GREENSTONE GOLD MINES

Hardrock Project Outcome of Detailed Engineering Design Optimizations

HP-MG004-EV-268-0004_0

April 30, 2019

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05/17/2019	**0**	**Final**	Signature:			
			Name:	<Name>	<Name>	<Name>

Document Revision History			
Rev.	**Date**	**Description**	**Originator**

1 Context

Greenstone Gold Mines GP Inc. (GGM) is planning to construct, operate and ultimately decommission a new open pit gold mine, process plant, and ancillary facilities, collectively known as the Hardrock Project (the Project). The Project is located in northwestern Ontario, approximately 275 kilometres (km) northeast of Thunder Bay, in the Municipality of Greenstone, Ward of Geraldton. The Final Environmental Impact Statement (EIS) / Environmental Assessment (EA) was submitted in July 2017 (referred to as EIS/EA), with supplemental information provided in June 2018 to meet the requirements of the federal and provincial EA processes. Federal approval was received (December 13, 2018) and Provincial approval was received (March 26, 2019). The EIS/EA site plan is presented as **Figure 1-1** (Appendix A).

In order to achieve continual improvement, design optimizations are considered by GGM on a continuous basis throughout the development of the Project. Since environmental assessment is a planning process, the EIS/EA identified that the Project was expected to be refined as the Project progressed, including through detailed engineering, during construction, and as production is optimized on an ongoing basis during operation.

GGM proactively utilized a conservative approach for locating Project components and assessing potential effects in the EIS/EA, and therefore any potential design optimizations and enhancements following the EIS/EA submission would not be expected to substantially affect the overall Project design or layout, nor result in environmental effects that exceed the conservative predictions, the conclusions related to mitigation measures, or the identification and significance of residual effects described in the EIS/EA. To the contrary, the detailed engineering process and outcome has improved upon conceptual level designs in the EA in accordance with GGM's continual improvement approach.

Following submission of the EIS/EA, GGM has worked to uphold commitments for specific design refinements identified as a result of stakeholder input. In addition, GGM has continued to progress detailed design and engineering, which, as outlined in the EIS/EA, has resulted in optimizations. The optimized site plan is presented as **Figure 1-2** (Appendix A). This report is intended to provide GGM with an opportunity to communicate these optimizations to interested parties. The majority of the optimizations have been discussed previously with interested parties through draft permit reviews.

2 Summary of Design Optimizations

A description of each of the design optimizations is provided in **Table 2-1**. Associated figures are provided in Appendix A.

Table 2-1: Summary of Design Optimizations

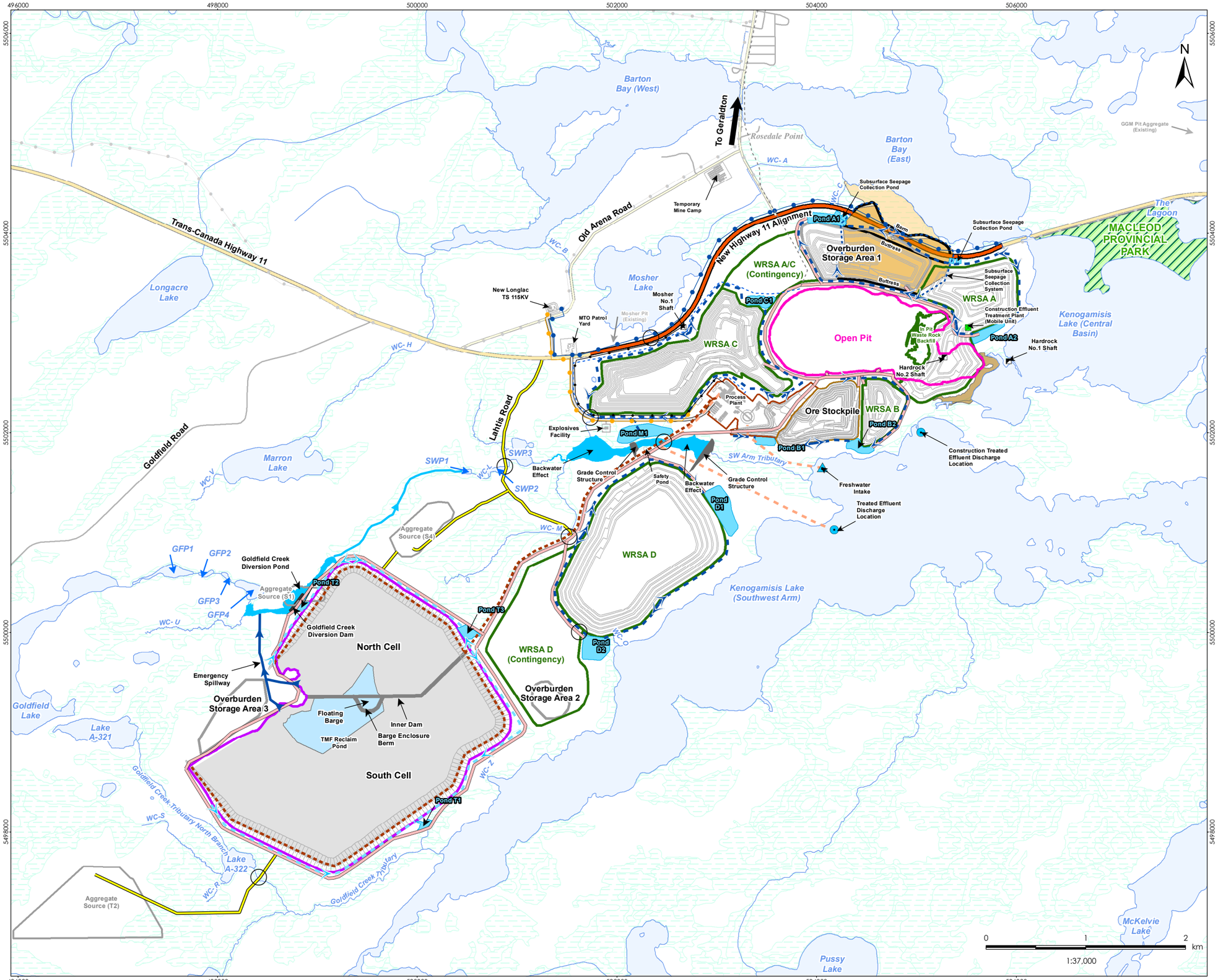
Project Component	Description of Optimization
Optimizations Made as a Result of EIS/EA Commitments	
Pond M1 **(Figure 2-1)**	Detailed engineering has optimized the sizing siting of Pond M1 with the goal of increasing the setback from the Goldfield Creek diversion. This design refinement was undertaken in response to comments from government agencies and Aboriginal communities on the EIS/EA, primarily relating to the proximity of the creek floodplain. The function of the pond remains unchanged from information presented in the EIS/EA. The pond continues to be the central water management pond in which contact water is directed towards for the site. The optimized location of Pond M1 is approximately 350 m to the northeast of the original location.
Access to the Southwest Arm of Kenogamisis Lake (East Access Road) (**Figure 2-2)**	GGM committed in the EIS/EA to maintaining public access to the Southwest Arm of Kenogamisis Lake. Maintaining this access is important for Aboriginal communities and the public to continue using the lake for fishing, harvesting and recreation. The holder of mineral exploration claims on the peninsula between the Central Basin and Southwest Arm of Kenogamisis Lake also expressed a desire for road access through the Project site to access the claimed area. An access road from Highway 11, located along the EIS/EA Project development area (PDA) boundary, is included to provide access to the lake during all phases of the Project. The entrance to Highway 11 will be designed in discussion with MTO in accordance with MTO design criteria and will be an uncontrolled intersection, subject to applicable MTO permits/approvals. The access road will run from Highway 11 along the east side of waste rock storage areas A and B. The road is approximately 4.5 km long, 20 m wide and will be a gravel surface.
Goldfield Creek Diversion Optimizations (**Figure 2-3**)	The Project's Independent TMF Review Board (ITRB) was established by GGM to review and advise on the design, construction, operation, performance, and closure planning for the TMF, with the objective of long-term safety and environmental protection. As a result of an ITRB recommendation and during progression of the TMF detailed design, the Goldfield Creek Diversion Dike detailed design was improved addressing geotechnical and constructability considerations related to the slurry cutoff wall. The optimized dike has been adjusted by approximately 100 m to the south that provides better foundations for the dike itself, and improved isolation of subsurface flows between the fresh water diversion and the TMF. The optimized dike location has resulted in detailed design optimizations to the associated components, including: • refinements to the Goldfield Creek Diversion Pond (GFDP) design including area, depth and location. The GFDP is now offers greater fish habitat offsetting area (approximately 19 ha) under normal water level conditions with water depths of up to 10 m • the TMF dike and Pond T2 were adjusted by approximately 100 m to the south to accommodate the diversion dyke optimization and improve foundation conditions. Another detailed design improvement associated with the Goldfield Creek Diversion is related to the haul road crossing of the Southwest Arm Tributary, which has been integrated into grade control structure #2 to minimize the number of cross valley

Project Component	Description of Optimization
	structures built. This design optimization improves constructability and minimizes construction disturbance within the existing floodplain.
Optimizations Made As A Result of Detailed Design and Engineering	
Aggregate Source T2 (**Figure 2-4**)	Detailed design and engineering since the EIS/EA has refined the footprint of the T2 aggregate extraction site. The refined boundary is entirely within GGM mineral claims, and is now 29 ha in size compared to the 72 ha identified in the EIS/EA. This includes an approximately 0.86 ha area immediately adjacent to the EIS/EA PDA. Of the 0.86 ha, the area proposed for extraction is 0.5 ha, with the remaining 0.36 ha comprising a setback buffer from the permit boundary. A terrestrial review of the 0.86 ha area adjacent to the PDA identified that the vegetation community in this area is upland forest habitat (ecosite B040, dry sandy aspen-birch hardwood), a community common within the ecoregion and previously identified in the PDA.
Aggregate Source T2 Access Road (**Figure 2-4**)	A significantly improved access road to aggregate source T2 was identified during the detailed design phase as a result of constructability considerations. The optimized access road has multiple benefits including avoidance of topographic constraints (safer gradient) and avoidance of an existing wetland, and a reduced footprint (0.7 km shorter than the original access road). A field assessment of watercourse crossings has been completed and identified one stream (Goldfield Creek Tributary North Branch) and one low point that is an ephemeral surface drainage feature with no defined channel at the crossing location (WC-S), where culvert installation will be required. A terrestrial assessment of the optimized access road was conducted to identify potential constraints associated with the proposed route. The area investigated included the access route as well as 120 m on either side. The optimized access road is located within upland forest habitat (ecosites B040, dry sandy aspen-birch hardwood; B034 jack pine-black spruce dominated and B104 fresh, silty to fine loamy aspen-birch hardwood). No terrestrial constraints were identified as a result of the field investigation. The vegetation community types are common within the ecoregion and all were previously identified in the PDA; none of these vegetation communities are designated as provincially rare; and no distinct wildlife habitat features (e.g. hibernacula, animal dens, raptor nests) were identified.
Aggregate Source S1 (**Figure 2-5**)	Detailed design and engineering since the EIS/EA has refined the extraction plan of the S1 aggregate extraction site. The boundary is entirely within GGM mineral claims that have been taken to a Mining Lease (CLM 535), including an approximately 1.7 ha area immediately adjacent to the EIS/EA PDA. The 1.7 ha area will accommodate a surface water diversion ditch to keep non-contact water away from the extraction site; no aggregate extraction will occur in the area outside of the PDA. The requirement for a diversion ditch was identified in the EIS/EA and the location updated based on detailed engineering input.
Temporary Effluent Treatment Plant (ETP) Discharge Pipeline (**Figure 2-6**)	Detailed engineering has identified an opportunity to improve the temporary Construction ETP discharge (also referred to as Temporary ETP) . The enhanced design consists of an effluent pipeline, with the addition of a diffuser at the end of the pipeline. The discharge location has been optimized to an outlet location approximately 340 m from the shoreline at a lake depth of approximately 2.75 m. Benefits of the updated design include avoidance of shoreline habitat and increased effectiveness of mixing and

Project Component	Description of Optimization
	dispersion of effluent, particularly during the winter months when there is ice buildup. The diffuser will be 5 m long and secured to a concrete block placed on the bottom of the lake.
Sand Washer - Seasonal Water Taking and Water Line (**Figure 2-7**)	Detailed design has determined that a sand washer will likely be required to remove fine silt-sized material from sand and gravel collected from S1 and S4 aggregate sources. The sand washer will source water seasonally from Kenogamisis Lake. The sand washer is anticipated to require approximately 900 m^3 per day and is consistent with the volume of water taking estimated in the EA.
Operational ETP Discharge Pipeline and Access Road (**Figure 2-8**)	Detailed engineering has identified an improved routing for the operational ETP discharge pipeline reducing the length within the shoreline Surface Rights Reservation. The discharge location (end of pipe) is the same as presented in the EIS/EA.
Fresh Water Intake Pipeline and Access Road (**Figure 2-9**)	Detailed engineering has identified an improved routing for the fresh water intake pipeline, which avoids wetlands surrounding the Southwest Arm Tributary. The water intake location remains the same as shown in the EIS/EA.
Power Line and Transformer Station Access Road (**Figure 2-10**)	The access road alignment to the Longlac Transformer Station is required to the east side of the MTO Patrol Yard. Highway 11 is designated as a controlled access highway and as such, permitted access must meet specific spacing requirements. The updated access point is required to accommodate these spacing requirements. Existing access points will remain including the existing Mosher access point for the Transmission Station access road. The access road corridor will continue to be used for utilities including the Project power lines.
Liquid Sulphur (SO_2) Dioxide Storage Tanks	As detailed engineering has progressed, an opportunity has been identified to simplify operations related to sourcing the SO_2 used in the cyanide detoxification process. Rather than undertaking the solid to liquid sulphur transformation process on site, liquid SO_2 will be delivered and stored in two above ground storage tanks located within the process plant. Delivery and storage of SO_2 is considered to provide a more reliable source for the cyanide destruction process, and is commonly used at most other gold mines in Ontario.

APPENDIX A

Figures



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Legend

Preliminary Site Plan

- Discharge Location
- Existing Mine Shaft
- Freshwater Intake
- Construction Effluent Treatment Plant
- Watercrossing
- Access Road
- Construction Access Road
- Diversion Channel
- Emergency Spillways
- Haul Road
- Potable Water Pipeline
- Pipeline (Intake and Discharge)
- 44 kV Distribution Line
- 12.5 kV Distribution Line
- 115 kV Transmission Line
- Seepage Collection Ditch
- Subsurface Seepage Collection System
- Contact Water Collection Ditch
- Tailings Pipeline and 13.8 kV Distribution Line
- Aggregate Source
- Collection Ponds
- Open Pit- Full Extent
- Ore Stockpile
- Process Plant Area
- Tailings Management Facility
- Waste Rock Storage Area

Highway Realignment

- New Highway 11 Alignment

Existing Features*

- Highway
- Major Road
- Local Road
- Existing Power Line
- Existing Potable Water Pipeline
- Watercourse
- Provincial Park
- Waterbody
- Wetland (Eco-Site Based)

Historical Tailings Areas

- Historical Hardrock Tailings
- Historical MacLeod High Tailings
- Historical MacLeod Low Tailings

Notes

1. Coordinate System: NAD 1983 UTM Zone 16N
2. Base features produced under license with the Ontario Ministry of Natural Resources © Queen's Printer for Ontario, 2013.

* Existing Features have been removed in the PDA and do not reflect current conditions.

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Greenstone Gold Mines GP Inc. (GGM)
Hardrock Project

Figure No.

1-1

Title

Final EIS/EA Site Plan

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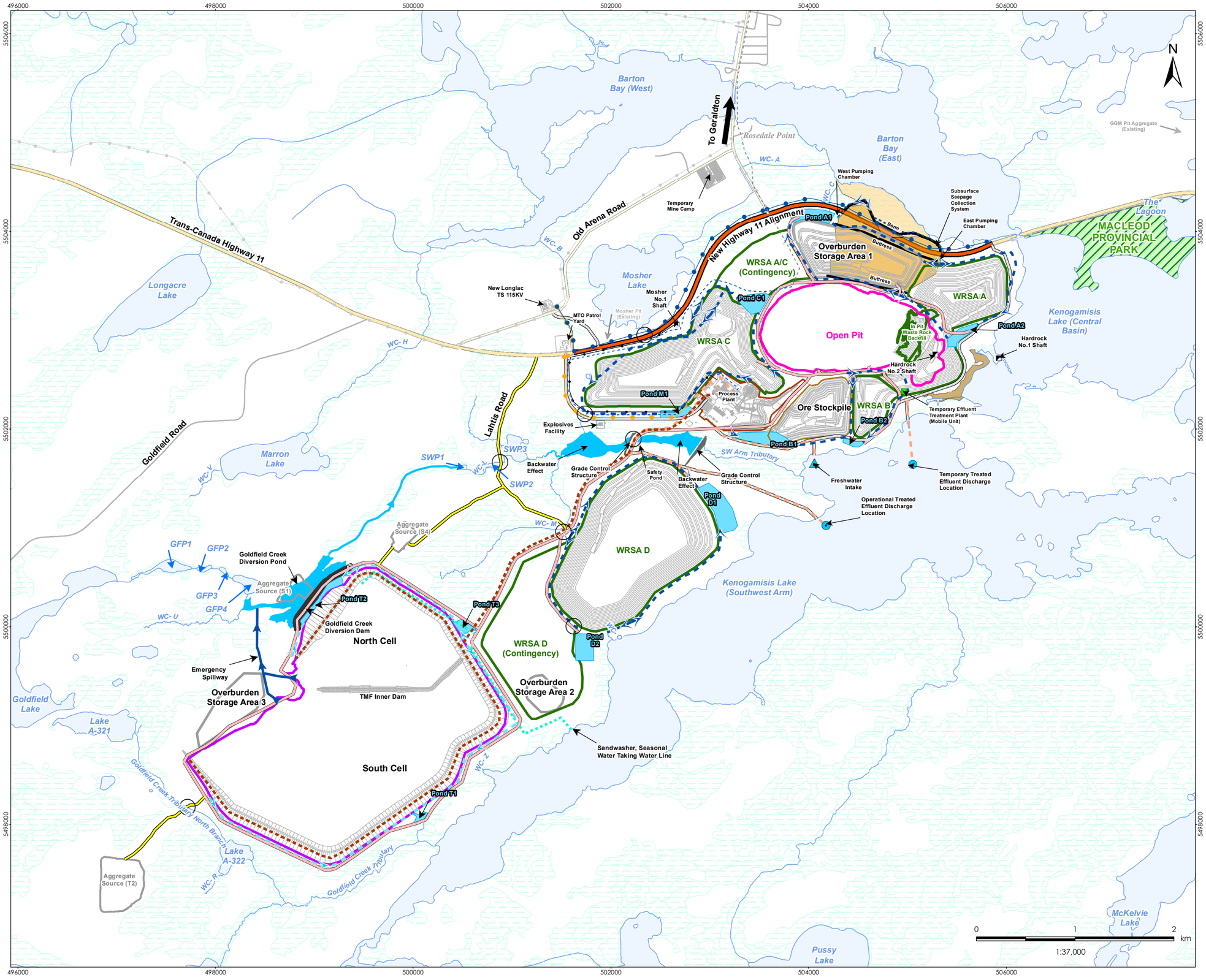
Revised: 2019-02-01 By: dharvey



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Legend

Preliminary Site Plan

- Discharge Location
- Existing Mine Shaft
- Freshwater Intake
- Temporary Effluent Treatment Plan
- Watercrossing
- Access Road
- Construction Access Road
- Diversion Channel
- Emergency Spillways
- Haul Road
- Potable Water Pipeline
- Pipeline (Intake and Discharge)
- 44 kV Distribution Line
- 12.5 kV Distribution Line
- 115 kV Transmission Line
- Seepage Collection Ditch
- Subsurface Seepage Collection System
- Contact Water Collection Ditch
- Tailings Pipeline and 13.8 kV Distribution Line
- Water Line
- Aggregate Source
- Collection Ponds
- Open Pit- Full Extent
- Ore Stockpile
- Process Plant Area
- Tailings Management Facility
- Waste Rock Storage Area

Highway Realignment

- New Highway 11 Alignment

Existing Features*

- Highway
- Major Road
- Local Road
- Existing Power Line
- Existing Potable Water Pipeline
- Watercourse
- Provincial Park
- Waterbody
- Wetland (Eco-Site Based)

Historical Tailings Areas

- Historical Hardrock Tailings
- Historical MacLeod High Tailings
- Historical MacLeod Low Tailings

Notes

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Greenstone Gold Mines GP Inc. (GGM)
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Figure No.

1-2

Title

Optimized Site Plan (Current as of May 2019)

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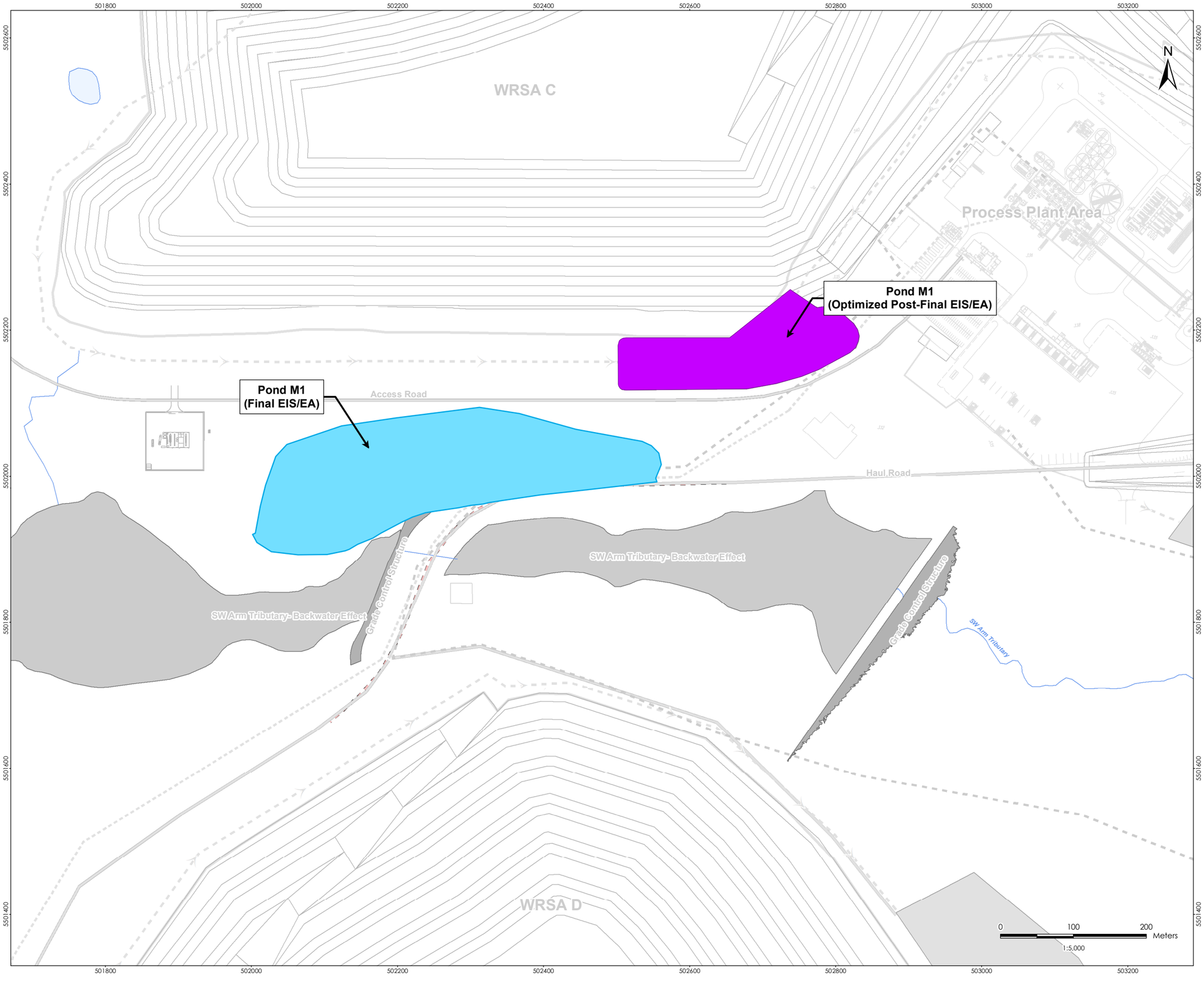
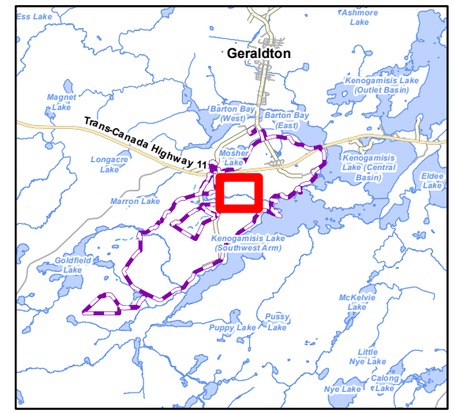
Revised: 2019-05-17 By: pworsell





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Legend

- Pond M1 (Optimized Post-Final EIS/EA)
- Pond M1 (Final EIS/EA)
- Watercourse
- Waterbody

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Greenstone Gold Mines GP Inc. (GGM)
Hardrock Project

Figure No.
2-1

Title

Pond M1 Location

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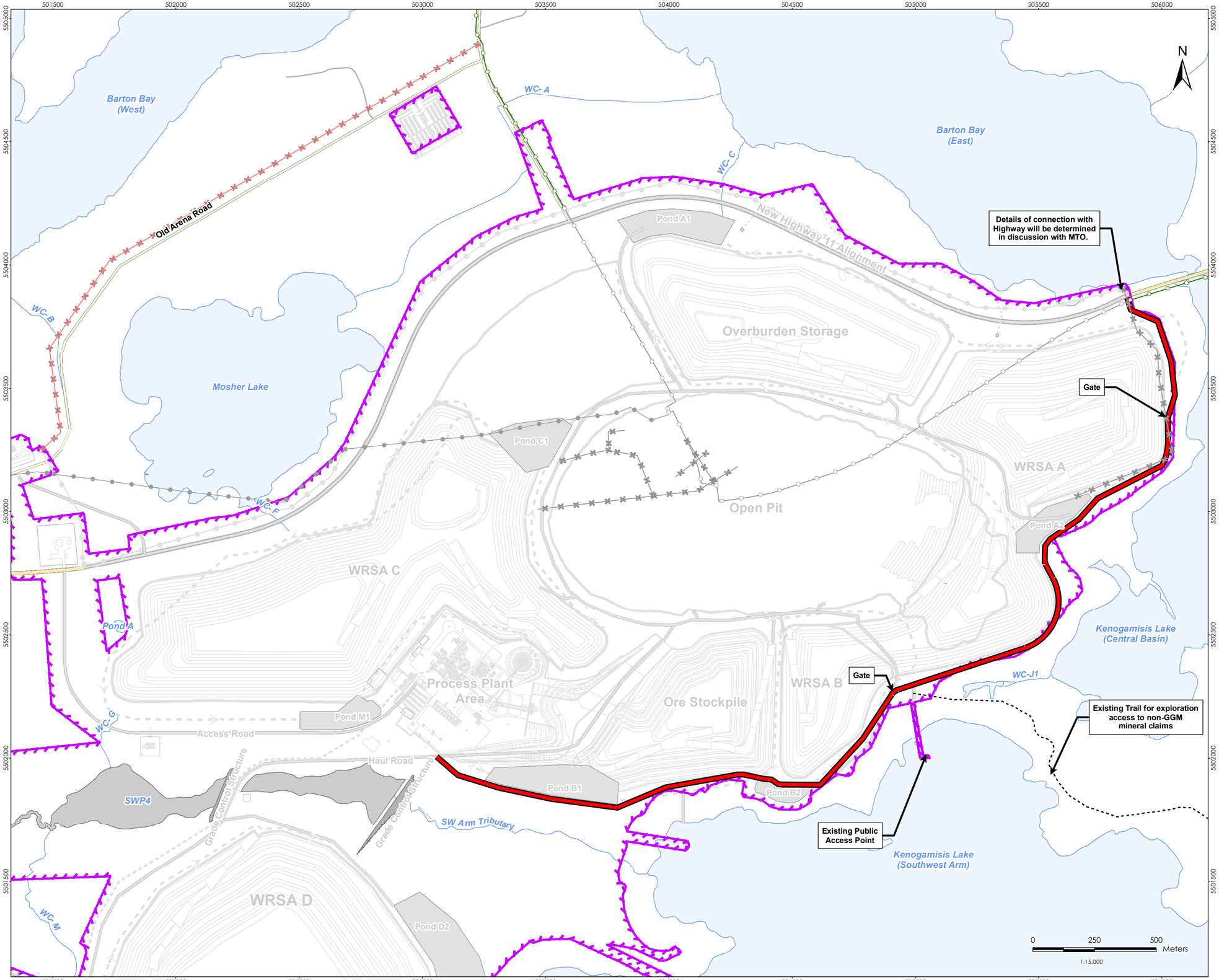

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Greenstone Gold Mines GP Inc. (GGM)
Hardrock Project

Figure No.
2-2

Title

East Access Road

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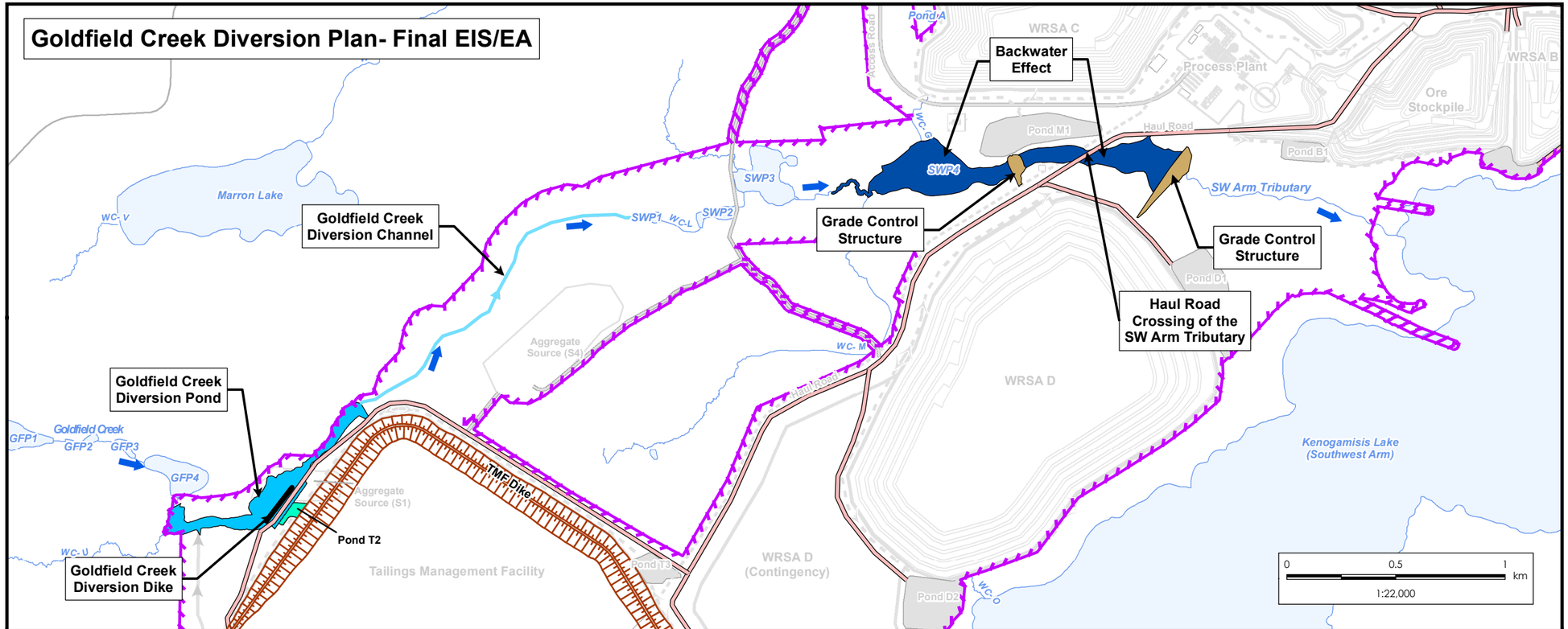
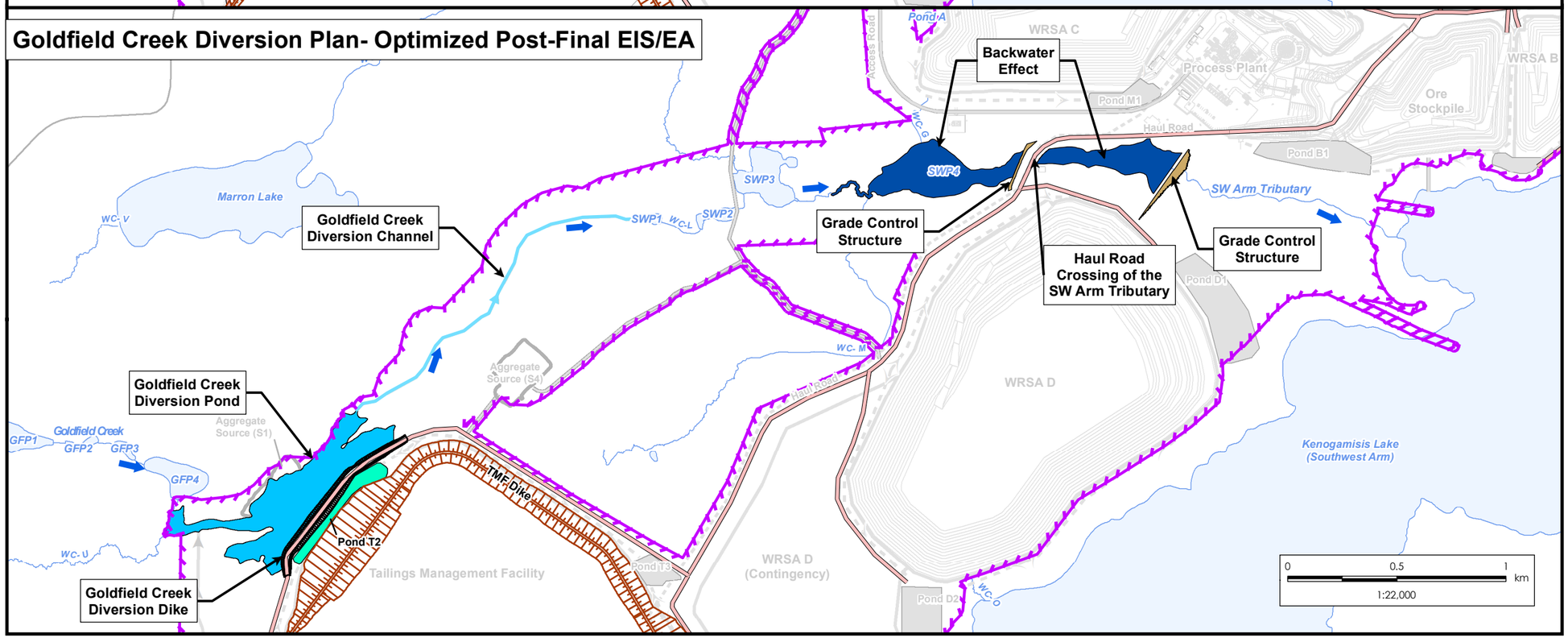
Revised: 2019-05-07 By: dharvey

Goldfield Creek Diversion Plan- Final EIS/EA



Goldfield Creek Diversion Plan- Optimized Post-Final EIS/EA



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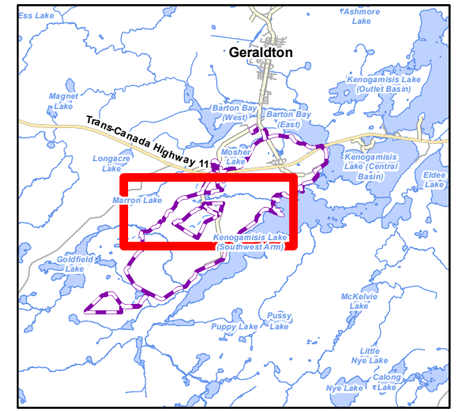
Legend

- Project Development Area (Final EIS/EA)
- Haul Road
- TMF Dam
- Goldfield Creek Diversion Dike
- Goldfield Creek Diversion Channel
- Backwater Effect
- Grade Control Structure
- Goldfield Creek Diversion Pond
- Pond T2
- Flow Direction
- Watercourse
- Waterbody



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Greenstone Gold Mines GP Inc. (GGM)
Hardrock Project

Figure No.

2-3

Title

Goldfield Creek Diversion Plan Optimizations

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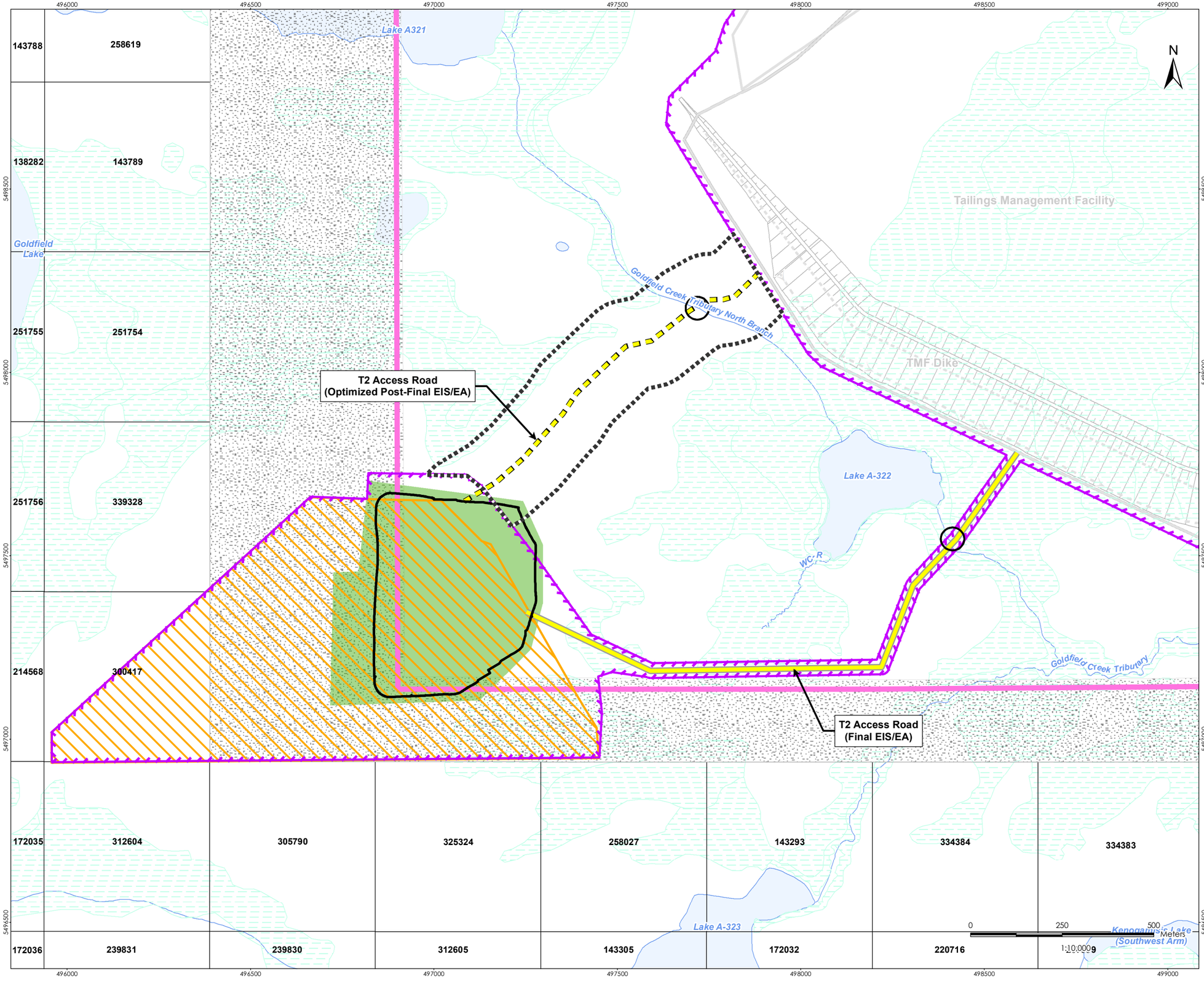

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Revised: 2019-05-17 By: pworsell

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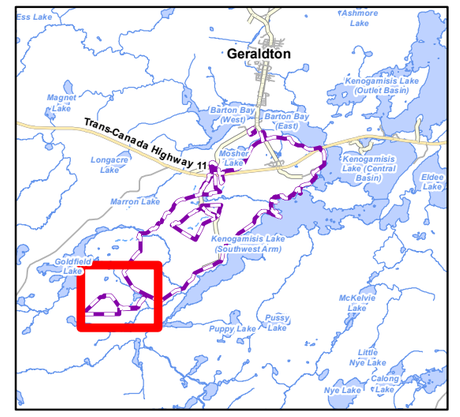
Legend

- Project Development Area (Final EIS/EA)
- Watercrossing
- T2 Access Road (Optimized Post-Final EIS/EA)
- T2 Access Road (Final EIS/EA)
- Aggregate Source T2 Footprint (Final EIS/EA)
- Aggregate Source T2 Permit Boundary (Optimized Post-Final EIS/EA)
- Proposed Aggregate Extraction Limit
- Watercourse
- Area of 2018 Field Studies to Verify Ecosite Communities
- Alienation- Withdrawal (Temporary) Feb 2018, Mining Rights Only
- GGM Mining Lease- CLM 535 (Lease # 109765)
- GGM- Unpatented Claim
- Waterbody
- Wetland



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Greenstone Gold Mines GP Inc. (GGM)
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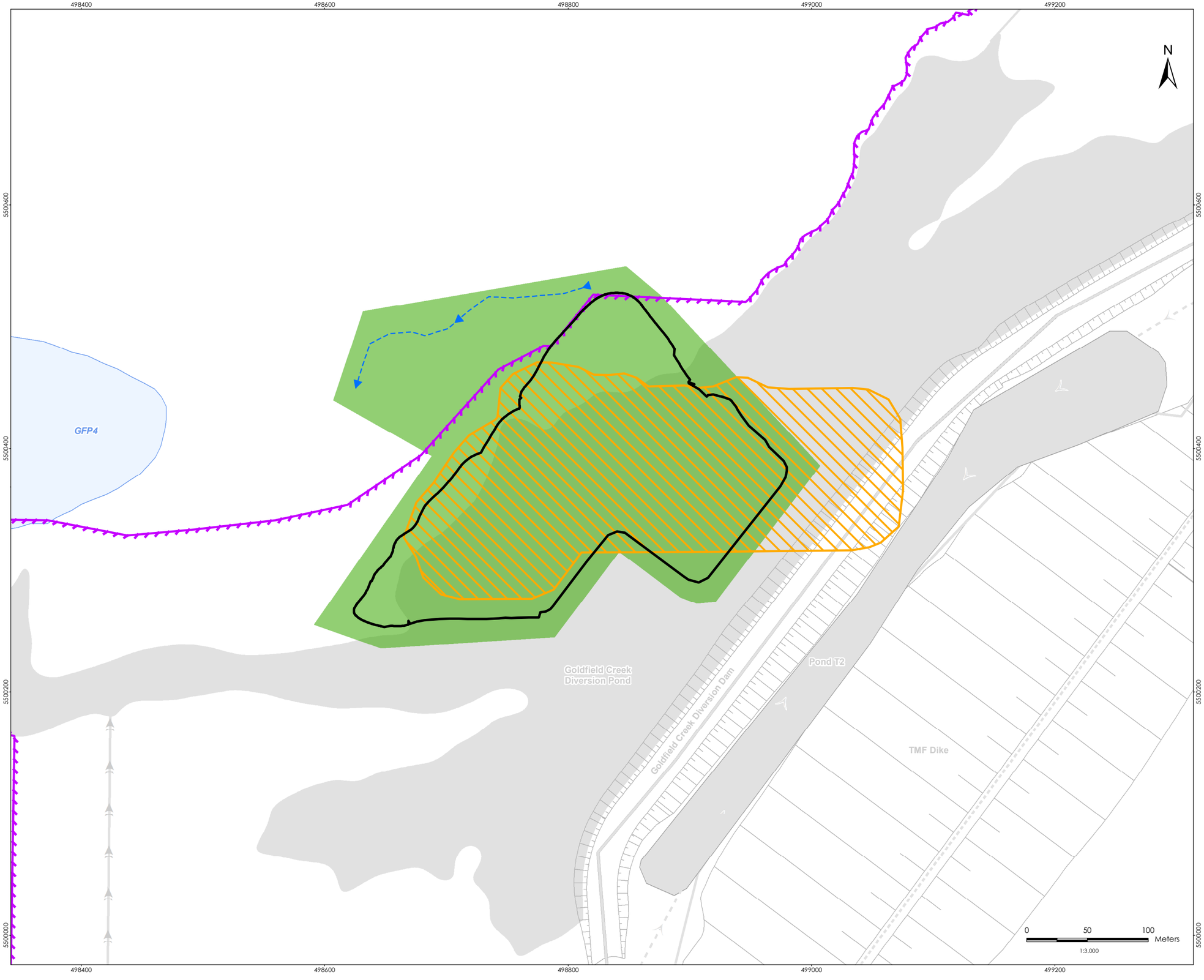
Figure No.

2-4

Title

Aggregate Source T2 Footprint and Access



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Legend

- Project Development Area (Final EIS/EA)
- Aggregate Source S1 Footprint (Final EIS/EA)
- Aggregate Source S1 Permit Boundary (Optimized Post-Final EIS/EA)
- Proposed Aggregate Extraction Limit (Optimized Post-Final EIS/EA)
- Diversion Ditch (Optimized Post-Final EIS/EA)
- Watercourse
- Waterbody

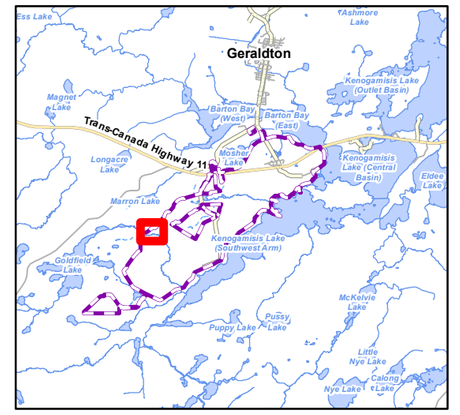

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Figure No.

2-5

Title

Aggregate Source S1 Footprint

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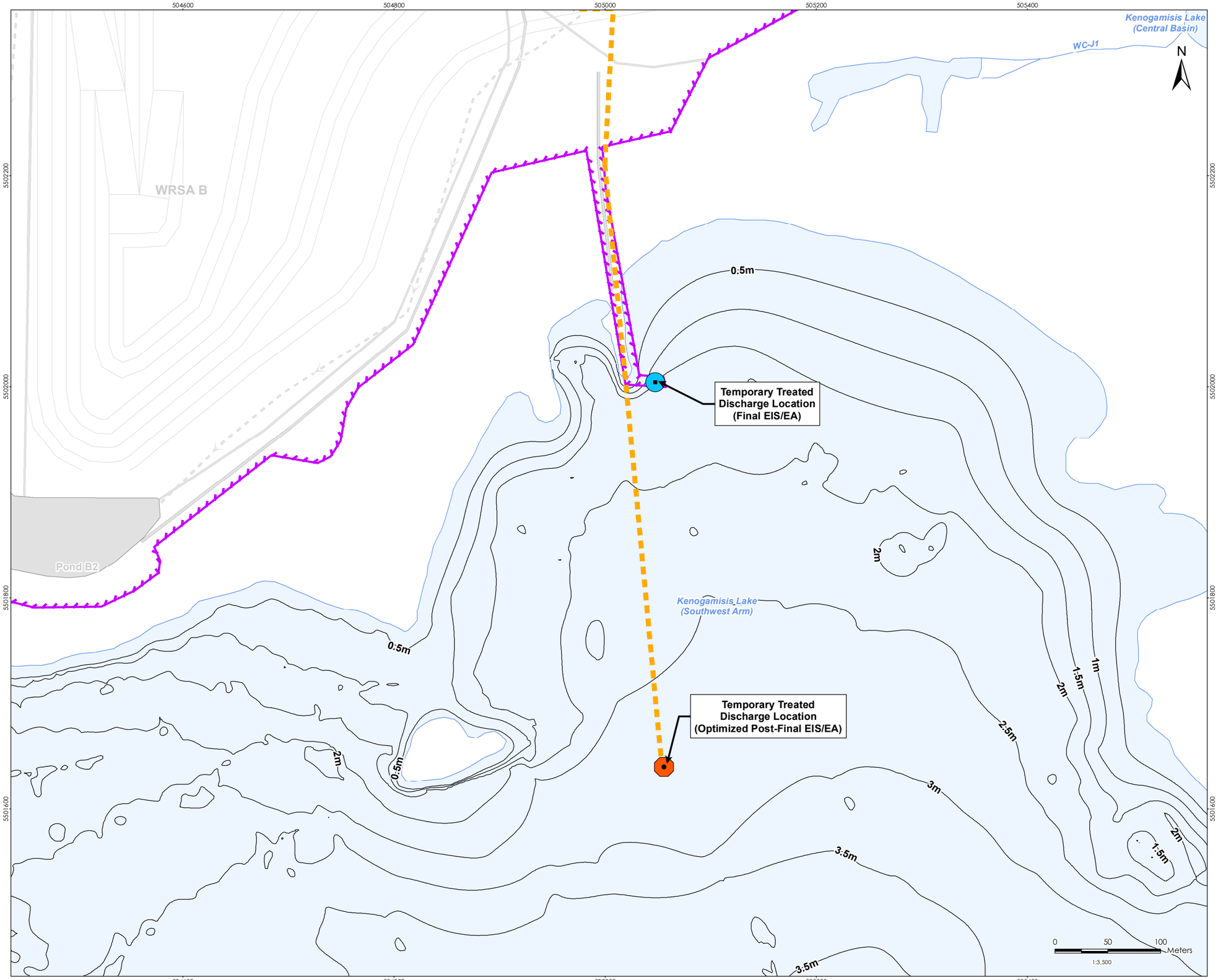

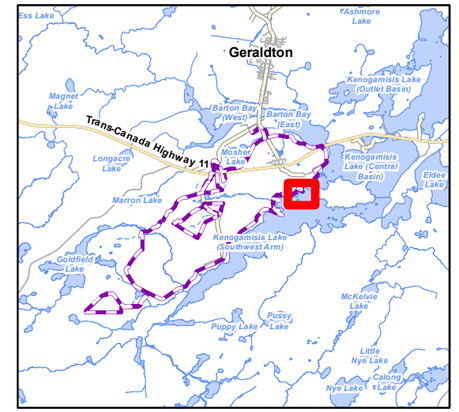

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Legend

- Project Development Area (Final EIS/ EA)
- Temporary Treated Discharge Location (Final EIS/EA)
- Temporary Treated Discharge Location (Optimized Post-Final EIS/EA)
- Effluent Discharge Pipeline (Optimized Post-Final EIS/EA)
- Watercourse
- Waterbody

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Hardrock Project

Figure No.

2-6

Title

Temporary ETP Discharge Pipeline and Diffuser

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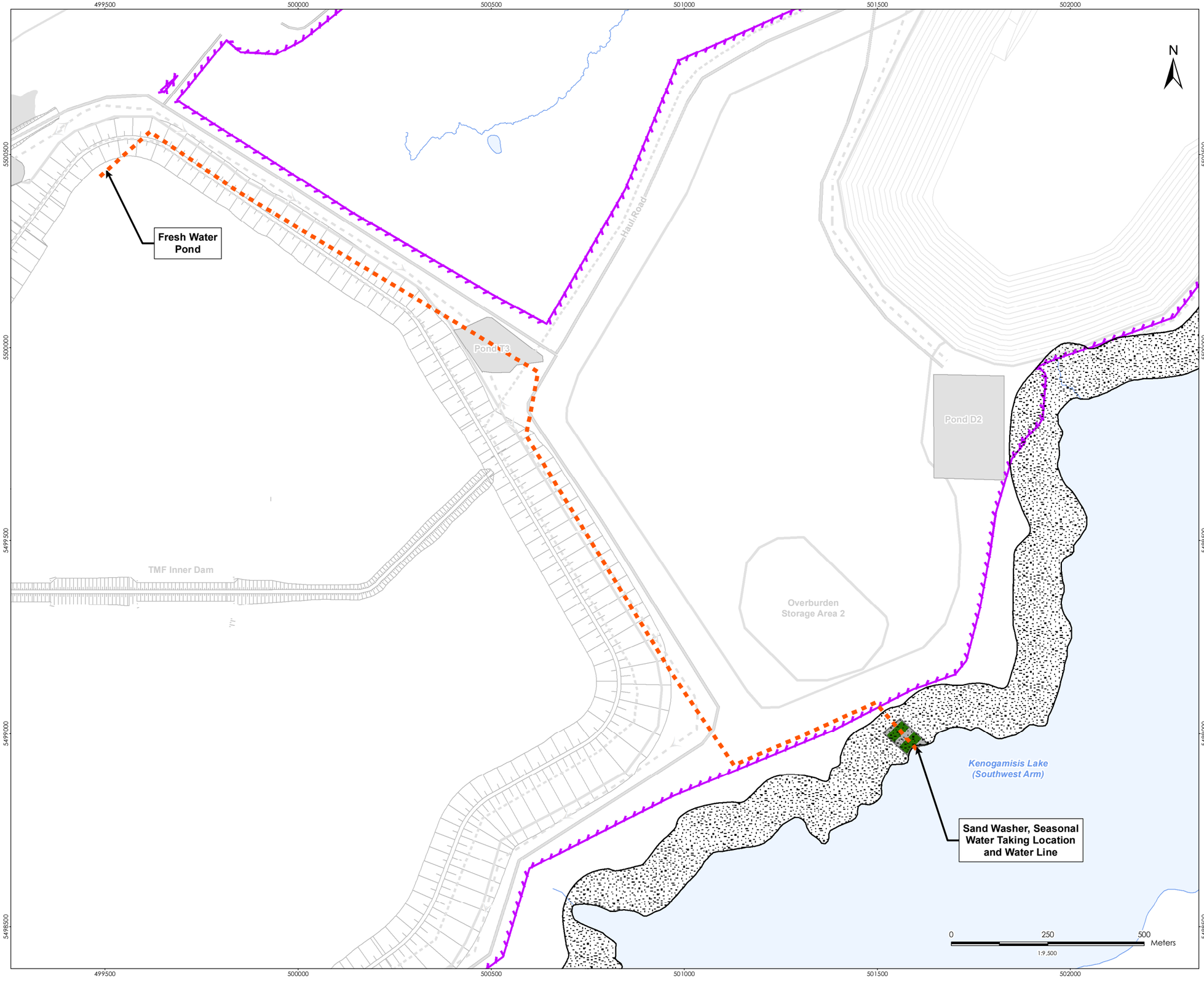

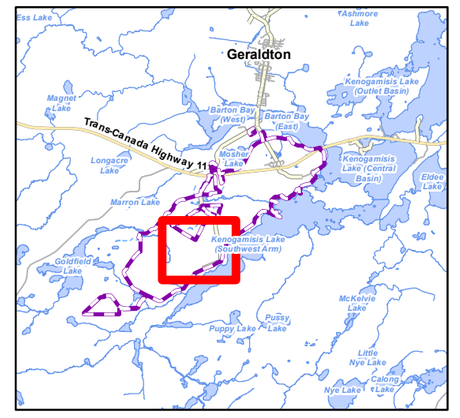

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Legend

- Project Development Area (Final EIS/EA)
- Sand Washer, Seasonal Water Taking Water Line (Added Post-Final EIS/EA)
- Watercourse
- 120m Surface Rights Reservation
- CL 12557
- Waterbody

Notes

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Greenstone Gold Mines GP Inc. (GGM)
Hardrock Project

Figure No.

2-7

Title

Sand Washer, Seasonal Water Taking Location and Water Line

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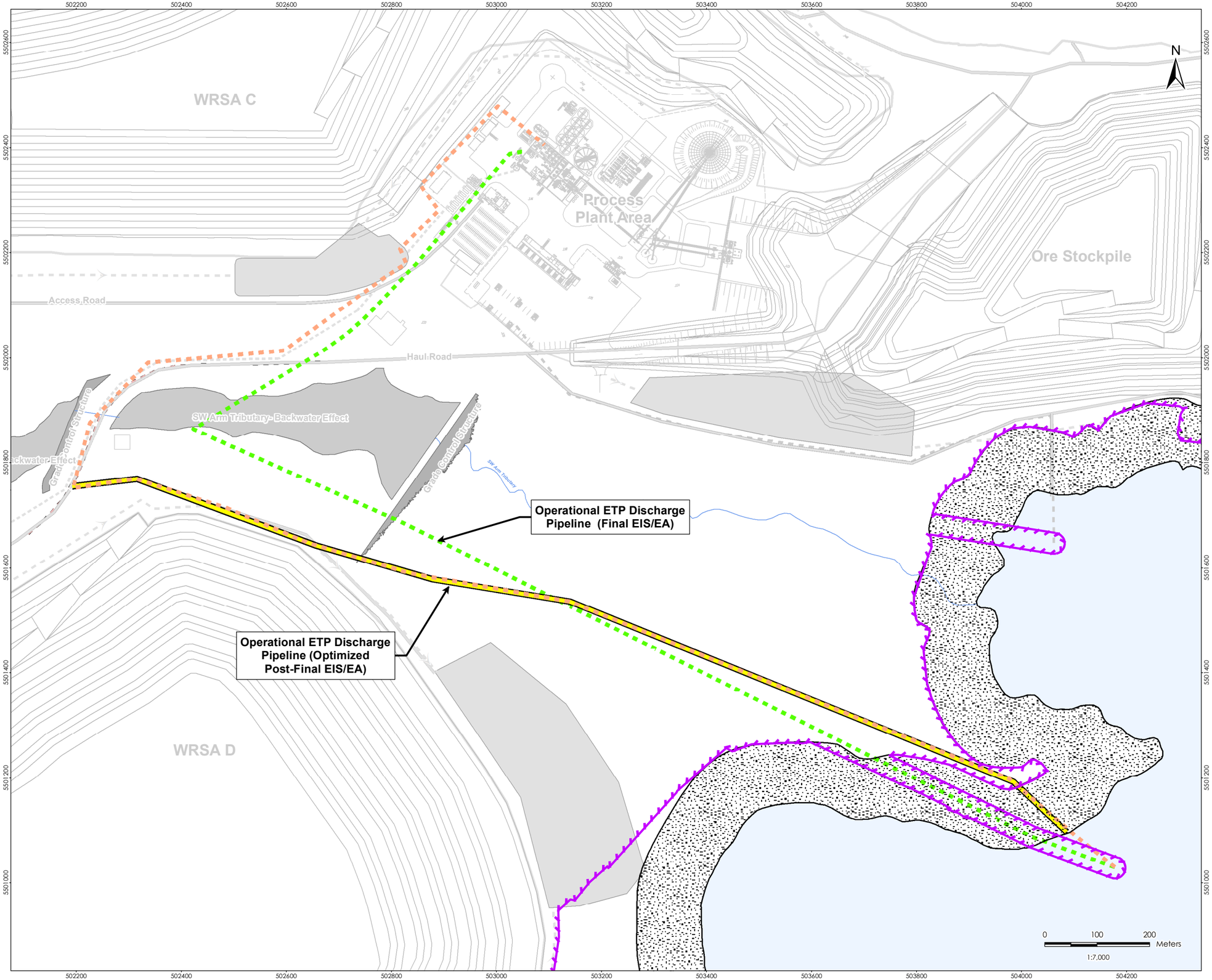

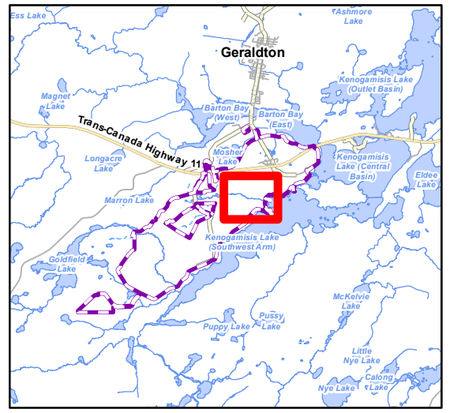

Stantec

Legend

- Project Development Area (Final EIS/EA)
- Operational ETP Discharge Pipeline Access Road (Added Post-Final EIS/EA)
- Operational ETP Discharge Pipeline (Optimized Post-Final EIS/EA)
- Operational ETP Discharge Pipeline (Final EIS/EA)
- Watercourse
- Waterbody
- 120m Surface Rights Reservation

Notes

1. Coordinate System: NAD 1983 UTM Zone 16N
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May 2019
160961111

Client/Project

Greenstone Gold Mines GP Inc. (GGM)
Hardrock Project

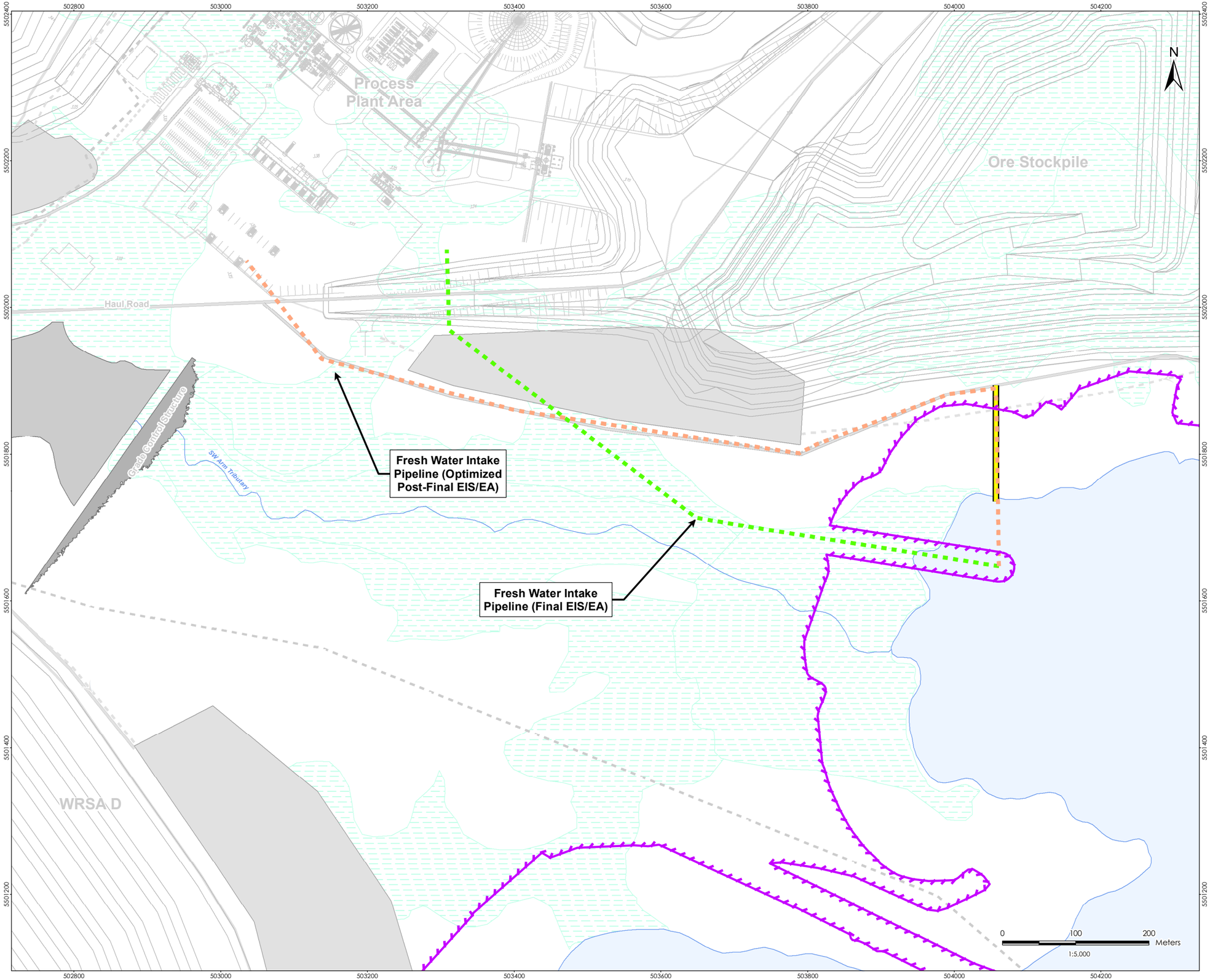
Figure No.

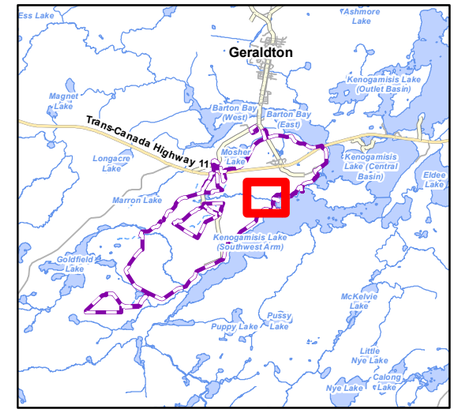
2-8

Title

Operational ETP Discharge Pipeline and Access Road

\\Cd1220-f02\work_group\01609\active\609608651\drawing\MXD\APC\ReportFigures\Design_Optimization\160961223_Fig_2_8_PermanentDischargePipeAndAccessRD_20190516.mxd
Revised: 2019-05-17 By: pworsell





Stantec

Legend

- Project Development Area (Final EIS/EA)
- Fresh Water Intake Pipeline Access Road (Added Post-Final EIS/EA)
- Fresh Water Intake Pipeline (Optimized Post-Final EIS/EA)
- Fresh Water Intake Pipeline (Final EIS/EA)
- Watercourse
- Waterbody
- Wetland

Notes

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Client/Project

Greenstone Gold Mines GP Inc. (GGM)
Hardrock Project

Figure No.

2-9

Title

Fresh Water Intake Pipeline

\\Cd1220-f02\work_group\01609\active\60960865\drawing\MXD\APC\ReportFigures\Design_Optimization\160961223_Fig_2_9_FreshWaterIntakePipeline_20190423.mxd
Revised: 2019-05-17 By: pworsell

501200
501400
501600
501800
5503200
5503000
5502800

Longlac Transformer Station

Mosher Lake

Old Arena Road

Transformer Station Access Road (Final EIS/EA)

44 kV Distribution Line (Final EIS/EA)

44 kV Distribution Line (Optimized Post-Final EIS/EA)

Transformer Station Access Road (Optimized Post-Final EIS/EA)

115 kV Transmission Line (Final EIS/EA)

115 kV Transmission Line (Optimized Post-Final EIS/EA)

MTO Patrol Yard

New Highway 11 Alignment

Trans-Canada Highway 11

Access Road

N

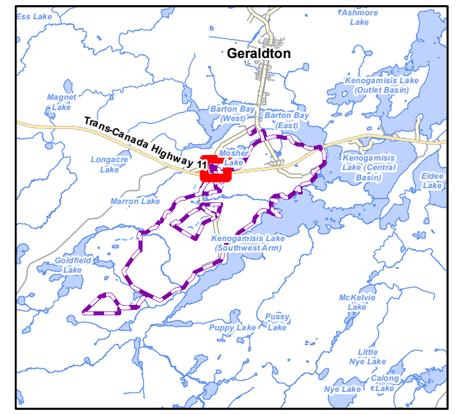
0 50 100 Meters

1:3,000

Stantec

Legend

- Project Development Area (Final EIS/EA)
- Transformer Station Access Road (Final EIS/EA)
- Transformer Station Access Road (Optimized Post-Final EIS/EA)
- 44 kV Distribution Line (Final EIS/EA)
- 44 kV Distribution Line (Optimized Post-Final EIS/EA)
- 115 kV Transmission Line (Final EIS/EA)
- 115 kV Transmission Line (Optimized Post-Final EIS/EA)
- Existing Mosher Pit Access Road
- Highway
- Major Road
- Existing Power Line
- Existing Mosher Pit (Approximate)
- Waterbody



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Client/Project

Greenstone Gold Mines GP Inc. (GGM)
Hardrock Project

Figure No.

2-10

Title

Power Line and Transformer Station Access Road

\\Cd1220-f02\work_group\01609\active\609608651\drawing\MXD\APC\ReportFigures\Design_Optimization\160961223_Fig_2_10_Power_Line_HON_AccessRD_20190506.mxd
Revised: 2019-05-17 By: pworsell