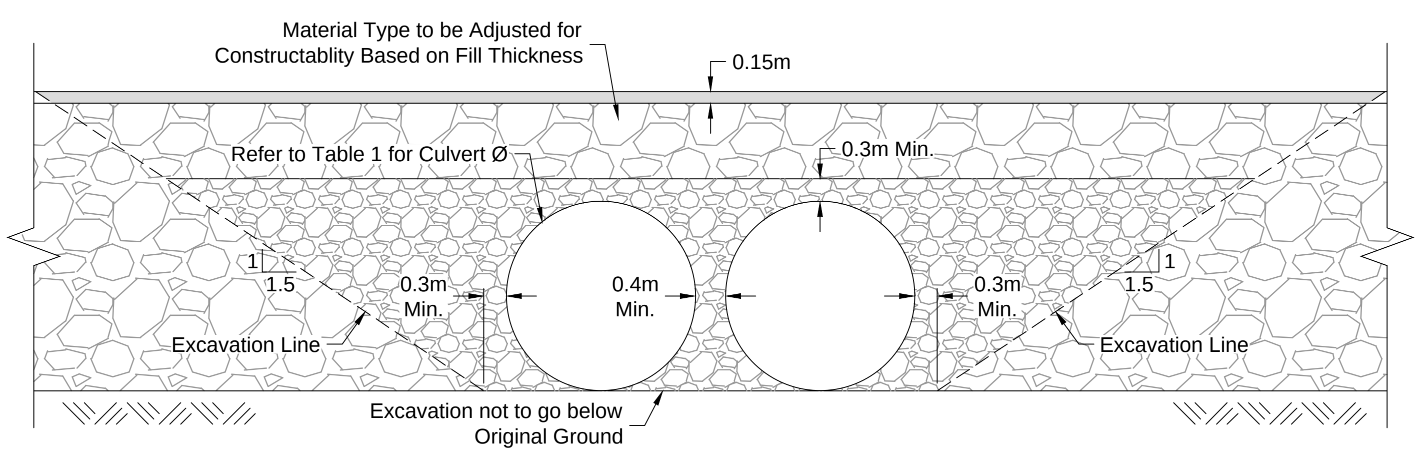
Typical Cross Section of Service Road

LEGEND

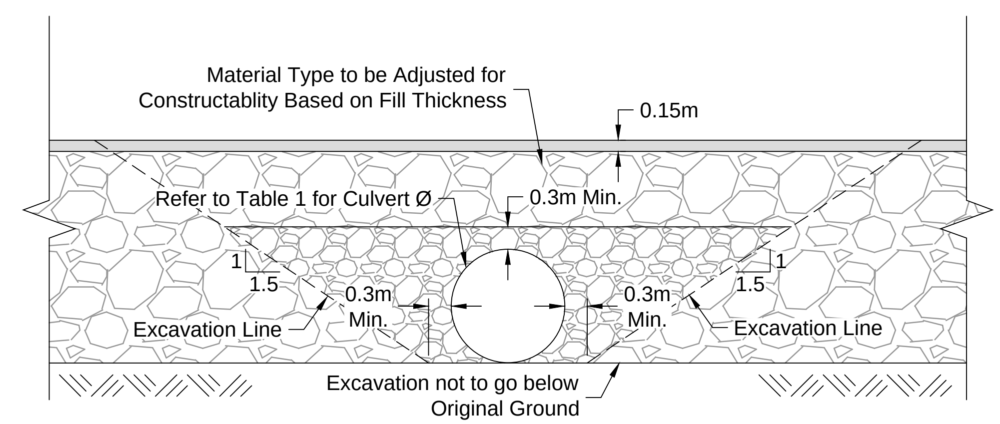
- Existing Ground Surface
- ROM (or ROQ)
- Engineered Fill
- Surfacing Material

NOTES

1. Where more than 3.0m drop-off exists at edge of road, a safety berm will be built at a height at least as high as the mid-axle height of the largest equipment piece that uses that road (NWT/NU Mines Act).
2. Not to scale.



Typical Cross Section of Double Culvert Crossing



Typical Cross Section of Single Culvert Crossing

TABLE 1: CULVERT SIZING AND LOCATION

Culvert Location	CSP Culvert Diameter Ø (m)	Number Required
Goose Culvert (C1)	2.5	2
Gander Pond Culvert (C2)	2.5	2
Goose Airstrip Culvert (C3)	2.5	2
Echo Culvert (C4)	1.2	1
Goose Creek Culvert (C5)	2.5	1

DRAWING NO.	DRAWING TITLE
-	-

REFERENCE DRAWINGS

NO.	DESCRIPTION	CHK'D	APP'D	DATE
-	-			

NO.	DESCRIPTION	CHK'D	APP'D	DATE
B	ISSUED FOR PERMIT	CP	EMR	17/08/30
A	ISSUED FOR PERMIT	CP	EMR	16/05/31

REVISIONS

Original Drawings Stamped and Signed by Engineer

This drawing is uncontrolled when printed unless stamped and signed with original ink and recorded on a Distribution Register.

PROFESSIONAL ENGINEERS STAMP

srk consulting

DESIGN: CP	DRAWN: MZS	REVIEWED: EMR
CHECKED: EMR	APPROVED: EMR	DATE: 2017/08/30

FILE NAME: 1CS020.011_RMP_FIGURE_4.1-2.dwg

Sabina

BACK RIVER PROJECT

SRK JOB NO.: 1CS020.01, Task 500

ROAD MANAGEMENT PLAN

All-Weather Road and Watercourse Crossing Typical Cross Sections

REVISION NO.	SHEET	FIGURE NO.
B	1 OF 1	4.1-2

4.1.1 Design Criteria for Haul Roads

The design criteria have been determined considering the *Mine Health and Safety Act* (Northwest Territories and Nunavut), and the appropriate Transportation Association of Canada Geometric Guidelines. The following design criteria were used for the haul roads:

- Design vehicle: Cat 775G or similar;
- Minimum width of travelling surface: 20 m;
- Design speed: 60 km/h;
- Side slopes: 2H:1V;
- Maximum grade: 10%;
- Safety berms for fills greater than 3 m in height: 1.1 m; and
- Drainage: major culverts and bridges to be designed to a 1-in-100-year return period.

4.1.2 Design Criteria for Service Roads

Service roads are used for smaller vehicles (i.e., light trucks) to access ancillary infrastructure, such as water supply sources, Goose Airstrip, and explosives storage facility. The following design criteria were used for the service roads:

- Design vehicle: light/medium truck;
- Minimum width of travelling surface: 4.5 m for single-lane or 8 m for double-lane;
- Design speed: 50 km/h;
- Side slopes: 2H:1V;
- Maximum grade: 10%;
- Safety berms for fills greater than 3 m in height: 0.55 m; and
- Drainage: major culverts and bridges to be designed to a 1-in-100-year return period.

4.1.3 Construction of All-weather Roads

The site roads at the Goose Property will be constructed as all-weather roads. All-weather roads will be constructed with run-of-mine or run-of-quarry rock placed directly onto the tundra to preserve the permafrost. A layer of graded surfacing material will be placed to provide a protective trafficking layer. Construction materials are assumed to be from locally developed geochemically suitable overburden and rock quarries. Construction of service roads will occur at the MLA in Y-4 and Y-3. Construction of service and haul roads at Goose Property will occur during Y-3 through Y-1. Pre-development work may also include the development of roads at the MLA or Goose Property.

4.1.3.1 Geotechnical Recommendations

The understanding of ground conditions for design and engineering of Goose Plant Site infrastructure, including all-weather roads, has been informed by four geotechnical investigations from 2010 to 2015 including test pits, drill holes, thermistor installations, and a variety of laboratory and in-situ testing. Geotechnical design is also supported by ERM Rescan's 2014 Cumulative Permafrost Baseline Data Report which includes observations on active layer freeze-thaw cycle and active layer depth from 2007 to 2014. Refer to the Site-Wide Geotechnical Properties Report (MAD Appendix F-2) for more detail.

Road preparation recommendations produced by SRK (refer to MAD Appendix F-2) as a result of geotechnical investigations and thermal modelling for the Goose Plant Site for unheated infrastructure such as roads, pipelines, and airstrips where some differential settlement is acceptable, include:

- 1.0 m compacted run-of-quarry rock-fill pad (or geochemically suitable waste rock) on top of undisturbed grade for service roads;
  - maximum rock size limited to 0.9 m.
- 1.5 to 2.0 m thickness for haul roads to minimize deformation
  - maximum rock size limited to 0.9 m.
- Rock shatter required where roads cross over rock highs that impact road grade.
- 150 mm of 2” minus topping directly on top of rock-fill pad for trafficability (no need for intermediate 6” minus layer).

4.1.4 Water Crossings

There are five culvert crossing locations planned for the Project, all of which are situated on the Goose Property (Figure 4.1-1). Roads will be incorporated into water retention and water diversion structures as described in the Water Management Plan (SD-05); however, no water courses will be diverted for the sake of building roads.

Two types of culverts are considered for the site roads and airstrip:

- Non-fish-bearing crossings; and
- fish-bearing crossings.

The non-fish-bearing crossings will consist of corrugated steel pipe and are currently designed with a diameter of either 1.2 m or 2.5 m, depending on the required flow. The fish-bearing crossings will be sized to keep maximum water velocities below 1.5 m/s such that they do not present a velocity barrier to migrating Arctic Grayling. In addition, the culverts will be embedded to a depth of 0.4 m and filled with streambed material to promote fish passage and habitat suitability. Culverts will be designed to minimize Permanent Alteration to, or Destruction of, fish habitat, and conform with Fisheries and Oceans Canada (DFO) Measures to Avoid Causing Harm to Fish and Fish Habitat.

4.1.5 Water Use for All-weather Roads

Up to 400 cubic metres (m^3) per day has been allocated in the Water Management Plan (SD-05) for dust suppression for all-weather roads, the airstrip, and pads at the Goose Property. It is expected dust from all-weather roads will not pose a significant problem during the colder winter and early spring months when snow and ice cover roadways.

At the MLA, water for dust suppression for the local service roads and laydown pads is included in a 24 m^3 per day allowance for Miscellaneous Industrial uses. At the MLA, water will be sourced from Bathurst Inlet desalination.

4.1.6 Measures to Prevent Permafrost Degradation

Roads have been designed, and will be constructed, to reduce the potential for permafrost degradation. Thermal modelling confirms that a run-of-quarry (or geochemically suitable waste rock) haul road thickness of 1.5 to 2-m thick will minimize deformation. Where thinner fill is used, and for roads constructed during summer, some thaw consolidation is expected. Once the active layer is re-established, which would likely be achieved within one or two seasons, no further settlement is expected. Where possible, roads will be constructed in winter months, when soils are frozen, to prevent permafrost degradation and limit differential settlement. More detail can be found in the MAD, Appendix F-2.

Other mitigation and environmental design features to reduce the potential for permafrost degradation include:

- Avoiding ice-rich, poorly-drained, frost-susceptible soil conditions where possible favouring higher, more competent, well-drained ground;
- Placing road fill directly over overburden soil limiting cuts that can lead to thaw degradation;
- Removing accumulated snow before placing fill;
- Increasing road fill thickness in areas with thaw susceptible soils where necessary; and
- Construct roads in winter months when possible over frozen ground conditions.

4.1.7 Measures to Protect Fish and Fish Habitat

Sabina is committed to ensuring that serious harm to fish is avoided where possible in compliance with the *Fisheries Act* when undertaking construction or operating near water. The presence of fish in potentially affected habitats was confirmed through the multi-year baseline fish sampling programs performed for the Environmental Assessment of the Project. For example, baseline sampling suggests that most waterbodies and watercourses have the potential to support small-bodied fish species, such as Ninespine Stickleback, for at least part of the open water season; whereas only deeper waterbodies have the potential to support large-bodied species such as Lake Trout during the winter (assuming water depths exceed the maximum ice thickness). Watershed position is also a consideration in the classification of fish-bearing status and distribution of species. Streams and ponds, including ephemeral streams and ponds, that connect two fish-bearing waterbodies with confirmed fish presence have a high likelihood of supporting fish for at least part of the open water season (e.g., spring freshet). Refer to Tables 6.3-1 and 6.3-2 of the Conceptual Fish Offsetting Plan for a list of all waterbodies and watercourses with total or partial habitat losses that were either confirmed to support fish or identified as being highly likely to support fish.

The fish-bearing crossings will be sized to keep maximum water velocities below 1.5 m/s such that they do not present a velocity barrier to migrating Arctic Grayling.

Sabina is committed to deploy all applicable recommended measures where possible, including those related to Project planning, erosion and sediment control, shoreline re-vegetation and stabilization, fish protection, and the operation of machinery, as per DFO's Measures to Avoid Causing Harm to Fish and Fish Habitat (http://www.dfo-mpo.gc.ca/pnw-ppe/measures-mesures/index-eng.html). The below information re-iterates what is provided within the assessment of watercourse crossings and water intake/discharge pipes in the FEIS (FEIS Volumes 6 and 10), and in the Type A Water Licence Application MAD and Water Management Plan (SD-05).

<u>Watercourse Crossings</u>

For the fish bearing crossing at Gander Outflow, effects related to the installation of the culvert were assessed in the FEIS (FEIS Volume 10, Chapter 21, Section 6.3.3,). Within the implementation of DFO's recommended measures, the fish-bearing crossing will continue to serve as a migration corridor, between Goose and Rascal lakes. For example, the culvert will be sized to keep maximum water velocities below

1.5 m/s such that it does not present a velocity barrier to migrating Arctic Grayling. In addition, the culvert will be embedded to a depth of 0.4 m and filled with streambed material to promote fish passage and habitat suitability. Timing of in-water construction activities will conform, when possible, to Nunavut timing windows for the protection of fish and their habitat. Additional details on the Gander Outflow crossing can be located in the Site Water Monitoring and Management Plan (FEIS Volume 10, Chapter 7). Detailed design drawings will be provided to the NWB at least 60 days prior to construction, and DFO for review during the permitting stage of the Project.

It is important to re-iterate that the construction and maintenance of all stream crossings, roads, and berms will follow DFO's Measures to Avoid Causing Harm to Fish and Fish Habitat. These include the following mitigation measures to guide these processes and to ensure that fish and aquatic habitat is not adversely affected by development (FEIS Volume 6, Chapter 7, Section 7.5.3):

- Design and plan in-water activities and works such that loss or disturbance to aquatic habitat is minimized and sensitive spawning habitats are avoided.
- Where possible, approaches will be designed to be perpendicular to the watercourse to minimize loss or disturbance to riparian vegetation.
- Instream activities will be undertaken in isolation of open or flowing water, or when frozen, to maintain the natural flow of water downstream and avoid introducing sediment into the watercourse.
- Effective erosion and sediment control measures will be installed before starting work to prevent sediment from entering the waterbody.
- Site isolation measures (e.g., silt boom or silt curtain) will be used to contain suspended sediment where in-water work is required.
- Regular inspection and maintenance of erosion and sediment control measures and structures will be conducted during the course of construction.
- Repairs to erosion and sediment control measures and structures will be promptly completed if damage occurs.
- Removal of non-biodegradable erosion and sediment control materials will be completed once site is stabilized.
- Clearing of riparian vegetation will be kept to a minimum to avoid disturbance to the riparian vegetation and prevent soil compaction.
- If replacement rock reinforcement/armouring is required to stabilize eroding or exposed areas, appropriately-sized, clean rock will be installed at a similar slope to maintain a uniform bank/shoreline and natural stream/shoreline alignment.
- All construction equipment and supplies will be removed from the construction site upon Project completion.
- Machinery will be in a clean condition and maintained free of fluid leaks, invasive species, and noxious weeds.
- Whenever possible, machinery will be operated on land above the high-water mark or on ice in a manner that minimizes disturbance to the banks and bed of the waterbody.
- Whenever possible, machine fording of a watercourse will be limited to a one-time event (i.e., over and back), and only if no alternative crossing method is available. If repeated crossings of the watercourse are required, a temporary crossing structure will be constructed.

- Service machinery will be washed, refuelled, and fuel and other materials for the machinery stored, in such a way to prevent any deleterious substances from entering the water.
- Screens will be used on all water intake hoses and pumps to prevent fish entrapment.

Disposal of excavated material will be in a location above the high water mark to ensure that this material does not enter the watercourse. Efforts shall be made to minimize the duration of any in-stream works and minimize disturbance at stream crossings. This practice will prevent the release of sediment or sediment-laden water into water frequented by fish. Exposed landscape surfaces will be protected, where possible, by the installation of covering material like riprap, aggregate, or rolled erosion control products. All in-stream works for waterbodies frequented by fish shall be completed in accordance with the relevant DFO Guidelines.

Sediment loading in runoff will be minimized by the application of measures to intercept Total Suspended Solids before it reaches the freshwater environment. Sediment control measures could include:

- Buffer zones to trap sediment and to reduce flow velocities;
- Installation of synthetic permeable barriers, fibre rolls, and/or silt fences as required;
- Installation of check dams, gabions, and sediment basins to reduce flow velocities and encourage sediment deposition; or
- Locating stockpiles well away from watercourses.

4.2 WINTER ICE ROADS

Overland access to the Project is possible between January and April each year. During the Mobilization and Construction phases, equipment, materials, and supplies delivered mainly overland via the WIR to Goose Property will be staged at the MLA. Annually, in early December, preparation of the WIR linking the MLA to Goose Property will be undertaken. Once the WIR is ready for traffic, the equipment, materials, fuel, and supplies staged at the MLA will be transported by trucks over the WIR to Goose Property. It is expected that the transfers will occur annually between January and April.

The WIR between the MLA and Goose Property will be approximately 160 km long, travelling over 58% water and 42% land. The George Exploration Camp could connect to this WIR by a winter spur road approximately 13 km in length. This spur may further extend to provide a connection to the proposed Bathurst Inlet Port and Road all-weather road.

4.2.1 Public Use of Winter Ice Road Corridors

All Project roads, including the WIR, are private and not intended for public use.

4.2.2 Expected Traffic on Winter Ice Roads

Winter ice roads will be used for the life of the Project. It is expected that vehicle traffic will be between January and April annually. The expected number of vehicles on the WIR is presented in Table 4.2-1. Freight hauling is expected to average 25 tonnes per load including double and triple-axle flat-deck trailers. Fuel hauling will utilize standard B-train tankers with an estimated 75,000 litres per load capacity.

Table 4.2-1. Estimated Annual Vehicle[1] Traffic on Winter Ice Roads

	Construction Cargo/Freight/Fuel	Operations Cargo/Freight/Fuel
MLA to Goose	Up to 16 trucks making a return trip every 1 to 1.5 days (up to 1,100 transits)	Up to 27 trucks making a return trip every 1 to 1.5 days (up to 2,300 transits)

1 includes trips by vehicles moving cargo, freight, and fuel over the WIR season; this does not include any personnel movement, or equipment movement on the WIR.

Environmental conditions determine the route selected for WIR corridors including:

- Ice of a sufficient thickness to support equipment so that pumping and using water to build up ice will be limited.
- Snow/ice thickness on land will be sufficient to prevent damage to soil and vegetation.
- Weather conditions permit safe transport of equipment and materials.

The "Guidelines for Safe Ice Construction" published by the Northwest Territories Department of Transportation (2015) will guide the planning and construction of the WIRs. Further details on studies, reports, and plans relevant to the design of WIRs are presented in Section 2.1.

The WIR will be constructed yearly in December and January. The road will be open to traffic from late January to April of each year. The roads will be designed to be capable of carrying legal highway loads.

The effective use and duration of a WIR depends on a number of variables, the most important of which are the climatic conditions (air temperatures and snowfall), surface conditions, and the amount and type of traffic that will be using it.

The WIR will be constructed over land and over ice. Overland crossings rely on a frozen subgrade to support the vehicle loads and a prepared surface layer to provide a level driving surface. Surface layers usually consist of compacted snow and/or ice where available. Ice-capped snow roads will be constructed for highway legal loads (e.g., B-trains). A discontinuous pad of granular fill may be required over short areas of rough terrain or where there is insufficient snow cover to create a smooth surface. If this is insufficient to provide an acceptable surface and gradient, additional grading effort may be required to create a road that meets the design criteria. Although Sabina currently does not anticipate any such locations, it is possible that operational requirements may require some fill. Should small quantities of material be required, only quarries or borrows with geochemically suitable material will be developed, and Sabina will work with the land owner (KIA or INAC) to obtain the necessary approvals.

Roads that will be built over floating ice covers on lakes and rivers for B-trains will be built to a minimum 30 m cleared width. This width is necessary to provide a 5 m buffer along the edges to separate the vehicle traffic from the thinner ice found under snow banks. This minimum width also provides additional lane width for when roads are blown with drifted snow. Snow banks need to be managed carefully as they are an additional load on the ice, and the thinner ice underneath is prone to cracking and flooding. The final cleared width to account for floating ice covers will be determined during the next stages of the Project.

In high wind locations, it is often desirable to initially open the road to widths greater than the 30 m, which will provide space for the operational width to narrow due to snow drifting throughout the season to a minimum width of 30 m. The final cleared width to account for high wind locations will be determined during the next stages of the Project.

4.2.3 Design Criteria for Winter Ice Roads

The following design criteria were used for the WIRs:

- Road widths:
  - On Ice - minimum 30 m.
  - On land – minimum 10 m, with maximum 5% grade.
- Operating speeds (maximum 60 km/h):
  - Loaded Trucks (>50% of maximum load limit):
    - 35 km/h on ice.
    - 40 km/h on land.
    - 10 km/h on and off portages (i.e., shoreline-lake transition points).
  - Empty Trucks (<50% of maximum load limit):
    - 60 km/h on ice.
    - 40 km/h on land.
- Load limits:
  - Table 4.2-2 provides minimum ice thickness and total allowable weight for various vehicle configurations.

Table 4.2-2. Load Limit at 100% of Highway Legal Gross Vehicle Weight

Vehicle Configuration	Minimum Ice Thickness (cm)	Total Allowable Weight (kg)
2-Axle Hotshot	66	14,600
3-Axle Hotshot	73	22,500
6-Axle Tractor Trailer	89	46,500
8 Axle Super B Train	99	63,500

4.2.4 Winter Ice Road Alignment

In response to TK and a request by the KIA, the winter ice road north of Tahikafflok Lake (Bathurst Lake) was realigned to address potential impacts to riparian zones identified during two local focus group workshops (Cambridge Bay Hunter Focus Group 2012; Kugluktuk Hunter Focus Group 2012). Sabina realigned a 5.5 km section of the winter road alignment away from the area identified. Approximately 200 m of the 160 km winter road will need to be assessed for vegetation prior to construction (see below commitment). Air photos and remote sensed images were used to perform a table top assessment of the area. Vegetation and archeological assessments have already been completed for the entire alignment with the exception of the 200 m mentioned above. Sabina will seek appropriate authorization from the KIA and/or Indigenous and Northern Affairs Canada prior to use.

4.2.5 Winter Ice Road Construction and Use

The WIR is anticipated to be constructed in early December when the subgrade is frozen to a sufficient depth and the ice can support light tracked vehicles. Construction of the WIR will take approximately 45 days utilizing two work fronts from Goose Property and the MLA.

Maintenance will be required over the operating season from late January to April annually, with crews accommodated at both the MLA and Goose Property.

The "Guidelines for Safe Ice Construction" published by the Northwest Territories Department of Transportation (2015), as well as the Land Use Guidelines published for Government of Northwest Territories and Nunavut (INAC 2010) will guide the construction and maintenance requirements of the WIR. Winter ice roads are not planned to be constructed during temporary or permanent Closure; however, the WIR may be utilized during the Closure Phase to facilitate back-hauling of materials from Goose Property to the MLA for permanent disposal off-site.

Winter ice road construction will adhere to the following guidelines based on DFO Operational Statements:

- Use existing trails or WIRs wherever possible as access routes to limit unnecessary clearing of additional vegetation and prevent soil compaction.
- Construct approaches and crossings perpendicular to the watercourse wherever possible.
- Construct ice bridge and snow fill approaches using clean, compacted snow and ice to a sufficient depth to protect the banks of the lake, river, or stream.
- Install sediment and erosion control measures before starting work to prevent the entry of sediment into the watercourse. Inspect them regularly during the course of construction and decommissioning activities and make all necessary repairs if any damage occurs.
- Operate machinery on land or on ice and in a manner that minimizes disturbance to the banks of the lake, river or stream.
- Ensure that the intakes are sized and adequately screened to prevent debris blockage and fish entrapment.
- Crossings do not impede water flow at any time of the year.
- When the crossing season is over and where it is safe to do so, create a v-notch in the centre of the ice bridge to allow it to melt from the centre and also to prevent blocking fish passage, channel erosion and flooding. Compacted snow should be removed from snow fills prior to the spring freshet.
- Stabilize any waste materials removed from the work site to prevent them from entering the lake, river, or stream. This could include covering spoil piles with biodegradable mats or tarps.
- The site should be stabilized using effective sediment and erosion control measures. In areas with permafrost, care should be exercised to ensure these measures do not cause thawing or frost heave.

4.2.6 Water Use for Winter Ice Road Construction and Maintenance

The expected water use for the construction and maintenance of the WIRs is estimated to be up to 675 m^3/km/year. The volume used will depend on environmental conditions and operational needs. Water will be drawn from various sources along the alignment of the WIR. Sabina will adhere to the DFO Operational Statements on Mineral Exploration, Ice Bridges, and Snow Fills, as well as DFO Under-Ice Water Withdrawal Protocol for the withdrawal of water. The supply locations and consumption rates will be provided at least 60 days prior to construction.

Water withdrawal will adhere to the following guidelines from DFO's Protocol for Winter Water Withdrawal from Ice-covered Waterbodies in the Northwest Territories and Nunavut (DFO 2010):

- In one ice-covered season, total water withdrawal from a single waterbody will not exceed 10% of the available water volume calculated using the appropriate maximum expected ice thickness.
- In cases where there are multiple users withdrawing water from a single waterbody, the total combined withdrawal volume will not exceed 10% of the available water volume.
- Only waterbodies with maximum depths that are ≥1.5 m than their corresponding maximum expected ice thickness should be considered for water withdrawal.

In addition, Sabina committed to implement all applicable DFO best management practices to avoid and mitigate serious harm to fish as a result of the construction, operation, and decommissioning of WIRs, and from under ice water withdrawals. This includes adequately screening the water intakes pipes to prevent impingement and entrainment of fish (FA-DFO-T-4).

The construction of ice bridges and snow fill approaches at the land-water interface will utilize only clean, compacted snow and ice to a sufficient depth to protect the shoreline. Speed limits will be enforced to prevent ice scour along shorelines. Sabina has committed to adhering to the following DFO guidelines based upon the Nunavut *Operational Statement for Ice Bridges and Snow Fills* (DFO 2007):

- Use existing trails or WIRs wherever possible as access routes to limit unnecessary clearing of additional vegetation and prevent soil compaction;
- Construct approaches and crossings perpendicular to the watercourse wherever possible;
- Construct ice bridge and snow fill approaches using clean, compacted snow and ice to a sufficient depth to protect the banks of the lake, river or stream;
- The use of material other than ice or snow to construct a temporary crossing over any ice covered stream is prohibited under section 11 of the Northwest Territories Fishery Regulations, unless authorized by a Fishery Officer;
- Install sediment and erosion control measures before starting work to prevent the entry of sediment into the watercourse. Inspect them regularly during the course of construction and decommissioning activities and make all necessary repairs if any damage occurs;
- Operate machinery on land or on ice and in a manner that minimizes disturbance to the banks of the lake, river, or stream.
  - Machinery is to arrive on-site in a clean condition and is to be maintained free of fluid leaks;
  - Wash, refuel and service machinery and store fuel and other materials for the machinery away from the water to prevent any deleterious substance from entering the water or spreading onto the ice surface;
  - Keep an emergency spill kit on-site in case of fluid leaks or spills from machinery; and
  - Restore banks to original condition if any disturbance occurs;
- Ensure that the intakes are sized and adequately screened to prevent debris blockage and fish mortality. Mesh size will not be larger than 2.54 mm;
- Crossings do not impede water flow at any time of the year;
- When the crossing season is over, and where it is safe to do so, create a v-notch in the centre of the ice bridge to allow it to melt from the centre and also to prevent blocking fish passage, channel erosion and flooding. Compacted snow should be removed from snow fills prior to the spring freshet;

- Stabilize any waste materials removed from the work site to prevent them from entering the lake, river, or stream. This could include covering spoil piles with biodegradable mats or tarps; and
- The site should be stabilized using effective sediment and erosion control measures. In areas with permafrost, care should be exercised to ensure these measures do not cause thawing or frost heave.

Sabina remains committed to ensuring that all withdrawal of water for the construction of WIRs is completed in a manner that avoids or minimizes the potential for serious harm to fisheries. An innovative plan has been developed to identify those waterbodies that would reduce the potential effects on fish and fish habitat due to water withdrawal from lakes along the WIR. This plan includes collecting the following information to support the decision making process:

- Identify the location of and generate bathymetric maps of all potential water withdrawal source lakes along the WIR Alignment using methods based on satellite imagery;
- DFO's protocol for winter water withdrawal will be applied, where no more than 10% of the under ice volume for lakes deeper than 3.5 m will be extracted;
- Provide locations of proposed water withdrawal sites, calculate the depth, volume, maximum withdrawal limits and maximum reduction in depth for each lake;
- Identify any potential for changes in overwintering capacity for fish; and
- Identify any potential for changes to spawning shoal habitat for fall spawning fish species.

A memorandum describing Sabina's strategy in further detail can be found in Appendix E-4 of the MAD.

4.2.6.1 Bathymetry of Water Bodies Along the Winter Ice Road

A geophysical field program, consisting of ground penetrating radar profiling by snowmobile, was carried out Tetra Tech in 2013 (FEIS, Appendix V6-3E). The field program included a ground penetrating radar-based ice thickness and bathymetric survey along the proposed WIR routes between the Goose Property and George Property and the MLA in Bathurst Inlet, and a ground penetrating radar survey of Bathurst Inlet in an attempt to identify areas of grounded sea ice in the vicinity of the proposed WIR alignment.

The alignment of the WIR route has been further enhanced since the 2013 geophysical program and may alter further in detailed engineering. Detailed bathymetry of waterbodies along the final alignment of the WIR will be provided at least 60 days prior to construction of the WIR.

Sabina has committed to providing the bathymetry, depth, and location of the proposed water withdrawal sites, volumes to be extracted, anticipated water level decreases, and fish habitat features within each water body proposed to be used for winter water withdrawal in support of the construction of the winter ice roads.

4.3 GOOSE AIRSTRIP

The proposed all-weather Goose Airstrip and connecting all-weather road will be privately-owned infrastructure built entirely on Inuit Owned Land (see MAD Appendix A, base Figure 3). This infrastructure will be constructed, operated, inspected, and maintained by Sabina. It will be built at the onset of construction activities by extending and upgrading the current exploration/development gravel airstrip. This airstrip will serve as the main air access to the Property throughout the life of the Project. The Goose Airstrip will be classified as a "registered aerodrome" and the design will be in accordance with Transport

Canada's Aerodrome Standards and Recommended Practices (Transport Canada 2005). The construction of the airstrip will follow generally accepted good engineering practices for building airstrips in permafrost areas of the Northwest Territories and Nunavut.

At the onset of construction activities, the all-weather airstrip and apron capable of servicing passenger and large cargo aircraft will be constructed at the Goose Property by extending and upgrading the current exploration/development gravel airstrip. This airstrip will serve as the main air access to the Property throughout the life of the Project. The airstrip will be up to 1,524 m long and 45 m wide. Due to the continuous permafrost and possible thaw degradation on the Goose Property, the airstrip extension, if completed, will be constructed with embankment fills of approximately 2 m thick. The fill material will be geochemically suitable quarried rock or waste rock. This will be topped by an approximately 0.3-m thick compacted granular base trafficable layer. The airstrip will be equipped with lights, communications equipment, and instrumentation in accordance with appropriate Federal regulations.

Environmental considerations are incorporated into design and routing. Wind direction and speeds, in addition to existing terrain and ground conditions, determined the optimal airstrip orientation. Road alignment, connecting the airstrip to the Goose Camp Accommodations and to the quarries, considered the existing terrain and topography to determine the optimal route for equipment movement. The design aimed to minimize the Project footprint. Additional fieldwork determined that the airstrip and road alignments did not include any archaeological sites or vegetation/wildlife species under the *Species at Risk Act*.

Establishing fish and fish habitat included water quality and quantity, fish population, and fish habitat studies. These data have been incorporated to determine the optimal alignment for the airstrip, the connecting road, and the associated water crossings. The Goose Airstrip will incorporate two water crossings similar to all-weather road water crossings described in Section 4.1.4 and Figure 4.1-2.

5. Roles and Responsibilities

The General Manager is ultimately responsible for the success of the Plan and approves all relevant policies and documents, auditing, action planning, and the verification process.

The Mine Manager, along with his/her direct reports, is responsible for the implementation of this plan including safety, traffic management, and maintenance.

The Environmental Superintendent, along with his/her direct reports, is responsible for monitoring the effective implementation of this plan.

6. Traffic Management and Road Safety

Sabina's traffic management and road safety regulations will be inspired from the Tibbitt to Contwoyto Winter Road Joint Venture, Winter Road Regulations, and Rules of the Roads. This comprehensive document on WIR regulation will be developed once the Project is approved. This document will address:

- General Regulations for Use of the WIRs:
  - general regulations;
  - enforcement;
  - signage; and
  - dispatching.
- Rules of the Road:
  - speed restrictions;
  - truck and convoy spacing;
  - right of way;
  - portage traffic;
  - dangerous driving and unsafe practices;
  - interference with security;
  - drug, alcohol, and firearms;
  - littering and refuse disposal;
  - safety restrictions and equipment;
  - hours of works/log book;
  - designated refuge and rest areas;
  - dispatching;
  - communications;
  - spills and dangerous/emergency situations;
  - stopping on lakes/water crossings;
  - wildlife; and
  - wildlife reporting.

Key concepts of the traffic and road safety plan are discussed below.

6.1 ROAD SAFETY AND COMMUNICATION

Sabina security personnel, along with Sabina's road supervisor, will monitor activity on all roads through radio contact with both staff and drivers on the roads, and through periodic patrols of the roads. All Sabina vehicles that routinely travel on the roads will be equipped with a radio set to the requisite road frequency. Similarly, contractor's vehicles that routinely travel on the roads will be equipped with a radio set to the requisite road frequency. Consequently, Sabina's traffic on the roads will always have radio contact.

This system will be used to report any unusual conditions along the roads such as:

- Location of other Sabina vehicles.
- Presence of wildlife on the roadway.

- Presence of non-Sabina vehicles, such as all-terrain vehicles, snowmobiles, or other.
- Presence and location of any non-Sabina vehicles broken down on the roads.
- Unsafe practices noticed.
- Special road conditions.
- Special weather conditions, etc.

The safety rules that will apply to all users of the roads, including Sabina's employees and contractor employees of the roads are as follows:

- Maximum speed limits will be enforced. Signs will be posted.
- Use of seat belts by all drivers and passengers is mandatory.
- Driving under the influence of alcohol or intoxicating drugs is prohibited.
- Wildlife has right-of-way on the roads, and no harassment of wildlife is allowed.
- No public traffic is allowed within mining areas; these are industrial work sites and, thus, non-Project related vehicles will be stopped and escorted to the camp. Signs will be posted.

Sabina may temporarily place emergency shelters approximately every 60 km along the WIR. These shelters will have the necessary safety supplies to allow stranded travelers to wait out an event, such as a prolonged blizzard.

All roads associated with the Project, including all WIRs and all-weather roads, are private roads.

6.2 ROAD SIGNAGE

Sabina will post appropriate road signs along the roads. Typically, signs will advise drivers of the posted speed limit, approaching bridges, approaching curves, and/or areas of lower visibility (e.g., blind hills or obstructed curves).

Speed limit signs will be posted at intervals of approximately every 20 km along all roads, and posted at smaller intervals where necessary. Reflective flags will be installed along one side of the road to help drivers identify the road shoulder during a blizzard, white out conditions, or dense fog. Typically, these flags will be black in colour to help them stand out in white-out conditions, and will be nominally placed at intervals of 500 m apart. Kilometre markers will be posted along the all-weather roads at 1-km increments and at appropriate intervals along the WIR.

6.3 POLICING

Responsibility for all road operation and maintenance activities will rest solely with Sabina. Sabina will concentrate on raising awareness and commitment to road safety, and improving communication, cooperation, and collaboration among all stakeholders on the safe use of the roads. Sabina employees and its contractors who will use the roads will be required to take road safety training before being allowed to drive on the roads.

Sabina will use its road supervisor and site security to monitor activity on the roads. This will be achieved through radio contact, through periodic patrols of the roads, and in conversations with drivers on the roads. Sabina will monitor speed limit infractions by direct observation of active road users. Sabina will also rely on radio contact with its employees and contractor vehicles on the roads to monitor unsafe conditions or activity.

6.3.1 Emergency Response

As a private road, the responsibility for response to any emergency or accident lies solely with Sabina. It will be Sabina personnel that respond and address any emergencies that occur on the road and airstrip. Sabina will have staff on-site trained in emergency response including firefighting, first aid, vehicle recovery, and spill response. Sabina does not anticipate that emergency response will result in any demand on local public service providers in Cambridge Bay (fire, police, ambulance, medical, maintenance).

In most circumstances, the emergency response will be met by Sabina personnel. Sabina's emphasis will be on prevention with ongoing awareness, training, and ongoing safety measures while at the same time keeping resources close at hand to respond to emergencies at the Project in a timely manner. Sabina will implement the Risk Management and Emergency Response Plan for roads if needed.

6.4 ACCIDENTS AND MALFUNCTIONS

Sabina's emphasis will be on prevention, while at the same time keeping resources close at hand to respond to emergencies on the roads in a timely manner.

Three possible causes of road emergencies are the road itself, vehicles, and people. It is the interplay of these three elements that lead to either safe use of the roads or potential emergency response. Sabina is fully responsible for the design, construction, and maintenance of the roads on the Project site. This will include regular inspection and maintenance of transportation infrastructure, including service roads, haul roads, road crossings, water crossings, signage, and any refuge stations located along the WIRs.

Sabina will ensure its vehicles are in good working order before road use is allowed. As well, Sabina will train its employees on road safety and emergency response (first aid, firefighting, spill response, etc.). By educating and protecting its workers, Sabina will lead by example in road safety.

Some accidents and malfunctions may have an indirect effect on local fauna. For example, fish spawning success appears to be strongly affected by stream blockages. Thus, improper decommissioning of ice bridges and snow fills may cause stream channels to become blocked to fish during the spring migration, which could in turn lead to fish failing to spawn. Sabina will ensure that streams along the road alignments are appropriately monitored, and that any issues will be addressed as soon as feasible.

A Sabina trained emergency response and spill response team will be available on-site with appropriate equipment to respond to all spills and road accidents. The Emergency Response Team will be trained in emergency response (firefighting, first aid, mine rescue, spill response, vehicle accidents, etc.). In addition, emergency response equipment is to be carried in all Sabina vehicles. This equipment will include survival gear, emergency first aid equipment, and initial spill response equipment. Spill response will be implemented by environmental staff who will advise, document, and report on initial response and clean-up actions. The Spill Contingency Plan will be activated in response to a spill.

6.4.1 Spill Prevention

Training and awareness are two major elements of spill prevention. All site staff and contractors will review the contents of the Spill Contingency Plan during their on-site orientation and will be informed of where copies of the Plan are stored. The mandatory site orientation will provide hazard awareness training, identify the locations of spill kits and other response equipment, and discuss appropriate application. A more detailed description of the training to be provided to site staff is provided in Section 5 of the Spill Contingency Plan.

In addition to training, all work sites and hazardous materials storage facilities will be routinely inspected. Good housekeeping practices will be adopted with emphasis on storage facilities and loading zones.

General practices, to be implemented by Sabina, that support spill prevention include the following:

- Assign spill response personnel and clearly publish their contact information;
- Provide easy access to current Safety Data Sheets for all hazardous materials on-site;
- Maintain updated inventory of hazardous materials present at each site (in the Hazardous Materials Management Plan [SD-13]);
- Store materials in appropriate containers to the specified capacity, in areas adequately protected from weather and physical damage;
- Conduct regular inspections of storage facilities;
- Segregate incompatible materials;
- Provide training involving the Spill Contingency Plan (SD-17), spill sits, and other response equipment;
- Stock adequate spill response materials and equipment, and have them readily available for transportation, transfer, and storage of hazardous materials; and
- Create an environment which promotes prompt communications of all spill incidents.

Spill prevention practices specific to roads include:

- Inspection and maintenance of roadways and vehicles (Section 7);
- Adhering to traffic management and road safety practices (Section 6.1); and
- Ensuring proper storage of materials during transportation (Spill Contingency Plan [SD-17]).

6.4.2 Incident Response

Despite the preventative and mitigation measures taken, should any incident arise as a result of human error or unforeseen circumstances, the response procedures outlined in the Spill Contingency Plan will be implemented. The types of accidents and malfunctions that may occur are as follows:

- Vehicle collisions that may result in personal injury and spillage of potential harmful materials such as fuel, lubricating fluids, or antifreeze.
- Contact between vehicles and wildlife that may result in harm to wildlife, personal injury, and spillage of potentially harmful materials.
- Single vehicle accidents that may result in personal injury and spillage of potentially harmful materials.
- Risk of people getting stranded on the roads in bad weather, such as in blizzard, white out or dense fog conditions, or due to mechanical breakdown.
- Risk of accident due to an intoxicated or impaired driver on the roads.
- Spills of harmful materials onto the land or into water through a vehicle rollover or tipping during bad weather.

Sabina will report all reportable-scale incidents to the appropriate authority; this may include the KIA, Mines Inspector, RCMP, NWB, Nunavut Spill Line, Environment and Climate Change Canada, Government of Nunavut Department of Environment, and DFO.

The following actions are to be taken in the event of an accident on the roads involving other vehicles (including all-terrain vehicles), or in the event of an accident involving contact with wildlife, such as caribou, muskox, bear, wolf, etc.:

- Check the condition of people involved in the accident and provide immediate first aid if appropriate.
- Call the Sabina road dispatch by radio and report the location and nature of the accident and indicate the type of assistance required (e.g., medical help, environmental cleanup, fire, and/or mechanical help).
- Secure the accident site so that any vehicles do not continue to present a hazard to others. This may involve moving the vehicles to the nearest pull off in the event of a minor accident, or blocking off the road in both directions in the event of a more serious accident.
- If safe to do so, secure the site to prevent continued spill or leakage of contaminants into the surrounding environment.

Upon receiving the accident call, the road dispatch will initiate the emergency response procedure passing along the information to the emergency response coordinator. The emergency response coordinator will then call out the required emergency response personnel to assist at the accident site.

Once the accident site is secured and all people requiring assistance have been relocated to receive appropriate medical care, the emergency coordinator will turn the accident scene over to the mine's safety personnel so that an appropriate accident investigation can be initiated.

In the event of an incident involving contact with wildlife, the road dispatch will notify the site security personnel and the environmental representatives. Security and the site environmental team will then initiate an appropriate accident investigation. The Environmental Department will ensure that appropriate reporting of such incidents is made on a timely basis to the KIA, relevant Hunters and Trappers Organization(s), and the Government of Nunavut Wildlife Officers.

In the event of a serious accident, the RCMP will be contacted and advised of the incident. The RCMP will then decide on whether they will become involved or take the lead on any subsequent accident investigation.

7. Inspection, Maintenance, and Monitoring of Roads

Sabina has sole responsibility for the ongoing inspection and maintenance of all components of roads and the airstrip, including the road bed, airstrip foundation, culverts, water crossings, and quarry sites. Sabina will have the Site Supervisor, or their designate, responsible for ongoing inspection and maintenance. The following is a summary of the procedures that will be applied.

7.1 ALL-WEATHER ROADS INSPECTION AND MAINTENANCE

Sabina recognizes that a good inspection program will lead to the early identification of areas of the airstrip and road where improvements are necessary. The early resolution of any deficiencies will result in less ongoing maintenance and repair of the infrastructure.

The all-weather roads and its shoulders will be inspected regularly during the summer period for evidence of seasonal freeze and thaw adjacent to the toe of the road embankment. Such movements are expected and may lead to longitudinal cracking and thaw settlement especially for portions of the road founded on thaw-susceptible (ice-rich) soil. When such areas are discovered, the affected area will be repaired using geochemically and geotechnically suitable granular material and/or crushed rock. Sabina will maintain stockpiles of such material for this purpose.

The all-weather roads and airstrip will be inspected for signs of accumulation of ponded water, either on the surface or along the sides. Where noticed, the Site Supervisor will evaluate and monitor the accumulation to determine why water is accumulating in these areas. Based on these evaluations, the Site Supervisor will take remedial action where and when necessary to correct the cause of such ponding, such as grading of the surface to remove areas of ponding or installation of additional culverts if the road is causing excessive water ponding.

The all-weather road surfaces will be maintained with gravel being spread as required and regular grading of the road. Granular surfacing required for yearly maintenance of the all-weather roads will be sourced and stockpiled from local quarries. Refer to the Borrow Pits and Quarry Management Plan (SD-03), as it develops, for each quarry site.

In fall, winter, and spring, maintenance will be adjusted according to the weather conditions. Snow clearing along the roads will be completed to ensure that the roads can be operated safely. The manner in which the snow is cleared will also take into account the road configuration to ensure that snow accumulation will not cause any complications during the freshet.

Inspection frequency will be increased during the following critical time periods:

- Just prior to spring freshet to ensure that the culverts and stream crossings are in a good state to accommodate the rapid spring thaw;
- During the spring freshet to ensure that the culverts and stream crossings are not impeding spring freshet and to initiate action when and where required to prevent wash outs; and
- Just after heavy rainfall events to monitor water accumulation, to ensure that culverts and diversion/collection channels and ponds are passing precipitation as planned and to initiate action when and where required to prevent erosion and wash outs.

7.1.1 Dust Management

The amount of dust generated along the road and airstrip is dependent on the dryness of the surface, the number of vehicles, weight and speed, and maintenance of the driving surface. Dust will not pose a significant problem in the winter and early spring when snow and ice cover road surfaces. The warmer and drier late spring and summer months will lead to more dust generation.

Dust suppression measures, which are typical of the current mine practices (e.g., Meliadine and Meadowbank Mine) and consistent with best management practices, will be considered through design, operation and closure activities to control the dust. Regular grading of the road and airstrip combined with the addition of granular material to the surface will be needed. This will improve road safety and also reduce dust. In areas or times identified by the Site Supervisor as being prone to high dust levels or areas where safe road visibility is impaired or in areas where dust deposition is impacting fish habitat and/or water quality, the Site Supervisor will arrange mitigation measures as appropriate. This could involve actions such as grading of the road surface, placement of new coarser topping, and/or watering of the road surface. Up to 400 m^3 per day has been allocated in the Water Management Plan (SD-05) for dust suppression at the Goose Property. Use of approved chemical dust suppressants may be used and only in accordance with the Environmental Guidance for Dust Suppression on Unpaved Roads (GN 2014).

All Sabina employees and contractors are instructed to report any road and airstrip maintenance problem or hazardous condition to Project Management. Regular scheduled safety meetings will incorporate discussion and reminders related to all-weather airstrip and road use, operation, and maintenance. Additional details on dust management can be found in the Mine Waste Rock Management Plan (SD-08).

7.1.1.1 Air Quality Monitoring

Dust and particulate matter from mobile equipment traffic on roads is a primary air quality concern related to all-weather roads. Wind erosion from roads can also generate particulate emissions.

Upon Project approval, dust fall monitoring will be carried out during the Construction and Operations phases of the Project. As described in the Air Quality Monitoring Plan (FEIS Volume 10, Chapter 17), at the Goose Property, the monitoring will be sited to ensure that all large sources of emissions including ore stockpiles and haul roads are monitored approximately 30 m, 100 m, 1 km, 3 km, and 5 km downwind of the location with the most activity.

Monitoring of total suspended particulate, PM_{10}, and $PM_{2.5}$ concentrations will be carried out according to the National Air Pollution Surveillance (Environment Canada 2011) schedule by drawing a known quantity of air through a pre-weighed filter using a BGI PQ100-FRM Sampler following a standard monitoring cycle where a single 24-hour sample is collected every six days. Specific station locations will be sited approximately 100 m downwind of the location with the most activity.

7.1.2 Watercourse Crossings Inspection and Maintenance

The watercourse crossing inspection and maintenance program has these main components:

- A regular inspection program to identify issues relating to watercourse crossings such a structural integrity and hydraulic function.
- All necessary repairs and adjustments will be conducted in a timely manner.
- An event inspection program to track the impacts of large storm events on watercourse crossings, such as structural integrity and hydraulic function.

- A culvert location inspection program to ensure that culverts have been installed in the right location with respect to the watercourse and that culvert capacity is adequate to ensure that the culvert(s) pass the water under all hydraulic conditions.

Culverts will be sized for each stream crossing to accommodate normal summer flows as well as spring freshet and heavy rainfall flows.

Visual monitoring will be conducted on a regular basis to ensure drainage and erosion controls are effective per the following guidelines:

- Culvert maintenance will be conducted following the DFO's advice, "Measures to Avoid Causing Harm to Fish and Fish Habitat" (DFO 2013).
- Instream work will be conducted during approved timing windows presented in the DFO's advice, "Measures to Avoid Causing Harm to Fish and Fish Habitat" (DFO 2013).
- Winter ice road construction will follow the DFO advice, "Measures to Avoid Harm to Fish and Fish Habitat" (DFO 2013).
- Water withdrawal will follow DFO's Protocol for Winter Water Withdrawal from Ice covered Waterbodies in the Northwest Territories and Nunavut (DFO 2010) and DFO's advice "Measures to Avoid Harm to Fish and Fish Habitat" (DFO 2013).

Starting during the freshet period (mid-May through June), crossing inspections will be performed during the ice-free period prior to fall freeze-up which typically occurs in October of each year. These activities for each watercourse crossing will consist of visual inspection to:

- Identify defects, cracks, or any other risks to structural integrity of the infrastructure. Particular attention will be paid to the inlet and outlet structures of culverts.
- Identify sediment or other debris accumulation impeding the free flow of water through the crossings. Maintenance operations will consist of hand removal of accumulated debris and repairing damage as soon as possible.
- Identify bed erosion or scour around the watercourse crossing of the upstream and downstream channel. Any erosion concerns will be addressed as soon as possible.

Particular attention will also be paid to potential sources of sediment transport at the crossing. Inspection results will be recorded to help track changes in conditions over time. Maintenance operations will consist of undertaking remediation of any detected problems and repairing damage as soon as possible.

7.1.3 Closure

In the event of temporary Closure, service roads will be maintained, including plowing snow from roads and the airstrip, repairing culverts, employing erosion and sediment control measures, etc. Infrastructure, including ditches and spillways, will be routinely inspected to ensure proper operation or to implement contingency measures. Camp facilities will be operated and maintained to support this effort. The level of effort involved in maintaining the site in a state of temporary Closure will depend upon the Project phase.

In the event of permanent Closure, culverts will be removed from all-weather roads and the natural drainage restored. Roads will otherwise remain intact to ensure preservation of permafrost and facilitate long-term site access for monitoring and inspection.

Any airstrips will remain functional with a gravel surface for use during Post-Closure monitoring. Final closure of the airstrip will be similar to the all-weather roads.

7.2 WINTER ICE ROADS INSPECTION AND MAINTENANCE

During WIR operations, the roads will be inspected and maintained in accordance with the "Guidelines for Safe Ice Construction" (GNWT DoT 2015). These regulations state that ice thickness testing inspections should be done once a week on snow roads, twice a week on ice roads, and daily on ice bridges. Test hole spacing and frequency as recommended in the field guide are presented below for each WIR construction phase in Table 7.2-1.

Table 7.2-1. Field Guide for Ice Construction Safety Recommended Ice Testing

	Preconstruction	Construction	Operations and Maintenance
	Initial test run	From start of construction until road is opened to traffic	This may overlap with construction activities at lower load levels
Rivers	If GPR is used, test holes are only required for calibration and for mapping of thin areas 30 meters between test holes along centre line	If GPR is used, test holes are only required for calibration and for mapping of thin areas 30 meters between test holes along alternate edges	If GPR is used, test holes are only required for calibration and for mapping of thin areas 30 meters between test holes along alternate edges Look for thin areas caused by river current
Lakes	If GPR is used, test holes are only required for calibration If within 250 metres of shore: 30 meters between test holes along centre line If more than 250 metres from shore: 250 metres between test holes along centre line	If GPR is used, test holes are only required for calibration If within 250 metres of shore: 30 metres between test holes along alternate edges If more than 250 metres from shore: 250 metres between test holes along alternate edges	If GPR is used, test holes are only required for calibration and for mapping of thin areas 250 metres between test holes along alternate edges
Mackenzie Delta	If GPR is used, test holes are only required for calibration 250 metres between test holes along centre line	If GPR is used, test holes are only required for calibration 250 metres between test holes along alternate edges	If GPR is used, test holes are only required for calibration and for mapping of thin areas

Source: Northwest Territories Department of Transportation. "Guidelines for Safe Ice Construction" 2015.
GPR = ground penetrating radar.

7.3 SNOW CLEARING

The Project is located near the northern boundary of the North American Continent in the vicinity of the Arctic Circle. The climate in the area is characterized by extremes. The Project area experiences relatively low amounts of precipitation, but due to sub-zero temperatures for much of the year, also experiences high snow accumulation. Summer is a season of nearly perpetual sunlight, while winter is dominated by night, twilight and extreme cold. Due to the relative absence of obstructions to impede the wind (e.g., trees, buildings, mountains), wind speeds are generally high. Refer to the Climate and Meteorology chapter of the FEIS (Volume 4, Chapter 3) for further information on Project area climate and meteorology.

A geophysical field program, consisting of ground penetrating radar profiling by snowmobile, was carried out Tetra Tech in 2013 (FEIS Appendix V6-3E). The field program included three main components:

- a ground penetrating radar-based (GPR) bathymetric survey of three lakes near the Goose Exploration Camp to calculate under-ice free water volume, for DFO winter water-withdrawal permitting purposes;
- a GPR-based ice thickness and bathymetric survey along several proposed winter road (i.e., “ice road”) routes between Sabina’s Goose and George Exploration Camps and Bathurst Inlet; and
- a GPR survey of Bathurst Inlet in an attempt to identify areas of grounded sea ice in the vicinity of the proposed WIR alignment.

This information, along with metrological information collected during baseline data collection from 2004 to 2014, was used to inform the design of the WIR, and inspection and maintenance plans for the all-weather roads.

The Project is expected to experience snow drifts due to strong winds and snow accumulation over the winter season. Roads will be cleared of snow drifts as needed to ensure a safe running surface is maintained. Routine spring snow management will include the removal of any snow that accumulates at culverts so that water at freshet can move freely through the culverts and waterway. In the case of culverts, snow is removed from both ends but not from the inside.

7.4 WATER MANAGEMENT

The Water Management Plan (SD-05) describes in detail water monitoring and management activities and design for the Project during all phases of Project life. A summary of monitoring practices applicable to roads include:

- Visual inspections to confirm that the mitigation measures identified in this document and other relevant management plans (e.g., the Environmental Management and Protection Plan [SD-20], Aquatic Effects Management Plan [SD-21]) are implemented satisfactorily;
- Visual inspections to monitor the effectiveness of sediment and erosion control and runoff collection measures on a regular basis (daily or weekly as appropriate); and
- Recording water consumption used for dust suppression and WIR construction and maintenance to ensure compliance with DFO (2010) winter water withdrawal guidelines.

For additional details on water management, refer to Water Management Plan (SD-05).

8. Wildlife Protection Measures

Wildlife may occasionally be observed near Project roads or the airstrip. This section describes the measures to ensure that wildlife is protected, including:

- Roles and responsibilities,
- Mitigation measures that will apply at all times,
- Management measures should wildlife be observed near all-weather roads, the WIR, and the airstrip, and
- Management of wildlife incidents.

Measures to protect fish and fish habitat are described in Section 4.1.7.

More information on the protection of wildlife is available in the Wildlife Mitigation and Monitoring Program Plan (Version 7, submitted with FEIS Addendum February 2017).

8.1 ROLES AND RESPONSIBILITIES

The protection measures described in this section apply to all Project personnel, contractors, and visitors to site who use Project roads or the airstrip. In cases of operational challenges (e.g., groups of caribou), the Environmental Manager and environmental personnel on-site will manage the situation. The Project personnel will be notified by radio if any wildlife is observed on the road according to current communication procedures.

8.2 MITIGATION DURING ROAD CONSTRUCTION

- The all-weather roads will be constructed to avoid active wildlife residences, such as dens or active bird nests. More information is available in the Wildlife Mitigation and Monitoring Program Plan.
- Road crossing structures will be built on all-weather roads at crossing locations identified by land users. Road crossing structures may include ramps, stretches of the road shoulder made of smaller rocks, or other methods identified through TK, land user information, scientific literature, or based on best practice.
- The WIR will be constructed each year so as to avoid active grizzly bear dens and avoid disturbing esker habitat used for carnivore dens. More information is available in the Wildlife Mitigation and Monitoring Program Plan.
- The WIR will be constructed each winter such that it is not a barrier to movement for caribou; the height of snowbanks will be limited to approximately 1 m and snow plowing will be conducted in such a way as to limit the angle and vertical height of the snowbank edge.

8.3 MITIGATION MEASURES FOR ALL ROADS

The following protocol will be implemented on the road and airstrip for the protection of wildlife:

- Traffic on all roads will be managed and monitored through a central dispatch.
- Observations of caribou and other large mammals will be reported to the environment department.

- Roads will be closed to the public.
- Vehicle speeds on the all-weather and WIR will be limited to 60 km/hr.
- It will be strictly forbidden for any individual to feed wildlife, litter or harvest wildlife while on-site.
- Appropriate mitigation strategies (e.g., signage) will be developed for areas with higher frequency of encounters with wildlife.

8.4 MANAGEMENT FOR THE ALL-WEATHER ROADS

- If a driver observes a caribou, 10 muskox, or other large mammal (e.g., grizzly bear, wolves, or wolverine) within 500 m of any road, the driver will slow to 40 km/hr, alert other drivers, and proceed with caution.
- If a driver on an all-weather road observes that caribou (or muskox, grizzly bear, wolves or wolverine) are on the road or within 50 m of the road and moving towards the road with the intention to cross the road, then the vehicle will stop, the driver will alert the Environment Department, and will proceed when the animals have crossed the road and moved off or may then proceed slowly after a wait of 20 minutes.
- If a driver on the all-weather road observed caribou on the road, they will stop the vehicle until the caribou move off. If other wildlife are standing on the road, then the driver will stop for up to 20 minutes, then proceed slowly to encourage the wildlife to move off the road.

8.5 MANAGEMENT FOR THE WINTER ICE ROAD

The WIR is planned to be operated from January through April of each year.

- If a driver observes a caribou (or other large mammal) within 500 m of any road, the driver will slow to 40 km/hr, alert other drivers, and proceed with caution.
- If a driver observes that caribou (or other large mammal) are within 50 m of the road and moving towards the road with the intention to cross it, then the vehicle will stop, the driver will alert the Environment Department, and will proceed when the animals have crossed the road and moved off; alternatively, after 20 minutes the driver may proceed slowly if animals have not made their road crossing.
- If caribou are resting on the road, then the driver will wait until the animals have moved off on their own.

Should unforeseen circumstances require operation of the WIR after April 15th, then some additional management will be conducted to protect Beverly/Ahiak caribou that may cross the WIR during spring migration:

- The WIR will be temporarily closed by the Environment Manager should collar information, results of caribou surveys or incidental observations indicate that groups of caribou are lingering near the road or moving towards the road with the intention to cross the WIR.
- Should a driver make an incidental observation that large groups of caribou are attempting to cross the road, the driver will stop, report the observation to the Environmental Manager – who will dispatch an environmental monitor and may close the road.
- To reduce the frequency of traffic on the WIR that may deter caribou from crossing, trucks may be grouped into convoys during the spring migration.

- If a driver observes that caribou are within 500 m of the road and moving towards the road with the intention to cross it, then the vehicle will stop, the driver will alert the Environment Department, and will proceed either when the animals have crossed the road and moved off or proceed at slow speed after a wait of 20 minutes.
- If a driver observes caribou at a distance greater than 500 m of the WIR and moving towards the road then they will alert the Environment Department, slow to 40 km/hr, and proceed with caution.

8.6 MANAGEMENT FOR THE AIRSTRIP

- Prior to aircraft landing on the airstrip, a visual inspection will be conducted to identify the presence of any wildlife on the airstrip. Small groups of wildlife will be escorted off the airstrip; the flight crew will be notified by radio that such action is taking place and aircraft will not be approved to land until the airstrip is clear.
- If groups of greater than 25 caribou are observed on the airstrip then no action will be taken. If the wildlife cannot be escorted from the airstrip within a reasonable length of time, the flight crew will be instructed to divert to another location.

8.7 MANAGEMENT OF WILDLIFE INCIDENTS

- All incidents between vehicles and wildlife must be reported to the environmental department whether they are:
  - near miss incidents;
  - collision with injury to the wildlife; or
  - wildlife mortality.
- Each incident will be investigated and measures taken to avoid reoccurrence. Disciplinary measures will be taken against any employee if the investigation concludes that the accident is the result of negligence.
- In the case of the accidental death of an animal, environment personnel will contact the Government of Nunavut Wildlife Officer, KIA Senior Lands Manager, and the Hunters and Trappers Organization office in Kugluktuk and Cambridge Bay to discuss what to do with the carcass. The default action will be to remove the carcass from the road for community use or incinerate it to avoid attracting scavengers, such as wolves, grizzly bear, Arctic fox, and/or wolverine.

More information on wildlife protection measures can be found in the Wildlife Mitigation and Monitoring Program Plan (Version 7; submitted with FEIS Addendum February 2017).

Wildlife monitoring will be incorporated into current wildlife tracking according to the terms and conditions of current land use permits. This includes a log of sightings that detail wildlife observed, estimate of numbers, and nearest kilometre marking along the all-weather or WIR. The data will be aggregated and reported in the annual Wildlife Effects Monitoring Program Report. Additional details can be found in the Wildlife Mitigation and Monitoring Program Plan (Version 7; submitted with FEIS Addendum February 2017).

Refer to Section 4.1.7 for measures to protect fish and fish habitat.

9. Adaptive Management

The Plan will be updated again prior to Construction if instructed to do so by the NWB during the licensing process. The Plan will be reviewed on a regular basis to incorporate any lessons learned, major changes to facility Operations or maintenance, and environmental monitoring results. Any updates to the RMP will be filed with the Annual Report submitted under the Type A Water Licence.

All employees will be informed of relevant updates and the updated RMP will be located in a designated area at each site.

Sabina will retain all raw data records and annual reporting for at least two years in digital format. The updated RMP, raw data, and annual reporting will be made available by Sabina at all times for review by the lands and waters inspectors, the NWB, and Environment and Climate Change Canada.

This plan represents an adaptive approach to understanding the effects of the Project on the landscape and the species that live there. In this context, the Plan is part of a continually evolving process that relies not only on the efficacy of data collection and analytical results, but is also dependent on feedback from the communities, government, Aboriginal groups, and the public. Having an adaptive and flexible program allows for appropriate and necessary changes to the design of monitoring studies, and the mitigation and monitoring plans. Some changes may come about through the observation of unanticipated effects or inadequacies in the sampling methods to detect measurable effects. Other changes may result from ecological knowledge acquired through working with Aboriginal community members and discussions with Elders, both in the field and through workshops.

Sabina is committed to considering and incorporating Traditional Knowledge into the Plan. The incorporation of Traditional Knowledge will occur throughout all stages of the Plan, including identification of mitigation measures, monitoring study design, data collection, and follow-up programs to obtain feedback.

10. Reclamation

Reclamation of the haul and service roads will follow the completion of mining. In some instances, progressive reclamation will lead to roads being reclaimed after they are no longer needed. As described in the Interim Closure and Reclamation Plan, the service roads should be the last mining component to be reclaimed. For additional information related to closure refer to Section 7.1.3.

Decommissioning of the roads will involve restoring natural drainage, which will be accomplished by removing all culverts, bridges, and other potential obstructions to drainage paths. Any slopes where there is potential for erosion will be stabilized. Stabilization measures may require pulling back of side-cast fills on locally steep slopes or buttressing and/or re-contouring of steepened slopes using non-acid generating material. Refer to the Interim Closure and Reclamation Plan for additional details on the closure of roads.

A Vegetation Monitoring Plan (Appendix H to the Interim Closure and Reclamation Plan [SD-26]) was submitted as part of the FEIS Addendum (February 2017). The Vegetation Monitoring Plan will be updated to include all commitments discussed throughout the Review of the Project, including commitments to consult with the Kitikmeot Inuit Association, the Government of Nunavut, and other relevant parties. The plan will be submitted to the Nunavut Impact Review Board and other authorizing agencies at least 90 days prior to construction of the WIR.

11. References

DFO (Fisheries and Oceans Canada). 2010. Protocol for Winter Water Withdrawal from Ice-Covered Waterbodies in the Northwest Territories and Nunavut. June 2010.

DFO. 2013. Advice, Measures to Avoid Causing Harm to Fish and Fish Habitat.

Environment Canada. 2011. *Analysis and Air Quality Section: National Air Pollution Surveillance Program (NAPS).* http://www.ec.gc.ca/rnspa-naps/ (accessed July 2013).

GNWT DoT (Department of Transportation of Northwest Territories). 1993. G Environmental Guidelines for the Construction, Maintenance and Closure of Winter Roads in the Northwest Territories. October 1993.

GNWT DoT. 2015. Guidelines for Safe Ice Construction. February 2015.

GN (Government of Nunavut Department of Environment). 2014. Environmental Guidance for Dust Suppression on Unpaved Roads. Available online: http://env.gov.nu.ca/sites/default/files/guideline_-_dust_suppression_on_unpaved_roads_2014.pdf. April 2014.

INAC (Indigenous and Northern Affairs Canada). 2010. Northern Land Use Guidelines – Access: Roads and Trails. January 2010. ISBN: 978-1100-14743-7. Link.

Roads and Transportation Association Canada. 1986. Manual of Geometric Design Standards for Canadian Roads.

Tibbitt to Contwoyto Winter Road Joint Venture, Winter Road Regulations and Rules of the Road, current version.

Transport Canada. 2015. Aerodromes Standards and Recommended Practices (TP 312) 5th Edition. Revised July 2015.

Appendix A. Applicable Legislation

Appendix A. Applicable Legislation

Acts	Regulations	Guidelines
Federal		
Canadian Environmental Protection Act (1999 c.33)	Storage Tank Systems for Petroleum Products and Allied Petroleum Products Regulations (SOR/2008-197) Environmental Emergency Regulations (SOR/2003-307) Export and Import of Hazardous Waste and Hazardous Recyclable Material Regulations (SOR/2005-149) Interprovincial Movement of Hazardous Waste and Hazardous Recyclable Material Regulations (SOR/2002-301) Federal Registration of Storage Tank Systems for Petroleum Products and Allied Petroleum Products on Federal Lands or Aboriginal Lands Regulations (SOR/97-10) Fuels Information Regulations, No. 1 (SOR/C.R.C., c. 407) Sulphur in Diesel Fuel Regulations (SOR/2002-254) Sulphur in Gasoline Regulations (SOR/99-236)	Canadian Council of the Ministers of Environment - Environmental Code of Practice for Aboveground and Underground Storage Tank Systems Containing Petroleum and Allied Petroleum Products Notice with respect to substances in the National Pollutant Release Inventory Canada-Wide Standards for Petroleum Hydrocarbons (PHC) in Soil
Canada Water Act (1985 c.11)		
Canada Wildlife Act (1985 w9)	Wildlife Area Regulations (C.R.C., c. 1609)	
Species at Risk Act (2002 c.29)		(Eskimo Curlew – endangered)
Migratory Birds Convention Act (1994 c.22)	Migratory Birds Regulations (C.R.C., c. 1035) Migratory Bird Sanctuary Regulations, [C.R.C., c.1036]	Avoidance Guidelines: • Reducing Risk to Migratory Birds • Technical Information • Guidelines to Avoid Disturbance to Seabird and Waterbird Colonies in Canada • Birds at Sea • General Nesting Periods of Migratory Birds in Canada

Acts	Regulations	Guidelines
Fisheries Act (1985, c. F-14)	Metal Mining Effluent Regulations (SOR/2002-2222) Applications for Authorization Under Paragraph 35(2)(B) of the Fisheries Act Regulations Aquatic Invasive Species Regulations (SOR/2015-121) Regulations Establishing Conditions for Making Regulations Under Subsection 36(5.2) of the Fisheries Act (SOR/2014-91)	Fisheries Protection Policy Statement Framework for Assessing the Ecological Flow Requirements to Support Fisheries in Canada DFO Protocol for Winter Water Withdrawal from Ice-covered Waterbodies in the Northwest Territories and Nunavut Implementing the New Fisheries Protection Provisions under the *Fisheries Act* - Discussion Paper General Fish-out Protocol for Lakes and Impoundments in the Northwest Territories and Nunavut Guidelines for the Use of Explosives In or Near Canadian Fisheries Waters Freshwater Intake End-of-Pipe Fish Screen Guideline Standard Operating Procedure – Clear Span Bridges
Explosives Act (1985 c.E-17)	Ammonium Nitrate and Fuel Oil Order (C.R.C., c. 598) Explosives Regulations (C.R.C., c. 599)	
Navigation Protection Act (R.S. 1985 c. N-22, s. 1; 2012, c.31, . 316)	Navigable Waters Bridges Regulations (C.R.C., c. 1231) Navigable Waters Works Regulations (C.R.C., c. 1232)	List of Scheduled Waters (Schedule in the Act)
Transport of Dangerous Goods Act (1992, c. 34)	Transportation of Dangerous Goods Regulations (SOR/2001-286)	
Territorial Lands Act (R.S. *1985, c. T-7)*	Northwest Territories and Nunavut Mining Regulations (C.R.C., c. 1516) Territorial Lands Regulations (CRC, c 1525) Territorial Land Use Regulations (CRC, c 1524) Territorial Quarrying Operations, [C.R.C., c. 1527] Northwest Territories Mining District and Nunavut Mining District Order	Northern Land Use Guidelines: Administrative Process
Nunavut Waters and Nunavut Surface Rights Tribunal Act (2002, c.10)	Nunavut Waters Regulations (SOR/2013-69)	
Nunavut Act (1993 c.28)	Nunavut Archaeological and Paleontological Sites Regulations (SOR/2001-220)	
Nunavut Land Claims Agreement Act (1993, c.29)		

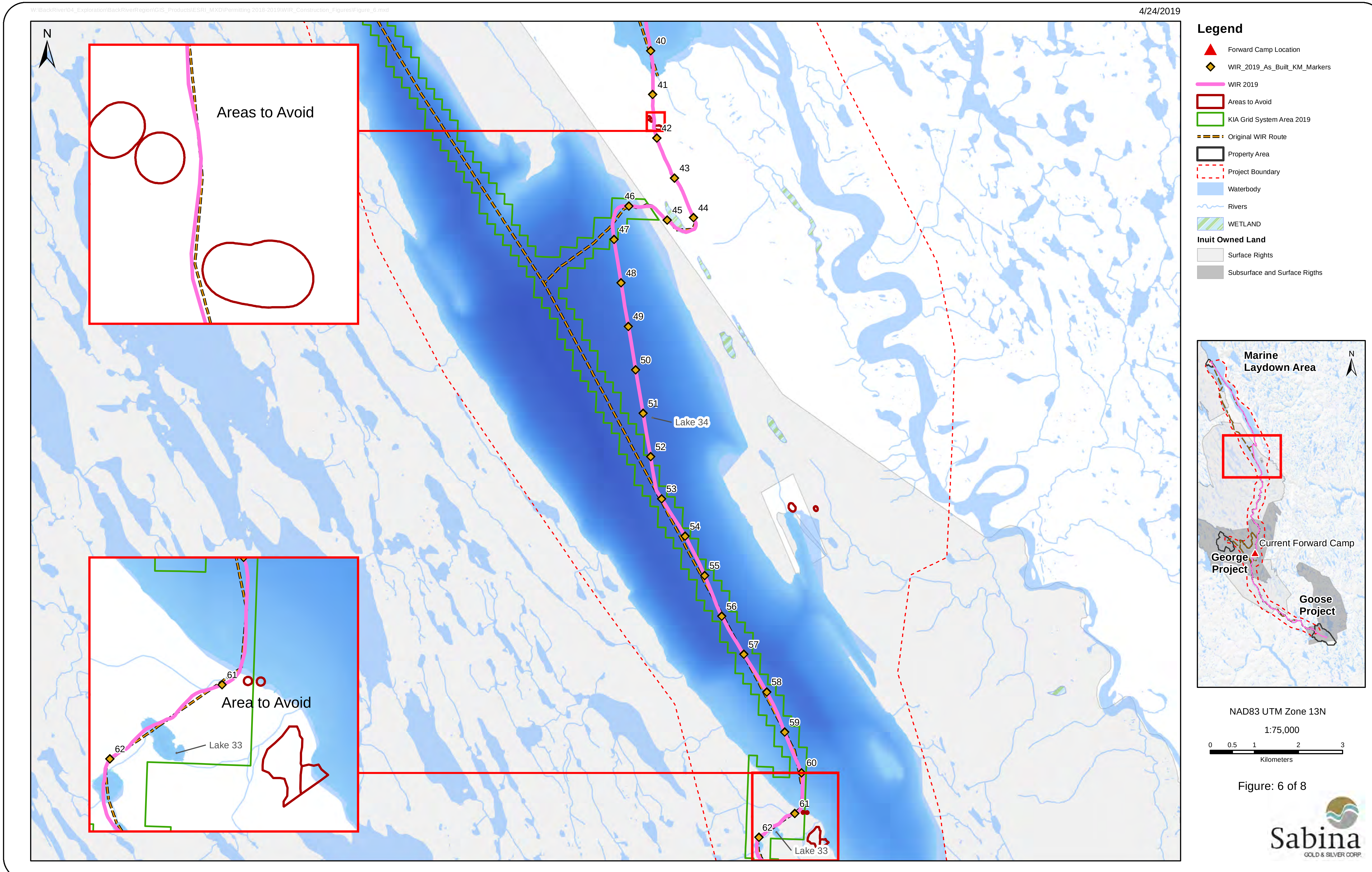
Acts	Regulations	Guidelines
Territorial		
Environmental Protection Act (RSNWT (nu) 1988, c E-7)	*Spill Contingency Planning and Reporting Regulations* (NWT Reg (Nu) 068-93) The removal of hazardous materials will require the registration with the Government of Nunavut, Department of Environment as a waste generator as well as carrier (if applicable) prior to transport. Asphalt Paving Industry Emission Regulations, R.R.N.W.T. 1990 c. E-23	Guideline on Dust Suppression Guideline for the General Management of Hazardous Waste in Nunavut Guideline for Industrial Waste Discharges in Nunavut Guideline for Air Quality – Sulphur Dioxide and Suspended Particulates Guideline for the Management of Waste Antifreeze Guideline for the Management of Waste Batteries Guideline for the Management of Waste Paint Guideline for the Management of Waste Solvents Guideline for Industrial Projects on Commissioner's land Canada-Wide Standards for Particulate Matter (PM) and Ozone Canada-Wide Standards for Petroleum Hydrocarbons (PHC) In Soil
Historical Resources Act RSNWT (Nu) 1988, c. H-3)		
Wildlife Act (RSNWT (Nu) 1988, c W-4)	*Wildlife General Regulations* (NWT Reg (Nu) 026-92) *Wildlife Licences And Permits Regulations* (NWT Reg (Nu) 027-92) *Wildlife Management Barren-Ground Caribou Areas Regulations* (NWT Reg (Nu) 099-98) *Wildlife Management Grizzly Bear Areas Regulations* (NWT Reg (Nu) 155-96) *Wildlife Management Zones Regulations* (RRNWT (Nu) 1990 c W-17) *Wildlife Regions Regulations* (NWT Reg (Nu) 108-98) Critical Wildlife Areas Regulations, R.R.N.W.T. 1990 c. W-3 Polar Bear Defence Kill Regulations, N.W.T. Reg. 037-93 Wildlife Management Muskox Areas Regulations, R.R.N.W.T. 1990 c. W-11 Wildlife Management Polar Bear Areas Regulations, R.R.N.W.T. 1990 c. W-13 Wildlife Sanctuaries Regulations, R.R.N.W.T. 1990 c. W-20 Wildlife Preserves Regulations, R.R.N.W.T. 1990 c. W-18	

Acts	Regulations	Guidelines
Territorial Parks Act (RSNWT (Nu) 1988, c T-4)	*Territorial Parks Regulations* (RRNWT (Nu) 1990 c T-13)	
Scientists Act (RSNWT (Nu) 1988 c S-4)	*Scientists Act Administration Regulations* (NWT Reg (Nu) 174-96)	
Commissioner's Land Act (RSNWT 1988, c C-11)	*Commissioner's Airport Lands Regulations* (NWT Reg (Nu) 067-97) *Commissioner's Land Regulations* (RRNWT 1990, c C-13)	
Mine Health And Safety Act (SNWT (Nu) 1994, c 25)	*Mine Health And Safety Regulations* (NWT Reg (Nu) 125-95) Mine Health and Safety Regulations, amendment, Nu. Reg. 016-2003	
Workers' Compensation Act (RSNWT, 1988, c. W-6)	*Workers' Compensation General Regulations* (Nu Reg 017-2010)	
All-Terrain Vehicles Act (RSNWT (Nu) 1988, c A-3)	*All-Terrain Vehicles Regulations* (RRNWT (Nu) 1990 c A-1)	
Apprenticeship, Trade And Occupations Certification Act (RSNWT (Nu) 1988, c A-4)	Apprenticeship, Trade And Occupations Certification Regulations (RRNWT (Nu) 1990 c A-8) Occupation Designation Order, N.W.T. Reg. 026-96 Trade Advisory Committees Order, R.R.N.W.T. 1990 c. A-9 Trade Designation Order, R.R.N.W.T. 1990 c. A-10	
Electrical Protection Act (RSNWT (Nu) 1988, c E-3)	*Electrical Protection Regulations* (RRNWT 1990 c. E-21)	
Explosives Use Act (RSNWT (Nu) 1988, c E-10)	*Explosives Regulations* (RRNWT (Nu) 1990 c E-27)	
Fire Prevention Act (RSNWT (Nu) 1988, c F-6)	Fire Prevention Regulations (RRNWT (Nu) 1990 c F-12) Propane Cylinder Storage Regulations, N.W.T. Reg. 094-91	
Hospital Insurance And Health And Social Services Administration Act (RSNWT 1988, c T-3)	Territorial Hospital Insurance Services Regulations (RRNWT (Nu) 1990 c T-12) Baffin Regional Health and Social Services Board Order, N.W.T. Reg. 059-98 Hospital Standards Regulations, R.R.N.W.T. 1990 c. T-6	
Labour Standards Act (RSNWT (Nu) 1988, c L-1)	*Various*	
Motor Vehicles Act (RSNWT (Nu) 1988, c M-16)	*Large Vehicle Control Regulations* (RRNWT (Nu) 1990 c M-30) *Motor Vehicle Registration And Licence Plate Regulations* (RWT Reg (Nu) 054-94)	

Acts	Regulations	Guidelines
Petroleum Products Tax Act (RSNWT (Nu) 1988, c P-5)	*Petroleum Products Tax Regulations* (RRNWT (Nu) 1990 c P-3)	
Public Health Act (RSNWT (Nu) 1988, c P-12)	*Camp Sanitation Regulations* (RRNWT (Nu) 1990 c P-12) *General Sanitation Regulations* (RRNWT (Nu) 1990 c P-16) *Public Water Supply Regulations, R.R.N.W.T. 1990 c. P-23* *Public Sewerage Systems Regulations, R.R.N.W.T. 1990 c. P-22*	
Public Highways Act (RSNWT (Nu) 1988, c P-13)	*Highway Designation And Classification Regulations* NWT Reg (Nu) 047-92)	
Safety Act (RSNWT 1988, c.S-1)	*General Safety Regulations, Amendment NU Reg 021-2000* (RRNWT (Nu) 1990 c S-1) Asbestos Safety Regulations, N.W.T. Reg. 016-92 General Safety Regulations, R.R.N.W.T. 1990 c. S-1 Safety Forms Regulations, N.W.T. Reg. 102-91 Silica Sandblasting Safety Regulations, N.W.T. Reg. 015-92 Work Site Hazardous Materials Information System Regulations, R.R.N.W.T. 1990 c. S-2	
Transportation Of Dangerous Goods Act (1990. RSNWT (Nu) 1988, c 81 (Supp))	*Transportation Of Dangerous Goods Regulations* (1991, NWT Reg (Nu) 095-91)	Emergency Response Assistance Plans (ERAPs)

Applicable Legislation and Guidelines for the Back River Project

Appendix C Final WIR Route Maps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Legend
Forward Camp Location
WIR_2019_As_Built_KM_Markers
WIR 2019
Areas to Avoid
KIA Grid System Area 2019
Original WIR Route
Property Area
Project Boundary
Waterbody
Rivers
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Surface Rights
Subsurface and Surface Rigths
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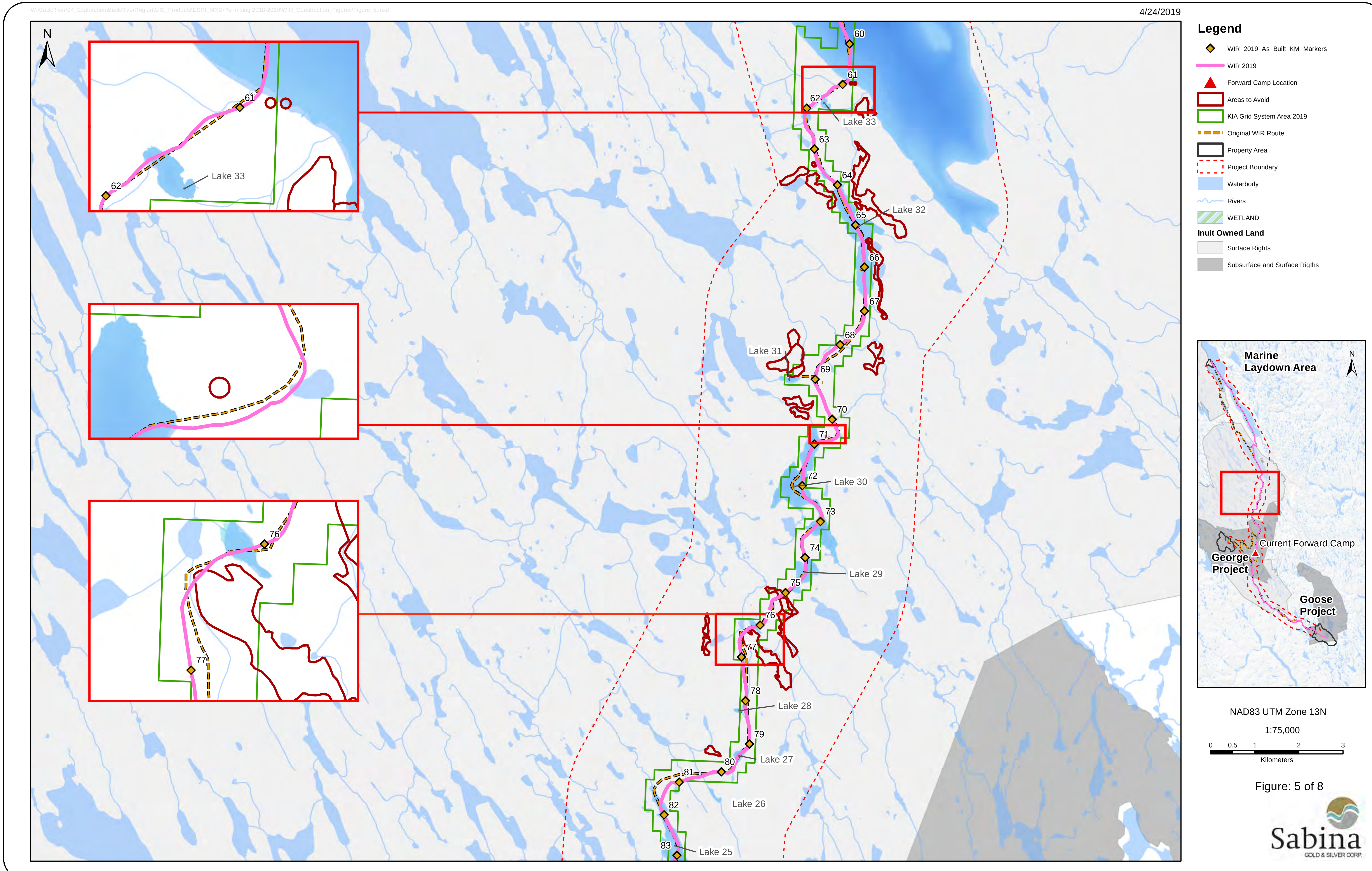

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Legend
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WIR 2019
Forward Camp Location
Areas to Avoid
KIA Grid System Area 2019
Original WIR Route
Property Area
Project Boundary
Waterbody
Rivers
WETLAND
Inuit Owned Land
Surface Rights
Subsurface and Surface Rigths
Marine Laydown Area
Current Forward Camp
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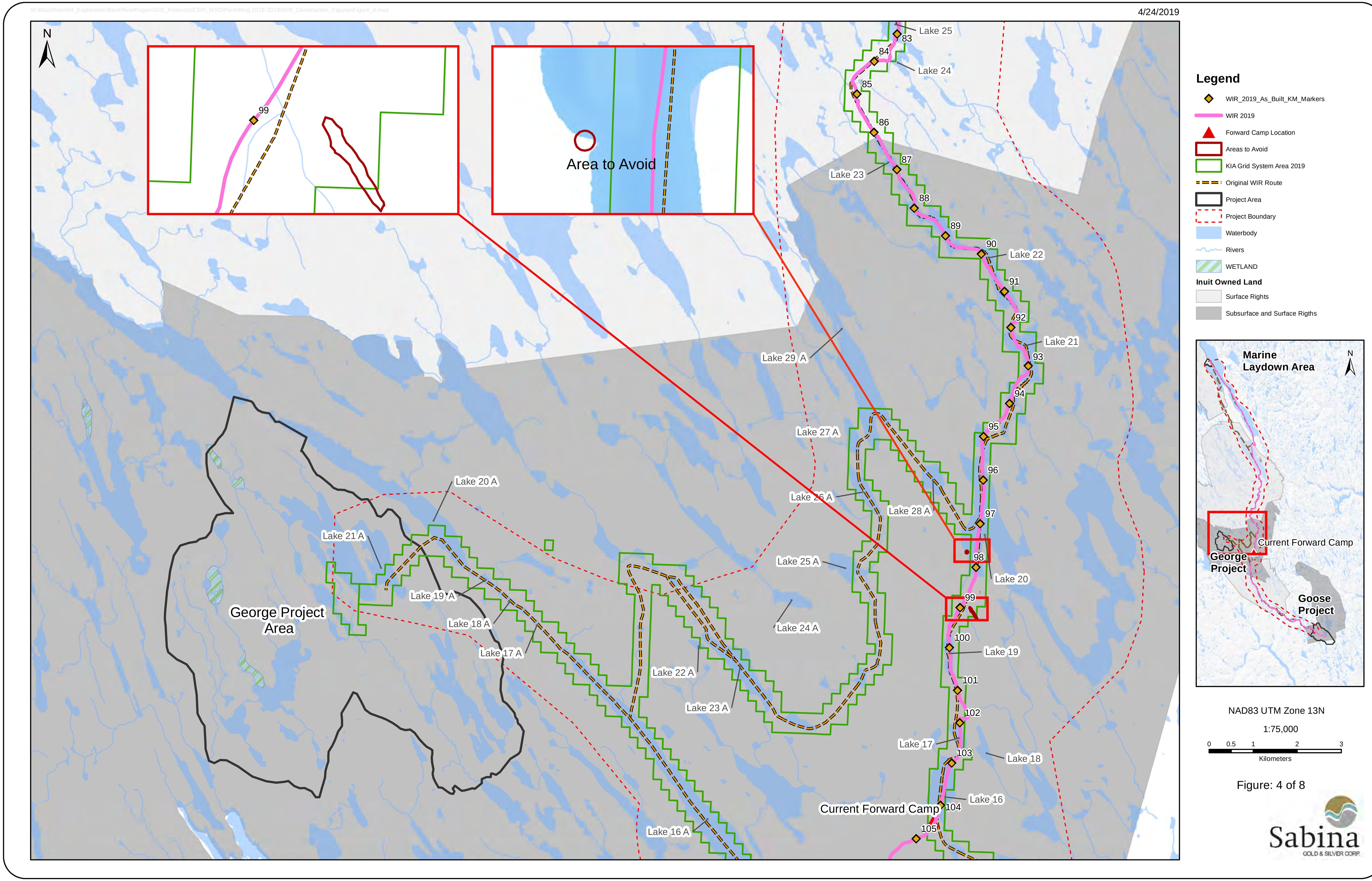
Sabina
GOLD & SILVER CORP.



4/24/2019
N
Area to Avoid
99
Legend
WIR_2019_As_Built_KM_Markers
WIR 2019
Forward Camp Location
Areas to Avoid
KIA Grid System Area 2019
Original WIR Route
Project Area
Project Boundary
Waterbody
Rivers
WETLAND
Inuit Owned Land
Surface Rights
Subsurface and Surface Rigths
Marine Laydown Area
Current Forward Camp
George Project
Goose Project
NAD83 UTM Zone 13N
1:75,000
0 0.5 1 2 3
Kilometers
Figure: 4 of 8
Sabina
GOLD & SILVER CORP.
Lake 25
Lake 24
Lake 23
Lake 22
Lake 21
Lake 20
Lake 19
Lake 18
Lake 17
Lake 16
Lake 29 A
Lake 27 A
Lake 26 A
Lake 28 A
Lake 25 A
Lake 24 A
Lake 23 A
Lake 22 A
Lake 21 A
Lake 20 A
Lake 19 A
Lake 18 A
Lake 17 A
Lake 16 A
George Project Area
Current Forward Camp
83
84
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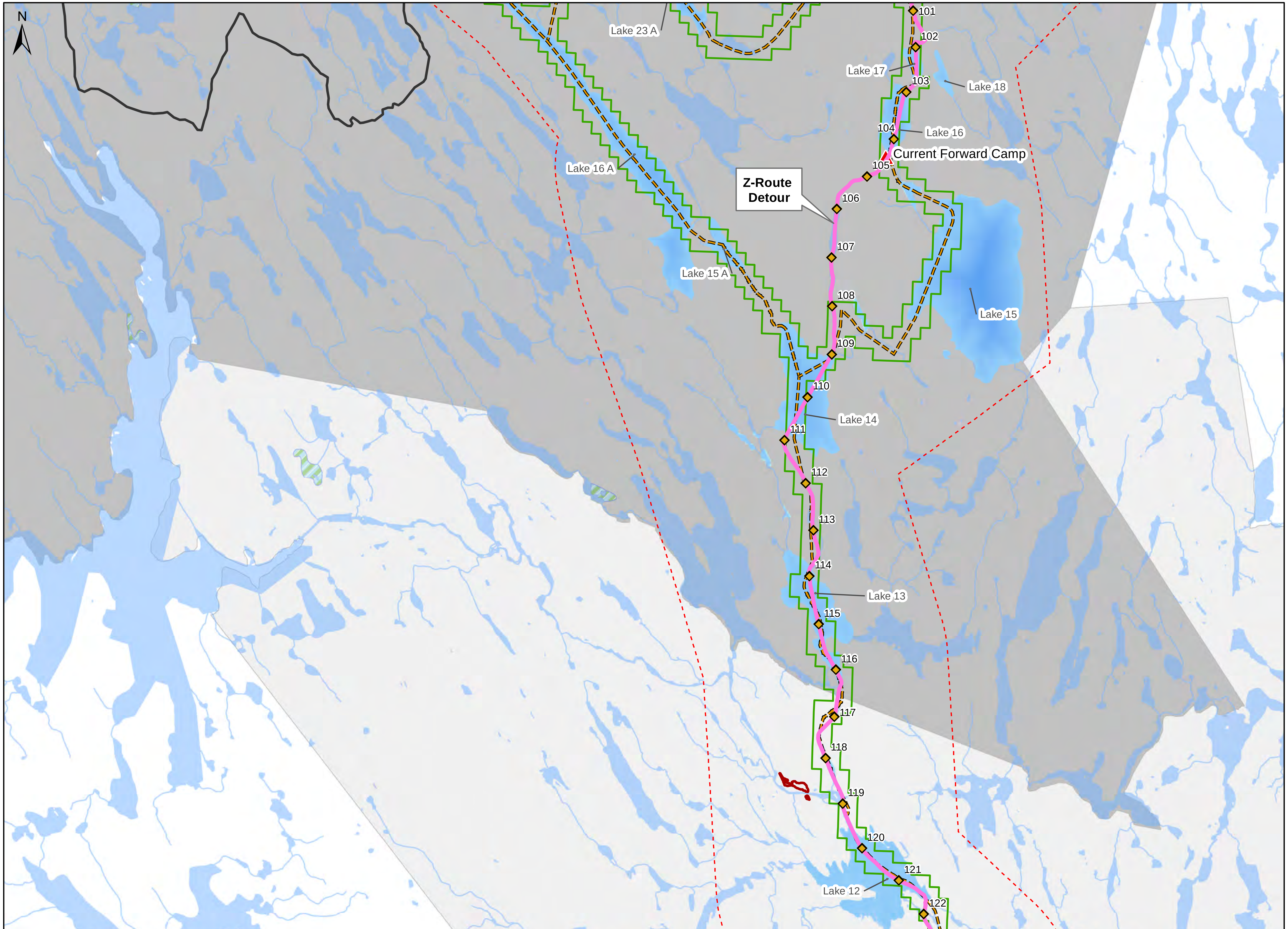
4/24/2019

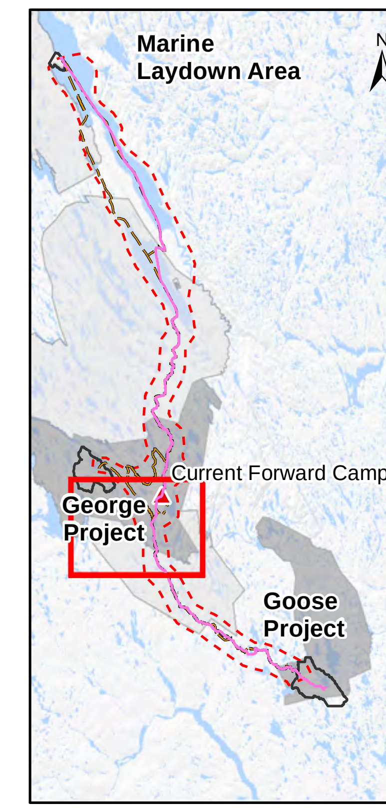


Legend

- WIR_2019_As_Built_KM_Markers
- WIR 2019
- Forward Camp Location
- Areas to Avoid
- KIA Grid System Area 2019
- Original WIR Route
- Project Area
- Project Boundary
- Waterbody
- Rivers
- WETLAND

Inuit Owned Land

- Surface Rights
- Subsurface and Surface Rigths



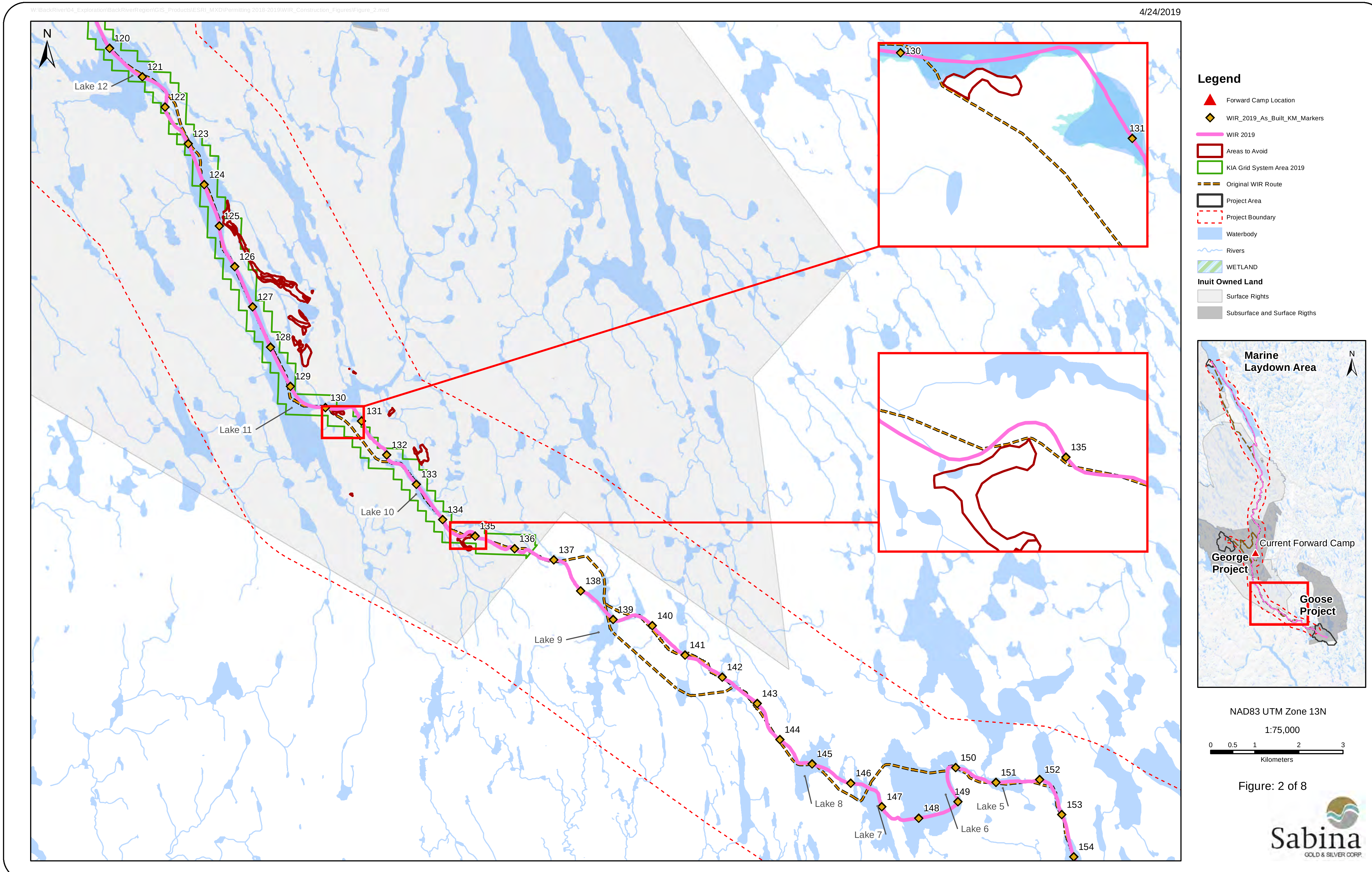
NAD83 UTM Zone 13N

1:75,000

0 0.5 1 2 3
Kilometers

Figure: 3 of 8

Sabina GOLD & SILVER CORP.


4/24/2019
N
Lake 12
Lake 11
Lake 10
Lake 9
Lake 8
Lake 7
Lake 6
Lake 5
120
121
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123
124
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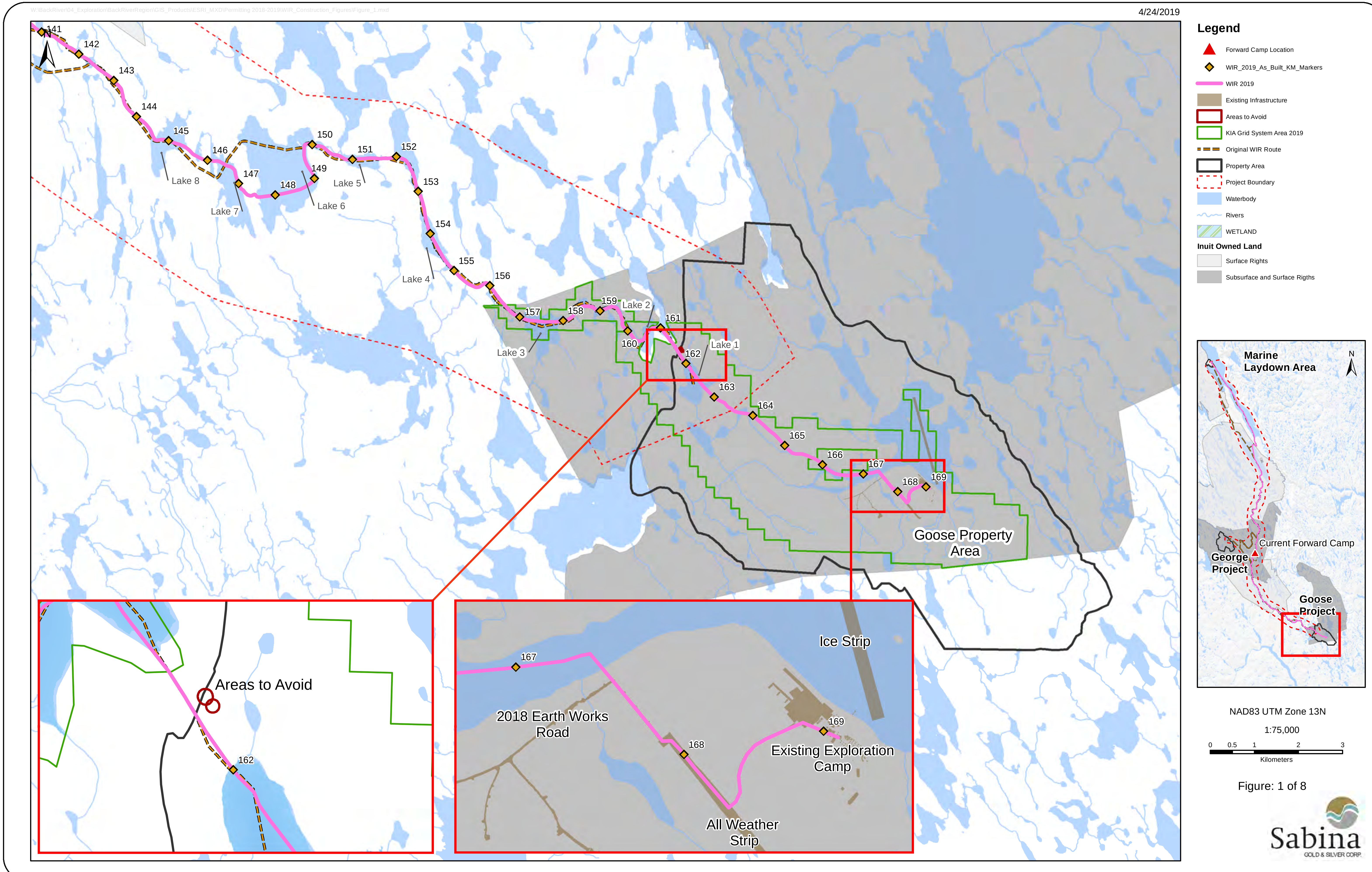
154
Legend
Forward Camp Location
WIR_2019_As_Built_KM_Markers
WIR 2019
Areas to Avoid
KIA Grid System Area 2019
Original WIR Route
Project Area
Project Boundary
Waterbody
Rivers
WETLAND
Inuit Owned Land
Surface Rights
Subsurface and Surface Rigths
Marine Laydown Area
Current Forward Camp
George Project
Goose Project
NAD83 UTM Zone 13N
1:75,000
0 0.5 1 2 3
Kilometers
Figure: 2 of 8
Sabina
GOLD & SILVER CORP.



4/24/2019
Legend
Forward Camp Location
WIR_2019_As_Built_KM_Markers
WIR 2019
Existing Infrastructure
Areas to Avoid
KIA Grid System Area 2019
Original WIR Route
Property Area
Project Boundary
Waterbody
Rivers
WETLAND
Inuit Owned Land
Surface Rights
Subsurface and Surface Rigths
141
142
143
144
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159
160
161
162
163
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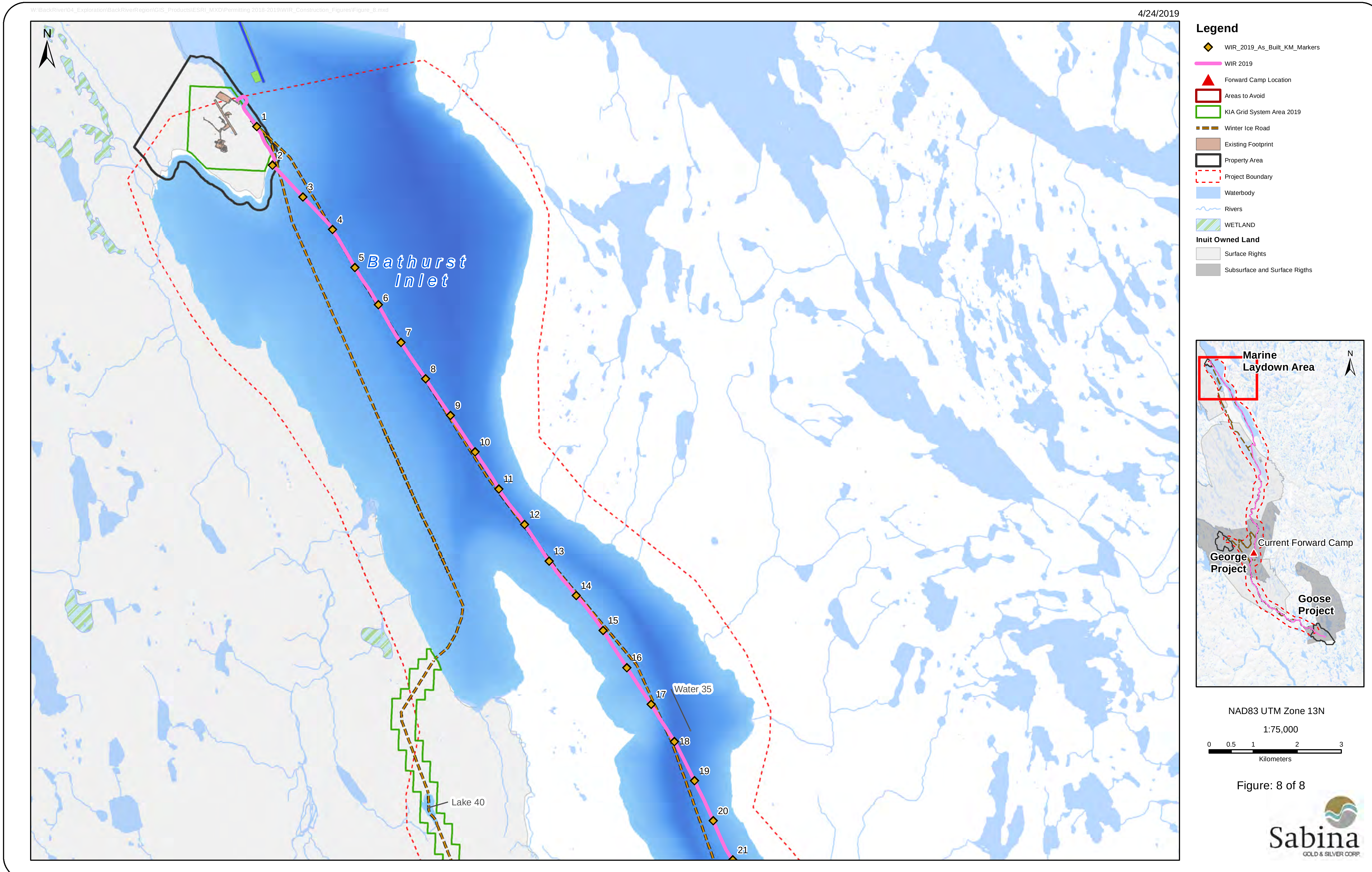
167
168
169
Lake 8
Lake 7
Lake 6
Lake 5
Lake 4
Lake 3
Lake 2
Lake 1
Goose Property Area
Areas to Avoid
Ice Strip
2018 Earth Works Road
Existing Exploration Camp
All Weather Strip
Marine Laydown Area
Current Forward Camp
George Project
Goose Project
N
NAD83 UTM Zone 13N
1:75,000
0 0.5 1 2 3
Kilometers
Figure: 1 of 8
Sabina
GOLD & SILVER CORP.



4/24/2019
N
Bathurst Inlet
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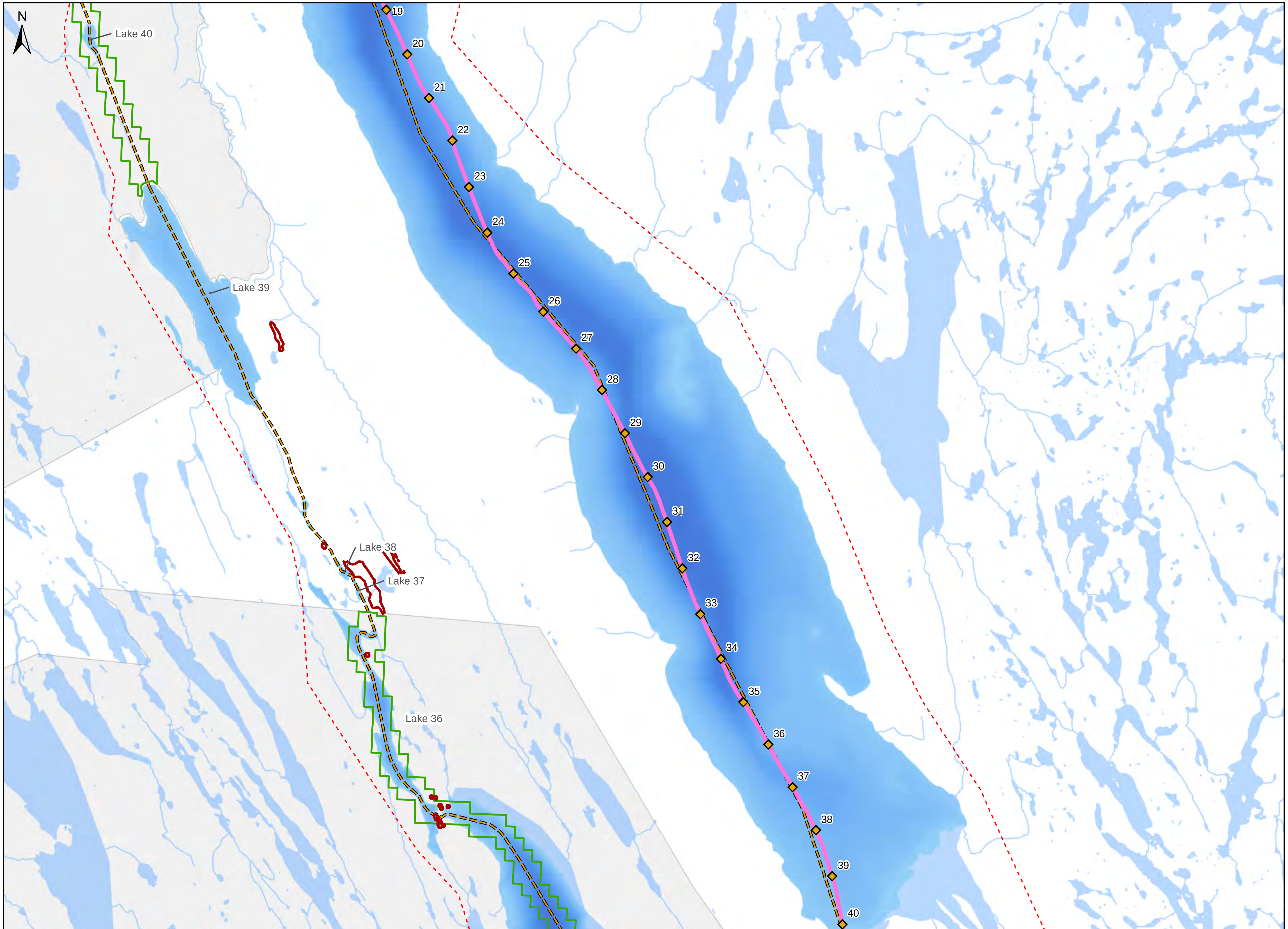
11
12
13
14
15
16
17
18
19
20
21
Water 35
Lake 40
Legend
WIR_2019_As_Built_KM_Markers
WIR 2019
Forward Camp Location
Areas to Avoid
KIA Grid System Area 2019
Winter Ice Road
Existing Footprint
Property Area
Project Boundary
Waterbody
Rivers
WETLAND
Inuit Owned Land
Surface Rights
Subsurface and Surface Rigths
Marine Laydown Area
Current Forward Camp
George Project
Goose Project
NAD83 UTM Zone 13N
1:75,000
0 0.5 1 2 3
Kilometers
Figure: 8 of 8
Sabina
GOLD & SILVER CORP.

4/24/2019

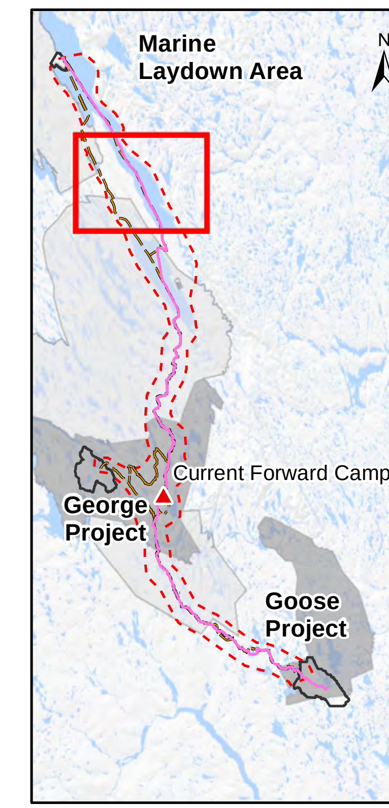


Legend

- Forward Camp Location
- WIR_2019_As_Built_KM_Markers
- WIR 2019
- Areas to Avoid
- KIA Grid System Area 2019
- Original WIR Route
- Property Area
- Project Boundary
- Waterbody
- Rivers
- WETLAND

Inuit Owned Land

- Surface Rights
- Subsurface and Surface Rigths



NAD83 UTM Zone 13N

1:75,000

0 0.5 1 2 3
Kilometers

Figure: 7 of 8

Sabina
GOLD & SILVER CORP.

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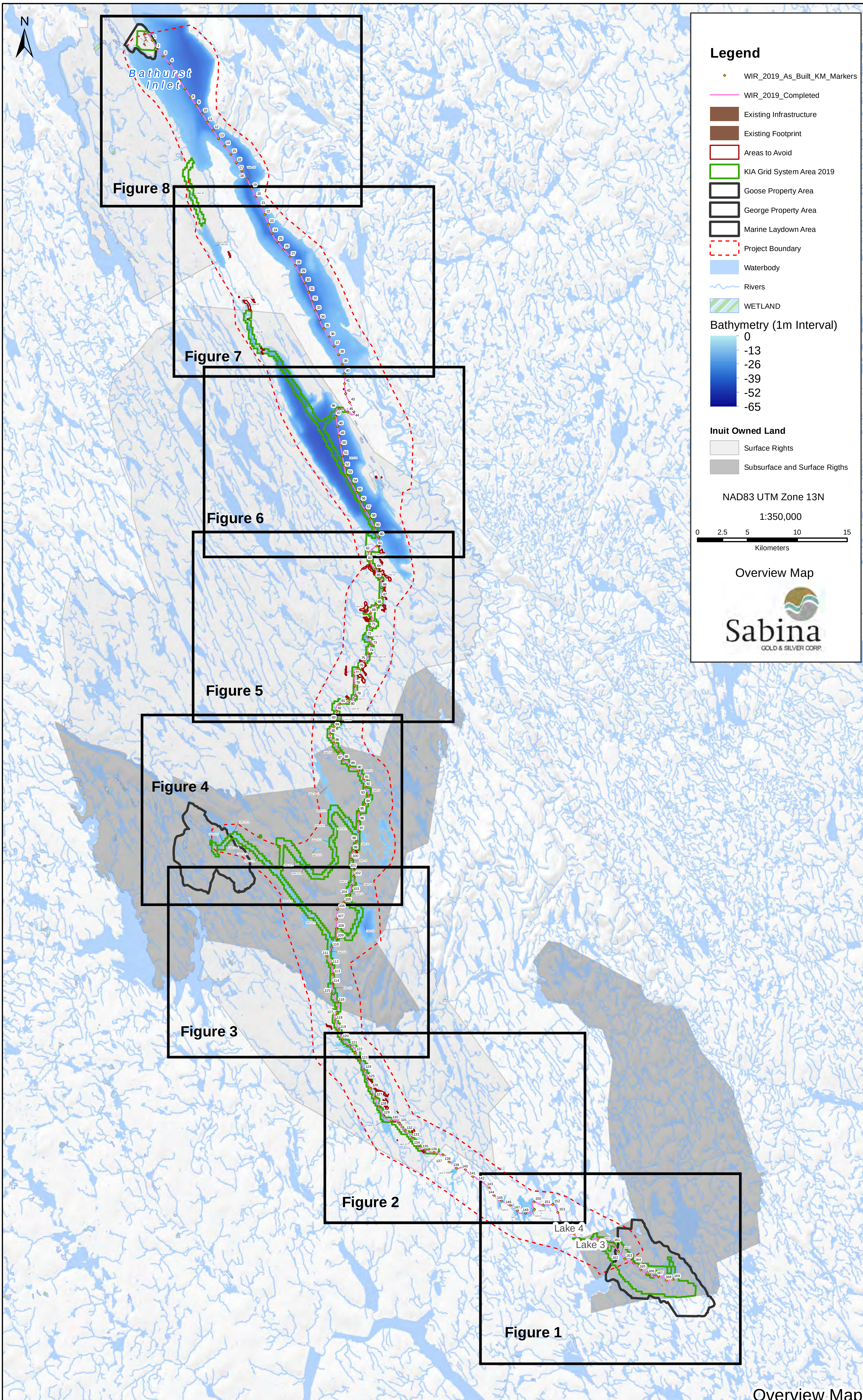

Appendix D Waste Disposal

Table 1. Incinerator and Open Burning Waste Disposal Quantities

Date	Load #	Time	Personnel	Food	Human Waste	Cardboard	Miscelaneous - M	Total Weight	How much was burned	Ash Weight
				lbs	lbs	lbs	lbs	lbs	%	lbs
1-Apr-19								0		89
2-Apr-19	1	13:10	JK	42	31	9		84		
3-Apr-19	1	13:30	JK	38	33	22		95		21
4-Apr-19	1	13:10	JK	75	62	21		160		
9-Apr-19	1		BB	80	40	5	10	136		
10-Apr-19	1		BB	74	31	1	80	187		
11-Apr-19	1		BB	108	51	2	180	342		50
	2		BB	110		4	23	139		
	3		BB	32			34	69		
	4		BB				61	65		
	5		BB				87	92		
12-Apr-19	1		BB	72	43	2	44	162		75
	2		BB	48	18		108	176		
13-Apr-19	1		BB	118	81	14	109	323		70
	2		BB	40				42		
14-Apr-19	1		BB	100	82	7	400	590		30
	2		BB	17		1	40	60		
	3		BB	12			90	105		
15-Apr-19	1		BB	96	88	1	2	188		
	2		BB	18		7		27		
16-Apr-19	1		BB	84	63	4	23	175		10
	2		BB	44				46		
	3		BB	18				21		
17-Apr-19	1		BB	11	50	1	800	863		0
	2		BB	91		2	41	136		
	3		BB	36		3	210	252		
18-Apr-19	1		BB	92	86	4	37	220		0
	2		BB	60		1	30	93		
	3		BB	120			58	181		
	4		BB	25			12	41		
	5		BB				40	45		
19-Apr-19	1		BB	92	81	1	40	215		140
	2		BB	31			40	73		
20-Apr-19	1		BB	31	80	1	120	233		111
	2		BB	27		4	31	64		
	3		BB				90	93		
	4		BB				2	6		
21-Apr-19	1		BB	12	86	2	31	132		28
	2		BB	61		1	14	78		
	3		BB	19				22		
	4		BB	55				59		
22-Apr-19	1		BB	178	108	2	20	309		45
	2		BB	17				19		
23-Apr-19	1		BB	136	100	3	58	298		15
24-Apr-19	1		BB	131	109	17	88	346		35
	2		BB	40				42		
25-Apr-19	1		BB	180	100	11	37	329		48
26-Apr-19	1		BB	113	91	11	41	257		0
	2		BB				40	42		
27-Apr-19	1		BB	181	93	15	165	455		55

	2		BB				27	29		
	3		BB				120	123		
	4		BB				41	45		
28-Apr-19	1		BB	126	21	2	35	185		0
	2		BB	80	38	11	120	251		
	3		BB	21			77	101		
29-Apr-19	1		BB	87	34	20	9	151		60
	2		BB	51	18	2	30	103		
	3		BB	33	17	7	45	105		
	4		BB		12		43	59		
30-Apr-19	1		BB	90	63	13	21	188		55
	2		BB				40	42		
	3		BB				14	17		
	4		BB				800	804		
	5		BB				160	165		
1-May-19	1		BB	56	104	1	140	302		0
	2		BB	68	21		29	120		
	3		BB				330	333		
2-May-19	1		BB	137	94	17	27	276		140
	2		BB	47	31		12	92		
3-May-19	1		BB	128	87	14	160	390		0
	2		BB	40			130	172		
	3		BB	40				43		
	4		BB	31				35		
4-May-19	1		BB	141	87	3	80	312		100
	2		BB	27			38	67		
	3		BB				37	40		
	4		BB				41	45		
	5		BB				9	14		
5-May-19	1		BB	108	99	7	3	218		120
	2		BB				500	502		
6-May-19	1		BB	40	76	1	5	123		45
	2		BB	87	43		21	153		
	3		BB				65	68		
	4		BB				19	23		
	5		BB				15	20		
	6		BB				200	206		
7-May-19	1		BB	128	87	1	40	257		60
	2		BB	11			40	53		
	3		BB				40	43		
	4		BB				5	9		
8-May-19	1		JK	11	20		82	114		128
	2		JK		153		77	232		
9-May-19	1		JK	109	69	7	44	230		24
10-May-19	1		JK	98	72	14	38	223		
	2		JK		26	32		60		
	3		JK				42	45		88
								0		
11-May-19	1		JK	110	82	9	49	251		
	2		JK	89		14	38	143		
	3		JK	48		16		67		
12-May-19	1		JK	135	102	12	42	292		61
	2		JK	42		11	34	89		
13-May-19	1		JK	154	79	6	44	284		
	2		JK			21		23		
	3		JK	32			38	73		52
14-May-19	1		JK	122	105	12	38	278		
	2		JK	25		6		33		

15-May-19	1		BB	118	87	31	28	265		0
	2		BB	60				62		
16-May-19	1		BB	128	91	11	300	531		0
17-May-19	1		BB	98	64	20	28	211		110
	2		BB				39	41		
	3		BB				50	53		
	4		BB				41	45		
18-May-19	1		BB	121	78	27	43	270		
	2		BB				17	19		
19-May-19	1		BB	119	78	17	135	350		45
	2		BB	120	9		41	172		
	3		BB	11			50	64		
	4		BB	35			60	99		
20-May-19	1		BB	43	68	1	80	193		
	2		BB	120				122		
	3		BB	18				21		
	4		BB	37				41		
21-May-19	1		BB	23	69	3	1	97		
	2		BB	68	7		11	88		75
	3		BB	12			85	100		
	4		BB				44	48		
	5		BB				57	62		
22-May-19	1		BB	141	81	2	135	360		65
	2		BB				20	22		
23-May-19	1		BB	134	80	2	110	327		40
	2		BB	12		9	15	38		
	3		BB				7	10		
	4		BB				36	40		
24-May-19	1		BB	118	51	17	107	294		45
	2		BB				11	13		
25-May-19	1		BB	135	81	4	190	411		60
	2		BB	27		4	90	123		
	3		BB	18			90	111		
	4		BB				12	16		
26-May-19	1		BB	120	72	4	63	260		0
	2		BB	98			47	147		
	3		BB				14	17		
	4		BB				52	56		
27-May-19	1		BB	94	79	11	135	320		0
	2		BB	120			40	162		
28-May-19	1		BB	133	72	11	163	380		70
	2		BB	21	31	4	44	102		
	3		BB	17			7	27		
	4		BB	20				24		
29-May-19	1		BB	81	64	5	72	223		85
	2		BB	52			49	103		
	3		BB				30	33		
30-May-19	1		BB	63	58	4	11	137		0
	2		BB	44	27		60	133		
	3		BB	44			38	85		
	4		BB	12			17	33		
	5		BB	40			21	66		
	6		BB	36				42		
31-May-19	1		BB	84	41	11	88	225		75
	2		BB		17		40	59		
	3		BB				25	28		
2-Jun-19	1		BB	70	94	11	88	264		20
	2		BB	240		3	47	292		

	3		BB	40			41	84		
3-Jun-19	1		BB	113	76	1	61	252		30
	2		BB				190	192		
4-Jun-19	1		BB	108	71	14	103	297		52
	2		BB	9			31	42		
	3		BB	28			81	112		
5-Jun-19	1		BB	81	64	1	107	254		45
	2		BB	4			33	39		
	3		BB				90	93		
	4		BB				31	35		
6-Jun-19	1		BB	54	58	2	230	345		45
	2		BB	30		4	27	63		
	3		BB				60	63		
	4		BB				15	19		
	5		BB				15	20		
	6		BB				40	46		
	7		BB				72	79		
7-Jun-19	1		BB	145	24	3	200	373		95
	2		BB	130			40	172		
	3		BB	70			80	153		
	4		BB				60	64		
8-Jun-19	1		BB	45	30		30	106		25
17-Jul-19	1		RD	80	75		50	206		
19-Jul-19	1		RD	100	25		78	204		40
21-Jul-19	1		RD	155	110	27	65	358		
22-Jul-19	1		RD	145	120	15	65	346		53
24-Jul-19	1		JW	95	75		45	216		
25-Jul-19	1		JW	70	95	15	25	206		42
27-Jul-19	1		JW	95	70	15	35	216		
5-Aug-19	1		JW	400				401		
6-Aug-19	1		JW	400				401		
7-Aug-19	1		JW	200				201		

Table 2. Waste Quantities Shipped Off Site to KBL Environmental

Date Received	Waste Stream	Waste Cla	Waste Type	UN#	Quantity
11/02/2019	BATTERIES-LEAD ACID	HAZ	D	2794	1.00
	NON REGULATED SOLIDS-INCINERATOR ASH	NONHAZ	D	NRS	4.00
01/03/2019	NON REGULATED SOLIDS-INCINERATOR ASH	NONHAZ	D	NRS	8.00
19/03/2019	BATTERIES-LEAD ACID	HAZ	D	2794	1.00
	NON REGUALTED SOLIDS - HYDRAULIC HOSES	NONHAZ	D	NRS	1.00
	NON REGULATED SOLIDS-INCINERATOR ASH	NONHAZ	D	NRS	4.00
	NON REGULATED SOLIDS-OIL/FUEL FILTERS	NONHAZ	D	NRS	1.00
03/04/2019	NON REGULATED SOLIDS-INCINERATOR ASH	NONHAZ	D	NRS	5.00
25/04/2019	NON REGULATED SOLIDS-INCINERATOR ASH	NONHAZ	D	NRS	11.00
21/05/2019	AEROSOLS PROCESSABLE	HAZ	D	1950	1.00
	BATTERIES-LEAD ACID	HAZ	E	2794	7.00
	NON REGULATED SOLIDS-GENERAL DEBRIS	NONHAZ	D	NRS	1.00
	NON REGULATED SOLIDS-INCINERATOR ASH	NONHAZ	D	NRS	6.00
	NON REGULATED SOLIDS-OIL/FUEL FILTERS	NONHAZ	D	NRS	1.00
	NON REGULATED SOLIDS-RAGS AND ABSORBENTS	NONHAZ	D	NRS	2.00
11/06/2019	NON REGULATED SOLIDS - CRUSHED OIL FILTERS	NONHAZ	D	NRS	1.00
	NON REGULATED SOLIDS-CALCIUM CHLORIDE	NONHAZ	D	NRS	1.00
	NON REGULATED SOLIDS-INCINERATOR ASH	NONHAZ	D	NRS	5.00
03/07/2019	NON REGULATED SOLIDS WHITE GOODS FREON (DEEP FREEZE)	NONHAZ	E	NRS	1.00
	NON REGULATED SOLIDS-SCRAP METAL(DELTA MOTORS)	NONHAZ	KG	NRS	3.00
08/07/2019	COMPRESSED GAS - FIRE EXTINGUISHERS	HAZ	E	1044	2.00
	NON REGULATED SOLIDS-GENERAL DEBRIS	NONHAZ	M	NRS	2.00
	NON REGULATED SOLIDS-PAPER FILTERS	NONHAZ	M	NRS	1.00
	NON REGULATED SOLIDS-SCRAP METAL	NONHAZ	D	NRS	8.00
			KG	NRS	352.00
23/07/2019	NON REGULATED SOLIDS-EMPTY DRUMS	NONHAZ	D	NRS	6.00
	NON REGULATED SOLIDS-GENERAL DEBRIS	NONHAZ	M	NRS	1.00
	NON REGULATED SOLIDS-SCRAP METAL	NONHAZ	D	NRS	2.00
25/07/2019	NON REGULATED SOLIDS-GENERAL DEBRIS(DOOR/WATER COOLER)	NONHAZ	M	NRS	1.00
	SOIL CONTAMINATED WITH HYDROCARBONS	NONHAZ	M	NRS	1.00
	TIRES	NONHAZ	E	NRS	1.00
14/08/2019	TREADMILL	NONHAZ	KG	NRS	1.00
20/08/2019	SOIL CONTAMINATED WITH HYDROCARBONS	NONHAZ	D	NRS	8.00
04/09/2019	NON REGULATED SOLIDS-SCRAP METAL	NONHAZ	D	NRS	4.00
	SOIL CONTAMINATED WITH HYDROCARBONS	NONHAZ	D	NRS	4.00
			P	NRS	4.00
	WATER CONTAMINATED WITH HYDROCARBONS	NONHAZ	D	NRL	6.00
06/09/2019	BATTERIES-LEAD ACID	HAZ	E	2794	18.00

Appendix E Monitoring Activity Overview by Station

Appendix E. 2019 Monitoring Activity Overview by Station

Monitoring Program Station	Monitoring Type	Description	Mine Phase	Group Code*	Frequency	Monitoring Activity
BRP-G-01 to BRP-G-TBD	Regulated Monitoring	**General Site Runoff** Surficial runoff anywhere at both Goose Property and MLA, including quarries; monitoring for erosion and sedimentation.	Construction	C	Weekly if flow enters a waterbody	No flow entering a waterbody was observed in 2019
BRP-S-01 to BRP-S-TBD	General Monitoring	**General Seeps** Seepage or runoff from excavated and/or stockpiled material anywhere at both Goose Property and MLA, including quarries, that does not gather into a collection system or the site is reclaimed.	Construction and Operations	A, D	Monthly during flow, or as found	No seepage was observed in 2019
BRP-01	Regulated Monitoring	**Goose Lake Discharge** (discharge point for release of dewatering effluent with or without treatment)	Construction	A, B, G	Weekly during dewatering	N/A – dewatering activities have not been initiated
				D	Four times during dewatering, at the same time as the weekly samples	
				H	Once per month during dewatering, at the same time as Group D	
				I	One time during dewatering, at the same time as Group D	
BRP-02	General Monitoring	**Llama Lake** (intake point for dewatering, triggers need for treatment prior to discharge at BRP-01)	Construction	C (TSS only)	Weekly if treatment is required; no sample if treatment is not required	N/A – dewatering activities have not been initiated
BRP-03	Verification Monitoring	**Llama Pit** (representative of collected pit water prior to transfer to tailings management facility)	Operations Stage 1 to Operations Stage 2	A, G	At Licensee's discretion	N/A – facility construction has not been initiated/ n/a mine phase
BRP-04	General Monitoring	**Llama Pit Lake** (representative of flooded pit during flooding and before overflow to the downstream environment)	Closure* to Post-Closure	A, D	Twice per year	N/A – facility construction has not been initiated/ n/a mine phase
BRP-05	Verification Monitoring	**Llama WRSA Pond** (representative of collected water quality)	Operations Stage 1 to Closure	A, G	At Licensee's discretion	N/A – facility construction has not been initiated/ n/a mine phase
BRP-06	General Monitoring	**Umwelt Lake** (intake point for dewatering, triggers need for treatment prior to discharge at BRP-01)	Construction	C (TSS only)	Weekly if treatment is required; no sample if treatment is not required	N/A – dewatering activities have not been initiated
BRP-07	Verification Monitoring	**Umwelt Pit** (representative of collected pit water prior to transfer to tailings management facility)	Construction to Operations Stage 2	A, G	At Licensee's discretion	N/A – facility construction has not been initiated
BRP-08	General Monitoring	**Umwelt Pit Lake** (representative of flooded pit during flooding and before overflow to the downstream environment)	Closure to Post-Closure	A, D	Twice per year	N/A – facility construction has not been initiated/ n/a mine phase

BRP-09	Verification Monitoring	**Umwelt WRSA Pond** (representative of collected water quality, including landfill seepage/runoff)	Construction to Closure (early)*	A, G	At Licensee's discretion	N/A – facility construction has not been initiated
BRP-10	Verification Monitoring	**Primary Water Pond** (representative of collected water quality)	Construction to Closure (early)	A, D	At Licensee's discretion	N/A – facility construction has not been initiated
BRP-11	Verification Monitoring	**Saline Water Pond** (representative of stored water quality)	Construction (late) to Closure (early)	A, D	At Licensee's discretion	N/A – facility construction has not been initiated
BRP-12	General Monitoring	**Big Lake Intake** (intake point for potable and industrial water withdrawal)	Construction to Closure	A, D B	Four times per year Weekly	N/A – facility construction has not been initiated
BRP-13	Verification Monitoring	**Ore Stockpile Pond** (representative of collected water quality)	Construction to Closure (early)	A, D	At Licensee's discretion	N/A – facility construction has not been initiated
BRP-14	Verification Monitoring	**ANFO Plant** (representative of collected water quality)	Construction to Closure	A, E	At Licensee's discretion	N/A – facility construction has not been initiated
BRP-15	Regulated Monitoring	**Goose Fuel Tank Farm** (representative of collected water quality)	Construction to Closure	A, E	Prior to discharge or transfer of water	N/A – facility construction has not been initiated
BRP-16	Regulated Monitoring	**Goose Hazardous Waste Management Area** (representative of collected water quality)	Construction to Closure	A, E	Prior to discharge or transfer of water	N/A – facility construction has not been initiated
BRP-17	Regulated Monitoring	**Goose Property Sewage Treatment Plant** (discharge point for treated sewage onto land)	Construction to Closure	A, F	Prior to discharge	N/A – facility construction has not been initiated
BRP-17A	Regulated Monitoring	**Goose Property Sewage Treatment Plant** (discharge point for treated sewage into Tailings Storage Facility or Tailing Facility)	Construction to Closure*	A, F	Prior to discharge	N/A – facility construction has not been initiated
BRP-18	General Monitoring	**Llama Watershed Outflow** (representative of non-contact water, PN04 from Water and Load Balance)	Operations Stage 1 to Closure	A, D	Once during freshet	N/A mine phase
BRP-19	General Monitoring	**Echo Outflow** (representative of non-contact water). PN09 from water and load balance	Operations Stage 1 to Closure	A, D	Once during freshet	N/A mine phase
BRP-20	Verification Monitoring	**Echo Pit** (representative of collected pit water prior to transfer to tailings management facility)	Operations Stage 2	A, G	At Licensee's discretion	N/A – facility construction has not been initiated/ n/a mine phase
BRP-21	General Monitoring	**Echo Pit Lake** (representative of flooded pit during flooding and before overflow to the downstream environment)	Closure to Post-Closure	A, D	Twice per year	N/A – facility construction has not been initiated/ n/a mine phase
BRP-22	Verification Monitoring	**Echo WRSA Pond** (representative of collected water quality)	Operations Stage 2 to Closure (early)	A, G	At Licensee's discretion	N/A – facility construction has not been initiated/ n/a mine phase
BRP-23	General Monitoring	**Gander Pond Outflow** (representative of non-contact water, PN07 from Water and Load Balance)	Operations Stage 1 to Closure	A, D	Once during freshet	N/A mine phase

BRP-24	General Monitoring	**Goose Lake Intake** (intake point for potable and industrial water withdrawal)	Operations Stage 1 to Closure (early)	B	Weekly	N/A- no water withdrawn under this Licence in 2019
BRP-25	Verification Monitoring	**Goose Pit** (representative of collected pit water prior to transfer to tailings management facility)	Operations Stage 1 to Operations Stage 2	A, G	At Licensee's discretion	N/A – facility construction has not been initiated/ n/a mine phase
BRP-26	General Monitoring	**Goose Pit Lake** (representative of flooded pit during flooding and before overflow to the downstream environment)	Closure* to Post-Closure	A, D	Twice per year	N/A – facility construction has not been initiated/ n/a mine phase
BRP-27	Verification Monitoring	**Goose Main Tailings Facility** (intake point for water treatment, represents pre-treatment water quality)	Operations Stage 3 to Closure	A, G	At Licensee's discretion	N/A – facility construction has not been initiated/ n/a mine phase
BRP-28	Verification Monitoring	**Goose Main Tailings Facility** (discharge point for water treatment, represents post-treatment water quality)	Operations Stage 3 to Closure	A, G	At Licensee's discretion	N/A – facility construction has not been initiated/ n/a mine phase
BRP-29	Verification Monitoring	**TSF WRSA Pond** (representative of collected water quality, including landfill seepage/runoff)	Operations Stage 1 to Closure	A, G	At Licensee's discretion	N/A – facility construction has not been initiated/ n/a mine phase
BRP-30	General Monitoring	**Goose Southeast Inflow** (representative of non-contact water, PN06 from Water and Load Balance)	Operations Stage 1 to Closure	A, D	Once during freshet	N/A mine phase
BRP-40	General Monitoring	**Bathurst Inlet Intake** (intake point in marine environment for potable and industrial water withdrawal)	Construction to Closure	A, D, B	At Licensee's discretion	Water was withdrawn from this location in 2019 and is reported in the Annual Report for PC No 007
BRP-41	General Monitoring	**Bathurst Inlet Discharge** (discharge point in marine environment for effluent from desalinization plant)	Construction to Closure	A, J	At Licensee's discretion	Water quality results are provided in the Annual Report for PC No 007
BRP-42	Regulated Monitoring	**MLA Greywater** (discharge point for treated greywater onto land)	Construction to Closure	A, F	Prior to discharge or transfer of water	No greywater was discharged under this Licence in 2019
BRP-43	Regulated Monitoring	**MLA Fuel Tank Farm** (representative of collected water quality)	Construction to Closure	A, E	Prior to discharge or transfer of water	N/A – facility under construction
BRP-44	Regulated Monitoring	**MLA Landfarm** (representative of collected water quality)	Construction to Closure	A, E	Prior to discharge or transfer of water	N/A – facility construction has not been initiated
BRP-45	Regulated Monitoring	**MLA Hazardous Waste Management Area** (representative of collected water quality)	Construction to Closure	A, E	Prior to discharge or transfer of water	N/A – facility construction has not been initiated
BRP-49	Regulated Monitoring	**MLA Temporary Fuel Storage Facility** (representative of collected water quality)	Construction	A, E	Prior to discharge or transfer of water	Water was sampled prior to discharge. See Annual report
BRP-51	Regulated Monitoring	**Goose Landfarm** (representative of collected water quality)	Construction to Closure	A, E	Prior to discharge or transfer of water	N/A - no water was discharged from this facility this month
BRP-52	General Monitoring	**MLA Pond S1** (intake point for potable and industrial water withdrawal)	Construction to Closure	A, D	Once per quarter when in use	Water was withdrawn from this location in 2019. See Annual Report for Volumes
				B	Weekly when in use	
BRP-53	General	**MLA Pond S2** (intake point for potable and industrial	Construction to	A, D	Once per quarter when in use	Water was not withdrawn from this

BRP-53	Monitoring	for potable and industrial water withdrawal)	Closure	B	Weekly when in use	withdrawn from this location in 2019
BRP-54	General Monitoring	**MLA Lake 3** (intake point for potable and industrial water withdrawal)	Construction to Closure	A, D	Once per quarter when in use	Water was withdrawn from this location in 2019. See Annual Report for Volumes
				B	Weekly when in use	
BRP-55	General Monitoring	**MLA Lake 4** (intake point for potable and industrial water withdrawal)	Construction to Closure	A, D	Once per quarter when in use	Water was not withdrawn from this location in 2019
				B	Weekly when in use	
BRP-I-01 to BRP-I-TBD	General Monitoring	**Interconnection Winter Ice Road Proximal Water Bodies** (intake points for fresh water used in the construction of the Interconnection Winter Ice Road)	Construction to Closure	B	Weekly when in use	Water was withdrawn from these locations in 2019. See Annual Report for Volumes

* Refers to Group Code from Water Licence 2AM-BRP1831 Schedule I Table 1

Appendix F Water Quality Analytical Results

SABINA GOLD & SILVER CORP.
ATTN: Merle Keefe
Suite 1800 - 555 Burrard St.
Box 220
Vancouver BC V7X 1M7

Date Received: 04-JUL-19
Report Date: 15-JUL-19 16:12 (MT)
Version: FINAL

Client Phone: 604-240-6619

Certificate of Analysis

Lab Work Order #: L2304080
Project P.O. #: NOT SUBMITTED
Job Reference:
C of C Numbers:
Legal Site Desc:

Comments: ADDITIONAL 14-JUL-19 16:02

Oliver Gregg
Account Manager

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L2304080-1	L2304080-2	L2304080-3	L2304080-4	L2304080-5
	Description	SURFACE WATE	SURFACE WATE	SURFACE WATE	SURFACE WATE	SURFACE WATE
	Sampled Date					
	Sampled Time					
	Client ID	MLA FUEL BERM 1	MLA FUEL BERM 2	MLA FUEL BERM 3	MLA FUEL BERM 4	MLA FUEL BERM 5
Grouping	**Analyte**					
WATER						
Physical Tests	pH (pH)	6.17	6.36	5.77	6.51	5.75
	Total Suspended Solids (mg/L)	5.2	7.4	4.2	4.0	7.2
Anions and Nutrients	Ammonia, Total (as N) (mg/L)	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050
Total Metals	Aluminum (Al)-Total (mg/L)	1.03	1.74	0.157	0.228	1.72
	Antimony (Sb)-Total (mg/L)	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
	Arsenic (As)-Total (mg/L)	0.00022	0.00022	<0.00010	0.00031	0.00034
	Barium (Ba)-Total (mg/L)	0.0249	0.0286	0.0227	0.0217	0.0195
	Beryllium (Be)-Total (mg/L)	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
	Bismuth (Bi)-Total (mg/L)	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
	Boron (B)-Total (mg/L)	<0.010	0.014	<0.010	<0.010	0.013
	Cadmium (Cd)-Total (mg/L)	0.0000233	0.0000437	0.0000093	0.0000121	0.0000157
	Calcium (Ca)-Total (mg/L)	0.677	1.27	0.346	2.36	0.724
	Cesium (Cs)-Total (mg/L)	0.000047	0.000096	0.000015	0.000011	0.000104
	Chromium (Cr)-Total (mg/L)	0.00048	0.00075	0.00031	0.00019	0.00077
	Cobalt (Co)-Total (mg/L)	0.00016	0.00025	<0.00010	0.00024	0.00024
	Copper (Cu)-Total (mg/L)	0.00097	0.00133	0.00092	0.00111	0.00165
	Iron (Fe)-Total (mg/L)	0.230	0.385	0.096	0.237	0.347
	Lead (Pb)-Total (mg/L)	0.000134	0.000224	0.000134	0.000093	0.000282
	Lithium (Li)-Total (mg/L)	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
	Magnesium (Mg)-Total (mg/L)	0.730	1.33	0.199	1.81	0.819
	Manganese (Mn)-Total (mg/L)	0.0256	0.0412	0.0131	0.0998	0.0206
	Molybdenum (Mo)-Total (mg/L)	<0.000050	0.000050	0.000172	<0.000050	<0.000050
	Nickel (Ni)-Total (mg/L)	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
	Phosphorus (P)-Total (mg/L)	0.443	0.327	0.815	0.259	0.147
	Potassium (K)-Total (mg/L)	1.12	1.53	0.165	0.676	1.48
	Rubidium (Rb)-Total (mg/L)	0.00184	0.00268	0.00031	0.00050	0.00276
	Selenium (Se)-Total (mg/L)	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
	Silicon (Si)-Total (mg/L)	1.59	2.63	0.24	0.38	2.50
	Silver (Ag)-Total (mg/L)	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010
	Sodium (Na)-Total (mg/L)	4.59	7.77	0.238	9.41	5.04
	Strontium (Sr)-Total (mg/L)	0.00530	0.00779	0.00265	0.00842	0.00607
	Sulfur (S)-Total (mg/L)	<0.50	<0.50	<0.50	<0.50	<0.50
	Tellurium (Te)-Total (mg/L)	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020
	Thallium (Tl)-Total (mg/L)	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010
	Thorium (Th)-Total (mg/L)	0.00013	0.00025	<0.00010	<0.00010	0.00023
	Tin (Sn)-Total (mg/L)	<0.00010	<0.00010	<0.00010	0.00023	0.00016
	Titanium (Ti)-Total (mg/L)	0.00536	0.00924	0.00193	0.00148	0.00876

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

Grouping	Analyte			
	Sample ID	L2304080-6	L2304080-7	L2304080-8
	Description	SURFACE WATE	SURFACE WATE	SURFACE WATE
	Sampled Date			
	Sampled Time			
	Client ID	MLA FUEL BERM 6	MLA FUEL BERM 7	MLA FUEL BERM 8
WATER				
Physical Tests	pH (pH)	4.49	6.69	5.75
	Total Suspended Solids (mg/L)	<3.0	7.4	5.2
Anions and Nutrients	Ammonia, Total (as N) (mg/L)	<0.0050	<0.0050	<0.0050
Total Metals	Aluminum (Al)-Total (mg/L)	0.115	0.326	0.232
	Antimony (Sb)-Total (mg/L)	0.00016	<0.00010	<0.00010
	Arsenic (As)-Total (mg/L)	0.00042	0.00023	<0.00010
	Barium (Ba)-Total (mg/L)	0.0265	0.0144	0.0165
	Beryllium (Be)-Total (mg/L)	<0.00010	<0.00010	<0.00010
	Bismuth (Bi)-Total (mg/L)	<0.000050	<0.000050	<0.000050
	Boron (B)-Total (mg/L)	<0.010	<0.010	<0.010
	Cadmium (Cd)-Total (mg/L)	0.0000257	0.0000213	0.0000227
	Calcium (Ca)-Total (mg/L)	0.796	0.951	0.599
	Cesium (Cs)-Total (mg/L)	<0.000010	0.000033	0.000013
	Chromium (Cr)-Total (mg/L)	0.00044	0.00026	0.00026
	Cobalt (Co)-Total (mg/L)	0.00014	0.00017	0.00012
	Copper (Cu)-Total (mg/L)	0.00373	0.00085	0.00175
	Iron (Fe)-Total (mg/L)	0.108	0.183	0.099
	Lead (Pb)-Total (mg/L)	0.000175	0.000140	0.000067
	Lithium (Li)-Total (mg/L)	<0.0010	<0.0010	<0.0010
	Magnesium (Mg)-Total (mg/L)	0.794	0.866	0.687
	Manganese (Mn)-Total (mg/L)	0.0250	0.0374	0.0285
	Molybdenum (Mo)-Total (mg/L)	0.000052	0.000109	<0.000050
	Nickel (Ni)-Total (mg/L)	<0.00050	<0.00050	<0.00050
	Phosphorus (P)-Total (mg/L)	0.397	0.886	0.204
	Potassium (K)-Total (mg/L)	0.590	0.646	0.613
	Rubidium (Rb)-Total (mg/L)	0.00035	0.00087	0.00055
	Selenium (Se)-Total (mg/L)	<0.000050	<0.000050	<0.000050
	Silicon (Si)-Total (mg/L)	0.20	0.49	0.34
	Silver (Ag)-Total (mg/L)	<0.000010	<0.000010	<0.000010
	Sodium (Na)-Total (mg/L)	4.74	6.47	4.37
	Strontium (Sr)-Total (mg/L)	0.00611	0.00489	0.00411
	Sulfur (S)-Total (mg/L)	<0.50	<0.50	<0.50
	Tellurium (Te)-Total (mg/L)	<0.00020	<0.00020	<0.00020
	Thallium (Tl)-Total (mg/L)	<0.000010	<0.000010	<0.000010
	Thorium (Th)-Total (mg/L)	<0.00010	<0.00010	<0.00010
	Tin (Sn)-Total (mg/L)	0.00103	<0.00010	<0.00010
	Titanium (Ti)-Total (mg/L)	DLM <0.00060	0.00189	DLM <0.0015

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

Grouping	Analyte	L2304080-1	L2304080-2	L2304080-3	L2304080-4	L2304080-5
	Description	SURFACE WATE	SURFACE WATE	SURFACE WATE	SURFACE WATE	SURFACE WATE
	Sampled Date					
	Sampled Time					
	Client ID	MLA FUEL BERM 1	MLA FUEL BERM 2	MLA FUEL BERM 3	MLA FUEL BERM 4	MLA FUEL BERM 5
WATER						
Total Metals	Tungsten (W)-Total (mg/L)	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
	Uranium (U)-Total (mg/L)	0.000049	0.000108	0.000022	0.000016	0.000114
	Vanadium (V)-Total (mg/L)	0.00057	0.00083	<0.00050	<0.00050	0.00086
	Zinc (Zn)-Total (mg/L)	0.291	0.134	0.642	0.226	0.217
	Zirconium (Zr)-Total (mg/L)	0.00082	0.00146	<0.00020	0.00023	0.00157
Aggregate Organics	Oil and Grease (mg/L)	<5.0	<5.0	<5.0	<5.0	10.8
	Oil And Grease (Visible Sheen)	NO	No	No	No	No
Volatile Organic Compounds	Benzene (mg/L)	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
	Bromodichloromethane (mg/L)	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
	Bromoform (mg/L)	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
	Carbon Tetrachloride (mg/L)	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
	Chlorobenzene (mg/L)	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
	Dibromochloromethane (mg/L)	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
	Chloroethane (mg/L)	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
	Chloroform (mg/L)	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
	Chloromethane (mg/L)	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050
	1,2-Dichlorobenzene (mg/L)	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
	1,3-Dichlorobenzene (mg/L)	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
	1,4-Dichlorobenzene (mg/L)	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
	1,1-Dichloroethane (mg/L)	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
	1,2-Dichloroethane (mg/L)	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
	1,1-Dichloroethylene (mg/L)	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
	cis-1,2-Dichloroethylene (mg/L)	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
	trans-1,2-Dichloroethylene (mg/L)	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
	Dichloromethane (mg/L)	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050
	1,2-Dichloropropane (mg/L)	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
	cis-1,3-Dichloropropylene (mg/L)	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
	trans-1,3-Dichloropropylene (mg/L)	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
	1,3-Dichloropropene (cis & trans) (mg/L)	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
	Ethylbenzene (mg/L)	<0.00050	<0.00050	<0.00050	0.00070	<0.00050
	Methyl t-butyl ether (MTBE) (mg/L)	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
	Styrene (mg/L)	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
	1,1,1,2-Tetrachloroethane (mg/L)	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
	1,1,2,2-Tetrachloroethane (mg/L)	<0.00020	<0.00020	<0.00020	<0.00020	DLCI <0.00080
	Tetrachloroethylene (mg/L)	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
	Toluene (mg/L)	<0.00045	<0.00045	<0.00045	<0.00045	<0.00045

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L2304080-6	L2304080-7	L2304080-8		
	Description	SURFACE WATE	SURFACE WATE	SURFACE WATE		
	Sampled Date					
	Sampled Time					
	Client ID	MLA FUEL BERM 6	MLA FUEL BERM 7	MLA FUEL BERM 8		
Grouping	**Analyte**					
WATER						
Total Metals	Tungsten (W)-Total (mg/L)	<0.00010	<0.00010	<0.00010		
	Uranium (U)-Total (mg/L)	<0.000010	0.000043	0.000011		
	Vanadium (V)-Total (mg/L)	<0.00050	<0.00050	<0.00050		
	Zinc (Zn)-Total (mg/L)	0.454	0.190	0.212		
	Zirconium (Zr)-Total (mg/L)	<0.00020	0.00045	<0.00020		
Aggregate Organics	Oil and Grease (mg/L)	28.4	<5.0	<5.0		
	Oil And Grease (Visible Sheen)	Yes	No	Yes		
Volatile Organic Compounds	Benzene (mg/L)	<0.00050	<0.00050	<0.00050		
	Bromodichloromethane (mg/L)	<0.0010	<0.0010	<0.0010		
	Bromoform (mg/L)	<0.0010	<0.0010	<0.0010		
	Carbon Tetrachloride (mg/L)	<0.00050	<0.00050	<0.00050		
	Chlorobenzene (mg/L)	<0.0010	<0.0010	<0.0010		
	Dibromochloromethane (mg/L)	<0.0010	<0.0010	<0.0010		
	Chloroethane (mg/L)	<0.0010	<0.0010	<0.0010		
	Chloroform (mg/L)	<0.0010	<0.0010	<0.0010		
	Chloromethane (mg/L)	<0.0050	<0.0050	<0.0050		
	1,2-Dichlorobenzene (mg/L)	<0.00050	<0.00050	<0.00050		
	1,3-Dichlorobenzene (mg/L)	<0.0010	<0.0010	<0.0010		
	1,4-Dichlorobenzene (mg/L)	<0.0010	<0.0010	<0.0010		
	1,1-Dichloroethane (mg/L)	<0.0010	<0.0010	<0.0010		
	1,2-Dichloroethane (mg/L)	<0.0010	<0.0010	<0.0010		
	1,1-Dichloroethylene (mg/L)	<0.0010	<0.0010	<0.0010		
	cis-1,2-Dichloroethylene (mg/L)	<0.0010	<0.0010	<0.0010		
	trans-1,2-Dichloroethylene (mg/L)	<0.0010	<0.0010	<0.0010		
	Dichloromethane (mg/L)	<0.0050	<0.0050	<0.0050		
	1,2-Dichloropropane (mg/L)	<0.0010	<0.0010	<0.0010		
	cis-1,3-Dichloropropylene (mg/L)	<0.00050	<0.00050	<0.00050		
	trans-1,3-Dichloropropylene (mg/L)	<0.00050	<0.00050	<0.00050		
	1,3-Dichloropropene (cis & trans) (mg/L)	<0.0010	<0.0010	<0.0010		
	Ethylbenzene (mg/L)	<0.00050	<0.00050	<0.00050		
	Methyl t-butyl ether (MTBE) (mg/L)	<0.00050	<0.00050	<0.00050		
	Styrene (mg/L)	<0.00050	<0.00050	<0.00050		
	1,1,1,2-Tetrachloroethane (mg/L)	<0.0010	<0.0010	<0.0010		
	1,1,2,2-Tetrachloroethane (mg/L)	<0.0030 DLCI	<0.00020	<0.00020		
	Tetrachloroethylene (mg/L)	<0.0010	<0.0010	<0.0010		
	Toluene (mg/L)	<0.00045	<0.00045	<0.00045		

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L2304080-1	L2304080-2	L2304080-3	L2304080-4	L2304080-5
	Description	SURFACE WATE	SURFACE WATE	SURFACE WATE	SURFACE WATE	SURFACE WATE
	Sampled Date					
	Sampled Time					
	Client ID	MLA FUEL BERM 1	MLA FUEL BERM 2	MLA FUEL BERM 3	MLA FUEL BERM 4	MLA FUEL BERM 5
Grouping	**Analyte**					
WATER						
Volatile Organic Compounds	1,1,1-Trichloroethane (mg/L)	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
	1,1,2-Trichloroethane (mg/L)	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
	Trichloroethylene (mg/L)	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
	Trichlorofluoromethane (mg/L)	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
	Vinyl Chloride (mg/L)	<0.00040	<0.00040	<0.00040	<0.00040	<0.00040
	ortho-Xylene (mg/L)	<0.00050	<0.00050	<0.00050	0.00175	0.0142
	meta- & para-Xylene (mg/L)	0.00056	<0.00050	<0.00050	0.00246	<0.00050
	Xylenes (mg/L)	<0.00075	<0.00075	<0.00075	0.00421	0.0142
	Surrogate: 4-Bromofluorobenzene (SS) (%)	75.8	76.1	76.5	78.5	78.3
	Surrogate: 1,4-Difluorobenzene (SS) (%)	102.9	102.5	101.7	101.5	102.0

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L2304080-6	L2304080-7	L2304080-8		
	Description	SURFACE WATE	SURFACE WATE	SURFACE WATE		
	Sampled Date					
	Sampled Time					
	Client ID	MLA FUEL BERM 6	MLA FUEL BERM 7	MLA FUEL BERM 8		
Grouping	**Analyte**					
WATER						
Volatile Organic Compounds	1,1,1-Trichloroethane (mg/L)	<0.0010	<0.0010	<0.0010		
	1,1,2-Trichloroethane (mg/L)	<0.00050	<0.00050	<0.00050		
	Trichloroethylene (mg/L)	<0.0010	<0.0010	<0.0010		
	Trichlorofluoromethane (mg/L)	<0.0010	<0.0010	<0.0010		
	Vinyl Chloride (mg/L)	<0.00040	<0.00040	<0.00040		
	ortho-Xylene (mg/L)	0.0225	<0.00050	0.00103		
	meta- & para-Xylene (mg/L)	0.00194	<0.00050	<0.00050		
	Xylenes (mg/L)	0.0244	<0.00075	0.00103		
	Surrogate: 4-Bromofluorobenzene (SS) (%)	77.0	76.9	77.9		
	Surrogate: 1,4-Difluorobenzene (SS) (%)	102.9	101.8	101.5		

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

Reference Information

QC Samples with Qualifiers & Comments:

QC Type Description	Parameter	Qualifier	Applies to Sample Number(s)
Laboratory Control Sample	trans-1,3-Dichloropropylene	LCS-ND	L2304080-1, -2, -3, -4, -5, -6, -7, -8
Matrix Spike	Aluminum (Al)-Total	MS-B	L2304080-1, -2, -3, -4, -5, -6, -7, -8
Matrix Spike	Barium (Ba)-Total	MS-B	L2304080-1, -2, -3, -4, -5, -6, -7, -8
Matrix Spike	Magnesium (Mg)-Total	MS-B	L2304080-1, -2, -3, -4, -5, -6, -7, -8
Matrix Spike	Manganese (Mn)-Total	MS-B	L2304080-1, -2, -3, -4, -5, -6, -7, -8
Matrix Spike	Sodium (Na)-Total	MS-B	L2304080-1, -2, -3, -4, -5, -6, -7, -8

Qualifiers for Individual Parameters Listed:

Qualifier	Description
DLCI	Detection Limit Raised: Chromatographic Interference due to co-elution.
DLM	Detection Limit Adjusted due to sample matrix effects (e.g. chemical interference, colour, turbidity).
LCS-ND	Lab Control Sample recovery was slightly outside ALS DQO. Reported non-detect results for associated samples were unaffected.
MS-B	Matrix Spike recovery could not be accurately calculated due to high analyte background in sample.

Test Method References:

ALS Test Code	Matrix	Test Description	Method Reference**
EC-SCREEN-VA	Water	Conductivity Screen (Internal Use Only)	APHA 2510

Qualitative analysis of conductivity where required during preparation of other tests - e.g. TDS, metals, etc.

MET-T-CCMS-VA	Water	Total Metals in Water by CRC ICPMS	EPA 200.2/6020A (mod)

Water samples are digested with nitric and hydrochloric acids, and analyzed by CRC ICPMS.

Method Limitation (re: Sulfur): Sulfide and volatile sulfur species may not be recovered by this method.

NH3-F-VA	Water	Ammonia in Water by Fluorescence	J. ENVIRON. MONIT., 2005, 7, 37-42, RSC

This analysis is carried out, on sulfuric acid preserved samples, using procedures modified from J. Environ. Monit., 2005, 7, 37 - 42, The Royal Society of Chemistry, "Flow-injection analysis with fluorescence detection for the determination of trace levels of ammonium in seawater", Roslyn J. Waston et al.

OGG-SF-VA	Water	Oil & Grease by Gravimetric	BCMOE (2010), EPA1664A

The procedure involves an extraction of the entire water sample with hexane. This extract is then evaporated to dryness, and the residue weighed to determine Oil and Grease.

OGG-VISIBLE-SHEEN-VA	Water	Oil and Grease - Visible Sheen	AER D50

"Visible Sheen" refers to a qualitative visual observation of the presence or absence of rainbow sheen, iridescence, or non-aqueous phase liquid (NAPL) on the surface of a drilling waste (fluid portion, clear liquid portion, or total waste) or on an aqueous sample. No hold time guidance is available for this test. Field observations should also be recorded, because sample characteristics may change between sampling and time of observation at the laboratory. This is a non-accredited test.

PH-PCT-VA	Water	pH by Meter (Automated)	APHA 4500-H pH Value

This analysis is carried out using procedures adapted from APHA Method 4500-H "pH Value". The pH is determined in the laboratory using a pH electrode

It is recommended that this analysis be conducted in the field.

TSS-VA	Water	Total Suspended Solids by Gravimetric	APHA 2540 D - GRAVIMETRIC

This analysis is carried out using procedures adapted from APHA Method 2540 "Solids". Solids are determined gravimetrically. Total Suspended Solids (TSS) are determined by filtering a sample through a glass fibre filter, TSS is determined by drying the filter at 104 degrees celsius.
Samples containing very high dissolved solid content (i.e. seawaters, brackish waters) may produce a positive bias by this method. Alternate analysis methods are available for these types of samples.

VOC-HSMS-VA	Water	VOCs in water by Headspace GCMS	EPA 5021A/8260C

The water sample, with added reagents, is heated in a sealed vial to equilibrium. The headspace from the vial is transferred into a gas chromatograph. Target compound concentrations are measured using mass spectrometry detection.

VOC7-HSMS-VA	Water	BTEX/MTBE/Styrene by Headspace GCMS	EPA 5021A/8260C

The water sample, with added reagents, is heated in a sealed vial to equilibrium. The headspace from the vial is transfered into a gas chromatograph. Target compound concentrations are measured using mass spectrometry detection.

VOC7/VOC-SURR-MS-VA	Water	VOC7 and/or VOC Surrogates for Waters	EPA 5035A/5021A/8260C
XYLENES-CALC-VA	Water	Sum of Xylene Isomer Concentrations	CALCULATION

Calculation of Total Xylenes

Total Xylenes is the sum of the concentrations of the ortho, meta, and para Xylene isomers. Results below detection limit (DL) are treated as zero.

Reference Information

The DL for Total Xylenes is set to a value no less than the square root of the sum of the squares of the DLs of the individual Xylenes.

** ALS test methods may incorporate modifications from specified reference methods to improve performance.

The last two letters of the above test code(s) indicate the laboratory that performed analytical analysis for that test. Refer to the list below:

Laboratory Definition Code	Laboratory Location
VA	ALS ENVIRONMENTAL - VANCOUVER, BRITISH COLUMBIA, CANADA

Chain of Custody Numbers:

GLOSSARY OF REPORT TERMS

Surrogate - A compound that is similar in behaviour to target analyte(s), but that does not occur naturally in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery.
mg/kg - milligrams per kilogram based on dry weight of sample.
mg/kg wwt - milligrams per kilogram based on wet weight of sample.
mg/kg lwt - milligrams per kilogram based on lipid-adjusted weight of sample.
mg/L - milligrams per litre.
< - Less than.
D.L. - The reported Detection Limit, also known as the Limit of Reporting (LOR).
N/A - Result not available. Refer to qualifier code and definition for explanation.

Test results reported relate only to the samples as received by the laboratory.
UNLESS OTHERWISE STATED, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.
Analytical results in unsigned test reports with the DRAFT watermark are subject to change, pending final QC review.

ALS Environmental

Chain of Custody / Analytical Request Form
Canada Toll Free: 1 800 668 9878
www.alsglobal.com

COC #

Report To:		Report Format / Distribution	
Company:	Sabina Gold and Silver Corp		
Contact:	Merle Keefe		
Address:	1800-555 Burrard St	Email 1:	mkeefe@sabinagoldsilver.com
	Vancouver, BC, V7X 1M7	Email 2:	
Phone:	604-240-6619 Fax:	Email 3:	
Invoice To	Same as Report ?	Client / Project Information	
Hardcopy of Invoice with Report?		Job #:	
Company:	Sabina Gold and Silver Corp	PO / AFE:	
Contact:	Accounts payable	LSD:	
Address:			
Phone:	Fax:	Quote #:	
Lab Work Order # (lab use only)	L2304080	ALS Contact:	Sampler: IE

Service Requested (Rush for routine analysis subject to availability)

Analysis Request

Please indicate below Filtered, Preserved or both (F, P, F/P)

Sample #	Sample Identification (This description will appear on the report)	Date (dd-mmm-yy)	Time (hh:mm)	Sample Type	pH	TSS	Oil & Grease (mg/L)	MET-T-CCMS-VA	VOC7-HSMS-VA								Number of Containers
1	MLA Fuel Berm 1			Surface Water	X	X	X	x	x								7
2	MLA Fuel Berm 2			Surface Water	X	X	X	x	x								7
3	MLA Fuel Berm 3			Surface Water	X	X	X	x	x								7
4	MLA Fuel Berm 4			Surface Water	X	X	X	x	x								7
5	MLA Fuel Berm 5			Surface Water	X	X	X	x	x								7
6	MLA Fuel Berm 6			Surface Water	X	X	X	x	x								7
7	MLA Fuel Berm 7			Surface Water	X	X	X	x	x								7
8	MLA Fuel Berm 8			Surface Water	X	X	X	x	x								7

Special Instructions / Regulations with water or land use (CCME-Freshwater Aquatic Life/BC CSR - Commercial/AB Tier 1 - Natural, etc) / Hazardous Details

Failure to complete all portions of this form may delay analysis. Please fill in this form LEGIBLY.

By the use of this form the user acknowledges and agrees with the Terms and Conditions as provided on a separate Excel tab.

Also provided on another Excel tab are the ALS location addresses, phone numbers and sample container / preservation / holding time table for common analyses.

SHIPMENT RELEASE (client use)			SHIPMENT RECEPTION (lab use only)				SHIPMENT VERIFICATION (lab use only)			
Released by: MICHAEL MARCHIONNA	Date (dd-mmm-yy)	Time (hh-mm)	Received by: OK	Date: 4/1	Time: 13:45	Temperature: 12.6 °C	Verified by:	Date:	Time:	Observations: Yes / No ? If Yes add SIF

04/07/19
10:10AM

GENF 18.01 Front

L2304080-COFC

SABINA GOLD & SILVER CORP.
ATTN: Merle Keefe
Suite 1800 - 555 Burrard St.
Box 220
Vancouver BC V7X 1M7

Date Received: 04-JUL-19
Report Date: 15-JUL-19 16:10 (MT)
Version: FINAL

Client Phone: 604-240-6619

Certificate of Analysis

Lab Work Order #: L2304060
Project P.O. #: NOT SUBMITTED
Job Reference:
C of C Numbers:
Legal Site Desc:

Oliver Gregg
Account Manager

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L2304060-1				
	Description	SURFACE WATE				
	Sampled Date					
	Sampled Time					
	Client ID	BRG-G-MLAQUARRY				
Grouping	**Analyte**					
WATER						
Physical Tests	pH (pH)	7.47				
	Total Suspended Solids (mg/L)	48.0				
Aggregate Organics	Oil and Grease (mg/L)	<5.0				
	Oil And Grease (Visible Sheen)	NO				
Volatile Organic Compounds	Benzene (mg/L)	<0.00050				
	Bromodichloromethane (mg/L)	<0.0010				
	Bromoform (mg/L)	<0.0010				
	Carbon Tetrachloride (mg/L)	<0.00050				
	Chlorobenzene (mg/L)	<0.0010				
	Dibromochloromethane (mg/L)	<0.0010				
	Chloroethane (mg/L)	<0.0010				
	Chloroform (mg/L)	<0.0010				
	Chloromethane (mg/L)	<0.0050				
	1,2-Dichlorobenzene (mg/L)	<0.00050				
	1,3-Dichlorobenzene (mg/L)	<0.0010				
	1,4-Dichlorobenzene (mg/L)	<0.0010				
	1,1-Dichloroethane (mg/L)	<0.0010				
	1,2-Dichloroethane (mg/L)	<0.0010				
	1,1-Dichloroethylene (mg/L)	<0.0010				
	cis-1,2-Dichloroethylene (mg/L)	<0.0010				
	trans-1,2-Dichloroethylene (mg/L)	<0.0010				
	Dichloromethane (mg/L)	<0.0050				
	1,2-Dichloropropane (mg/L)	<0.0010				
	cis-1,3-Dichloropropylene (mg/L)	<0.00050				
	trans-1,3-Dichloropropylene (mg/L)	<0.00050				
	1,3-Dichloropropene (cis & trans) (mg/L)	<0.0010				
	Ethylbenzene (mg/L)	<0.00050				
	Methyl t-butyl ether (MTBE) (mg/L)	<0.00050				
	Styrene (mg/L)	<0.00050				
	1,1,1,2-Tetrachloroethane (mg/L)	<0.0010				
	1,1,2,2-Tetrachloroethane (mg/L)	DLCI <0.00030				
	Tetrachloroethylene (mg/L)	<0.0010				
	Toluene (mg/L)	<0.00045				
	1,1,1-Trichloroethane (mg/L)	<0.0010				
	1,1,2-Trichloroethane (mg/L)	<0.00050				
	Trichloroethylene (mg/L)	<0.0010				

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L2304060-1				
	Description	SURFACE WATE				
	Sampled Date					
	Sampled Time					
	Client ID	BRG-G-MLAQUARRY				
Grouping	**Analyte**					
WATER						
Volatile Organic Compounds	Trichlorofluoromethane (mg/L)	<0.0010				
	Vinyl Chloride (mg/L)	<0.00040				
	ortho-Xylene (mg/L)	<0.00050				
	meta- & para-Xylene (mg/L)	<0.00050				
	Xylenes (mg/L)	<0.00075				
	Surrogate: 4-Bromofluorobenzene (SS) (%)	79.1				
	Surrogate: 1,4-Difluorobenzene (SS) (%)	102.7				

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

Reference Information

QC Samples with Qualifiers & Comments:

QC Type Description	Parameter	Qualifier	Applies to Sample Number(s)
Laboratory Control Sample	trans-1,3-Dichloropropylene	LCS-ND	L2304060-1

Qualifiers for Individual Parameters Listed:

Qualifier	Description
DLCI	Detection Limit Raised: Chromatographic Interference due to co-elution.
LCS-ND	Lab Control Sample recovery was slightly outside ALS DQO. Reported non-detect results for associated samples were unaffected.

Test Method References:

ALS Test Code	Matrix	Test Description	Method Reference**
EC-SCREEN-VA	Water	Conductivity Screen (Internal Use Only)	APHA 2510

Qualitative analysis of conductivity where required during preparation of other tests - e.g. TDS, metals, etc.

ALS Test Code	Matrix	Test Description	Method Reference**
OGG-SF-VA	Water	Oil & Grease by Gravimetric	BCMOE (2010), EPA1664A

The procedure involves an extraction of the entire water sample with hexane. This extract is then evaporated to dryness, and the residue weighed to determine Oil and Grease.

ALS Test Code	Matrix	Test Description	Method Reference**
OGG-VISIBLE-SHEEN-VA	Water	Oil and Grease - Visible Sheen	AER D50

"Visible Sheen" refers to a qualitative visual observation of the presence or absence of rainbow sheen, iridescence, or non-aqueous phase liquid (NAPL) on the surface of a drilling waste (fluid portion, clear liquid portion, or total waste) or on an aqueous sample. No hold time guidance is available for this test. Field observations should also be recorded, because sample characteristics may change between sampling and time of observation at the laboratory. This is a non-accredited test.

ALS Test Code	Matrix	Test Description	Method Reference**
PH-PCT-VA	Water	pH by Meter (Automated)	APHA 4500-H pH Value

This analysis is carried out using procedures adapted from APHA Method 4500-H "pH Value". The pH is determined in the laboratory using a pH electrode

It is recommended that this analysis be conducted in the field.

ALS Test Code	Matrix	Test Description	Method Reference**
TSS-VA	Water	Total Suspended Solids by Gravimetric	APHA 2540 D - GRAVIMETRIC

This analysis is carried out using procedures adapted from APHA Method 2540 "Solids". Solids are determined gravimetrically. Total Suspended Solids (TSS) are determined by filtering a sample through a glass fibre filter, TSS is determined by drying the filter at 104 degrees celsius.
Samples containing very high dissolved solid content (i.e. seawaters, brackish waters) may produce a positive bias by this method. Alternate analysis methods are available for these types of samples.

ALS Test Code	Matrix	Test Description	Method Reference**
VOC-HSMS-VA	Water	VOCs in water by Headspace GCMS	EPA 5021A/8260C

The water sample, with added reagents, is heated in a sealed vial to equilibrium. The headspace from the vial is transferred into a gas chromatograph. Target compound concentrations are measured using mass spectrometry detection.

ALS Test Code	Matrix	Test Description	Method Reference**
VOC7-HSMS-VA	Water	BTEX/MTBE/Styrene by Headspace GCMS	EPA 5021A/8260C

The water sample, with added reagents, is heated in a sealed vial to equilibrium. The headspace from the vial is transfered into a gas chromatograph. Target compound concentrations are measured using mass spectrometry detection.

ALS Test Code	Matrix	Test Description	Method Reference**
VOC7/VOC-SURR-MS-VA	Water	VOC7 and/or VOC Surrogates for Waters	EPA 5035A/5021A/8260C
XYLENES-CALC-VA	Water	Sum of Xylene Isomer Concentrations	CALCULATION

Calculation of Total Xylenes

Total Xylenes is the sum of the concentrations of the ortho, meta, and para Xylene isomers. Results below detection limit (DL) are treated as zero. The DL for Total Xylenes is set to a value no less than the square root of the sum of the squares of the DLs of the individual Xylenes.

** ALS test methods may incorporate modifications from specified reference methods to improve performance.

The last two letters of the above test code(s) indicate the laboratory that performed analytical analysis for that test. Refer to the list below:

Laboratory Definition Code	Laboratory Location
VA	ALS ENVIRONMENTAL - VANCOUVER, BRITISH COLUMBIA, CANADA

Chain of Custody Numbers:

Reference Information

GLOSSARY OF REPORT TERMS

Surrogate - A compound that is similar in behaviour to target analyte(s), but that does not occur naturally in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery.
mg/kg - milligrams per kilogram based on dry weight of sample.
mg/kg wwt - milligrams per kilogram based on wet weight of sample.
mg/kg lwt - milligrams per kilogram based on lipid-adjusted weight of sample.
mg/L - milligrams per litre.
< - Less than.
D.L. - The reported Detection Limit, also known as the Limit of Reporting (LOR).
N/A - Result not available. Refer to qualifier code and definition for explanation.

Test results reported relate only to the samples as received by the laboratory.
UNLESS OTHERWISE STATED, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.
Analytical results in unsigned test reports with the DRAFT watermark are subject to change, pending final QC review.

ALS Environmental

Chain of Custody / Analytical Request Form
Canada Toll Free: 1 800 668 9878
www.alsglobal.com

COC #

Page 1 of 1

Report To:		Report Format / Distribution	Service Requested (Rush for routine analysis subject to availability)
Company:	Sabina Gold and Silver Corp		
Contact:	Merle Keefe		
Address:	1800-555 Burrard St	Email 1: mkeefe@sabinagoldsilver.com	
	Vancouver, BC, V7X 1M7	Email 2:	
Phone:	604-240-6619 Fax:	Email 3:	Analysis Request
Invoice To	Same as Report ?	Client / Project Information	Please indicate below Filtered, Preserved or both (F, P, F/P)
Hardcopy of Invoice with Report?		Job #:	
Company:	Sabina Gold and Silver Corp	PO / AFE:	
Contact:	Accounts payable	LSD:	
Address:			
Phone:	Fax:	Quote #:	
Lab Work Order # (lab use only)	L2304060	ALS Contact: / Sampler: IE	

Sample #	Sample Identification (This description will appear on the report)	Date (dd-mmm-yy)	Time (hh:mm)	Sample Type	pH	TSS	Oil & Grease (vis. Sheen)	Oil & Grease (mg/L)	Benzene	Toluene	Ethylbenzene						Number of Containers
	BRG-G-MLAQuarry			Surface Water	X	X	X	x	x	x	x						

L2304060-COFC

Special Instructions / Regulations with water or land use (CCME-Freshwater Aquatic Life/BC CSR - Commercial/AB

Failure to complete all portions of this form may delay analysis. Please fill in this form LEGIBLY.

By the use of this form the user acknowledges and agrees with the Terms and Conditions as provided on a separate Excel tab.

Also provided on another Excel tab are the ALS location addresses, phone numbers and sample container / preservation / holding time table for common analyses.

SHIPMENT RELEASE (client use)			SHIPMENT RECEPTION (lab use only)				SHIPMENT VERIFICATION (lab use only)			
Released by:	Date (dd-mmm-yy)	Time (hh-mm)	Received by:	Date:	Time:	Temperature:	Verified by:	Date:	Time:	Observations: Yes / No ? If Yes add SIF
MICHAEL MACHADO	04/07/19	10:50	[illegible]	4-Jul-19	13:45	12.6 °C				

GENF 18.01 Front

SABINA GOLD & SILVER CORP.
ATTN: Merle Keefe
Suite 1800 - 555 Burrard St.
Box 220
Vancouver BC V7X 1M7

Date Received: 22-AUG-19
Report Date: 12-MAR-20 15:28 (MT)
Version: FINAL REV. 2

Client Phone: 604-240-6619

Certificate of Analysis

Lab Work Order #: **L2334873**

Project P.O. #: NOT SUBMITTED
Job Reference:
C of C Numbers:
Legal Site Desc:

Oliver Gregg
Account Manager

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L2334873-1	L2334873-2	L2334873-3		
	Description	SURFACE WATE	SURFACE WATE	SURFACE WATE		
	Sampled Date	22-AUG-19	22-AUG-19	22-AUG-19		
	Sampled Time					
	Client ID	MLA BERM 5	MLA BERM 6	WINDSOTCK BERM		
Grouping	**Analyte**					
WATER						
Physical Tests	Hardness (as CaCO3) (mg/L)	4.52 HTC	4.50 HTC	8.62 HTC		
	pH (pH)	5.35	4.52	6.92		
	Total Suspended Solids (mg/L)	<3.0	<3.0	7.0		
Anions and Nutrients	Ammonia, Total (as N) (mg/L)	<0.0050	<0.0050	<0.0050		
Total Metals	Aluminum (Al)-Total (mg/L)	0.317	0.0359	0.0690		
	Antimony (Sb)-Total (mg/L)	<0.00010	0.00024	0.00018		
	Arsenic (As)-Total (mg/L)	0.00012	0.00084	<0.00010		
	Barium (Ba)-Total (mg/L)	0.0400	0.0522	0.0874		
	Beryllium (Be)-Total (mg/L)	<0.000020	<0.000020	<0.000020		
	Bismuth (Bi)-Total (mg/L)	<0.000050	<0.000050	<0.000050		
	Boron (B)-Total (mg/L)	<0.010	<0.010	0.108		
	Cadmium (Cd)-Total (mg/L)	0.0000398	0.0000338	0.0000383		
	Calcium (Ca)-Total (mg/L)	0.782	0.800	2.08		
	Chromium (Cr)-Total (mg/L)	0.00037	0.00054	0.00026		
	Cobalt (Co)-Total (mg/L)	0.00017	0.00016	0.00042		
	Copper (Cu)-Total (mg/L)	0.00197	0.00321	<0.00050		
	Iron (Fe)-Total (mg/L)	0.206	0.280	1.25		
	Lead (Pb)-Total (mg/L)	0.000177	0.000215	0.000075		
	Lithium (Li)-Total (mg/L)	<0.0010	<0.0010	0.0015		
	Magnesium (Mg)-Total (mg/L)	0.62	0.61	0.83		
	Manganese (Mn)-Total (mg/L)	0.0303	0.0288	0.0441		
	Molybdenum (Mo)-Total (mg/L)	0.000072	0.000055	0.0113		
	Nickel (Ni)-Total (mg/L)	0.00087	0.00102	0.00091		
	Phosphorus (P)-Total (mg/L)	0.482	0.406	0.334		
	Potassium (K)-Total (mg/L)	0.85	0.48	1.01		
	Selenium (Se)-Total (mg/L)	<0.000050	<0.000050	<0.000050		
	Silicon (Si)-Total (mg/L)	0.54	<0.10	0.16		
	Silver (Ag)-Total (mg/L)	<0.000010	<0.000010	<0.000010		
	Sodium (Na)-Total (mg/L)	3.91	3.47	5.78		
	Strontium (Sr)-Total (mg/L)	0.00484	0.00618	0.00924		
	Sulfur (S)-Total (mg/L)	<0.50	<0.50	0.79		
	Thallium (Tl)-Total (mg/L)	<0.000010	<0.000010	<0.000010		
	Tin (Sn)-Total (mg/L)	<0.00010	<0.00010	<0.00010		
	Titanium (Ti)-Total (mg/L)	0.00175	<0.00030	<0.00060 DLM		
	Uranium (U)-Total (mg/L)	0.000043	<0.000010	<0.000010		
	Vanadium (V)-Total (mg/L)	<0.00050	<0.00050	<0.00050		
	Zinc (Zn)-Total (mg/L)	0.598	1.93	0.193		

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L2334873-1	L2334873-2	L2334873-3		
	Description	SURFACE WATE	SURFACE WATE	SURFACE WATE		
	Sampled Date	22-AUG-19	22-AUG-19	22-AUG-19		
	Sampled Time					
	Client ID	MLA BERM 5	MLA BERM 6	WINDSOTCK BERM		
Grouping	**Analyte**					
WATER						
Total Metals	Zirconium (Zr)-Total (mg/L)	0.00044	<0.00030	<0.00030		
Aggregate Organics	Oil and Grease (mg/L)	7.2	17.8	<5.0		
Volatile Organic Compounds	Benzene (mg/L)	<0.00050	<0.00050	<0.00050		
	Ethylbenzene (mg/L)	<0.00050	0.00094	<0.00050		
	Methyl t-butyl ether (MTBE) (mg/L)	<0.00050	<0.00050	<0.00050		
	Styrene (mg/L)	<0.00050	<0.00050	<0.00050		
	Toluene (mg/L)	<0.00045	0.00079	<0.00045		
	ortho-Xylene (mg/L)	0.00350	0.0145	<0.00050		
	meta- & para-Xylene (mg/L)	0.00117	0.00860	<0.00050		

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

Reference Information

QC Samples with Qualifiers & Comments:

QC Type Description	Parameter	Qualifier	Applies to Sample Number(s)
Matrix Spike	Barium (Ba)-Total	MS-B	L2334873-1, -2, -3
Matrix Spike	Boron (B)-Total	MS-B	L2334873-1, -2, -3
Matrix Spike	Calcium (Ca)-Total	MS-B	L2334873-1, -2, -3
Matrix Spike	Iron (Fe)-Total	MS-B	L2334873-1, -2, -3
Matrix Spike	Magnesium (Mg)-Total	MS-B	L2334873-1, -2, -3
Matrix Spike	Manganese (Mn)-Total	MS-B	L2334873-1, -2, -3
Matrix Spike	Potassium (K)-Total	MS-B	L2334873-1, -2, -3
Matrix Spike	Silicon (Si)-Total	MS-B	L2334873-1, -2, -3
Matrix Spike	Sodium (Na)-Total	MS-B	L2334873-1, -2, -3
Matrix Spike	Strontium (Sr)-Total	MS-B	L2334873-1, -2, -3

Qualifiers for Individual Parameters Listed:

Qualifier	Description
DLM	Detection Limit Adjusted due to sample matrix effects (e.g. chemical interference, colour, turbidity).
HTC	Hardness was calculated from Total Ca and/or Mg concentrations and may be biased high (dissolved Ca/Mg results unavailable).
MS-B	Matrix Spike recovery could not be accurately calculated due to high analyte background in sample.

Test Method References:

ALS Test Code	Matrix	Test Description	Method Reference**
BE-T-L-CCMS-VA	Water	Total Be (Low) in Water by CRC ICPMS	EPA 200.2/6020A (mod)

Water samples are digested with nitric and hydrochloric acids, and analyzed by CRC ICPMS.

EC-SCREEN-VA	Water	Conductivity Screen (Internal Use Only)	APHA 2510

Qualitative analysis of conductivity where required during preparation of other tests - e.g. TDS, metals, etc.

HARDNESS-CALC-VA	Water	Hardness	APHA 2340B

Hardness (also known as Total Hardness) is calculated from the sum of Calcium and Magnesium concentrations, expressed in CaCO3 equivalents. Dissolved Calcium and Magnesium concentrations are preferentially used for the hardness calculation.

MET-T-CCMS-VA	Water	Total Metals in Water by CRC ICPMS	EPA 200.2/6020A (mod)

Water samples are digested with nitric and hydrochloric acids, and analyzed by CRC ICPMS.

Method Limitation (re: Sulfur): Sulfide and volatile sulfur species may not be recovered by this method.

NH3-F-VA	Water	Ammonia in Water by Fluorescence	J. ENVIRON. MONIT., 2005, 7, 37-42, RSC

This analysis is carried out, on sulfuric acid preserved samples, using procedures modified from J. Environ. Monit., 2005, 7, 37 - 42, The Royal Society of Chemistry, "Flow-injection analysis with fluorescence detection for the determination of trace levels of ammonium in seawater", Roslyn J. Waston et al.

OGG-SF-VA	Water	Oil & Grease by Gravimetric	BCMOE (2010), EPA1664A

The procedure involves an extraction of the entire water sample with hexane. This extract is then evaporated to dryness, and the residue weighed to determine Oil and Grease.

PH-PCT-VA	Water	pH by Meter (Automated)	APHA 4500-H pH Value

This analysis is carried out using procedures adapted from APHA Method 4500-H "pH Value". The pH is determined in the laboratory using a pH electrode

It is recommended that this analysis be conducted in the field.

TSS-VA	Water	Total Suspended Solids by Gravimetric	APHA 2540 D - GRAVIMETRIC

This analysis is carried out using procedures adapted from APHA Method 2540 "Solids". Solids are determined gravimetrically. Total Suspended Solids (TSS) are determined by filtering a sample through a glass fibre filter, TSS is determined by drying the filter at 104 degrees celsius.
Samples containing very high dissolved solid content (i.e. seawaters, brackish waters) may produce a positive bias by this method. Alternate analysis methods are available for these types of samples.

VOC7-HSMS-VA	Water	BTEX/MTBE/Styrene by Headspace GCMS	EPA 5021A/8260C

The water sample, with added reagents, is heated in a sealed vial to equilibrium. The headspace from the vial is transfered into a gas chromatograph. Target compound concentrations are measured using mass spectrometry detection.

** ALS test methods may incorporate modifications from specified reference methods to improve performance.

The last two letters of the above test code(s) indicate the laboratory that performed analytical analysis for that test. Refer to the list below:

Reference Information

Laboratory Definition Code	Laboratory Location
VA	ALS ENVIRONMENTAL - VANCOUVER, BRITISH COLUMBIA, CANADA

Chain of Custody Numbers:

GLOSSARY OF REPORT TERMS

Surrogate - A compound that is similar in behaviour to target analyte(s), but that does not occur naturally in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery.
mg/kg - milligrams per kilogram based on dry weight of sample.
mg/kg wwt - milligrams per kilogram based on wet weight of sample.
mg/kg lwt - milligrams per kilogram based on lipid-adjusted weight of sample.
mg/L - milligrams per litre.
< - Less than.
D.L. - The reported Detection Limit, also known as the Limit of Reporting (LOR).
N/A - Result not available. Refer to qualifier code and definition for explanation.

Test results reported relate only to the samples as received by the laboratory.
UNLESS OTHERWISE STATED, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.
Analytical results in unsigned test reports with the DRAFT watermark are subject to change, pending final QC review.

Quality Control Report

Client: SABINA GOLD & SILVER CORP.
Suite 1800 - 555 Burrard St. Box 220
Vancouver BC V7X 1M7

Contact: Merle Keefe

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
BE-T-L-CCMS-VA	**Water**							
Batch R4769111								
WG3142772-2 LCS								
Beryllium (Be)-Total			98.5		%		80-120	25-AUG-19
WG3142772-1 MB								
Beryllium (Be)-Total			<0.000020		mg/L		0.00002	25-AUG-19
MET-T-CCMS-VA	**Water**							
Batch R4769111								
WG3142772-2 LCS								
Aluminum (Al)-Total			99.95		%		80-120	25-AUG-19
Antimony (Sb)-Total			103.3		%		80-120	25-AUG-19
Arsenic (As)-Total			99.9		%		80-120	25-AUG-19
Barium (Ba)-Total			100.8		%		80-120	25-AUG-19
Bismuth (Bi)-Total			100.5		%		80-120	25-AUG-19
Boron (B)-Total			117.3		%		80-120	25-AUG-19
Cadmium (Cd)-Total			101.4		%		80-120	25-AUG-19
Calcium (Ca)-Total			99.2		%		80-120	25-AUG-19
Chromium (Cr)-Total			102.5		%		80-120	25-AUG-19
Cobalt (Co)-Total			99.96		%		80-120	25-AUG-19
Copper (Cu)-Total			100.7		%		80-120	25-AUG-19
Iron (Fe)-Total			101.3		%		80-120	25-AUG-19
Lead (Pb)-Total			103.5		%		80-120	25-AUG-19
Lithium (Li)-Total			96.0		%		80-120	25-AUG-19
Magnesium (Mg)-Total			104.6		%		80-120	25-AUG-19
Manganese (Mn)-Total			100.7		%		80-120	25-AUG-19
Molybdenum (Mo)-Total			97.2		%		80-120	25-AUG-19
Nickel (Ni)-Total			99.6		%		80-120	25-AUG-19
Phosphorus (P)-Total			105.7		%		80-120	25-AUG-19
Potassium (K)-Total			101.5		%		80-120	25-AUG-19
Selenium (Se)-Total			100.4		%		80-120	25-AUG-19
Silicon (Si)-Total			105.3		%		80-120	25-AUG-19
Silver (Ag)-Total			100.1		%		80-120	25-AUG-19
Sodium (Na)-Total			105.9		%		80-120	25-AUG-19
Strontium (Sr)-Total			102.1		%		80-120	25-AUG-19
Sulfur (S)-Total			103.7		%		80-120	25-AUG-19
Thallium (Tl)-Total			104.4		%		80-120	25-AUG-19
Tin (Sn)-Total			99.3		%		80-120	25-AUG-19

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
MET-T-CCMS-VA	**Water**							
Batch R4769111								
WG3142772-2 LCS								
Titanium (Ti)-Total			97.4		%		80-120	25-AUG-19
Uranium (U)-Total			106.7		%		80-120	25-AUG-19
Vanadium (V)-Total			102.2		%		80-120	25-AUG-19
Zinc (Zn)-Total			101.2		%		80-120	25-AUG-19
Zirconium (Zr)-Total			98.7		%		80-120	25-AUG-19
WG3142772-1 MB								
Aluminum (Al)-Total			<0.0030		mg/L		0.003	25-AUG-19
Antimony (Sb)-Total			<0.00010		mg/L		0.0001	25-AUG-19
Arsenic (As)-Total			<0.00010		mg/L		0.0001	25-AUG-19
Barium (Ba)-Total			<0.00010		mg/L		0.0001	25-AUG-19
Bismuth (Bi)-Total			<0.000050		mg/L		0.00005	25-AUG-19
Boron (B)-Total			<0.010		mg/L		0.01	25-AUG-19
Cadmium (Cd)-Total			<0.0000050		mg/L		0.000005	25-AUG-19
Calcium (Ca)-Total			<0.050		mg/L		0.05	25-AUG-19
Chromium (Cr)-Total			<0.00010		mg/L		0.0001	25-AUG-19
Cobalt (Co)-Total			<0.00010		mg/L		0.0001	25-AUG-19
Copper (Cu)-Total			<0.00050		mg/L		0.0005	25-AUG-19
Iron (Fe)-Total			<0.010		mg/L		0.01	25-AUG-19
Lead (Pb)-Total			<0.000050		mg/L		0.00005	25-AUG-19
Lithium (Li)-Total			<0.0010		mg/L		0.001	25-AUG-19
Magnesium (Mg)-Total			<0.0050		mg/L		0.005	25-AUG-19
Manganese (Mn)-Total			<0.00010		mg/L		0.0001	25-AUG-19
Molybdenum (Mo)-Total			<0.000050		mg/L		0.00005	25-AUG-19
Nickel (Ni)-Total			<0.00050		mg/L		0.0005	25-AUG-19
Phosphorus (P)-Total			<0.050		mg/L		0.05	25-AUG-19
Potassium (K)-Total			<0.050		mg/L		0.05	25-AUG-19
Selenium (Se)-Total			<0.000050		mg/L		0.00005	25-AUG-19
Silicon (Si)-Total			<0.10		mg/L		0.1	25-AUG-19
Silver (Ag)-Total			<0.000010		mg/L		0.00001	25-AUG-19
Sodium (Na)-Total			<0.050		mg/L		0.05	25-AUG-19
Strontium (Sr)-Total			<0.00020		mg/L		0.0002	25-AUG-19
Sulfur (S)-Total			<0.50		mg/L		0.5	25-AUG-19
Thallium (Tl)-Total			<0.000010		mg/L		0.00001	25-AUG-19
Tin (Sn)-Total			<0.00010		mg/L		0.0001	25-AUG-19

Quality Control Report

Test		Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
MET-T-CCMS-VA		**Water**							
Batch	**R4769111**								
WG3142772-1	**MB**								
Titanium (Ti)-Total				<0.00030		mg/L		0.0003	25-AUG-19
Uranium (U)-Total				<0.000010		mg/L		0.00001	25-AUG-19
Vanadium (V)-Total				<0.00050		mg/L		0.0005	25-AUG-19
Zinc (Zn)-Total				<0.0030		mg/L		0.003	25-AUG-19
Zirconium (Zr)-Total				<0.00020		mg/L		0.0002	25-AUG-19
NH3-F-VA		**Water**							
Batch	**R4768878**								
WG3142854-2	**LCS**								
Ammonia, Total (as N)				98.7		%		85-115	26-AUG-19
WG3142854-1	**MB**								
Ammonia, Total (as N)				<0.0050		mg/L		0.005	26-AUG-19
Ammonia, Total (as N)				<0.0050		mg/L		0.005	26-AUG-19
OGG-SF-VA		**Water**							
Batch	**R4769069**								
WG3143382-2	**LCS**								
Oil and Grease				94.2		%		70-130	26-AUG-19
WG3143382-1	**MB**								
Oil and Grease				<5.0		mg/L		5	26-AUG-19
PH-PCT-VA		**Water**							
Batch	**R4768971**								
WG3142790-2	**CRM**		**VA-PH7-BUF**						
pH				6.99		pH		6.9-7.1	25-AUG-19
WG3142790-4	**DUP**		**L2334873-3**						
pH			6.92	6.63	J	pH	0.29	0.3	25-AUG-19
TSS-VA		**Water**							
Batch	**R4768660**								
WG3142776-5	**LCS**								
Total Suspended Solids				88.5		%		85-115	25-AUG-19
WG3142776-4	**MB**								
Total Suspended Solids				<3.0		mg/L		3	25-AUG-19
VOC7-HSMS-VA		**Water**							
Batch	**R4720762**								
WG3142828-2	**LCS**								
Benzene				94.2		%		70-130	25-AUG-19
Ethylbenzene				89.3		%		70-130	25-AUG-19

Quality Control Report

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
VOC7-HSMS-VA	**Water**							
Batch R4720762								
WG3142828-2 LCS								
Methyl t-butyl ether (MTBE)			94.1		%		70-130	25-AUG-19
Styrene			84.1		%		70-130	25-AUG-19
Toluene			87.9		%		70-130	25-AUG-19
meta- & para-Xylene			94.0		%		70-130	25-AUG-19
ortho-Xylene			87.6		%		70-130	25-AUG-19
WG3142828-1 MB								
Benzene			<0.00050		mg/L		0.0005	25-AUG-19
Ethylbenzene			<0.00050		mg/L		0.0005	25-AUG-19
Methyl t-butyl ether (MTBE)			<0.00050		mg/L		0.0005	25-AUG-19
Styrene			<0.00050		mg/L		0.0005	25-AUG-19
Toluene			<0.00045		mg/L		0.00045	25-AUG-19
meta- & para-Xylene			<0.00050		mg/L		0.0005	25-AUG-19
ortho-Xylene			<0.00050		mg/L		0.0005	25-AUG-19

Quality Control Report

Legend:

Limit	ALS Control Limit (Data Quality Objectives)
DUP	Duplicate
RPD	Relative Percent Difference
N/A	Not Available
LCS	Laboratory Control Sample
SRM	Standard Reference Material
MS	Matrix Spike
MSD	Matrix Spike Duplicate
ADE	Average Desorption Efficiency
MB	Method Blank
IRM	Internal Reference Material
CRM	Certified Reference Material
CCV	Continuing Calibration Verification
CVS	Calibration Verification Standard
LCSD	Laboratory Control Sample Duplicate

Sample Parameter Qualifier Definitions:

Qualifier	Description
J	Duplicate results and limits are expressed in terms of absolute difference.

Quality Control Report

Hold Time Exceedances:

ALS Product Description	Sample ID	Sampling Date	Date Processed	Rec. HT	Actual HT	Units	Qualifier
Physical Tests							
pH by Meter (Automated)							
	1	22-AUG-19	25-AUG-19 14:02	0.25	74	hours	EHTR-FM
	2	22-AUG-19	25-AUG-19 14:02	0.25	74	hours	EHTR-FM
	3	22-AUG-19	25-AUG-19 14:02	0.25	74	hours	EHTR-FM

Legend & Qualifier Definitions:

EHTR-FM:	Exceeded ALS recommended hold time prior to sample receipt. Field Measurement recommended.
EHTR:	Exceeded ALS recommended hold time prior to sample receipt.
EHTL:	Exceeded ALS recommended hold time prior to analysis. Sample was received less than 24 hours prior to expiry.
EHT:	Exceeded ALS recommended hold time prior to analysis.
Rec. HT:	ALS recommended hold time (see units).

Notes*:
Where actual sampling date is not provided to ALS, the date (& time) of receipt is used for calculation purposes.
Where actual sampling time is not provided to ALS, the earlier of 12 noon on the sampling date or the time (& date) of receipt is used for calculation purposes. Samples for L2334873 were received on 22-AUG-19 15:00.

ALS recommended hold times may vary by province. They are assigned to meet known provincial and/or federal government requirements. In the absence of regulatory hold times, ALS establishes recommendations based on guidelines published by the US EPA, APHA Standard Methods, or Environment Canada (where available). For more information, please contact ALS.

The ALS Quality Control Report is provided to ALS clients upon request. ALS includes comprehensive QC checks with every analysis to ensure our high standards of quality are met. Each QC result has a known or expected target value, which is compared against pre-determined data quality objectives to provide confidence in the accuracy of associated test results.

Please note that this report may contain QC results from anonymous Sample Duplicates and Matrix Spikes that do not originate from this Work Order.

272093

ALS Environmental

Chain of Custody / Analytical Request Form
Canada Toll Free: 1 800 668 9878
www.alsglobal.com

COC #

Page 1 of 1

Report To:		Report Format / Distribution		Service Requested (Rush for routine analysis subject to availability)
Company:	Sabina Gold and Silver Corp			Emergency (1 day)
Contact:	Merle Keefe			
Address:	1800-555 Burrard St	Email 1:	mkeefe@sabinagoldsilver.com	
	Vancouver, BC, V7X 1M7	Email 2:		
Phone:	604-240-6619 Fax:	Email 3:		Analysis Request
Invoice To	Same as Report ?	Client / Project Information		Please indicate below Filtered, Preserved or both (F, P, F/P)
Hardcopy of Invoice with Report?		Job #:		
Company:	Sabina Gold and Silver Corp	PO / AFE:		
Contact:	Accounts payable	LSD:		
Address:				
Phone:	Fax:	Quote #:		
Lab Work Order # (lab use only)		ALS Contact:	Sampler:	

Sample #	Sample Identification (This description will appear on the report)	Date (dd-mmm-yy)	Time (hh:mm)	Sample Type	pH	TSS	Oil & Grease (mg/L)	MET-T-CCMS-VA	VOC7-HSMS-VA	Ammonia							Number of Containers
	MLA Berm 5	22-Aug-19		Surface Water	X	X	X	x	x	X							7
	MLA Berm 6	22-Aug-19		Surface Water	X	X	X	x	x	X							7
	Windsock Berm	22-Aug-19		Surface Water	X	X	X	x	x	X							7

Special Instructions / Regulations with water or land use (CCME-Freshwater Aquatic Life/BC CSR - Con

L2334873-COFC

Failure to complete all portions of this form may delay analysis. Please fill in this form LEGIBLY.

By the use of this form the user acknowledges and agrees with the Terms and Conditions as provided on a separate Excel tab.

Also provided on another Excel tab are the ALS location addresses, phone numbers and sample container / preservation / holding time table for common analyses.

SHIPMENT RELEASE (client use)			SHIPMENT RECEPTION (lab use only)				SHIPMENT VERIFICATION (lab use only)			
Released by:	Date (dd-mmm-yy)	Time (hh-mm)	Received by: CP	Date: 8/22/19	Time: 1500	Temperature: 8.6 °C	Verified by:	Date:	Time:	Observations: Yes / No ? If Yes add SIF

GENF 18.01 Front

SABINA GOLD & SILVER CORP.
ATTN: Merle Keefe
Suite 1800 - 555 Burrard St.
Box 220
Vancouver BC V7X 1M7

Date Received: 25-JUL-19
Report Date: 30-JUL-19 17:15 (MT)
Version: FINAL

Client Phone: 604-240-6619

Certificate of Analysis

Lab Work Order #: L2317254

Project P.O. #: NOT SUBMITTED
Job Reference:
C of C Numbers:
Legal Site Desc:

Oliver Gregg
Account Manager

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L2317254-1				
	Description	WATER				
	Sampled Date	25-JUL-19				
	Sampled Time	09:30				
	Client ID	MLA FUEL BERM 8				
Grouping	**Analyte**					
WATER						
Physical Tests	pH (pH)	8.72				
	Total Suspended Solids (mg/L)	<3.0				
Anions and Nutrients	Ammonia, Total (as N) (mg/L)	<0.0050				
Total Metals	Aluminum (Al)-Total (mg/L)	0.120				
	Antimony (Sb)-Total (mg/L)	<0.00010				
	Arsenic (As)-Total (mg/L)	<0.00010				
	Barium (Ba)-Total (mg/L)	0.0232				
	Beryllium (Be)-Total (mg/L)	<0.00010				
	Bismuth (Bi)-Total (mg/L)	<0.000050				
	Boron (B)-Total (mg/L)	<0.010				
	Cadmium (Cd)-Total (mg/L)	0.0000336				
	Calcium (Ca)-Total (mg/L)	0.604				
	Cesium (Cs)-Total (mg/L)	<0.000010				
	Chromium (Cr)-Total (mg/L)	0.00020				
	Cobalt (Co)-Total (mg/L)	0.00012				
	Copper (Cu)-Total (mg/L)	0.00229				
	Iron (Fe)-Total (mg/L)	0.119				
	Lead (Pb)-Total (mg/L)	0.000100				
	Lithium (Li)-Total (mg/L)	<0.0010				
	Magnesium (Mg)-Total (mg/L)	0.612				
	Manganese (Mn)-Total (mg/L)	0.0312				
	Molybdenum (Mo)-Total (mg/L)	0.000080				
	Nickel (Ni)-Total (mg/L)	<0.00050				
	Phosphorus (P)-Total (mg/L)	0.739				
	Potassium (K)-Total (mg/L)	0.546				
	Rubidium (Rb)-Total (mg/L)	0.00042				
	Selenium (Se)-Total (mg/L)	<0.000050				
	Silicon (Si)-Total (mg/L)	0.22				
	Silver (Ag)-Total (mg/L)	<0.000010				
	Sodium (Na)-Total (mg/L)	4.07				
	Strontium (Sr)-Total (mg/L)	0.00425				
	Sulfur (S)-Total (mg/L)	<0.50				
	Tellurium (Te)-Total (mg/L)	<0.00020				
	Thallium (Tl)-Total (mg/L)	<0.000010				
	Thorium (Th)-Total (mg/L)	<0.00010				
	Tin (Sn)-Total (mg/L)	<0.00010				
	Titanium (Ti)-Total (mg/L)	DLM <0.00060				

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L2317254-1				
	Description	WATER				
	Sampled Date	25-JUL-19				
	Sampled Time	09:30				
	Client ID	MLA FUEL BERM 8				
Grouping	**Analyte**					
WATER						
Total Metals	Tungsten (W)-Total (mg/L)	<0.00010				
	Uranium (U)-Total (mg/L)	<0.000010				
	Vanadium (V)-Total (mg/L)	<0.00050				
	Zinc (Zn)-Total (mg/L)	0.374				
	Zirconium (Zr)-Total (mg/L)	<0.00020				
Aggregate Organics	Oil and Grease (mg/L)	<5.0				
Volatile Organic Compounds	Benzene (mg/L)	<0.00050				
	Ethylbenzene (mg/L)	<0.00050				
	Methyl t-butyl ether (MTBE) (mg/L)	<0.00050				
	Styrene (mg/L)	<0.00050				
	Toluene (mg/L)	<0.00045				
	ortho-Xylene (mg/L)	0.00136				
	meta- & para-Xylene (mg/L)	0.00175				

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

Reference Information

QC Samples with Qualifiers & Comments:

QC Type Description	Parameter	Qualifier	Applies to Sample Number(s)
Method Blank	Copper (Cu)-Total	MB-LOR	L2317254-1
Matrix Spike	Aluminum (Al)-Total	MS-B	L2317254-1
Matrix Spike	Barium (Ba)-Total	MS-B	L2317254-1
Matrix Spike	Calcium (Ca)-Total	MS-B	L2317254-1
Matrix Spike	Iron (Fe)-Total	MS-B	L2317254-1
Matrix Spike	Magnesium (Mg)-Total	MS-B	L2317254-1
Matrix Spike	Manganese (Mn)-Total	MS-B	L2317254-1
Matrix Spike	Silicon (Si)-Total	MS-B	L2317254-1
Matrix Spike	Sodium (Na)-Total	MS-B	L2317254-1
Matrix Spike	Strontium (Sr)-Total	MS-B	L2317254-1
Matrix Spike	Titanium (Ti)-Total	MS-B	L2317254-1

Qualifiers for Individual Parameters Listed:

Qualifier	Description
DLM	Detection Limit Adjusted due to sample matrix effects (e.g. chemical interference, colour, turbidity).
MB-LOR	Method Blank exceeds ALS DQO. Limits of Reporting have been adjusted for samples with positive hits below 5x blank level.
MS-B	Matrix Spike recovery could not be accurately calculated due to high analyte background in sample.

Test Method References:

ALS Test Code	Matrix	Test Description	Method Reference**
EC-SCREEN-VA	Water	Conductivity Screen (Internal Use Only)	APHA 2510

Qualitative analysis of conductivity where required during preparation of other tests - e.g. TDS, metals, etc.

MET-T-CCMS-VA	Water	Total Metals in Water by CRC ICPMS	EPA 200.2/6020A (mod)

Water samples are digested with nitric and hydrochloric acids, and analyzed by CRC ICPMS.

Method Limitation (re: Sulfur): Sulfide and volatile sulfur species may not be recovered by this method.

NH3-F-VA	Water	Ammonia in Water by Fluorescence	J. ENVIRON. MONIT., 2005, 7, 37-42, RSC

This analysis is carried out, on sulfuric acid preserved samples, using procedures modified from J. Environ. Monit., 2005, 7, 37 - 42, The Royal Society of Chemistry, "Flow-injection analysis with fluorescence detection for the determination of trace levels of ammonium in seawater", Roslyn J. Waston et al.

OGG-SF-VA	Water	Oil & Grease by Gravimetric	BCMOE (2010), EPA1664A

The procedure involves an extraction of the entire water sample with hexane. This extract is then evaporated to dryness, and the residue weighed to determine Oil and Grease.

PH-PCT-VA	Water	pH by Meter (Automated)	APHA 4500-H pH Value

This analysis is carried out using procedures adapted from APHA Method 4500-H "pH Value". The pH is determined in the laboratory using a pH electrode

It is recommended that this analysis be conducted in the field.

TSS-VA	Water	Total Suspended Solids by Gravimetric	APHA 2540 D - GRAVIMETRIC

This analysis is carried out using procedures adapted from APHA Method 2540 "Solids". Solids are determined gravimetrically. Total Suspended Solids (TSS) are determined by filtering a sample through a glass fibre filter, TSS is determined by drying the filter at 104 degrees celsius.
Samples containing very high dissolved solid content (i.e. seawaters, brackish waters) may produce a positive bias by this method. Alternate analysis methods are available for these types of samples.

VOC7-HSMS-VA	Water	BTEX/MTBE/Styrene by Headspace GCMS	EPA 5021A/8260C

The water sample, with added reagents, is heated in a sealed vial to equilibrium. The headspace from the vial is transfered into a gas chromatograph. Target compound concentrations are measured using mass spectrometry detection.

** ALS test methods may incorporate modifications from specified reference methods to improve performance.

The last two letters of the above test code(s) indicate the laboratory that performed analytical analysis for that test. Refer to the list below:

Laboratory Definition Code	Laboratory Location
VA	ALS ENVIRONMENTAL - VANCOUVER, BRITISH COLUMBIA, CANADA

Chain of Custody Numbers:

Reference Information

GLOSSARY OF REPORT TERMS

Surrogate - A compound that is similar in behaviour to target analyte(s), but that does not occur naturally in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery.
mg/kg - milligrams per kilogram based on dry weight of sample.
mg/kg wwt - milligrams per kilogram based on wet weight of sample.
mg/kg lwt - milligrams per kilogram based on lipid-adjusted weight of sample.
mg/L - milligrams per litre.
< - Less than.
D.L. - The reported Detection Limit, also known as the Limit of Reporting (LOR).
N/A - Result not available. Refer to qualifier code and definition for explanation.

Test results reported relate only to the samples as received by the laboratory.
UNLESS OTHERWISE STATED, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.
Analytical results in unsigned test reports with the DRAFT watermark are subject to change, pending final QC review.

Quality Control Report

Client: SABINA GOLD & SILVER CORP.
Suite 1800 - 555 Burrard St. Box 220
Vancouver BC V7X 1M7
Contact: Merle Keefe

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
MET-T-CCMS-VA	**Water**							
Batch R4730422								
WG3118023-2 LCS								
Aluminum (Al)-Total			103.9		%		80-120	30-JUL-19
Antimony (Sb)-Total			103.2		%		80-120	30-JUL-19
Arsenic (As)-Total			96.7		%		80-120	30-JUL-19
Barium (Ba)-Total			98.0		%		80-120	30-JUL-19
Beryllium (Be)-Total			94.8		%		80-120	30-JUL-19
Bismuth (Bi)-Total			94.9		%		80-120	30-JUL-19
Boron (B)-Total			92.9		%		80-120	30-JUL-19
Cadmium (Cd)-Total			99.6		%		80-120	30-JUL-19
Calcium (Ca)-Total			96.7		%		80-120	30-JUL-19
Cesium (Cs)-Total			102.6		%		80-120	30-JUL-19
Chromium (Cr)-Total			98.8		%		80-120	30-JUL-19
Cobalt (Co)-Total			98.4		%		80-120	30-JUL-19
Copper (Cu)-Total			97.2		%		80-120	30-JUL-19
Iron (Fe)-Total			98.8		%		80-120	30-JUL-19
Lead (Pb)-Total			96.4		%		80-120	30-JUL-19
Lithium (Li)-Total			93.1		%		80-120	30-JUL-19
Magnesium (Mg)-Total			98.1		%		80-120	30-JUL-19
Manganese (Mn)-Total			100.6		%		80-120	30-JUL-19
Molybdenum (Mo)-Total			93.5		%		80-120	30-JUL-19
Nickel (Ni)-Total			99.6		%		80-120	30-JUL-19
Phosphorus (P)-Total			100.5		%		80-120	30-JUL-19
Potassium (K)-Total			99.0		%		80-120	30-JUL-19
Rubidium (Rb)-Total			99.8		%		80-120	30-JUL-19
Selenium (Se)-Total			100.3		%		80-120	30-JUL-19
Silicon (Si)-Total			106.1		%		80-120	30-JUL-19
Silver (Ag)-Total			99.1		%		80-120	30-JUL-19
Sodium (Na)-Total			99.6		%		80-120	30-JUL-19
Strontium (Sr)-Total			97.5		%		80-120	30-JUL-19
Sulfur (S)-Total			101.2		%		80-120	30-JUL-19
Tellurium (Te)-Total			98.2		%		80-120	30-JUL-19
Thallium (Tl)-Total			94.9		%		80-120	30-JUL-19
Thorium (Th)-Total			100.9		%		80-120	30-JUL-19
Tin (Sn)-Total			100.5		%		80-120	30-JUL-19
Titanium (Ti)-Total			97.1		%		80-120	30-JUL-19

Quality Control Report

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
MET-T-CCMS-VA	**Water**							
Batch R4730422								
WG3118023-2 LCS								
Tungsten (W)-Total			97.3		%		80-120	30-JUL-19
Uranium (U)-Total			101.3		%		80-120	30-JUL-19
Vanadium (V)-Total			100.4		%		80-120	30-JUL-19
Zinc (Zn)-Total			95.0		%		80-120	30-JUL-19
Zirconium (Zr)-Total			94.6		%		80-120	30-JUL-19
WG3118023-1 MB								
Aluminum (Al)-Total			<0.0030		mg/L		0.003	30-JUL-19
Antimony (Sb)-Total			<0.00010		mg/L		0.0001	30-JUL-19
Arsenic (As)-Total			<0.00010		mg/L		0.0001	30-JUL-19
Barium (Ba)-Total			<0.00010		mg/L		0.0001	30-JUL-19
Beryllium (Be)-Total			<0.00010		mg/L		0.0001	30-JUL-19
Bismuth (Bi)-Total			<0.000050		mg/L		0.00005	30-JUL-19
Boron (B)-Total			<0.010		mg/L		0.01	30-JUL-19
Cadmium (Cd)-Total			<0.0000050		mg/L		0.000005	30-JUL-19
Calcium (Ca)-Total			<0.050		mg/L		0.05	30-JUL-19
Cesium (Cs)-Total			<0.000010		mg/L		0.00001	30-JUL-19
Chromium (Cr)-Total			<0.00010		mg/L		0.0001	30-JUL-19
Cobalt (Co)-Total			<0.00010		mg/L		0.0001	30-JUL-19
Copper (Cu)-Total			0.00127	MB-LOR	mg/L		0.0005	30-JUL-19
Iron (Fe)-Total			<0.010		mg/L		0.01	30-JUL-19
Lead (Pb)-Total			<0.000050		mg/L		0.00005	30-JUL-19
Lithium (Li)-Total			<0.0010		mg/L		0.001	30-JUL-19
Magnesium (Mg)-Total			<0.0050		mg/L		0.005	30-JUL-19
Manganese (Mn)-Total			<0.00010		mg/L		0.0001	30-JUL-19
Molybdenum (Mo)-Total			<0.000050		mg/L		0.00005	30-JUL-19
Nickel (Ni)-Total			<0.00050		mg/L		0.0005	30-JUL-19
Phosphorus (P)-Total			<0.050		mg/L		0.05	30-JUL-19
Potassium (K)-Total			<0.050		mg/L		0.05	30-JUL-19
Rubidium (Rb)-Total			<0.00020		mg/L		0.0002	30-JUL-19
Selenium (Se)-Total			<0.000050		mg/L		0.00005	30-JUL-19
Silicon (Si)-Total			<0.10		mg/L		0.1	30-JUL-19
Silver (Ag)-Total			<0.000010		mg/L		0.00001	30-JUL-19
Sodium (Na)-Total			<0.050		mg/L		0.05	30-JUL-19
Strontium (Sr)-Total			<0.00020		mg/L		0.0002	30-JUL-19

Quality Control Report

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
MET-T-CCMS-VA	**Water**							
Batch R4730422								
WG3118023-1 MB								
Sulfur (S)-Total			<0.50		mg/L		0.5	30-JUL-19
Tellurium (Te)-Total			<0.00020		mg/L		0.0002	30-JUL-19
Thallium (Tl)-Total			<0.000010		mg/L		0.00001	30-JUL-19
Thorium (Th)-Total			<0.00010		mg/L		0.0001	30-JUL-19
Tin (Sn)-Total			<0.00010		mg/L		0.0001	30-JUL-19
Titanium (Ti)-Total			<0.00030		mg/L		0.0003	30-JUL-19
Tungsten (W)-Total			<0.00010		mg/L		0.0001	30-JUL-19
Uranium (U)-Total			<0.000010		mg/L		0.00001	30-JUL-19
Vanadium (V)-Total			<0.00050		mg/L		0.0005	30-JUL-19
Zinc (Zn)-Total			<0.0030		mg/L		0.003	30-JUL-19
Zirconium (Zr)-Total			<0.00020		mg/L		0.0002	30-JUL-19
NH3-F-VA	**Water**							
Batch R4728645								
WG3117026-2 LCS								
Ammonia, Total (as N)			96.6		%		85-115	27-JUL-19
WG3117026-1 MB								
Ammonia, Total (as N)			<0.0050		mg/L		0.005	27-JUL-19
WG3117026-4 MS		**L2317254-1**						
Ammonia, Total (as N)			96.2		%		75-125	27-JUL-19
OGG-SF-VA	**Water**							
Batch R4731076								
WG3118783-2 LCS								
Oil and Grease			101.3		%		70-130	30-JUL-19
WG3118783-1 MB								
Oil and Grease			<5.0		mg/L		5	30-JUL-19
TSS-VA	**Water**							
Batch R4730304								
WG3118197-3 DUP		**L2317254-1**						
Total Suspended Solids		<3.0	<3.0	RPD-NA	mg/L	N/A	20	29-JUL-19
WG3118197-2 LCS								
Total Suspended Solids			96.3		%		85-115	29-JUL-19
WG3118197-1 MB								
Total Suspended Solids			<3.0		mg/L		3	29-JUL-19
VOC7-HSMS-VA	**Water**							

Quality Control Report

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
VOC7-HSMS-VA	**Water**							
Batch R4720762								
WG3119130-3 DUP		**L2317254-1**						
Benzene		<0.00050	<0.00050	RPD-NA	mg/L	N/A	30	30-JUL-19
Ethylbenzene		<0.00050	<0.00050	RPD-NA	mg/L	N/A	30	30-JUL-19
Methyl t-butyl ether (MTBE)		<0.00050	<0.00050	RPD-NA	mg/L	N/A	30	30-JUL-19
Styrene		<0.00050	<0.00050	RPD-NA	mg/L	N/A	30	30-JUL-19
Toluene		<0.00045	<0.00045	RPD-NA	mg/L	N/A	30	30-JUL-19
meta- & para-Xylene		0.00175	0.00173		mg/L	1.1	30	30-JUL-19
ortho-Xylene		0.00136	0.00138		mg/L	1.7	30	30-JUL-19
WG3119130-2 LCS								
Benzene			96.8		%		70-130	30-JUL-19
Ethylbenzene			95.3		%		70-130	30-JUL-19
Methyl t-butyl ether (MTBE)			99.5		%		70-130	30-JUL-19
Styrene			89.4		%		70-130	30-JUL-19
Toluene			114.1		%		70-130	30-JUL-19
meta- & para-Xylene			99.8		%		70-130	30-JUL-19
ortho-Xylene			92.5		%		70-130	30-JUL-19
WG3119130-1 MB								
Benzene			<0.00050		mg/L		0.0005	30-JUL-19
Ethylbenzene			<0.00050		mg/L		0.0005	30-JUL-19
Methyl t-butyl ether (MTBE)			<0.00050		mg/L		0.0005	30-JUL-19
Styrene			<0.00050		mg/L		0.0005	30-JUL-19
Toluene			<0.00045		mg/L		0.00045	30-JUL-19
meta- & para-Xylene			<0.00050		mg/L		0.0005	30-JUL-19
ortho-Xylene			<0.00050		mg/L		0.0005	30-JUL-19

Quality Control Report

Legend:

Limit	ALS Control Limit (Data Quality Objectives)
DUP	Duplicate
RPD	Relative Percent Difference
N/A	Not Available
LCS	Laboratory Control Sample
SRM	Standard Reference Material
MS	Matrix Spike
MSD	Matrix Spike Duplicate
ADE	Average Desorption Efficiency
MB	Method Blank
IRM	Internal Reference Material
CRM	Certified Reference Material
CCV	Continuing Calibration Verification
CVS	Calibration Verification Standard
LCSD	Laboratory Control Sample Duplicate

Sample Parameter Qualifier Definitions:

Qualifier	Description
MB-LOR	Method Blank exceeds ALS DQO. Limits of Reporting have been adjusted for samples with positive hits below 5x blank level.
RPD-NA	Relative Percent Difference Not Available due to result(s) being less than detection limit.

Quality Control Report

Hold Time Exceedances:

ALS Product Description	Sample ID	Sampling Date	Date Processed	Rec. HT	Actual HT	Units	Qualifier
Physical Tests							
pH by Meter (Automated)							
	1	25-JUL-19 09:30	28-JUL-19 10:44	0.25	73	hours	EHTR-FM

Legend & Qualifier Definitions:

EHTR-FM:	Exceeded ALS recommended hold time prior to sample receipt. Field Measurement recommended.
EHTR:	Exceeded ALS recommended hold time prior to sample receipt.
EHTL:	Exceeded ALS recommended hold time prior to analysis. Sample was received less than 24 hours prior to expiry.
EHT:	Exceeded ALS recommended hold time prior to analysis.
Rec. HT:	ALS recommended hold time (see units).

Notes*:
Where actual sampling date is not provided to ALS, the date (& time) of receipt is used for calculation purposes.
Where actual sampling time is not provided to ALS, the earlier of 12 noon on the sampling date or the time (& date) of receipt is used for calculation purposes. Samples for L2317254 were received on 25-JUL-19 11:45.

ALS recommended hold times may vary by province. They are assigned to meet known provincial and/or federal government requirements. In the absence of regulatory hold times, ALS establishes recommendations based on guidelines published by the US EPA, APHA Standard Methods, or Environment Canada (where available). For more information, please contact ALS.

The ALS Quality Control Report is provided to ALS clients upon request. ALS includes comprehensive QC checks with every analysis to ensure our high standards of quality are met. Each QC result has a known or expected target value, which is compared against pre-determined data quality objectives to provide confidence in the accuracy of associated test results.

Please note that this report may contain QC results from anonymous Sample Duplicates and Matrix Spikes that do not originate from this Work Order.

ALS Environmental
www.alsglobal.com

Chain of Custody (COC) / Analytical Request Form

Canada Toll Free: 1 800 668 9878

Affix ALS barcode label here (lab use only)

COC Number: 15 - 584906

Page of

Report To	Contact and company name below will appear on the final report
Company:	Sabina Gold : Silver Corp
Contact:	Merle Keefe
Phone:	604 - 240 - 6619
	Company address below will appear on the final report
Street:	1800 - 555 Burrard St.
City/Province:	Vancouver, BC
Postal Code:	V7X 1M7
Invoice To	Same as Report To ☒ YES ☐ NO
	Copy of Invoice with Report ☒ YES ☐ NO
Company:	Sabina " " "
Contact:	Accounts Payable

Report Format / Distribution	
Select Report Format:	☒ PDF ☒ EXCEL ☐ EDD (DIGITAL)
Quality Control (QC) Report with Report	☐ YES ☒ NO
☐ Compare Results to Criteria on Report - provide details below if box checked	
Select Distribution:	☒ EMAIL ☐ MAIL ☐ FAX
Email 1 or Fax	mKeefe@sabinagoldsilver.com
Email 2	
Email 3	
Invoice Distribution	
Select Invoice Distribution:	☒ EMAIL ☐ MAIL ☐ FAX
Email 1 or Fax	mKeefe@ " " "
Email 2	accountspayable@sabinagoldsilver.com

Select Service Level Below - Please confirm all E&P TATs with your AM - surcharges will apply

Regular [R] ☐ Standard TAT if received by 3 pm - business days - no surcharges apply

PRIORITY (Business Days): 4 day [P4] ☐ 3 day [P3] ☐ 2 day [P2] ☐

EMERGENCY: 1 Business day [E1] ☒ Same Day, Weekend or Statutory holiday [E0] ☐

Date and Time Required for all E&P TATs:

For tests that can not be performed according to the service level selected, you will be contacted.

Project Information	
ALS Account # / Quote #:	
Job #:	
PO / AFE:	
LSD:	
ALS Lab Work Order # (lab use only)	L2317254

Oil and Gas Required Fields (client use)	
AFE/Cost Center:	PO#
Major/Minor Code:	Routing Code:
Requisitioner:	
Location:	
ALS Contact:	Sampler:

Analysis Request

Indicate Filtered (F), Preserved (P) or Filtered and Preserved (F/P) below

ALS Sample # (lab use only)	Sample Identification and/or Coordinates (This description will appear on the report)	Date (dd-mmm-yy)	Time (hh:mm)	Sample Type	pH	TSS	Oil: Grease	MET-T-CCMS-VA	VOC7-HSMS-VA	Ammonia	Number of Containers
	MLA Fuel Berm 8	25-Jul-19	09:30	H_2O	X	X	X	X	X	X	7

L2317254-COFC

Drinking Water (DW) Samples[1] (client use)	Special Instructions / Specify Criteria to add on report by clicking on the drop-down list below (electronic COC only)
Are samples taken from a Regulated DW System? ☐ YES ☐ NO	
Are samples for human drinking water use? ☐ YES ☐ NO	

SIF Observations: Frozen ☐ Ice Packs ☐ Ice Cubes ☐ Cooling Initiated ☐ Custody seal intact Yes ☐ No ☐

INITIAL COOLER TEMPERATURES °C: 14.9 16.6

FINAL COOLER TEMPERATURES °C:

SHIPMENT RELEASE (client use)			INITIAL SHIPMENT RECEPTION (lab use only)			FINAL SHIPMENT RECEPTION (lab use only)		
Released by: Merle Keefe	Date: 25-Jul-19	Time: 12:00	Received by: Mikhail	Date: July 25/19	Time: [illegible]	Received by:	Date:	Time:

REFER TO BACK PAGE FOR ALS LOCATIONS AND SAMPLING INFORMATION WHITE - LABORATORY COPY YELLOW - CLIENT COPY

Failure to complete all portions of this form may delay analysis. Please fill in this form LEGIBLY. By the use of this form the user acknowledges and agrees with the Terms and Conditions as specified on the back page of the white - report copy.

1 If any water samples are taken from a **Regulated Drinking Water (DW) System**, please submit using an **Authorized DW COC form**.

GENERAL TERMS AND CONDITIONS:

These terms and conditions are incorporated in and form part of the Agreement between ALS Group's Environmental Division and the party named in the Offer (the "Client").

1. Definitions. Capitalized Terms not defined in these Terms and Conditions have the definitions set out in the other Agreement documents.
2. The Services. ALS will provide the Services to the Client as described in the Offer and in any chain of custody form provided with any sample.
3. Prices. ALS may review and change all prices, fees, surcharges or other charges set out in the Agreement if there are changes to ALS's cost beyond ALS's control, including changes in legislative requirements, Client variations of sample numbers and Client requests for changes to standard reporting requirements. Notwithstanding Condition 3, all quotations are reviewed and updated on a yearly basis or expire after one year.
4. Payment Terms. The Client shall pay ALS within 30 days of the invoice date OAC. ALS may, for reasonable business reasons, require the Client to arrange for payment in advance.
5. Quotation Numbers. The Client shall provide the quotation number to ALS (where applicable) to ensure correct pricing.
6. Taxes. Applicable taxes are not included in prices - surcharges and additional fees will be added at the time of invoicing.
7. Quality Control. ALS has an extensive QA/QC program. Clients' samples are analyzed using approved, referenced procedures followed by thorough data validation prior to reporting the analytical results.
8. Test Results are Not Guaranteed. Results are obtained from analytical measurements that are subject to inherent variability. Measurement results reflect characteristics of submitted test samples at time of analysis. The Client is responsible for informing itself on the limitation of test results and acknowledges that test results are not guaranteed.
9. Standard of Care. ALS will use reasonable care and diligence as required by the laws of the province or territory where the sample is tested.
10. Storage. Where possible, ALS will store samples for 30 days from the date a final report is issued to the Client, after which ALS may discard the samples.
11. Holds. If the Client requests a sample to be placed on hold, ALS will store the sample for 30 days from date of receipt, after which ALS will invoice the Client and discard the sample. Longer hold periods are available upon request.
12. Archives. If the Client requests a sample be archived, ALS will invoice in advance and store the sample for the period requested, after which ALS may discard the sample.
13. Handling Protocol. Legal sample handling protocol must be arranged before samples are collected. ALS charges a surcharge on the list price plus the hourly technologist or chemist rates for legal sample protocol. Additional charges will apply for samples that require storage by ALS.
14. Samples. The quality, condition, content and source of samples stored and tested are not known to ALS except as declared and described on the chain of custody form completed and submitted by the Client and accompanying the sample.
15. Risk of Loss. ALS will use reasonable care to protect samples during storage, however all samples are stored at the Client's risk and the Client is responsible for obtaining appropriate insurance, if desired. The Client acknowledges that during the performance of the Services samples may be altered, lost, damaged or destroyed and the Client releases ALS from any claim the Client may have for any loss or damage to the sample.
16. Environmental. The Client must comply with all applicable environment legislation, including labeling all hazardous samples to comply with WHMIS and TDG regulations, and must provide appropriate Safety Data Sheets (previously referred to as 'MSDS") that include the nature of the hazard and a contact name and phone number to call for information. The Client will indemnify ALS for all loss or damages, including any fine or cost of complying with an order of any government authority, resulting from the Client's breach of this paragraph.
17. Hazardous Materials Disposal. ALS may return, at the Client's cost, hazardous material to the Client for disposal.
18. Hazardous Materials Surcharge. ALS may apply an additional surcharge for handling of hazardous samples or samples with Naturally Occurring Radioactive Materials (NORM), H_2S, CN, etc.
19. Sample Containers. ALS may ship sample containers to the Client's location by the most cost effective means using ALS preferred courier suppliers, within the specified project timeline.
20. Additional Charges. ALS may charge the Client (a) its cost for emergency bottle shipments and shipments to and from a remote site, and (b) where pick up and delivery services are provided, subject in each instance to a minimum charge of $25.00.
21. Re-Tests. ALS reserves the right to re-test any samples that remain in its possession. Re-tests requested by the Client may be charged.
22. Waiver. The Client is responsible for making any assessment regarding the suitability of the Services and the intended results for the Client's purposes and waives any claims against ALS it may have as a result of the interpretation of the results. The Client shall indemnify ALS for all claims made by any third party against ALS in respect of all losses however arising from the performance of the Services or the use of any report provided in the performance of the Services.
23. Limitation of Liability. In no event shall ALS be liable for any consequential, indirect, incidental, special, exemplary or punitive damages, whether foreseeable or unforeseeable, (including claims for loss of profits or revenue or losses caused by stoppage of other work or impairment of other assets) incurred by the Client arising out of breach or failure of express or implied warranty, breach of contract, breach of warranty, misrepresentation, negligence, strict liability in tort or otherwise. In any event, the liability of ALS to the Client shall be limited to the cost of testing the sample as requested in the chain of custody form under which the sample was originally deposited. For the purposes of this paragraph and paragraphs 8, 15, 16, 22 and 24, as the applicable, "ALS" includes without limitations its directors, officers, employees and affiliates and the "Client" includes without limitation any third party that may have a claim against ALS through the Client.
24. Notice of Liability. Notwithstanding paragraph 23, ALS shall not be liable to the Client unless the Client provides notice in writing to ALS of such loss or damage, together with full particulars thereof, within 30 days of the Client's receipt of the report of the analysis of the sample giving rise to such liability. The provisions of this paragraph allocate the risk under the Agreement between the Client and ALS, and the fees to be paid by the Client to ALS reflect this allocation of risks and the limitations of liability in this Agreement.
25. Entire Agreement. The Agreement is the entire agreement between the parties and supersedes and takes precedence over any terms and conditions contained in any documentation provided by the Client. ALS's execution of any subsequent documentation from the Client only acknowledges receipt and not acceptance of any terms or conditions therein. If there is a conflict between these terms and conditions and any other Agreement document, these terms and conditions prevail.
26. Term. Providing the first batch of samples to which this tender refers is submitted within three months of the starting date of this quotation, the following prices, terms and conditions will remain firm until the closing date. This offer and terms and conditions will automatically lapse if the offer has not been accepted and samples not delivered to ALS within the Closing Date.
27. Termination. (a) Either party may terminate this Agreement for any reason by giving the other party thirty (30) days written notice (Notice Period).(b) If the Agreement is terminated pursuant to clause (a), then the Client must pay ALS for all Services performed up to the expiry of the Notice Period.

Appendix G Back River Project Incinerator Management Plan

BACK RIVER PROJECT
Incineration Management Plan

July 2019

BACK RIVER PROJECT

INCINERATION MANAGEMENT PLAN

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Revision Log

Date	Section	Page	Revision	Prepared by:
December 2013	All	All	Original document prepared in support of Final Environmental Impact Statement (FEIS)	Sabina Gold and Silver Corp. (Sabina)
October 2017	All	All	Minor revisions for submission as supporting document for Type A Water Licence Application=	Sabina
July 2019	All	All	Full update of document following issuance of NIRB Project Certificate No. 007 and NWB Water Licence 2AM-BPR-1831 and prior to initiation of Project Construction	Katsky Venter on behalf of Sabina

Sabina Representative Responsible for this Plan Update:	Merle Keefe
Department:	Environment & Sustainability
Title:	Manager, Environmental Permitting
Date:	
Signature:	

Sabina Representative Responsible for Review and Approval of this Update:	Matthew Pickard
Department:	Environment & Sustainability
Title:	Vice President – Environment & Sustainability
Date:	
Signature:	

Distribution List: Organization/Department

NIRB

KIA

Acronyms

CCME	Canadian Council of Ministers of the Environment
EC	Environment Canada
GHG	Greenhouse Gas
GN	Government of Nunavut
IMP or Plan	Incineration Management Plan
MAD	Main Application Document
MLA	Marine Laydown Area
Project	Back River Project
Sabina	Sabina Gold & Silver Corp.
QA	Quality Assurance
QC	Quality Control
WIR	Winter Ice Road

Executive Summary

This Plan describes the waste management processes at the Back River Project relevant to on site incineration. This Plan ensures that 1) only appropriate burnable material enters the incinerator waste stream, 2) animal attractants are promptly incinerated or safely stored, 3) the incinerator is operated in a manner that reduces harmful emissions, 4) residual ash is handled and disposed of properly, and 5) that all compliance monitoring and reporting associated with incinerator operations occurs.

1. Introduction

The Back River Project (the Project) is a gold project owned by Sabina Gold & Silver Corp. (Sabina) within the West Kitikmeot region of southwestern Nunavut. It is situated approximately 400 kilometres (km) southwest of Cambridge Bay, 95 km southeast of the southern end of Bathurst Inlet, and 520 km northeast of Yellowknife, Northwest Territories. The Project is located predominantly within the Queen Maud Gulf Watershed (Nunavut Water Regulations, Schedule 4).

The Project is comprised of two main areas, Goose Property and the Marine Laydown Area (MLA) with interconnecting winter ice roads. The majority of annual resupply will be completed using the MLA situated along the western shore of southern Bathurst Inlet, which is connected seasonally to Goose via an approximately 160 km long winter ice road.

The Incineration Management Plan (IMP or Plan) outlines the approach for managing waste appropriate for incineration at both the MLA in southern Bathurst Inlet and at the Goose Property. These measures demonstrate how Sabina will avoid, minimize, mitigate and/or manage to an acceptable level, the potential adverse effects on the environment associated with waste incineration.

The Plan was prepared following the requirements of the Nunavut Impact Review Board (NIRB) to Sabina (NIRB 2013), Project Certificate No. 007, Water Licence 2AM-BRP1831, and in accordance with best management practices and in conformance with current Federal and Territorial statutory requirements.

This plan is a living document to be updated upon changes in related regulatory requirements, management reviews, incident investigations, changes to facility operation or maintenance, and environmental monitoring results, best practice updates or other Project specific protocols once construction starts through to Project closure activities. Any updates will be filed with the Annual Report submitted to the NIRB in accordance with Project Certificate No.007 and the Nunavut Water Board (NWB) in accordance with Water Licence 2AM-BRP1831.

The information presented herein is current as of July 2019. The Plan will be reviewed as needed for changes in operation and technology and as directed by regulators where appropriate. Completion of the updated Plan will be documented through signatures of the personnel responsible for reviewing, updating, and approving the Plan

2. Scope and Objectives

The IMP is one of the documents that forms part of Sabina's overall Waste Management Program for the Project. This plan addresses requirements of the Type A Water Licence 2AM-BRP1831 as well as Project Certificate No. 007 and applies to all Sabina projects in the Kitikmeot region.

This plan is divided into the following components:

- Applicable Legislation and Guidelines (Section 3);
- Planning and Implementation (Section 4);
- Roles and Responsibilities (Section 5);
- Operational and Maintenance (Section 6);
- Environmental Protection Measures (Section 7);
- Monitoring (Section 8);
- Record Keeping (Section 9);
- Environmental Reporting (Section 10);
- Adaptive Management (Section 11); and
- Reclamation (Section 12).

Incineration is an essential part of waste management at the Back River site. The incineration of acceptable solid waste from the accommodation complex, kitchen, lunch rooms, shops, warehouses, and offices minimizes accumulation of wildlife attractants and will divert waste transported off-site and from the on-site landfill once constructed. Sewage sludge from the planned sewage treatment plant at the Goose Property will also be incinerated, as is any Pacto waste generated (i.e. human waste from waterless toilets). Incineration has the advantage of eliminating waste that could potentially attract wildlife to the Project and landfill, thereby reducing possible interactions between humans and wildlife.

Waste products are safely managed from the time they are produced to their final disposal. Reduce, reuse, and recycle initiatives, as well as a waste segregation program are used to minimize the quantity of waste incinerated or directed to the landfill. Waste that is deemed unsuitable for incineration, including hazardous materials, will be handled appropriately as per the Landfill and Waste Management Plan and Hazardous Materials Management Plan.

By implementation of the waste management program and selection of appropriately designed incinerators incineration practices will comply with air quality requirements for the protection of the environment and human health.

The objectives of incineration management through all phases of the Project are to:

1. Characterize the quantity and composition of the waste products to be generated at the Back River site, and effectively separate wastes acceptable for incineration from waste that is not;
2. Select appropriate batch waste incinerators based on the characteristics and quantity of waste;

3. Locate incinerators at appropriate sites and set back an appropriate distance from other infrastructure;
4. Operate incinerators to achieve optimal combustion and avoid the formation of dioxins, furans, and mercury in the combustion process;
5. Implement incinerator operational practices and to document frequency and incinerator operating parameters, including the safe handling and disposal of incinerator residues; and
6. Demonstrate compliance with applicable Federal and Territorial regulations for environmental protection.

2.1 RELATED DOCUMENTS

This Plan is intended for use in conjunction with the following Plans:

- Air Quality Monitoring and Management Plan;
- Environmental Management and Protection Plan;
- Landfill and Waste Management Plan;
- Hazardous Materials Management Plan;
- Risk Management and Emergency Response Plan;
- Spill Contingency Plan; and
- Fuel Management Plan.

3. Applicable Legislation and Guidelines

Federal and Territorial legislation that is applicable to solid waste incineration management in Nunavut is presented in Table 3-1.

Provincial and/or territorial regulations that pertain to emissions from incinerators are not available for Nunavut or the Northwest Territories. Therefore, performance limits for Project incinerators will be in accordance with the emission guidelines set out by the Canadian Council of Ministers of the Environment (CCME): Canada-Wide Standard for Dioxins and Furans (CCME 2001), and Canada-Wide Standards for Mercury Emissions (CCME 2000).

Ash produced from the incineration process will be disposed of in accordance with the Nunavut Environmental Guideline for Industrial Waste Discharges (GN 2011b).

Table 3-1. Applicable Legislation to the Incineration Management Plan

Acts	Regulations	Guidelines
Federal		
Canadian Environmental Protection Act (CEPA 1999 c.33)	Schedule 1: List of Toxic Substances Interprovincial Movement of Hazardous Waste and Hazardous Recyclable Material Regulations (SOR/2002-301)	Environment Canada (EC) Technical Document for Batch Waste Incineration (EC 2010) Canada-Wide Standards for Dioxins and Furans (CCME 2001) Canada-Wide Standards for Mercury (CCME 2000)
Hazardous Products Act	Controlled Products Regulations	Workplace Hazardous Materials Information System (WHMIS 2015)
Territorial – Nunavut		
Nunavut Environmental Protection Act		Environmental Guideline for Industrial Waste Discharges into Municipal Solid Waste and Sewage Treatment Facilities (GN 2011b) Environmental Guidelines for the Burning and Incineration of Solid Waste (GN 2012a) Environmental Guidelines for Ambient Air Quality (GN 2011a) Environmental Guideline for Mercury-Containing Products and Waste Mercury (GN 2010) Environmental Guideline for Used Oil and Waste Fuel (GN 2012b)

Additionally, the NIRB Project Certificate No. 007 condition 4 states that *"The Proponent shall develop and implement an Incineration Management Plan that demonstrates consideration for the recommendations provided in Environment and Climate Change Canada's Technical Document for Batch Waste Incineration (2010)."* Additional commentary related to Condition 4 indicates that:

> *"The initial Incineration Management Plan must be submitted to the Nunavut Impact Review Board at least 60 days prior to the commencement of construction and must be tested within the first year of operations.*
>
> *Subsequently, unless otherwise directed by Environment and Climate Change Canada, every (3) three years the Proponent shall provide the Nunavut Impact Review Board with confirmation of any changes to the Proponent's Incineration Management Plan in the Proponent's annual report to the Nunavut Impact Review Board."*

The Incineration Management Plan is also a plan applicable to NWB Water Licence 2AM-BRP1831, where the incinerators are defined as being of a "*controlled-air, batch, dual chamber incinerator*" type.

4. Planning and Implementation

4.1 INCINERATOR SELECTION

The Project will select and operate incinerators based on Environment Canada's Technical Document for Batch Waste Incineration (EC 2010). Typical modern, controlled-air, batch, dual chamber incinerators are designed using the principles of pyrolysis (starved-air burning condition) in the primary chamber and complete oxidation (high temperature, excess oxygen, and sufficient combustion time) in the secondary chamber. The incineration system will be a two-stage process. In the first stage, waste will be converted to gas in the primary chamber at approximately 650 to 850 degrees Celsius (°C). This process will be self-fueling until the volume is reduced by 90%. Gasses from the primary chamber will enter the secondary chamber of oxygen-rich and turbulent conditions, which is typically at a higher temperature of approximately 1000°C. Combustion will be complete after a retention time of about two seconds. The temperature of combustion gases exiting the stack is anticipated to exceed 700°C and to flash cool in the ambient air, thereby leaving little opportunity for the de novo synthesis of dioxins/furans. Heat capture will not be used on the exhaust gases.

Critical process parameters, such as temperature, air flow, and burner output will be computer-controlled to maintain optimal combustion conditions.

A controlled-air, batch, dual chamber Ketek CY-100-CA-D incinerator has been purchased for use at the Goose Property and will be installed and commissioned during Project construction. The existing incinerator at Goose, a Ketek CY-50-CA, will continue to be used at Goose until that time, at which point it will be transferred to the MLA to upgrade from the existing Firelake MFG Model # A850X-20 incinerator. Both the CY-100 and the CY-50-CA incinerators meet the selection criteria described above. Operational manuals for the Ketek incinerators are provided in Appendix A and B of this Plan.

4.2 INCINERATOR LOCATIONS

The incinerators at both the Goose Property and the MLA will continue to be located more than 31 meters from any waterbody and are equipped with sufficient secure storage and workspace to allow waste drop off and sorting in one location and to prevent wildlife access to food scraps.

5. Roles and Responsibilities

The Construction Manager is ultimately responsible for the success and implementation of this plan including overall operator training, operation, adaptive management, operational record keeping and execution of stack testing.

The Manager, Environmental Permitting is responsible for the development and revision of this Plan, waste management audits, coordination of stack tests and compliance reporting.

Other relevant personnel designated by the Construction Manager or Environmental Permitting Manager which may be responsible for incineration management will be require to complete and maintain compliance with appropriate training requirements as defined in this plan, Sabina's Standard Operating Procedures, current Best Management Practices, and applicable Health and Safety Laws and Regulations.

5.1 TRAINING

Incinerator operators complete a training program prior to commencement of incinerator operation. This training includes recommendations presented in Environment Canada's Technical Document for Batch Waste Incineration (2010) and has been developed in conjunction with the training manual provided by the incinerator supplier.

The training program educates operators in the following areas:

- hazard recognition and safety protocols;
- identification of waste types and understanding of how waste composition affects operation;
- incinerator start-up and operating procedures, including identification of adjustments to increase operating efficiency;
- incinerator clean-out and maintenance procedures; and
- record keeping and reporting requirements.

Initial operator training on a new incinerator is provided by a qualified technician experienced in the operation of controlled-air, batch, dual chamber incinerators in compliance with regulatory guidelines. The incineration process of this incinerator is automated and requires minimal attendance during operation. A computerized incinerator will typically require one operator to interact with the equipment for approximately 1 to 1.5 hours per day, largely for ash removal, loading, and start-up. Each incinerator will be designed, installed, and operated so that the operators are not exposed to high temperatures during loading or ash removal in accordance with the complete cool down after each burn cycle.

6. Operation and Maintenance

This section provides general guidance and standard operating procedures for the operation of the incinerator. The incinerator operator is to refer to the operational manual provided by the manufacturer for specific instructions and optimal operating conditions for each incinerator. A full set of incinerator operating procedures will be developed in consultation with the supplier/manufacturer prior to use of a new incinerator. The Standard Operating Procedures shall include the following general procedures:

- Waste sorting on the basis of origin and heating value. Food waste and waste that has been in contact with food will have priority for incineration.
- Waste mixing to ensure a calorific value within incinerator specifications and to achieve good combustion inside the primary chamber.
- The operator will observe the start of the burn cycle for at least 15 minutes to ensure incinerators are operating correctly, and the primary and secondary chambers operate in the temperature ranges specified by the manufacturer.
- Incinerator doors will only be opened after the burn cycle is complete and the unit is fully cooled.

Ash disposal procedures are provided in Section 6.2.1.

Operation of the incinerators will be conducted in accordance with Environment Canada's Technical Document for Batch Waste Incineration (EC 2010). Additional acts, regulations, and guidelines applicable to the operation of the incinerators are listed in Section 3.

Key operational control procedures that will help maintain good operation of the incinerator are provided in the following sections.

6.1 WASTE STREAM MANAGEMENT

Only authorized waste may be incinerated. Table 6.1-1 provides a list of waste that is considered acceptable for incineration and examples of waste that is considered unacceptable. To facilitate the initial sorting of material, waste will be collected in transparent bags so that the contents are readily visible. Verification of correct sorting and mixing procedures will be ensured by periodic spot checks and Quality Assurance (QA)/Quality Control (QC) management by a trained staff member.

Table 6.1-1. Waste Classification for Incineration

Acceptable Wastes for Incineration	Unacceptable Wastes for Incineration
• organic matter including food; • food containers and packaging, including plastics that are contaminated by food; • untreated wood including lumber and plywood; • medical waste from the Health Care Station; • paper, cardboard; • painted wood except wood painted with lead or PCB-amended paint • hydrocarbon spill absorbents; • plastic and Styrofoam, except plastic containing chlorine; • dead animals; • used oils and waste fuel; • Pacto waste; and • dewatered sewage sludge from the Goose Site Sewage Treatment Plant.	• chlorinated plastics; • inert materials, such as concrete, bricks, ceramics, ash; • machinery parts or large metal goods (i.e., appliances); • radioactive materials, such as smoke detectors; • potentially explosive materials, such as propane tanks, other pressurized vessels, unused or ineffective explosives; • hazardous materials such as organic chemicals (pesticides), other toxic substances (arsenic, cyanide); • electronics and/or batteries; • asbestos; • dry wall; vehicles and machinery; • fluorescent light bulbs; • whole tires; • paints and solvents; any materials containing mercury; and • any other wastes not considered ‘acceptable’.

6.1.1 Waste Volumes

Quantity of waste incinerated will be recorded by batch in kg and as an estimate of volume in cubic meters.

6.2 INCINERATOR OPERATION

Each day, the Primary Chamber should be loaded to design capacity or, at a minimum, to half capacity with waste types and quantities conducive to a clean burn. If waste quantities are not sufficient to operate the machine daily, the waste may temporarily be stored in a secure area, such as a seacan, to prevent wildlife access. A front-end loader may be used to manually load feed waste.

Once loading is complete, the door should be sealed shut and the Secondary Chamber fired. The system is interlocked so that Primary Chamber waste is not allowed to combust until the Secondary Chamber is at operating temperature.

The system will complete the burn-cycle and cool-down phases automatically. Based on the waste quantity and description, the burn-cycle is expected to occur over 5 - 10 hours depending on system size, but could be longer depending on waste characteristics, to allow for thorough burn down. The cool-down phase that automatically follows is generally also 5 to 10 hours.

Upon completion of the cool-down phase, the operator will open the Primary Chamber door and clean out the ash. Incinerator doors should only be opened after the burn cycle is complete and the unit is completely cooled.

The complete system is automated from start to finish, however, after loading the waste, the operator is required to remain present to supervise the beginning of the process (start-up), generally the first hour of the burn. The operator should check that the primary and secondary chambers operate in the temperature ranges specified by the manufacturer. The entire process is controlled by computer in the Main Control Panel. The Operator can see the status of all the critical components and parameters, such as temperature, air flow, and burner output in addition to any malfunction alarms.

6.2.1 Ash Disposal

Incinerator ash should be handled and disposed of appropriately, following these steps:

- Ash is removed from each incinerator before it is charged with the next load of waste to be incinerated.
- Incinerator ash is packaged in labelled drums or sacks and the whole container landfilled, minimizing wind-blown effects.
- The concentration of trace metals will be tested as per the Government of Nunavut's Environmental Guidelines for Industrial Waste Discharges (GN 2011b) for on-site disposal.
- Ash exceeding the above standard will be handled as per the Hazardous Materials Management Plan.
- Ash generated at Goose Property and MLA and meeting the standard will be disposed in the on-site landfill at Goose or be back-hauled off side for disposal.
- Containers of ash will be labelled in a manner to ensure ash sampling results can be traced back to specific containers/incineration batch(es) of concern, in case results indicate landfilling is not appropriate.

6.2.2 Odour and Dust Control

Current state of the art incinerators are designed with a non-turbulent atmosphere in the primary burn chamber which reduces the formation of particulate matter. Additional dust or odour control is therefore not anticipated. Ash residues generated in the primary chamber will be manually removed and packaged in a drum or sack before being disposed of in the on-site landfill, thus eliminating wind-blown effects.

6.2.3 Used Oil and Waste Fuel

The incinerator will be capable of efficiently and safely burning oil and waste fuel. Sabina will manage used oil and waste fuel according to the Environmental Guideline for Used Oil and Waste Fuel (GN 2012b). The regulations stipulate the maximum level of contaminants in used oil that is allowed for incineration. Specifics of the used oil and waste fuel regulations are referenced in the Fuel Management Plan.

6.3 CONTINGENCIES

In the event of an incinerator breakdown, the operator should consult the manufacturer-provided operations manual to try and diagnose the cause. A local technician should be contacted for assistance if needed. The operator should assess the likely downtime of the incinerator and alternative disposal and/or secure waste storage methods should be implemented until the incinerator is repaired. Contingency or alternative waste storage procedures to be implemental until the incinerator is repaired, which are dependent on the length of incinerator down time may include:

- short-term shutdown of incinerator will be mitigated through temporary storage in sealed, wildlife-proof containers;

- long-term shutdown of incinerator will require backhauling to an operational on-site incinerator or off-site disposal by a waste services provider; and
- food waste would be prioritized for storage in both instances with alternative disposal methods for other material considered.

Long-term storage due to the presence of putrescibles in the domestic waste is impractical due to the potential of attracting wildlife. In the event of long-term shutdown generation of organic wastes would be minimized as much a feasibly possible.

Spills associated with the incinerator or waste disposal steams will trigger the implementation of the Spill Contingency Plan. Any accidents and malfunctions will trigger the implementation of the Risk Management and Emergency Response Plan.

7. Environmental Protection Measures

Sabina has an ongoing commitment to implementing environmental protection measures in all aspects of its operations and is committed to reducing incinerator emissions using technologically advanced, best available, and economically feasible procedures.

Sabina is committed to reducing waste volumes to be incinerated, while managing and minimizing dioxin, furan, and mercury emissions. Sabina also implements appropriate material handling procedures for the disposal of ash material generated by incineration.

A summary of the Canada-Wide Standards, as prepared by CCME, for dioxins, furans and mercury emission limits is presented in Table 7-1.

Table 7-1. Canada-Wide Standards for Waste Incineration Emissions

Waste Incineration Compound	Sector	Emission Limit (Max)
Dioxins and Furans[1]	Municipal Solid Waste[3] Sewage Sludge Incineration	80 picograms of International Toxic Equivalents (I-TEQ) per cubic metre (pg/m^3)
Mercury[2]	Municipal Solid Waste Sewage Sludge Incineration	20 micrograms per cubic metre (µg/m^3) 70 micrograms per cubic metre (µg/m^3)

[1] CCME 2001
[2] CCME 2000
[3] According to the Canada-Wide Standards (CWS) , "municipal solid waste" includes any waste that might be disposed of in a non-secure landfill site if not incinerated (i.e., non-hazardous wastes regardless of origin), but does not include "clean" wood waste.

These emission limits apply to waste incineration at new facilities across Canada. Compliance with these standards will be achieved through the installation and use of state of the art technologies and a detailed and conscientious waste management program. The permanent incinerators at the Project are expected to achieve full compliance immediately upon attaining normal full-scale operation. Should elevated concentrations be found adaptive management strategies would be implemented (see Section 11).

7.1 WASTE REDUCTION AND MITIGATION STRATEGIES

Waste reduction, reuse, and recycling are undertaken where reasonable to minimize the quantity of waste to be incinerated or directed to the landfill. These initiatives include:

Reduce

- Purchasing only the required amounts of materials and buying in bulk when the opportunity is available.
- Employing inventory control methods to ensure that quantities of materials are completely utilized.
- Establishing maintenance schedules that are consistent with the equipment manufacturers' suggested replacement.
- Maintaining and protecting materials to prevent damage and breakage.

- Eliminating unnecessary plastic and bulky packaging by buying kitchen supplies in bulk (i.e. ketchup, salad dressings, syrups, etc.).
- Cutting down on plastic food packaging.
- Substituting less hazardous chemicals where possible.
- Selecting products that provide the maximum "life-of-material".

Re-Use

- If appropriate, collect and return materials to the system (i.e. equipment, operations, etc.) following maintenance or repair.
- Evaluation of use of waste oil burners to heat selected facilities.
- Use of oil/water separators to reduce the amount of contaminated water.
- If appropriate, filter and/or use additives to replenish lost properties of material in order to extend its useful life.
- Testing to ensure items (i.e. batteries) are “spent” before removing from service.

Recycle

- Commercial companies are used to the maximum extent practical to recycle appropriate materials on a fee for service basis.
- Explore waste management options that allow for the recycling of a material or product instead of disposal.

7.2 DIOXANS AND FURANS

Polychlorinated dibenzo-p-dioxins and polychlorinated dibenzofurans, commonly known as dioxins and furans, are toxic chemicals which persist in the environment for long periods of time and are subject to bio-accumulation in plants and animals. Their presence in the environment results predominantly from human activity, most notably the large-scale incineration of municipal and medical wastes. The quantity of dioxins and furans in the incinerator emissions will vary depending on the type and volume of the waste stream. Sabina recognizes the importance of reducing the presence of dioxins and furans in emissions. Monitoring of dioxins and furans in the exhaust stream will be conducted and is described in more detail in Section 8.1.

7.3 MERCURY

Mercury is a naturally occurring substance, which can be transformed through biological processes to methyl mercury, a persistent substance which bio-accumulates in the food chain and is particularly toxic to humans and wildlife. The quantity of mercury in the incinerator emissions will vary depending on the type and volume of the waste stream. Sabina understands the importance of reducing the concentrations of mercury in emissions. Monitoring of mercury content in the exhaust stream will be conducted and is described in more detail in Section 8.1.

7.4 PREVENTION OF WILDLIFE ATTRACTION

Project personnel are educated on the importance of proper food waste (or other potential attractant) management to ensure animals are not attracted to worksites. All food waste is returned daily to the main camp facilities so it is captured in the domestic waste stream. Collection and transfer of food wastes is performed so that these attractants are stored safely, moved between facilities securely and are burned in the incinerator promptly.

8. Monitoring

Sabina will implement a testing and monitoring program to ensure that criteria for applicable air quality standards and guidelines and ash disposal are being met. The monitoring program is outlined in the following sections.

8.1 INCINERATOR EMISSIONS TESTING

The incinerator stack design will allow stack testing to be undertaken during incineration. Complete stack emissions testing for incinerators will occur within the first year of operations to ensure achievement of the Canada-wide Standards for Dioxins and Furans and the Canada-wide Standards for Mercury (CCME 2000, 2001).

8.2 ASH TESTING

Provided the materials that go into the incinerator are controlled to exclude all hazardous materials, then the incinerator ash should be non-hazardous. Ash testing will be implemented as required to ensure that the incinerator ash is suitable for disposal in the landfill. The samples will be compared to the *Environmental Guideline for Industrial Waste Discharges into Municipal Solid Waste and Sewage Treatment Facilities* (GN 2011b) presented in Table 8.2-1.

Table 8.2-1. Guidelines for Solid Waste/Process Residuals (Ash) Leachate Suitable for Landfill

Parameter	Maximum concentration (mg/L)
Arsenic	2.5
Barium	100
Cadmium	0.5
Chromium	5
Lead	5
Mercury	0.1
Selenium	1
Silver	5
Zinc	500

If monitoring indicates the ash is above the guidelines and not suitable for landfilling, an investigation will be undertaken to identify the cause and eliminate the source of exceedance. If monitoring indicates the ash meets the guidelines, ash containers will be stored and landfilled as per the Landfill Management Plan in the container to eliminate any windblown effects.

Containers of ash identified as having elevated metals concentrations will be sent to a licensed hazardous waste disposal facility. Hazardous waste shipments will follow the Transportation of Dangerous Goods (TDG) regulations as well as the Interprovincial Movements of Hazardous Waste regulations. Certificates of Disposal for waste shipped off site are provided by the off-site waste handling facility. This is provided so waste generators can demonstrate to regulatory authorities that their waste is being handled by an approved facility and that the waste was disposed according to applicable federal and territorial regulations.

8.3 WASTE AUDITING

A waste audit will be completed following incinerator commissioning and periodically thereafter to confirm adherence to waste segregation practices and identify waste stream volumes that can be minimized prior to incineration. The waste audit will inform the improvement of waste segregation procedures and policies as well as revisions to the comprehensive list of acceptable and unacceptable waste for incineration. The identification of unacceptable waste for incineration will be based on the EC Technical Document for Batch Waste Incineration (EC 2010) and the regulations discussed in Section 3.

8.4 QUALITY ASSURANCE/QUALITY CONTROL

The collection and analysis of incinerator emissions samples will be conducted in compliance with appropriate stack test methods and undertaken by an accredited laboratory. Following each stack emissions testing program an Incinerator Stack Testing Compliance Report will be completed. This report will include a description of the incinerator and how it was being operated at the time of the stack emissions testing program, the methods used for sampling and analysis.

Incinerator ash samples will be collected in lab-provided containers and will be appropriately labelled to allow tracking to individual ash containers if exceedances are identified. The samples will be analyzed by an accredited laboratory.

Additional QA/QC procedures for incineration include:

- Incinerator operational data including temperature, differential pressure in the primary chamber, auxiliary burner operation, fan amperage will be recorded continuously, consistent with detailed written operating instructions from qualified personnel;
- Detailed training programs will be implemented to ensure that all staff working with the incinerator are competent and qualified for their respective task;
- Analysis of sampled emissions during monitoring will be completed by an accredited laboratory;
- Stack testing samples of emissions and ash samples will be collected and handled according to operating instructions prepared by qualified personnel; and
- Qualified personnel will calculate emission concentrations for monitored air quality parameters based on laboratory results and compare against the applicable guidelines.

9. Record Keeping

Maintenance and inspection procedures should be carried out in accordance with the manufacturer's specifications.

A maintenance log is required to be kept for regulatory review. The maintenance log will be used to record routine maintenance activities or operational changes, the date completed, personnel responsible, and observations during maintenance activities. The maintenance log will also note any problems encountered. Maintenance personnel should determine the cause of any failure to help avoid or reduce similar failures.

Operational data will be collected by a data logger and stored continuously, even when the incinerator is not operating. The data will be used to monitor operating conditions to ensure that normal operating parameters are not exceeded. In the event that normal operating conditions are not met, the data will be used to identify causes of failure and to optimize the system.

Prior to incineration, the type of waste in each bag will be determined, weighed and the source noted. The total weight of each type of waste will be recorded before the burn cycle is started. After the cool-down period, the ash will be removed and weighed before it is sent for disposal. This information will be stored electronically with the operational data from the incinerator. This data will assist Sabina in determining incinerator waste generation rates at the facility, and in turn, provide data on the effectiveness of waste diversion, reduction and recycling programs.

Regulatory compliance reporting requirements will be defined in various regulatory authorization issued including the water licence.

10. Environmental Reporting

To demonstrate conformity with performance limits, an annual incineration summary will be prepared and submitted as part of annual reporting to authorizing agencies. Any stack testing results will also be integrated into the annual air quality monitoring report.

The following information will be included in the incineration summary report:

- the quantity and type of materials incinerated on-site during operations;
- results from any stack emissions and ash monitoring;
- record of ash disposal, including weight of ash disposed, location of disposal, and the transportation/load details;

The annual reporting will also identify any major changes to the operation and efficiency of the incinerator or necessary changes to this Plan.

11. Adaptive Management

The IMP will be reviewed annually and updated as needed to incorporate any lessons learned, major changes to the incinerator operation or maintenance, and environmental monitoring results and to reflect the operating conditions at the Project during Construction, Operations, and Closure.

The need for any corrective actions related to emission management or installation of additional control measures will be determined on a case-by-case basis. Indications of the need for corrective actions and additional control measures may include:

- monitoring data showing concentration greater than applicable standards (i.e., elevated metals, dioxins, and furans);
- monitoring data showing an increasing trend in contaminant concentrations; and
- issues raised by on-site staff, regulators, or local communities.

Discussions will be initiated to resolve any issues as soon as possible after the issue has been identified.

Relevant employees will be informed of updates to incineration management procedures and the updated IMP will be stored appropriately on-site.

Sabina will retain all raw data records and annual reporting for at least two years. The updated IMP, raw data, and annual reporting will be made available by Sabina at all times for review by the Government of Nunavut, Nunavut Impact Review Board, and Environment and Climate Change Canada.

12. Reclamation

In accordance with the Interim Closure and Reclamation Plan, all buildings, machinery, and equipment that is not salvageable will be disposed of in an on-site landfill after any hazardous material has been removed.

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Appendix A. Ketek CY-100-CA Incinerator

MANUAL

OPERATION & MAINTENANCE

CY-100-CA

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1. Introduction

Thank you for selecting **KETEK GROUP INC.** to provide you with a reliable, proven and cost-effective system to manage your waste in an environmentally sound manner. This manual has been prepared to allow you to operate and maintain the system safely and efficiently, thereby ensuring its proper operation and continued use for a long period of time.

It also contains information on the combustion process. We think that a good understanding of the basic principles would make you knowledgeable, and hence a better operator.

Table 1 outlines the contents of this manual. We encourage you to read Chapter 2 although only Chapters 4 and 5 contain the most relevant information.

TABLE 1 ORGANIZATION OF MANUAL

Chapter	Title / Description
2	**Waste Incineration and General Guidelines for Waste Management**
3	**Roles and Responsibilities**
4	**Principles of waste incineration** What incineration is, how it is affected by waste properties, including incinerator capacity and the design and operational features of the system.
5	**System Description** List of photographs of the components of the system and their functions
6	**Operation and Maintenance** How to operate and maintain the system, including discussion on safety aspects

2. Waste Incineration and General Guidelines for Waste Management

Incineration of waste is recognized as an effective and environmentally sound disposal method for a wide range of wastes, provided the incinerator is properly operated and maintained. However, waste segregation, recycle and reuse shall be considered before the final waste is sent for waste incineration. Examine the waste to determine the opportunities that exist for:

- reducing the overall quantity of waste generated,
- reusing materials; and
- recycling as much as possible before disposal.

Incineration of wastes can lead to the emission of pollutants. Polychlorinated dihenzop-dioxins and polychlorinated dibenzofurans (PCDDF), commonly known as dioxins/furans can be generated from incomplete combustion resulting from the use of inefficient operation of incineration system. Dioxins and furans are toxic, persistent, and bio-accumulative and therefore must be controlled in the final emission from the incinerator. Mercury is another high priority potential contaminant released from incinerators. Mercury is toxic and bioaccumulates in the environment. Mercury is not emitted unless the waste items incinerated contain mercury. The best method to control mercury is therefore waste segregation to limit the amount of mercury in the waste fed into the incinerator.

Waste Management and segregation before incineration will help in providing cleaner emissions, and provide reduction of waste; maintaining an environmentally way of disposing waste products.

3. Roles and Responsibilities

3.1 Waste Management In charge / Site Services

- Ensure that relevant waste handling training is provided to all waste management personnel at site and only properly trained individuals (Qualified Incinerator Operators) operate the incinerator.

- Ensure that the Incinerator Operator follows the requirements of the Incinerator Operational Plan, Operation Manual and other relevant guidelines of the company.

- Ensure that all checklists and data logs are filled up, and the records required by this guidance document are collected and maintained.

- Ensure adequate re-training is provided to the operators are regular interval.

- Ensure the safety of all personnel and the site.

- Carryout periodic inspections and record observations in Supervision checklist appended in this document.

3.2 Incinerator Operator

- Ensure the safe operation of the incinerator and the associated work and storage area.

- Ensure the operation and maintenance of the incinerator is carried out in accordance with the Equipment Operation Manual.

- Ensure that only appropriate wastes are incinerated, and all other inappropriate wastes including plastics, aerosol cans, metallic containers or cans filled with waste oil are removed and handled accordingly.

- Document and maintain the required logs and records as appended in the document (pre operational checklist, operational checklist and waste incineration log).

- Notify the supervisor or waste management In charge of any incinerator upsets, malfunctions or required repairs.

- Wear proper Personal Protective Equipment at all times while working with the incinerator or waste.

3.3 Maintenance Personnel

- Carry out timely Inspections and maintain the records

- Carry out preventive maintenance at scheduled intervals; record and report any unusual observations on the equipment.

- Do not alter the electrical wiring and incinerator components.

- Consult **KETEK** for any clarifications or guidance related to maintenance of the equipment

- Fill and record the inspection and maintenance checklist and follow the checklist for weekly, monthly and annual inspection and maintenance

- Make sure to lock out/tag out the unit as per the company’s existing procedures if there is a problem.

4. Principles of Waste Incineration

4.1 Combustion

Combustion, burning, incineration, and thermal oxidation all denote the same process, which is the reaction of a "combustible" matter with oxygen that occurs at temperatures higher than the ignition temperature[1] of that matter. The reaction is exothermic, meaning that it generates heat in the form of hot gas.

In the case of waste, it may also contain non-combustible matter which does not react with oxygen. In waste incineration, the non-combustible component ends up as ash and a small portion of it is also present in the hot gas in the form of particulate matter or dust.

Figure 1 shows schematically the process of waste incineration. The oxygen used comes from air, which contains 21% of oxygen by volume, and the hot gas is typically referred to as flue gas.

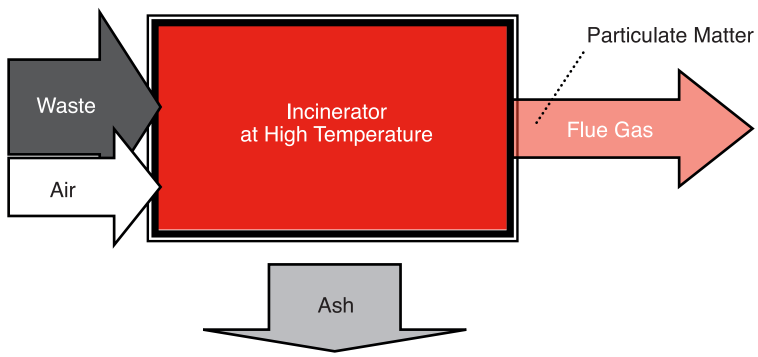


FIGURE 1 SCHEMATIC DIAGRAM OF INCINERATION PROCESS

4.2 Why incinerate waste?

The main purpose is to reduce the mass and volume for final disposal. Another important reason, since the waste may contain pathogenic, infectious or toxic materials, is to "detoxify" it. And in remote areas where wildlife is present, scavenging and spreading of diseases can be prevented by incineration.

In some cases, incineration is used to recover the energy contained in the waste in the form of electricity, steam, hot fluids or hot air. And in other cases, valuable materials can be recovered from the ash, or the ash as a whole can be used for soil amendment or as a construction material.

4.3 Waste components

There are different ways of characterizing waste, depending on the purpose for doing it. Here, it is sufficient to characterize the components as follows: [2]

A. WATER is an important component because in incineration it has to be evaporated, which requires a lot of energy, [3] which in turn, has the effect of lowering the temperature of the flue gas.

B. COMBUSTIBLE is the component that reacts with oxygen and releases heat in the process. [4] The higher the combustible content in the waste the more air per kg of waste is needed for incineration.

This component can be further classified as:

(i) Volatile, which is released to the gas phase when the combustible matter is heated without the presence of oxygen, and
(ii) Fixed carbon which remains in the solid waste after the volatile has been released. This is often referred to as charcoal.

C. NON-COMBUSTIBLE OR ASH is the component that does not react with oxygen. [5] As previously mentioned, this forms ash, and some of it is entrained in the flue gas in the form of particulate matter or dust. The higher the ash content in the waste, the less quantity of waste that can be incinerated without removing ash from the combustion chamber. Note also if the waste contains metals, such as lead and cadmium, these metals will be present in the ash as well as in the particulate matter.

4.4 Heating Value

Heating value, calorific value and heat of combustion are synonyms that quantify the heat released by the combustible component in the waste upon complete combustion. An understanding of the concept can be gained from the hypothetical processes shown in **Figure 2.**

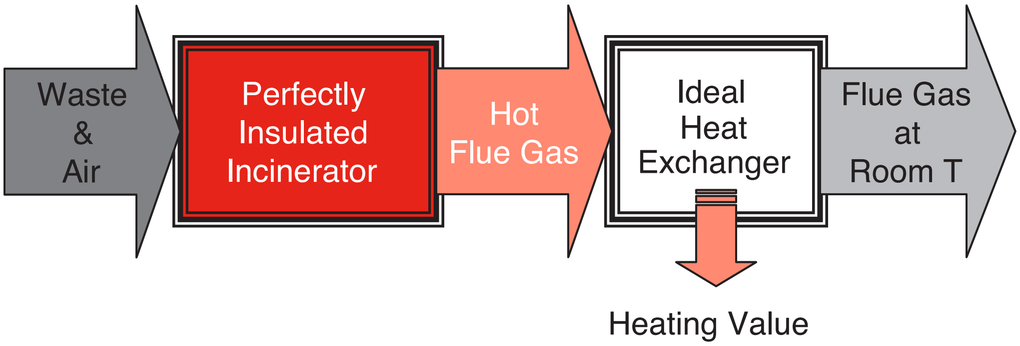


FIGURE 2 THE CONCEPT OF HEATING VALUE

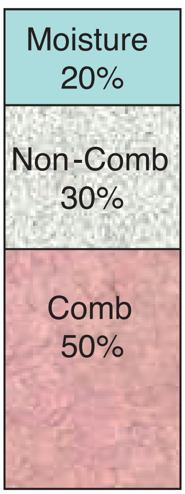
A measured mass of dry waste and a sufficient amount of oxygen , at room temperature, are ignited, and the resulting hot flue gas is passed through a heat exchanger, where heat is extracted until the flue gas is brought back to room temperature. Let M be the mass (kg) of the dry waste fed, and H (MJ) the heat extracted from the heat exchanger. The heating value of the dry waste is H/M (MJ/kg).

1 Below the ignition temperature combustion does not take place. Consider, for example, gasoline or wood: it has to be "ignited" for combustion to take place. That is, the temperature in some portion of the matter must be brought up to the ignition temperature for combustion to start..
2 This is referred to as proximate analysis. Another method is elemental analysis, which produces the elemental composition (C, H, O, N, S, Cl …) of the waste.
3 It takes ~ 2.3 MJ (2200 BTU or 90 cc of propane or 60 cc of diesel) to evaporate 1 L or 1 kg of water. This is referred to as the latent heat of evaporation.
4 The term "organic" is also used, which is strictly incorrect in that some "inorganic" elements or compounds are combustible, such as carbon, sulphur and carbon monoxide.
5 The terms "ash" and "inorganic" are also used. Note that the latter is inaccurate as explained previously.

4.5 Different Expressions for Heating Value

Two different values are reported in the literature (a) “high” or “gross”, and (b) “low” or “net”. The former corresponds to the case where the moisture in the flue gas is condensed, and hence the high or gross heating value includes the latent heat of evaporation of the water formed in combustion (see Footnote 3). The latter excludes the latent heat evaporation. The low or net heating value thus represents the maximum available energy that can be recovered from the flue gas without condensation.

To be noted also is the basis on which the heating value is expressed, which can be (a) as fired, (b) dry basis or (c) ash free. The distinction is illustrated in **Figure 3**. An understanding of the different bases can be gained by noting that heating value is a property of the combustible component in the waste. Water and the non-combustible component simply “dilute” the heating value. In terms of incinerator operation, the relevant basis is “as fired”.



* HV as measured:
15 MJ/kg “ Dry Basis ”

* HV of whole waste:
= (30 + 50)/100 * 15 = 12 MJ/kg “ As Fired”

* HV of combustible component:
= (30 + 50)/50 * 15 = 24 MJ/kg “ Ash Free”

FIGURE 3 DIFFERENT BASES FOR EXPRESSING HEATING VALUE (HV)

4.6 Examples of waste characteristics

Proximate compositions and heating values of commonly found wastes are given in **Table 2.**

TABLE 2 CLASSIFICATION AND PROPERTIES OF COMMON WASTES

Type*	Description	Components	Weight %			MJ/kg
			Moist	Comb	Non-C	HHV (A/F)
0	Trash	Paper, cardboard, cartons wood boxes and combustible floor sweepings from commercia l and industrial activities. Up to 10% by weight of plastic bags, coated paper, laminated paper, treated corrugated cardboard, oily rags and plastic or rubber scraps.	10%	85%	5%	19.7
1	Rubbish	Trash + Type 3 (up to 20%)	25%	65%	10%	15
2	Refuse	Rubbish and Garbage	50%	43%	7%	10
3	Garbage	Animal and vegetable wastes, restaurants, hotels, markets, institutional, commercial and club sources	70%	25%	5%	5.8
4	Animal/ Pathological	Carcasses, organs, hospital and laboratory abbatoit, animal pound, veterinary s ources	85%	10%	5%	2.3

Notes:
Moist = moisture, Comb = Combustible, Non-C = Non-combustible, HHV = High Heating Value, A/F = As Fired
* In some cases Roman numerals are used. That is Types 0, I, II, III and IV

4.7 Incinerator Capacity and Load Size

Incinerator capacity is dependent on waste composition. In general, the higher the heating value, the lower is the capacity in terms of kg/h that can be incinerated. This can be explained by noting that a waste that has a higher heating value requires more air per unit mass than that required to incinerate a waste with a lower heating value. To put it another way, for the same amount of air, more mass of a waste with a lower heating value can be incinerated.

Another important consideration is the size of the batch loaded to the incinerator. The higher the heating value, the smaller (lighter) the load should be. Otherwise, insufficient amount of air would generate black smoke.

Unfortunately, waste composition is not always known. Nevertheless there may be indications of the components present. To assist in getting a qualitative estimate of the heating value of a batch of waste, the heating values of common "generic" waste components are shown in Table 3.

TABLE 3 HIGH HEATING VALUES (APPROXIMATE) OF COMMON WASTE COMPONENTS

Component	MJ/kg A/F *	Component	MJ/kg A/F *
Kerosene, Diesel …	44	Leather	16
Plastics	46	Wax paraffin	44
Rubber, Latex	23	Rags (linen, cotton)	17
Wood	18	Animal fats	39
Paper	17	Citrus rinds	4
Agricultural waste	17	Linoleum	25

* A/F: As Fired

Another important waste component is the volatile content in the waste. Table 4 shows the proximate components of various materials and wastes.

In general, this component is responsible for smoke generation. Therefore, as in the case with heating value, the higher the volatile content, the smaller the load that should be charged to the incinerator.

TABLE 4 PROXIMATE COMPOSITION OF VARIOUS MATERIALS

Material	Volatile	Moisture	FC	Ash	FC/V
	%wt	%wt	%wt	%wt	-
Coal (bituminous)	30	5	45	20	1.5
Peat	65	7	20	8	0.3
Wood	85	6	8	1	0.1
Paper	75	4	11	10	0.15
Sewage sludge	30	5	20	45	0.66
MSW	33	40	7	20	0.21
RDF	60	20	8	12	0.13
PDF	73	1	3	13	0.04
TDF	65	2	30	3	0.46
PE,PP,PS	100	0	0	0	0
Plastics + Colour	98	0	0	2	0
PVC	93	0	7	0	0.08

Notes: FC = Fixed Carbon; FC/V = Ratio of Fixed Carbon to Volatile
RDF = Refuse Derived Fuel; PDF = Paper Derived Fuel;
TDF = Tire Derived Fuel; PE = Polyethylene; PP = Polypropylene;
PS = Polystyrene; PVC = Polyvinylchloride

5.1 Overview

Regardless of the model of your incinerator, the main components are similar. Figure 4
shows a schematic diagram of the incineration system. It consists of a Primary Chamber and a Secondary Chamber, which are connected by a “flame-port”. Combustion air to the secondary chamber is delivered via the flame-port by the flame-port blower. Auxiliary burners are provided for start-up and to maintain the minimum temperatures set in the primary and secondary chambers.

Thermocouples are used to measure the temperatures in the primary and secondary chambers, the outputs of which are used by on-off Omron controllers which regulate the operation of the auxiliary burners.

The secondary chamber combined with high temperatures maintained by the auxiliary burner, and the turbulence created from the delivery of air (oxygen) by the flame-port air blower, ensures that black smoke is not generated provided the size of the waste load is not too large.

Waste is charged manually and intermittently via the waste charging door (1), and ash is removed manually and batch-wise after previous operation. Waste charging door is also used to rake the waste in the primary chamber after several loads have been charged, which is necessary to expose the fixed carbon component in the waste to the oxygen.

5. System Description

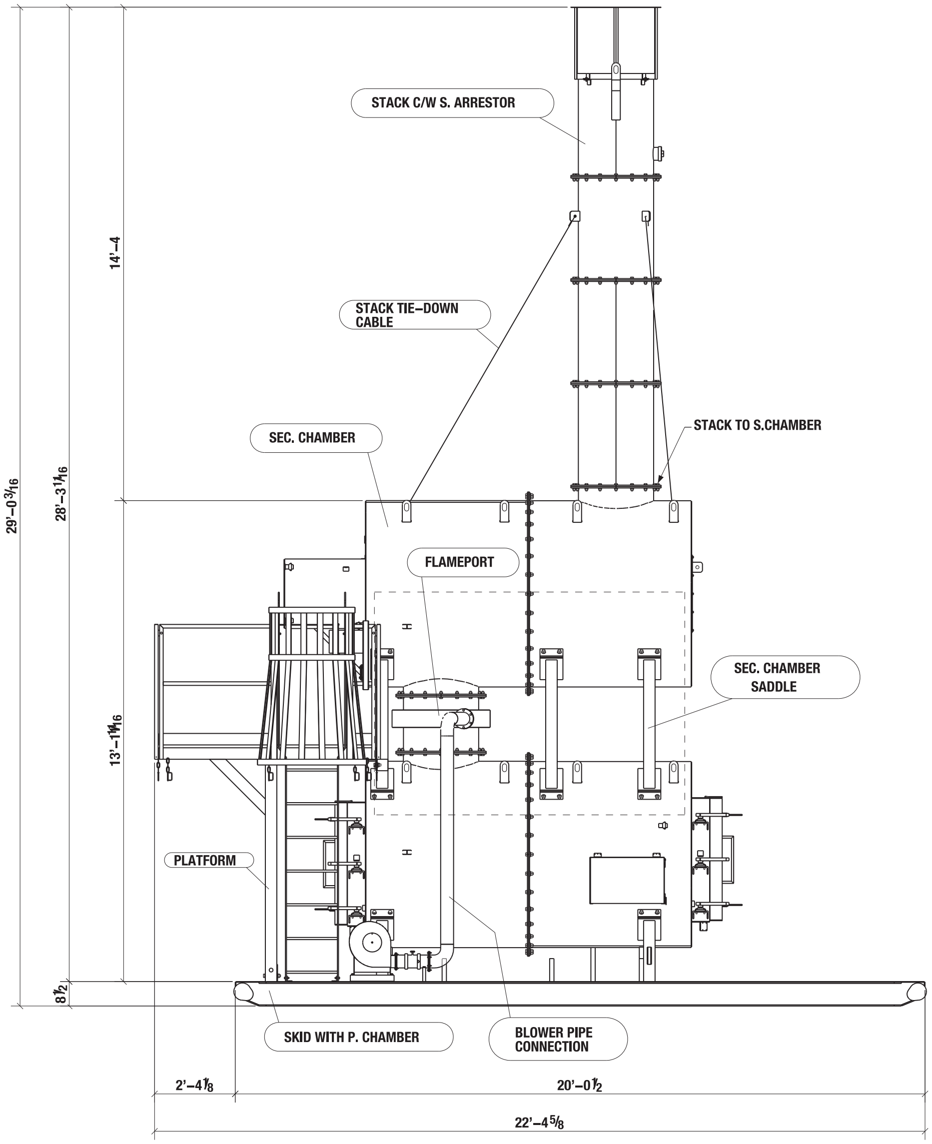


FIGURE 4 SCHEMATIC OF THE INCINERATION SYSTEM

5.2 Description of system components

For convenience, the system has been grouped into sections, as shown in Figure 5. In each section, the components are shown in subsequent photographs. Each component is designated with a code corresponding to the section to which it belongs. These codes are unique and will be used in later sections on operation, maintenance and trouble shooting. The following Tables contain all the components in the system, their codes and brief descriptions of their functions.

Information on components that are not manufactured in-house, such as blowers and burners, is given in the accompanying binder. Please consult the corresponding manuals for details of operation and maintenance.

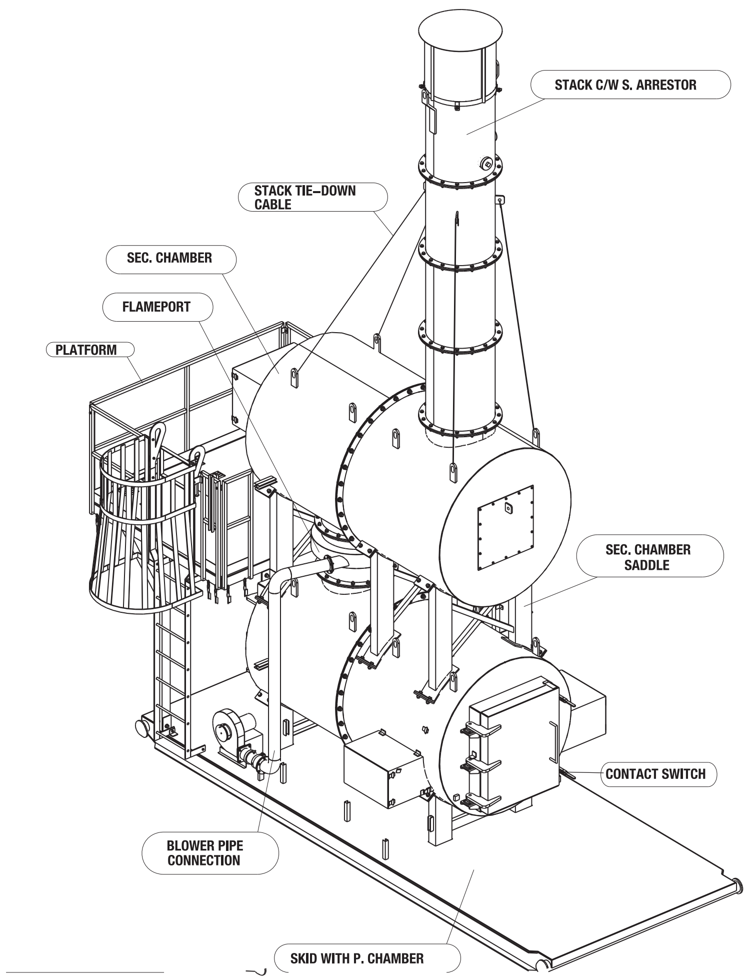


FIGURE 5 OVERALL VIEW SHOWING THE SECTIONS

5.3 Primary Chamber Section

Table 5 Components in the Primary Chamber Section (Figure 6 & Figure 7)

Code	Component	Description	Function
PC	Primary Chamber	Built in-house. Inside Vol: 2.74m³ Refractory + Insulation	Pyrolysis and gasification Combustion of fixed carbon
PC_B	Auxiliary Burner	Becket 2 x WIC-201; 770,000 BTU/h (Each); 5.5 USG/h (Each)	Start-up and maintains a minimum temperature
PC_T	Thermocouple	Stainless Steel	Used by PC Temp. Controller to regulate burner
PC_D	Charging Door & Ash Door	Built in-house. Feed Door: 90 cm(Height) x 70 cm (Width) Ash Door : 86 cm(Height) x 70 cm (Width)	Load waste and ash removal
PC_S	Contact Switch	Square D ZCKJ1H7 (2)	Turn off PC burner when Feed door/Ash door is opened

5.4 Secondary Chamber Section

Table 6 Components in the Secondary Chamber Section (Figure 6 & Figure 7)

Code	Component	Description	Function
SC	Secondary Chamber	Built in-house. Inside Vol: 2.87m³ Refractory Insulation	Complete combustion of gases and soot generated in primary chamber
SC_B	Auxiliary Burner	Becket WIC-301; 1,600,000 BTU/h; 13.0 USG/h	Start-up and maintain minimum set temperature
SC_T	Thermocouple	Ceramic	Measure temperature in secondary chamber
FP_P	Flame-port Plenum	Turbulent vortex flow built In-house.	Mixing of combustible gases and flame-port air
FP_B	Flame-port Blower	4C 108 Dayton; 1 HP; 3600 rpm	Combustion air supply to flame-port plenum
FP_T	Flame-port Throttle	Butterfly valve	Controls flame-port airflow
ST	Stack	Refractory + Insulation, built in-house.	Dispersal of flue gas

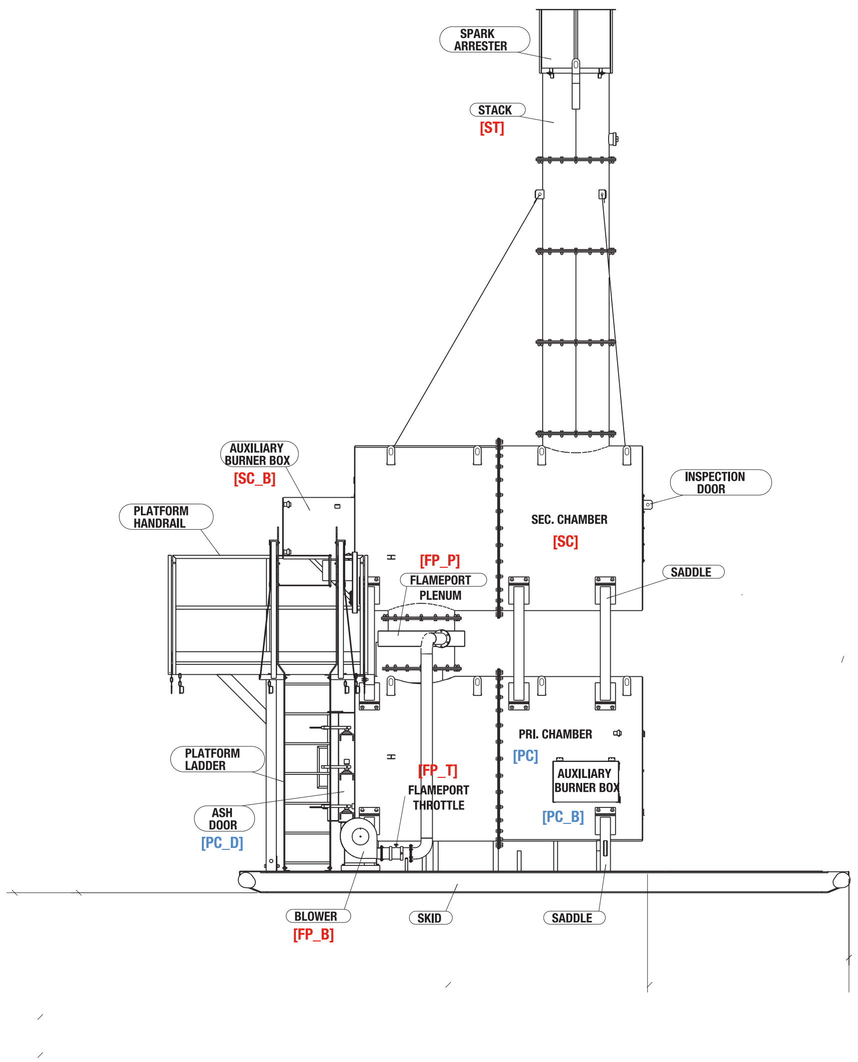


FIGURE 6 COMPONENTS IN THE PRIMARY AND SECONDARY CHAMBER SECTIONS (1)

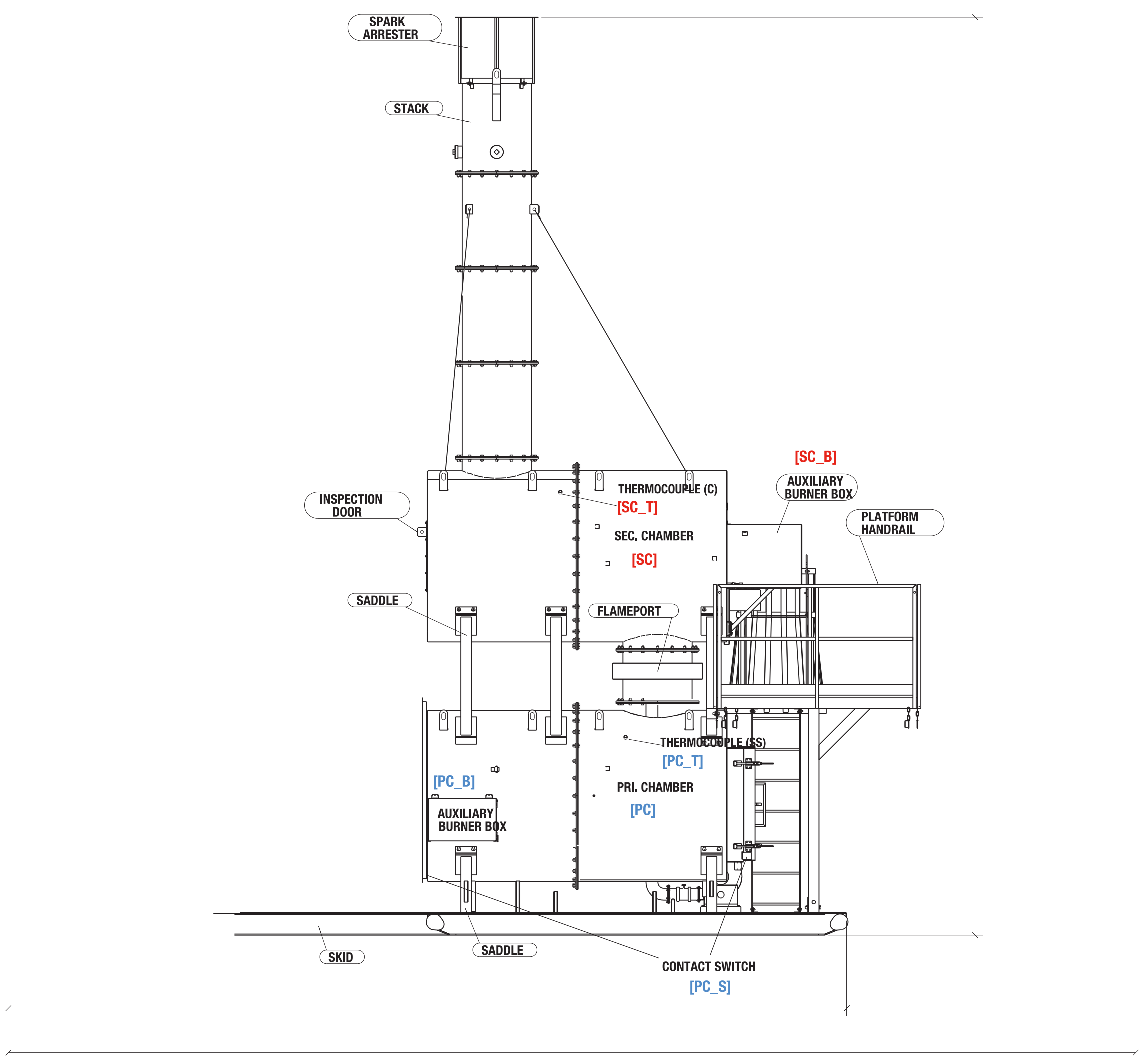


FIGURE 7 COMPONENTS IN THE PRIMARY AND SECONDARY CHAMBER SECTIONS (2)

5.5 Control Panel Section

The components are listed in Table 7.

Figure 8 Overview of Control Panel, Showing the Main Sections shows a photograph of the whole control panel, which has been divided into sub-sections marked A, B, C, and D.

TABLE 7 COMPONENTS IN THE CONTROL PANEL SECTION

Code	Label	Function
Sub-Section A: Indicator LEDs (ON-OFF)		
C3,C5 **C8**	Primary Blower Secondary Blower	GREEN PC_BL GREEN SC_BL
C6	Flameport Blower	GREEN FP_B
C2,C4 **C7**	Primary Burner Secondary Burner	RED PC_B RED SC_B
Sub-Section B: Burn Timer		
T1	Burn Timer	Set burn-cycle duration to the specified time. (Start switch restarts timer)
Sub-Section B and C: Main Controller and Controllers for Burners and Blower		
PB1	Start Switch	Initiate Pre-Purge, Burn, Burn-Down, Cool-Down Automatic Cycles.
PB2	Emergency Stop	Emergency Use Only. For Normal Stop, Set Burn Time to 0.
R1	Contact Switch	Safety Apparatus, Will Turn ON/OFF Primary Chamber Burner When Feed Door is OPEN/CLOSED.
Sub-Section D: Omron Temperature Controllers and Indicators		
TC1 **TC2** **TC3**	Primary Chamber T.C. Secondary T.C. Secondary Trigger T.C.	Temperature Displays and Control of Minimum Temperatures in Primary and Secondary Chambers by Setting Adjustable Set Points (OMRON E5CN). Primary Burner Enabled When Secondary Trigger Reaches its Specified Temperature Set Point.
Sub-Section E: Primary Pressure		
	Magnehelic Gauge Box	Displays pressure of Primary Chamber Should be Negative Pressure between 0 and -0.5 inches

NOTE: This panel has been configured with Burner Protection which ensures that if the primary and/or secondary chamber is hot, the corresponding burner-blower will run even if the cool-down period has elapsed, or if there has been a power disruption.

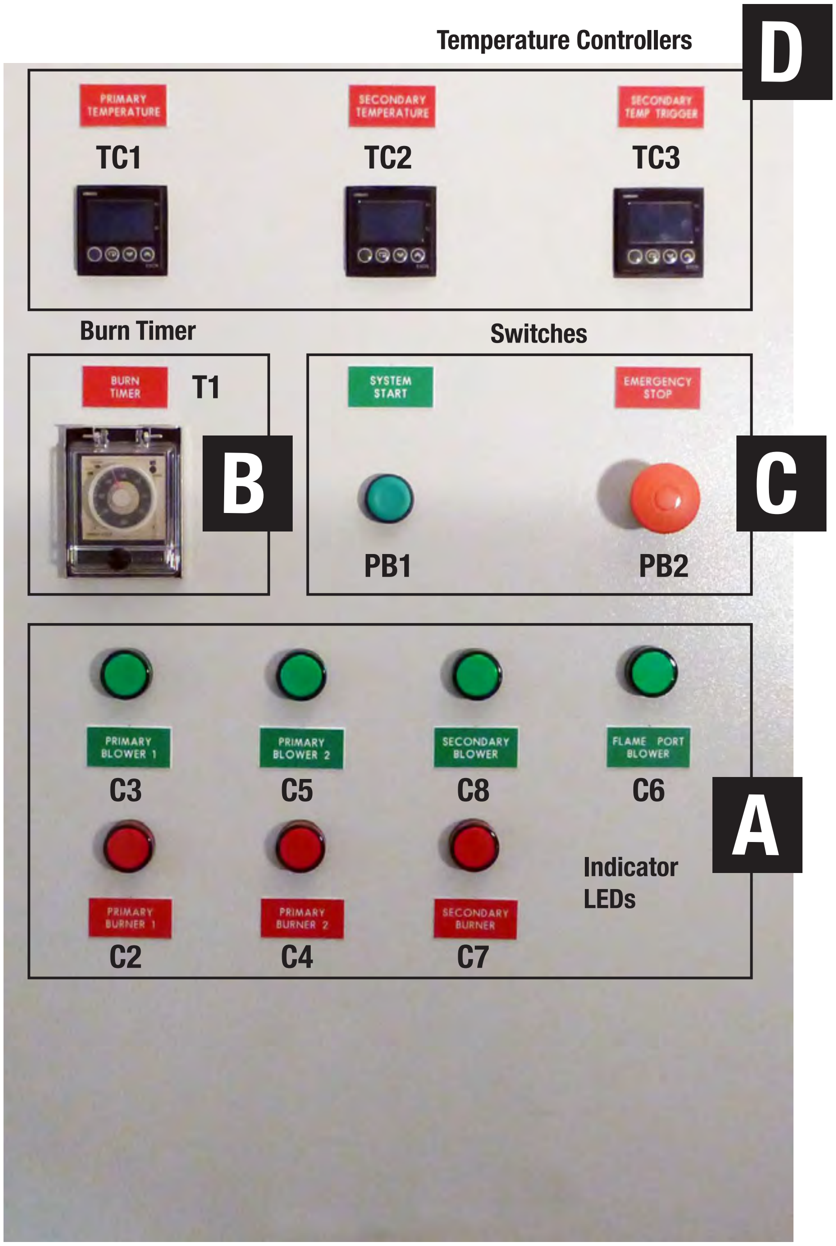


FIGURE 8 OVERVIEW OF CONTROL PANEL, SHOWING THE MAIN SECTIONS

The operation of the incinerator can be described by distinct sequential steps as shown in Figure 9. In addition there are additional necessary steps which involve safety, routine inspection and waste batch preparation, which will be first described.

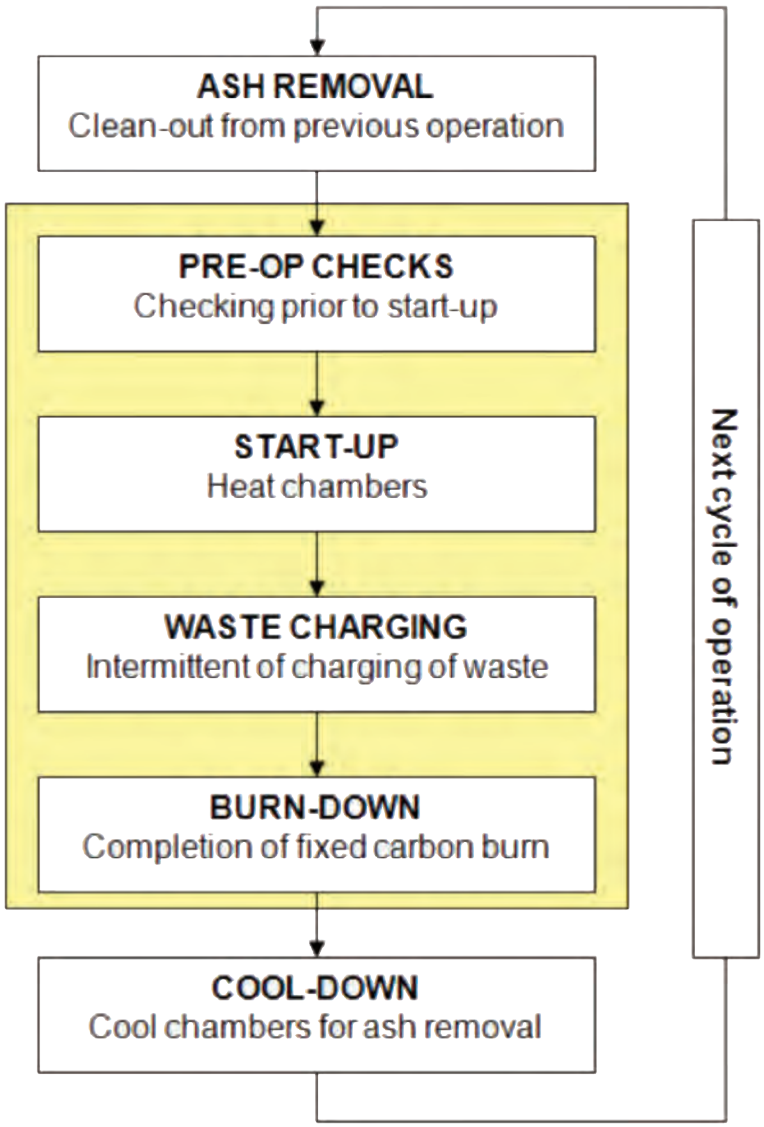


FIGURE 9 STEPS IN THE OPERATION OF THE INCINERATOR

6. Operation & Maintenance

6.1 Safety equipment

The following personal protective equipment should be used while operating the incinerator system:

- Long sleeved shirt and long pants;
- Long cuffed, puncture resistant gloves;
- CSA approved, Grade 1 safety footwear;
- CSA/ANSI approved safety glasses.

The personal protective equipment related to specific tasks are listed below:

- Ash removal and handling: NIOSH N95 respirator
- Waste charging: (i) heat protective clothing and gloves, and (2) CSA/ANSI approved full face shield.

The hazards that could be encountered arise from the following (not in any order of importance):

- Contact with waste (infectious or toxic components, or sharps);
- Exposure to heat, from contact with hot surface or radiation from the primary combustion chamber when the waste charging door or ash removal door is opened.

Therefore, the general precautionary actions include:

- Not opening waste batches
- Not touching hot surfaces, and minimum exposure to heat radiation through open doors (charging / ash doors while combustion is taking place).
- Wearing appropriate personal protective equipment (PPE) for charging waste and raking the primary chamber, AND minimizing the time for those tasks.

6.2 Routine inspection and maintenance

- Check fuel lines for leak and check connections
- Check spark arrestor to ensure no plugging
- During ash removal (see next section):
  - o Inspect refractory for large cracks (not expansion cracks)
  - o Inspect door gaskets for damages

6.3 Waste batch preparation

The following cautionary notes should be followed:

- NO explosives, aerosol cans or containers containing combustible liquids
- Make sure that every batch can go through the waste charging door easily, regardless of its weight. If others prepare the batches, the operator should tell them about the maximum batch size.
- DO NOT open batches and “rearrange” the contents for health/safety reasons.

6.4 Ash removal

Typically the ash from previous operation was left to cool, and ash removal is done first prior to current operation.

- Make sure combustion chamber is sufficiently cool
- (Do NOT spray water into the combustion chamber)
- While removing ash, avoid damaging the burner tip
- Use non-combustible container
- Minimize dust generation
- Light water spraying on ash in the container is OK to minimize dust generation
- Ash to be removed daily (After sufficient cool down period)
- Dispose of ash as specified in the guidelines or regulations

6.5 Pre-operational checks

- When diesel or propane is used: check fuel tank to make sure there is enough fuel (see Figure 14 for estimates of fuel consumption, depending on burner size and length of operation)
- Conduct inspection around incinerator, make sure there is no debris or fire hazards; area should be clean
- Open fuel valve
- Check fuel lines for leaks and check all connections
- Check for any physical damage on incinerator including stack and spark arrestor
- Inspect thermocouples, feed door/ash door seals, and blower inlets
- Re-check that the combustion chamber is empty
- Check power connection
- When diesel is used, bleed the diesel lines to the burners if necessary

6.6 Operational Procedure

1. The first step in managing waste is to understand the quantity and composition of the waste that is generated. A waste audit should be completed. (Ketek Group Inc. Sustainability Consulting can provide a Waste Audit for an additional charge) A waste audit can provide the following:

- Determine the quantity of waste from each type of operation
- Characterize the waste stream to determine what opportunities exist for:
- Reducing the quantity of waste generated; Reusing materials; and
- Recycling as much as possible before considering disposal.

2. Prior before operation of any incinerator the area surrounding the incinerator shall be free of any debris and tripping hazards; maintaining a proper housekeeping procedure for the incinerator is very important and will reduce safety hazards such as slips, trips and falls.

3. A pre-operational checklist should be completed prior before operation of the incinerator. (Pre-Operational Checklist can be created by Ketek Group Inc. for an additional charge) Make sure all ash is removed properly from the previous burn. Record the weight of ash on checklist.

4. The operational checklist should be continually filled out with the required information throughout the day and operation of the incinerator.

5. The incinerator should be loaded to the limited charging capacity (both in terms of waste quantity and the calorific value of waste charge). The incinerator should be charged with the appropriate mix and quantity of waste, the operator should close the door, ensure all interlocks are engaged, and start the burn cycle.

6. Turn the timer to 12 hours and press the Green “Start” button.

7. Proceed with inspecting of the incinerator and make certain that all burner blowers (2 burners in primary chamber and 1 in secondary chamber) are functioning correctly.

8. After 5 minutes primary burner motor will shut off and the secondary burner (flame) should be running and you will see the temperature increase on the temperature display “Secondary Chamber T.C”.

9. The secondary burner heats up to the specified temperature in “Secondary Temperature Trigger”.

10. At this point primary burners (flame and blowers) and flame port blower would come on and you will see the temperature increasing on the temperature display “Primary Chamber T.C” as well.

11. The temperature will keep increasing until it goes up to the set point and after that burners will continually function on/off to maintain the specified temperature set on the incinerator control system.

12. After about 2-3 hours into the burning process, open the door and check the status of the waste and rake if necessary. Always rake from the ash door side.

13. After about approximately 1 hour after the rake, check the waste status again, if not burned then rake it and close the door. If waste seems burned and you do not need to burn another batch then manually run the burn timer to zero, if you need to burn more batches then lower the set point on “Primary Chamber T.C” to 0 by pressing the “▼” down arrow. Give about 30-60 minutes for the primary chamber to cool down.

14. Load the next batch in the primary chamber and turn the timer to 12 hours and increase the set point on “Primary Chamber T.C” to 600˚C by pressing the “▲” up arrow.

15. Repeat steps 11 to 13 for other batches of the day.

16. For the final batch of the day turn the timer to about 5-6 hours. Rake in between if required.

17. After the timer runs out, the primary burners will no longer produce flames, but the blowers will continue to run. At this time the secondary chamber burner will still keep running for another half hour.

18. After secondary burners shuts down all the blowers will keep running for another 5-6 hours to give enough time for the incinerator to cool down and prevent any damage to the burners. If after the cool down process the temperature in the chambers is still above 250˚C then the blowers will continue to run until the temperature drops below the 250˚C value.

19. The pre-operational checklist should be given to the supervisor for documentation and any further procedures. Pre-Operational Checklist should be filed and kept for record.

Note:

a) Do not operate the incinerator if something is not functioning properly, immediately tell your supervisors.
b) Do not overload the incinerator
c) It is important that waste should neither be open-burned nor burned in a barrel
d) Wear all required PPE (gloves, face-shield, dust mask, flame retardant coveralls, etc.)
e) If flame detection control locks out try resetting it by pressing red button on the burner control, if it keeps resetting again and again, let your supervisor know immediately.
f) Always ask if unsure about something.

1. Perform Pre-Op Checks

2. Load First Waste Charge

3. Ensure Emergency Stop is Pulled Out

4. Set Burner Timer

5. Press Start

6. Observe Blowers in Pre-Purge

7. Set Trigger TC to 650°C

8. Set Secondary TC to ~ 1100°C

9. Set Primary TC to ~600°C

10. Observe Secondary Burner

11. Once Trig Temp is Reached Observe All Blowers and Primary Chamber.

12. Automatic Operation until burn timer expires. Burn Down and Cool-Down Cycles follow Automatically.

FIGURE 10 OPERATING SEQUENCE

Note: Temperatures in Steps 8 and 9 may be governed by regulations:
If so, SET TEMPERATURES TO THE REGULATORY VALUES

6.7 Waste charging:

For Batch feeding (recommended) see **Figure 11.**

1. After de-ashing the cooled- down incinerator, load waste on the hearth. Refer to training notes and operating experience.

2. Ensure Burn Timer is set to 4-5 hours, depending on load size. Pressing Start button begins a new cycle.

3. Primary burners will start once secondary chamber is at trigger temperature (TC3 set-point typically at 650°C)

4. After 3 hours, open door, check state of ash, rake if needed.

FIGURE 11. PROCEDURE FOR BATCH WASTE CHARGING

Additional Notes to **Figure 11**:
**: The main danger is from exposure to heat radiation, and from waste catching fire before it is inside the primary chamber. Precautionary steps include:
(a) Wear proper PPE,
(b) Make sure waste batch can go through the charge door easily,
(c) Open door, charge waste and close door as quickly as possible.
***: The time for complete combustion varies, depending on batch size, weight and composition. Check burning conditions from charge door. Rake if necessary.

6.8 Waste Incineration Records

To demonstrate appropriate operation and maintenance of the incinerator, we recommend that the facility should maintain records containing at least the following information; or as per permits / regulations:

- A list of all staff who have been trained to operate the incinerator; type of training conducted and by whom; dates of the training; dates of the refresher courses.
- All preventative maintenance activities undertaken on the equipment.
- Records of operation of the incinerator.
- Records of quantities of waste incinerated
- Summarized annual auxiliary fuel usage.
- A list of all shipments / disposal of incinerator residues, including the weight transported and disposed of by type if necessary, and the location of the disposal site.
- Results of any stack emission monitoring and ash sampling information.

All raw data records from the operation of the incinerator will be retained for inspection by the appropriate authorities for a period of 3 years (or any other time period as deemed necessary).

6.9 Burn-Down and Cool-Down: see Figure 12

For Batch feeding (recommended) see **Figure 11**.

1. Automatic Burn-Down cycle begins after burner timer expires. Primary burners shut down immediately.
2. Automatic Cool-Down cycle follows. Secondary burner shuts down.
3. Blowers automatically shut down once chambers have cooled to 250°C. Cycle is complete.

FIGURE 12. PROCEDURE FOR BURN DOWN.

6.10 Maintenance and Inspection

In addition to the routine inspection and maintenance previously mentioned, only the burner(s) and the blower(s) require maintenance, which is quite minimal; see manuals in the binder. The following inspection steps are recommended:

TABLE 8 RECOMMENDED INSPECTIONS

How Often	Component	Inspection and checking
Daily	Thermocouples PC_T and SC_T	Check that the readings of temperature controllers are "close" to the estimated temperatures of the primary and secondary chambers
	Contact switches PC_S	Free movement, no obstruction
	Gasket/seal waste feed door PC_D	Wear and tear; proper sealing
	Refractory in primary chamber PC	No large (not expansion) cracks; pieces falling out repair if necessary.
Weekly	Blowers PC_B, SC_B, FP_B	Inspect clean in-takes, clean if necessary
Monthly	External surfaces of PC and secondary chamber SC	"Spotty" discoloration may indicates damage to refractory and/or insulation
Annual	Refractory in SC	No large (not expansion) cracks; repair if necessary

6.11 Trouble Shooting

Table 9 shows a list of operational problems that may be encountered, the possible causes and corrective measures. No list can cover all potential problems. Please report problems or unusual observations, even if you have corrected them yourself.

TABLE 9 TROUBLE SHOOTING GUIDELINES

Phases	Observation	Points/Items to look at.
Start -Up	Incinerator won't start	☐ Make sure there is power. ☐ Check emergency stop is not engaged. ☐ Timer is set to an actual value. ☐ Make sure there is power on all phases/legs coming into the incinerator.
Pre-Purge Phase	Skipping or not starting the Pre-purge.	☐ Check that pre-purge timer works correctly. ☐ Check emergency stop is not engaged. ☐ Make sure there is power on all phases/legs coming into the incinerator.
	Auxiliary burner blower(s) won't run in pre-purge cycle.	☐ Check Fuses. ☐ Check burner blower contacts are energized. ☐ Check that overload switch on the motor is not tripped. ☐ Check there is power at the burner on the wire supplying power to the motor (Use Multi meter) ☐ Check for a seized motor by manually spinning the blower wheel. (Make sure power is off and locked out)
Pre-heat Phase	Secondary auxiliary burner won't ignite	☐ Check Fuses. ☐ Check there is power at the Genisys Control. ☐ Check that Genisys control is not locked out.
	Burner keeps Locking out after manual reset.	☐ Check all fuel valves are on. ☐ Check Burner contacts are energized. ☐ Check there is sufficient fuel in the tank. ☐ Bleed the pump at the 3/8" bleed screw and make sure there is fuel flow and no air bubbles are present. If diesel is gelled it will not let the burner operate efficiently. ☐ If there is no fuel coming out of the pump and the motor is running then it could be a damaged coupling or seized pump. ☐ If bubbles do not disappear after a while then there is a possible minute leak in the supply line. Make sure all the fittings and joints are tight. ☐ Check that CAD cell is clean. ☐ Try and hear the spark at the electrodes.
Burn Phase	Primary auxiliary burner(s) won't ignite.	☐ Check Door Switch(s) are engaged. ☐ Check Fuses. ☐ Check there is power at the Genisys Control. ☐ Check that Genisys control is not locked out.
	Burner keeps Locking out after manual reset.	☐ Check all fuel valves are on. ☐ Check Burner contacts are energized. ☐ Check there is sufficient fuel in the tank. ☐ Bleed the pump at the 3/8" bleed screw and make sure there is fuel flow and no air bubbles

Phases	Observation	Points/Items to look at.
Start -Up	Incinerator won't start	☐ Make sure there is power. ☐ Check emergency stop is not engaged. ☐ Timer is set to an actual value. ☐ Make sure there is power on all phases/legs coming into the incinerator.
Pre-Purge Phase	Skipping or not starting the Pre-purge.	☐ Check that pre-purge timer works correctly. ☐ Check emergency stop is not engaged. ☐ Make sure there is power on all phases/legs coming into the incinerator.
	Auxiliary burner blower(s) won't run in pre-purge cycle.	☐ Check Fuses. ☐ Check burner blower contacts are energized. ☐ Check that overload switch on the motor is not tripped. ☐ Check there is power at the burner on the wire supplying power to the motor (Use Multi meter) ☐ Check for a seized motor by manually spinning the blower wheel. (Make sure power is off and locked out)
Pre-heat Phase	Secondary auxiliary burner won't ignite	☐ Check Fuses. ☐ Check there is power at the Genisys Control. ☐ Check that Genisys control is not locked out.
	Burner keeps Locking out after manual reset.	☐ Check all fuel valves are on. ☐ Check Burner contacts are energized. ☐ Check there is sufficient fuel in the tank. ☐ Bleed the pump at the 3/8" bleed screw and make sure there is fuel flow and no air bubbles are present. If diesel is gelled it will not let the burner operate efficiently. ☐ If there is no fuel coming out of the pump and the motor is running then it could be a damaged coupling or seized pump. ☐ If bubbles do not disappear after a while then there is a possible minute leak in the supply line. Make sure all the fittings and joints are tight. ☐ Check that CAD cell is clean. ☐ Try and hear the spark at the electrodes.
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	Burner keeps Locking out after manual reset.	☐ Check all fuel valves are on. ☐ Check Burner contacts are energized. ☐ Check there is sufficient fuel in the tank. ☐ Bleed the pump at the 3/8" bleed screw and make sure there is fuel flow and no air bubbles

6.12 Auxiliary Fuel Consumption Rate

Figure 13 shows the volumetric flow rates of propane and diesel as a function of burner rating. If the TOTAL burner rating is X million Btu/h, and the operating time from start-up to the end of burn-down is t hours, the maximum fuel needed is:

V = Y * t USG
where Y is the fuel consumption rate for X million Btu/h rating, as shown in the graph.

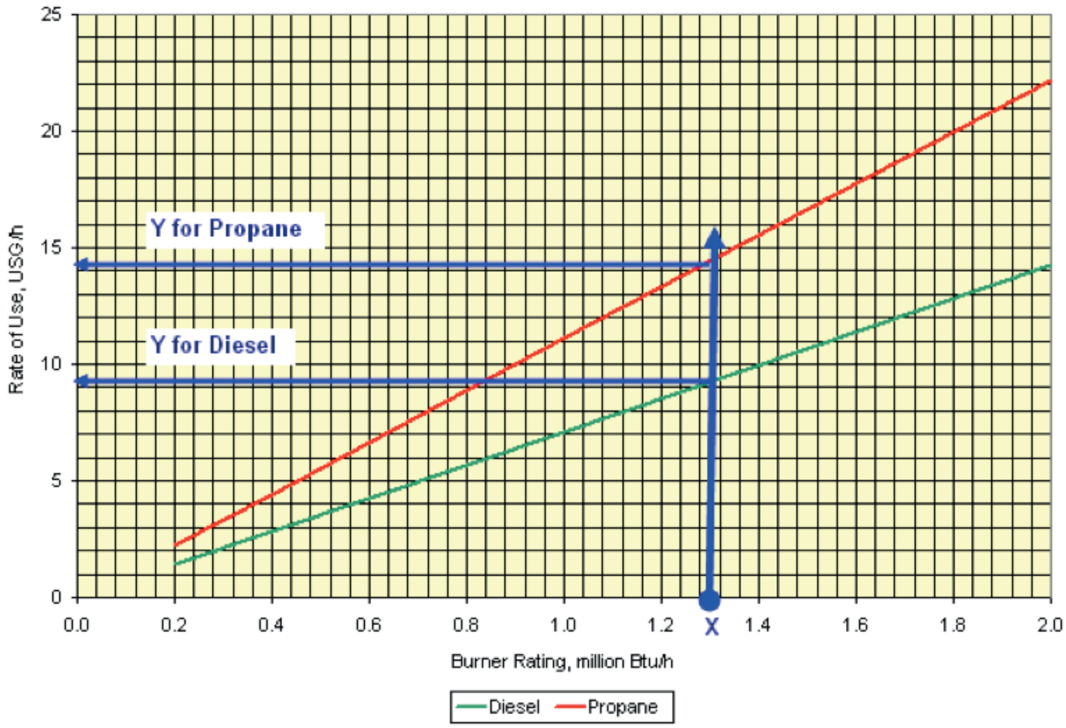


FIGURE 13 CONSUMPTION RATES OF PROPANE AND DIESEL

APPENDIX A

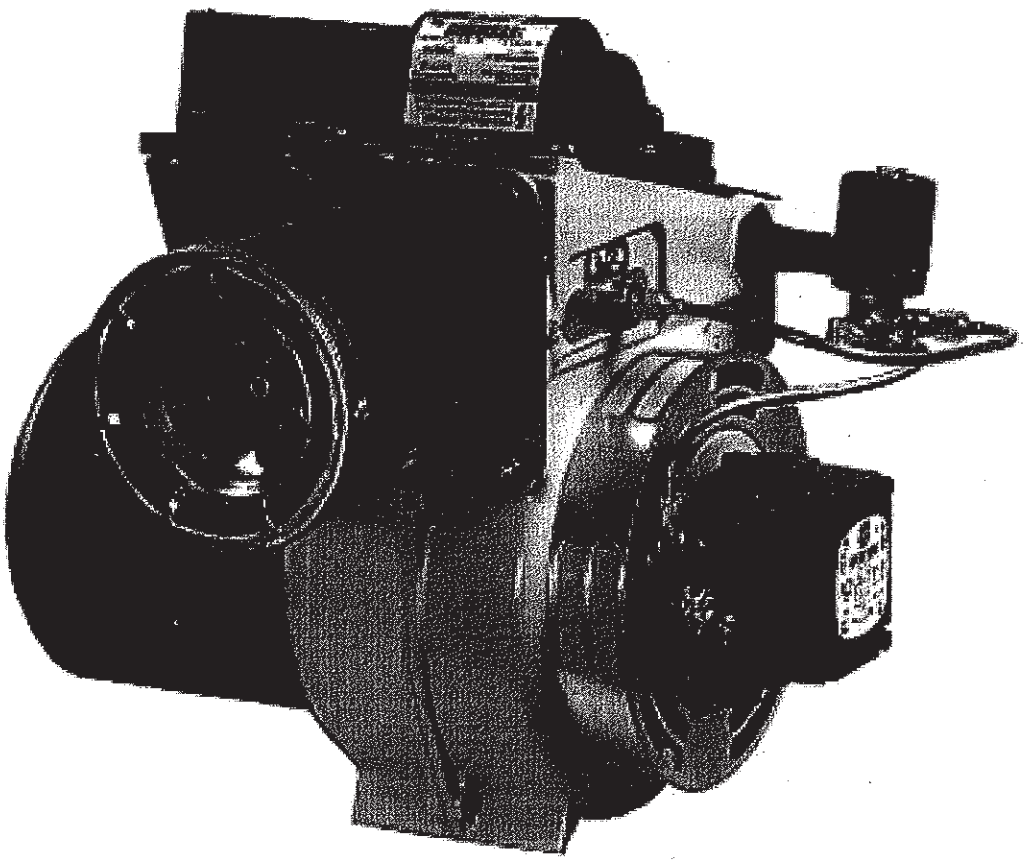
1. Suggested Spare Parts List
2. Burner WIC 201
3. Burner WIC 301
4. Blower Dayton 4C 108
5. Inspection Checklist
6. Wiring Diagram

7.1 Suggested Spare Parts List

CY-100-CA-D Recommended Spare Parts List

Description	Qty	KETEK Part No.
Gun Burner Beckett, WIC 201 16" (5.5GPH)	**2**	129230
Gun Burner Beckett, WIC 301 10-1/4" (7.0GPH)	**1**	129240
Dayton 4C-108 Flameport Blower	**1**	129305
Air Tube Combination for WIC 201 6 5/8	**2**	129420
Air Tube Combination for WIC 301 10-1/4"	**1**	129455
Motor for WIC 201	**2**	129480
Motor for WIC 301	**1**	129520
Coupling, Flex for WIC 201	**4**	129400
Coupling, Flex for WIC 301	**2**	129510
Fuel Pump A2YA-7916 Suntec	**2**	129320
Fuel Pump B2TA-8851 Suntec	**1**	129321
Blower Wheel for WIC 201	**2**	129410
Blower Wheel for WIC 301	**1**	129411
Transformer, Ignition "S" for WIC 201	**2**	129360
Transformer, Ignition "S" for WIC 301	**1**	129530
Nozzle (5.5 GPH 60° B)	**2**	144700
Cad Detector Cell (If Applicable)	**4**	120730
Beckett Genysis Control (If Applicable)	**2**	177800
Timer, H3CR-A 11pin	**1**	152760
Omron Temperature Controller	**1**	131850
Panel Fuse 10A	**2**	no item #
Panel Fuse 15A	**6**	no item #
Thermocouple Ceramic (Secondary Chamber)-12.75"	**2**	130140
Thermocouple Stainless Steel (Primary Chamber)-12.75"	**2**	163670
Proximity Switch Door	**1**	132600
Limit Switch Assembly	**1**	130090
Gasket, Ceramic Fibre 1/4" x 2"(price per foot)	**100 ft.**	132610
Gasket Cement, HT Silicone Tube	**4**	132620
Spark Arrester, Stainless Steel (Crating Not Included in Price)	**1**	130341
Filter Adapter (For Fuel Tank)	**1**	147840
Filter, Fuel LFF2 (For Fuel Tank)	**2**	133460

Models SF & SM Oil Burners



WARNING **Potential for Fire, Smoke and Asphyxiation Hazards**

Incorrect installation, adjustment, or misuse of this burner could result in death, severe personal injury, or substantial property damage.

To the Homeowner or Equipment Owner:

- Please read and carefully follow all instructions provided in this manual regarding your responsibilities in caring for your heating equipment.
- Contact a professional, qualified service agency for installation, start-up or service work.
- Save this manual for future reference.

To the Professional, Qualified Installer or Service Agency:

- Please read and carefully follow all instructions provided in this manual before installing, starting, or servicing this burner or heating system.
- The Installation must be made in accordance with all state and local codes having jurisdiction.

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Owner's Information

To the Owner:

Thank you for purchasing a Beckett burner for use with your heating appliance. Please pay attention to the Safety Warnings contained within this instruction manual. Keep this manual for your records and provide it to your qualified service agency for use in professionally setting up and maintaining your oil burner.

Your Beckett burner will provide years of efficient operation if it is professionally installed and maintained by a qualified service technician. If at any time the burner does not appear to be operating properly, **immediately contact your qualified service agency** for consultation.

We recommend annual inspection/service of your oil heating system by a qualified service agency.

Daily – Check the room in which your burner/appliance is installed. Make sure:

- Air ventilation openings are clean and unobstructed
- Nothing is blocking burner inlet air openings
- No combustible materials are stored near the heating appliance
- There are no signs of oil or water leaking around the burner or appliance

Weekly

- Check your oil tank level. Always keep your oil tank full, especially during the summer, in order to prevent condensation of moisture on the inside surface of the tank.

WARNING **Owner's Responsibility**

Incorrect installation, adjustment, and use of this burner could result in severe personal injury, death, or substantial property damage from fire, carbon monoxide poisoning, soot or explosion.

Contact a professional, qualified service agency for the installation, adjustment and service of your oil heating system. This work requires technical training, trade experience, licensing or certification in some states and the proper use of special combustion test instruments.

Please carefully read and comply with the following instructions:

- Never store or use gasoline or other flammable liquids or vapors near this burner or appliance.
- Never attempt to burn garbage or refuse in this appliance.
- Never attempt to light the burner/appliance by throwing burning material into the appliance.
- Never attempt to burn any fuel not specified and approved for use in this burner.
- Never restrict the air inlet openings to the burner or the combustion air ventilation openings in the room.

NOTICE

This manual contains information that applies to both SM and SF burners. These burners may appear to be basically identical, but there are differences in design and performance. Please review the comparison chart below:

Feature	SM	SF
Firing Rate Range	1.25 to 3.00 gph	1.25 to 5.50 gph
Motor	1/5 HP	1/4 HP
Fuel pump capacity	3 gph (standard)	7 gph (standard)
UL Air Tube Combinations	See Table 2	See Table 2
Blocking oil solenoid valve	Optional	Required above 3 gph
Primary control lockout timing	15 to 45 seconds (optional)	15 seconds maximum

Hazard Definitions

DANGER **Indicates an imminently hazardous situation, which, if not avoided, will result in death, serious injury, or property damage.**

WARNING **Indicates a potentially hazardous situation, which, if not avoided, could result in death, severe personal injury, and/or substantial property damage.**

CAUTION **Indicates a potentially hazardous situation, which, if not avoided, may result in personal injury or property damage.**

Within the boundaries of the hazard warning, there will be information presented describing consequences if the warning is not heeded and instructions on how to avoid the hazard.

NOTICE

Intended to bring special attention to information, but not related to personal injury or property damage.

General Information

Table 1 – Burner Specifications

Model SM Capacity (Note1)	Firing rate range: ....01.25 – 3.00 GPH Input: .... 175,000 – 420,000 Btu/hr
Model SF Capacity (Note1)	Firing rate range: ....1.25 - 5.50 GPH Input: .... 175,000 – 770,000 Btu/hr
Certifications/ Approvals	Model SM - UL listed to comply with ANSI/ UL296 & certified to CSA B140.0. Model SF - UL listed to comply with ANSI/UL 296 & certified to CSA B140.0.
Fuels	U. S: No.1 or No.2 heating oil only (ASTM D396) Canada: No. 1 stove oil or No. 2 furnace oil only
Electrical	Power supply: .... 120 volts AC, 60 Hz, single phase Operating load (SM): ....5.8 Amps max Operating load (SF): ....7.1 Amps max Motor (SM): .... 1/5 hp, 3450 rpm, NEMA 'N' flange, manual reset over load protection Motor (SF): .... 1/4 hp, 3450 rpm, NEMA 'N' flange, manual reset over load protection Ignition: ... Continuous duty solid-state igniter
Fuel pump	Outlet pressure: .... Note 2
Air tube	ATC code: ....See Table 2
Dimensions (Standard)	Height ....12.5 inches Width ....15 inches Depth .... 8.50 inches Air tube diameter .... 4.00 inches
Air tube	ATC code: ....See Table 2

Note 1: *Approval agency listed rating for Model SM is 1.25 to 3.00 gph and Model SF is 1.25 to 5.50 gph. However, the firing rate range is limited by the specific air tube combination being used. Refer to Table 2.*

Note 2. *UL Recognized to 4.0 GPH with a CleanCut pump for use in pressure washers.*

Note 3. *See appliance manufacturer's burner specifications for recommended pump discharge pressure.*

- **Notice Special Requirements**
  - For recommended installation practice in Canada, refer to the latest version of CSA Standard B139 & B140.
  - Concealed damage — If you discover damage to the burner or controls during unpacking, notify the carrier at once and file the appropriate claim.
  - When contacting Beckett for service information — Please record the burner serial number (and have available when calling or writing). You will find the serial number on the silver label located on the left rear of the burner. Refer to Figure 1.

WARNING **Professional Service Required**

Incorrect installation, adjustment, and use of this burner could result in severe personal injury, death, or substantial property damage from fire, carbon monoxide poisoning, soot or explosion.

Please read and understand the manual supplied with this equipment. This equipment must be installed, adjusted and put into operation only by a qualified individual or service agency that is:

- Licensed or certified to install and provide technical service to oil heating systems.
- Experienced with all applicable codes, standards and ordinances.
- Responsible for the correct installation and commission of this equipment.
- Skilled in the adjustment of oil burners using combustion test instruments.

The installation must strictly comply with all applicable codes, authorities having jurisdiction and the latest revision of the National Fire Protection Association Standard for the installation of Oil-burning Equipment, NFPA 31 (or CSA B139 and B140 in Canada).
Regulation by these authorities take precedence over the general instructions provided in this installation manual.

Table 2 – Air Tube Combination (ATC) codes

Firing Rate (gph)	Head	Static plate size	ATC Codes for usable air tube lengths ('A' in inches; See Figure 3.)			
(min-max)		(inches)	6-5/8	9	13	16
For SF Burner Only						
1.25-2.25	F12	2-3/4	SF65VW	SF90VW	SF130VW	SF160VW
1.75-2.75	F22	2-3/4	SF65VP	SF90VP	SF130VP	SF160VP
1.75-3.25	F220	None	SF65FD	SF90FD	SF130FD	SF160FD
2.5-5.5	F310	None	SF65FU	SF90FU	SF130FU	SF160FU
For SM Burner Only						
1.25-2.00	F12	2-3/4	SM65VW	SM90VW	SM130VW	SM160VW
2.00-3.00	F220	None	SM65FF	SM90FF	SM130FF	SM160FF
2.00-3.00	F22	None	SM65VM	SM90VM	SM130VM	SM160VM

Inspect/Prepare Installation Site

- **Chimney or vent**
  - Inspect the chimney or vent, making sure it is properly sized and in good condition for use.
  - For those installations not requiring a chimney, such as through-the-wall vented appliances, follow the instructions given by the appliance and power venter (if used) manufacturers.

- **Combustion air supply**

WARNING **Adequate Combustion and Ventilation Air Supply Required**

Failure to provide adequate air supply could seriously affect the burner performance and result in damage to the equipment, asphyxiation, explosion or fire hazards.

- The burner cannot properly burn the fuel if it is not supplied with a reliable combustion air source.
- Follow the guidelines in the latest editions of the NFPA 31 and CSA-B139 regarding providing adequate air for combustion and ventilation.

See NFPA 31 Standard for complete details.

<u>Appliance located in confined space</u>

The confined space should have two (2) permanent openings: one near the top of the enclosure and one near the bottom of the enclosure. Each opening shall have a free area of not less than (1) one square inch per 1,000 BTU's per hour of the total input rating of all appliances within the enclosure. The openings shall have free access to the building interior, which should have adequate infiltration from the outside.

Exhaust fans and other air-using devices

Size air openings large enough to allow for all air-using devices in addition to the minimum area required for combustion air. If there is any possibility of the equipment room developing negative pressure (because of exhaust fans or clothes dryers, for example), either pipe combustion air directly to the burner or provide a sealed enclosure for the burner and supply it with its own combustion air supply.

• Clearances to burner and appliance

- Provide space around burner and appliance for easy service and maintenance.
- Check minimum clearances against those shown by the appliance manufacturer and by applicable building codes.

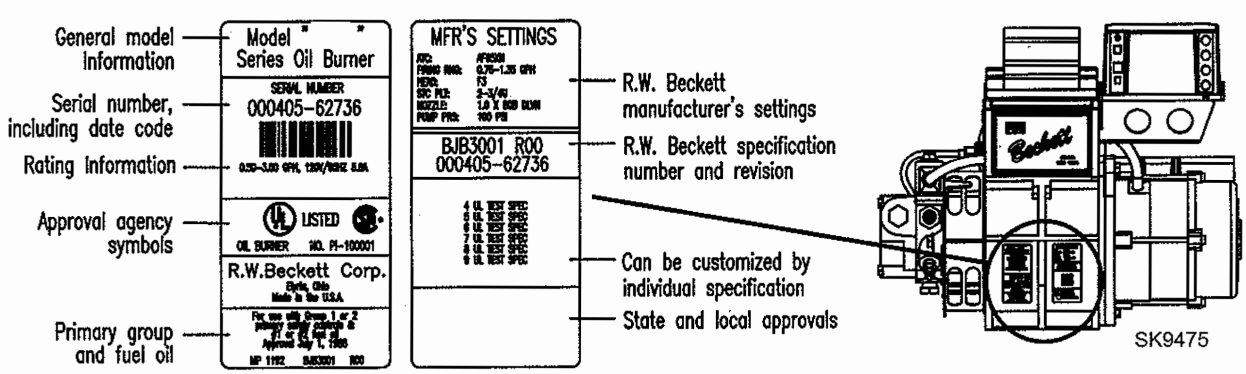
• Combustion chamber — Burner retrofitting

Verify that the appliance combustion chamber provides at least the minimum dimensions given in Table 3.

Table 3. Chamber Dimensions

Chamber Dimensions (inches)					
Firing Rate (GPH)	Round I.D.	Rectangular Width	Rectangular Length	Height	Floor to nozzle
1.25	11	10	11	12	5-6
1.50	12	11	12	13	6-7
2.00	14	12	15	13	6-7
2.50	16	13	17	14	7-8
3.00	18	14	18	15	7-8
3.50	19	15	19	15	7-8
4.00	20	16	21	16	8-9
5.00	23	18	23	18	9-10
5.50	24	19	24	19	10-11

Figure 1. Burner Label Location



WARNING **Protect Steel Combustion Chamber From Burnout**

Failure to comply could result in damage to the heating equipment and result in fire or asphyxiation hazards.

- When retrofitting appliances that have unlined stainless steel combustion chambers, protect the chamber by lining the inside surfaces with a ceramic fiber blanket, such as a wet-pac or other suitable refractory material.
- Some steel chambers may not require liners because the appliance was designed and tested for use with flame retention burners. Refer to the manufacturer's instructions.

Prepare the Burner

• Burner fuel unit

Verify that the burner fuel unit is compatible with the oil supply system. For more details, refer to "Connect fuel lines" later in this manual.

• Attach air tube (if not already installed)

If using a flange and gasket, slide them onto the air tube. Then attach the air tube to the burner chassis using the four sheet metal screws provided. Refer to Figure 3 for details.

• Install burner nozzle (if not already installed)

1. Remove the plastic plug protecting the nozzle adapter threads
2. Place a ¾" open-end wrench on the nozzle adapter. Insert the nozzle into the adapter and finger tighten. Finish tightening with a ⅝" open-end wrench. Use care to avoid bending the electrodes.

WARNING Correct Nozzle and Flow Rate Required

Incorrect nozzles and flow rates could result in impaired combustion, under-firing, over-firing, sooting, puff-back of hot gases, smoke and potential fire or asphyxiation hazards.

Use only nozzles having the brand, flow rate (gph), spray angle and pattern specified by the appliance manufacturer.

Follow the appliance manufacturer's specifications for the required pump outlet pressure for the nozzle, since this affects the flow rate.

- Nozzle manufacturers calibrate nozzle flow rates at 100 psig.
- When pump pressures are higher than 100 psig, the actual nozzle flow rate will be greater than the gph stamped on the nozzle body. (Example: A 1.00 gph nozzle at 140 psig = 1.18 gph)

Securely tighten the nozzle (torque to 90 inch pounds). For typical nozzle flow rates at various pressures refer to Table 5.

Table 5. Nozzle Flow Rate by Size

Nozzle flow rate U. S. gallons per hour of No. 2 fuel oil when pump pressure (psig) is:					
Nozzle size (rated at 100 psig)	**125 psi**	**140 psi**	**150 psi**	**175 psi**	**200 psi**
1.25	1.39	1.48	1.53	1.65	1.77
1.35	1.51	1.60	1.65	1.79	1.91
1.50	1.68	1.77	1.84	1.98	2.12
1.65	1.84	1.95	2.02	2.18	2.33
1.75	1.96	2.07	2.14	2.32	2.48
2.00	2.24	2.37	2.45	2.65	2.83
2.25	2.52	2.66	2.76	2.98	3.18
2.50	2.80	2.96	3.06	3.31	3.54
2.75	3.07	3.25	3.37	3.64	3.90
3.00	3.35	3.55	3.67	3.97	4.24
3.25	3.63	3.85	3.98	4.30	4.60
3.50	3.91	4.14	4.29	4.63	4.95
3.75	4.19	4.44	4.59	4.96	5.30
4.00	4.47	4.73	4.90	5.29	-
4.50	5.04	5.32	5.51	-	-
5.00	5.59	-	-	-	-
5.50	-	-	-	-	-

Table 6. Nozzle Spray Angles

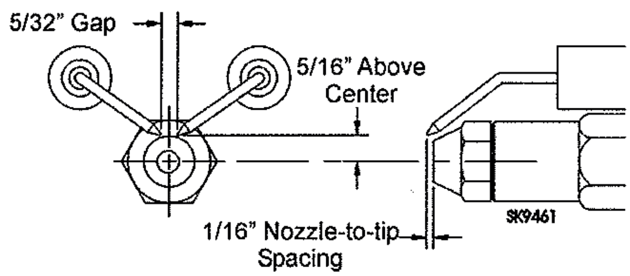
Recommended nozzle spray angles	
"F" head	70°, 80° or 90° nozzle

Note: Always follow the appliance manufacturer's nozzle specification, when available.

3. If the nozzle is already installed, remove the nozzle line assembly to verify that the nozzle size and spray pattern are correct for the application (per appliance manufacturer's information). Verify that the electrode tip settings comply with Figure 2.
4. If the nozzle is not installed, obtain a nozzle having the capacity and spray angle specified in the appliance manufacturer's information. For conversions or upgrades, when information is not available for the application:
   - Refer to Table 6 to select the mid-range nozzle spray angle for the head type being used.
   - Fire the burner and make sure the combustion is acceptable and the flame is not impinging on chamber surfaces.
   - If a shorter flame is needed, select a wider spray angle. If a longer flame is needed, select a narrower spray angle.
   - Either hollow or solid spray patterns may be used. If combustion results are not satisfactory with the selected spray pattern, try the other pattern.

• Check/adjust electrodes

Figure 2. – Electrode Tip Adjustment



Check the electrode tip settings. Adjust if necessary to comply with the dimensions shown in Figure 2. To adjust, loosen the electrode clamp screw and slide/rotate electrodes as necessary. Securely tighten the clamp screw when finished.

• Servicing nozzle line assembly

1. Turn off power to burner before proceeding.
2. Disconnect oil connector tube from nozzle line.
3. Loosen the two screws securing igniter retaining clips and rotate both clips to release igniter baseplate. Then tilt igniter back on its hinge.
4. Remove splined nut.
5. "F" head air tube. - Remove nozzle line assembly from burner, being careful not to damage the electrodes or insulators while handling. To ease removal of long assemblies (over 9 inches), rotate assembly 180° from installed position after pulling partially out of tube.
6. To replace the nozzle assembly, reverse the above steps.

Mount Burner on Appliance

⚠WARNING Do Not use Adjustable Mounting Flange on Mobile Units

The shock and vibration could cause loss of burner alignment and insertion problems resulting in flame impingement, heavy smoke, fire and equipment damage.

- Only use specified factory-welded flange and air tube combinations.

• Mounting options

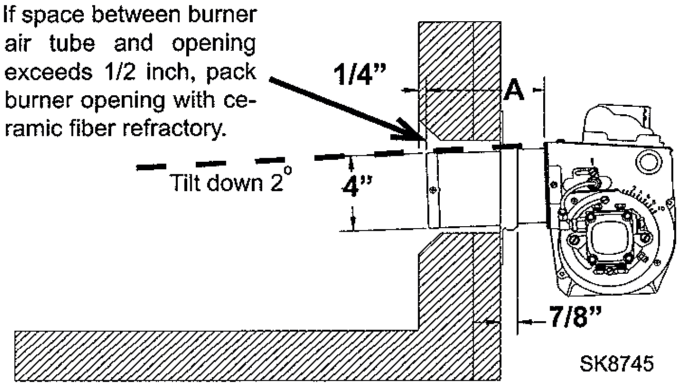
Bolt the burner to the appliance using the factory-mounted flange or an adjustable flange.

• Mounting dimensions

1. When using the Beckett universal adjustable flange, mount the air tube at a 2° downward pitch unless otherwise specified by the appliance manufacturer.
2. Verify that the air tube installed on the burner provides the correct insertion depth. See Figure 3.
3. The end of the air tube should normally be ¼" back from the inside wall of the combustion chamber. Never allow the leading edge of the head assembly to extend into the chamber, unless otherwise specified by the heating appliance manufacturer. Carefully measure the insertion depth when using an adjustable flange. Verify the insertion depth when using a welded flange.

Figure 3. – Mounting Burner in Appliance

If space between burner air tube and opening exceeds 1/2 inch, pack burner opening with ceramic fiber refractory.



• Connect fuel lines

Carefully follow the fuel unit manufacturer's literature and the latest edition of NFPA 31 for oil supply system specifications.

⚠WARNING Do Not Install By-pass Plug with 1-Pipe System

Failure to comply could cause Immediate pump seal failure, pressurized oil leakage and the potential for a fire and injury hazard.

- The burner is shipped without the by-pass plug installed. **EXCEPTION**: Unless specified by the equipment manufacturer and noted on the label at top of pump cover.
- Install the by-pass plug in two-pipe oil supply systems ONLY.

⚠CAUTION Oil Supply Pressure Control Required

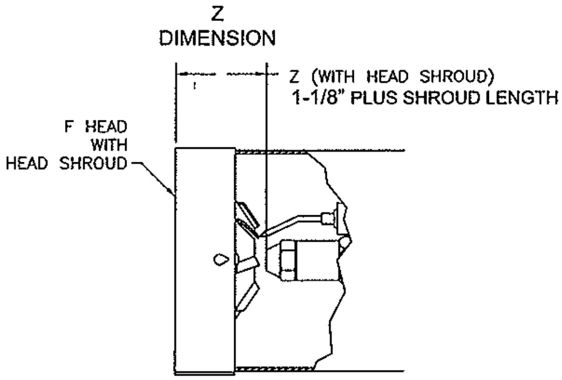
Damage to the filter or pump seals could cause oil leakage and a fire hazard.

- The oil supply inlet pressure to the burner ***cannot exceed 3 psig***.
- Insure that a pressure limiting device is installed in accordance with the latest edition of NFPA 31.
- Do not install valves in the return line. (NFPA 31, Chapter 8)
- **Gravity Feed Systems:** Always install an anit-siphon valve in the oil supply line or a solenoid valve (RWB Part # 2182602U or 2233U) in the pump/nozzle discharge tubing to provide backup oil flow cut-off protection.

Fuel supply level with or above burner – The burner may be equipped with a single-stage fuel unit for these installations. Connect the fuel supply to the burner with a single supply line if you want a one-pipe system (making sure the bypass plug is NOT installed in the fuel unit.) Manual bleeding of the fuel unit is required on initial start-up. If connecting a two-pipe fuel supply, install the fuel unit bypass plug.

Fuel supply below the level of the burner – When the fuel supply is more than eight feet below the level of the burner, a two-pipe fuel supply system is required. Depending on the fuel line diameter and horizontal and vertical length, the installation may also require a two-stage pump. Consult the fuel unit manufacturer's literature for lift and vacuum capability.

Check/Adjust 'Z' Dimension for 'F' Heads



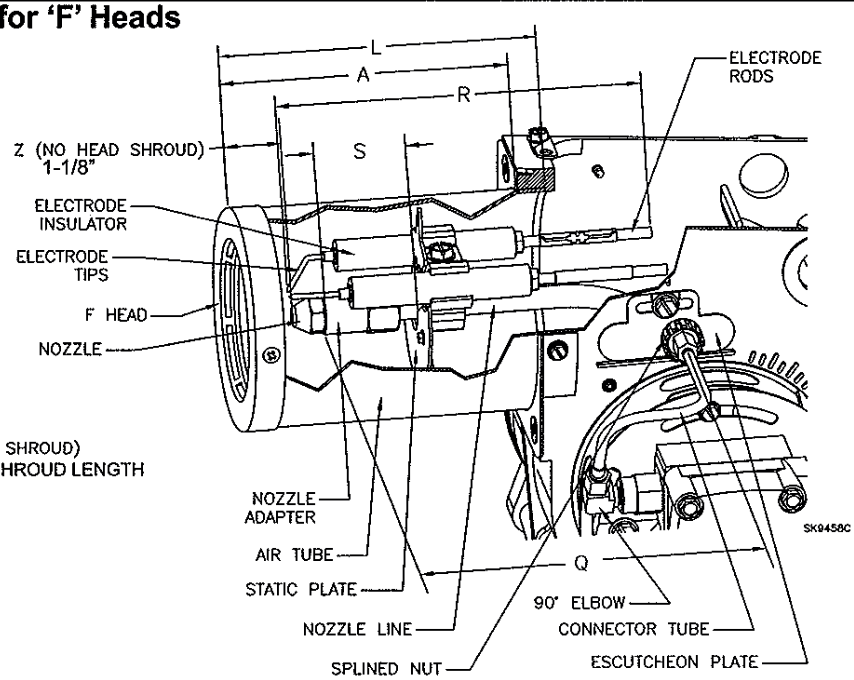


Figure 4. 'F' Head

• Check/Adjust 'Z' Dimension - 'F' heads

WARNING **Adjust the 'Z' dimension to the required specification.**

Incorrect Adjustments could cause combustion problems, carbon deposition from flame impingement, heavy smoke generation and fire hazard.

- Make all adjustments exactly as outlined in the following information.

1. The important 'Z' dimension is the distance from the face of the nozzle to the flat face of the head (or heat shield, if applicable). This distance for F heads is 1-⅛" (1-⅜" if the air tube has a heat shield). The "Z" dimension is factory set for burners shipped with the air tube installed. Even if factory set, verify that the "Z" dimension has not been changed.
2. Use the following procedure to adjust the "Z" dimension, if it is not correct:
   - Turn off power to the burner.
   - Disconnect the oil connector tube from the nozzle line
   - See above figure. Loosen the splined nut from the nozzle line. Loosen the hex head screw securing the escutcheon plate to the burner housing.
   - Place the end of a ruler at the face of the nozzle and, using a straight edge across the head, measure the distance to the face of the head. A Beckett T501 or T650 gauge may also be used.
   - Slide the nozzle line forward or back until the Z dimension for F heads is 1-⅛" (1-1/8" plus shroud length, if using a straight edge).
   - Tighten the hex head screw to secure the escutcheon plate to the burner chassis. Then tighten the splined nut and attach the oil connector tube.
3. Recheck the "Z" dimension periodically when servicing to ensure the escutcheon plate has not been moved. You will need to reset the "Z" dimension if you replace the air tube or nozzle line assembly. The Beckett Z gauge (part number Z-2000) is available to permit checking the F head "Z" dimension without removing the burner from the appliance.

• Burner Dimensions - Models SM & SF

Dimension (inches)	F Head
A = Usable air length (inches)	(Measure accurately)
L (Total tube length)	A+1/2
R (electrode length), ± 1/4	A+2-1/4
S (adapter to static plate), ± 1/16	(Note 1)
Q (nozzle line length),	A+ 15/16
Z (F head w/o head shroud) (F head-with head shroud)	1-1/8 1-1/8 + shroud length. (Note 2)

Note 1: 1-3/8 for dimension A less than 4"; 1-5/8 for dimension A from 4" through 4-1/2 ", 2-13/32 for dimension A greater than 4-1/2".
Note 2: When using a straight edge.

Fuel line installation –

CAUTION Do Not Use Teflon Tape

Damage to the pump could cause impaired burner operation, oil leakage and appliance soot-up.

- Never use Teflon tape on fuel oil fittings.
- Tape fragments can lodge in fuel line components and fuel unit, damaging the equipment and preventing proper operation.
- Use of Teflon tape will void the Suntec warranty.
- Use oil-resistant pipe sealant compounds.

Continuous lengths of heavy wall copper tubing are recommended. **Always use flare fittings. Never use compression fittings.**

- Always install fittings in accessible locations. Proper routing of fuel lines is required to prevent air cavitation and vibration.

Fuel line valve and filter –

- Install two high quality fusible-handle design shutoff valves in accessible locations on the oil supply line to comply with the NFPA 31 Standard and authorities having jurisdiction. Locate one close to the tank and the other close to the burner, upstream of the filter.
- Install a generous capacity filter inside the building between the fuel tank shutoff valve and the burner, locating both the filter and the valve close to the burner for ease of servicing. Filter should be rated for 50 microns or less.

Wire Burner

WARNING Electrical Shock Hazard

Electrical shock can cause severe personal injury or death.

- Disconnect electrical power before installing or servicing the burner.
- Provide ground wiring to the burner, metal control enclosures and accessories. (This may also be required to aid proper control system operation.)
- Perform all wiring in compliance with the National Electrical Code ANSI/NFPA 70 (Canada CSA C22.1)

- **Burner packaged with appliance**

Refer to appliance manufacturer's wiring diagram for electrical connections.

- **Burner installed at jobsite**

Refer to Figure 5, for typical burner wiring, showing cad cell primary controls. Burner wiring may vary, depending on primary control actually used.

The R7184 primary control with valve-on delay (prepurge) and burner motor-off delay (postpurge), requires a constant 120 volts AC power source supplied to the BLACK wire on the control. The RED wire goes to the appliance limit circuit. Please note that other control manufacturers may use different wire colors for power and limit connections.

Start Up Burner/Set Combustion

WARNING Explosion and Fire Hazard

Failure to follow these instructions could lead to equipment malfunction and result in heavy smoke emission, soot-up, hot gas puff-back, fire and asphyxiation hazards.

- Do not attempt to start the burner when excess oil has accumulated in the appliance, the appliance is full of vapor, or when the combustion chamber is very hot.
- Do not attempt to re-establish flame with the burner running if the flame becomes extinguished during start-up, venting, or adjustment.
- <u>Vapor-Filled Appliance:</u> Allow the unit to cool off and all vapors to dissipate before attempting another start.
- <u>Oil-Flooded Appliance:</u> Shut off the electrical power and the oil supply to the burner and then clear all accumulated oil before continuing.
- If the condition still appears unsafe, contact the Fire Department. Carefully follow their directions.
- Keep a fire extinguisher nearby and ready for use.

1. Open the shutoff valves in the oil supply line to the burner.
2. If the air control is not preset, close air band and partially open air shutter. This is an initial air setting for the pump bleeding procedure only. Additional adjustments must be made with instruments to prevent smoke and carbon monoxide generation.
3. Set the thermostat substantially above room temperature.

Typical Burner Wiring & Burner Sequence of Operation for R7184 Control.

Refer to the appliance manufacturer's wiring diagram for actual specifications.

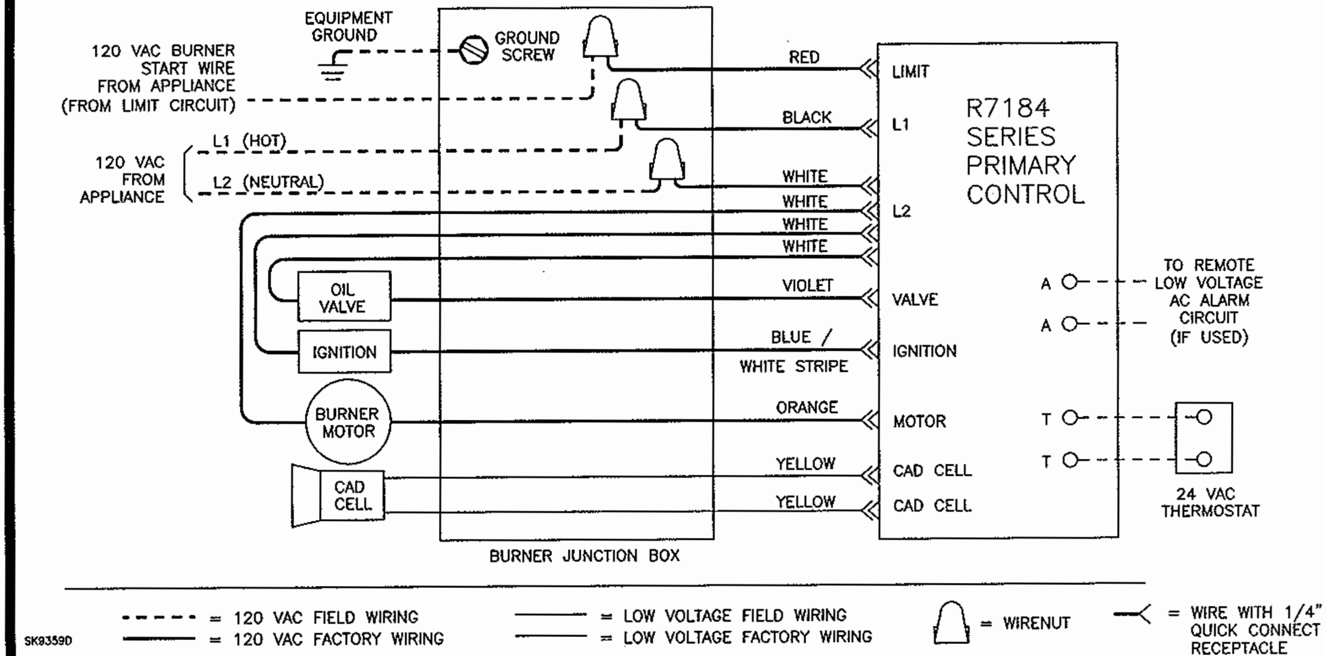
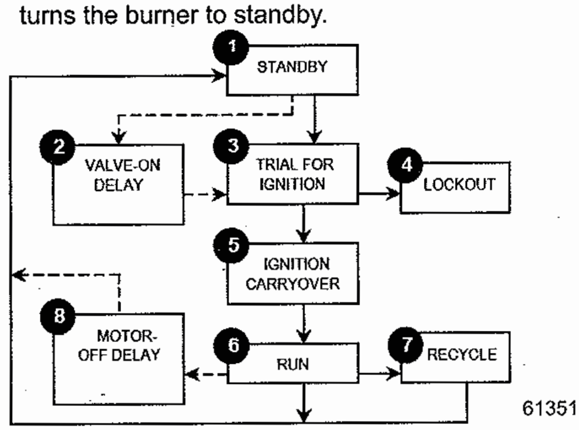


Figure 5. – Typical Burner Wiring

1. **STANDBY.** The burner is idle, waiting for a call for heat. When a call for heat is initiated, there is a 3-10 second delay while the control performs a safe start check.
2. **VALVE-ON DELAY.** The ignition and motor are turned on for a 15 second valve-on delay.
3. **TRIAL FOR IGNITION (TFI).** The fuel valve is opened. A flame should be established within the 15 second lockout time.
4. **LOCKOUT.** If flame is not sensed by the end of the TFI, the control shuts down on safety lockout and must be manually reset. If the control locks out three times in a row, the control enters restricted lockout.
5. **IGNITION CARRYOVER.** Once flame is established, the ignition remains on for 10 seconds to ensure flame stability before turning off. If the control is wired for intermittent duty ignition, the ignition unit stays on the entire time the motor is running.
6. **RUN.** The burner runs until the call for heat is satisfied. The burner is then sent to burner motor off delay, if applicable, or it is shut down and sent to standby.
7. **RECYCLE.** If the flame is lost while the burner is firing, the control shuts down the burner, enters a 60 second recycle delay, and then repeats the above ignition sequence. If flame is lost three times in a row, the control locks out to prevent cycling with repetitious flame loss due to poor combustion.
8. **BURNER MOTOR-OFF DELAY.** The fuel valve is closed and the burner motor is kept on for the selected motor-off delay time before the control returns the burner to standby.



Control System Features

Feature	Interrupted ignition	Limited reset, Limited recycle	Diagnostic LED, cad cell indicator	Valve-on delay	Burner motor off delay	Alarm Contacts
R7184A	YES	YES	YES	—	—	—
R7184B	YES	YES	YES	YES	—	—
R7184P	YES	YES	YES	YES	YES	Optional

4. Close the line voltage switch to start the burner. If the burner does not start immediately you may have to reset the safety switch of the burner primary control.
5. Bleed air from fuel unit as soon as burner motor starts rotating.
   - To bleed the fuel unit, attach a clear plastic hose over the vent fitting. Loosen the fitting and catch the oil in an empty container. Tighten the fitting when all air has been purged from the oil supply system.
   - If the burner locks out on safety during bleeding, reset the safety switch and complete the bleeding procedure. Note — Electronic safety switches can be reset immediately; others may require a three- to five-minute wait.
   - If burner stops after flame is established, additional bleeding is probably required. Repeat the bleeding procedure until the pump is primed and a flame is established when the vent fitting is closed.
   - For R7184 primary controls, see Technician's Quick Reference Guide, part number 61351 for special pump priming sequence.
   - Prepare for combustion tests by drilling a ¼" sampling hole in the flue pipe between the appliance and the barometric draft regulator.
6. Initial air adjustment — Test the flue gas for smoke. Adjust the air shutter (and air band, if necessary) to obtain a clean flame. Now the additional combustion tests with instruments can be made

• Set combustion with instruments

1. Allow the burner to run for approximately 5 to 10 minutes.
2. Set the stack or over-fire draft to the level specified by the appliance manufacturer.
   - **Natural Draft Applications;** typically over-fire draft is -0.01" or -0.02" w.c.
   - **Direct Venting**; typically may not require draft adjustment.
   - **High Efficiency/Positive Pressure Appliances**; also vary from traditional appliances (see manufacturer's recommendations).
3. Follow these four steps to properly adjust the burner:

   Step 1: Adjust the air shutter/band until a trace of smoke is achieved.

   Step 2: At the trace of smoke level, measure the CO_2 (or O_2) . This is the vital reference point for further adjustments. Example: 13.5% CO_2 (2.6% O_2)

   Step 3: Increase the air to reduce the CO_2 by 1.5 to 2 percentage points. (O_2 will be increased by approximately 2.0 to 2.7 percentage points.) Example: Reduce CO_2 from 13.5% to 11.5% (2.6% to 5.3% O_2).

   Step 4: Recheck smoke level. It should be Zero.
   - This procedure provides a margin of reserve air to accommodate variable conditions.
   - If the draft level has changed, recheck the smoke and CO2 levels and readjust the burner, if necessary
4. Once combustion is set, tighten all fasteners on air band, air shutter and escutcheon plate.
5. Start and stop the burner several times to ensure satisfactory operation. Test the primary control and all other appliance safety controls to verify that they function according to the manufacturer's specifications.

Perform Regular Maintenance

WARNING **Annual Professional Service Required**

Tampering with or making incorrect adjustments could lead to equipment malfunction and result in asphyxiation, explosion or fire.

- Do not tamper with the burner or controls or make any adjustments unless you are a trained and qualified service technician.
- To ensure continued reliable operation, a qualified service technician must service this burner annually.
- More frequent service intervals may be required in dusty or adverse environments.
- Operation and adjustment of the burner requires technical training and skillful use of combustion test instruments and other test equipment.

- ☐ Replace the oil supply line filter. The line filter cartridge must be replaced to avoid contamination of the fuel unit and nozzle.
- ☐ Inspect the oil supply system. All fittings should be leak-tight. The supply lines should be free of water, sludge and other restrictions.
- ☐ Remove and clean the pump strainer if applicable.
- ☐ Replace the nozzle with the exact brand, pattern, gph flow rate and spray angle..
- ☐ Clean and inspect the electrodes for damage, replacing any that are cracked or chipped.
- ☐ Check electrode tip settings. Replace electrodes if tips are rounded.
- ☐ Inspect the igniter spring contacts.
- ☐ Clean the cad cell lens surface, if necessary.
- ☐ Inspect all gaskets. Replace any that are damaged or would fail to seal adequately.
- ☐ Inspect the combustion head and air tube. Remove any carbon or foreign matter. Replace all damaged units with exact parts.
- ☐ Clean the blower wheel, air inlet, air guide, burner housing and static plate of any lint or foreign material.
- ☐ If motor is not permanently lubricated, oil motor with a few drops of SAE 20 nondetergent oil at each oil hole. DO NOT over oil motor. Excessive oiling can cause motor failure.
- ☐ Check motor current. The amp draw should not exceed the nameplate rating.
- ☐ Check all wiring for secure connections or insulation breaks.
- ☐ Check the pump pressure and cutoff function.
- ☐ Check primary control safety lockout timing.
- ☐ Check ignition system for proper operation.
- ☐ Inspect the vent system and chimney for soot accumulation or other restriction.
- ☐ Clean the appliance thoroughly according to the manufacturer's recommendations.
- ☐ Check the burner performance. Refer to the section "Set combustion with test instruments".
- ☐ It is good practice to make a record of the service performed and the combustion test results.

• Replacing the blower wheel:

- When replacing the blower wheel, insure that the wheel is centered between the two sides of the burner housing as shown below.

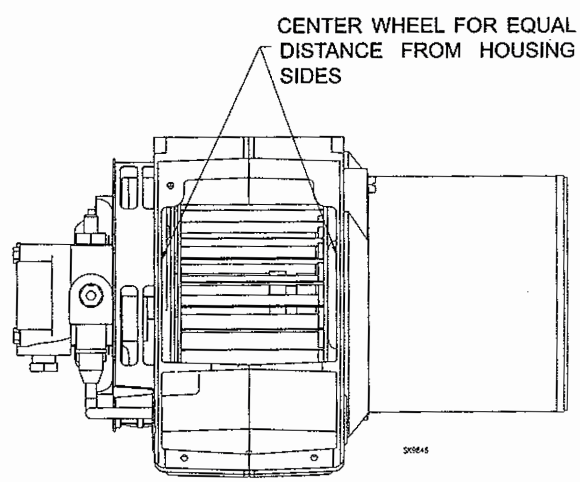
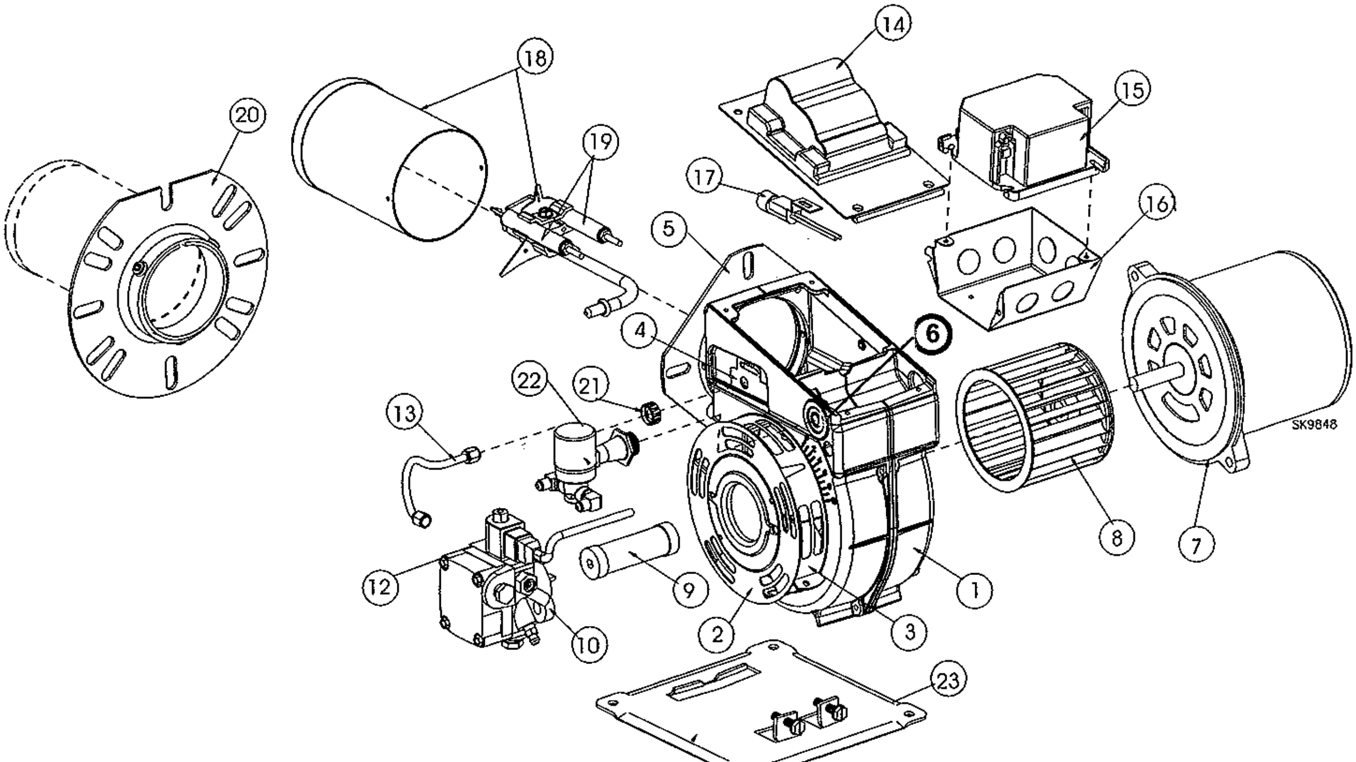


Figure 6. Blower Wheel Assembly

Burner Parts Diagram



SK9848

For best performance specify genuine Beckett replacement parts

#	Part No.	Description
1		Burner Housing Assembly with Inlet Bell
2	3215	Air shutter, 10 Slot
3	3819	Bulk Air Band, 10 Slot
4	3493	Nozzle-line Escutcheon Plate
5	Specify ** 3399	Unit Flange or Square Plate
Not Shown	3416	Air Tube Gasket
6	2139	Hole Plug - Wiring Box
7	2900U 2364U	Drive Motor, 1/5 HP (SM Models) Drive Motor, 1/4 HP (SF Models)
8	2383U	Blower Wheel (6-1/4 X 3-7/16)
9	2433	Flexible Coupling (Fits 5/16" pump shaft)
10	 2591U 21188U	Fuel Units SF only Single-Stage 'A' Two-Stage 'B'
10	 2184404U 2460	Fuel Units SM only CleanCut Single-Stage 'A'
12	2256	Pump outlet fitting
	482	Pump holding screws (not shown)
13	5394	Connector tube assembly, pump to nozzle line

#	Part No.	Description
14	51824U	Igniter and Base Plate
14	2289U	Ignition Transformer (10,000 V/23mA)
15	7455U	R7184A - Interrupted Ignition
	7456U	R7184B - Pre-purge
	7457U	R7184P - Pre and Post-purge
	7458U	R7184P w/ Alarm Contacts
16	5770	Electrical Box
17	7006U	Cad Cell Detector
18	Specify **	Air Tube Combination
19	5780	Electrode Kit - F Head up to 9"
	5782	Electrode Kit - F Head over 9"
20	5432 3616	Universal Flange w/ Gasket Gasket Only
21	3666	Splined Nut
22	2182602U	Blocking Oil Solenoid Valve
23	5685	Base Pedestal Kit

** Contact your Beckett Representative for part number and pricing.

WIC 301 BURNER

Beckett
COMMERCIAL

CF1400 CF2300

OIL BURNER MANUAL

Operation: Low/High
Rate: CF1400: 4.0 to 13.6 GPH
CF2300: 7.0 to 19.9 GPH

WARNING **Potential for Fire, Smoke and Asphyxiation Hazards**

Incorrect installation, adjustment, or misuse of this burner could result in death, severe personal injury, or substantial property damage.

To the Homeowner or Equipment Owner:

- Please read and carefully follow all instructions provided in this manual regarding your responsibilities in caring for your heating equipment.
- Contact a professional, qualified service agency for installation, start-up or service work.
- Save this manual for future reference.

To the Professional, Qualified Installer or Service Agency:

- Please read and carefully follow all instructions provided in this manual before installing, starting, or servicing this burner or heating system.
- The Installation must be made in accordance with all state and local codes having jurisdiction.

Before you begin . . .

The following resources will give you additional information for your installation. We suggest that you consult these resources whenever possible. Pay particular attention to the appliance manufacturer's instructions.

Appliance manufacturer's instructions *-Always follow the appliance manufacturer's instructions for burner installation, equipment and set-up.*

1–800–OIL–BURN *- Beckett's technical services hot-line.*
www.beckettcorp.com *- Beckett's website.*

To the Owner:

Thank you for purchasing a Beckett burner for use with your heating appliance. Please pay attention to the Safety Warnings contained within this instruction manual. Keep this manual for your records and provide it to your qualified service agency for use in professionally setting up and maintaining your oil burner.

Your Beckett burner will provide years of efficient operation if it is professionally installed and maintained by a qualified service technician. If at any time the burner does not appear to be operating properly, **immediately contact your qualified service agency** for consultation.

We recommend annual inspection/service of your oil heating system by a qualified service agency.

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Hazard definitions

DANGER **Indicates an imminently hazardous situation, which, if not avoided, will result in death, serious injury, or property damage.**

WARNING **Indicates a potentially hazardous situation, which, if not avoided, could result in death, severe personal injury, and/or substantial property damage.**

CAUTION **Indicates a potentially hazardous situation, which, if not avoided, may result in personal injury or property damage.**

NOTICE

Intended to bring special attention to information, but not related to personal injury or property damage.

Note: Within the boundaries of the hazard warning, there will be information presented describing consequences if the warning is not heeded and instructions on how to avoid the hazard.

Agency approvals

- UL listed to comply with ANSI/UL296 and certified to CSA B140.0.
- Accepted by N.Y.C. M.E.A.
- Other approvals may be available and must be specified at time of order.

Specifications

Fuels	#1 or #2 Fuel Oil
Firing Range	BCF1400 - 4.0 to 13.6 gph BCF2300 - 7.0 to 19.9 gph
Motor	**CF1400:** 1/2 HP 3450 rpm 120/60 Hz Standard 6.5 amps @ 120 VAC **CF2300:** 3/4 HP 3450 rpm 120/60 Hz Standard 12.5 amps @ 120 VAC **Optional Voltages** (CF1400 & CF2300): 240 VAC/1-PH, 208, 240, 480 VAC/3-PH, 50 Hz
Ignition Trans.	Continuous Duty, 120V/12,000V
Housing	Cast aluminum
Fuel Unit	100 to 300 psig
Oil Nozzle	45º to 70º Solid
Dimensions	Refer to Figure 7.

Owner's Responsibility:

WARNING **Follow These Instructions Exactly**

Failure to follow these instructions, misuse, or incorrect adjustment of the burner could lead to equipment malfunction and result in asphyxiation, explosion or fire.

Contact a professional, qualified service agency for the installation, adjustment and service of your oil burning system. Thereafter, have your equipment adjusted and inspected at least annually to ensure reliable operation. This work requires technical training, trade experience, licensing or certification in some states and the proper use of special combustion test instruments.

Please carefully read and comply with the following instructions:

- Never store or use gasoline or other flammable liquids or vapors near this burner or appliance.
- Never attempt to burn garbage or refuse in this appliance.
- Never attempt to light the burner by throwing burning material into the appliance.
- Never attempt to burn any fuel not specified and approved for use in this burner.
- Never restrict the air inlet openings to the burner or the combustion air ventilation openings in the room.

Professional Installer/Service Agency Responsibility:

WARNING **Follow These Instructions Exactly**

Failure to follow these instructions could lead to equipment malfunction and result in asphyxiation, explosion or fire.

- Please read all instructions before proceeding. Follow all instructions completely.
- This equipment must be installed, adjusted and started by a qualified service agency that is licensed and experienced with all applicable codes and ordinances and responsible for the installation and commission of the equipment.
- The installation must comply with all local codes and ordinances having jurisdiction and the latest editions of the NFPA 31 and CSA-B139 & B140 in Canada.

NOTICE

50 Hz Motors - The burner ratings, air settings and nozzle ratings are based on standard 60 Hz motors (at 3450 rpm). Derate all ratings 20% when using 50 hz motors. Consult factory for specific application data.

NOTICE

High altitude installation - Accepted industry practice requires no derate of burner capacity up to 2000 feet above sea level. For altitudes higher than 2000 feet, derate burner capacity 2% for each 1000 feet above sea level.

Pre-installation checklist

❑ Combustion air supply

WARNING **Adequate Combustion and Ventilation Air Supply Required**

Failure to provide adequate air supply could seriously affect the burner performance and result in damage to the equipment, asphyxiation, explosion or fire hazards.

- The burner cannot properly burn the fuel if it is not supplied with a reliable combustion air source.
- Follow the guidelines in the latest editions of the NFPA 31 and CSA-B139 regarding providing adequate air for combustion and ventilation.

The burner requires combustion air and ventilation air for reliable operation. Assure that the building and/or combustion air openings comply with National Fire Protection Standard for Oil-Burning Equipment, NFPA 31. For appliance/burner units in confined spaces, the room must have an air opening near the top of the room plus one near the floor, each with a free area at least one square inch per 1,000 Btu/hr input of all fuel burning equipment in the room. For other conditions, refer to NFPA 31 (CSA B1139-M91 in Canada).

If there is a risk of the space being under negative pressure or of exhaust fans or other devices depleting available air for combustion and ventilation, the appliance/burner should be installed in an isolated room provided with outside combustion air.

❑ Clearances

With the burner installed in the appliance, there must be adequate space in front of and on the sides of the burner to allow access and operation. Verify that the clearance dimensions comply with all local codes and with the appliance manufacturer's recommendations.

❑ Fuel supply

CAUTION **Oil Supply Pressure Control Required**

Damage to the filter or pump seals could cause oil leakage and a fire hazard.

- The oil supply inlet pressure to the burner ***cannot exceed 3 psig***.
- Do not install valves in return line.
- Insure that a pressure limiting device is installed in accordance with the latest edition of NFPA 31.
- Gravity Feed Systems: Always install an anti-siphon valve in the oil supply line or a solenoid valve (RWB Part # 21789) in the pump/nozzle discharge tubing to provide backup oil flow cut-off protection.

- The fuel supply piping and tank must provide #1 or #2 fuel oil at pressure or vacuum conditions suitable for the fuel unit (oil pump) on the burner. Refer to fuel unit literature in the literature envelope in the burner carton to verify allowable suction pressure.

If fuel supply is level with or higher than fuel unit —

- When the fuel unit is not required to lift the oil, the installation is usually suitable for either a one-pipe or two-pipe oil system. The oil pressure at the inlet of the fuel unit must not exceed 3 psig.
- The fuel unit is shipped with the by-pass plug installed. Leave the by-pass plug installed for all low/high firing burners, regardless whether one-pipe (with by-pass loop) or two-pipe. See ***Figure 9*** for installation of the by-pass loop required for one-pipe fuel supply installations. See ***Figure 10*** for connections to the fuel unit for two-pipe fuel supply installations.

When fuel supply is below the burner fuel unit —

- Use a two-pipe oil system when the fuel unit must lift the oil more than 8 feet. The return line provided by the two-pipe system is needed to minimize the effects of air-related problems during operation.

❑ Nozzle pressure

WARNING **Correct Nozzle and Flow Rate Required**

Incorrect nozzles and flow rates could result in impaired combustion, under-firing, over-firing, sooting, puff-back of hot gases, smoke and potential fire or asphyxiation hazards.

Use only nozzles having the brand, flow rate (gph), spray angle and pattern specified by the appliance manufacturer.

Follow the appliance manufacturer's specifications for the required pump outlet pressure for the nozzle, since this affects the flow rate.

- Nozzle manufacturers calibrate nozzle flow rates at 100 psig.
- This burner utilizes pressures higher than 100 psig, so the actual nozzle flow rate will be greater than the gph stamped on the nozzle body. (Example: A 8.00 gph nozzle at 150 psig = 9.80 gph and at 300 psig = 13.86 gph)

For typical nozzle flow rates at various pressures see accompanying chart.

- The fuel unit nozzle port pressure is factory set at 300 psig. Some original equipment manufacturer burner applications may call for a lower pressure to obtain a required firing rate. Do not change this pressure unless directed to do so by the appliance manufacturer.

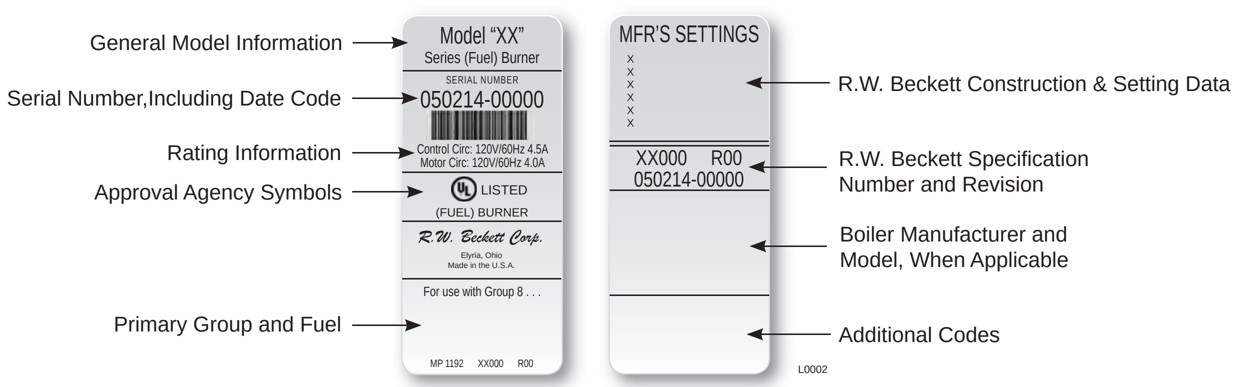
❑ Electrical supply

Verify that the power connections available are correct for the burner. Refer to ***Figure 1***. All power must be supplied through fused disconnect switches.

❑ Vent system

The flue gas venting system must be in good condition and must comply with all applicable codes.

Figure 1 – Typical Nameplate



❑ Verify burner components —

- Burner nameplate ***(figure 1)***, Model CF1400 or CF2300A
- Air tube assembly
- Mounting flange kit
- Pedestal mounting assembly kit (recommended)
- Oil nozzle, per ***Table 1*** — Use only 45° to 70° solid pattern nozzles unless otherwise shown by appliance manufacturer or on the burner nameplate rating label.

Find the required firing rate in the 300 psig column (high fire rate).
Select the corresponding nozzle from column 1 (***Rated gph @ 100 psig***).

(Example: a 500 gph nozzle @ 300 psi = 8.66 gph)

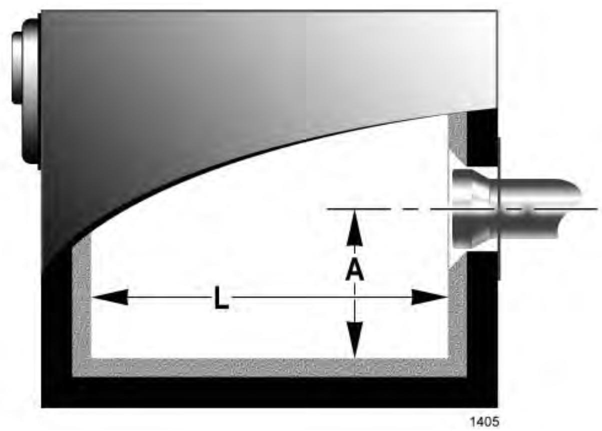
Table 1 - Nozzle capacities

Rated gph @ 100 psig	Pressure - Pounds per square inch							
	125	140	150	175	200	250	275	300
3.00	3.35	-	3.67	3.97	4.24	4.74	4.97	5.20
3.50	3.91	-	4.29	4.63	4.95	5.53	5.80	6.06
4.00	4.47	-	4.90	5.29	5.66	6.32	6.63	6.93
4.50	5.04	5.32	5.51	5.95	6.36	7.11	7.46	7.79
5.00	5.59	5.92	6.12	6.61	7.07	7.91	8.29	8.66
5.50	6.15	6.51	6.74	7.27	7.78	8.70	9.12	9.53
6.00	6.71	7.10	7.35	7.94	8.49	9.49	9.95	10.39
6.50	7.26	7.69	7.96	8.60	9.19	10.28	10.78	11.26
7.00	7.82	8.28	8.57	9.25	9.90	11.07	11.61	12.12
7.50	8.38	8.87	9.19	9.91	10.61	11.86	12.44	12.99
8.00	8.94	9.47	9.80	10.58	11.31	12.65	13.27	13.86
8.50	9.50	10.06	10.41	11.27	12.02	13.44	14.10	14.72
9.00	10.06	10.65	11.02	11.91	12.73	14.23	14.93	15.59
9.50	10.60	11.24	11.64	12.60	13.44	15.02	15.75	16.45
10.00	11.18	11.83	12.25	13.23	14.14	15.81	16.58	17.32
10.50	11.74	12.42	12.86	13.89	14.85	16.60	17.41	18.19
11.00	12.30	13.02	13.47	14.55	15.56	17.39	18.24	19.05
12.00	13.42	14.20	14.70	15.88	16.97	18.97	19.90	20.79

❑ Verify firing rate

Refer to appliance manufacturer's instructions (if available) for firing rate and nozzle selection. Otherwise, the maximum recommended firing rate for the burner depends on the length of the firing chamber and the distance from the burner center to the chamber floor. Verify that the chamber dimensions are at least as large as the minimum values given in ***Figure 2***. If the appliance dimensions are smaller than recommended, reduce the firing rate accordingly.

Figure 2 – Chamber Dimensions



Model	Firing Rate (gph)	Minimum Dimensions			
		Refractory Lined		Wet-based Boilers	
		A	L	A	L
CF1400	0 to 5	7.0"	25.0"	7.0"	25.0"
	5 to 10	8.0"	35.0"	8.0"	40.0"
CF2300	5 to 10	8.0"	35.0"	8.0"	40.0"
	10 to 15	9.0"	40.0"	9.0"	50.0"
	15 to 20	11.0"	55.0"	11.0"	60.0"

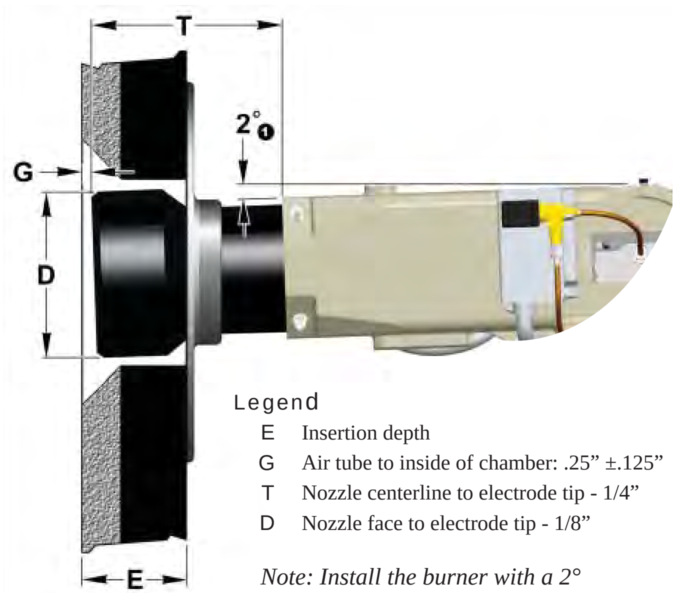
❑ Verify air tube

The information in this section may be disregarded if the air tube is supplied by the appliance manufacturer.

- On the **CF1400**, there are two tube arrangements available –
  Tube A — 4.0 to 11.0 GPH per Table 2
  Tube B — 7.0 to 13.6 GPH per Table 2
- The **CF1400** maximum firing capacity depends on the firebox pressure. Use ***Table 2*** to verify the correct air tube type for the firing rate required. Use Tube B only when Tube A cannot provide the firing rate required.

- On the **CF2300**, there are two tube arrangements available –
  Tube A — 7.0 to 19.9 GPH per Table 2
  Tube B — 10.0 to 19.9 GPH per Table 2
- The **CF2300** maximum firing capacity depends on the firebox pressure. Use ***Table 2*** to verify the correct air tube type for the firing rate required. Use Tube B only when Tube A cannot provide the firing rate required.
- See ***Figure 3*** to verify the correct air tube length and air tube combination code.

Figure 3 – Air tube mounting dimensions



Legend

- E Insertion depth
- G Air tube to inside of chamber: .25” ±.125”
- T Nozzle centerline to electrode tip - 1/4”
- D Nozzle face to electrode tip - 1/8”

Note: Install the burner with a 2° pitch as shown.

Air Tube Combination Codes					
Model	Tube	Dimension T	Dimension D	Code	Dimension E
CF1400	A	6.75”	5.5”	CF 66 KD	-
		10.25”	5.5”	CF 102 KD	-
		13.75”	5.5”	CF 136 KD	-
		17.75”	5.5”	CF 176 KD	-
	B	6.75”	5.75”	CF 66 KE	-
		10.25”	5.75”	CF 102 KE	-
		13.75”	5.75”	CF 136 KE	-
		17.75”	5.75”	CF 176 KE	-
CF2300	A	6.75”	6.5”	CF 66 KG	2.94”
		10.25”	6.5”	CF 102 KG	2.94”
		13.75”	6.5”	CF 136 KG	2.94”
		17.75”	6.5”	CF 176 KG	2.94”
	B	6.75”	8.125”	CF 66 KS	3.69”
		8.375”	8.125”	CF 86 KS	3.69”
		11.0”	8.125”	CF 110 KS	3.69”
		14.5”	8.125”	CF 144 KS	3.69”
		18.5”	8.125”	CF 184 KS	3.69”

Table 2 - Air tube capacity Versus firebox pressure

Air Tube Capacity vs Firebox Pressure				
Model	Tube	Firebox Pressure (In W.C.)	No Reserve Air	10% Turndown* (GPH)
CF1400	A	0.0	11.0	10.0
		0.2	10.5	9.45
		0.4	10.1	9.10
		0.6	9.6	8.64
		0.8	9.2	8.30
		1.0	8.7	7.83
	B	0.0	13.6	12.20
		0.2	13.1	11.70
		0.4	12.5	11.20
		0.6	12.0	10.80
		0.8	11.4	10.30
		1.0	10.9	9.80
CF2300	A	0.0	19.9	19.90
		0.2	19.2	19.10
		0.4	18.5	18.30
		0.6	17.9	17.60
		0.8	17.2	16.80
		1.0	16.5	16.00
	B	0.0	19.9	19.90
		0.2	19.7	19.60
		0.4	19.5	19.30
		0.6	19.4	19.10
		0.8	19.2	18.80
		1.0	19.0	18.50

Note: 10% turndown indicates sufficient reserve air to reduce the CO_2 in the flue to 90% of its value. The above ratings may vary 5% due to variations in actual job conditions.

***CF2300** can fire higher but is limited by UL requirements

❑ Stray light

CAUTION **Protect Against Stray Light Lockout**

Failure to follow these instructions could cause loss of burner operation resulting in no heat, an unplanned process interruption, work stoppage and the potential for frozen plumbing or other cold weather property damage.

- The control must detect a dark, no-flame condition in order to start the burner or it will hold in the stray light lockout mode.
- Shield the burner view window from direct exposure to intense light.

❑ Dust and Moisture

WARNING **Protect Against Dust and Moisture**

Wet, dusty environments could lead to blocked air passages, corrosion damage to components, impaired combustion performance and result in asphyxiation, explosion or fire.

- This burner is designed for clean, dry installations.
- Electrical controls are not protected against rain or sprayed water.
- Keep the installation clear of dust, dirt, corrosive vapors, and moisture.
- Protective covers and more frequent maintenance may be required.

Mount the burner

❑ Mount flange(s) on air tube

CAUTION **Protect the Air Tube From Overheating**

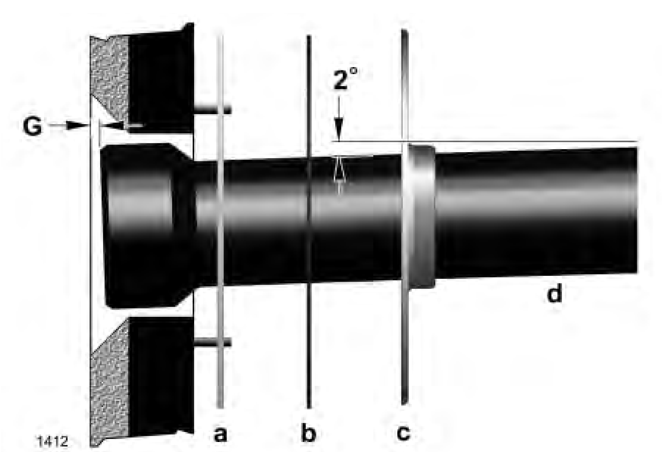
Overheating could cause damage to the air tube and other combustion components leading to equipment malfunction and impaired combustion performance.

- The end of the air tube must not extend into the combustion chamber unprotected unless it has been factory-tested and specified by the appliance manufacturer.
- Position the end of the air tube 1/4" back from flush with the refractory inside entry wall to prevent damage from overheating.

This section does not apply to burners with welded flanges.

- Do not install air tube on burner.
- For non-pressure firing flange, refer to ***Figure 4***: Install gasket (item **a**) and flange (item **c**). Ignore the next paragraph.
- For pressure-firing flange, refer to ***Figure 4***: Slide gasket (item **a**) onto the air tube, making sure the top of the air tube is up. Predrill holes in the pressure firing plate (item **b**) to match the appliance studs. Slide the pressure firing plate (item **b**) and flange (item **d**) onto the air tube as shown. Wrap ceramic fiber rope (not shown) around the air tube and press tightly into the inside diameter of the flange (item **c**).
- Slide the air tube (item **d**) into position in the appliance front. Tighten the flange-mounting-stud nuts. Set the insertion of the air tube so dimension **G** is **1/4"** nominal.
- Pitch the air tube at 2° from horizontal as shown and secure the flange to the air tube.

Figure 4 – Mount flange(s) on air tube



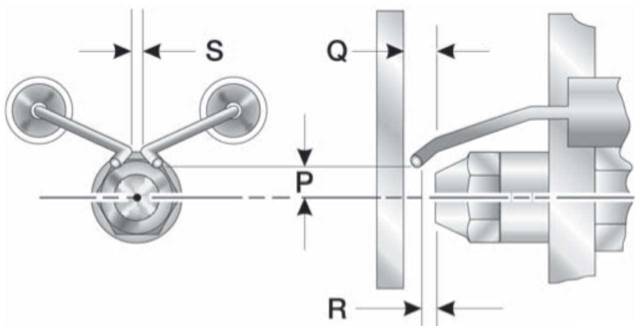
❑ Mount air tube to burner

- Remove the rear access door from the back of the burner for improved access to the interior.
- Attach the air tube to the burner with the bolts and acorn nuts provided. The acorn nuts must go on the outside of the burner, with the bolts inserted from the inside.

❑ Install nozzle

See ***Figure 5***. Install the oil nozzle in the nozzle adapter. Use a **3/4”** open-end wrench to steady the nozzle adapter and a **5/8”** open-end wrench to turn the nozzle. Tighten securely but do not overtighten.
Check, and adjust if necessary, the critical dimensions **P**, **Q**, **R** and **S** shown in the drawing. Verify that the oil tube assembly and electrodes are in good condition, with no cracks or damage.

Figure 5 – Nozzle and nozzle line assembly



Legend

S	Electrode spacing - 3/32”
Q	Nozzle to head - 1/4”
P	Nozzle centerline to electrode tip - 1/4”
R	Nozzle face to electrode tip - 1/8”

❑ Check electrode settings

WARNING **Maintain Electrode Specifications**

Failure to properly maintain these specifications could cause ignition malfunction, puff-back of hot gases, heavy smoke, asphyxiation, explosion and fire hazards.

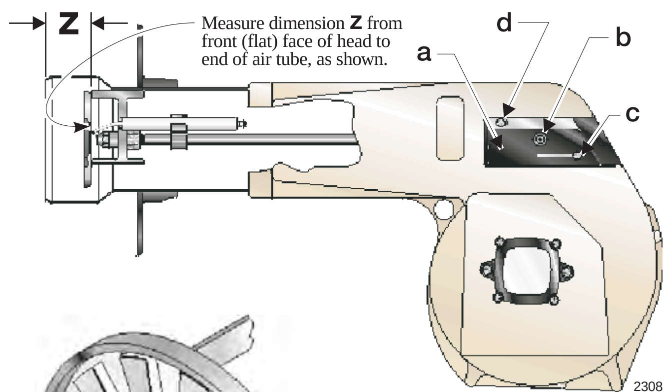
- Adjust the electrode gap and position in relation to the nozzle to the specifications shown in ***Figure 5***.

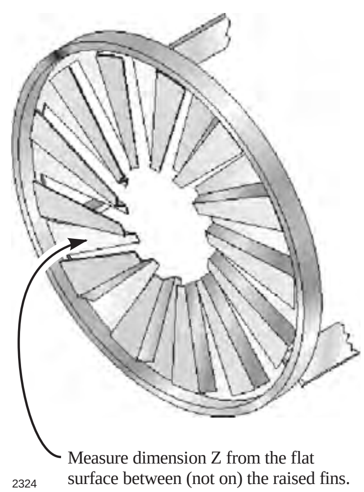
Check, and adjust if necessary, the critical dimensions shown in ***Figure 5***. Verify that the oil tube assembly and electrodes are in good condition, with no cracks or damage.

❑ Install nozzle line assembly

- Insert the nozzle line assembly into the burner air tube as in ***Figure 6.***
- See ***Figures 6 and 7***. Assemble the adjusting plate assembly per the instructions in the assembly packet.
- Slide the secondary adjusting plate (item **f**) completely to the left on the indicator adjusting plate (item **e**). Finger-tighten acorn nut (item **c**) to secure the two plates together. Slide both plates completely to the left on the primary adjusting plate (item **g**) and finger-tighten acorn nut (item **d**).
- Slide the completed adjusting plate assembly over the nozzle line end. Move the plate assembly and the nozzle line so the plate assembly fits into position as shown in ***Figure 6***.
- Install the spline nut (***Figure 6***, item **b**) on the end of the nozzle line, leaving the nut loosely placed so the plates can be moved.
- Connect the high-voltage leads from the ignition transformer to the electrodes.

Figure 6 – Nozzle line assembly in burner





Z = 1-3/4” ± 1/16”

Legend (Figure 6)

a	Adjusting plate assembly
b	Spline nut for securing nozzle line
c	Bottom acorn nut
d	Top acorn nut (for setting dim. Z only)

❑ Set dimension Z

- Replace the rear access door on the burner, making sure that the adjusting plate assembly is now securely in the groove.
- Loosen acorn nut (item **d**) in ***Figure 5***. Slide the nozzle line and plate assembly until dimension Z in ***Figure 5*** is **1-3/4 ±1/16"** (CF1400 and CF2300). When dimension Z (from end of air tube to flat area of front face of head) is correctly set, tighten acorn nut (item **d**). Verify that the adjusting plate assembly is properly seated in the groove.
- Attach the oil line from the oil valve to the nozzle line end. Tighten securely.
- Before proceeding, check dimension Z once again. Loosen acorn nut (item **d**) if necessary to reposition the nozzle line. Once dimension Z is set, **do not loosen acorn nut** (item **d**) again.

❑ Insert burner

- Position the burner in the front of the appliance and loosely tighten the nuts on the mounting studs. The burner should be pitched downward 2° as shown in ***Figures 4 and 8***.
- See ***Figure 8***. Install the pedestal support kit (recommended) by attaching the **3/4"** npt flange (item **a**) to the bottom of the burner using the (4) #10 screws provided. Cut and thread (one end only) a **3/4"** pipe nipple (item **b**) **with length 11 inches less than dimension D** in ***Figure 8***. Thread the pipe into the flange. Then slip the pipe end into the floor flange (item **c**).
- Secure the burner to the appliance by tightening the nuts on the burner flange mounting studs. Then secure the pedestal support floor flange set screw to the pipe.

Figure 7 – Adjusting plate assy.

Legend

- a Adjusting plate assembly
- b Spline nut for securing nozzle line
- c Bottom acorn nut
- d Top acorn nut (for setting dim. Z only)
- e Indicator adjusting plate
- f Secondary adjusting plate
- g Primary adjusting plate

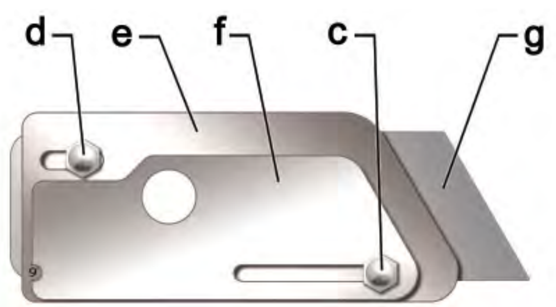
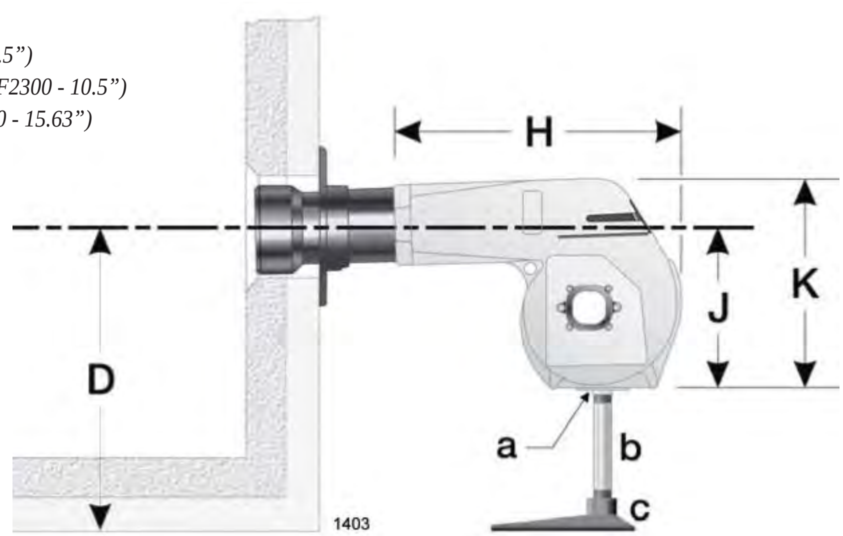


Figure 8 – Burner installed in appliance front

Legend

- H Housing total length *(CF1400 - 18", CF2300 - 18.5")*
- J Center to bottom of housing *(CF1400 - 10.88", CF2300 - 10.5")*
- K Overall housing height *(CF1400 - 13.63", CF2300 - 15.63")*



❑ Fuel unit by-pass plug

WARNING **Install Oil Supply To Specifications**

Failure to properly install the oil supply system could cause oil leakage, equipment malfunction, puff-back of hot gases, heavy smoke, asphyxiation, explosion and fire

- Carefully install the oil supply lines, fittings and components using the guidelines provided in this section.
- The oil supply must comply with the latest edition of NFPA 31 (Canada CSA B139) and all applicable codes.
- Do NOT install valves in the return line.
- If the oil supply inlet pressure to the pump exceeds 3 psig or for gravity feed systems, install an oil safety or pressure reducing valve (Webster OSV, Suntec PRV or equivalent).

The burner is shipped with a by-pass plug installed in the fuel unit. For low/high operation, the by-pass plug must be left in the fuel unit, regardless of the fuel system used (one-pipe with by-pass loop or two-pipe). Do not remove the by-pass plug.

❑ One-pipe oil system by-pass loop

WARNING **Factory-Installed Pump Bypass Plug**

Failure to follow these guidelines will cause the fuel pump seals to rupture and result in oil leakage, burner malfunction and potential fire and injury hazards.

- Models CF1400 and CF2300 are shipped with the pump bypass plug installed.
- Do not remove the bypass plug from the pump. It is required for step-firing (Lo/Hi) operation.
- Do not operate the burner unless a return line or bypass loop is installed or the pump seal will rupture.
- Carefully comply with the following instructions provided in this section of the manual.

Refer to ***Figure 9*** (item **m**). Note the addition of a field-installed by-pass loop (use 3/8” copper tubing) from the fuel unit Return port to the Inlet port. This line is required for low/high operation. It simulates the flow of a two-pipe system at the fuel unit.

❑ Oil supply/return lines

- Install the oil tank and oil lines in accordance with all applicable codes.
- Size the oil supply and return lines using the guidelines given in the fuel unit literature included in the literature envelope. Oil line flow rate will equal the burner rate for one-pipe systems. For two-pipe systems, refer to ***Table 3*** for the fuel unit gearset capacity - the rate at which fuel is recirculated when connected to a two-pipe system. Size two-pipe oil lines based on this flow rate.
- Use continuous lengths of heavy-wall copper tubing, routed under the floor where possible. Do not attach fuel lines to the appliance or to floor joists if possible. This reduces vibration and noise transmission problems.
- Install an oil filter sized to handle the fuel unit gearset flow capacity (***Table 3***) for two-pipe systems. However, size the filter for the firing rate for one-pipe systems. Locate the filter immediately adjacent to the burner fuel unit.
- Install two high-quality shutoff valves in accessible locations on the oil supply line. Locate one valve close to the tank. Locate the other valve close to the burner, upstream of the fuel filter.

❑ Burner fuel flow

One-pipe systems – See ***Figure 9*** for the fuel flow paths for high-fire and low-fire operation. The low-fire by-pass regulation is done internally for type **B** fuel units. Oil supply connects to one of the fuel unit Inlet ports.

Two-pipe systems – See ***Figure 10*** for the fuel flow paths for high-fire and low-fire operation. The low-fire by-pass regulation is done internally for type B fuel units. Oil supply connects to one of the fuel unit Inlet ports. Oil return connects to the fuel unit Return port.

Low-fire/high-fire operation – The fuel unit nozzle port pressure is factory set at 300 psig.

- At high fire, full pressure (300 psig) is applied at the oil nozzle, causing full input.
- At low fire, the by-passing is done inside the fuel unit when the by-pass valve operates.
- This by-passing of oil reduces the oil pressure at the nozzle (to between 125 psig and 175 psig), reducing the input.

Figure 9 – One-pipe oil flow with "B" pump

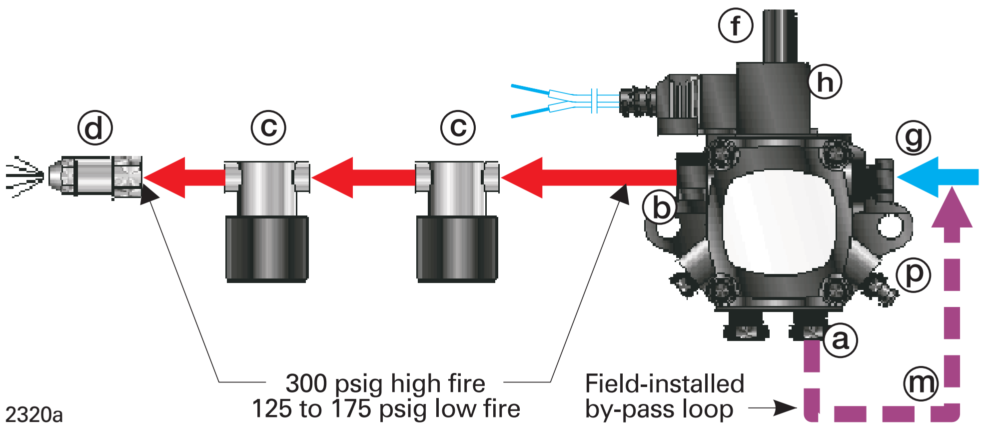
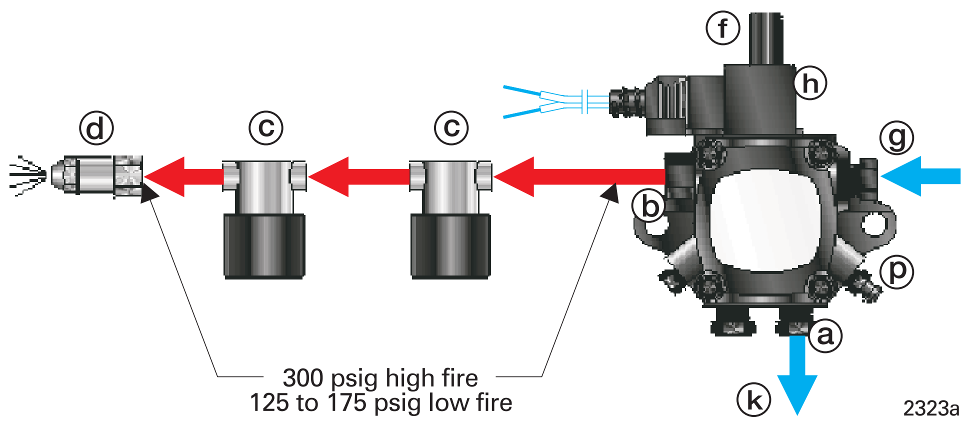


Figure 10 – Two-pipe oil flow with "B" pump



Legend (figure 9 & 10)

a	Return port
b	Nozzle port
c	Oil valves
d	Nozzle & adapter
f	By-pass pressure regulator
g	Inlet port
h	By-pass valve ("B" pump)
k	Return line to oil tank
m	One-pipe by-pass loop, 3/8"
p	Air bleed valve

Table 3 – Fuel unit gearset capacities

Model	Fuel Unit Model Number	Gearset Capacity (gph)
CF1400	B2TA-8245	21
CF2300	B2TA-8852	39

- **Nozzle pressure** – The fuel unit nozzle port pressure is factory set at 300 psig. Some original equipment manufacturer burner applications may call for a lower pressure to obtain a required firing rate. Do not change this pressure unless directed to do so by the appliance manufacturer.

Wire the burner — R7184B

WARNING Electrical Shock Hazard

Electrical shock can cause severe personal injury or death.

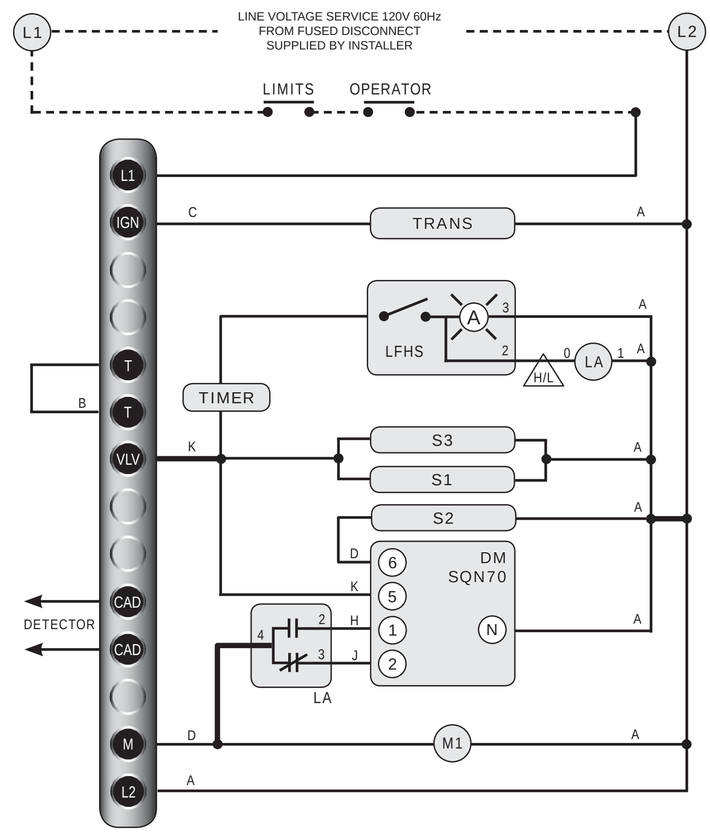
- Disconnect electrical power before installing or servicing the burner.
- Provide ground wiring to the burner, metal control enclosures and accessories. (This may also be required to aid proper control system operation)
- Perform all wiring in compliance with the National Electric Code ANSI/NFPA 70 (Canada CSA C22.1).

Install the burner and all wiring in accordance with the National Electrical Code and all applicable local codes or requirements.

Wire the burner in compliance with all instructions provided by the appliance manufacturer. Verify operation of all controls in accordance with the appliance manufacturer's guidelines.

See ***Figure 11*** for a typical wiring diagram, with R7184 oil primary, for reference purposes only.

Figure 11. - Typical wiring (R7184B)



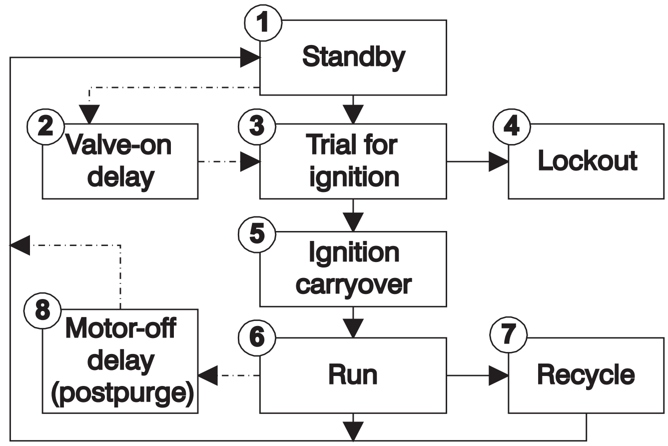
Legend

CC	Flame sensor, cad cell typical
DM	Damper motor
FD	Fused Disconnect, by others
F-F	Cad cell flame sensor terminals
H/L	Low/high control wiring tag
LFHS	Low fire hold switch
LM	Limit controls, by others
M1	Burner motor
OP	Operating controls, by others
PR	Oil primary control, R7184 typ.
S2	High/low valve
S1, S3	On/off valve
TR	Ignition transformer
T-T	24-volt thermostat/limit terminals

Sequence of operation — typical

Install the burner and all wiring in accordance with the National Electrical Code and all applicable local codes or requirements.

Wire the burner in compliance with all instructions provided by the appliance manufacturer. Verify operation of all controls in accordance with the appliance manufacturer's guidelines.



Sequence of operation — typical

1. **Standby** — The burner is idle, waiting for a call for heat. When a call for heat is initiated, there is a 3- to 10-second delay while the control performs a safe start check.
2. **Valve-on delay** — As applicable, the ignition and motor are turned on for a 15-second prepurge.
3. **Trial for ignition (TFI)** — The fuel valve is opened, as applicable. A flame should be established within the 15-second lockout time (30-second lockout time is available).
4. **Lockout** — If flame is not sensed by the end of the TFI, the control shuts down on safety lockout and must be manually reset. If the control locks out three times in a row, the control enters restricted lockout. Call a qualified service technician.
5. **Ignition carryover** — Once flame is established, the ignition remains on for 10 seconds to ensure flame stability. It then turns off.
6. **Run** — The burner runs until the call for heat is satisfied. The burner is then sent to burner motor-off delay, as applicable, or it is shut down and sent to standby.
7. **Recycle** — If the flame is lost while the burner is firing, the control shuts down the burner, enters a 60-second recycle delay, and then repeats the ignition steps outlined above. If the flame is lost three times in a row, the control locks out to prevent continuous cycling with repetitious flame loss caused by poor combustion.
8. **Burner motor-off delay** — If applicable, the fuel valve is closed and the burner motor is kept on for the selected postpurge time before the control returns the burner to standby.

Resetting to OHM

- If the control locks out three times in a row without a complete heat cycle between attemps, the lockout becomes restricd. A qualified service technician should be called to inspect the burner.

Prepare the burner for start-up

WARNING — Professional Installation and Service Required

Incorrect installation and mishandling of start-up could lead to equipment malfunction and result in asphyxiation, explosion or fire.

- This burner must be installed and prepared for start-up by a qualified service technician who is trained and experienced in commercial oil burner system installation and operation.
- Do not attempt to start the burner unless you are fully qualified.
- Do not continue with this procedure until all items in the "Prepare the burner for start-up" section have been verified.
- Carefully follow the wiring diagrams, control instruction sheets, flame safeguard sequence of operation, test procedures and all appliance manufacturer's directions that pertain to this installation.
- If any of these items are not clear or are unavailable, call Beckett at 1-800-645-2876 for assistance.

WARNING — Do Not Bypass Safety Controls

Tampering with, or bypassing safety controls could lead to equipment malfunction and result in asphyxiation, explosion or fire.

- Safety controls are designed and installed to provide protection.
- Do not tamper with, or bypass any safety control.
- If a safety control is not functioning properly, shut off all main electrical power and fuel supply to the burner and call a qualified service agency immediately.

CAUTION — Keep Service Access Covers Securely Installed

These covers must be securely in place to prevent electrical shock, damage from external elements, and protect against injury from moving parts.

- All covers or service access plates must be in place at all times except during maintenance and service.
- This applies to all controls, panels, enclosures, switches, and guards or any component with a cover as part of its design.

Start-up checklist – Verify the following before attempting to start burner.

- ☐ Combustion air supply and venting have been inspected and verified to be free of obstructions and installed in accordance with all applicable codes.
- ☐ Oil nozzle has been selected correctly and securely installed in the nozzle adapter.
- ☐ Fuel unit by-pass plug ***has not*** been installed for one-pipe oil system.
- ☐ By-pass plug ***has been*** installed for two-pipe oil system.
- ☐ Fuel connection to nozzle line assembly is secure.
- ☐ Dimension Z has been set per this instruction manual.
- ☐ Fuel supply line is correctly installed, the oil tank is sufficiently filled, and shut-off valves are open.
- ☐ Burner is securely mounted in appliance, with pressure firing plate and gasket installed for pressurized chamber application.
- ☐ Appliance has been filled with water (boilers) and controls have been operationally checked.
- ☐ Burner has been installed in accordance with appliance manufacturer's instructions (when available).
- ☐ Also refer to appliance manufacturer's instructions (when available) for start-up procedures.

☐ Z dimension

Should be set per these instructions (see **page 10**). The top acorn nut (***Figure 12***, item **d**) should never be loosened once the Z dimension is initially set.

☐ Adjusting plate assembly (Figure 12)

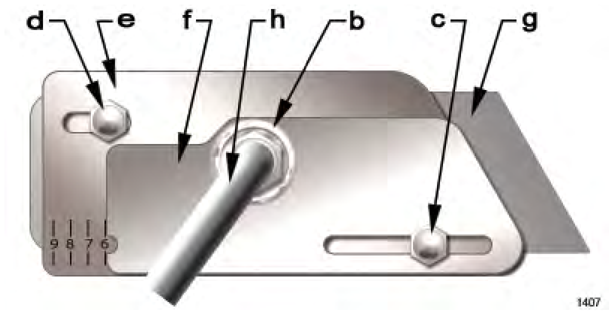
Make sure spline nut (item **b**) and bottom acorn nut (item **c**) are loose before proceeding to next section.

☐ Initial head position (Figure 12)

The indicator plate assembly (item **e**) markings correspond to head position settings.

- Slide the secondary adjusting plate (item **f**) toward the rear of the burner until the number on the indicator plate corresponds to the initial head setting given in ***Tables 4a*** and ***4b*** for the desired firing rate and burner (high-fire).
- ***Figure 12*** shows a typical example, with a head setting of 6.
- When the head position has been set, tighten the bottom acorn nut (item **c**) and the spline nut (item **b**).

Figure 12 – Adjusting plate initial setting, typical



Legend
- b Spline nut for securing nozzle line
- c Bottom acorn nut (for head adjustments)
- d Top acorn nut (for setting dim. Z only - do not loosen after setting Z)
- e Indicator adjusting plate
- f Secondary adjusting plate
- g Primary adjusting plate
- h Copper oil line from oil valve to nozzle line

Table 4a. CF1400 Initial indicator adjustment plate settings

	Tube	Head Position		Damper Position	
		Approximate Head Setting	Firing Rate (gph)	Approximate Air Damper Setting	Firing Rate (gph)
CF1400	A	0	4.00	0	--
		1	4.50	10	--
		2	5.00	20	4.00
		3	6.00	30	5.00
		4	7.00	40	7.00
		5	7.50	50	8.00
		6	8.00	60	10.00
		7	9.00	70	11.00
		8	9.50	80	--
		9	10.00	90	--
		10	11.00	100	--
		--	--	110	--
		--	--	120	--
	B	0	7.00	0	--
		1	7.50	10	--
		2	8.00	20	--
		3	9.00	30	--
		4	10.00	40	7.00
		5	10.50	50	8.00
		6	11.00	60	10.00
		7	12.00	70	11.00
		8	13.00	80	12.00
		9	13.25	90	12.50
		10	13.60	100	13.00
		--	--	110	13.25
		--	--	120	13.60

Table 4b. CF2300 Initial indicator adjustment plate settings

	Tube	Head Position		Damper Position	
		Approximate Head Setting	Firing Rate (gph)	Approximate Air Damper Setting	Firing Rate (gph)
CF2300	A	0	11.0	0	--
		1	12.0	10	7.0
		2	13.0	20	10.0
		3	14.0	30	13.0
		4	15.0	40	14.0
		5	16.0	50	15.0
		6	17.0	60	16.0
		7	18.0	70	17.0
		8	19.0	80	18.0
		9	20.0	90	19.0
		--	--	100	20.0
	B	0	12.5	0	--
		1	13.0	10	10.0
		2	14.0	20	13.0
		3	15.0	30	14.0
		4	16.0	40	15.0
		5	17.0	50	16.0
		6	18.0	60	17.0
		7	18.5	70	18.0
		8	19.0	80	18.5
		9	20.0	90	19.0
		--	--	100	20.0

❑ Initial air settings

The following steps outline the procedure for initially setting the damper. Refer to ***Figure 13*** and ***Tables 4a*** or ***4b*** for this procedure.

1. Remove the cover screw (**A**) then the cover (**B**) and place to one side.

2. Using the wrench (**C**) supplied with the damper motor, adjust the blue low fire cam (**D**) to the initial setting listed in ***Tables 4a*** or ***4b***.

3. Using the same wrench, adjust the red high fire cam (**H**) to the initial settings listed in ***Tables 4a*** or ***4b***.

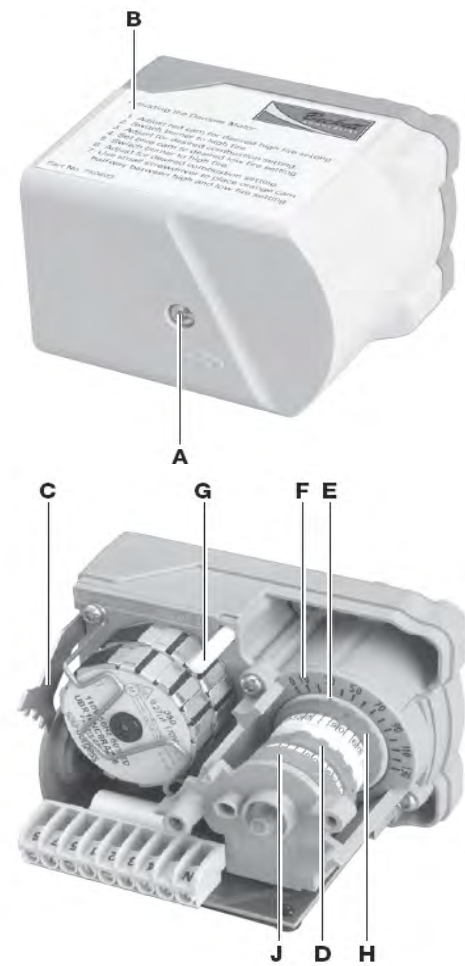
4. Ensure the damper plate is in the correct position. The cam notch (**E**) should align with the low fire setting on the damper motor scale (**F**).

5. If the damper plate is not in the correct position, disengage the motor by pushing in on the motor pin (**G**), then rotating the damper plate until the cam notch and motor scale setting are aligned. Re-engage the pin.

6. To adjust the high fire transition, use a small straight edge screw driver, turn the white adjustment screw, located in the orange transition cam, either clockwise or counterclockwise until the cam indicator is half way between the high and low settings on the scale.

   - Rotate the air adjusting plate until the lower edge of the pointer is opposite the number from ***Tables 4a*** or ***4b*** corresponding to the desired low fire rate.
   - This initial setting should be adequate for starting the burner at low fire. Once the burner is in operation, the air setting will be adjusted for best performance as discussed later in this manual.
   - Follow the procedures described later in this manual to fine tune the air settings.

Figure 13 - Damper Motor



Legend (figure 13)

A	Cover screw	F	Damper motor scale
B	Cover	G	Disengaging pin
C	Wrench	H	High fire cam (red)
D	Low fire cam (blue)	J	Transition cam (orange)
E	Cam notch		

NOTICE

The damper plate is attached by screws to its shaft, and bears against a flat on the shaft for alignment. The shaft is secured to the damper motor by a sleeve coupling with two setscrews bearing against the damper shaft and two more against the motor shaft. The motor shaft has a flat matching the one on the damper shaft. The flats on the damper shaft and the motor shaft should be aligned so that the position indicator in the damper motor reads accurately. The best way to align the flats is to tighten the setscrews that bear against the flats on the shafts first, and then tighten the ones that bear against the round surface of the shafts afterward.

The test for proper alignment is to disengage the damper motor from its shaft using the disengaging pin (Item **G** in ***Figure 13B***) and rotate the damper plate to its full closed position. The position indicator should point to 0° within + 5° tolerance.

❑ Set appliance limit controls

- Set the appliance limit controls in accordance with the appliance manufacturer’s recommendations.
- Move the low-fire hold switch (not shown) to the low fire hold position. This will hold the burner in low fire during initial start-up.

❑ Prepare the fuel unit for air venting

- To vent air from one-pipe oil systems, attach a clear hose to the vent plug on the fuel unit. Provide a container to catch the oil. Loosen the vent plug.
- Vent the air as described under ‘Start the Burner’.

Start the burner

WARNING **Explosion and Fire Hazard**

Failure to follow these instructions could lead to equipment malfunction and result in heavy smoke emission, soot-up, hot gas puff-back, fire and asphyxiation hazards.

- Do not attempt to start the burner when excess oil has accumulated in the appliance, the appliance is full of vapor, or when the combustion chamber is very hot.
- Do not attempt to re-establish flame with the burner running if the flame becomes extinguished during start-up, venting, or adjustment.
- **Vapor-Filled Appliance:** Allow the unit to cool off and all vapors to dissipate before attempting another start.
- **Oil-Flooded Appliance:** Shut off the electrical power and the oil supply to the burner and then clear all accumulated oil before continuing.
- If the condition still appears unsafe, contact the Fire Department. Carefully follow their directions.
- Keep a fire extinguisher nearby and ready for use.

WARNING **Professional Service Required**

Incorrect installation, adjustment, and use of this burner could result in severe personal injury, death, or substantial property damage from fire, carbon monoxide poisoning, soot or explosion.

Please read and understand the manual supplied with this equipment. This equipment must be installed, adjusted and put into operation only by a qualified individual or service agency that is:

- Licensed or certified to install and provide technical service to oil heating systems.
- Experienced with all applicable codes, standards and ordinances.
- Responsible for the correct installation and commission of this equipment.
- Skilled in the adjustment of oil burners using combustion test instruments.

The installation must strictly comply with all applicable codes, authorities having jurisdiction and the latest revision of the National Fire Protection Association Standard for the installation of Oil-burning Equipment, NFPA 31 (or CSA B139 and B140 in Canada).

Regulation by these authorities take precedence over the general instructions provided in this installation manual.

Do not proceed unless all prior steps in this manual have been completed.

❑ Start burner and vent air from oil line

WARNING **Hot Gas Puff-back and Heavy Smoke Hazard**

Failure to bleed the pump properly could result in unstable combustion, hot gas puff-back and heavy smoke.

- Do not allow oil to intermittently spray into a hot combustion chamber while bleeding.
- Install a gauge in the nozzle discharge port tubing or fully open the pump bleed valve to prevent oil spray from accumulating in the combustion chamber when venting air from the fuel pump.
- Ensure that all bubbles and froth are purged from the oil supply system before tightening the pump air bleed valve.

❑ Disable function

- Any time the motor is running, press and hold the reset button to disable the burner. The burner will remain off as long as the button is held and will return to standby when released.

❑ CAD cell resistance check

- While the burner is firing, and after the ignition has been turned off, press and release the reset button (hold 1/2 second or less) to check the cad cell resistance. The LED will flash 1 to 4 times, depending on the cad cell resistance (refer to the table below).

Number of LED flashes	Cad Cell Resistance (ohms)
1	Normal (0 to 400)
2	Normal (400 to 800)
3	Normal (800 to 1600)
4	Limited (1600-Lockout)*

** Lockout can occur above 4000 ohms.*

LED Indicator	Status
On	Flame sensed
Off	Flame not sensed
Flashing (1/2 sec off - 1/2 sec on)	Lockout/Restricted Lockout
Flashing (2 sec off - 2 sec on)	Recycle

❑ Operating the burner

1. Move the **low-fire hold** switch to the **low fire hold** position (to hold burner in low fire when started).
2. Verify that the air adjusting cam (***Figure 13b***, item **d**) has been set to the initial low-fire air setting as described under Initial air settings.
3. Open the oil shutoff valves in the oil supply (and return) line(s) to the burner.
4. Set the thermostat (or operating control) to call for heat.
5. Close the line switch to the burner. The burner motor should start immediately.
6. If the burner motor does not start, reset the motor overload switch (if so equipped) and press the reset switch of the burner primary control.
7. Vent the fuel unit as soon as the burner motor starts rotating. To vent —
   - Attach a clear plastic tube to the air bleed valve (***Figure 9 or 10*** **as applies, item p**).
   - Place the end of the tube in a container to catch the oil. Then loosen the fuel unit air vent valve.
   - Tighten the air vent valve after all air has been purged.
   - **IF burner stops during venting —**
     - The burner primary control will lockout if flame is not established within its time limit. This is typically 15 seconds for R7184B primary controls, but may be less for other flame supervisory controls.
     - The burner may lockout several times during the period needed to purge all the air. To extend air venting time, press the red reset button for 1/2 second during the prepurge cycle to continue purging.
   - **IF burner stops after flame established —**
     - Additional venting is probably required. Repeat the air venting procedure.
8. Once flame is steady, proceed to Set high-fire air.

❑ Set high-fire air

1. Allow the burner to run at **low fire** until the appliance has warmed sufficiently.
2. Visually check the flame. The flame should not be dark orange or smoky. If the flame appears to be smoking, increase the amount of air by readjusting the damper indicator to a higher number.
3. Once the appliance has warmed, the **high-fire** setting can be checked and adjusted.
4. Locate the approximate air adjusting plate setting for **high fire** in ***Table 4a*** **or** ***4b***.
5. Place the **low-fire hold** switch in the **high-fire position**. The damper motor will begin to rotate after four seconds.
6. Use combustion test instruments to adjust the burner.
   a. Adjust the air by moving the red cam to a lower number until a trace of smoke is achieved with CO_2 level as high as possible (lowest possible O_2). **Example**: 13.5% CO_2 (2.5% O_2) with a trace of smoke.
   b. Increase the air by increasing the red cam number to reduce CO_2 by 2 percentage points at a zero smoke level. (Increase O_2 by 3 percentage points at a zero smoke level.)
   Example: Reduce CO_2 from 13.5% to 11.5%, with zero smoke (or increase O_2 from 2.5% to 5.5%).
   c. A margin of reserve air has been added to accommodate variable conditions.
7. Check the breech draft pressure against the appliance manufacturer's recommended setting (typically + 0.1" W.C.).
8. If the breech pressure is higher or lower than recommended level, adjust the appliance breech damper to achieve the specified setting. Recheck the smoke and CO_2 levels. Adjust burner air if necessary.
9. Once all settings are complete and satisfactory, proceed to 'Set low-fire air'.

❑ Set low-fire air

1. Move the **low-fire hold** switch from the **"High Fire position"** to the **"Low Fire Hold"** position.
   a. The damper will return to the **low-fire** air setting.
2. Check the smoke and CO_2 (O_2) levels.
   a. Pull a smoke sample from the flue.
   b. The sample should be clean (zero smoke level).
   c. Check the CO_2 (O_2) level:
   CO_2 should be at 11 to 12% (O_2 at 5.9 to 4.5%).
   If the CO_2 is less than 11% (O_2 more than 5.9%), decrease the air and check the smoke level.
3. Operate the burner from **low fire** to **high fire** and back to verify operation.
4. Turn the burner off. Wait one or two minutes (for chamber to clear) and then turn on again to verify starting characteristics.
5. Perform limit circuit performance test specified by appliance manufacturer to verify operation of burner/appliance combination.

Maintenance and Service

⚠ WARNING **Annual Professional Service Required**

Tampering with or making incorrect adjustments could lead to equipment malfunction and result in asphyxiation, explosion or fire.

- Do not tamper with the burner or controls or make any adjustments unless you are a trained and qualified service technician.
- To ensure continued reliable operation, a qualified service technician must service this burner annually.
- More frequent service intervals may be required in dusty or adverse environments.
- Operation and adjustment of the burner requires technical training and skillful use of combustion test instruments and other test equipment.

Annual Service

- ❒ Replace the oil supply line filter. The line filter cartridge must be replaced to avoid contamination of the fuel unit and nozzle.
- ❒ Inspect the oil supply system. All fittings should be leak-tight. The supply lines should be free of water, sludge and other restrictions.
- ❒ Remove and clean the pump strainer if applicable.
- ❒ Replace the nozzle with the exact brand, pattern, gph, flow rate and spray angle.
- ❒ Clean and inspect the electrodes for damage, replacing any that are cracked or chipped.
- ❒ Check electrode tip settings. Replace electrodes if tips are rounded.
- ❒ Inspect the igniter spring contacts.
- ❒ Clean the cad cell lens surface, if necessary.
- ❒ Inspect all gaskets. Replace any that are damaged or would fail to seal adequately.
- ❒ Inspect the combustion head and air tube. Remove any carbon or foreign matter. Replace all damaged units with exact parts.
- ❒ Clean the blower wheel, air inlet, air guide, burner housing and static plate of any lint or foreign material.
- ❒ If motor is not permanently lubricated, oil motor with a few drops of SAE 20 nondetergent oil at each oil hole. DO NOT over oil motor. Excessive oiling can cause motor failure.
- ❒ Check motor current. The amp draw should not exceed the nameplate rating.
- ❒ Check all wiring for secure connections or insulation breaks.
- ❒ Check the pump pressure and cutoff function.
- ❒ Check primary control safety lockout timing.
- ❒ Check ignition system for proper operation.
- ❒ Inspect the vent system and chimney for soot accumulation or other restriction.
- ❒ Clean the appliance thoroughly according to the manufacturer's recommendations.
- ❒ Check the burner performance. Refer to the section "Set combustion with test instruments".
- ❒ It is good practice to make a record of the service performed and the combustion test results.

Monthly maintenance — by owner

- ❒ Observe combustion air openings and vent system for integrity. Openings must be clean and free of obstructions.
- ❒ Check oil lines and fittings to verify there are no leaks.
- ❒ Observe burner ignition and performance to verify smooth operation.
- ❒ Shut the system down if you observe abnormal or questionable operation. Call a qualified service agency for professional inspection and service.

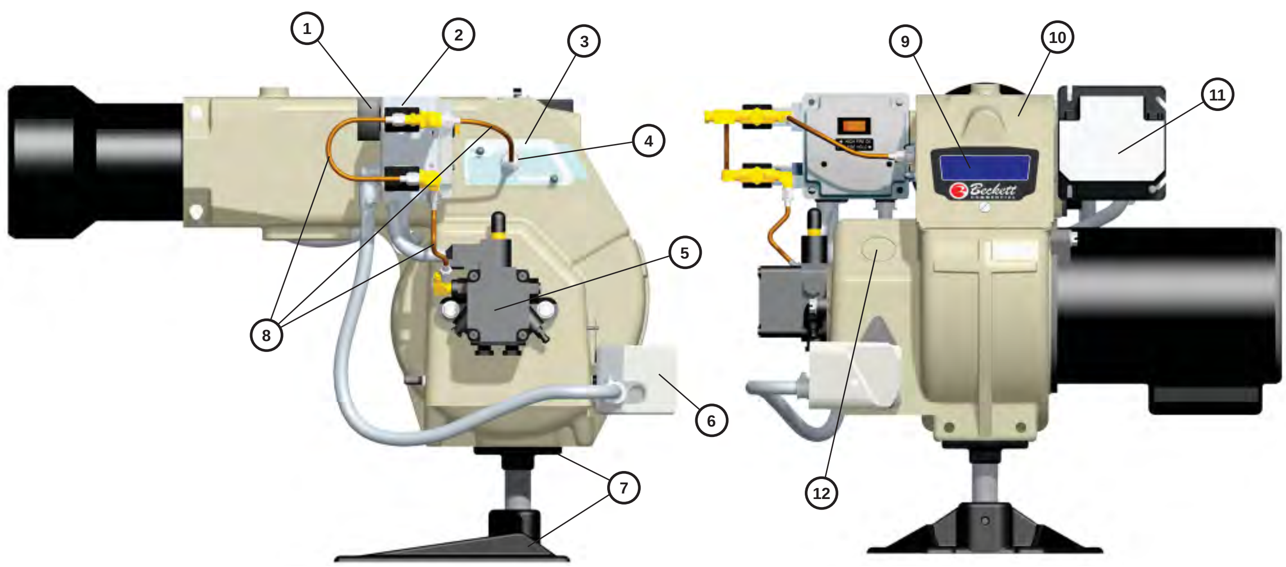
See next page for Beckett replacement parts ▶

Replacement Parts

For best performance specify genuine *Beckett* replacement parts

Item	Part Name	Description		Part No.
1	Timer	Nozzle valve delay		21295U
2	Oil Valve	Box mounted		21789U
3	Knurled Nut	All models		3666
4	Adjusting plate assembly	w/ cast aluminum door w/ stamped sheet-metal door		5994U 5201701U
5	Fuel pump	B2TA-8245 H3PAN-C150H		21313U 21309U
6	Damper motor	2-stage		750601U
7	Pedestal kit	All models		51193
8	Fuel lines	Specify length		-
9	Sight glass	All models		31346
10	Rear cover door assembly	w/ cast aluminum door* w/ stamped sheet-metal door*	CF1400 CF2300 CF1400 CF2300	5994U 51204U 5201301U 5201302U
11	Control	Specify		-
12	Coupling hole plug Coupling access door	use with threaded hole use with rectangular opening		32439U 16703GY
13	Head assembly	CF1400 CF2300		5978 51203
14	Electrode assembly	All models		51212
15	Ignition leads	8-1/4” long 11-3/4” long 15-1/4” long 19-1/4” long		5990082 5990116 5990152 5990192
16	Nozzle line assembly	Refer to ***Figure 5, Page 9***		
17	Air tube	Refer to ***Figure 4, Page 8***		
18	Transformer	12,000 volt		51214
19	Coupling	B pump H pump		21290 21308
20	Blower wheel	CF1400 - 5.59” x 3.09” CF2300 - 6.75” x 3.13”		21268U 21267U
21	Motor	120/208-230 single phase 208-230/460 three phase	CF1400 CF2300 CF1400 CF2300	21401U 21402U 21638U 21499U
	Motor relay (not shown)	120V single phase 208V single phase three phase		7273 7300 2194301
	Adjustable flange	see ***Figure 15*** on opposite page		

Figure 14 – Burner Replacement Parts



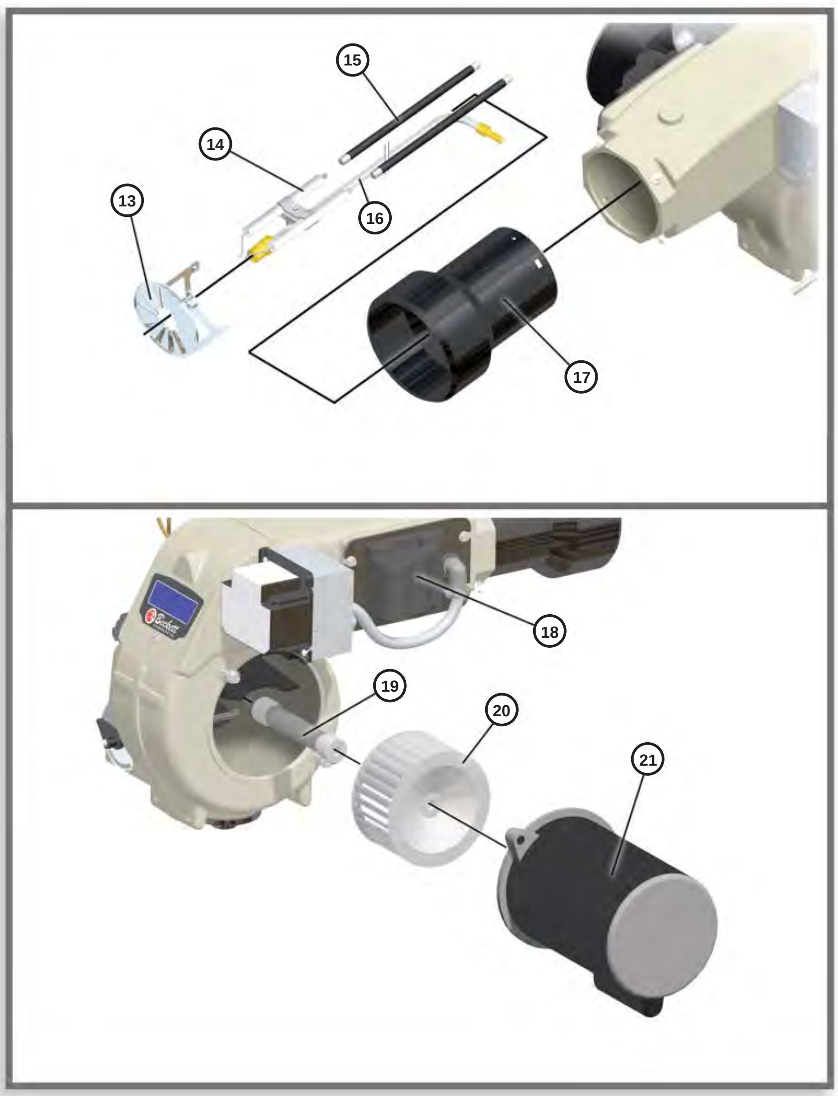
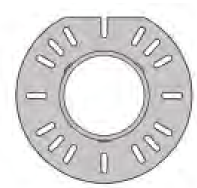
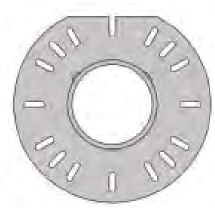


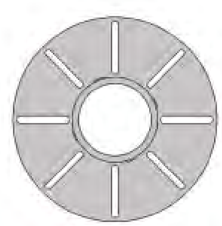
Figure 15 – Adjustable mounting plates



Flange A



Flange B



Flange C

Model	Flange **A**	Flange **B**	Flange **C**
CF1400	51312 (10.00" DIA.)	n/a	51629 (12.25" DIA.)
CF2300	51313 (12.44" DIA.)	51498 (13.92" DIA.)	51630 (16.00" DIA.)

Limited

WARRANTY

For Residential, Commercial and Specialty Burners

The R. W. BECKETT CORPORATION ("Beckett") warrants to persons who purchase its Beckett burners from Beckett for resale or for incorporation into a product for resale ("Customers") that its equipment is free from defects in material and workmanship under normal use and service for 60 months from the date of manufacture for Residential Burners and 18 months from the date of manufacture for Commercial and Specialty Burners. *Residential burner models include:* AF, AFG, AFII, NX, SF, SR and SMG. *Commercial burner models include:* CF375, CF500, CF800, CF1400, CF2300A, CF2500, CF3500A, CG10, CG15, CG25 and CG50. *Specialty burner models include:* ADC, ADCP, ARV, SDC and SM. The provisions of this warranty are extended to individual major burner components as follows:

a) 60 months from date of manufacture for all Beckett-branded major components, except for 12 Vdc components.
b) 18 months from date of manufacture for all non-Beckett-branded major components and Beckett branded 12 Vdc components.

Note: Normal service items found to be defective upon receipt by the customer are covered by this warranty.

THIS WARRANTY DOES NOT EXTEND TO EQUIPMENT SUBJECTED TO MISUSE, NEGLECT, OR ACCIDENT: NOR DOES THIS WARRANTY APPLY UNLESS THE PRODUCT COVERED BY IT IS PROPERLY INSTALLED BY A QUALIFIED, COMPETENT TECHNICIAN, WHO IS LICENSED WHERE STATE AND LOCAL CODES REQUIRE, AND WHO IS EXPERIENCED IN MAKING SUCH INSTALLATIONS, IN ACCORDANCE WITH THE LATEST EDITION OF NFPA NO. 31 OF THE NATIONAL FIRE PROTECTION ASSOCIATION, THE LATEST EDITION OF THE NATIONAL FUEL GAS CODE (NFPA NO. 54) AND IN ACCORDANCE WITH ALL APPLICABLE LOCAL, STATE AND NATIONAL CODES HAVING JURISDICTIONAL AUTHORITY.

Equipment, which is defective in material or workmanship and within the warranty period, may be returned for credit as follows:

Beckett Burners, Beckett-branded major components and non-Beckett-branded major components that came as original equipment on a Beckett burner or were sold as a replacement part by Beckett should be returned, freight prepaid, to Beckett's home office. Credit will be issued to the customer unless the returned equipment is determined by Beckett to be out of warranty or damaged by user, in which case the equipment will be scrapped.

Note: Beckett is not responsible for any labor cost for removal and replacement of equipment.

THIS WARRANTY IS LIMITED TO THE PRECISE TERMS SET FORTH ABOVE, AND PROVIDES EXCLUSIVE REMEDIES EXPRESSLY IN LIEU OF ALL OTHER REMEDIES, AND IN PARTICULAR THERE SHALL BE EXCLUDED THE IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE. IN NO EVENT WILL BECKETT BE LIABLE FOR ANY INCIDENTAL OR CONSEQUENTIAL DAMAGE OF ANY NATURE. Beckett neither assumes nor authorizes any person to assume for Beckett any other liability or obligation in connection with the sale of this equipment, Beckett's liability and Customer's exclusive remedy being limited to credit as set forth above.

R.W. BECKETT CORPORATION
P.O. Box 1289 Elyria, Ohio 44036

Form No. 61545 R72905

The Oilheat Manufacturers' Association supports the use of low sulfur fuels as defined by ASTM D396, Grades No. 1 Low Sulfur and No. 2 Low Sulfur, as the preferred heating fuel for the following reasons:
• Low sulfur fuels reduce deposits on heat exchanger surfaces, extending the service interval between cleanings.
• The reduced deposits increase the efficiency of the appliance.
• Low sulfur fuels reduce particulate emissions.
• Low sulfur fuels reduce oxides of nitrogen emissions.

R.W. BECKETT CORPORATION
U.S.A.: P.O. Box 1289 · Elyria, Ohio 44036
www.beckettcorp.com
Canada: R.W. Beckett Canada, Ltd. · Unit #3, 430 Laird Road · Guelph, Ontario N1G 3X7

INSTALLATION INFORMATION

SUNTEC® industries incorporated

MODEL A SINGLE STAGE TWO-STEP MODEL B TWO-STAGE TWO-STEP FUEL UNITS AND MODEL B TWO-STAGE HIGH PRESSURE FUEL UNITS

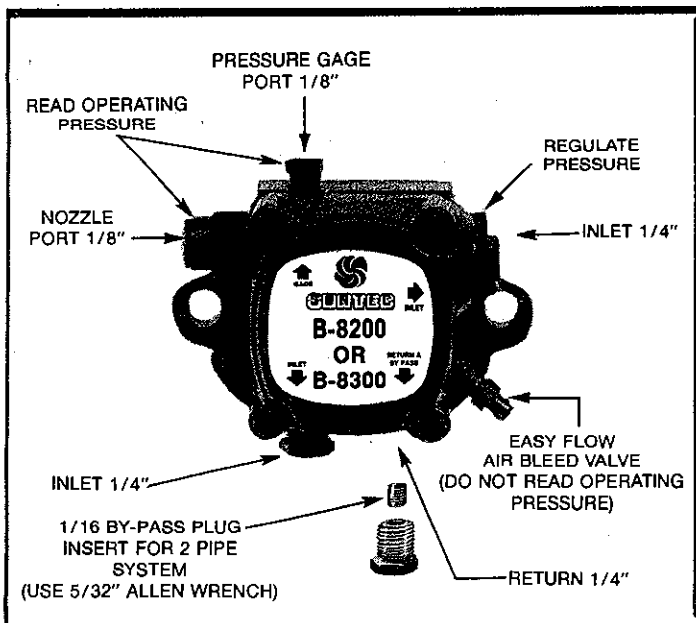


FIGURE 1

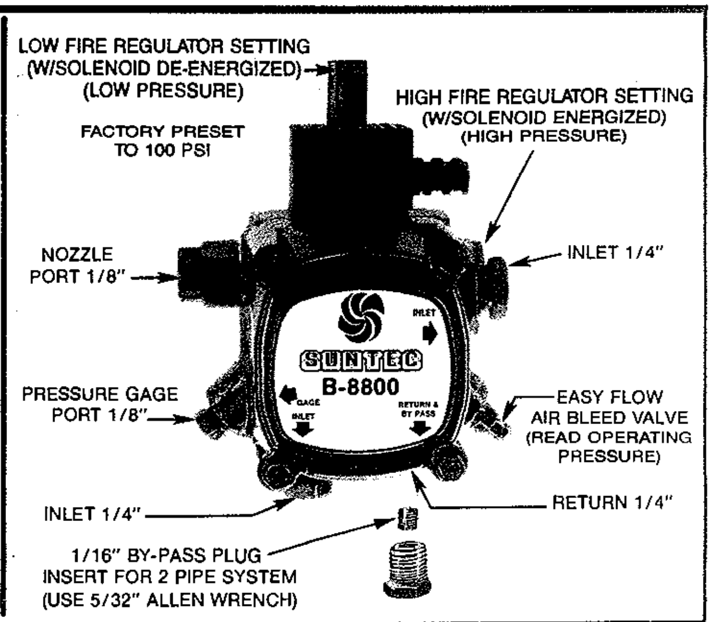


FIGURE 2

ONE-PIPE SYSTEM • *FIGURE 3*

DO NOT INSTALL BYPASS PLUG! Connect inlet line to pump inlet. Start burner. Arrange primary burner control for continuous operation during purging. Open easy flow bleed valve 1 turn CCW. Bleed unit until all air bubbles disappear — HURRIED BLEEDING WILL IMPAIR EFFICIENT OPERATION OF UNIT. Tighten easy flow bleed valve securely.

TWO-PIPE SYSTEM • *FIGURE 4*

REMOVE 1/16" BY-PASS PLUG FROM PLASTIC BAG ATTACHED TO UNIT. Remove 1/4" plug from return port. Insert by-pass plug (See Figure 1 or 2), tighten plug. Attach return and inlet lines. Start burner — Air bleeding is automatic. Opening Easy Flow Air Bleed Valve will allow a faster bleed if desired. Return line must terminate 3-4" above supply line inlet. (See Figure 4). Failure to do this may introduce air into the system and could result in loss of prime.

TWO STEP PUMPS • *FIGURE 2*

MODEL SHOWN IS RIGHT HAND ROTATION; ALL PORTS ARE REVERSED FOR LEFT HAND ROTATION.

SOLENOID WIRING Refer to burner manufacturer's manual for instructions.

NOTE: Wiring of the solenoid in parallel with the safety control circuit will bypass the low fire regulator.

REGULATOR SETTING Install pressure gage in gage port (remove after adjustment) with proper nozzle in nozzle line

- Low Fire — Factory preset to 100 PSI with rated nozzle.
- High Fire — With solenoid energized adjust high fire regulator to desired pressure. (Range 200 to 300 PSI)

NOTE: EXTERNAL CUTOFF VALVE (120V MAXIMUM) IS REQUIRED.

GENERAL INFORMATION • *ALL SYSTEMS*

IMPORTANT INFORMATION Long or oversized inlet lines may require the pump to operate dry during initial bleeding period. In such cases, the priming may be assisted by injecting fuel oil into the pump gearset. Under lift conditions, oil lines and fittings must be air tight. To assure this, "Pipe Dope" may be applied to both the used and unused inlet and both return fittings. DO NOT USE TEFLON TAPE!! DO NOT USE COMPRESSION FITTINGS!!

MOUNTING POSITION Model "A" Single Stage Fuel Unit may be mounted in any position. Model "B" Two Stage Fuel Unit may be mounted in any position except upside down (1/8" ports pointed down).

VACUUM CHECK A Vacuum Gage may be installed in either of the 1/4" inlet ports or in the 1/8" return port (on single pipe installations), whichever is most convenient. The Model "A" pump should be used where the vacuum does not exceed 6" hg. single pipe and 12" hg. two pipe. The Model "B" should be used where vacuum does not exceed 17" hg. Running vacuum is the total of all pressure drops (ΔP) from the tank to the inlet of the pump.

CAUTION

Pressurized or gravity feed installations must not exceed 10 P.S.I. on inlet line or return line at the pump. A pressure greater than 10 P.S.I. may cause damage to the shaft seal.

ONE-PIPE SYSTEM • MODEL A

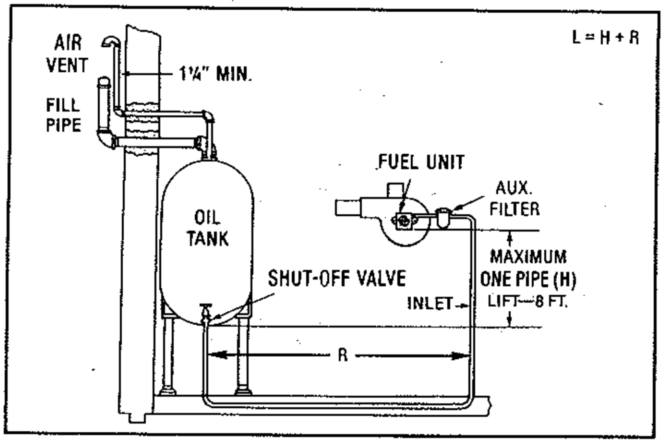


FIGURE 3

The SUNTEC MODEL "A"-70 FUEL UNIT may be installed ONE-PIPE with Gravity Feed or Lift.

The maximum allowable lift is 8 ft. — See Figure 3.

IMPORTANT: One-pipe installations must be absolutely air tight or leaks or loss of prime may result. Bleed line and fuel unit completely. **Bleed for 15 seconds after last air is seen from easy flow to be certain lines are air free.**

L = Line Length in Feet H = Head in Feet Q = Firing Rate in GPH

3/8" line $L = \dfrac{6 - .75H}{.0086\ Q}$ 1/2" line $L = \dfrac{6 - .75H}{.00218\ Q}$

If tank is above pump change - to +. Fittings, valves, and filters will reduce total length allowed.

TWO-PIPE SYSTEM • MODEL A AND B

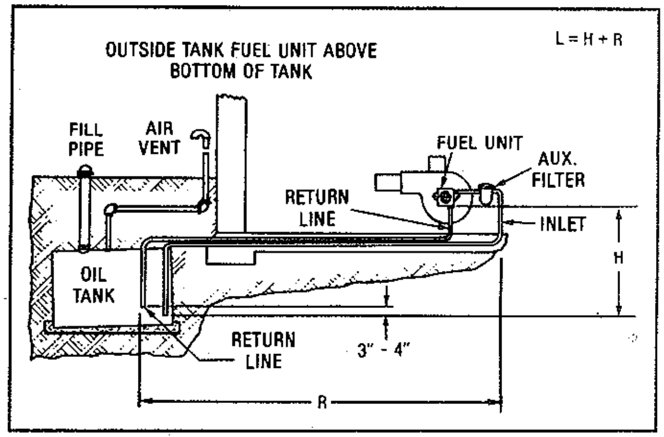


FIGURE 4

Always terminate return line as shown in Figure 4. Line lengths include both vertical and horizontal lengths.

MODEL A SINGLE-STAGE TWO-STEP • *TWO-PIPE MAXIMUM LINE LENGTH (H + R)*

Lift "H" Figure 4	3450 RPM					
	3/8" OD Tubing		1/2" OD Tubing			5/8" OD Tubing
	10 GPH	16 GPH	10 GPH	16 GPH	23 GPH	23 GPH
0'	33'	29'	100'	100'	72'	100'
1'	31'	27'	100'	100'	66'	100'
2'	28'	25'	100'	98'	59'	100'
3'	25'	23'	100'	89'	53'	100'
4'	23'	20'	92'	80'	46'	100'
5'	21'	18'	82'	72'	40'	100'
6'	18'	16'	72'	63'	34'	100'
7'	16'	14'	62'	55'	27'	88'
8'	13'	12'	52'	46'	20'	72'
9'	11'	9'	43'	37'	14'	56'
10'	—	—	33'	29'	8'	39'

MODEL B TWO-STAGE TWO-STEP AND TWO-STAGE HIGH-PRESSURE • *TWO-PIPE MAXIMUM LINE LENGTH (H + R)*

Lift "H" Figure 4	3450 RPM					
	3/8" OD Tubing		1/2" OD Tubing			5/8" OD Tubing
	10 GPH	16 GPH	10 GPH	16 GPH	23 GPH	23 GPH
0'	70'	60'	100'	100'	100'	100'
2'	64'	55'	100'	100'	100'	100'
4'	58'	50'	100'	100'	100'	100'
6'	52'	44'	100'	100'	100'	100'
8'	45'	39'	100'	100'	100'	100'
10'	39'	34'	100'	100'	100'	100'
12'	33'	28'	100'	100'	94'	100'
14'	27'	23'	100'	91'	76'	100'
16'	21'	18'	81'	70'	59'	100'
18'	—	—	57'	49'	41'	100'

PUMP USAGE IDENTIFICATION

IDENTIFICATION EXAMPLE

MODEL — STRAINER — SERIES NUMBER

A1VA — 7112

ROTATION & NOZZLE LOCATION

STRAINER TYPE	UL Strainer Rating (GPH)* #2 Fuel Oil
V	3
Y	7
T	23
G	34

*Max. firing rate not to exceed max. nozzle capacity or strainer rating whichever is LESS. A greater firing rate requires a suitable external strainer.

ALL INSTALLATIONS SHOULD BE MADE WTH LOCAL AND NATIONAL CODES.

SUNTEC® industries incorporated

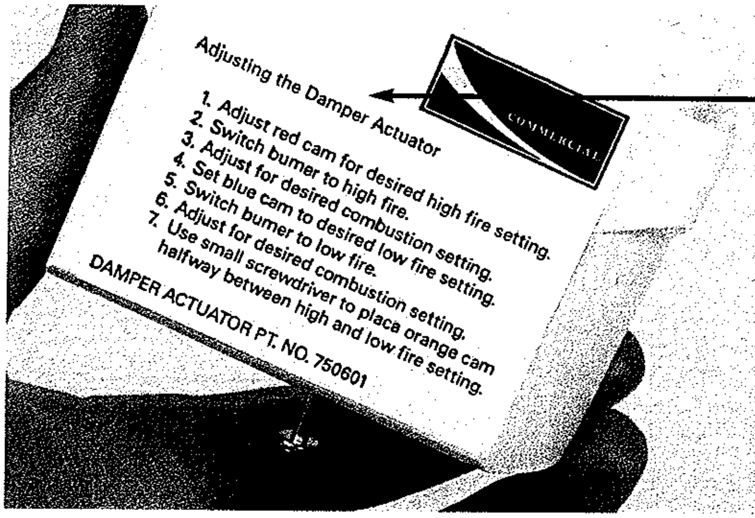
GLASGOW, KY 42142-5000

... working harder to serve you even better.

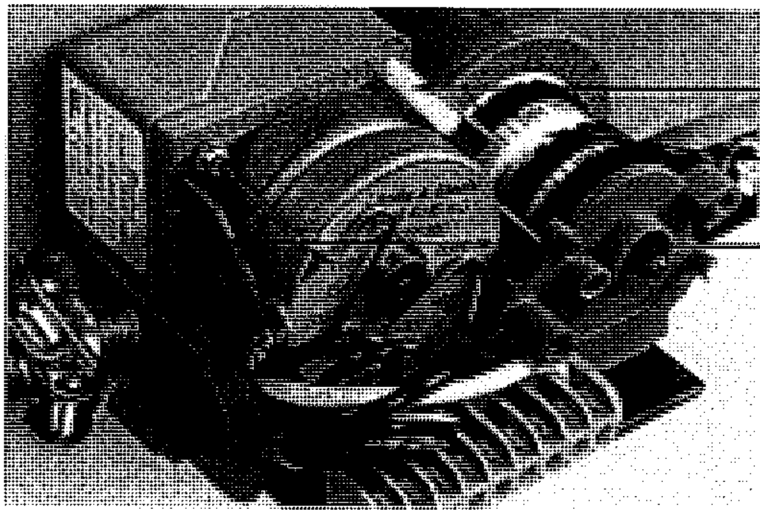
Form No. 2130
December 1995

Beckett

Damper Actuator
For Commercial Two-Stage Burners
Adjustment Instructions



Adjustment Instructions Printed on Cover



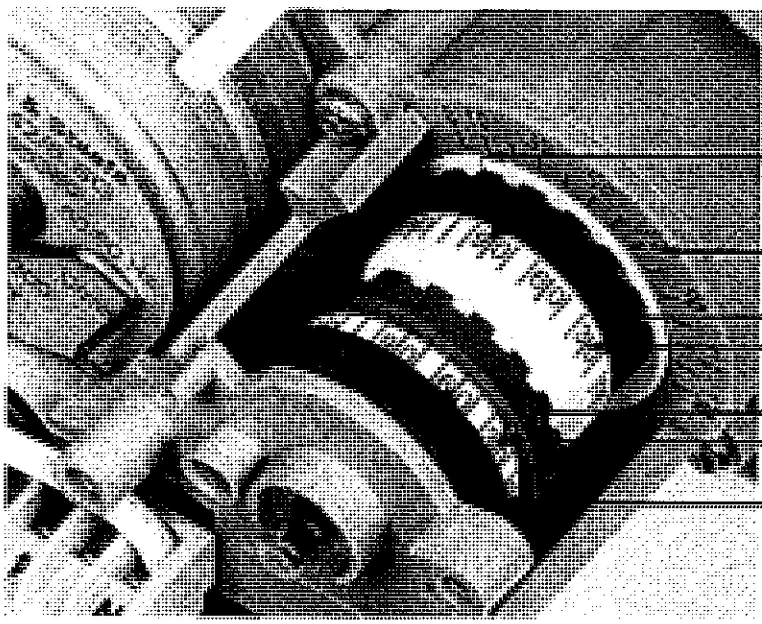
Disengaging Pin in the Engaged (out) Position

Cam Stack

Adjustment Wrench

The **Disengaging Pin** allows the Damper and Cam Stack to be rotated by hand.

***The Disengaging Pin** must be in the engaged position (out) when the burner is operating.*



Damper Position Indicator (Notch in White Ring)

Damper Position Scale

Red High Fire Cam with White Adjustment Scale

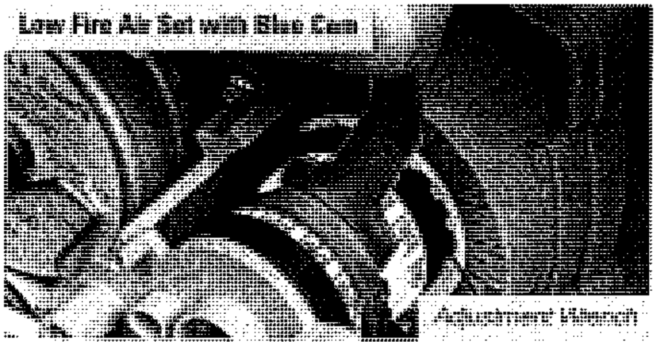
Blue Low Fire Cam with White Adjustment Scale

Transition Cam shares Adjustment Scale

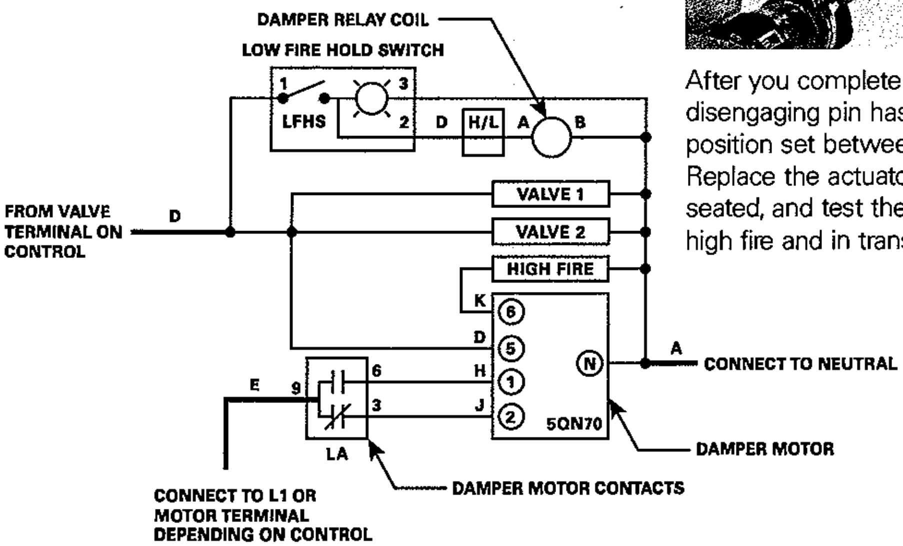
Damper Actuator

For Commercial Two-Stage Burners
Adjustment Instructions

Setting the High Fire Air and Low Fire Air

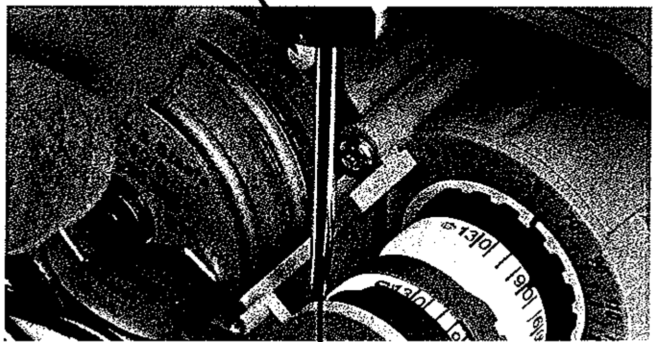


An old air setting specification of 7 is equal to 70° on the damper position scale of this new damper actuator.
If adjusting the air settings while the burner is operating, it is necessary to cycle the burner from High to Low Fire or Low to High by using the lighted low fire hold switch.



Setting the Transition

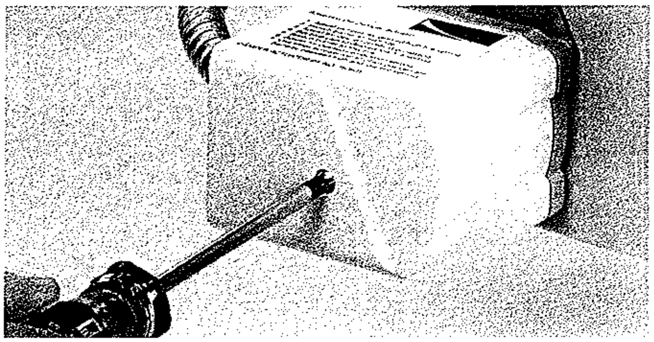
Cam is disengaged



Transition Cam is set with Screwdriver

The **ORANGE CAM** sets the transition point between Low Fire Oil and High Fire Oil.

It should be set halfway between the settings of the RED Cam and the BLUE Cam.

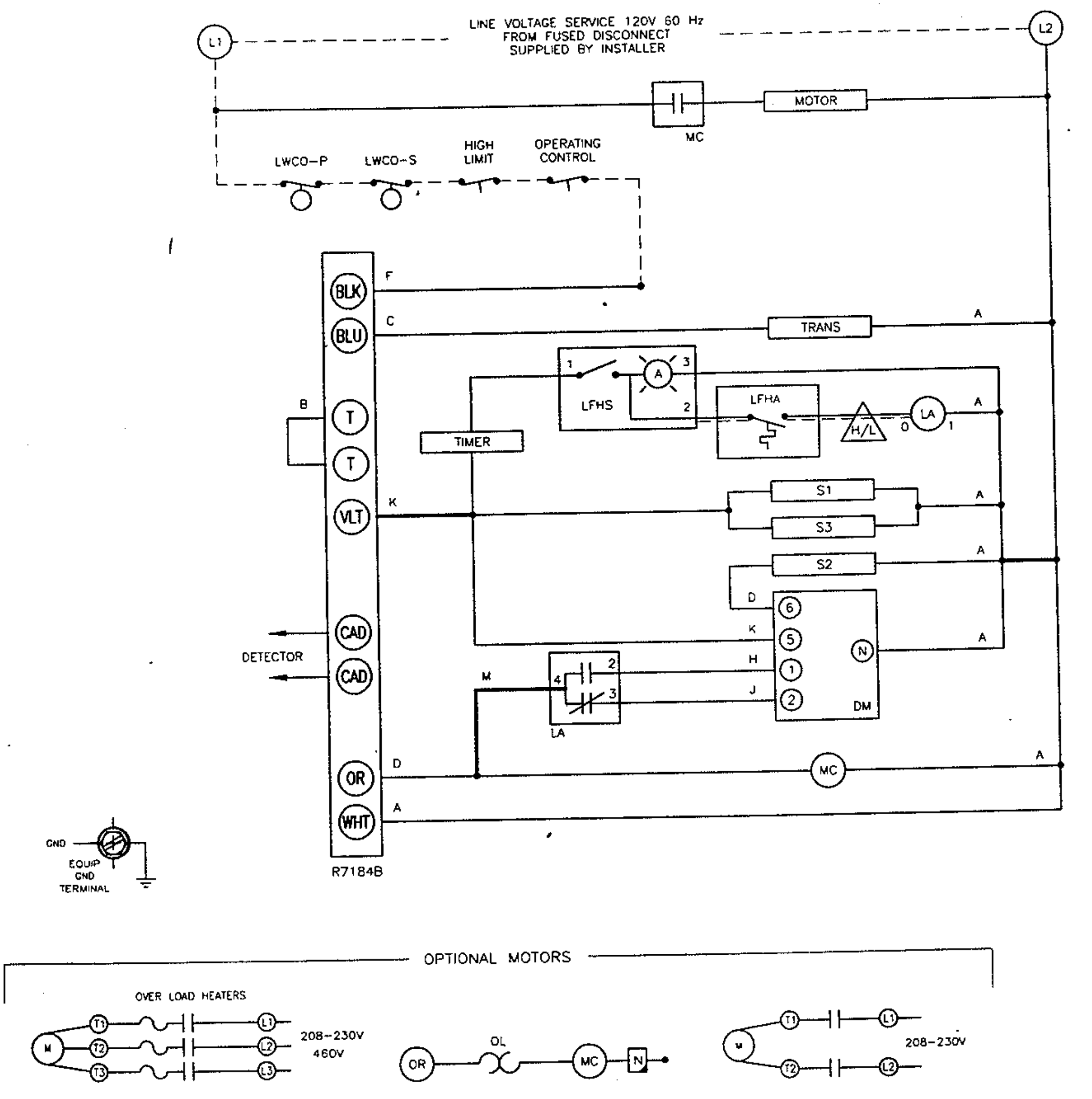


After you complete your adjustments make certain the disengaging pin has been reengaged with the damper position set between the high fire and low fire limits. Replace the actuator cover, making sure it is correctly seated, and test the burner for proper firing at low fire, high fire and in transition between low and high.

For more information, contact: **www.beckettcorp.com**

R.W. Beckett Corporation • P.O. Box 1289 • Elyria, Ohio 44036 • (800) 645-2876 • (440) 327-1060 • FAX (440) 327-1064
R.W. Beckett Canada Ltd. • Unit 3 - 430 Laird Road • Guelph, Ontario, Canada N1G 3X7 • (800) 665-6972 • FAX (519) 763-5656

Form No. 61578 09/04
Printed in U.S.A.



KEY

DM = DAMPER MOTOR
H/L = LO/HI CONTROL WIRING TAG
LA = LOW FIRE AIR RELAY
LFHA = LOW FIRE HOLD AQUASTAT
LFHS = LOW FIRE HOLD SWITCH
LWCO-P = LOW WATER CUTOFF - PRIMARY
LWCO-S = LOW WATER CUTOFF - SECONDARY (IF USED)
M = MOTOR
MC = MOTOR CONTACTOR
S1, S3 = ON/OFF VALVE
S2 = HIGH/LOW VALVE
TRANS = IGNITION TRANSFORMER

LEGEND

= CONTACT/DAMPER COIL
= LIGHT
= WIRING SUPPLIED BY INSTALLER
= CROSSOVER WIRES
= FACTORY JUMPER, TO BE CUT FOR FIELD WIRING TIE-IN

WIRE COLOR

A – WHITE
B – BLACK
C – BLUE
D – ORANGE
E – BROWN/RED
F – RED
G – BROWN
H – RED/WHITE
J – BLUE/WHITE
K – VIOLET
L – BLACK/RED
M – BLACK/WHITE
P – GREEN

MOTOR WIRE – 14GA.
ALL OTHER WIRE – 16 GA.

UNSPECIFIED WIRE COLORS BASED ON COMPONENTS

LIGHT COLOR

R = RED
G = GREEN
A = AMBER

NOTES

1. LOCATE HIGH/LOW OPERATOR BETWEEN DAMPER MOTOR AND LFHS.

DESCRIPTION: CF1400 / CF2300 LOW/HIGH/OFF R7184B CONTROL				Beckett COMMERCIAL
DRAWN/REV. BY: TB	CHECKED BY: RM	DRAWN/REV. DATE: 12/07/06	REVISION: 1	SCHEMATIC NO.: 6998004
LAST CHANGE: ADDED OPTIONAL AQUASTAT				

OPERATING INSTRUCTIONS & PARTS MANUAL

HIGH PRESSURE DIRECT-DRIVE BLOWERS

MODELS 2C940, 2C820, 4C108, 4C329 AND 4C330

FORM 5S2052
06820
0390/073/5M

READ CAREFULLY BEFORE ATTEMPTING TO ASSEMBLE, INSTALL, OPERATE OR MAINTAIN THE PRODUCT DESCRIBED. PROTECT YOURSELF AND OTHERS BY OBSERVING ALL SAFETY INFORMATION. FAILURE TO COMPLY WITH INSTRUCTIONS COULD RESULT IN PERSONAL INJURY AND/OR PROPERTY DAMAGE! RETAIN INSTRUCTIONS FOR FUTURE REFERENCE.

Description

Dayton direct-drive high pressure blowers are used for small exhaust systems where air is laden with dust or where dust-collection bags are necessary. Applications include handling long stringy material, paper trim, fiberous material such as textile scrap, wool and ensilage. Not suitable for coarse material. Heavy or abrasive dust. Dynamically balanced self-cleaning cast aluminum wheels. 16 GA housing and motor base. Maximum operating temperature 180°F (82°C). Finished in baked-on gray enamel. Blower can be assembled for CW or CCW rotation and any one of eight standard discharge positions. See Figure 2. Dayton motors packed separately when blowers are ordered complete.

General Safety Information

1. Follow all local electrical and safety codes, as well as the National Electrical Code (NEC) and the Occupational Safety and Health Act (OSHA).
2. Blower must be securely and adequately grounded. This can be accomplished by wiring with a grounded, metal-clad raceway system by using a separate ground wire connected to the bare metal of blower frame, or other suitable means.
3. Always disconnect power source before working on or near a motor or its connected load. If the power disconnect point is out-of-sight, lock it in the open position and tag to prevent unexpected application of power.
4. Be careful when touching the exterior of an operating motor — it may be hot enough to be painful or cause injury. With modern motors this condition is normal when operated at rated load and voltage — modern motors are built to operate at higher temperatures.
5. Protect the power cable from coming in contact with sharp objects.
6. Do not kink power cable and never allow the cable to come in contact with oil, grease, hot surfaces, or chemicals.
7. Make certain that the power source conforms to the requirements of your equipment.
8. When cleaning electrical or electronic equipment, always use an approved cleaning agent such as dry cleaning solvent.
9. Not recommended as an explosion proof blower. Do not use where explosive fumes or gases are present.
10. If blower is operated without an inlet or outlet duct, guard openings in accordance with OSHA regulations to prevent contact with rotating blower wheel.

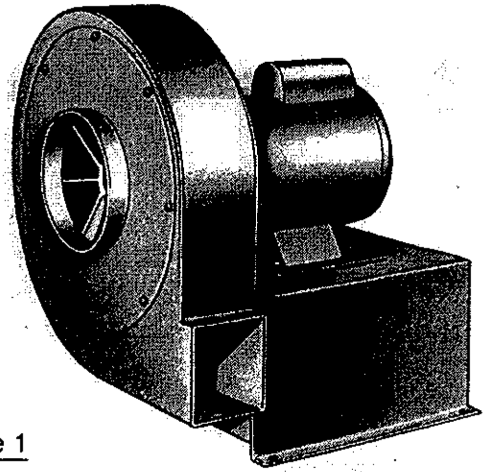


Figure 1

⚠ WARNING ⚠

KEEP HANDS AWAY FROM INLET WHILE BLOWER IS IN OPERATION.

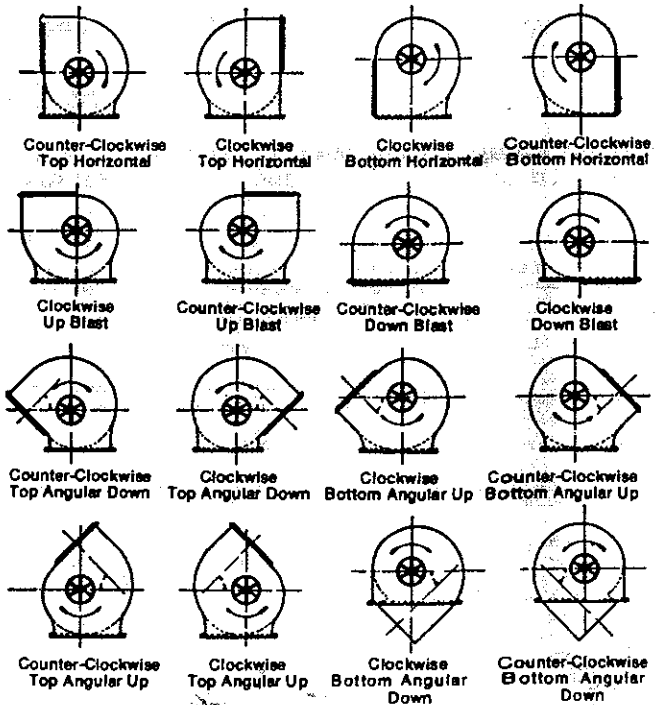


Figure 2

Specifications

MODEL	WHEEL DIA.	WHEEL W	WHEEL BORE	A	B	C	D	E	F	G	H	J	K	L	O	P	R	S	V	X ADJ. MIN.	X ADJ. MAX.
2C940	7¾"	2 5/16"	½"	11"	8"	3"	3"	5"	7"	½"	5⅜"	4⅞"	5⅞"	5⅞"	12¼"	4"	6⅝"	5½"	—	8¼"	9¾"
2C820	9	2 13/16	½	12⅛	8	3½	3½	5⅝	7	½	6⅜	5¾	6⅞	6¾	12¾	5	7½	6⅜	—	9⅛	10⅝
4C108	10 9/16	3	⅝	14¾	9	4	3½	6⅞	7½	¾	7¼	6½	8	7⅝	14	6	8⅝	8¼	—	11⅜	12⅞
4C329	12½	3	⅞	17	11¼	5	4	8	9¾	¾	8¼	7½	9	9⅝	17	7	10	7⅛	—	10⅝	10⅝
4C330	13½	4⅜	1⅛	17½	11¼	7⅛	5¾	8	9½	1	10½	9⅝	11⅜	11	18⅞	8	11½	8⅛	7¼	12⅝	12⅝

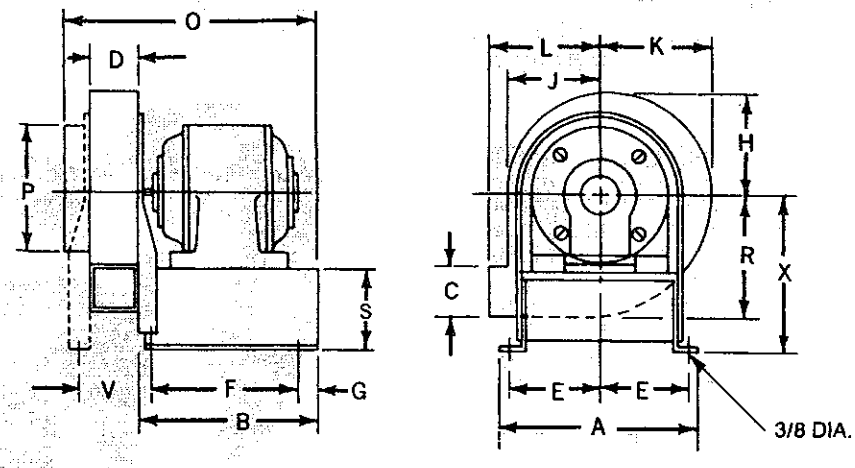


Figure 3

Performance

MODEL	HP REQ'D.	MOTOR FRAME	VOLTS	MOTOR TYPE	CFM AIR DELIVERY AT 3450 RPM 1" SP	2" SP	3" SP	4" SP	5" SP	6" SP	7" SP	8" SP	SHPG. WT.
2C940	1/3	48	115	Split	290	230	160	—	—	—	—	—	13
2C820	1/3	48	115	Split	530	470	415	335	165	—	—	—	17
4C108	1	56	115/230	Cap. (†)	800	745	680	610	510	375	225	—	25
4C329	3	145T	230/460	3-Ph.	1200	1140	1070	1010	940	870	790	695	37
4C330	5	182T	230/460	3-Ph.	2140	2030	1930	1820	1710	1615	1500	1375	64

(†) Also available in 208-230/460, 60Hz, 3-Phase.
Based on standard test codes of (AMCA) Air Moving and Conditioning Association

⚠ CAUTION

Must not be used where static pressure is less than shown in table. Severe motor overload will result. Motor overload protection, closely matched to motor full-load current, is highly recommended.

LIMITED WARRANTY

DAYTON ONE-YEAR LIMITED WARRANTY. High pressure direct drive blowers, Models 2C940, 2C820, 4C108, 4C329, & 4C330, are warranted by Dayton Electric Mfg. Co. (Dayton) to the original user against defects in workmanship or materials under normal use for one year after date of purchase. Any part which is determined by Dayton to be defective in material or workmanship and returned to an authorized service location, as Dayton designates, shipping costs prepaid, will be, as the exclusive remedy, repaired or replaced at Dayton's option. For limited warranty claim procedures, see PROMPT DISPOSITION below. This limited warranty gives purchasers specified legal rights which vary from state to state.

LIMITATION OF LIABILITY. To the extent allowable under applicable law, Dayton's liability for consequential and incidental damages is expressly disclaimed. Dayton's liability in all events is limited to, and shall not exceed, the purchase price paid.

WARRANTY DISCLAIMER. Dayton has made a diligent effort to illustrate and describe the products in this literature accurately; however, such illustrations and descriptions are for the sole purpose of identification, and do not express or imply a warranty that the products are merchantable, or fit for a particular purpose, or that the products will necessarily conform to the illustrations or descriptions.

Except as provided below, no warranty or affirmation of fact, expressed or implied, other than as stated in "LIMITED WARRANTY" above is made or authorized by Dayton.

PRODUCT SUITABILITY. Many states and localities have codes and regulations governing sales, construction, installation, and/or use of products for certain purposes, which may vary from those in neighboring areas. While Dayton attempts to assure that its products comply with such codes, it cannot guarantee compliance, and cannot be responsible for how the product is installed or used. Before purchase and use of a product, please review the product application, and national and local codes and regulations, and be sure that the product, installation, and use will comply with them.

Certain aspects of disclaimers are not applicable to consumer products; e.g., (a) some states do not allow the exclusion or limitation of incidental or consequential damages, so the above limitation or exclusion may not apply to you; (b) also, some states do not allow limitations on how long an implied warranty lasts, consequently the above limitation may not apply to you; and (c) by law, during the period of the Limited Warranty, any implied warranties of merchantability or fitness for a particular purpose applicable to consumer products purchased by consumers, may not be excluded or otherwise disclaimed.

PROMPT DISPOSITION. Dayton will make a good faith effort for prompt correction or other adjustment with respect to any product which proves to be defective within limited warranty. For any product believed to be defective within limited warranty, first write or call dealer from whom product was purchased. Dealer will give additional directions. If unable to resolve satisfactorily, write to Dayton at address below, giving dealer's name, address, date and number of dealer's invoice, and describing the nature of the defect. Title and risk of loss pass to buyer on delivery to common carrier. If product was damaged in transit to you, file claim with carrier.

Manufactured for Dayton Electric Mfg. Co., 5959 W. Howard St., Chicago, IL 60648

Assembly

1. Attach base upright to the motor mounting base as shown in the exploded view. Hand tighten (4) 1/4-20 x 1/2" bolts, washers, and nuts through slotted holes in base upright. Place motor on motor base and align the center hole of the base upright with the motor shaft. Secure the four 1/4-20 bolts. Models 4C329 and 4C330 have a welded motor base assembly.
2. Bolt the housing to the base upright in the desired discharge position using #10 x 3/8 or 5/16-18 x 3/4" self tapping bolts. Blower is clockwise rotation. Refer to exploded view showing clockwise bottom horizontal discharge.
3. With the motor shaft through the center hole of the base upright, align the mounting holes of the motor to the pre-drilled holes in the motor base. Install two bolts to retain proper motor alignment but do not tighten. Mount the wheel to the motor shaft. Refer to exploded view drawing.
4. Mount the inlet ring to the housing and secure with #10 x 3/8" or 5/16-18 x 3/4" self tapping bolts.
5. Slide the wheel toward the inlet ring so there is at least 1/4" clearance between the wheel and cone. The motor shaft should extend through the hub of the wheel so when the setscrews are securely tightened, they will make contact with the motor shafts.
6. Install the remaining nuts, bolts, and washers (not provided) to the motor mounting holes of the motor and secure to the blower motor base.

Installation

1. Make sure all bolts and screws are tightened before mounting on a rigid, flat, level foundation. Bolt the blower securely into position.
2. Check the interior of the fan housing to be sure it is free of debris. Rotate the wheel to insure that it is not rubbing or binding. Check the clearance of the wheel and the inlet ring. If rubbing exists, loosen the bolts on the ring and shift the ring until clearance is obtained. If still rubbing, loosen the set screw on the wheel and shift the wheel rearward to obtain clearance. Retighten the set screw.

Operation

1. Before connecting the motor to the electric supply, check the electrical characteristics as indicated on the motor nameplate to insure proper voltage and phase.

⚠ CAUTION

A ground wire must run from the blower motor housing to a suitable electrical ground such as a properly grounded metallic raceway or a ground wire system.

2. After electrical connections are completed, apply just enough power to start the unit. Be sure that the rotation of the wheel is correct as indicated by directional arrows on the unit. If proper rotation, apply full electrical power.
3. With the air system in full operation and all ducts attached, measure current input to the motor and compare with the nameplate rating to determine if the motor is operating under safe load conditions.

Maintenance

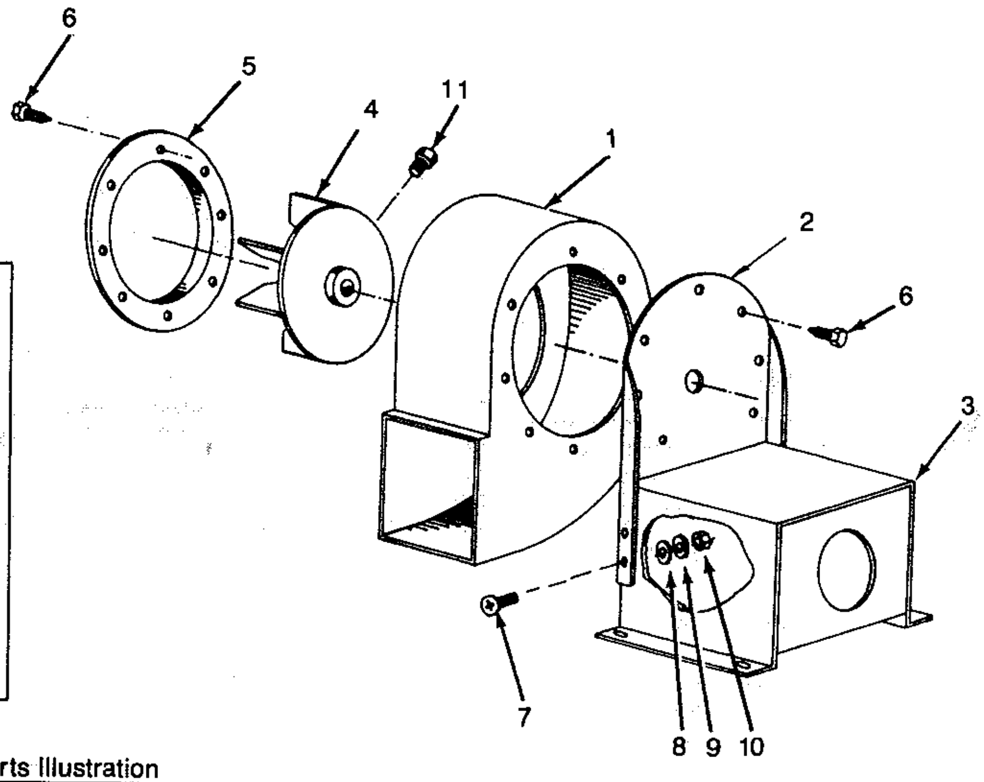
⚠ CAUTION

Before attempting any repair work, be certain that all power to the motor and electrical accessories are turned off and locked in the off position.

A. Periodically remove dirt from blower wheel and housing.
B. Check tightness of wheel setscrews.
C. After disconnecting the power source, check the wiring to see if insulation is damaged or frayed.
D. Relubricate motor per manufacturer's instructions. Remove any excess lubricants.

Troubleshooting Chart

SYMPTOM	POSSIBLE CAUSE(S)	CORRECTIVE ACTION
Noise.	1. Foreign objects in housing. 2. Loose setscrew on wheel. 3. Incorrect wheel rotation.	1. Remove. 2. Tighten. 3. Reverse rotation.
Motor bearing noise.	Lack of bearing lubrication.	Lubricate.
Excessive vibration.	1. Loose wheel on shaft. 2. Loose mounting bolts. 3. Motor out of balance. 4. Wheel out of balance. 5. Accumulation of material on wheel.	1. Tighten setscrews. 2. Tighten. 3. Replace. 4. Replace or rebalance. 5. Clean.
Motor overloaded.	System static pressure less than 1" water column.	Increase system static pressure.



ORDER REPLACEMENT PARTS BY CALLING TOLL FREE

1-800-323-0620

Please provide the following information:
- Model Number
- Serial Number (if any)
- Parts Description and Number as shown in Parts List

Address parts correspondence to:

Parts Company of America
1657 Shermer Road
Northbrook, IL 60062-5362

Figure 4 — Replacement Parts Illustration

Replacement Parts List

REF. NO.	DESCRIPTION	PART NO. FOR MODEL:				
		2C940	2C820	4C108	4C329	4C330 (‡)
1	Housing scroll	201-08-4005-5	201-09-4003-5	201-11-4005-5	201-12-4004-5	201-14-4005-5
2	Base upright	618-08-7001-5	618-09-7001-5	618-11-7002-5	—	—
3	Motor base assembly	203-08-7001-5	203-09-7001-5	203-11-7005-5	203-12-4016-5	203-14-4011-5
4	Wheel	602-08-4001-5	602-09-4001-5	602-11-4002-5	602-12-4004-5	602-14-4003-5
5	Inlet ring	609-08-4002-5	609-09-4001-5	609-11-4003-5	602-12-4003-5	609-14-4001-5
6	Hex hd. screw	#10 x 3/8″ 8 Req'd.	#10 x 3/8″ 14 Req'd.	#10 x 3/8″ 14 Req'd.	5/16-18 x 3/4″ 16 Req'd.	5/16-18 x 3/4″ 16 Req'd.
7	Slotted machine screw*	1/4-20 x 1/2″ 4 Req'd.	1/4-20 x 1/2″ 4 Req'd.	1/4-20 x 1/2″ 4 Req'd.	—	—
8	Flat washer*	1/4 4 Req'd.	1/4 4 Req'd.	1/4 4 Req'd.	—	—
9	Split washer*	1/4 4 Req'd.	1/4 4 Req'd.	1/4 4 Req'd.	5/16 16 Req'd.	5/16 16 Req'd.
10	Hex nut*	1/4″-20 4 Req'd.	1/4″-20 4 Req'd.	1/4″-20 4 Req'd.	—	—
11	Setscrew	†	†	†	†	†

NOTE — Models 4C329 and 4C330 have welded 1 piece motor base & upright assembly.
(‡) Model 4C330 has inlet upright supports (not shown) to support housing. Order by P/N 617-13-7002-5.
(*) Standard hardware item, available locally.
(†) Available with wheel.

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Inspection Checklist for Supervisors

Facility:			Date:	
	Activity	**Yes**	**No**	**Remarks**
A.	**Safety**			
1.	Is there adequate personal protective equipment (PPE)?			
2.	Is the PPE being used?			
3.	Is the PPE in good condition?			
4.	Is there restricted entry to the waste incineration/ash disposal site?			
5.	Is there functional fire safety equipment?			
6.	Do the operators know how to use the equipment?			
7.	Is there adequate first aid kit?			
8.	Are the operators conversant with use of the kit?			
9.	Is flammable material stored away from the incinerator?			
10.	Are warning signs distinctly displayed?			
Additional Comments on Safety:				

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Results Driven.

Inspection Checklist for Supervisors

B.	Operation			
	Activity	**Yes**	**No**	**Remarks**
1.	Is there a sufficient supply of fuel?			
2.	Is the procedure for preparation of waste for incineration being followed?			
3..	Is the incinerator cleaned daily?			
4.	Is the waste weighed upon reception?			
5.	Is the waste temporarily stored neatly?			
6.	Is the loading of incinerator done in the right way?			
7.	Is the temperature regulated adequately during the burn?			
8.	IS the incinerator allowed to burn down and cool before cleaned?			
9.	Is the ash properly disposed as specified by compliance procedures?			
10.	Are the following tools and equipment available?			
a.	Ash Rake			
b.	Shovel			
c.	Hand brush/Dustpan			
d.	Hard broom			
e.	Non-Combustible Ash Disposal Drums			
f.	Weighing Scale			
g.	Fire Extinguisher			
h.	Fire Retardant Gloves			
i.	Eye Protection/ Face Mask			
j.	Fire Retardant Coveralls or suitable clothing to cover the upper body, including the lower arms			
k.	Safety First Aid Kit			
Additional Comments on Operation:				

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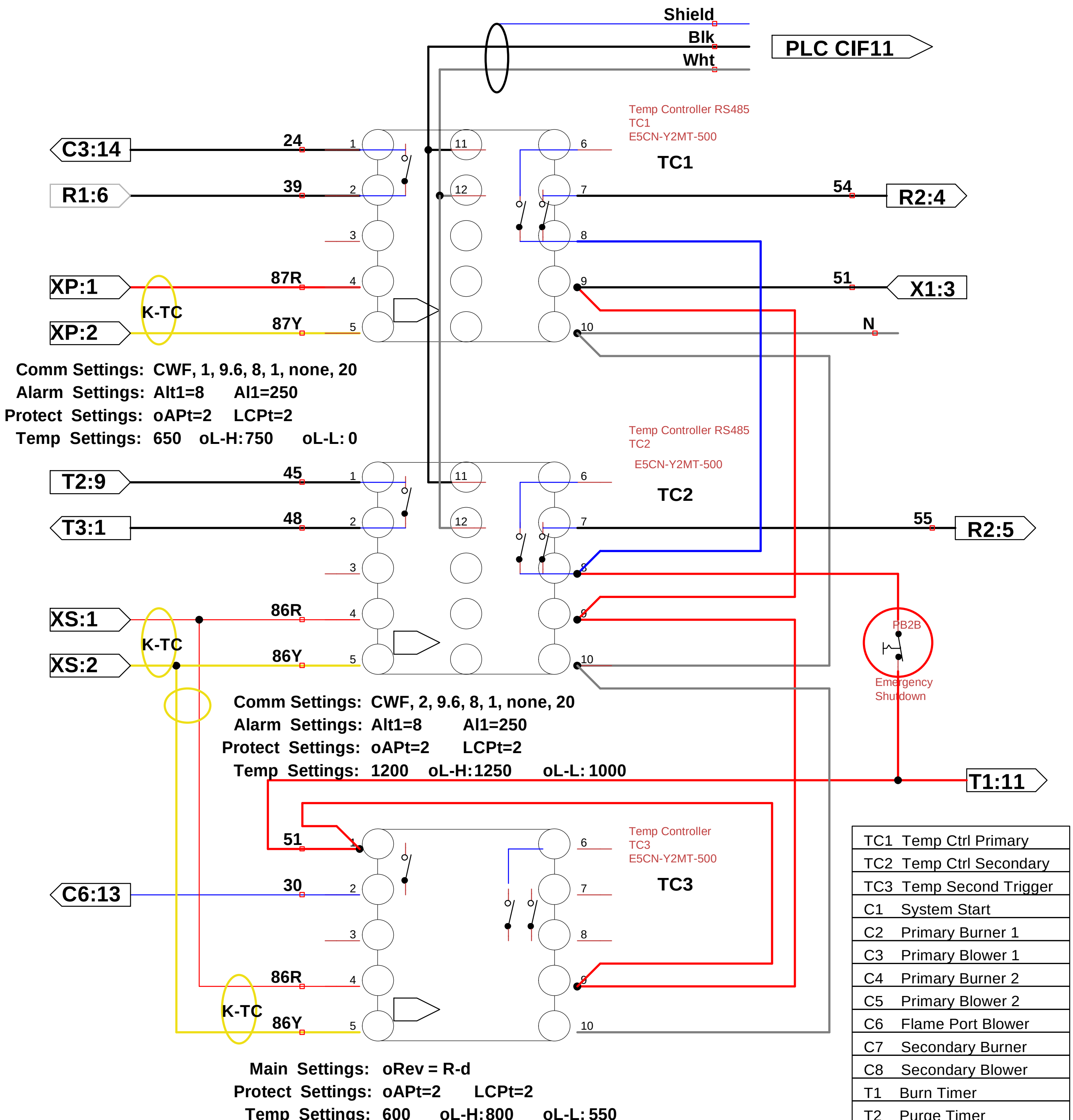
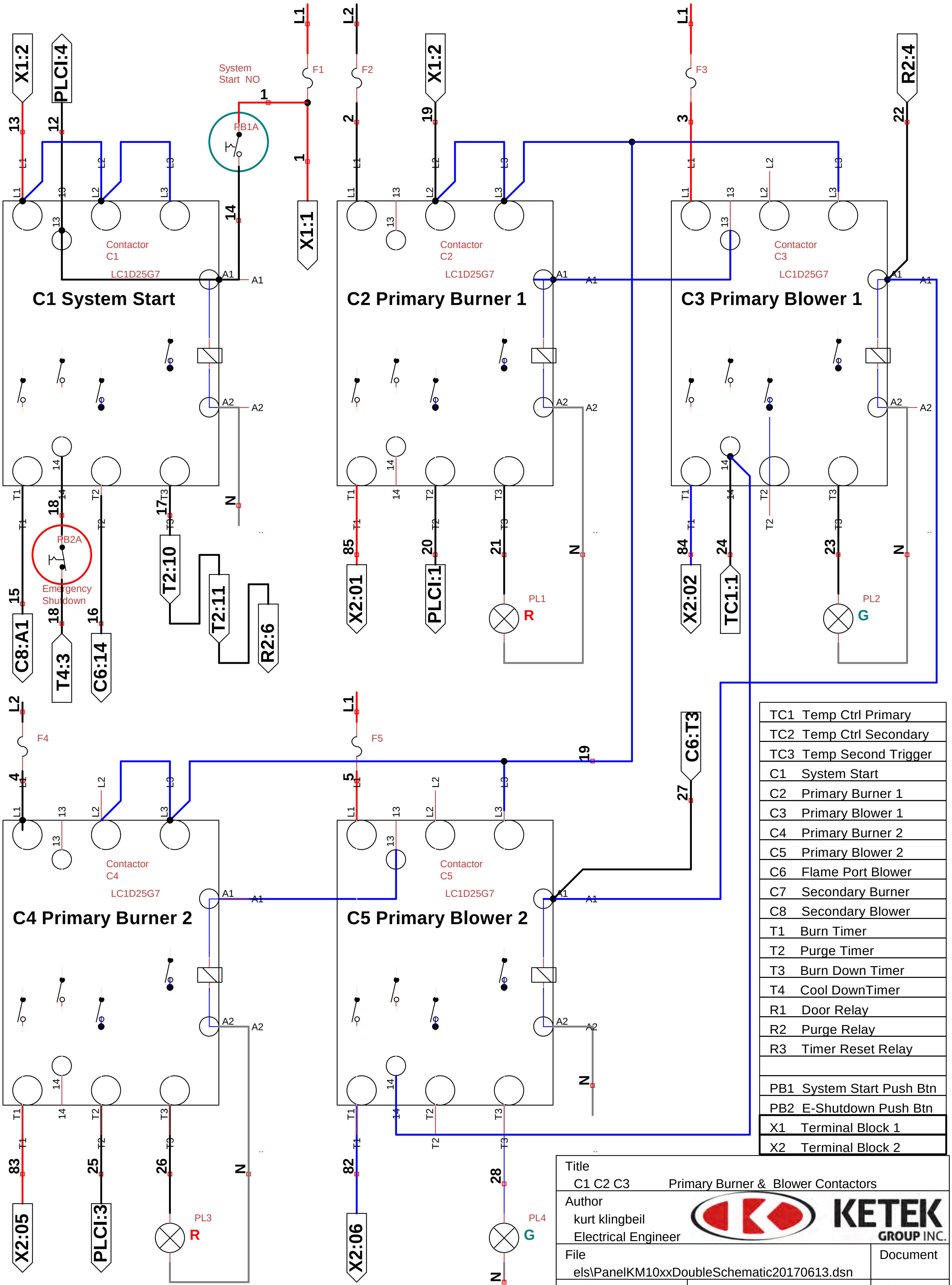
Inspection Checklist for Supervisors

C.	Maintenance			
	Activity	**Yes**	**No**	**Remarks**
1.	Is there evidence of cracks in the refractor? (Do not include heat expansion cracks)			
2.	Is there good housekeeping?			
3.	Is the status of the ash handling and disposal system good?			
Additional Comments on Maintenance:				
D.	**Records**			
	Activity	**Yes**	**No**	**Remarks**
1.	Are the relevant forms available?			
2.	Are the forms filled accurately and completely?			
3.	Are incidents recorded?			
4.	Are reports of the waste incinerated done on time?			
Additional Comments on Records:				
Name of Supervisor:		Signature:		Designation:



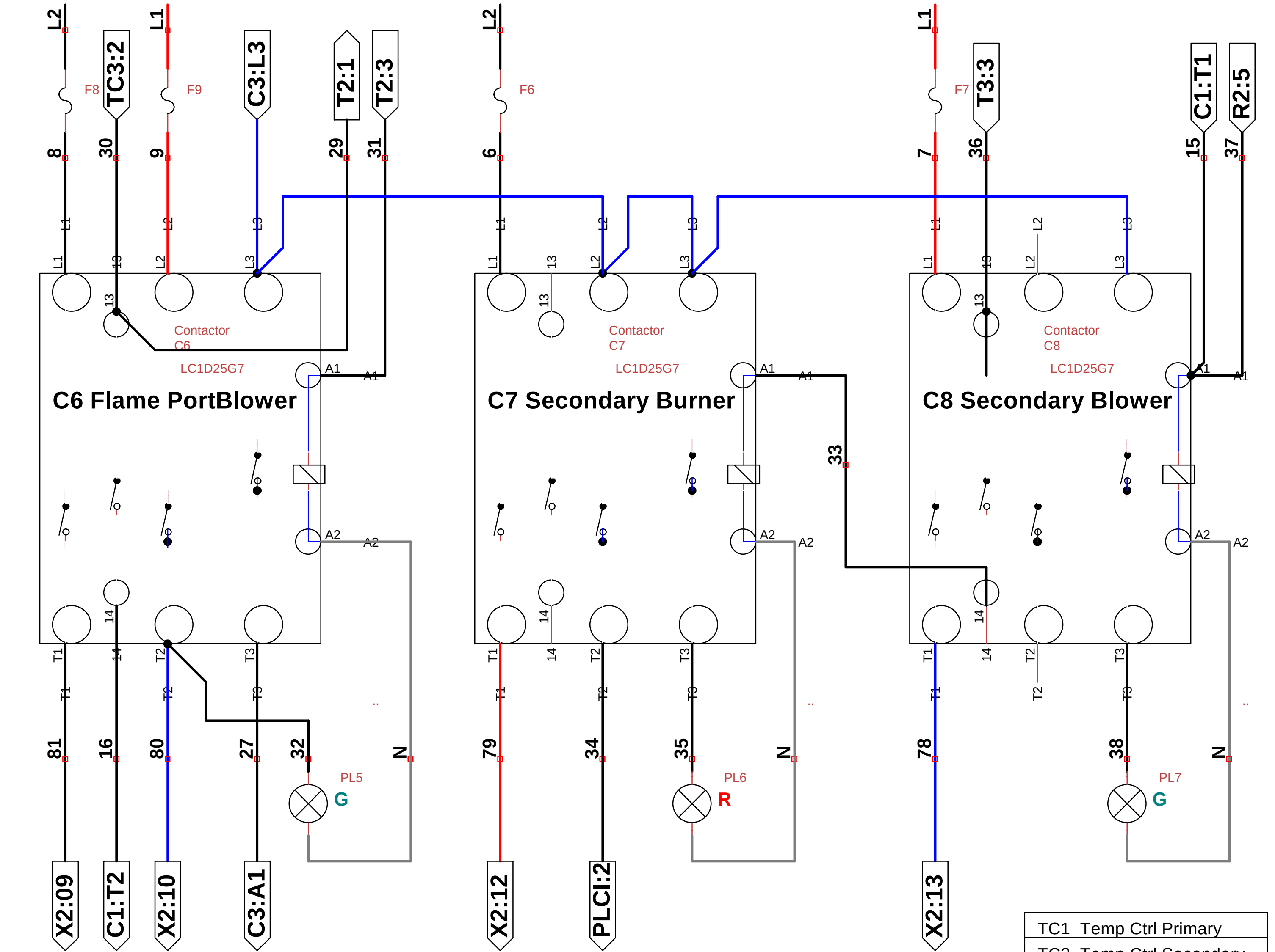
TC1	Temp Ctrl Primary
TC2	Temp Ctrl Secondary
TC3	Temp Second Trigger
C1	System Start
C2	Primary Burner 1
C3	Primary Blower 1
C4	Primary Burner 2
C5	Primary Blower 2
C6	Flame Port Blower
C7	Secondary Burner
C8	Secondary Blower
T1	Burn Timer
T2	Purge Timer
T3	Burn Down Timer
T4	Cool DownTimer
R1	Door Relay
R2	Purge Relay
R3	Timer Reset Relay
PB1	System Start Push Btn
PB2	E-Shutdown Push Btn
X1	Terminal Block 1
X2	Terminal Block 2

Title		
TC1 TC2 TC3 Temperature Controllers		
Author: kurt klingbeil, Electrical Engineer		KETEK GROUP INC.
File: els\PanelKM10xxDoubleSchematic20170613.dsn		Document
Revision: 1.37	Date: 2017-01-05	Sheets: 1 of 7

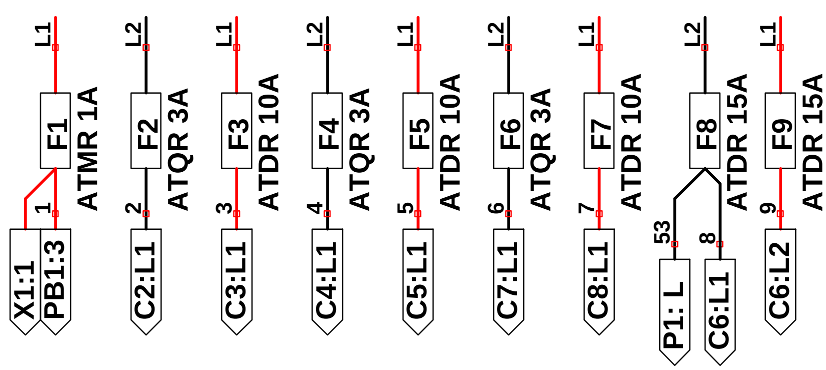


TC1	Temp Ctrl Primary
TC2	Temp Ctrl Secondary
TC3	Temp Second Trigger
C1	System Start
C2	Primary Burner 1
C3	Primary Blower 1
C4	Primary Burner 2
C5	Primary Blower 2
C6	Flame Port Blower
C7	Secondary Burner
C8	Secondary Blower
T1	Burn Timer
T2	Purge Timer
T3	Burn Down Timer
T4	Cool DownTimer
R1	Door Relay
R2	Purge Relay
R3	Timer Reset Relay
PB1	System Start Push Btn
PB2	E-Shutdown Push Btn
X1	Terminal Block 1
X2	Terminal Block 2

Title C1 C2 C3 Primary Burner & Blower Contactors		
Author kurt klingbeil Electrical Engineer	KETEK GROUP INC.	
File els\PanelKM10xxDoubleSchematic20170613.dsn		Document
Revision 1.36	Date 2017-01-05	Sheets 2 of 7



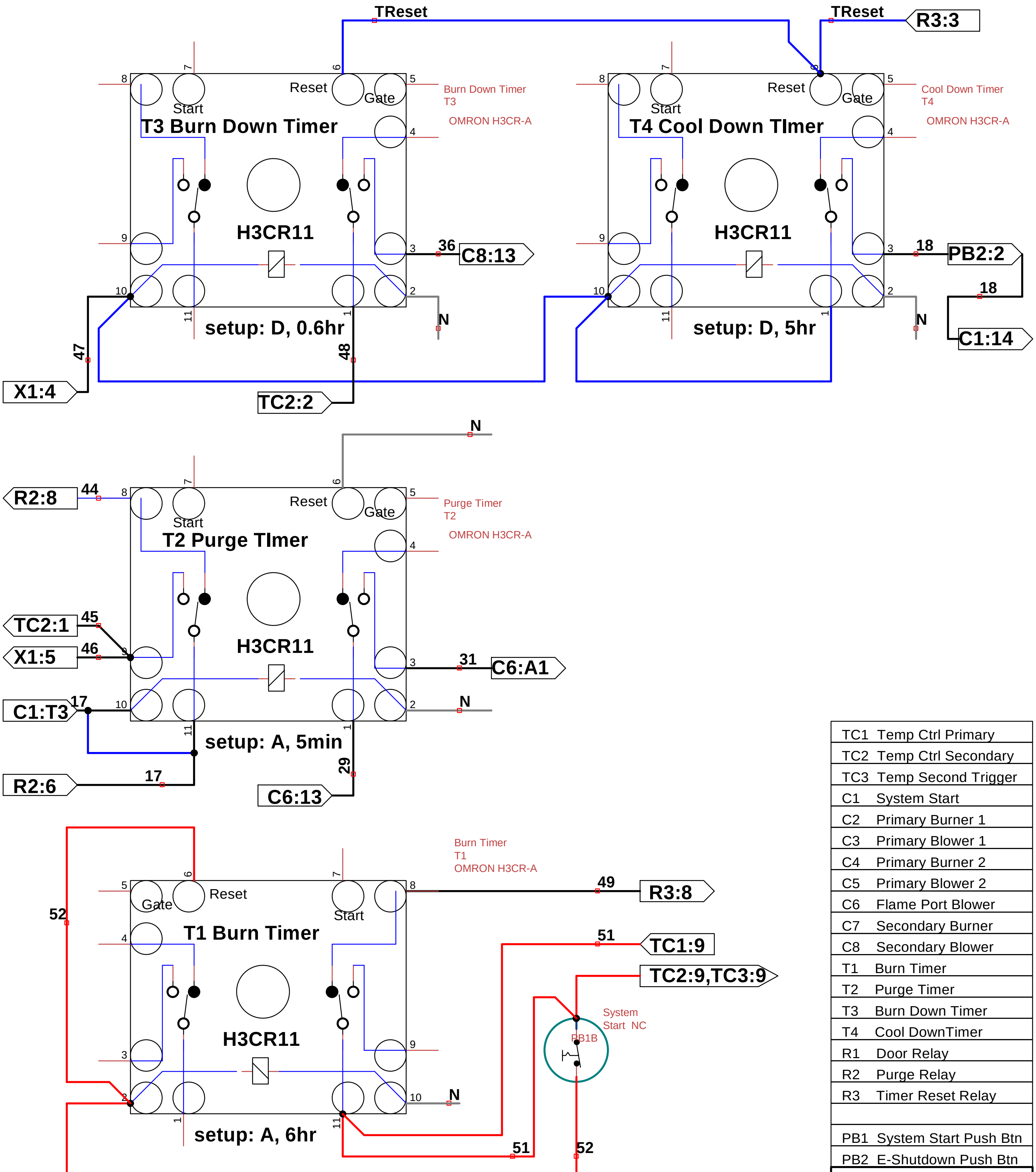
FUSES - SUMMARY



Fuse sizes could change based on model of Burners/Blowers

TC1	Temp Ctrl Primary
TC2	Temp Ctrl Secondary
TC3	Temp Second Trigger
C1	System Start
C2	Primary Burner 1
C3	Primary Blower 1
C4	Primary Burner 2
C5	Primary Blower 2
C6	Flame Port Blower
C7	Secondary Burner
C8	Secondary Blower
T1	Burn Timer
T2	Purge Timer
T3	Burn Down Timer
T4	Cool DownTimer
R1	Door Relay
R2	Purge Relay
R3	Timer Reset Relay
P1	Instrument Plug
PB1	System Start Push Btn
PB2	E-Shutdown Push Btn
X1	Terminal Block 1
X2	Terminal Block 2

Title		
C6 C7 C8 Secondary Burner & Blower Contactors		
Author: kurt klingbeil, Electrical Engineer		KETEK GROUP INC.
File: els\PanelKM10xxDoubleSchematic20170613.dsn		Document
Revision: 1.36	Date: 2017-01-05	Sheets: 3 of 7



TC1	Temp Ctrl Primary
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TC3	Temp Second Trigger
C1	System Start
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C3	Primary Blower 1
C4	Primary Burner 2
C5	Primary Blower 2
C6	Flame Port Blower
C7	Secondary Burner
C8	Secondary Blower
T1	Burn Timer
T2	Purge Timer
T3	Burn Down Timer
T4	Cool DownTimer
R1	Door Relay
R2	Purge Relay
R3	Timer Reset Relay
PB1	System Start Push Btn
PB2	E-Shutdown Push Btn
X1	Terminal Block 1
X2	Terminal Block 2

Title
Timers: T1-Burn, T2-Purge, T3-BurnDown, T4 -CoolDown

Author
kurt klingbeil
Electrical Engineer

KETEK GROUP INC.

File		Document
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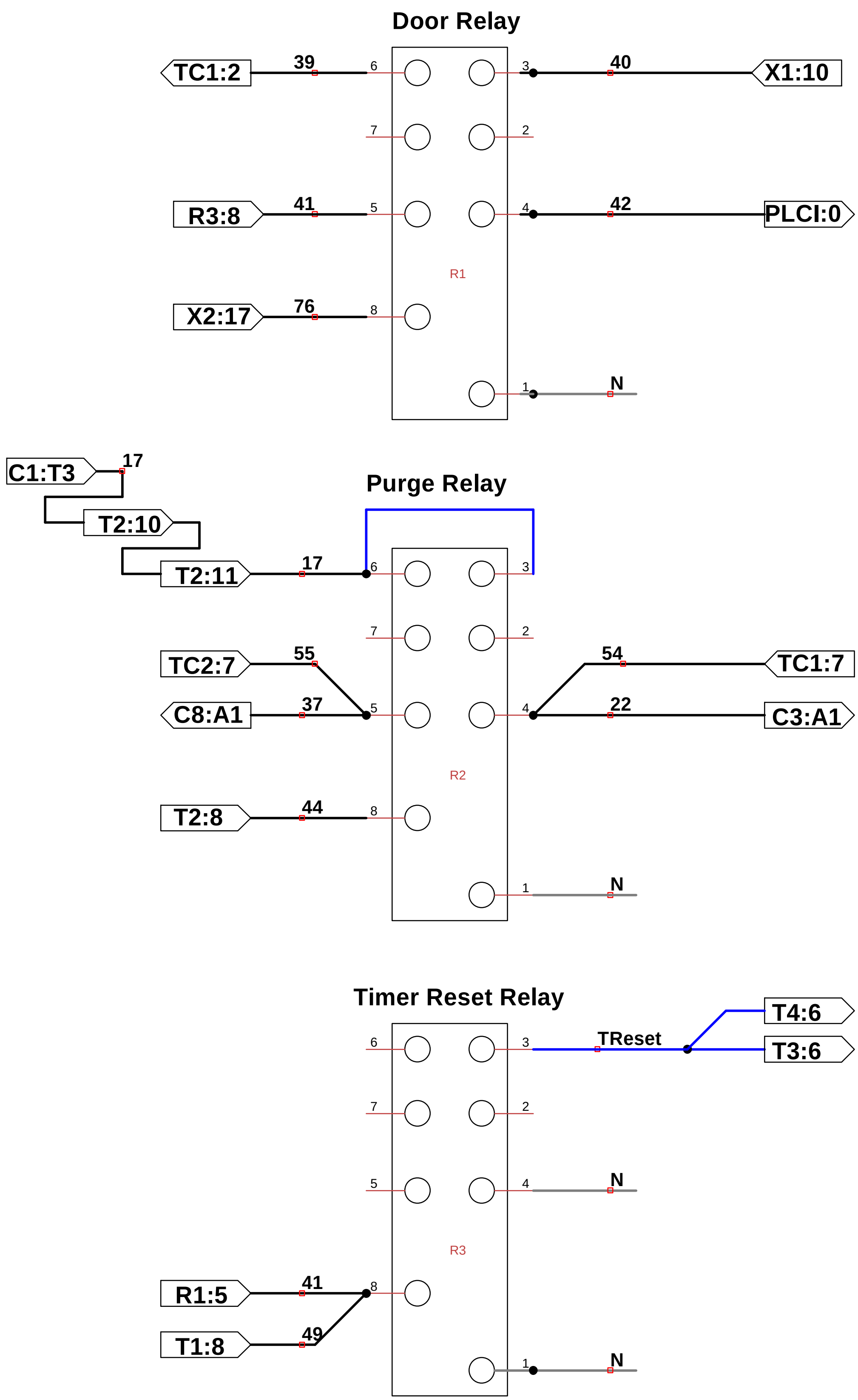
Revision	Date	Sheets
1.36	2017-01-05	4 of 7



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TC3	Temp Second Trigger
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T4	Cool DownTimer
R1	Door Relay
R2	Purge Relay
R3	Timer Reset Relay
PB1	System Start Push Btn
PB2	E-Shutdown Push Btn
X1	Terminal Block 1
X2	Terminal Block 2

Title
Relays: R1-Door Switch, R2 Timer Reset, R3 Purge1, R4 Purge 2

Author
kurt klingbeil
Electrical Engineer

KETEK GROUP INC.

File		Document
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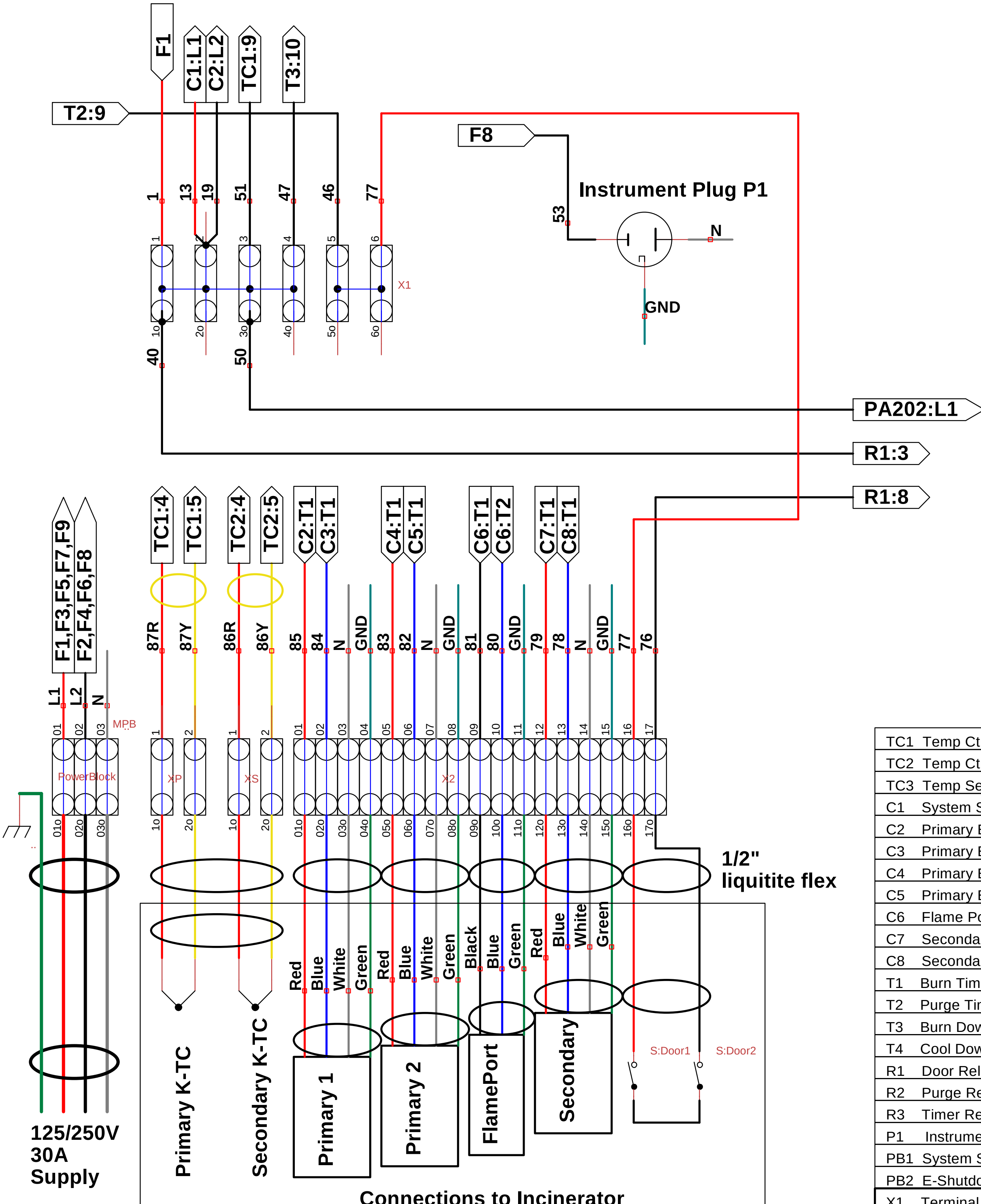
Revision	**Date**	**Sheets**
1.36	2017-01-05	5 of 7



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TC3	Temp Second Trigger
C1	System Start
C2	Primary Burner 1
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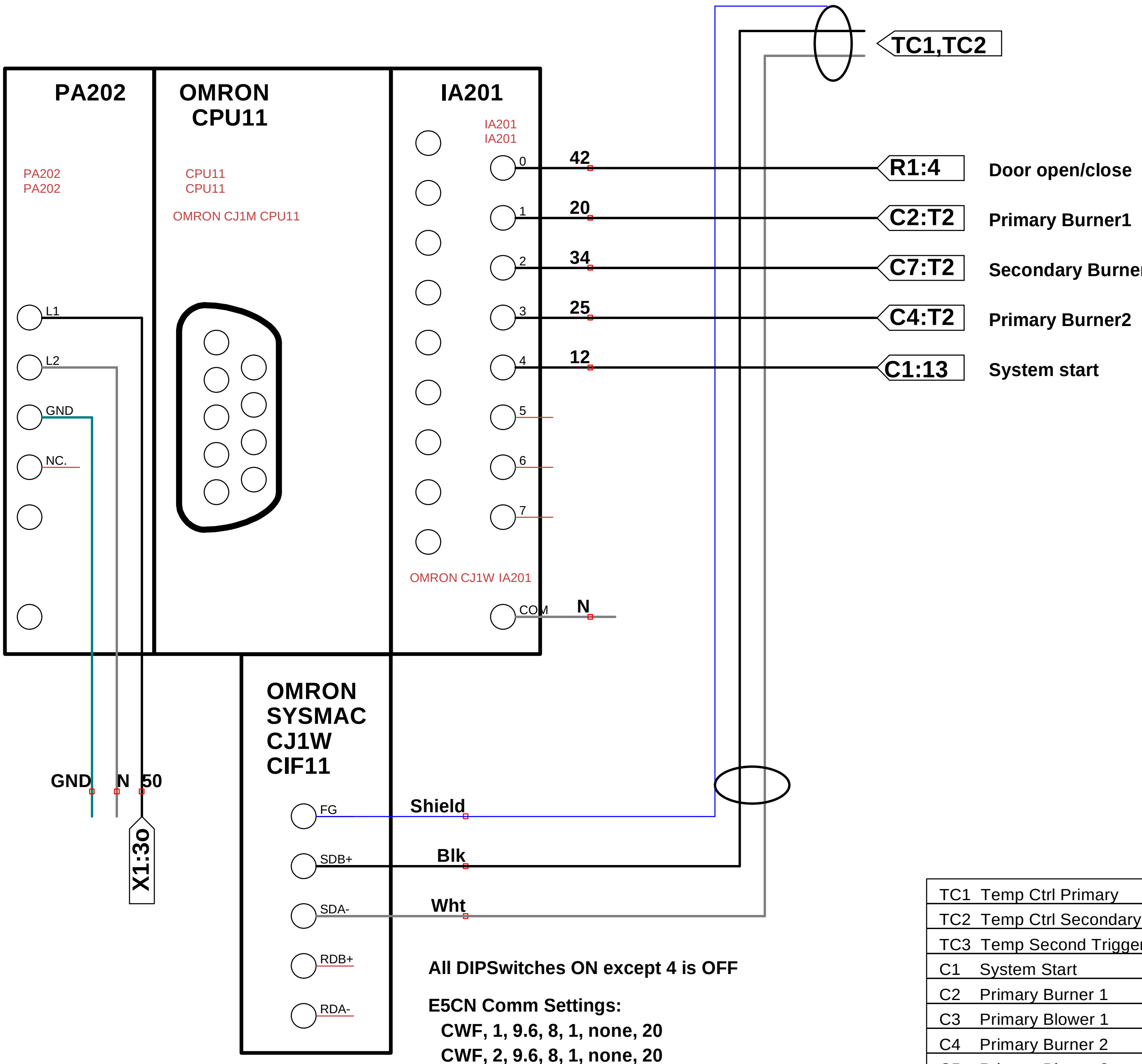
T4	Cool DownTimer
R1	Door Relay
R2	Purge Relay
R3	Timer Reset Relay
P1	Instrument Plug
PB1	System Start Push Btn
PB2	E-Shutdown Push Btn
X1	Terminal Block 1
X2	Terminal Block 2

Title Terminal Strips		
Author kurt klingbeil Electrical Engineer	KETEK GROUP INC.	
File els\PanelKM10xxDoubleSchematic20170613.dsn		Document
Revision 1.36	Date 2017-01-05	Sheets 6 of 7



TC1	Temp Ctrl Primary
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TC3	Temp Second Trigger
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R2	Purge Relay
R3	Timer Reset Relay
PB1	System Start Push Btn
PB2	E-Shutdown Push Btn
X1	Terminal Block 1
X2	Terminal Block 2

Title
PLC and Data collection Hardware

Author
kurt klingbeil
Electrical Engineer

KETEK GROUP INC.

File		Document
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Revision	Date	Sheets
1.36	2017-01-05	7 of 7

CERTIFICATE OF REGISTRATION

This is to certify that

Ketek Group Inc.

Main Site
20204 110 Avenue NW, Edmonton, Alberta T5S 1X8 Canada

operates a

Quality Management System

which complies with the requirements of

ISO 9001:2008

for the following scope of certification

Design, manufacture, sales and service of air, water and solid waste treatment equipment and their components.

This registration is supported by the following site(s) at:
11004 205 Street NW Edmonton, Alberta T5S 1Z4 Canada

Certificate No.:	CERT-0097513	Original Certification Date:	July 17, 2013
File No.:	1647520	Certification Effective Date:	August 25, 2016
Issue Date:	August 8, 2016	Certificate Expiry Date:	September 14, 2018

Paul Simpson
Global Head of Policy, Risk and Compliance

Certified System

ANAB ACCREDITED ISO/IEC 17021 MANAGEMENT SYSTEMS CERTIFICATION BODY

ISO 9001

Registered by:
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To verify that this certificate is current, please refer to the **SAI Global** On-Line Certification Register: www.qmi-saiglobal.com/qmi_companies/

SAI GLOBAL
INFORM. INSPIRE. IMPROVE.

KETEK GROUP INC.

Warranty - New

1. Ketek Group Inc. hereby warrants to the Purchaser, for a one (1) year period of time from the date of acceptance and upon the conditions hereinafter set forth, each new product sold by it, to be free from defects in material and workmanship (specifically excluding there from component parts and accessories manufactured, furnished, and supplied by others) under normal use, maintenance and service. Except for the above Warranty, it is agreed and understood that no other WARRANTY or CONDITION whether express, implied, or statutory is made by Ketek Group Inc.
2. The obligation of Ketek Group Inc. under this Warranty shall be limited to the repair or replacement (**not in excess of its factory labour rate**) of its units; which, upon examination by Ketek Group Inc., shall disclose to their satisfaction to have been defective in material and/or workmanship under normal use, maintenance, and service.
3. The foregoing shall be the Purchaser's sole and exclusive remedy whether in contract, tort, or otherwise; and Ketek Group Inc. shall not be liable for injuries to persons, for damage to property or for loss of any kind which results (whether directly or indirectly) from such defects in material or workmanship, or for any other reason; and, it is agreed and understood that the Purchaser shall keep Ketek Group Inc. indemnified against any such claim. In no event shall Ketek Group Inc. be liable for incidental or consequential damages, or commercial losses, or for any loss or damage except as set forth in paragraph 2 herein.
4. This Warranty does not apply to, and no warranty or condition is made by Ketek Group Inc. regarding any purchased components, parts, and accessories; manufactured, supplied and/or furnished by others, or any non-standard features or items specified by the Purchaser; nor does this Warranty expand, enlarge upon, or alter in any way, the warranties provided by the makers and suppliers of such component parts and accessories.
5. The liability of Ketek Group Inc. under this Warranty shall cease and determine if:
   - (a) The Purchaser shall not have paid in full all invoices as submitted by Ketek Group Inc., or affiliated companies on or before their due dates:
   - (b) Representatives of Ketek Group Inc., are denied full and free right of access to the units:
   - (c) The Purchaser permits persons other than the agents of Ketek Group Inc. or those approved or authorized by Ketek Group Inc. to effect any replacement of parts, maintenance, adjustments, or repairs to the units:
   - (d) The Purchaser has not properly maintained the units in accordance with instructions, pamphlets or directions given or issued by Ketek Group Inc. at the time of the sale and/or from time to time thereafter:
   - (e) The Purchaser uses any spare parts or replacements not manufactured by or on behalf of Ketek Group Inc. and supplied by it, or by someone authorized by it, or fails to follow the instructions for the use of the same:
   - (f) The Purchaser misuses, or uses this unit for any purpose other than that for which it was intended or manufactured:
   - (g) The defective parts are not returned to Ketek Group Inc. within 15 days of repair.
6. No condition is made or is to be implied, nor is any Warranty given or to be implied as to the life or wear of the units supplied; or that they will be suitable for use under any specific conditions; notwithstanding that such conditions may be known or made known to the seller.
7. Defects in material and/or workmanship must be brought to the attention of Ketek Group Inc. by written notification within ten (10) days of discovery, and repairs must be commenced within forty-five (45) days thereafter.
8. It is agreed and understood that the Purchaser is responsible for and must pay for the transporting of the defective goods or of the replacement parts to the place of repair. Premium freight charges (such as air express or air fare charges for transportation of personnel, tools and for replacement parts) and other expenses, apart from servicemen's regular straight time travel, mileage, and regular straight time labour required to repair or replace defective parts and the cost of the parts, will be paid for by the customer at Ketek Group Inc. regular billing rates on usual credit terms.
9. The liability of Ketek Group Inc. under this Warranty is limited to the purchase price of the unit and in no case shall a claim be advanced for more than such amount.
10. All repairs and replacements are made and furnished subject to the same terms, conditions, warranties, disclaimer or warranty and limitations of liability and remedy as applied to each new unit sold.
11. This warranty and the Purchaser's rights under it, is not transferable, or is it assignable.

DATE IN SERVICE: ______________________________ PURCHASED BY: ______________________________

MODEL NUMBER: ______________________________ SELLING BRANCH: ______________________________

SERIAL NUMBER: ______________________________

Appendix B. Ketek CY-50-CA Incinerator

KETEK MANUFACTURING

MEMBER OF KETEK GROUP INC.

ketek.ca

OPERATING & MAINTENANCE MANUAL

CY-50-CA

CY-50-CA

Phone: (780) 447-5052
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1.INTRODUCTION

Thank you for selecting **KETEK MANUFACTURING** to provide you with a reliable, proven and cost-effective system to manage your waste in an environmentally sound manner. This manual has been prepared to allow you to operate and maintain the system safely and efficiently, thereby ensuring its proper operation and continued use for a long period of time.

It also contains information on the combustion process. We think that a good understanding of the basic principles would make you knowledgeable, and hence a better operator.

Table 1 outlines the contents of this manual. We encourage you to read Chapter 2 although only Chapters 2 and 3 contain the most relevant information.

TABLE 1 ORGANIZATION OF MANUAL

Chapter Number	**Title** Brief Description
2	**Principles of waste incineration** What incineration is, how it is affected by waste properties, including incinerator capacity and the design and operational features of the system.
3	**System Description** List and photographs of the components of the system and their functions.
4	**Operation and Maintenance** How to operate and maintain the system, including discussion on safety aspects
5	**Warranty** Terms of the warranty

2.1. Combustion

Combustion, burning, incineration, and thermal oxidation all denote the same process, which is the reaction of a "combustible" matter with oxygen that occurs at temperatures higher than the ignition temperature[1] of that matter. The reaction is exothermic, meaning that it generates heat in the form of hot gas.

In the case of waste, it may also contain non-combustible matter which does not react with oxygen. In waste incineration, the non-combustible component ends up as ash and a small portion of it is also present in the hot gas in the form of particulate matter or dust.

Figure 1 shows schematically the process of waste incineration. The oxygen used comes from air, which contains 21% of oxygen by volume, and the hot gas is typically referred to as flue gas.

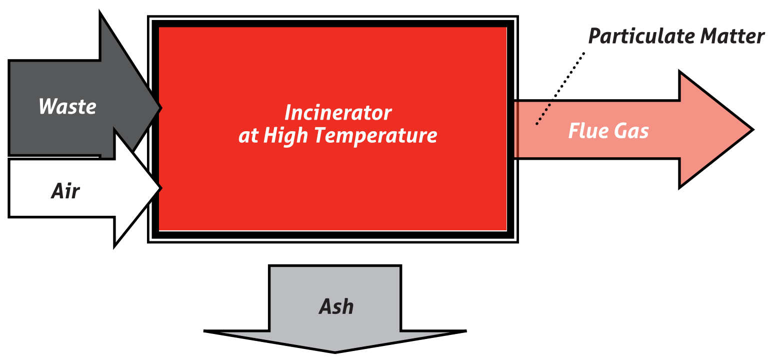


FIGURE 1 SCHEMATIC DIAGRAM OF INCINERATION PROCESS

2.2. Why incinerate waste?

The main purpose is to reduce the mass and volume for final disposal. Another important reason, since the waste may contain pathogenic, infectious or toxic materials, is to "detoxify" it. And in remote areas where wildlife is present, scavenging and spreading of diseases can be prevented by incineration.

In some cases, incineration is used to recover the energy contained in the waste in the form of electricity, steam, hot fluids or hot air. And in other cases, valuable materials can be recovered from the ash, or the ash as a whole can be used for soil amendment or as a construction material.

2.3. Waste components

There are different ways of characterizing waste, depending on the purpose for doing it. Here, it is sufficient to characterize the components as follows: [2]

A. WATER is an important component because in incineration it has to be evaporated, which requires a lot of energy, [3] which in turn, has the effect of lowering the temperature of the flue gas.

B. COMBUSTIBLE is the component that reacts with oxygen and releases heat in the process. [4] The higher the combustible content in the waste the more air per kg of waste is needed for incineration.

This component can be further classified as:

(i) Volatile, which is released to the gas phase when the combustible matter is heated without the presence of oxygen, and
(ii) Fixed carbon which remains in the solid waste after the volatile has been released. This is often referred to as charcoal.

C. NON-COMBUSTIBLE OR ASH is the component that does not react with oxygen. [5] As previously mentioned, this forms ash, and some of it is entrained in the flue gas in the form of particulate matter or dust. The higher the ash content in the waste, the less quantity of waste that can be incinerated without removing ash from the combustion chamber. Note also if the waste contains metals, such as lead and cadmium, these metals will be present in the ash as well as in the particulate matter.

2.4. Heating Value

Heating value, calorific value and heat of combustion are synonyms that quantify the heat released by the combustible component in the waste upon complete combustion. An understanding of the concept can be gained from the hypothetical processes shown in Figure 2.

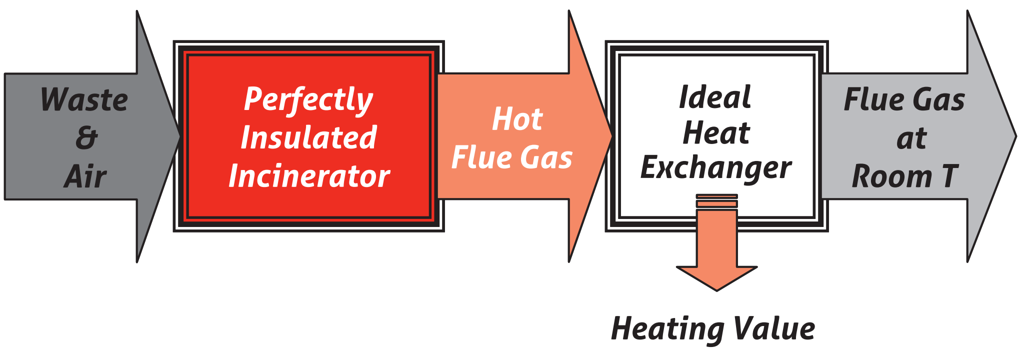


FIGURE 2 THE CONCEPT OF HEATING VALUE

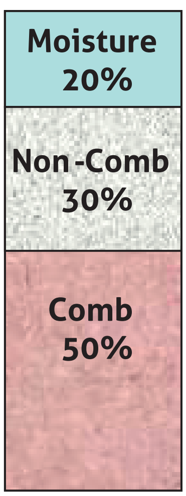
A measured mass of dry waste and a sufficient amount of oxygen , at room temperature, are ignited, and the resulting hot flue gas is passed through a heat exchanger, where heat is extracted until the flue gas is brought back to room temperature. Let M be the mass (kg) of the dry waste fed, and H (MJ) the heat extracted from the heat exchanger. The heating value of the dry waste is H/M (MJ/kg).

1 Below the ignition temperature combustion does not take place. Consider, for example, gasoline or wood: it has to be "ignited" for combustion to take place. That is, the temperature in some portion of the matter must be brought up to the ignition temperature for combustion to start..
2 This is referred to as proximate analysis. Another method is elemental analysis, which produces the elemental composition (C, H, O, N, S, Cl ...) of the waste.
3 It takes ~ 2.3 MJ (2200 BTU or 90 cc of propane or 60 cc of diesel) to evaporate 1 L or 1 kg of water. This is referred to as the latent heat of evaporation.
4 The term "organic" is also used, which is strictly incorrect in that some "inorganic" elements or compounds are combustible, such as carbon, sulphur and carbon monoxide.
5 The terms "ash" and "inorganic" are also used. Note that the latter is inaccurate as explained previously.

2.5. Different Expressions for Heating Value

Two different values are reported in the literature (a) "high" or "gross", and (b) "low" or "net". The former corresponds to the case where the moisture in the flue gas is condensed, and hence the high or gross heating value includes the latent heat of evaporation of the water formed in combustion (see Footnote 3). The latter excludes the latent heat evaporation. The low or net heating value thus represents the maximum available energy that can be recovered from the flue gas without condensation.

To be noted also is the basis on which the heating value is expressed, which can be (a) as fired, (b) dry basis or (c) ash free. The distinction is illustrated in Figure 3. An understanding of the different bases can be gained by noting that heating value is a property of the combustible component in the waste. Water and the non-combustible component simply "dilute" the heating value. In terms of incinerator operation, the relevant basis is "as fired".



*** HV as measured:**
15 MJ/kg "Dry Basis "

*** HV of whole waste:**
= (30 + 50)/100 * 15 = 12 MJ/kg "As Fired"

*** HV of combustible component:**
= (30 + 50)/50 * 15 = 24 MJ/kg "Ash Free"

FIGURE 3 DIFFERENT BASES FOR EXPRESSING HEATING VALUE (HV)

2.6. Examples of waste characteristics

Proximate compositions and heating values of commonly found wastes are given in Table 2.

TABLE 2 CLASSIFICATION AND PROPERTIES OF COMMON WASTES

Type*	Description	Components	Weight %			MJ/kg
			Moist	Comb	Non-C	HHV (A/F)
0	Trash	Paper, cardboard, cartons wood boxes and combustible floor sweepings from commercial and industrial activities. Up to 10% by weight of plastic bags, coated paper, laminated paper, treated corrugated cardboard, oily rags and plastic or rubber scraps.	10%	85%	5%	19.7
1	Rubbish	Trash + Type 3 (up to 20%)	25%	65%	10%	15
2	Refuse	Rubbish and Garbage	50%	43%	7%	10
3	Garbage	Animal and vegetable wastes, restaurants, hotels, markets, institutional, commercial and club sources	70%	25%	5%	5.8
4	Animal/ Pathological	Carcasses, organs, hospital and laboratory abbatoit, animal pound, veterinary sources	85	10	5	2.3

Notes:
Moist = moisture, Comb = Combustible, Non-C = Non-combustible, HHV = High Heating Value, A/F = As Fired
*** In some cases Roman numerals are used. That is Types 0, I, II, III and IV**

2.7. Incinerator Capacity and Load Size

Incinerator capacity is dependent on waste composition. In general, the higher the heating value, the lower is the capacity in terms of kg/h that can be incinerated. This can be explained by noting that a waste that has a higher heating value requires more air per unit mass than that required to incinerate a waste with a lower heating value. To put it another way, for the same amount of air, more mass of a waste with a lower heating value can be incinerated.

Another important consideration is the size of the batch loaded to the incinerator. The higher the heating value, the smaller (lighter) the load should be. Otherwise, insufficient amount of air would generate black smoke.

Unfortunately, waste composition is not always known. Nevertheless there may be indications of the components present. To assist in getting a qualitative estimate of the heating value of a batch of waste, the heating values of common "generic" waste components are shown in Table 3.

TABLE 3 HIGH HEATING VALUES (APPROXIMATE) OF COMMON WASTE COMPONENTS

Component	MJ/kg A/F *	Component	MJ/kg A/F *
Kerosene, Diesel ...	44	Leather	16
Plastics	46	Wax paraffin	44
Rubber, Latex	23	Rags (linen, cotton)	17
Wood	18	Animal fats	39
Paper	17	Citrus rinds	4
Agricultural waste	17	Linoleum	25

*** A/F: As Fired**

Another important waste component is the volatile content in the waste. Table 4 shows the proximate components of various materials and wastes.

In general, this component is responsible for smoke generation. Therefore, as in the case with heating value, the higher the volatile content, the smaller the load that should be charged to the incinerator.

TABLE 4 PROXIMATE COMPOSITION OF VARIOUS MATERIALS

Material	Volatile	Moisture	FC	Ash	FC/V
	%wt	%wt	%wt	%wt	-
Coal (bituminous)	30	5	45	20	1.5
Peat	65	7	20	8	0.3
Wood	85	6	8	1	0.1
Paper	75	4	11	10	0.15
Sewage sludge	30	5	20	45	0.66
MSW	33	40	7	20	0.21
RDF	60	20	8	12	0.13
PDF	73	1	3	13	0.04
TDF	65	2	30	3	0.46
PE,PP,PS	100	0	0	0	0
Plastics + Colour	98	0	0	2	0
PVC	93	0	7	0	0.08

Notes: **FC** = Fixed Carbon; **FC/V** = Ratio of Fixed Carbon to Volatile
RDF = Refuse Derived Fuel; **PDF** = Paper Derived Fuel;
TDF = Tire Derived Fuel; **PE** = Polyethylene; **PP** = Polypropylene;
PS = Polystyrene; **PVC** = Polyvinylchloride

2.8. Dual-Chamber Design and Starved-Air Operation

The mechanisms of solid waste combustion consist of the following stages:

a. Evaporation of water or drying,

b. Devolatilization, involving pyrolysis and gasification, generating "volatile" combustible gas and in some cases, soot ; [6]

c. Combustion of the devolatilization products in the gas phase, and

d. Char oxidation, where the "fixed carbon" is oxidized, leaving the ash residue.

With a dual chamber design operated under a starved air condition, stages (a), (b) and (d) take place in the primary chamber, and (d) in the secondary chamber. The initial stages (a) and (b) occur under starved-air (sub-stoichiometric) condition, meaning that there is not sufficient air for complete combustion. Stage (c) occurs in the secondary chamber following the addition of flameport air, introduced into the flameport which connects the primary and secondary chambers. The final stage (d) occurs in the primary chamber.

The low flow rate in the primary chamber reduces the entrainment of particulate matter (dust) and hence its emission. The flameport can be designed to promote good mixing ("turbulence") between flameport air and the "volatiles" generated in the primary chamber, which promotes complete combustion.

6 Pyrolysis: thermal break-down in the absence of O2; gasification: partial oxidation with sub-stoichiometric O2: soot: fine carbonaceous particles.

A schematic diagram of the system is shown in Figure 4.

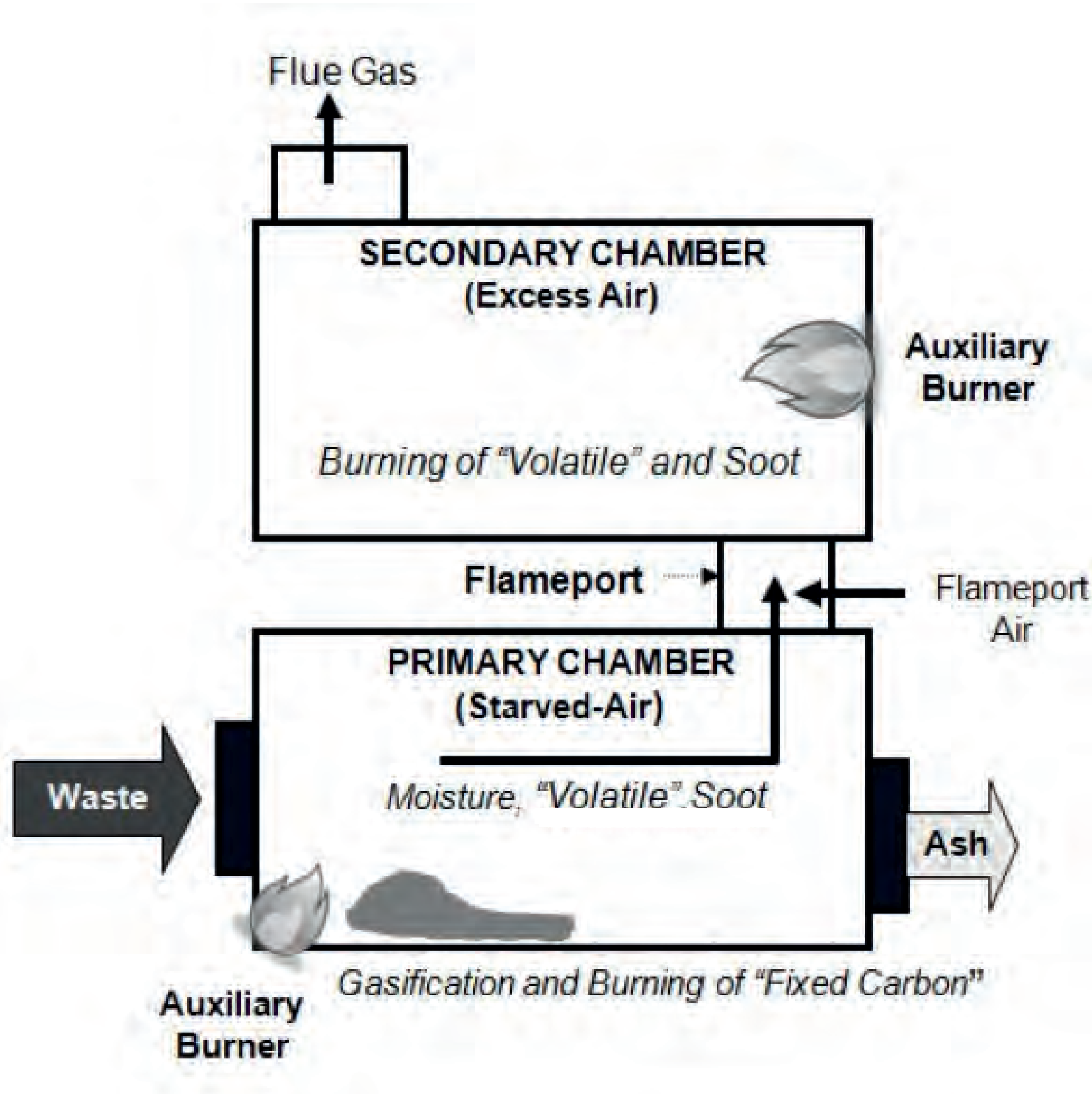


FIGURE 4. SCHEMATIC A DIAGRAM OF DUAL-CHAMBER, STARVED-AIR INCINERATOR

A photograph of the system is shown in Figure 5, identifying its major components:

- Primary Chamber
- Secondary Chamber
- Flameport
- Control Panel
- Stack

The components are shown in more detail in Figure 6 to Figure 8, and their functions are summarized in the next Section in Table 5.

Notes on design simplification. (i) No underfire air blower is used. The underfire air is supplied by the excess air in the auxiliary burner in the primary chamber. (ii) Ash removal is done via the waste loading door

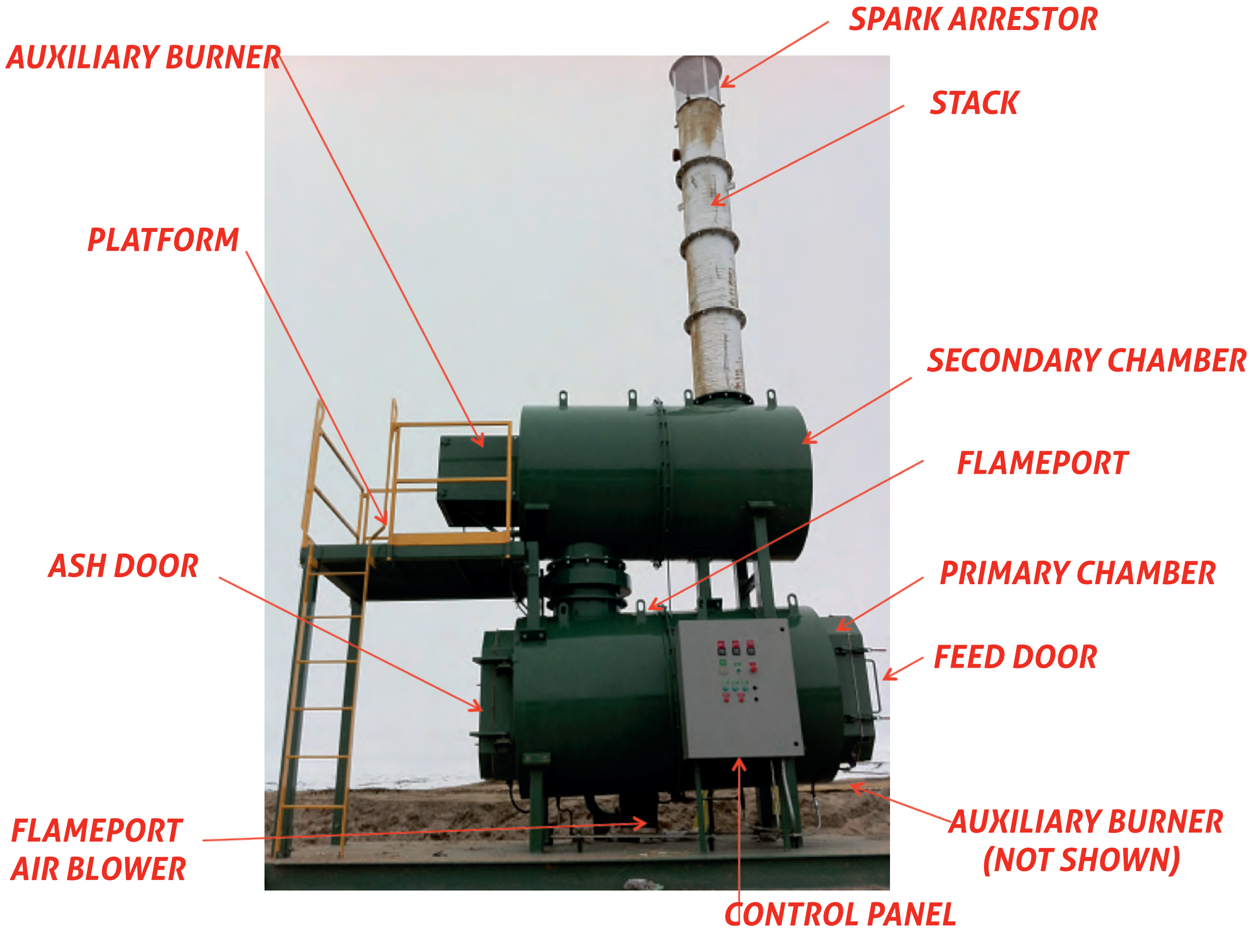


FIGURE 5. OVERALL VIEW OF SYSTEM AND ITS MAJOR COMPONENTS

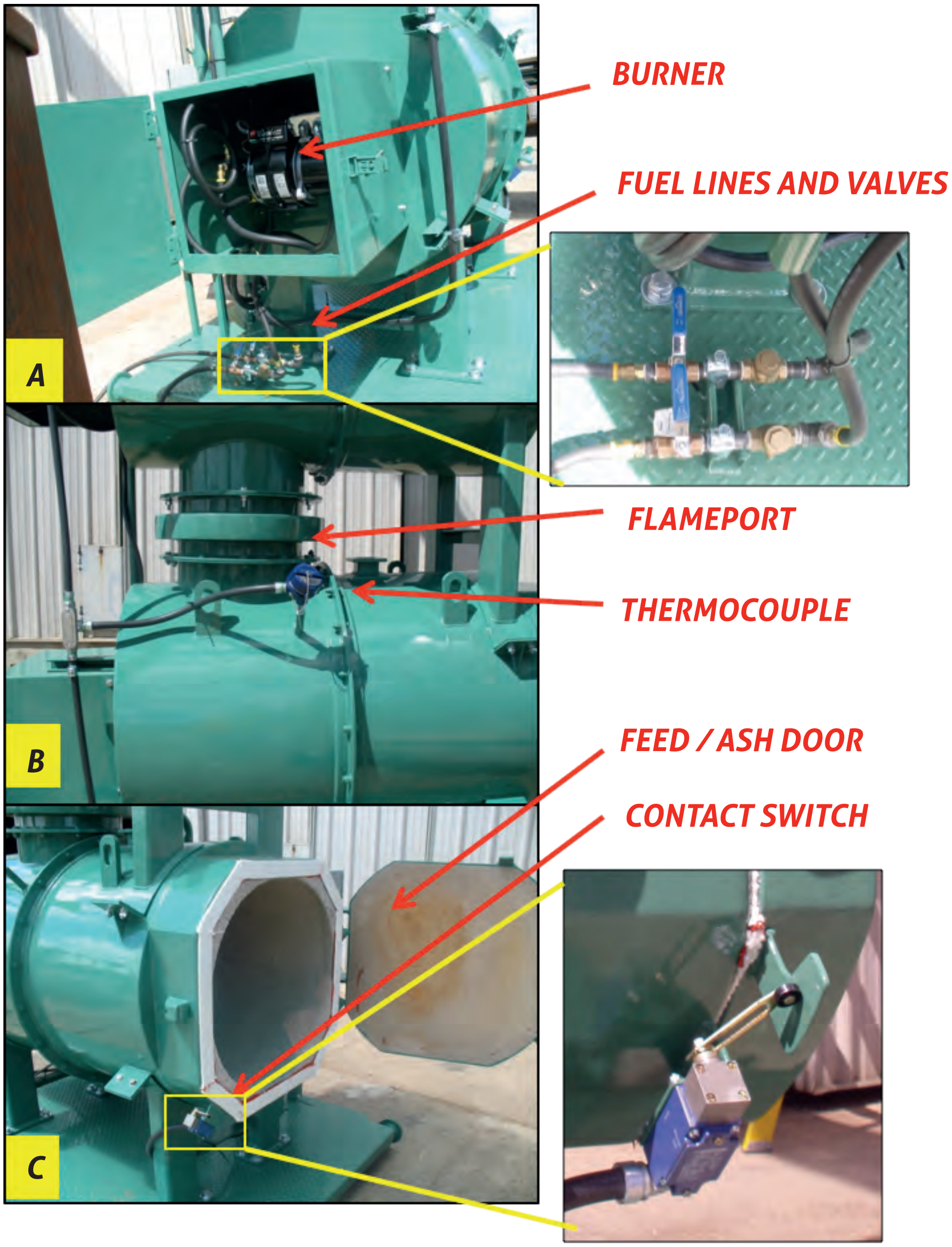


FIGURE 6. PRIMARY CHAMBER

FIGURE 7. SECONDARY CHAMBER AND OTHER COMPONENTS

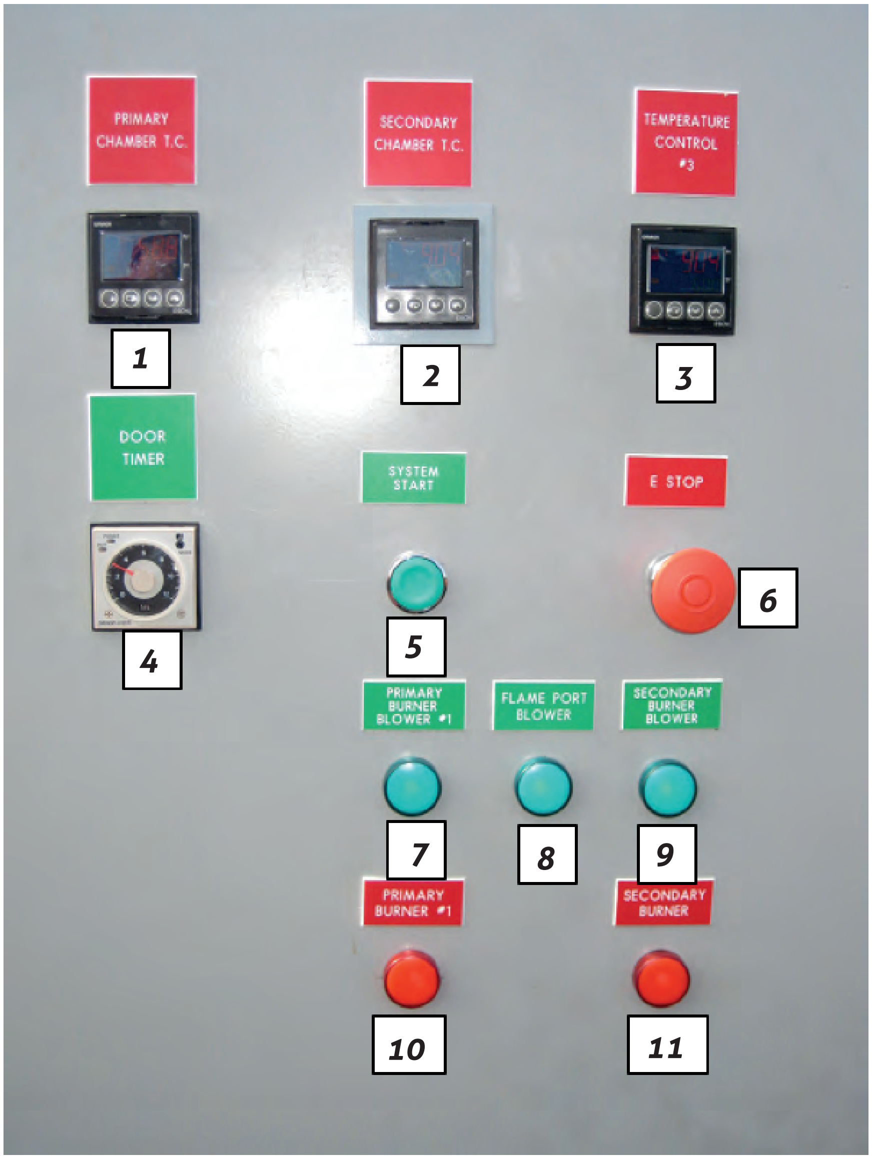


FIGURE 8. CONTROL PANEL

LEGEND. 1. Primary Chamber Temperature Indicator and Controller (TIC); **2.** Secondary Chamber TIC; **3**: Controller for set point of secondary chamber temperature to trigger Primary Chamber Burner during pre-heating; **4:** Timer for Burn Time; **5.** Start Button; **6:** Emergency Stop Button **7 to 9:** Light Indicators for Blowers; **10 and 11**: Light Indicators for Burners (Flame ON).

3.1. System components

The components are listed in Table 5, together brief descriptions of their functions and reference photographs.

TABLE 5 COMPONENTS AND THEIR FUNCTIONS

COMPONENT	FUNCTION	Reference	
Primary Chamber	Water evaporation, pyrolysis and gasification, generating combustible gases (volatiles) and soot	**Figure 6**	
1 Burner	Supply heat to maintain a minimum pre-set (variable) temperature	**Figure 6**	A
2 Fuel line and valve	Connection to fuel supply	**Figure 6**	A
3 Thermocouple	Measure, display and input to ON-OFF controller	**Figure 6**	B
4 Feed/ash door	Access to primary chamber for waste loading and ash removal	**Figure 6**	C
5 Contact switch	Input to safety interlock to shut-off burner when door is open.	**Figure 6**	C
Secondary Chamber	Complete combustion of gases and soot generated in the primary chamber	**Figure 7**	
6 Burner	Supply heat to maintain a minimum pre-set (variable) temperature	**Figure 7**	
7 Fuel line and valve	Connection to fuel supply	**Figure 6**	A
8 Thermocouple	Measure, display and input to ON-OFF controller	**Figure 7**	
Flameport	Mixing of combustible gas and air, promoting "turbulence"	**Figure 6** **Figure 7**	B
9 Blower	Supply air (oxygen) for combustion	**Figure 7**	
10 Manual valve	Control flameport air flow rate	**Figure 7**	
Control Panel	Automation of operation	**Figure 8**	
Stack	Disperse hot flue gas	**Figure 5**	
(Fuel Supply Tank)	Supply of auxiliary fuel	Not shown	

The controllers and indicators of in the Control Panel are described below (see Figure 8):

TABLE 6. CONTROL PANEL (FIGURE 8)

LEGEND	FUNCTION
1	• Displays Primary Chamber temperature • Set-point for minimum temperature in the Primary Chamber
2	• Displays Secondary Chamber temperature • Set-point for minimum temperature in the Secondary Chamber
3	Set-point for Secondary Chamber temperature to trigger Primary Chamber Burner during pre-heating (Factory pre-set)
4	START-UP BUTTON to initiate pre-heating and execute complete burning cycle after waste loading
5	Burn TIMER to pre-set period of burning time in the Primary Chamber
6	(Spare)
7, 8, 9	Indicator lights showing BLOWER ON for flameport, primary and secondary chamber burners.
10, 11	Indicator lights showing BURNER (fuel/flame) ON for primary and secondary burners.

The operation of the system is cyclic, as shown in Figure 9 and each step is described in the following sections.

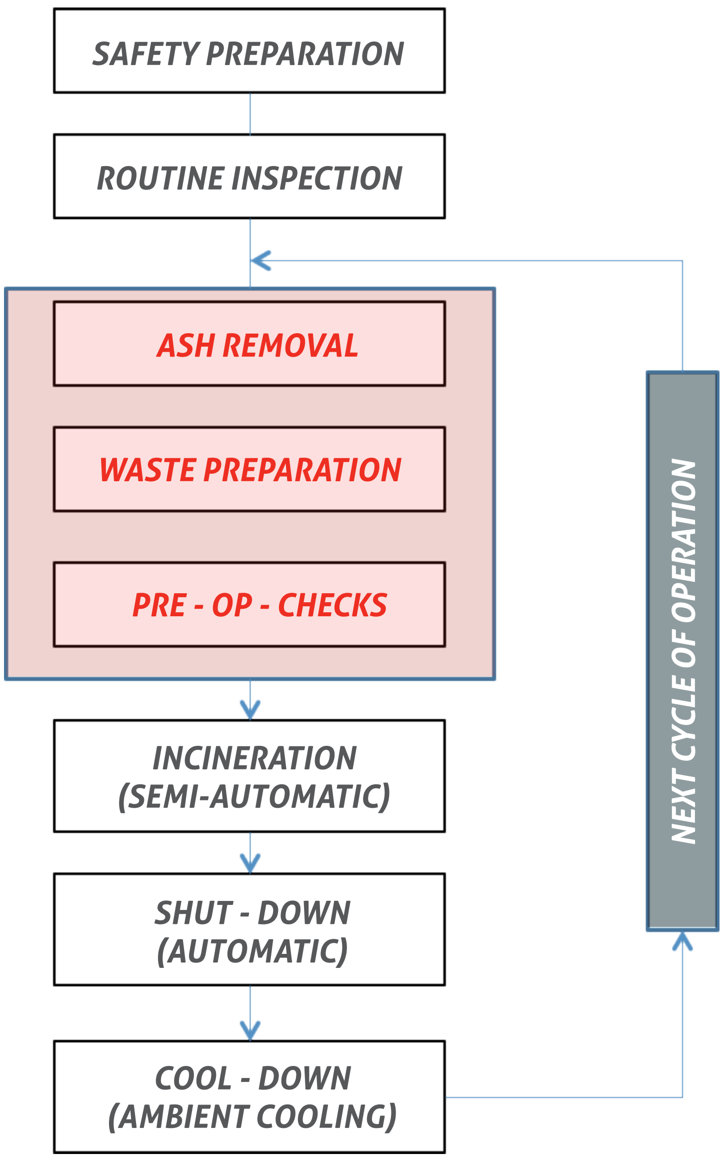


FIGURE 9. SCHEMATIC OF OPERATIONAL STEPS

4.1. Safety equipment

The following personal protective equipment should be used while operating the incinerator system:

- Long sleeved shirt and long pants;
- Long cuffed, puncture resistant gloves;
- CSA approved, Grade 1 safety footwear;
- CSA/ANSI approved safety glasses.

The personal protective equipment related to specific tasks are listed below:

- Ash removal and handling: NIOSH N85 respirator
- [*See Chapter 4.7*: Intermittent feeding and raking : (i) heat protective clothing and gloves, and (2) CSA/ANSI approved full face shield. Note: This is NOT required under batch operation.]

4.2. Routine inspection and maintenance

- Check fuel lines for leak and check connections
- Check spark arrestor to ensure no plugging
- During ash removal (see next section):
  - o Inspect refractory for large cracks (not expansion cracks)
  - o Inspect door gaskets for damages

4.3. Ash removal

Typically the ash from previous operation was left to cool, and ash removal is done first prior to current operation.

- Make sure combustion chamber is sufficiently cool
- (Do NOT spray water into the combustion chamber)
- While removing ash, avoid plugging the combustion air holes and damaging the burner tip
- Use non-combustible container
- Minimize dust generation
- Light water spraying on ash in the container is OK to minimize dust generation
- Dispose of ash as specified in the guidelines or regulations

4.4. Waste batch preparation

As previously mentioned incinerator capacity in kg/h is dependent on the heating value of the waste, which is normally not known. This system can generally be loaded with 200 kg of Type 3 waste (Table 2). In general, the higher the heating value, the smaller batch should be loaded. The proper size should be determined from experience.

The following cautionary notes should be followed:

- NO explosives, aerosol cans or containers containing combustible liquids
- Make sure that every batch can go through the waste charging door easily, regardless of its weight. If others prepare the batches, the operator should tell them about the maximum batch size.
- DO NOT open batches and "rearrange" the contents for health/safety reasons.

4.5. Pre-operational checks

- Check fuel tank to make sure enough fuel.
- Open fuel valves.
- (Connect electrical plug and turn power ON)).
- Prime burner pumps if necessary.

4.6. Incineration (Batch Operation)

1. [Check and reset if necessary set points in primary chamber (650 C) and secondary chamber (900 C)]
2. Open feed/ash door and load waste to Primary Chamber (For Type 3 waste, about 80% of the chamber volume).
3. Close feed/ash door.
4. Set burner timer according to the size of the load
5. Press "Start" button.

4.7. Notes on Intermittent Feeding Operation

In intermittent feeding operation, waste is loaded ***while incineration process is occurring.*** This mode of operation increases incinerator capacity, especially when "raking" is also practiced. But it has the following drawbacks:

- Disturbance and cooling in the primary chamber will increase emission of particulate matter and generates "spikes" of carbon monoxide, and potentially also dioxin emission;
- Particular attention should be paid with respect to safety, including the need for additional PPE as mentioned in *Chapter 4.1.*
- Increased in man-power requirement.

The protocol for intermittent feeding consists of undertaking Steps (2) to (5) described in previous Chapter 4.6. Note that the size of the batch loaded is much smaller, a maximum of about 20 kg for Type 3 waste. Otherwise, black smoke could be generated. Raking is done in the same way, except that no waste is loaded, but instead, the waste is primary chamber is "raked" to expose un-burnt components, thereby increasing the burn rate, and hence the incinerator capacity.

4.8. Shut-down and Cool-down

- Automatically done.

4.9. Burner and blower maintenance

In addition to the routine inspection and maintenance previously mentioned, only the burner(s) and the blower(s) require maintenance, which is quite minimal; see manuals supplied.

4.10. Diesel Requirement

Figure 10 shows the requirement for diesel as a function of running time and total capacity, expressed in USG/h. Note that: 1 USG/h ~ 140,000 Btu/h or 0.15 GJ/h.

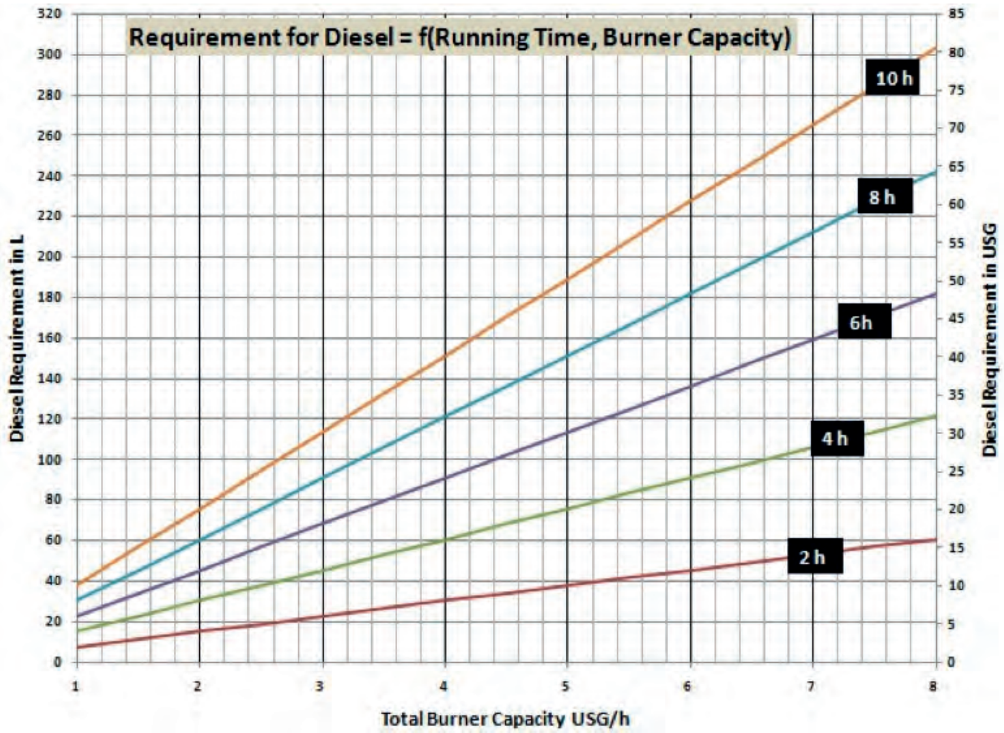


FIGURE 10. REQUIREMENT FOR DIESEL

1. **KETEK MANUFACTURING** hereby warrants to the Purchaser, for a one (1) year period of time from the date of acceptance and upon the conditions hereinafter set forth, each new product sold by it, to be free from defects in material and workmanship (specifically excluding therefrom component parts and accessories manufactured, furnished, and supplied by others) under normal use, maintenance and service. Except for the above Warranty, it is agreed and understood that no other WARRANTY or CONDITION whether express, implied, or statutory is made by KETEK MANUFACTURING.

2. The obligation of KETEK MANUFACTURING under this Warranty shall be limited to the repair or replacement **(not in excess of its factory labour rate)** of its units; which, upon examination by Westland Environmental Services Inc.., shall disclose to their satisfaction to have been defective in material and/or workmanship under normal use, maintenance, and service.

3. The foregoing shall be the Purchaser's sole and exclusive remedy whether in contract, tort, or otherwise; and KETEK MANU FACTURING shall not be liable for injuries to persons, for damage to property or for loss of any kind which results (whether directly or indirectly) from such defects in material or workmanship, or for any other reason; and, it is agreed and under stood that the Purchaser shall keep KETEK MANUFACTURING indemnified against any such claim. In no event shall KETEK MANUFACTURING be liable for incidental or consequential damages, or commercial losses, or for any loss or damage except as set forth in paragraph 2 herein.

4. This Warranty does not apply to, and no warranty or condition is made by KETEK MANUFACTURING regarding any purchased components, parts, and accessories; manufactured, supplied and/or furnished by others, or any non-standard features or items specified by the Purchaser; nor does this Warranty expand, enlarge upon, or alter in any way, the warran ties provided by the makers and suppliers of such component parts and accessories.

5. The liability of KETEK MANUFACTURING under this Warranty shall cease and determine if:
(a) The Purchaser shall not have paid in full all invoices as submitted by KETEK MANUFACTURING, or affiliated compa nies on or before their due dates:

(b) Representatives of KETEK MANUFACTURING, are denied full and free right of access to the units:
(c) The Purchaser permits persons other than the agents of KETEK MANUFACTURING or those approved or authorized by KETEK MANUFACTURING to effect any replacement of parts, maintenance, adjustments, or repairs to the units:
(d) The Purchaser has not properly operated and maintained the units in accordance with instructions, pamphlets or directions given or issued by KETEK MANUFACTURING at the time of the sale and/or from time to time thereafter:
(e) The Purchaser uses any spare parts or replacements not manufactured by or on behalf of KETEK MANUFACTURING and supplied by it, or by someone authorized by it, or fails to follow the instructions for the use of the same:
(f) The Purchaser misuses, or uses this unit for any purpose other than that for which it was intended or manufactured:
(g) The defective parts are not returned to KETEK MANUFACTURING within 15 days of repair.

6. No condition is made or is to be implied, nor is any Warranty given or to be implied as to the life or wear of the units supplied; or that they will be suitable for use under any specific conditions; notwithstanding that such conditions may be known or made known to the seller.

7. Defects in material and/or workmanship must be brought to the attention of KETEK MANUFACTURING by written notifica tion within ten (10) days of discovery, and repairs must be commenced within forty-five (45) days thereafter.

8. It is agreed and understood that the Purchaser is responsible for and must pay for the transporting of the defective goods or of the replacement parts to the place of repair. Premium freight charges (such as air express or air fare charges for transportation of personnel, tools and for replacement parts) and other expenses, apart from servicemen's regular straight time travel, mileage, and regular straight time labour required to repair or replace defective parts and the cost of the parts, will be paid for by the customer at KETEK MANUFACTURING regular billing rates on usual credit terms.

9. The liability of KETEK MANUFACTURING under this Warranty is limited to the purchase price of the unit and in no case shall a claim be advanced for more than such amount.

10. All repairs and replacements are made and furnished subject to the same terms, conditions, warranties, disclaimer or warranty and limitations of liability and remedy as applied to each new unit sold.

11. This warranty and the Purchaser's rights under it, is not transferable, or is it assignable.

DATE IN SERVICE: ________________________ MODEL NUMBER: ________________________

SERIAL NUMBER: ________________________

CY-50-CA

Appendix H Back River Project Engagement Record

Record of Meetings and Major Correspondence with Community and Stakeholder Groups

Date	Individual(s) / Organization	Type of Activity
Cambridge Bay		
February 14, 2012	Brenda Sitatak HTO Manager	Introductions and information sharing.
February 14, 2012	Renee Krucas Executive Director, Kitikmeot Heritage Society	Introductions and information sharing.
February 14, 2012	Connie Kapolak High School Principal	Introductions and information sharing.
March 27, 2012	Brenda Sitatak HTO Manager	Introductions and update.
March 27, 2012	Stephen King, Senior Administrative Officer Jim McEchrean, Economic Development Officer Hamlet of Cambridge Bay	Project introduction.
April 5, 2012	Renee Krucas Executive Director, Kitikmeot Heritage Society	Letter / invitation to nominate representatives to the Cambridge Bay Community Advisory Group.
April 5, 2012	Stephen King, Senior Administrative Officer Hamlet of Cambridge Bay	Letter / invitation to nominate representative to the Cambridge Bay Community Advisory Group.
April 5, 2012	Brenda Sitatak HTO Manager	Letter / invitation to nominate representative to the Cambridge Bay Community Advisory Group.
June 14, 2012	General public	Call-in radio show.
June 14, 2012	Jessie Lyall, HTO Board Member Brenda Sitatak, HTO Manager	Project introduction.
June 14, 2012	General public	Public meeting - Project overview.
June 14, 2012	Hamlet Council and administration	Project introduction.
June 15, 2012	Cambridge Bay Community Advisory Group	Project introduction.
September 11-12, 2012	Cambridge Bay Community Advisory Group	Sabina hosted a dinner and meeting for the Cambridge Bay and Kugluktuk Community Advisory Groups (CAGs) in Cambridge Bay on September 11, 2012. The CAGs also visited the Back River Project site on September 12, 2012.
September 27-29, 2012	Interviews conducted with a number of individuals representing a variety of interests in the community including: government administration; health, wellness and social services; safety and protection services; business and economic development; and education and training	Socio-economic baseline data collection; documentation of expected Project benefits, Project concerns, and suggested mitigation measures.
November 19, 2012	General public	Call-in radio show.

November 19, 2012	High school students and staff	Mining and geology presentation.
November 19, 2012	General public	Public open house.
November 19, 2012	Cambridge Bay Community Advisory Group	Project update.
November 30 - December 1, 2012	Local hunters from Cambridge Bay	Land use focus group.
February 5-6, 2013	General public	Sabina representatives participated in NIRB's scoping meetings for the Project and were available to the public for questions and information sharing.
February 5, 2013	Cambridge Bay Community Advisory Group	Project update.
April 23, 2013	General public	Public meeting - Project overview/update.
April 23, 2013	Cambridge Bay HTO	Project overview/update.
August 20, 2013	General public	Sabina provided an overview of the Back River Project and its traditional knowledge study.
August 20, 2013	General public	The Kitikmeot Inuit Association provided an overview of the Naonaiyaotit Traditional Knowledge Project (NTKP) report completed for the Back River Project and additional traditional knowledge workshops being conducted.
August 21, 2013	Cambridge Bay Community Advisory Group	Project update and review of Inuinnaqtun terminology for traditional seasons.
August 21-23, 2013	Selected elders and knowledge holders	A series of traditional knowledge workshops were held with selected elders and local knowledge holders for Sabina's traditional knowledge study. These workshops focused on the topics of 'heritage and land use', 'terrestrial environment' and 'marine environment'.
November 19, 2013	General public	Public meeting - Project overview/update & DEIS submission overview.
November 19, 2013	Cambridge Bay Community Advisory Group	Project update.
November 19, 2013	Cambridge Bay high school students	Project overview and discussion of future employment opportunities.
November 19, 2013	General public	Radio update.
January 23, 2014	General public	Career fair participation.
February 2014	Kitikmeot Heritage Society	Letter – Update on January 2014 DEIS submission to NIRB and NWB. DEIS Plain Language Summary included.
February 2014	Cambridge Bay Community Advisory Group	Letter – Update on January 2014 DEIS submission to NIRB and NWB. DEIS Plain Language Summary included.
February 2014	Hamlet of Cambridge Bay	Letter – Update on January 2014 DEIS submission to NIRB and NWB. DEIS Plain Language Summary included.

February 2014	Cambridge Bay HTO	Letter – Update on January 2014 DEIS submission to NIRB and NWB. DEIS Plain Language Summary included.
March 25, 2014	General public	NIRB held community information sessions for the Project's DEIS and were available to the public for questions and information sharing. Note – Sabina representatives were unable to attend due to flight cancellations.
March 28, 2014	Cambridge Bay Community Advisory Group	Project update.
April 27, 2014	General public	Radio update / call-in radio show.
April 28, 2014	Jim McEchrean, Economic Development Officer, Hamlet of Cambridge Bay	Project update.
April 28, 2014	Brendan Griebel, Executive Director, Kitikmeot Heritage Society	Introductions and Project update/overview.
April 28, 2014	General public	Radio update / call-in radio show.
June 7-10, 2014	Selected elders and knowledge holders	A series of traditional knowledge interviews were held with selected elders and local knowledge holders as a component of proposed fish offsetting activities in the Bernard Harbour, Nunavut area.
July 14-15, 2014	Cambridge Bay Community Advisory Group	Sabina hosted the Cambridge Bay and Kugluktuk Community Advisory Groups at the Back River Project site on July 14-15. Site tours were provided and Project information was shared.
October 28,2014	Hamlet of Cambridge Bay	Project update.
November 20, 2014	Cambridge Bay Community Readiness Initiative Committee	Sabina met with Cambridge Bay's Community Readiness Initiative Committee.
December 18, 2014	Cambridge Bay Community Readiness Initiative Committee	Sabina met with Cambridge Bay's Community Readiness Initiative Committee.
February 5, 2015	Cambridge Bay high school students	Project overview and discussion of future employment opportunities.
February 9, 2015	Kitikmeot Heritage Society representatives	Project update and discussion of potential future donations.
February 9, 2015	Gordon Bligh, Arctic College	Project update and discussion of mine-related training/education.
March 10, 2015	Cambridge Bay Community Readiness Initiative Committee	Sabina met with Cambridge Bay's Community Readiness Initiative Committee.
April 7, 2015	Cambridge Bay Community Readiness Initiative Committee	Sabina met with Cambridge Bay's Community Readiness Initiative Committee.
May 10, 2015	Cambridge Bay Community Readiness Initiative Committee	Sabina met with Cambridge Bay's Community Readiness Initiative Committee.

June 15, 2015	Cambridge Bay Community Advisory Group	Project update and FEIS submission overview.
June 16, 2015	Hamlet of Cambridge Bay Representatives	Project update and FEIS submission overview.
June 16, 2015	General public	Public meeting – Project update and FEIS submission overview.
October 7, 2015	Cambridge Bay HTO	Project update and FEIS submission overview.
February 10, 2016	Cambridge Bay Community Advisory Group	Project update and FEIS submission/NIRB final hearings overview.
March 5, 2016	Hamlet of Cambridge Bay Cambridge Bay HTO	Emailed letter re: Sabina's FEIS submission.
April 11-12, 2016	Cambridge Bay HTO Representative Cambridge Bay Community Wellness Centre Representative	Representatives from the Cambridge Bay HTO and Community Wellness Centre participated in meetings and a Back River Project site visit hosted by Sabina.
July 6, 2016	Cambridge Bay Community Advisory Group	Project update re: NIRB final hearing report.
July 6, 2016	General Public	Public Meeting – Project update re: NIRB final hearing report.
July 7, 2016	Cambridge Bay HTO	Project update re: NIRB final hearing report.
September 15, 2016	General Public	Sabina participated in the Cambridge Bay portion of the 2016 Kitikmeot Career Fair.
September 19, 2016	Hamlet of Cambridge Bay	Project update re: NIRB final hearing report (Sabina representatives participated in-person and via teleconference).
November 30, 2016	General Public	Project update and update on revised Wildlife Mitigation and Monitoring Program.
December 1, 2016	Cambridge Bay HTO	Project update and update on revised Wildlife Mitigation and Monitoring Program.
December 1, 2016	General Public	Sabina representatives set up an informational table at the Co-op regarding the revised Wildlife Mitigation and Monitoring Program.
December 1, 2016	Cambridge Bay Community Advisory Group	Project update and update on revised Wildlife Mitigation and Monitoring Program.
January 23, 2017	Cambridge Bay Community Advisory Group members (various) Past Project employee	Letter – Update on January 12, 2017 INAC Minister's decision and thank you for providing letter of support.
April 21, 2017	Cambridge Bay HTO	Project update and FEIS Addendum overview.
April 21, 2017	Hamlet of Cambridge Bay Representatives	Project update and FEIS Addendum overview.
April 21, 2017	General Public	Public meeting - Project update and FEIS Addendum overview.

September 2017	Various Parties (e.g. Hamlet of Cambridge Bay, selected Cambridge Bay Community Advisory Group members, individual)	Letter – Project update and thank you for providing letter of support.
October 2, 2017	General public	Career fair participation.
Kugluktuk		
April 11, 2012	Barbara Adjun HTO Manager	Letter / invitation to nominate representative to the Kugluktuk Community Advisory Group.
April 26, 2013	Donald LeBlanc, Senior Administrative Officer Hamlet of Kugluktuk	Letter / invitation to nominate representative to the Kugluktuk Community Advisory Group.
June 12, 2012	Kugluktuk HTO	Project introduction.
June 12, 2012	General public	Public meeting - Project overview.
June 13, 2012	Donald LeBlanc, Senior Administrative Officer Hamlet of Kugluktuk	Project introduction.
June 13, 2012	Kugluktuk Community Advisory Group	Project introduction.
September 11-12, 2012	Kugluktuk Community Advisory Group	Sabina hosted a dinner and meeting for the Kugluktuk and Cambridge Bay Community Advisory Groups (CAGs) in Cambridge Bay on September 11, 2012. The CAGs also visited the Back River Project site on September 12, 2012.
October 1-3, 2012	Interviews conducted with a number of individuals representing a variety of interests in the community including: government administration; health, wellness and social services; safety and protection services; business and economic development; and education and training	Socio-economic baseline data collection; documentation of expected Project benefits, Project concerns, and suggested mitigation measures.
November 21, 2012	High school students and staff	Mining and geology presentation.
November 21, 2012	General public	Public meeting - Project overview/update.
November 21, 2012	Kugluktuk Community Advisory Group	Project update.
November 27, 2012	Local hunters from Kugluktuk	Land use focus group.
February 7-8, 2013	General public	Sabina representatives participated in NIRB's scoping meetings for the Project and were available to the public for questions and information sharing.
February 8, 2013	Kugluktuk Community Advisory Group	Project update.
April 22, 2013	General public	Public meeting - Project overview/update.
April 22, 2013	Kugluktuk Community Advisory Group	Project update.
August 12, 2013	General public	Sabina provided an overview of the Back River Project and its traditional knowledge study.

August 13, 2013	General public	The Kitikmeot Inuit Association provided an overview of the Naonaiyaotit Traditional Knowledge Project (NTKP) report completed for the Back River Project and additional traditional knowledge workshops being conducted.
August 14-16, 2013	Selected elders and knowledge holders	A series of traditional knowledge workshops were held with selected elders and local knowledge holders for Sabina's traditional knowledge study. These workshops focused on the topics of 'heritage and land use', 'terrestrial environment' and 'marine environment'.
November 18, 2013	General public	Public meeting - Project overview/update & DEIS submission overview.
November 18, 2013	Kugluktuk Hamlet Council	Project update.
November 18, 2013	Kugluktuk Community Advisory Group	Project update.
November 18, 2013	Kugluktuk high school students	Project overview and discussion of future employment opportunities.
January 24, 2014	General public	Career fair participation.
February 12, 2014	Donald LeBlanc, Senior Administrative Officer Hamlet of Kugluktuk	Letter / invitation to nominate representative to the Kugluktuk Community Advisory Group.
February 2014	Kugluktuk Community Advisory Group	Letter – Update on January 2014 DEIS submission to NIRB and NWB. DEIS Plain Language Summary included.
February 2014	Hamlet of Kugluktuk	Letter – Update on January 2014 DEIS submission to NIRB and NWB. DEIS Plain Language Summary included.
February 2014	Kugluktuk HTO	Letter – Update on January 2014 DEIS submission to NIRB and NWB. DEIS Plain Language Summary included.
March 19, 2014	David Nivingalok (Chairperson) and Kevin Klengenberg (Secretary-Treasurer), Kugluktuk HTO	Teleconference to discuss proposed fish offsetting work to be conducted at Bernard Harbour.
March 24, 2014	General public	Sabina representatives participated in NIRB's community information sessions for the Project's DEIS and were available to the public for questions and information sharing.
March 24, 2014	Kugluktuk Community Advisory Group	Project update.
March 25, 2014	Kugluktuk HTO	Meeting to discuss proposed fish offsetting work to be conducted at Bernard Harbour and the associated TK study.
April 29, 2014	Kugluktuk HTO	Meeting to discuss Kugluktuk HTO-Sabina Bernard Harbour Restoration Project Agreement.
April 30, 2014	Kugluktuk Community Readiness Initiative Committee	Sabina met with Kugluktuk's Community Readiness Initiative Committee in Kugluktuk to discuss the plans and goals of the committee and how Sabina might contribute.

April 30, 2014	Donald LeBlanc, SAO, Hamlet of Kugluktuk	Project update.
May 2, 2014	Kugluktuk Community Readiness Initiative Committee	Sabina met with Kugluktuk's Community Readiness Initiative Committee in Yellowknife to discuss the plans and goals of the committee and how Sabina might contribute.
June 1-6, 2014	Selected elders and knowledge holders	A series of traditional knowledge interviews were held with selected elders and local knowledge holders as a component of proposed fish offsetting activities in the Bernard Harbour, Nunavut area. A project overview meeting/presentation was also held with local study participants prior to the interviews commencing.
July 13, 2014	Bernard Harbour TK study participants, HTO chairperson, and acting HTO manager	A TK study results verification meeting was held with participants in the Bernard Harbour TK study and with the Kugluktuk HTO chairperson and acting manager. Various clarifications were made by the participants, which were later incorporated into the final TK study report.
July 14-15, 2014	Kugluktuk Community Advisory Group	Sabina hosted the Cambridge Bay and Kugluktuk Community Advisory Groups at the Back River Project site on July 14-15. Site tours were provided and Project information was shared.
July 17, 2014	Kugluktuk HTO chairperson	The chairperson of the Kugluktuk HTO accompanied Sabina representatives and various other attendees during a day-long site visit to the Bernard Harbour stream restoration project.
February 12, 2015	Kugluktuk Community Advisory Group	Sabina provided a Project update and administered a country food consumption questionnaire.
February 12, 2015	Kugluktuk HTO representatives	Sabina met with the Kugluktuk HTO chairperson, treasurer, and manager to provide an update on the Bernard Harbour restoration project and Bernard Harbour TK study.
February 17, 2015	Kugluktuk HTO	Letter and copy of the draft 'Traditional Knowledge Study Report on the Arctic Char Fishery in the Nulahugyuk Creek – Hingittok Lake Area (Bernard Harbour), Nunavut' provided to the HTO.
April 21, 2015	Kugluktuk HTO	Final copy of the 'Traditional Knowledge Study Report on the Arctic Char Fishery in the Nulahugyuk Creek – Hingittok Lake Area (Bernard Harbour), Nunavut' provided to the HTO.
May 8, 2015	Barbara Adjun, Kugluktuk HTO Manager	Phone update on the Bernard Harbour restoration project.
May 21, 2015	David Nivingalok, Kugluktuk HTO Chairperson	Phone update on the Bernard Harbour restoration project.
May 27, 2015	Hamlet of Kugluktuk	Sabina participated (via teleconference) in a multi-stakeholder information session hosted on Kugluktuk's

		Community Readiness Initiative where feedback was sought on the draft Kugluktuk Community Readiness Report.
June 17, 2015	General public	Public meeting – Project update and FEIS submission overview. The results of the Bernard Harbour TK study and plans for the Bernard Harbour restoration project were also reviewed.
June 18, 2015	Kugluktuk Community Advisory Group	Project update and FEIS submission overview.
June 18, 2015	Kugluktuk HTO	Project update and FEIS submission overview. The results of the Bernard Harbour TK study and plans for the Bernard Harbour restoration project were also reviewed.
June 19, 2015	Hamlet of Kugluktuk	Project update and FEIS submission overview.
July 8, 2015	David Nivingalok, Kugluktuk HTO Chairperson	Letter providing information on the 2015 Bernard Harbour work proposal.
February 11, 2016	Kugluktuk HTO	Project update and FEIS submission/NIRB final hearings overview. Bernard Harbour project update.
February 12, 2016	Kugluktuk Community Advisory Group	Project update and FEIS submission/NIRB final hearings overview.
March 5, 2016	Hamlet of Kugluktuk Kugluktuk HTO	Emailed letter re: Sabina's FEIS submission.
March 16-17, 2016	Kugluktuk Job Fair and Graduation Ceremony	Sabina participated in a job fair and graduation ceremonies in Kugluktuk.
April 11-12, 2016	Kugluktuk HTO Representatives	Representatives from the Kugluktuk HTO participated in meetings and a Back River Project site visit hosted by Sabina.
June 7, 2016	General Public	Public Meeting on the Bernard Harbour Restoration Project
June 8-9, 2016	Kugluktuk HTO and Invited Participants	Bernard Harbour Restoration Project Workshop
June 17, 2016	Kugluktuk HTO	Teleconference Project update re: NIRB final hearing report.
July 5, 2016	Hamlet of Kugluktuk	Project update re: NIRB final hearing report.
July 5, 2016	General Public	Public meeting – Project update re: NIRB final hearing report.
July 6, 2016	Kugluktuk Community Advisory Group	Project update re: NIRB final hearing report.
September 16, 2016	General Public	Sabina participated in the Kugluktuk portion of the 2016 Kitikmeot Career Fair.
November 9, 2016	Kugluktuk HTO	Sabina provided a Bernard Harbour Restoration Project update by teleconference.

December 2, 2016	Kugluktuk HTO	Project update, Bernard Harbour project update, and update on revised Wildlife Mitigation and Monitoring Program
December 3, 2016	General Public	Call-in radio show - Project update and update on revised Wildlife Mitigation and Monitoring Program
December 3, 2016	General Public	Project update and update on revised Wildlife Mitigation and Monitoring Program
December 4, 2016	Kugluktuk Community Advisory Group	Project update and update on revised Wildlife Mitigation and Monitoring Program
January 23, 2017	Hamlet of Kugluktuk Kugluktuk HTO Three elders Community member	Letter – Update on January 12, 2017 INAC Minister's decision and thank you for providing letter of support.
April 24, 2017	Hamlet of Kugluktuk	Project update and FEIS Addendum overview.
April 24, 2017	Kugluktuk HTO	Project update and FEIS Addendum overview.
April 24, 2017	General Public	Public meeting - Project update and FEIS Addendum overview.
September 2017	Various Parties (e.g. Hamlet of Kugluktuk, Kugluktuk HTO, selected Elders, individual)	Letter – Project update and thank you for providing letter of support.
October 5, 2017	General public	Career fair participation.
Kingaok and Omingmaktok		
April 5, 2012	Sam Kapolak, Chairperson Bathurst Inlet HTO	Letter / invitation to nominate representative to the Cambridge Bay Community Advisory Group.
April 5, 2012	Peter Kapolak, Chairperson Omingmaktok HTO	Letter / invitation to nominate representative to the Cambridge Bay Community Advisory Group.
November 18, 2012	Various residents of Kingaok and Omingmaktok	Sabina hosted a Project information meeting in Cambridge Bay specifically for residents of Kingaok and Omingmaktok.
November 30 - December 1, 2012	Local hunters from the Bathurst Inlet area	Land use focus group.
Fall 2012	Interviews conducted with selected individuals from the Bathurst Inlet area for Sabina's socio-economic study	Socio-economic baseline data collection; documentation of expected Project benefits, Project concerns, and suggested mitigation measures.
January 1, 2013	Boyd Warner President, Bathurst Inlet Lodge	Project discussion (via phone).
August 14-16, 2013 (in Kugluktuk) August 21-23 (in Cambridge Bay)	Selected elders and knowledge holders from or familiar with the Bathurst Inlet area	A series of traditional knowledge workshops were held with selected elders and local knowledge holders for Sabina's traditional knowledge study. These workshops focused on the topics of 'heritage and land use', 'terrestrial environment' and 'marine environment'.

November 19, 2013	Various residents of Kingaok and Omingmaktok	Project update in Cambridge Bay specifically for residents of Kingaok and Omingmaktok and the Cambridge Bay community advisory group.
February 2014	Omingmaktok HTO	Letter – Update on January 2014 DEIS submission to NIRB and NWB. DEIS Plain Language Summary included.
September 24, 2014	Residents of Kingaok and Omingmaktok	Letter / invitation to attend October 28, 2014 dinner and meeting on the Back River Project in Cambridge Bay, specifically for residents of Kingaok and Omingmaktok.
October 28, 2014	Residents of Kingaok and Omingmaktok	Dinner and meeting on the Back River Project in Cambridge Bay, specifically for residents of Kingaok and Omingmaktok.
January 21, 2015	Residents of Kingaok and Omingmaktok	Letter / invitation to attend February 8, 2015 dinner and meeting on the Back River Project in Cambridge Bay, specifically for residents of Kingaok and Omingmaktok.
May 21, 2015	Residents of Kingaok and Omingmaktok	Letter / invitation to attend June 15, 2015 dinner and meeting on the Back River Project in Cambridge Bay, specifically for residents of Kingaok and Omingmaktok.
June 15, 2015	Residents of Kingaok and Omingmaktok	Dinner and meeting on the Back River Project (re: Project update and FEIS submission overview) in Cambridge Bay, specifically for residents of Kingaok and Omingmaktok.
February 9, 2016	Residents of Kingaok and Omingmaktok	Dinner and meeting on the Back River Project (re: Project update, FEIS submission, and NIRB final hearings overview) in Cambridge Bay, specifically for residents of Kingaok and Omingmaktok.
March 5, 2016	Bathurst Inlet HTO Bay Chimo HTO	Emailed letter re: Sabina's FEIS submission.
April 11-12, 2016	Bathurst Inlet HTO Representative Bay Chimo HTO Representative	Representatives from the Bathurst Inlet HTO and Bay Chimo HTO participated in meetings and a Back River Project site visit hosted by Sabina.
December 1, 2016	Residents of Kingaok and Omingmaktok	Project update and update on revised Wildlife Mitigation and Monitoring Program
April 23, 2017	Kingaok and Omingmaktok Representatives	Project update and FEIS Addendum overview.
Gjoa Haven		
June 20, 2012	Hamlet Council members and staff	Project introduction.
June 20, 2012	General public	Public meeting - Project overview.
September 17-19, 2012	Interviews conducted with a number of individuals representing a variety of interests in the community including: government administration; health, wellness and social services; business and economic development; and education and training	Socio-economic baseline data collection; documentation of expected Project benefits, Project concerns, and suggested mitigation measures.

February 12, 2013	General public	Sabina representatives participated in NIRB's scoping meeting for the Project and were available to the public for questions and information sharing.
February 13, 2013	General public	Radio Show - Project update and notice of upcoming Actua educational program for Kitikmeot youth.
April 24, 2013	General public	Public meeting - Project overview/update.
April 24, 2013	Gjoa Haven HTO	Project overview/update.
April 24, 2013	General public	Radio Show - Project update.
November 20, 2013	General public	Public meeting - Project overview/update & DEIS submission overview.
November 20, 2013	Gjoa Haven HTO	Project update.
November 20, 2013	Hamlet of Gjoa Haven representatives	Project update.
November 20, 2013	Gjoa Haven high school students	Project overview and discussion of future employment opportunities.
November 20, 2013	General public	Radio update.
January 21, 2014	General public	Career fair participation.
February 2014	Hamlet of Gjoa Haven	Letter – Update on January 2014 DEIS submission to NIRB and NWB. DEIS Plain Language Summary included.
February 2014	Gjoa Haven HTO	Letter – Update on January 2014 DEIS submission to NIRB and NWB. DEIS Plain Language Summary included.
March 26, 2014	General public	NIRB held community information sessions for the Project's DEIS and were available to the public for questions and information sharing. Note – Sabina representatives were unable to attend due to flight cancellations.
March 5, 2016	Hamlet of Gjoa Haven Gjoa Haven HTO	Emailed letter re: Sabina's FEIS submission.
March 7, 2016	Hamlet of Gjoa Haven Gjoa Haven HTO Residents of Gjoa Haven	Emailed letter re: recent attempts by Sabina to host a public meeting in Gjoa Haven.
April 11-12, 2016	Hamlet of Gjoa Haven Representative Kitikmeot Inuit Association (Gjoa Haven) Representative	Representatives from the Hamlet of Gjoa Haven and Kitikmeot Inuit Association (Gjoa Haven) participated in meetings and a Back River Project site visit hosted by Sabina.
July 8, 2016	Hamlet of Gjoa Haven representatives	Project update re: NIRB final hearing report.
July 8, 2016	General Public	Public meeting - Project update re: NIRB final hearing report.
January 23, 2017	Hamlet of Gjoa Haven Past Project employees (various)	Letter – Update on January 12, 2017 INAC Minister's decision and thank you for providing letter of support.

April 18, 2017	Hamlet of Gjoa Haven	Project update and FEIS Addendum overview.
April 18, 2017	General Public	Public meeting - Project update and FEIS Addendum overview.
September 2017	Various Parties (e.g. Hamlet of Gjoa Haven, individuals)	Letter – Project update and thank you for providing letter of support.
Taloyoak		
June 19, 2012	General public	Public meeting - Project overview.
June 19, 2012	Taloyoak HTO	Project overview.
June 19, 2012	Tommy Aiyout, Mayor of Taloyoak David Irqquit, Assistant SAO Hamlet of Taloyoak	Project overview.
September 25-26, 2012	Interviews conducted with a number of individuals representing a variety of interests in the community including: government administration; health, wellness and social services; safety and protection services; business and economic development; and education and training	Socio-economic baseline data collection; documentation of expected Project benefits, Project concerns, and suggested mitigation measures.
February 13, 2013	General public	Sabina representatives participated in NIRB's scoping meeting for the Project and were available to the public for questions and information sharing.
February 14, 2013	General public	Radio Show - Project update and notice of upcoming Actua educational program for Kitikmeot youth.
April 25, 2013	General public	Public meeting - Project overview/update.
April 25, 2013	General public	Radio Show - Project update.
November 21, 2013	General public	Public meeting - Project overview/update & DEIS submission overview.
November 21, 2013	Taloyoak HTO	Project update.
November 21, 2013	Taloyoak Hamlet Council	Project update.
November 21, 2013	Taloyoak high school students	Project overview and discussion of future employment opportunities.
November 21, 2013	General public	Radio update.
January 20, 2014	General public	Career fair participation.
February 2014	Hamlet of Taloyoak	Letter – Update on January 2014 DEIS submission to NIRB and NWB. DEIS Plain Language Summary included.
February 2014	Taloyoak HTO	Letter – Update on January 2014 DEIS submission to NIRB and NWB. DEIS Plain Language Summary included.
March 28, 2014	General public	NIRB held community information sessions for the Project's DEIS and were available to the public for

		questions and information sharing. Note – Sabina representatives were unable to attend due to flight cancellations.
June 17, 2015	General public	Public meeting – Project update and FEIS submission overview.
June 17, 2015	Hamlet of Taloyoak	Project update and FEIS submission overview.
March 5, 2016	Hamlet of Taloyoak Taloyoak HTO	Emailed letter re: Sabina's FEIS submission.
April 11-12, 2016	Hamlet of Taloyoak Representative Taloyoak HTO Representative	Representatives from the Hamlet of Taloyoak and Taloyoak HTO participated in meetings and a Back River Project site visit hosted by Sabina.
July 7, 2016	Taloyoak HTO	Project update re: NIRB final hearing report.
July 7, 2016	Hamlet of Taloyoak representatives	Project update re: NIRB final hearing report.
July 7, 2016	General Public	Public meeting - Project update re: NIRB final hearing report.
January 23, 2017	Hamlet of Taloyoak	Letter – Update on January 12, 2017 INAC Minister's decision and thank you for providing letter of support.
April 20, 2017	Taloyoak HTO	Project update and FEIS Addendum overview.
April 20, 2017	Hamlet of Taloyoak Representatives	Project update and FEIS Addendum overview.
April 20, 2017	General Public	Public meeting - Project update and FEIS Addendum overview.
September 2017	Hamlet of Taloyoak	Letter – Project update and thank you for providing letter of support.
October 3, 2017	General public	Career fair participation.
Kugaaruk		
June 18, 2012	General public	Public meeting - Project overview.
September 20-21, 2012	Interviews conducted with a number of individuals representing a variety of interests in the community including: government administration; health, wellness and social services; safety and protection services; business and economic development; and education and training	Socio-economic baseline data collection; documentation of expected Project benefits, Project concerns, and suggested mitigation measures.
February 11, 2013	General public	Sabina representatives participated in NIRB's scoping meeting for the Project and were available to the public for questions and information sharing.
February 11, 2013	General public	Radio Show - Project update and notice of upcoming Actua educational program for Kitikmeot youth.
April 26, 2013	General public	Public meeting - Project overview/update.
April 26, 2013	General public	Radio Show - Project update.

April 26, 2013	Kugaaruk Hamlet Council	Project overview/update.
November 22, 2013	General public	Public meeting - Project overview/update & DEIS submission overview.
November 22, 2013	Kugaaruk Hamlet Council	Project update.
November 22, 2013	Kugaaruk high school students	Project overview and discussion of future employment opportunities.
November 22, 2013	General public	Radio update.
January 22, 2014	General public	Career fair participation.
February 2014	Hamlet of Kugaaruk	Letter – Update on January 2014 DEIS submission to NIRB and NWB. DEIS Plain Language Summary included.
February 2014	Kugaaruk HTO	Letter – Update on January 2014 DEIS submission to NIRB and NWB. DEIS Plain Language Summary included.
March 27, 2014	General public	NIRB held community information sessions for the Project's DEIS and were available to the public for questions and information sharing. Note – Sabina representatives were unable to attend due to flight cancellations.
June 16, 2015	General public	Public meeting – Project update and FEIS submission overview.
March 5, 2016	Hamlet of Kugaaruk Kugaaruk HTO	Emailed letter re: Sabina's FEIS submission.
April 11-12, 2016	Hamlet of Kugaaruk Representative Kugaaruk HTO Representative	Representatives from the Hamlet of Kugaaruk and Kugaaruk HTO participated in meetings and a Back River Project site visit hosted by Sabina.
July 6, 2016	Kugaaruk HTO	Project update re: NIRB final hearing report.
July 6, 2016	Hamlet of Kugaaruk	Project update re: NIRB final hearing report.
July 6, 2016	General Public	Public meeting - Project update re: NIRB final hearing report.
January 23, 2017	Hamlet of Kugaaruk	Letter – Update on January 12, 2017 INAC Minister's decision and thank you for providing letter of support.
April 19, 2017	General Public	Public meeting - Project update and FEIS Addendum overview.
September 2017	Hamlet of Kugaaruk	Letter – Project update and thank you for providing letter of support.
Yellowknife / Other Locations in the Northwest Territories		
November 15, 2012	Yellowknives Dene First Nation representatives	Project overview.
November 16, 2012	General public	Public meeting – Project overview.

February 20, 2013	General public	Sabina representatives participated in NIRB's scoping meeting for the Project and were available to the public for questions and information sharing.
November 12, 2013	Tlicho Government / Kwe Beh Working Group representatives	Project overview.
November 13, 2013	Deninu K'ue First Nation representatives	Project overview.
November 13, 2013	General public	Public meeting - Project overview/update.
November 14, 2013	Yellowknives Dene First Nation representative (T. Slack)	Project update.
November 15, 2013	North Slave Métis Alliance representatives	Project overview.
January 24, 2013	Yellowknives Dene First Nation (Attn: Todd Slack)	Delivery of two USB memory sticks with full digital versions of Sabina's DEIS submission included on each.
January 24, 2013	Tlicho Government / Kwe Beh Working Group (Attn: Henry Zoe and Sonny Zoe)	Delivery of two USB memory sticks with full digital versions of Sabina's DEIS submission included on each.
January 24, 2013	North Slave Métis Alliance (Attn: Eric Binion)	Delivery of two USB memory sticks with full digital versions of Sabina's DEIS submission included on each.
January 24, 2013	Deninu K'ue First Nation (Attn: Chief Louis Balsillie and Stephen Cuthbert)	Delivery of two USB memory sticks with full digital versions of Sabina's DEIS submission included on each.
April 1, 2014	General public	Sabina representatives participated in NIRB's community information sessions for the Project's DEIS and were available to the public for questions and information sharing.
May 8, 2014	Yellowknives Dene First Nation	Email update re: DEIS / NIRB regulatory process.
May 8, 2014	Tlicho Government / Kwe Beh Working Group	Email update re: DEIS / NIRB regulatory process.
May 8, 2014	North Slave Métis Alliance	Email update re: DEIS / NIRB regulatory process.
May 8, 2014	Lutsel K'e Dene First Nation	Email update re: DEIS / NIRB regulatory process.
May 8, 2014	Deninu K'ue First Nation	Email update re: DEIS / NIRB regulatory process.
May 8, 2014	Dene Nation	Email update re: DEIS / NIRB regulatory process.
July 24, 2014	Yellowknives Dene First Nation	Email update re: Sabina's DEIS IR responses.
July 24, 2014	Tlicho Government / Kwe Beh Working Group	Email update re: Sabina's DEIS IR responses.
July 24, 2014	North Slave Métis Alliance	Email update re: Sabina's DEIS IR responses.
July 24, 2014	Lutsel K'e Dene First Nation	Email update re: Sabina's DEIS IR responses.
July 24, 2014	Deninu K'ue First Nation	Email update re: Sabina's DEIS IR responses.
July 24, 2014	Dene Nation	Email update re: Sabina's DEIS IR responses.
July 25, 2014	North Slave Métis Alliance representative (Matt Hoover)	Phone call to discuss Sabina's DEIS Information Request responses and future regulatory timelines/requirements.
May 28, 2015	Yellowknives Dene First Nation	Emailed letter and notice of June 15, 2015 public meeting in Yellowknife.

May 28, 2015	Tlicho Government	Emailed letter and notice of June 15, 2015 public meeting in Yellowknife.
May 28, 2015	Deninu Kue First Nation	Emailed letter and notice of June 15, 2015 public meeting in Yellowknife.
May 28, 2015	North Slave Métis Alliance	Emailed letter and notice of June 15, 2015 public meeting in Yellowknife.
May 28, 2015	Lutsel K'e Dene First Nation	Emailed letter and notice of June 15, 2015 public meeting in Yellowknife.
June 15, 2015	General public	Public meeting - Project update and FEIS submission overview.
February 8, 2016	North Slave Métis Alliance	Project / FEIS update meeting.
March 5, 2016	Yellowknives Dene First Nation	Emailed letter re: Sabina's FEIS submission.
March 5, 2016	Tlicho Government / Kwe Beh Working Group	Emailed letter re: Sabina's FEIS submission.
March 5, 2016	North Slave Métis Alliance	Emailed letter re: Sabina's FEIS submission.
March 5, 2016	Lutsel K'e Dene First Nation	Emailed letter re: Sabina's FEIS submission.
July 8, 2016	North Slave Métis Alliance	Project update re: NIRB final hearing report.
July 8, 2016	General Public	Public meeting - Project update re: NIRB final hearing report.
April 17, 2017	General public	Public meeting - Project update and FEIS Addendum overview.
April 25, 2017	Yellowknives Dene First Nation Representatives	Project update and FEIS Addendum overview.
Other (e.g. northern trade shows and conferences, SEMCs, newsletters)		
February 13-15, 2012	Various community, government, and industry stakeholders participated	Sabina participated in the Kitikmeot Trade Show in Cambridge Bay.
March 28, 2012	Various community, government, and industry stakeholders participated	Sabina participated in the Kitikmeot Socio-Economic Monitoring Committee meeting in Cambridge Bay.
April 16-19, 2012	Various community, government, and industry stakeholders participated	Sabina participated in the Nunavut Mining Symposium in Iqaluit.
September 25-27, 2012	Various community, government, and industry stakeholders participated	Sabina participated in the Nunavut Trade Show in Iqaluit.
October 30-31, 2012	Various community, government, and industry stakeholders participated	Sabina participated in the Kitikmeot Stakeholders Meeting in Cambridge Bay to discuss training and labour market needs in the Kitikmeot Region.
November 13-15, 2012	Various community, government, and industry stakeholders participated	Sabina participated in the Yellowknife Geoscience Forum.
March 30, 2013	Various community, government, industry, and other stakeholders	Sabina issued the winter 2013 edition of its Project newsletter 'Back River News' via email and at various locations in the Kitikmeot communities.

February 11-13, 2013	Various community, government, and industry stakeholders participated	Sabina participated in the Kitikmeot Trade Show in Cambridge Bay.
April 8-11, 2013	Various community, government, and industry stakeholders participated	Sabina participated in the Nunavut Mining Symposium in Iqaluit.
June 28, 2013	Various community, government, industry, and other stakeholders	Sabina issued the summer 2013 edition of its Project newsletter 'Back River News' via email and at various locations in the Kitikmeot communities.
September 12, 2013	Various community, government, and industry stakeholders participated	Sabina participated in a meeting on Community Readiness in the Kitikmeot Region, hosted by the Kitikmeot Inuit Association and Canadian Northern Economic Development Agency, in Cambridge Bay.
September 24-26, 2013	Various community, government, and industry stakeholders participated	Sabina participated in the Nunavut Trade Show in Iqaluit.
October 9, 2013	Various community, government, industry, and other stakeholders	Sabina provided an email update on the results of its pre-feasibility study for the Back River Project.
October 18, 2013	Various community, government, and industry stakeholders participated	Sabina participated (via teleconference) in the Kitikmeot Stakeholders Working Group meeting in Cambridge Bay to discuss training and employment activities and opportunities in the Kitikmeot Region.
November 15, 2013	Various community, government, industry, and other stakeholders	Sabina issued the fall 2013 edition of its Project newsletter 'Back River News' via email and at various locations in the Kitikmeot communities.
November 19-21, 2013	Various community, government, and industry stakeholders participated	Sabina participated in the Yellowknife Geoscience Forum.
November 20-21, 2013	Various community, government, and industry stakeholders participated	Sabina participated in the Kitikmeot Socio-Economic Monitoring Committee meeting in Cambridge Bay.
December 3, 2013	Various community, government, and industry stakeholders participated	Sabina participated (via teleconference) in the Kitikmeot Stakeholders Working Group meeting in Cambridge Bay to discuss training and employment activities and opportunities in the Kitikmeot Region.
January 22, 2014	Various community, government, industry, and other stakeholders	Sabina issued the spring 2014 edition of its Project newsletter 'Back River News' via email and at various locations in the Kitikmeot communities.
February 10-12, 2014	Various community, government, and industry stakeholders participated	Sabina participated in the Kitikmeot Trade Show in Cambridge Bay.
February 12, 2014	Various community, government, industry, and other stakeholders	Sabina provided an email update on the DEIS conformity decision it received for the Back River Project.
February 18, 2014	Various community, government, and industry stakeholders participated	Sabina participated (via teleconference) in the Kitikmeot Stakeholders Working Group meeting in Cambridge Bay to discuss training and employment activities and opportunities in the Kitikmeot Region.

March 4, 2014	Various community, government, industry, and other stakeholders	Sabina provided an email update on the updated mineral resource estimate it produced for the Back River Project.
April 7-10, 2014	Various community, government, and industry stakeholders participated	Sabina participated in the Nunavut Mining Symposium in Iqaluit.
April 28, 2014	Various community, government, industry, and other stakeholders	Sabina provided an email update on recent agreements signed between Sabina and the KIA for the Back River Project.
June 5, 2014	Various community, government, and industry stakeholders participated	Sabina participated (via teleconference) in the Kitikmeot Stakeholders Working Group meeting in Cambridge Bay to discuss training and employment activities and opportunities in the Kitikmeot Region.
October 7-9, 2014	Various community, government, and industry stakeholders participated	Sabina participated in the Nunavut Trade Show in Iqaluit.
October 22, 2014	Various community, government, and industry stakeholders participated	Sabina participated (via teleconference) in the Kitikmeot Stakeholders Working Group meeting in Cambridge Bay to discuss training and employment activities and opportunities in the Kitikmeot Region.
November 13-19, 2014	Various community and government stakeholders participated	Sabina participated in the Nunavut Impact Review Board's Technical Meeting and Pre-Hearing Conference for the Back River Project in Cambridge Bay.
November 25-27, 2014	Various community, government, and industry stakeholders participated	Sabina participated in the Yellowknife Geoscience Forum.
January 13, 2015	Various community, government, industry, and other stakeholders	Email update to Sabina email distribution list re: environmental assessment progress and anticipated FEIS submission.
January 27, 2015	Various community, government, industry, and other stakeholders	Sabina issued the winter 2015 edition of its Project newsletter 'Back River News' via email and at various locations in the Kitikmeot communities.
February 4, 2015	Various government and KIA representatives participated	Sabina participated in a meeting in Cambridge Bay to establish a Terms of Reference for the Back River Socio-Economic Monitoring Committee Working Group.
February 9-11, 2015	Various community, government, and industry stakeholders participated	Sabina participated in the Kitikmeot Trade Show in Cambridge Bay.
April 13-16, 2015	Various community, government, and industry stakeholders participated	Sabina participated in the Nunavut Mining Symposium in Iqaluit.
April 21-23, 2015	Various community, government, and industry stakeholders participated	Sabina participated in the Kitikmeot Mayors' Conference in Cambridge Bay.
September 14, 2015	Various community, government, industry, and other stakeholders	Email update to Sabina email distribution list re: Initial Project Feasibility Study.

November 3-4, 2015	Various community, government, and industry stakeholders participated	Sabina participated in the Kitikmeot Socio-Economic Monitoring Committee meeting in Cambridge Bay.
December 9, 2015	Various community, government, industry, and other stakeholders	Email update to Sabina email distribution list re: FEIS submission.
February 9, 2016	Selected youth from the Kitikmeot Region	Sabina met with selected youth from the Kitikmeot Region who were participating in the Kitikmeot Trade Show, to discuss education and career opportunities.
February 9-10, 2016	Various community, government, and industry stakeholders participated	Sabina participated in and presented a Project update at the Kitikmeot Trade Show in Cambridge Bay.
February 17, 2016	Various community, government, industry, and other stakeholders	Sabina issued the winter 2016 edition of its Project newsletter 'Back River News' via email and at various locations in the Kitikmeot communities.
April 4-6, 2016	Various community, government, and industry stakeholders participated	Sabina participated in the Nunavut Mining Symposium in Iqaluit.
April 19-21, 2016	Various community, government, and industry stakeholders participated	Sabina participated in the Kitikmeot Mayors' Conference in Cambridge Bay.
April 25-30, 2016	Various community and government stakeholders participated	Sabina participated in the Nunavut Impact Review Board's Final Hearing for the Back River Project in Cambridge Bay.
November 15-17, 2016	Various community, government, and industry stakeholders participated	Sabina participated in the Yellowknife Geoscience Forum in Yellowknife.
November 30-December 1, 2016	Various community, government, and industry stakeholders participated	Sabina participated in the Kitikmeot Socio-Economic Monitoring Committee meeting in Cambridge Bay.
December 2, 2016	Back River Socio-Economic Monitoring Working Group Members	Sabina participated in a Back River Socio-Economic Monitoring Working Group meeting in Cambridge Bay.
February 6-8, 2017	Various community, government, and industry stakeholders participated	Sabina participated in the Kitikmeot Trade Show in Cambridge Bay.
April 3-6, 2017	Various community, government, and industry stakeholders participated	Sabina participated in the Nunavut Mining Symposium in Iqaluit.
May 31-June 3, 2017	Various community and government stakeholders participated	Sabina participated in the Nunavut Impact Review Board's FEIS Addendum Final Hearing for the Back River Project in Cambridge Bay.
September 14-15, 2017	Various community, government, and industry stakeholders participated	Sabina participated in a Socio-Economic Monitoring Workshop held in Iqaluit.
October 3-5, 2017	Various community, government, and industry stakeholders participated	Sabina participated in the Kitikmeot Mayors' Conference in Cambridge Bay.
November 14-16, 2017	Various community, government, and industry stakeholders participated	Sabina participated in the Yellowknife Geoscience Forum in Yellowknife.

November 21-23, 2017	Various community, government, and industry stakeholders participated	Sabina participated in the Kitikmeot Economic Development Strategy Workshop hosted by the Kitikmeot Chamber of Commerce in Cambridge Bay
March 19-20, 2018	Various community, government, and industry stakeholders participated	Sabina participated in the Kitikmeot Socio-Economic Development Meeting in Cambridge Bay
March 20, 2018	Various community, government, and industry stakeholders participated	Sabina participated in the Back River Socio-Economic Meeting Working Group in Cambridge Bay
May 2, 2018	Various community, government and Industry stakeholders participated	Sabina participated in the Community Meeting for the Nunavut Water Board during Type A Water Licence Technical Meetings
May 10, 2019	Various community, government and Industry stakeholders participated	Sabina participated in the KIA's Stakeholders Working Group in Cambridge Bay
August 3, 2018	Hamlet of Kugluktuk	Sabina met with the Hamlet to discuss infrastructure projects in Kugluktuk
August 8, 2018	Various community, government and Industry stakeholders participated	Sabina participated in the Community Meeting for the Nunavut Water Board during Type A Water Licence Final Hearing in Cambridge Bay
September 18, 2018	Various community, government and Industry stakeholders participated	Sabina participated in the KIA's Stakeholders Working Group in Cambridge Bay
September 19, 2018	Various community, government and Industry stakeholders participated	Sabina participated in the Kitikmeot Mayors Meeting In Cambridge Bay
October 17, 2018	Hamlet of Cambridge Bay	Sabina met with the SAO for a Community Update
October 18, 2018	Various community, government and Industry stakeholders participated	Sabina participated in the Kitikmeot Inuit Association Annual General Meeting in Cambridge Bay

January 29, 2019	Hamlet of Kugluktuk	Met with the Hamlet of Kugluktuk in Vancouver,BC to discuss Infrastructure Projects
January 29, 2019	Various community, government and Industry stakeholders participated	Sabina hosted a breakfast in Vancouver during RoundUp 2019 for Various community, government and Industry stakeholders
February 12-13, 2019	Various community, government and Industry stakeholders participated	Sabina participated in the Kitikmeot Trade Show's 20th Anniversary on Cambridge Bay
March 6, 2019	Kitikmeot Inuit Association	Sabina and KIA 2019 Presidents Meeting
April 1 – 4, 2019	Various community, government and Industry stakeholders participated	Sabina participated in the Nunavut Mining Symposium in Iqaluit
??	Various community, government and Industry stakeholders participated	Merles Arctic Council Trip Presentation
April 11-12, 2019	Kitikmeot Socio-Economic Monitoring Committee	Sabina participated in the 2019 KSEMC and Back River SEMCWG in Cambridge Bay
May 25 – 31, 2019	Kitikmeot Community Tour	Sabina hosted a Kitikmeot Tour. Visiting each of the five communities, holding public meetings as well as delivering 80 Leitz Microscopes and hosting workshops in each school regarding the Microscopes
September 9, 2019	Hamlet of Kugluktuk	Sabina met with the Hamlet to discuss the Regional Wealth Creation Fund
September 9, 2019	Kugluktuk	Sabina hosted a public meeting to consult on possible upcoming project changes
September 10, 2019	Cambridge Bay	Sabina met with NIRB and NPC to discuss possible upcoming project changes

September 10, 2019	Cambridge Bay	Sabina hosted a public meeting to consult on possible upcoming project changes
September 11, 2019	Kugaaruk	Sabina presented at the KIA Board Meeting
September 11, 2019	Gjoa Haven	Sabina met with Nunavut Water Board to discuss possible upcoming project changes