APPENDIX M
AQUATIC ECOLOGY

Attachment 8A FISH PASSAGE ANALYSIS

Stantec

Memo

To:	Paul Harper	From:	John Menninger Dan Hoffman
	Calgary		Cincinnati
File:	110773396	Date:	September 13, 2017 Revision A

Reference: Springbank Off-stream Storage Project (SR1) – Hydraulic Modeling to Support Fish Passage Assessment

Hydraulic modeling was completed to assess the existing conditions and the effects of the proposed project on the velocity and depth of water in the Elbow River at varying flow rates. Two-dimensional (2D) numerical modeling was developed using the RiverFlow2D Plus, version 5.1 two-dimensional finite volume river dynamics model software developed by Hydronia, LLC.

Two model geometries were developed for this assessment representing existing conditions and the proposed conditions with mitigation measures. The model domain is comprised of a triangular mesh with elevations assigned from a digital terrain model. Model mesh elements vary in size from less than 1 m to 7 m depending on the complexity of the terrain and detail of proposed project features.

Manning's roughness parameters in the model are spatially varied based on terrain data and aerial imagery. The roughness parameters were selected based on field reconnaissance photos and recommended literature values included in "Open-Channel Hydraulics" (Chow, 1959). Table 1 below summarizes the Manning's values used in the model.

Table 1. 2D Numerical Model Roughness Parameters

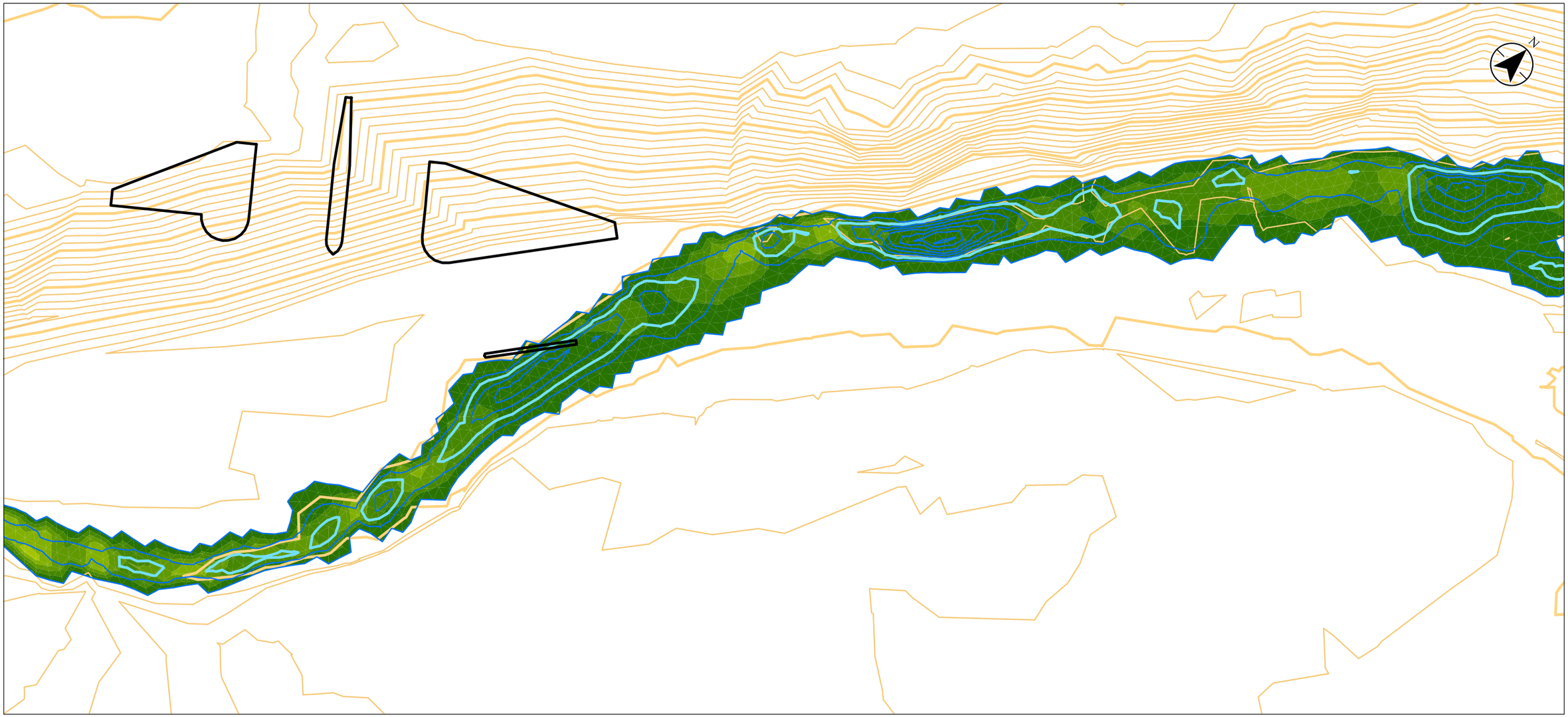
Surface / Land Use Type	Manning's "n"
Open Space / Grass	0.040
Wooded Area	0.100
Wooded Island	0.080
Main Channel / Riprap	0.038
Diversion Structure Concrete	0.013
Auxiliary Spillway RCC	0.020
Exposed Bedrock	0.025

Reference: Springbank Off-stream Storage Project (SR1) – Hydraulic Modeling to Support Fish Passage Assessment

The model domain includes approximately 3.5 km of the Elbow River extending from approximately 1.2 km downstream of the Diversion Structure (just above Highway 22) and 2.3 km upstream. The downstream boundary of the Elbow River at Highway 22 was set using a rating curve developed from the 1D regulatory model of the Elbow River. For each scenario, a fixed water surface elevation was set based on the selected river discharge. Due to their long distance downstream of the Diversion Structure, the selected downstream boundary conditions were observed to have a negligible effect on model results at the Diversion Structure.

The upstream boundary for each model scenario is a specified constant discharge rate. The simulation is then run until a steady-state condition is reached within the model. Model simulations were completed for the following discharge values: 0.8, 2.4, 2.8, 3.5, 9.8, 15, 70, 76 m^3/s.

Results of the analysis (depth averaged velocity and flow depth) are presented on the attached figures.



Legend

- Model Domain Lines
- **Depth Contours (0.1 m interval)**
  - All depth contours
  - 0.2 m depth contour
- **Bed Contours (1 m interval)**
  - Intermediate
  - Index

Velocity (m/s)

- 3.5 - 3.75
- 3.25 - 3.5
- 3 - 3.25
- 2.75 - 3
- 2.5 - 2.75
- 2.25 - 2.5
- 2 - 2.25
- 1.75 - 2
- 1.5 - 1.75
- 1.25 - 1.5
- 1 - 1.25
- 0.75 - 1
- 0.5 - 0.75
- 0.25 - 0.5
- 0 - 0.25
- 0

0 20 40 Meters

1:1,000 (At original document size of 11x17)

Notes

1. Coordinate System: NAD 1983 3TM 114

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Technical Review by ABC on 2017-02-xx
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Client/Project
Alberta Transportation
Springbank Off-Stream Reservoir (SR1)

Figure No.
1 of 2

Title
Fish Passage Simulation
Existing Conditions, 0.8 cms

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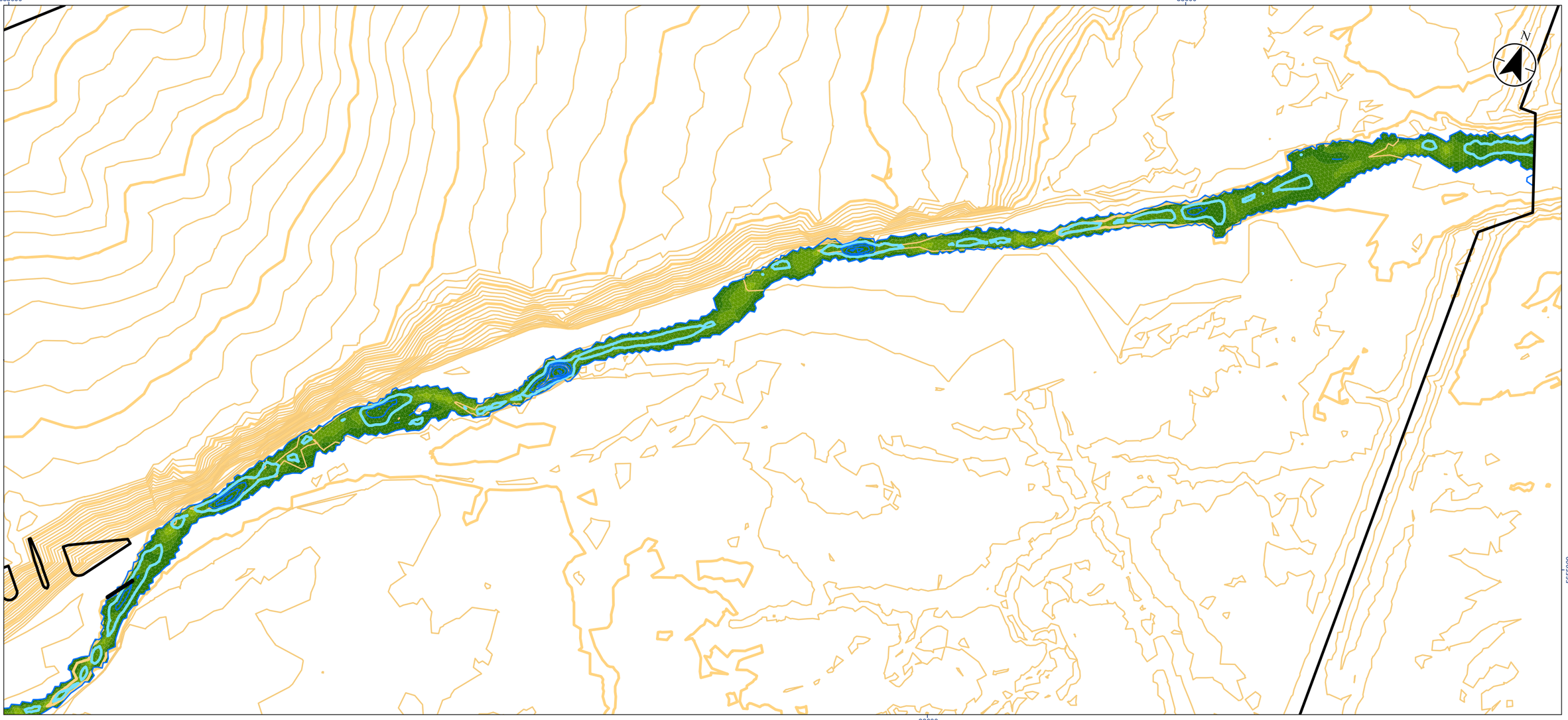

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Legend

- Model Domain Lines

Depth Contours (0.2 m interval)

- All depth contours
- 0.2 m depth contour

Bed Contours (1 m interval)

- Intermediate
- Index

Velocity (m/s)

- 3.5 - 3.75
- 3.25 - 3.5
- 3 - 3.25
- 2.75 - 3
- 2.5 - 2.75
- 2.25 - 2.5
- 2 - 2.25
- 1.75 - 2
- 1.5 - 1.75
- 1.25 - 1.5
- 1 - 1.25
- 0.75 - 1
- 0.5 - 0.75
- 0.25 - 0.5
- 0 - 0.25
- 0

0 60 120 Meters

1:3,000 (At original document size of 11x17)

Notes

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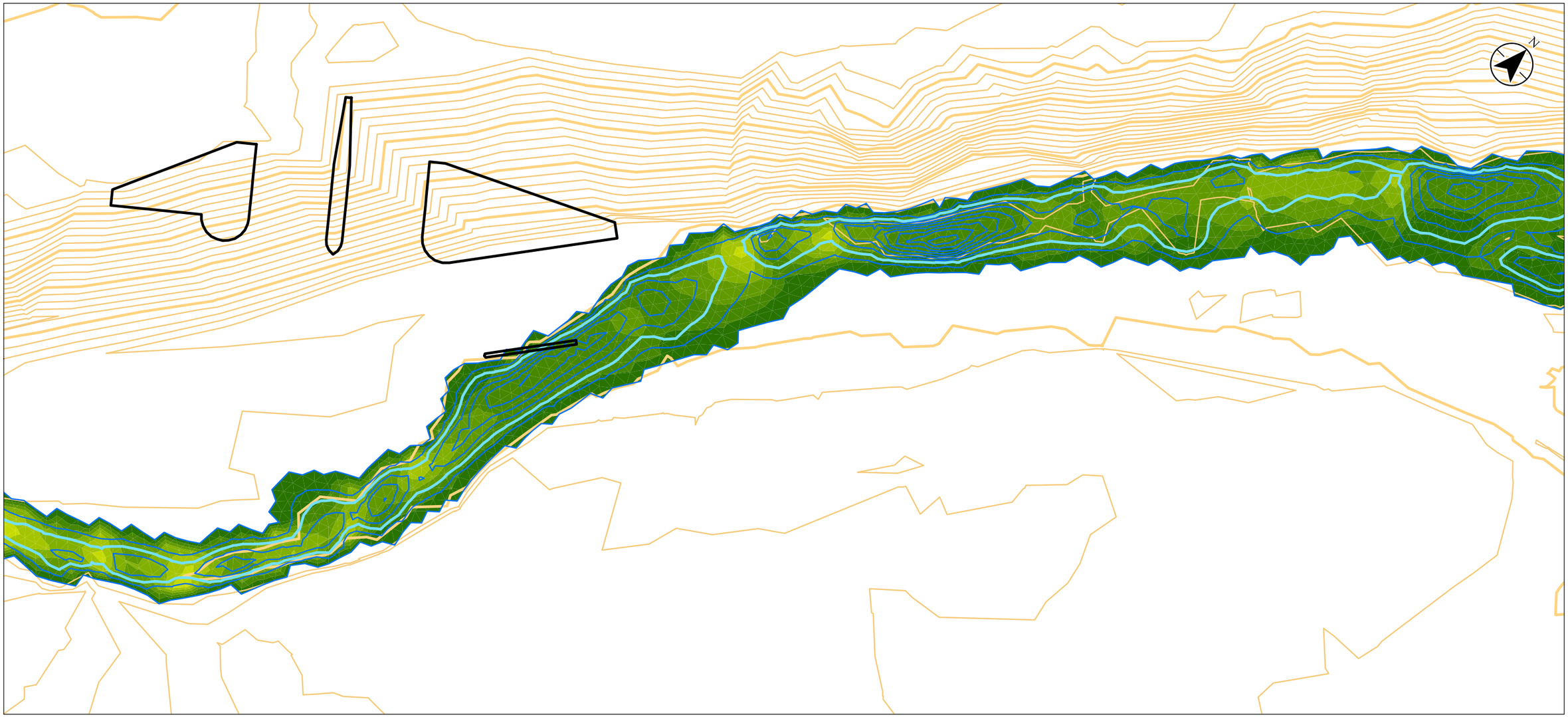
Figure No.
2 of 2

Title
Fish Passage Simulation
Existing Conditions, 0.8 cms



Legend

- Model Domain Lines

Depth Contours (0.1 m interval)

- All depth contours
- 0.2 m depth contour

Bed Contours (1 m interval)

- Intermediate
- Index

Velocity (m/s)

- 3.5 - 3.75
- 3.25 - 3.5
- 3 - 3.25
- 2.75 - 3
- 2.5 - 2.75
- 2.25 - 2.5
- 2 - 2.25
- 1.75 - 2
- 1.5 - 1.75
- 1.25 - 1.5
- 1 - 1.25
- 0.75 - 1
- 0.5 - 0.75
- 0.25 - 0.5
- 0 - 0.25
- 0

0 20 40 Meters

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Figure No.
1 of 2

Title
Fish Passage Simulation
Existing Conditions, 2.38 cms

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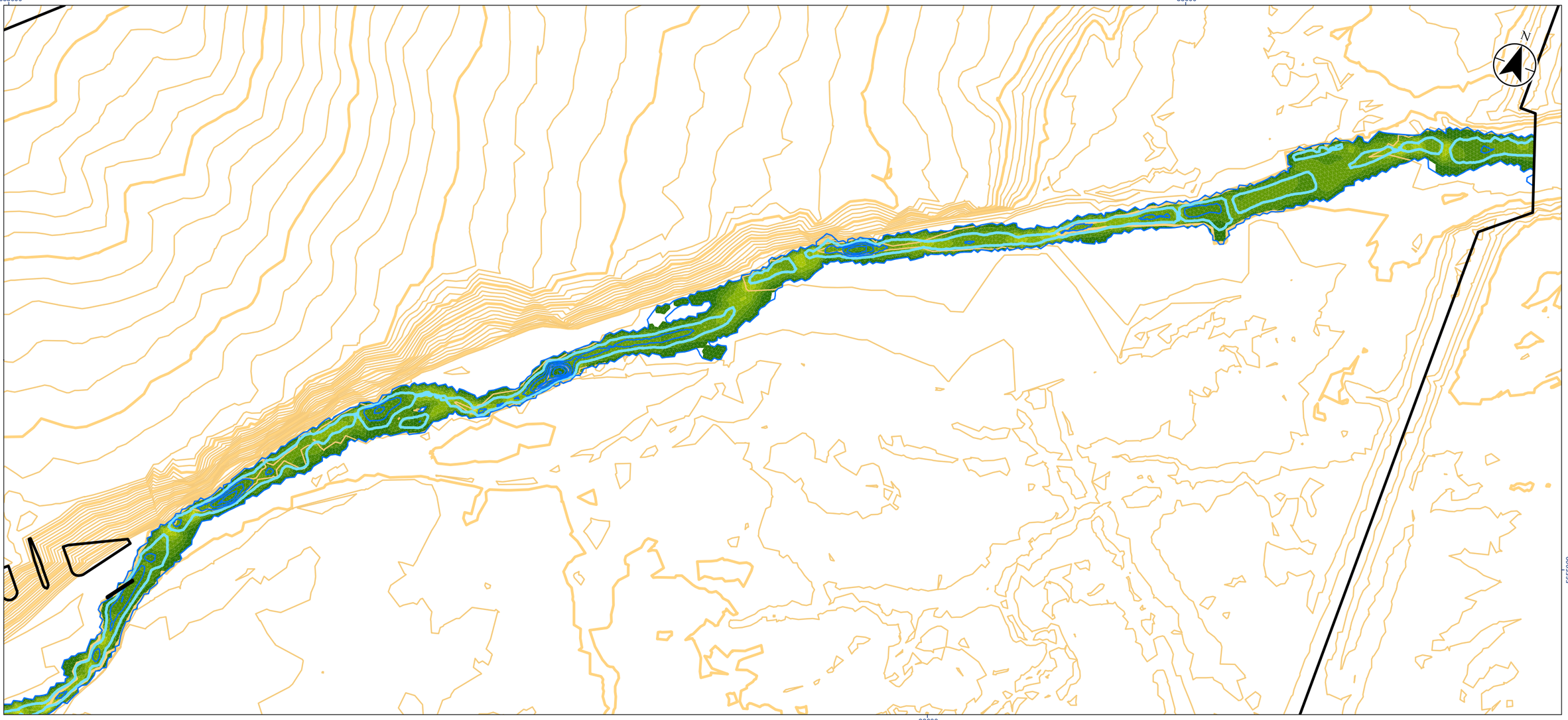

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Legend

- Model Domain Lines

Depth Contours (0.2 m interval)

- All depth contours
- 0.2 m depth contour

Bed Contours (1 m interval)

- Intermediate
- Index

Velocity (m/s)

- 3.5 - 3.75
- 3.25 - 3.5
- 3 - 3.25
- 2.75 - 3
- 2.5 - 2.75
- 2.25 - 2.5
- 2 - 2.25
- 1.75 - 2
- 1.5 - 1.75
- 1.25 - 1.5
- 1 - 1.25
- 0.75 - 1
- 0.5 - 0.75
- 0.25 - 0.5
- 0 - 0.25
- 0

0 60 120 Meters

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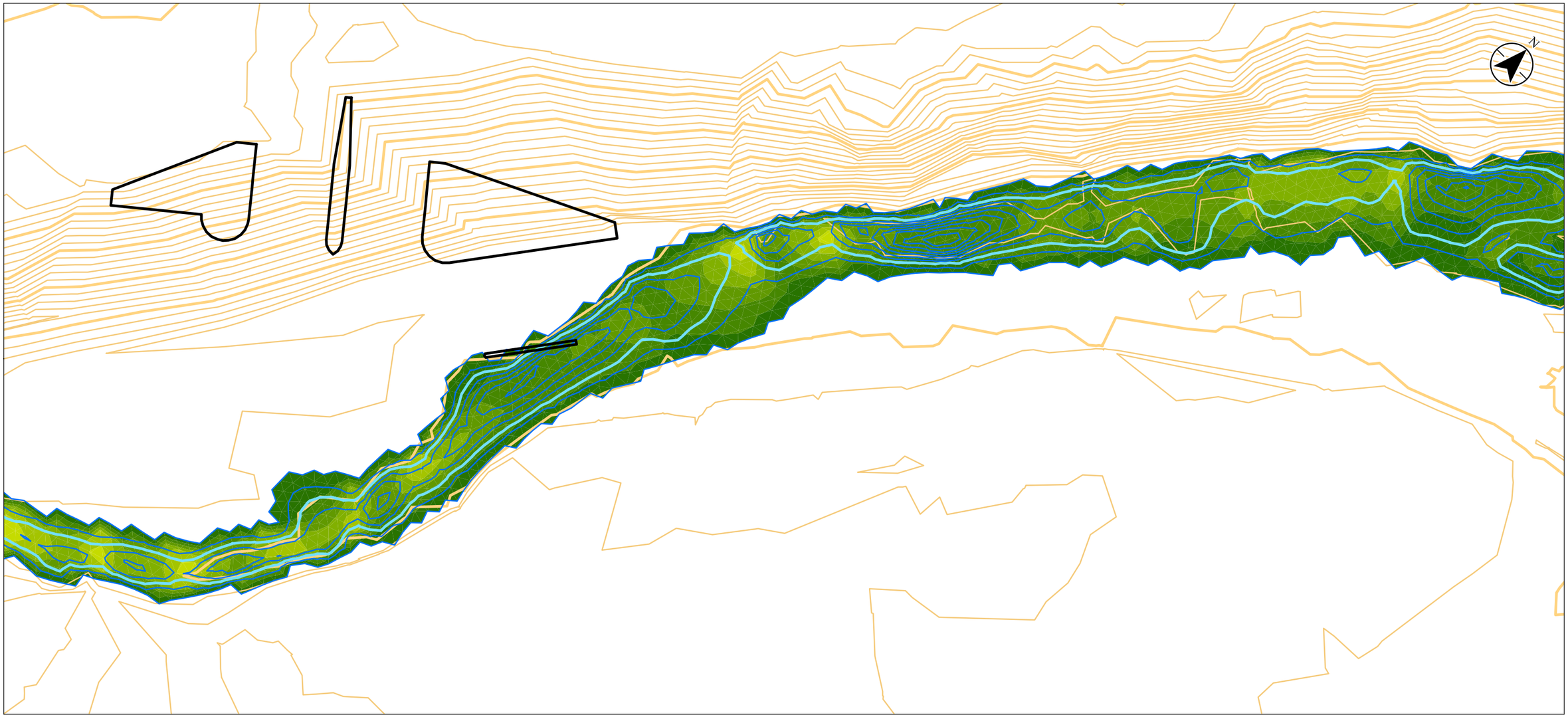
Figure No.
2 of 2

Title
Fish Passage Simulation
Existing Conditions, 2.38 cms



Legend

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Depth Contours (0.1 m interval)

- All depth contours
- 0.2 m depth contour

Bed Contours (1 m interval)

- Intermediate
- Index

Velocity (m/s)

- 3.5 - 3.75
- 3.25 - 3.5
- 3 - 3.25
- 2.75 - 3
- 2.5 - 2.75
- 2.25 - 2.5
- 2 - 2.25
- 1.75 - 2
- 1.5 - 1.75
- 1.25 - 1.5
- 1 - 1.25
- 0.75 - 1
- 0.5 - 0.75
- 0.25 - 0.5
- 0 - 0.25
- 0

0 20 40 Meters

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Figure No.
1 of 2

Title
Fish Passage Simulation
Existing Conditions, 2.8 cms

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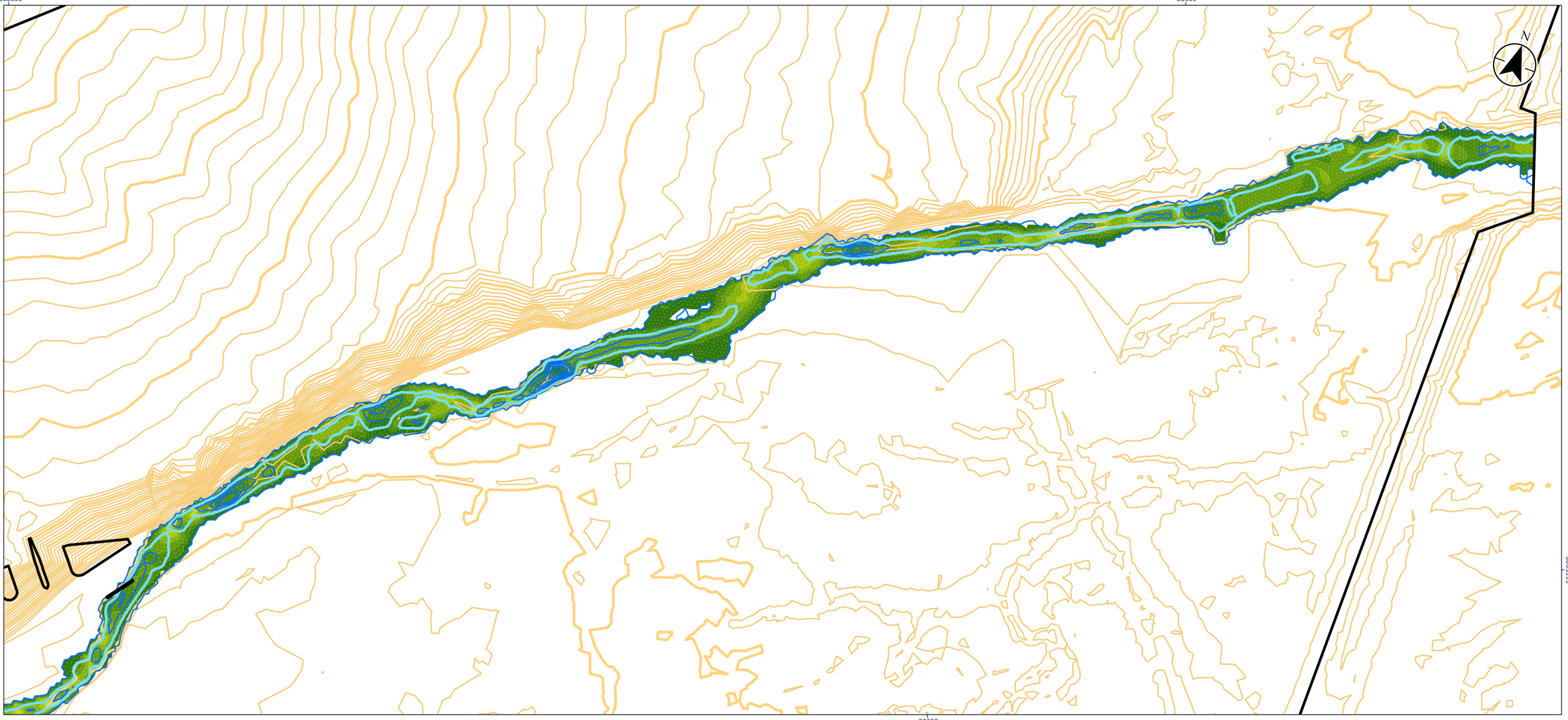

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Legend

- Model Domain Lines

Depth Contours (0.2 m interval)

- All depth contours
- 0.2 m depth contour

Bed Contours (1 m interval)

- Intermediate
- Index

Velocity (m/s)

- 3.5 - 3.75
- 3.25 - 3.5
- 3 - 3.25
- 2.75 - 3
- 2.5 - 2.75
- 2.25 - 2.5
- 2 - 2.25
- 1.75 - 2
- 1.5 - 1.75
- 1.25 - 1.5
- 1 - 1.25
- 0.75 - 1
- 0.5 - 0.75
- 0.25 - 0.5
- 0 - 0.25
- 0

0 60 120 Meters

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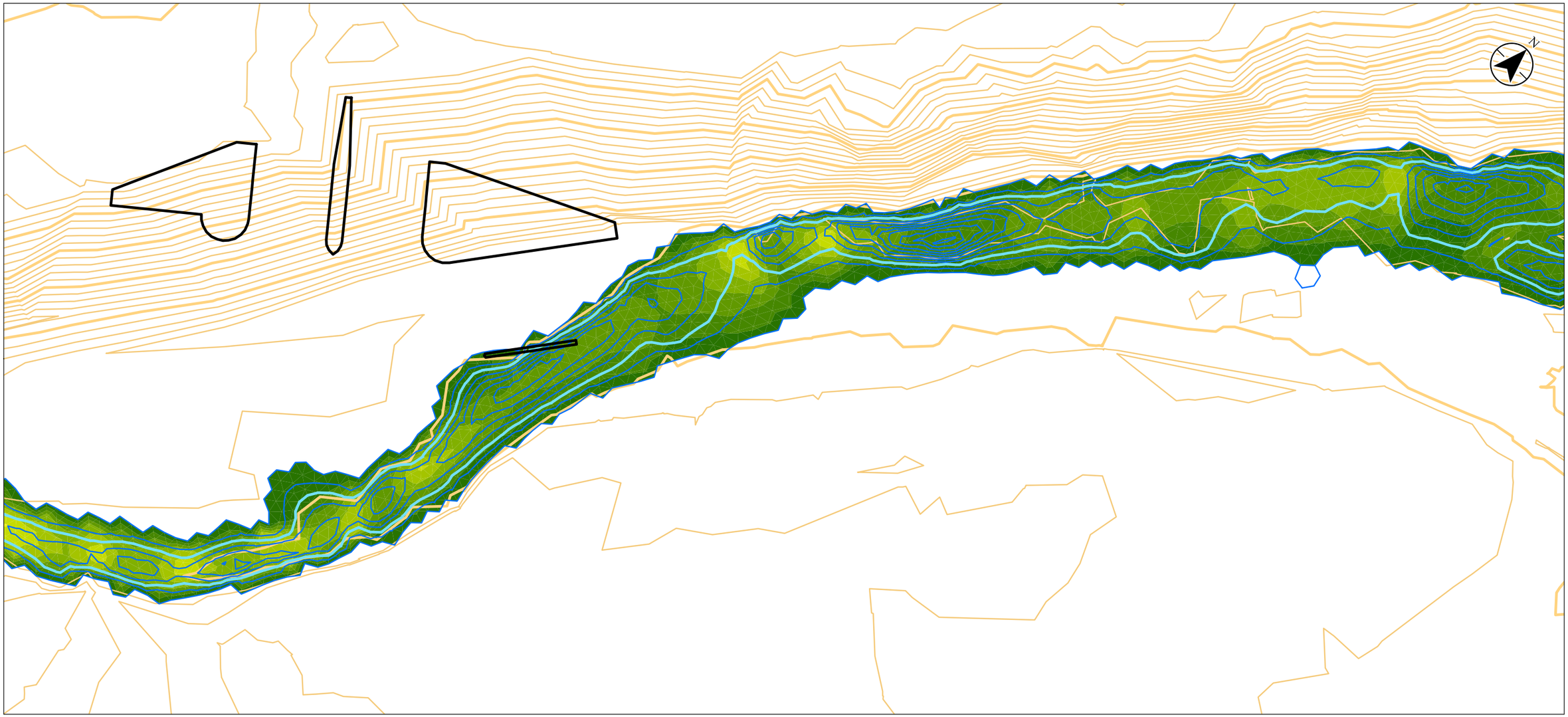
Figure No.
2 of 2

Title
Fish Passage Simulation
Existing Conditions, 2.8 cms



Legend

- Model Domain Lines

Depth Contours (0.1 m interval)

- All depth contours
- 0.2 m depth contour

Bed Contours (1 m interval)

- Intermediate
- Index

Velocity (m/s)

- 3.5 - 3.75
- 3.25 - 3.5
- 3 - 3.25
- 2.75 - 3
- 2.5 - 2.75
- 2.25 - 2.5
- 2 - 2.25
- 1.75 - 2
- 1.5 - 1.75
- 1.25 - 1.5
- 1 - 1.25
- 0.75 - 1
- 0.5 - 0.75
- 0.25 - 0.5
- 0 - 0.25
- 0

0 20 40 Meters

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Figure No.
1 of 2

Title
Fish Passage Simulation
Existing Conditions, 3.47 cms

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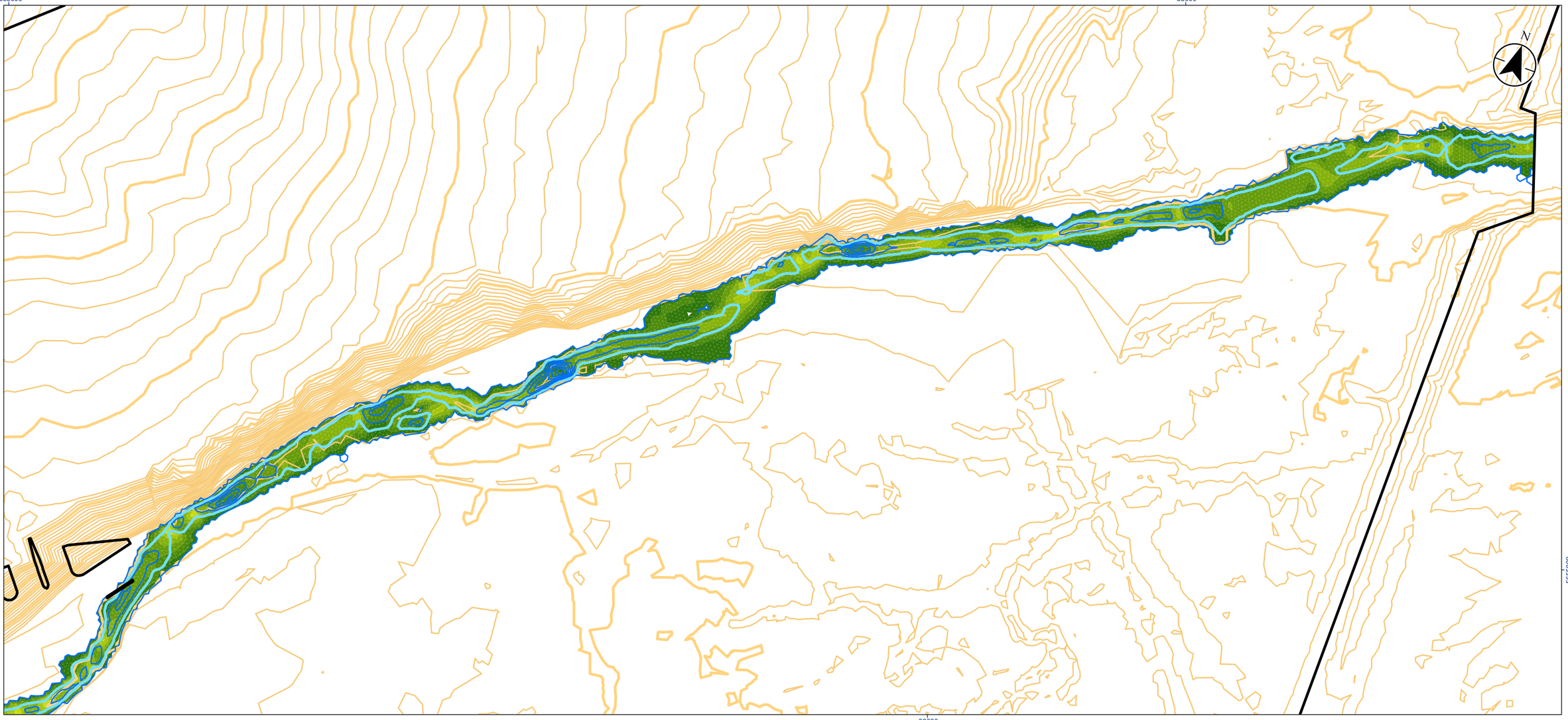

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Legend

- Model Domain Lines

Depth Contours (0.2 m interval)

- All depth contours
- 0.2 m depth contour

Bed Contours (1 m interval)

- Intermediate
- Index

Velocity (m/s)

- 3.5 - 3.75
- 3.25 - 3.5
- 3 - 3.25
- 2.75 - 3
- 2.5 - 2.75
- 2.25 - 2.5
- 2 - 2.25
- 1.75 - 2
- 1.5 - 1.75
- 1.25 - 1.5
- 1 - 1.25
- 0.75 - 1
- 0.5 - 0.75
- 0.25 - 0.5
- 0 - 0.25
- 0

0 60 120 Meters

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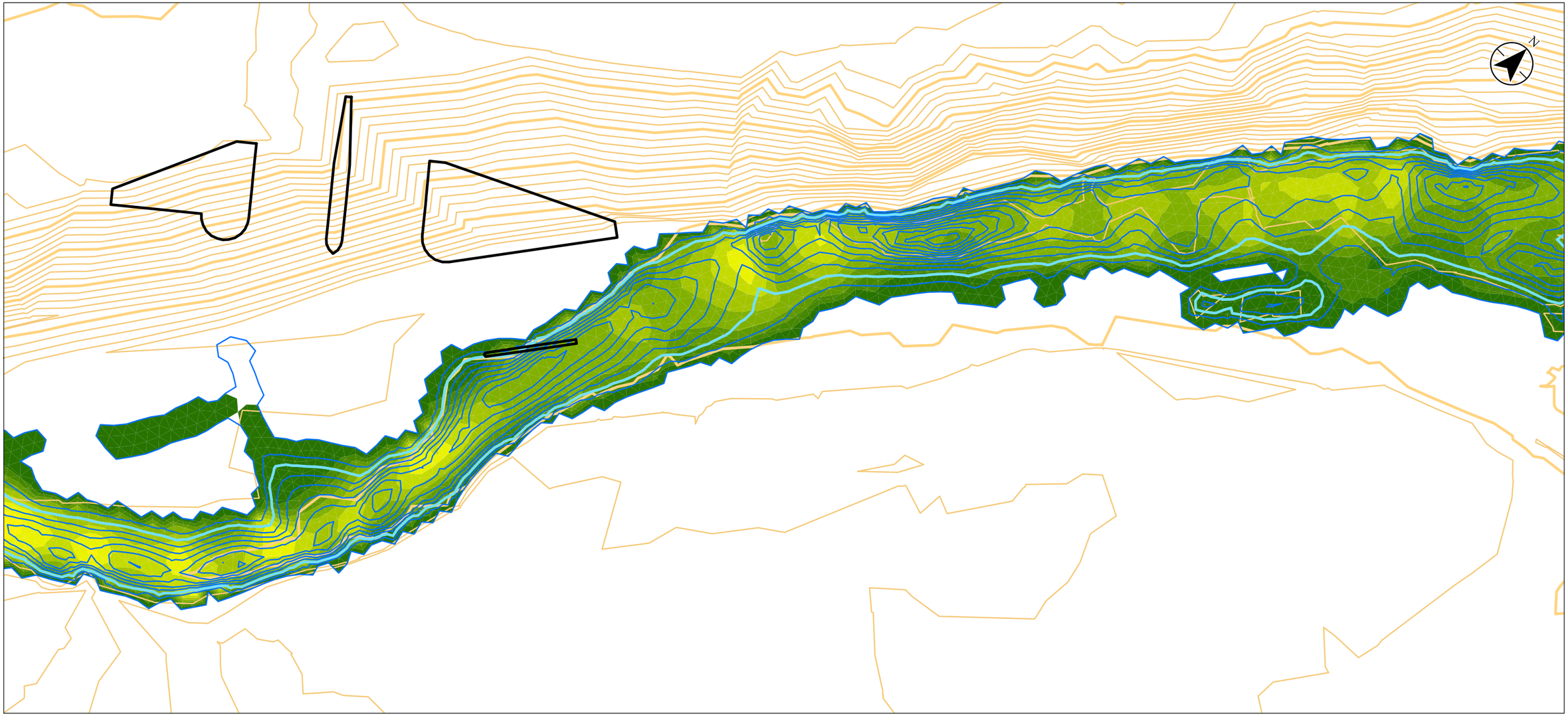
Client/Project
Alberta Transportation
Springbank Off-Stream Reservoir (SR1)

Figure No.
2 of 2

Title
Fish Passage Simulation
Existing Conditions, 3.47 cms



Legend

- Model Domain Lines

Depth Contours (0.1 m interval)

- All depth contours
- 0.2 m depth contour

Bed Contours (1 m interval)

- Intermediate
- Index

Velocity (m/s)

- 3.5 - 3.75
- 3.25 - 3.5
- 3 - 3.25
- 2.75 - 3
- 2.5 - 2.75
- 2.25 - 2.5
- 2 - 2.25
- 1.75 - 2
- 1.5 - 1.75
- 1.25 - 1.5
- 1 - 1.25
- 0.75 - 1
- 0.5 - 0.75
- 0.25 - 0.5
- 0 - 0.25
- 0

0 20 40 Meters

1:1,000 (At original document size of 11x17)

Notes

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Client/Project
Alberta Transportation
Springbank Off-Stream Reservoir (SR1)

Figure No.
1 of 2

Title
Fish Passage Simulation
Existing Conditions, 9.81 cms

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Revised: 2017-08-23 By: dhoffmann

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Legend

- Model Domain Lines

Depth Contours (0.2 m interval)

- All depth contours
- 0.2 m depth contour

Bed Contours (1 m interval)

- Intermediate
- Index

Velocity (m/s)

- 3.5 - 3.75
- 3.25 - 3.5
- 3 - 3.25
- 2.75 - 3
- 2.5 - 2.75
- 2.25 - 2.5
- 2 - 2.25
- 1.75 - 2
- 1.5 - 1.75
- 1.25 - 1.5
- 1 - 1.25
- 0.75 - 1
- 0.5 - 0.75
- 0.25 - 0.5
- 0 - 0.25
- 0

0 60 120 Meters

1:3,000 (At original document size of 11x17)

Notes

1. Coordinate System: NAD 1983 3TM 114

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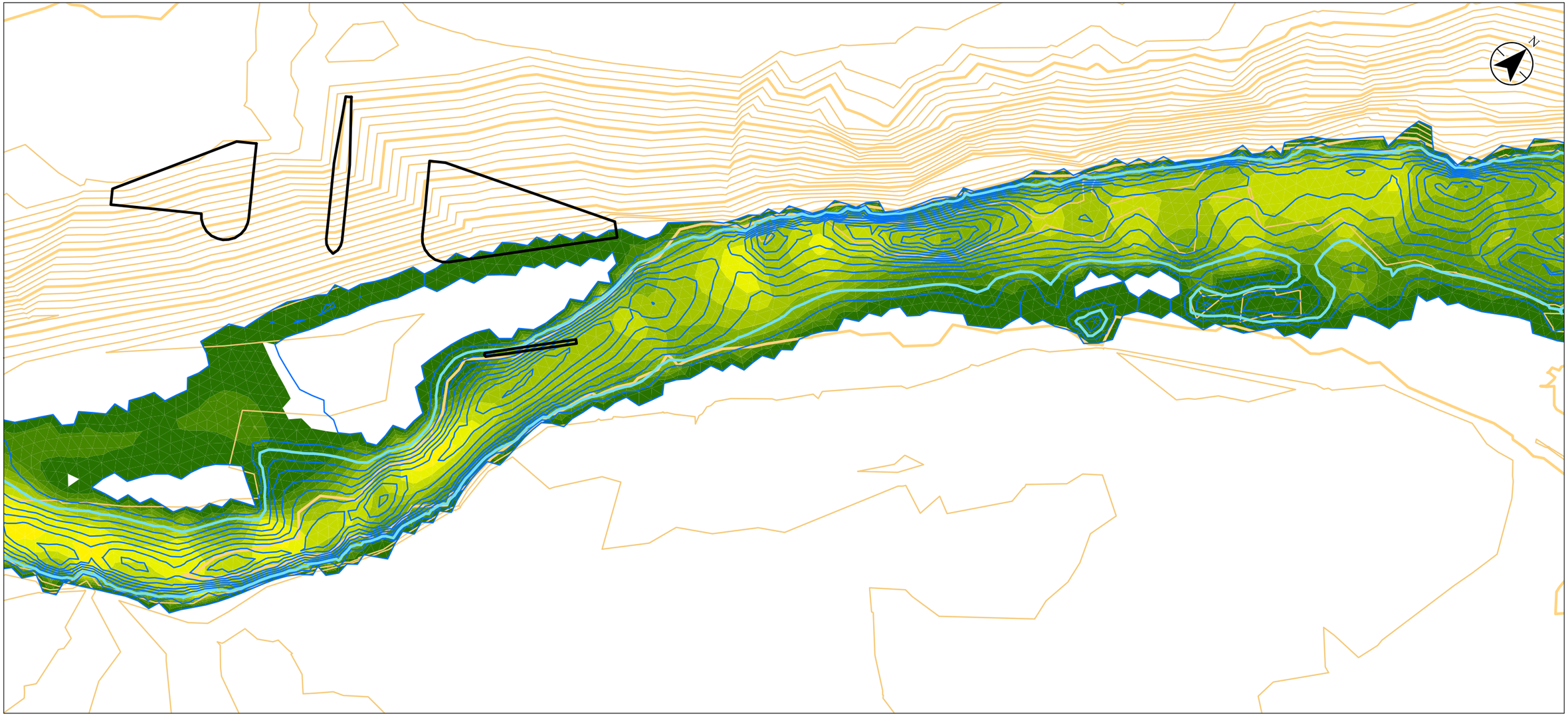
Client/Project
Alberta Transportation
Springbank Off-Stream Reservoir (SR1)

Figure No.
2 of 2

Title
Fish Passage Simulation
Existing Conditions, 9.81 cms



Legend

- Model Domain Lines

Depth Contours (0.1 m interval)

- All depth contours
- 0.2 m depth contour

Bed Contours (1 m interval)

- Intermediate
- Index

Velocity (m/s)

- 3.5 - 3.75
- 3.25 - 3.5
- 3 - 3.25
- 2.75 - 3
- 2.5 - 2.75
- 2.25 - 2.5
- 2 - 2.25
- 1.75 - 2
- 1.5 - 1.75
- 1.25 - 1.5
- 1 - 1.25
- 0.75 - 1
- 0.5 - 0.75
- 0.25 - 0.5
- 0 - 0.25
- 0

0 20 40 Meters

1:1,000 (At original document size of 11x17)

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Alberta Transportation
Springbank Off-Stream Reservoir (SR1)

Figure No.
1 of 2

Title
Fish Passage Simulation
Existing Conditions, 15 cms

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5655000

-33000

Legend

Model Domain Lines

Depth Contours (0.2 m interval)

All depth contours

0.2 m depth contour

Bed Contours (1 m interval)

Intermediate

Index

Velocity (m/s)

3.5 - 3.75

3.25 - 3.5

3 - 3.25

2.75 - 3

2.5 - 2.75

2.25 - 2.5

2 - 2.25

1.75 - 2

1.5 - 1.75

1.25 - 1.5

1 - 1.25

0.75 - 1

0.5 - 0.75

0.25 - 0.5

0 - 0.25

0

0 60 120 Meters

1:3,000 (At original document size of 11x17)

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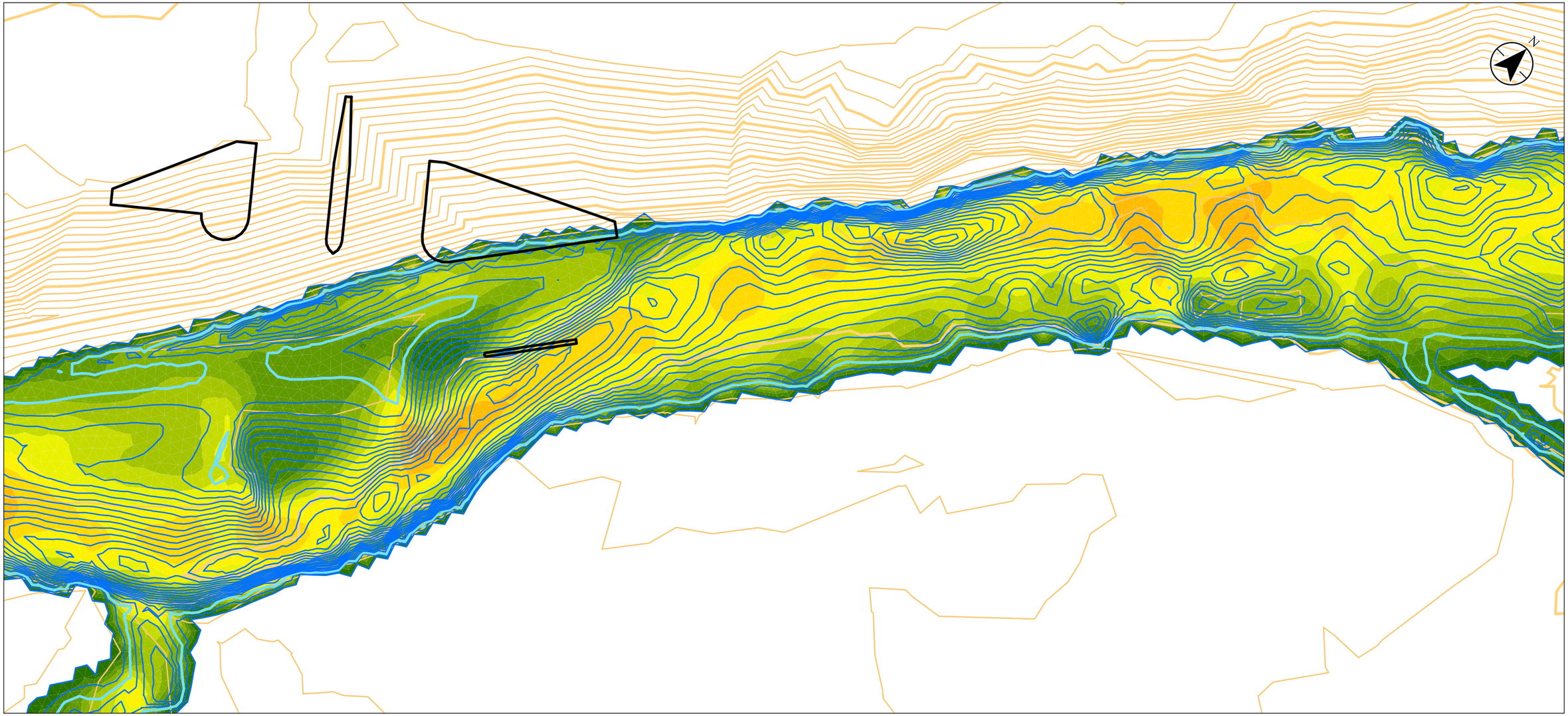
Figure No.
2 of 2

Title
Fish Passage Simulation
Existing Conditions, 15 cms



Legend

- Model Domain Lines

Depth Contours (0.1 m interval)

- All depth contours
- 0.2 m depth contour

Bed Contours (1 m interval)

- Intermediate
- Index

Velocity (m/s)

- 3.5 - 3.75
- 3.25 - 3.5
- 3 - 3.25
- 2.75 - 3
- 2.5 - 2.75
- 2.25 - 2.5
- 2 - 2.25
- 1.75 - 2
- 1.5 - 1.75
- 1.25 - 1.5
- 1 - 1.25
- 0.75 - 1
- 0.5 - 0.75
- 0.25 - 0.5
- 0 - 0.25
- 0

0 20 40 Meters

1:1,000 (At original document size of 11x17)

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Client/Project
Alberta Transportation
Springbank Off-Stream Reservoir (SR1)

Figure No.
1 of 2

Title
Fish Passage Simulation
Existing Conditions, 69.5 cms

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Revised: 2017-09-23 By: dhoffmann

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Legend

- Model Domain Lines

Depth Contours (0.2 m interval)

- All depth contours
- 0.2 m depth contour

Bed Contours (1 m interval)

- Intermediate
- Index

Velocity (m/s)

- 3.5 - 3.75
- 3.25 - 3.5
- 3 - 3.25
- 2.75 - 3
- 2.5 - 2.75
- 2.25 - 2.5
- 2 - 2.25
- 1.75 - 2
- 1.5 - 1.75
- 1.25 - 1.5
- 1 - 1.25
- 0.75 - 1
- 0.5 - 0.75
- 0.25 - 0.5
- 0 - 0.25
- 0

0 60 120 Meters

1:3,000 (At original document size of 11x17)

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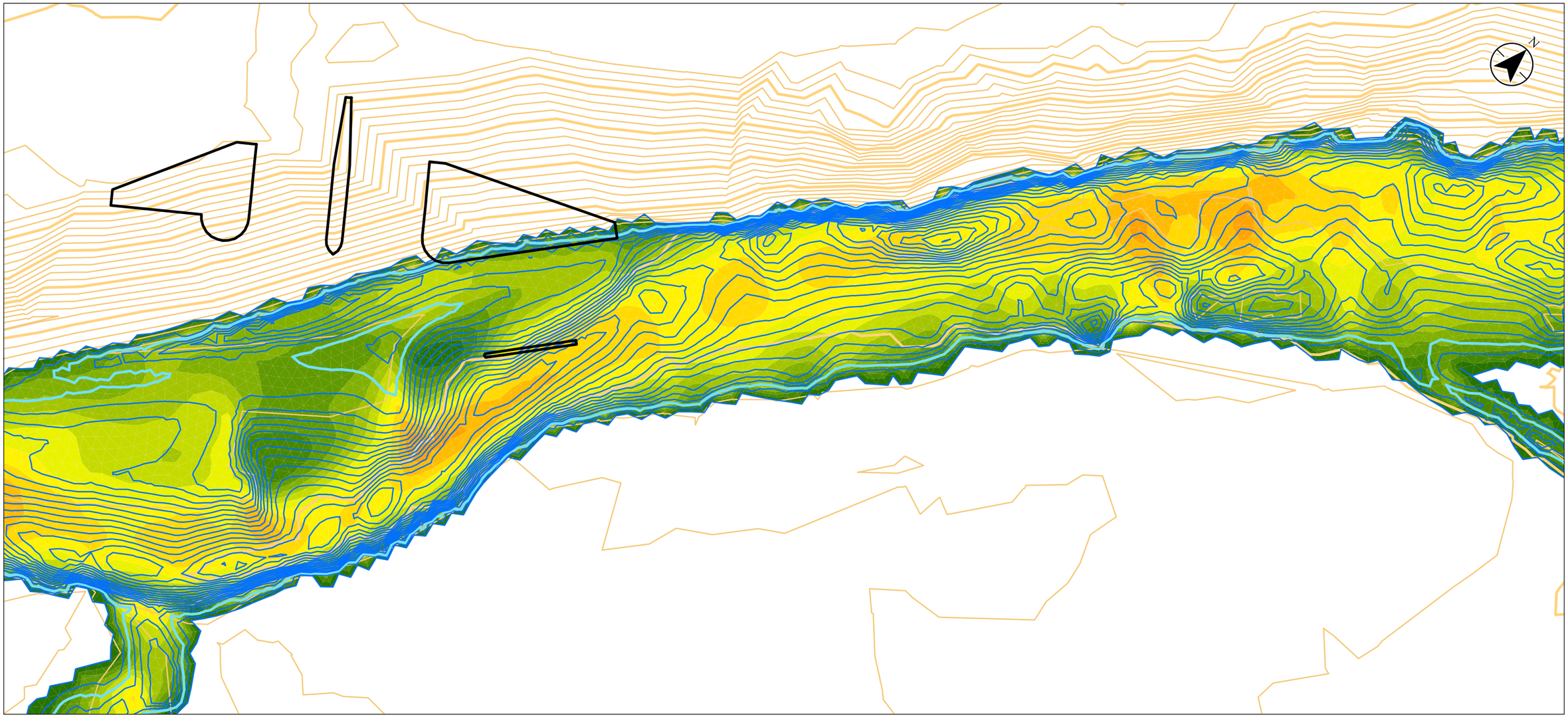
Springbank Off-Stream Reservoir (SR1)

Figure No.
2 of 2

Title
Fish Passage Simulation
Existing Conditions, 69.5 cms



Legend

- Model Domain Lines

Depth Contours (0.1 m interval)

- All depth contours
- 0.2 m depth contour

Bed Contours (1 m interval)

- Intermediate
- Index

Velocity (m/s)

- 3.5 - 3.75
- 3.25 - 3.5
- 3 - 3.25
- 2.75 - 3
- 2.5 - 2.75
- 2.25 - 2.5
- 2 - 2.25
- 1.75 - 2
- 1.5 - 1.75
- 1.25 - 1.5
- 1 - 1.25
- 0.75 - 1
- 0.5 - 0.75
- 0.25 - 0.5
- 0 - 0.25
- 0

0 20 40 Meters

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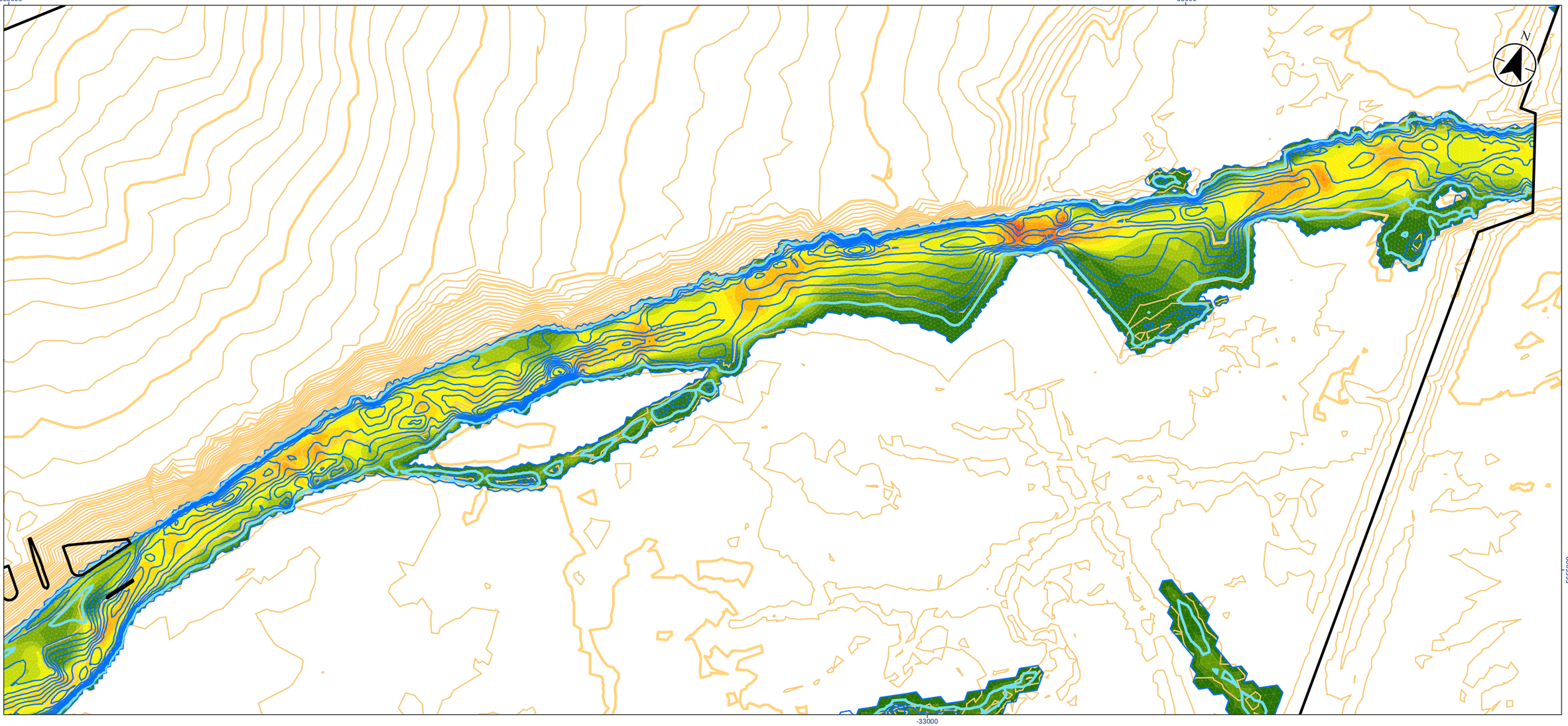
1 of 2

Title
Fish Passage Simulation
Existing Conditions, 75.7 cms

5655000

-33000



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Legend

- Model Domain Lines

Depth Contours (0.2 m interval)

- All depth contours
- 0.2 m depth contour

Bed Contours (1 m interval)

- Intermediate
- Index

Velocity (m/s)

- 3.5 - 3.75
- 3.25 - 3.5
- 3 - 3.25
- 2.75 - 3
- 2.5 - 2.75
- 2.25 - 2.5
- 2 - 2.25
- 1.75 - 2
- 1.5 - 1.75
- 1.25 - 1.5
- 1 - 1.25
- 0.75 - 1
- 0.5 - 0.75
- 0.25 - 0.5
- 0 - 0.25
- 0

0 60 120 Meters

1:3,000 (At original document size of 11x17)

Notes

1. Coordinate System: NAD 1983 3TM 114

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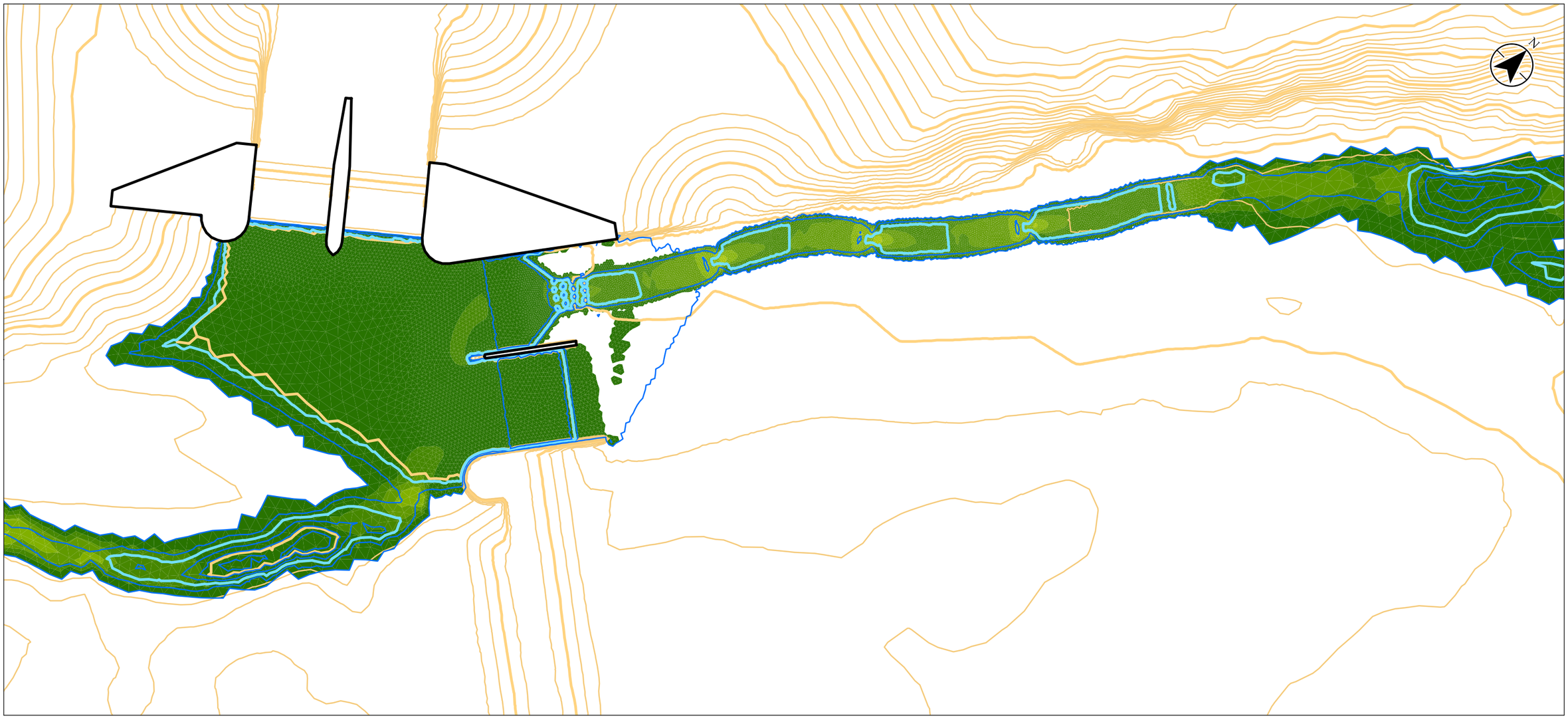
Client/Project
Alberta Transportation
Springbank Off-Stream Reservoir (SR1)

Figure No.
2 of 2

Title
Fish Passage Simulation
Existing Conditions, 75.7 cms



Legend

- Model Domain Lines

Depth Contours (0.1 m interval)

- All depth contours
- 0.2 m depth contour

Bed Contours (1 m interval)

- Intermediate
- Index

Velocity (m/s)

- 3.5 - 3.75
- 3.25 - 3.5
- 3 - 3.25
- 2.75 - 3
- 2.5 - 2.75
- 2.25 - 2.5
- 2 - 2.25
- 1.75 - 2
- 1.5 - 1.75
- 1.25 - 1.5
- 1 - 1.25
- 0.75 - 1
- 0.5 - 0.75
- 0.25 - 0.5
- 0 - 0.25
- 0

0 20 40 Meters

1:1,000 (At original document size of 11x17)

Notes

1. Coordinate System: NAD 1983 3TM 114

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Client/Project
Alberta Transportation
Springbank Off-Stream Reservoir (SR1)

Figure No.
1 of 2

Title
Fish Passage Simulation
Preliminary Design, 0.8 cms

5655000

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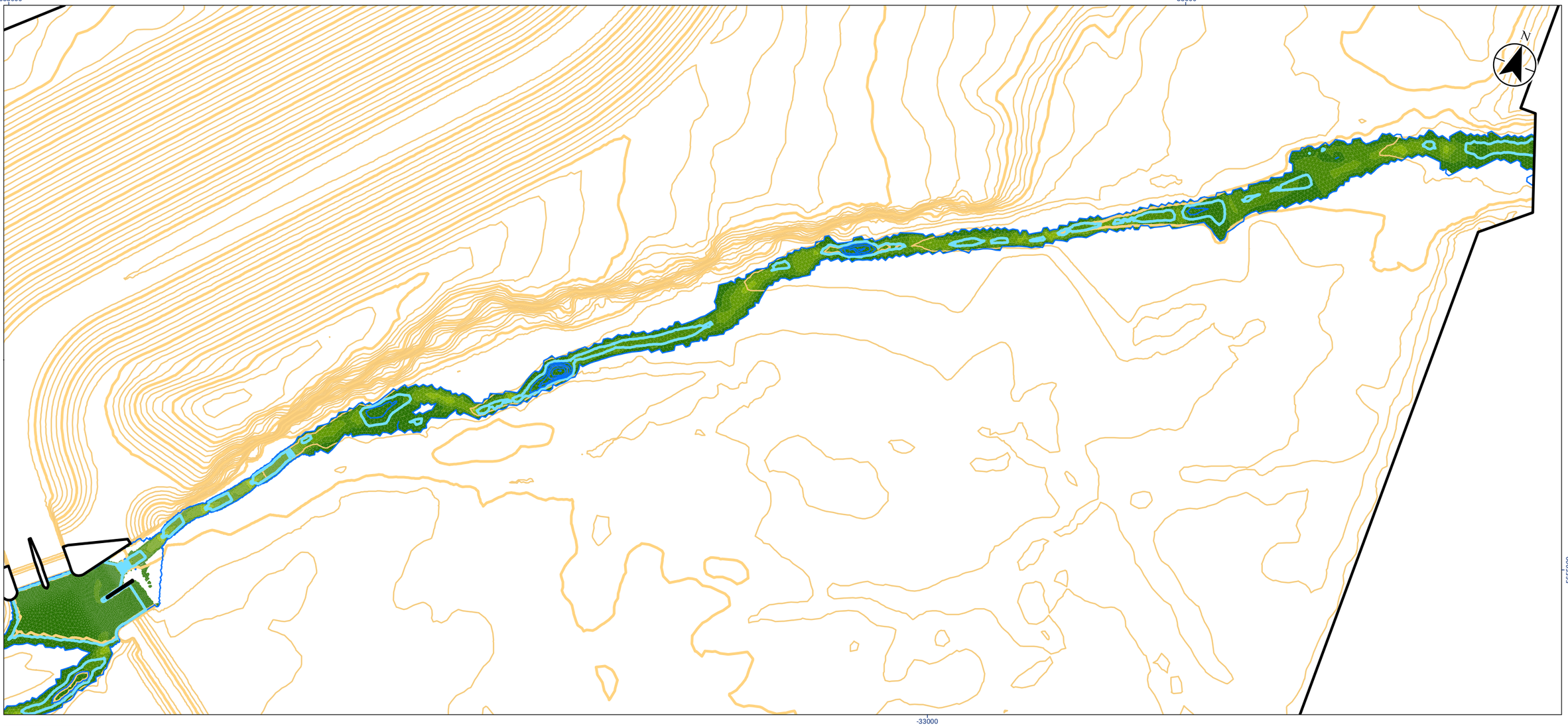

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-33000

Legend

- Model Domain Lines

Depth Contours (0.2 m interval)

- All depth contours
- 0.2 m depth contour

Bed Contours (1 m interval)

- Intermediate
- Index

Velocity (m/s)

- 3.5 - 3.75
- 3.25 - 3.5
- 3 - 3.25
- 2.75 - 3
- 2.5 - 2.75
- 2.25 - 2.5
- 2 - 2.25
- 1.75 - 2
- 1.5 - 1.75
- 1.25 - 1.5
- 1 - 1.25
- 0.75 - 1
- 0.5 - 0.75
- 0.25 - 0.5
- 0 - 0.25
- 0

0 60 120 Meters

1:3,000 (At original document size of 11x17)

Notes

1. Coordinate System: NAD 1983 3TM 114

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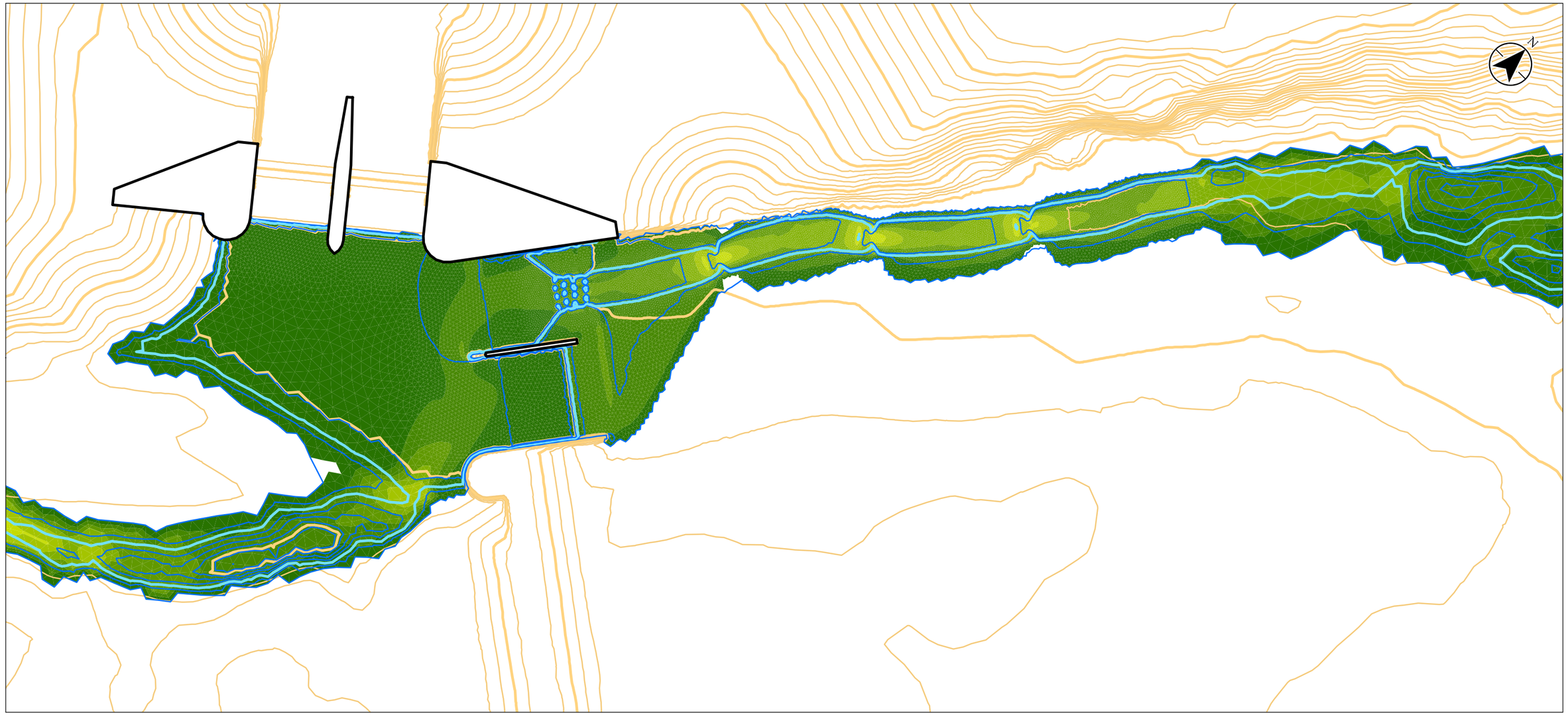
Client/Project
Alberta Transportation
Springbank Off-Stream Reservoir (SR1)

Figure No.
2 of 2

Title
Fish Passage Simulation
Preliminary Design, 0.8 cms



Legend

- Model Domain Lines

Depth Contours (0.1 m interval)

- All depth contours
- 0.2 m depth contour

Bed Contours (1 m interval)

- Intermediate
- Index

Velocity (m/s)

- 3.5 - 3.75
- 3.25 - 3.5
- 3 - 3.25
- 2.75 - 3
- 2.5 - 2.75
- 2.25 - 2.5
- 2 - 2.25
- 1.75 - 2
- 1.5 - 1.75
- 1.25 - 1.5
- 1 - 1.25
- 0.75 - 1
- 0.5 - 0.75
- 0.25 - 0.5
- 0 - 0.25
- 0

0 20 40 Meters

1:1,000 (At original document size of 11x17)

Notes

1. Coordinate System: NAD 1983 3TM 114

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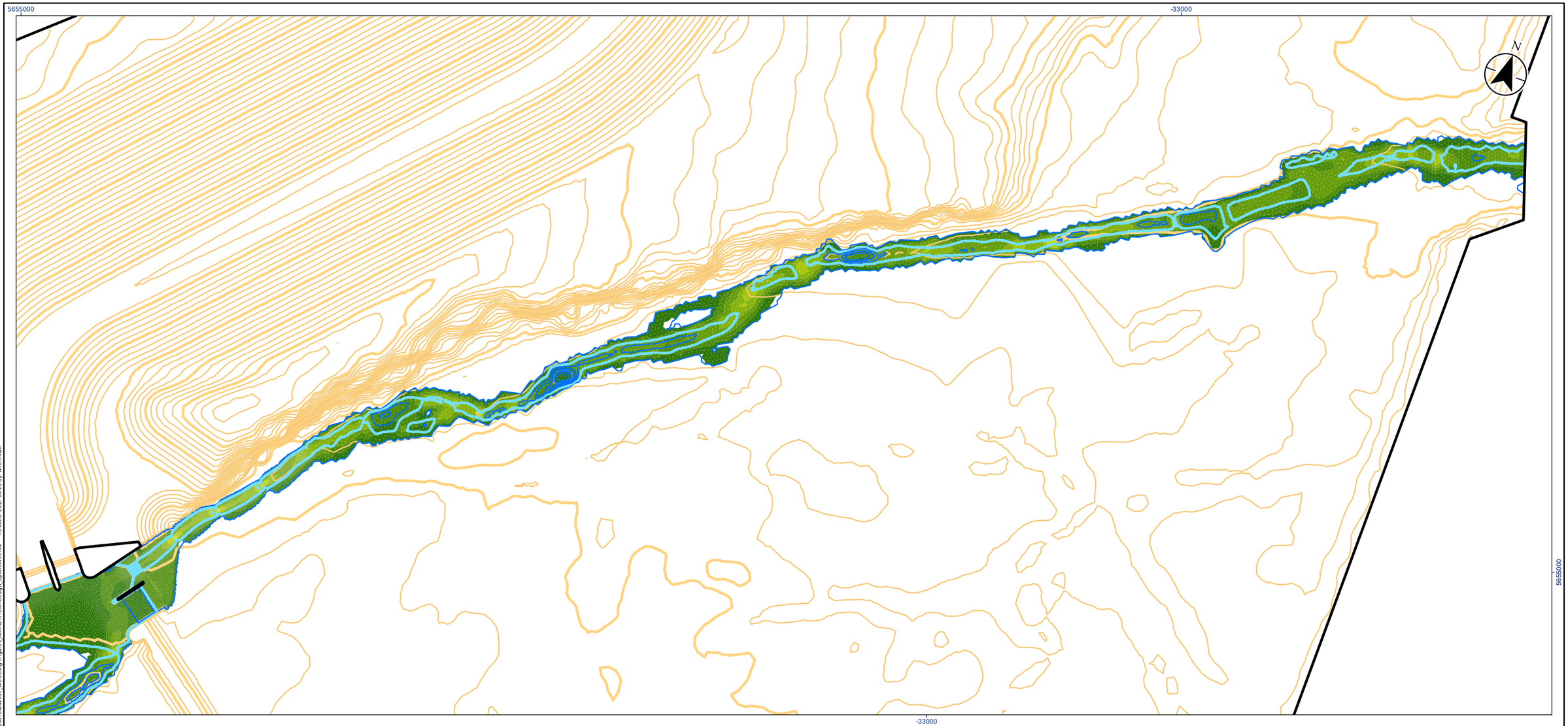
Client/Project
Alberta Transportation
Springbank Off-Stream Reservoir (SR1)

Figure No.
1 of 2

Title
Fish Passage Simulation
Preliminary Design, 2.38 cms



Legend

- Model Domain Lines

Depth Contours (0.2 m interval)

- All depth contours
- 0.2 m depth contour

Bed Contours (1 m interval)

- Intermediate
- Index

Velocity (m/s)

- 3.5 - 3.75
- 3.25 - 3.5
- 3 - 3.25
- 2.75 - 3
- 2.5 - 2.75
- 2.25 - 2.5
- 2 - 2.25
- 1.75 - 2
- 1.5 - 1.75
- 1.25 - 1.5
- 1 - 1.25
- 0.75 - 1
- 0.5 - 0.75
- 0.25 - 0.5
- 0 - 0.25
- 0

0 60 120 Meters

1:3,000 (At original document size of 11x17)

Notes

1. Coordinate System: NAD 1983 3TM 114

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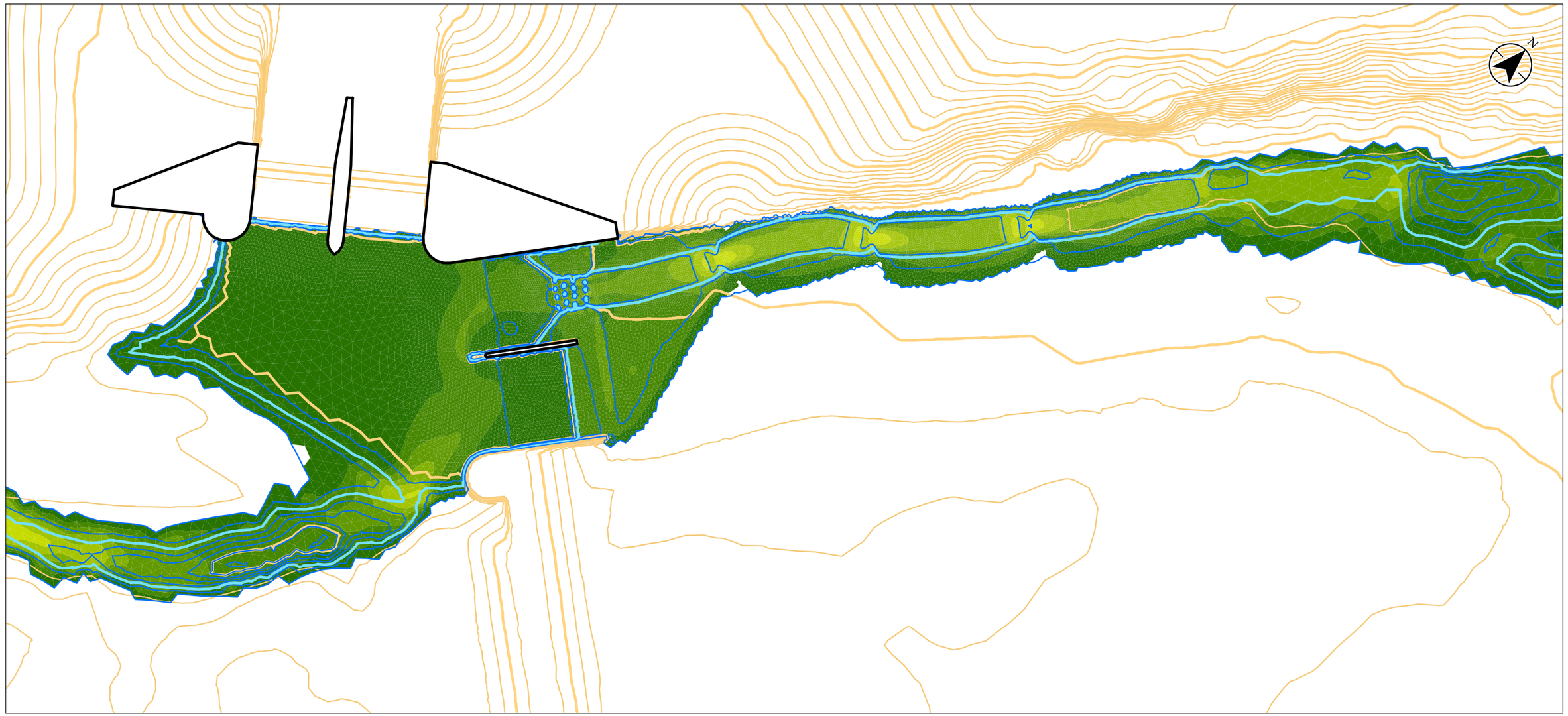
Client/Project
Alberta Transportation
Springbank Off-Stream Reservoir (SR1)

Figure No.
2 of 2

Title
Fish Passage Simulation
Preliminary Design, 2.38 cms



Legend

- Model Domain Lines

Depth Contours (0.1 m interval)

- All depth contours
- 0.2 m depth contour

Bed Contours (1 m interval)

- Intermediate
- Index

Velocity (m/s)

- 3.5 - 3.75
- 3.25 - 3.5
- 3 - 3.25
- 2.75 - 3
- 2.5 - 2.75
- 2.25 - 2.5
- 2 - 2.25
- 1.75 - 2
- 1.5 - 1.75
- 1.25 - 1.5
- 1 - 1.25
- 0.75 - 1
- 0.5 - 0.75
- 0.25 - 0.5
- 0 - 0.25
- 0

0 20 40 Meters

1:1,000 (At original document size of 11x17)

Notes

1. Coordinate System: NAD 1983 3TM 114

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Client/Project
Alberta Transportation
Springbank Off-Stream Reservoir (SR1)

Figure No.
1 of 2

Title
Fish Passage Simulation
Preliminary Design, 2.8 cms

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N

5595000

-33000

Legend

Model Domain Lines

Depth Contours (0.2 m interval)

All depth contours

0.2 m depth contour

Bed Contours (1 m interval)

Intermediate

Index

Velocity (m/s)

- 3.5 - 3.75
- 3.25 - 3.5
- 3 - 3.25
- 2.75 - 3
- 2.5 - 2.75
- 2.25 - 2.5
- 2 - 2.25
- 1.75 - 2
- 1.5 - 1.75
- 1.25 - 1.5
- 1 - 1.25
- 0.75 - 1
- 0.5 - 0.75
- 0.25 - 0.5
- 0 - 0.25
- 0

0 60 120 Meters

1:3,000 (At original document size of 11x17)

Notes

1. Coordinate System: NAD 1983 3TM 114

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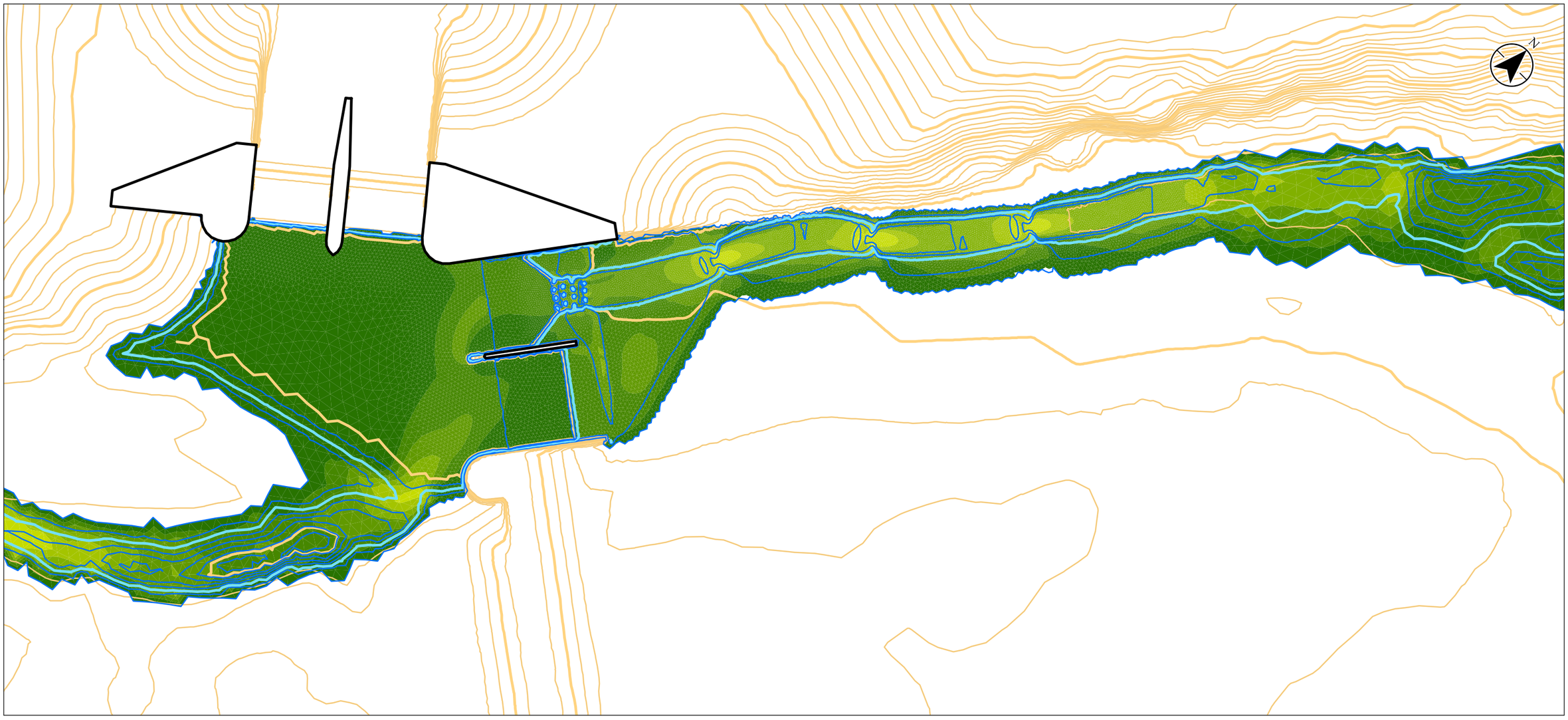
Client/Project
Alberta Transportation
Springbank Off-Stream Reservoir (SR1)

Figure No.
2 of 2

Title
Fish Passage Simulation
Preliminary Design, 2.8 cms



Legend

- Model Domain Lines

Depth Contours (0.1 m interval)

- All depth contours
- 0.2 m depth contour

Bed Contours (1 m interval)

- Intermediate
- Index

Velocity (m/s)

- 3.5 - 3.75
- 3.25 - 3.5
- 3 - 3.25
- 2.75 - 3
- 2.5 - 2.75
- 2.25 - 2.5
- 2 - 2.25
- 1.75 - 2
- 1.5 - 1.75
- 1.25 - 1.5
- 1 - 1.25
- 0.75 - 1
- 0.5 - 0.75
- 0.25 - 0.5
- 0 - 0.25
- 0

Notes

1. Coordinate System: NAD 1983 3TM 114

0 20 40 Meters

1:1,000 (At original document size of 11x17)

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Project Location
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Independent Review by ABC on 2017-02-xx

Client/Project
Alberta Transportation
Springbank Off-Stream Reservoir (SR1)

Figure No.
1 of 2

Title
Fish Passage Simulation
Preliminary Design, 3.47 cms

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N

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Legend

Model Domain Lines

Depth Contours (0.2 m interval)

All depth contours

0.2 m depth contour

Bed Contours (1 m interval)

Intermediate

Index

Velocity (m/s)

3.5 - 3.75
3.25 - 3.5
3 - 3.25
2.75 - 3
2.5 - 2.75
2.25 - 2.5
2 - 2.25
1.75 - 2
1.5 - 1.75
1.25 - 1.5
1 - 1.25
0.75 - 1
0.5 - 0.75
0.25 - 0.5
0 - 0.25
0

0 60 120 Meters

1:3,000 (At original document size of 11x17)

Notes

1. Coordinate System: NAD 1983 3TM 114

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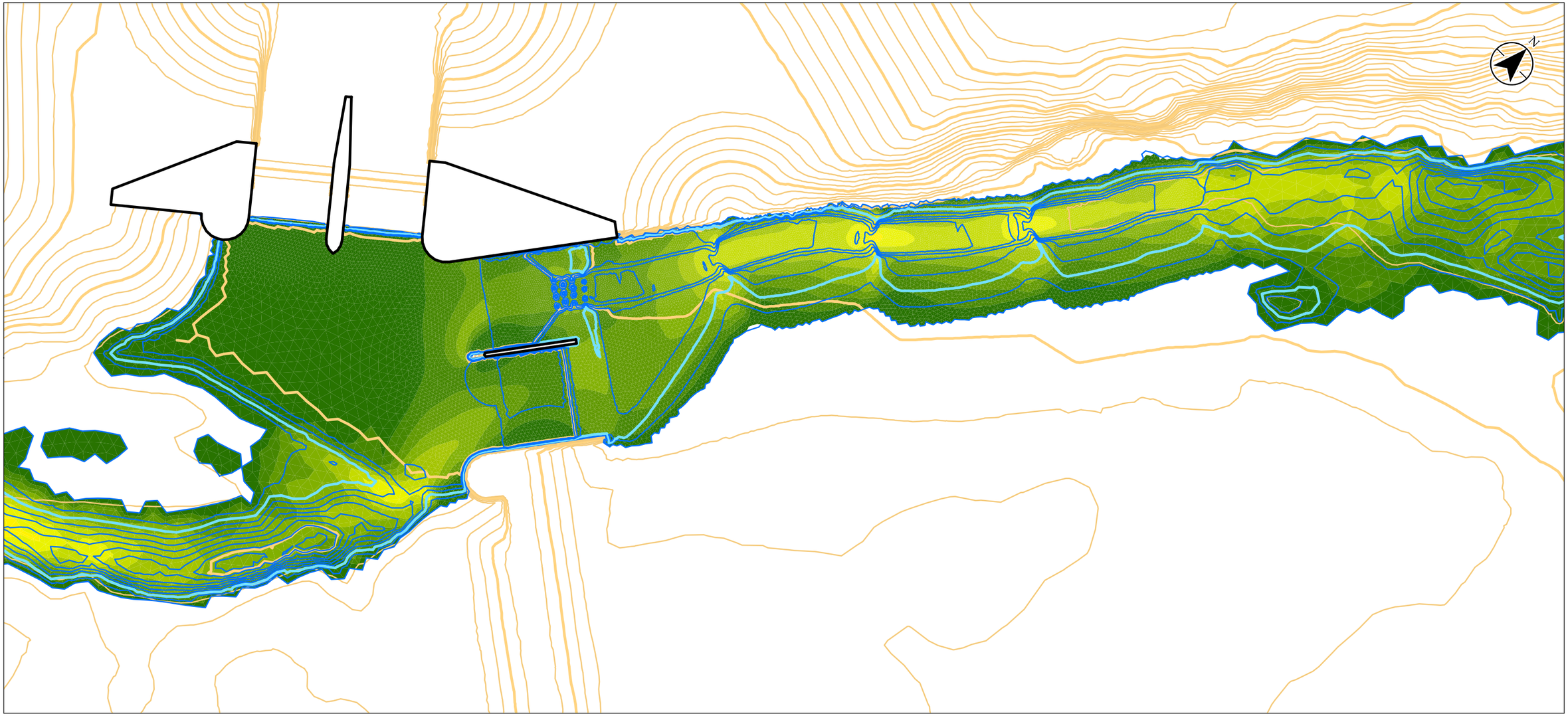
Independent Review by ABC on 2017-02-xx

Client/Project
Alberta Transportation
Springbank Off-Stream Reservoir (SR1)

Figure No.
2 of 2

Title
Fish Passage Simulation
Preliminary Design, 3.47 cms



Legend

- Model Domain Lines

Depth Contours (0.1 m interval)

- All depth contours
- 0.2 m depth contour

Bed Contours (1 m interval)

- Intermediate
- Index

Velocity (m/s)

- 3.5 - 3.75
- 3.25 - 3.5
- 3 - 3.25
- 2.75 - 3
- 2.5 - 2.75
- 2.25 - 2.5
- 2 - 2.25
- 1.75 - 2
- 1.5 - 1.75
- 1.25 - 1.5
- 1 - 1.25
- 0.75 - 1
- 0.5 - 0.75
- 0.25 - 0.5
- 0 - 0.25
- 0

0 20 40 Meters

1:1,000 (At original document size of 11x17)

Notes

1. Coordinate System: NAD 1983 3TM 114

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Technical Review by ABC on 2017-02-xx
Independent Review by ABC on 2017-02-xx

Client/Project
Alberta Transportation
Springbank Off-Stream Reservoir (SR1)

Figure No.
1 of 2

Title
Fish Passage Simulation
Preliminary Design, 9.81 cms

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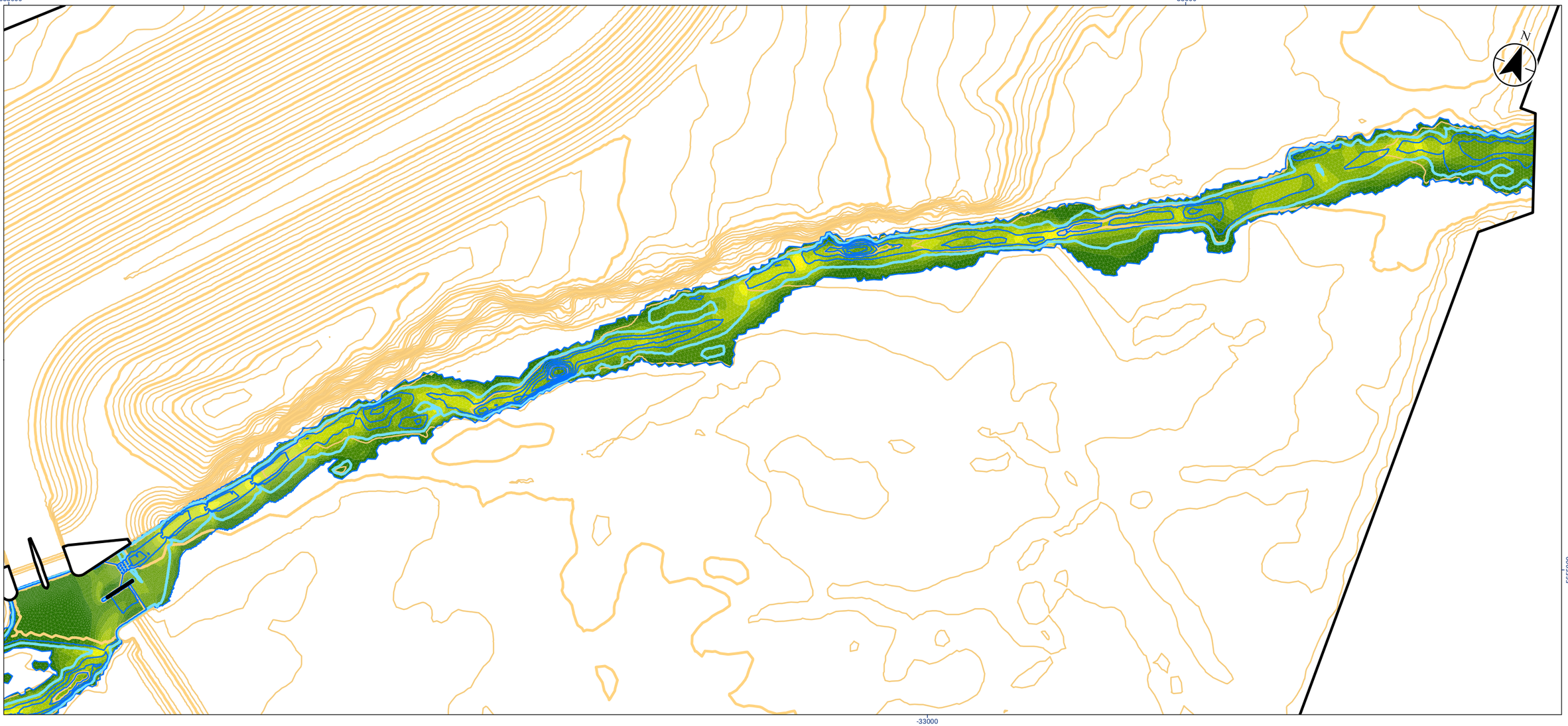

5655000

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Legend

- Model Domain Lines

Depth Contours (0.2 m interval)

- All depth contours
- 0.2 m depth contour

Bed Contours (1 m interval)

- Intermediate
- Index

Velocity (m/s)

- 3.5 - 3.75
- 3.25 - 3.5
- 3 - 3.25
- 2.75 - 3
- 2.5 - 2.75
- 2.25 - 2.5
- 2 - 2.25
- 1.75 - 2
- 1.5 - 1.75
- 1.25 - 1.5
- 1 - 1.25
- 0.75 - 1
- 0.5 - 0.75
- 0.25 - 0.5
- 0 - 0.25
- 0

0 60 120 Meters

1:3,000 (At original document size of 11x17)

Notes

1. Coordinate System: NAD 1983 3TM 114

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Project Location
City of Calgary
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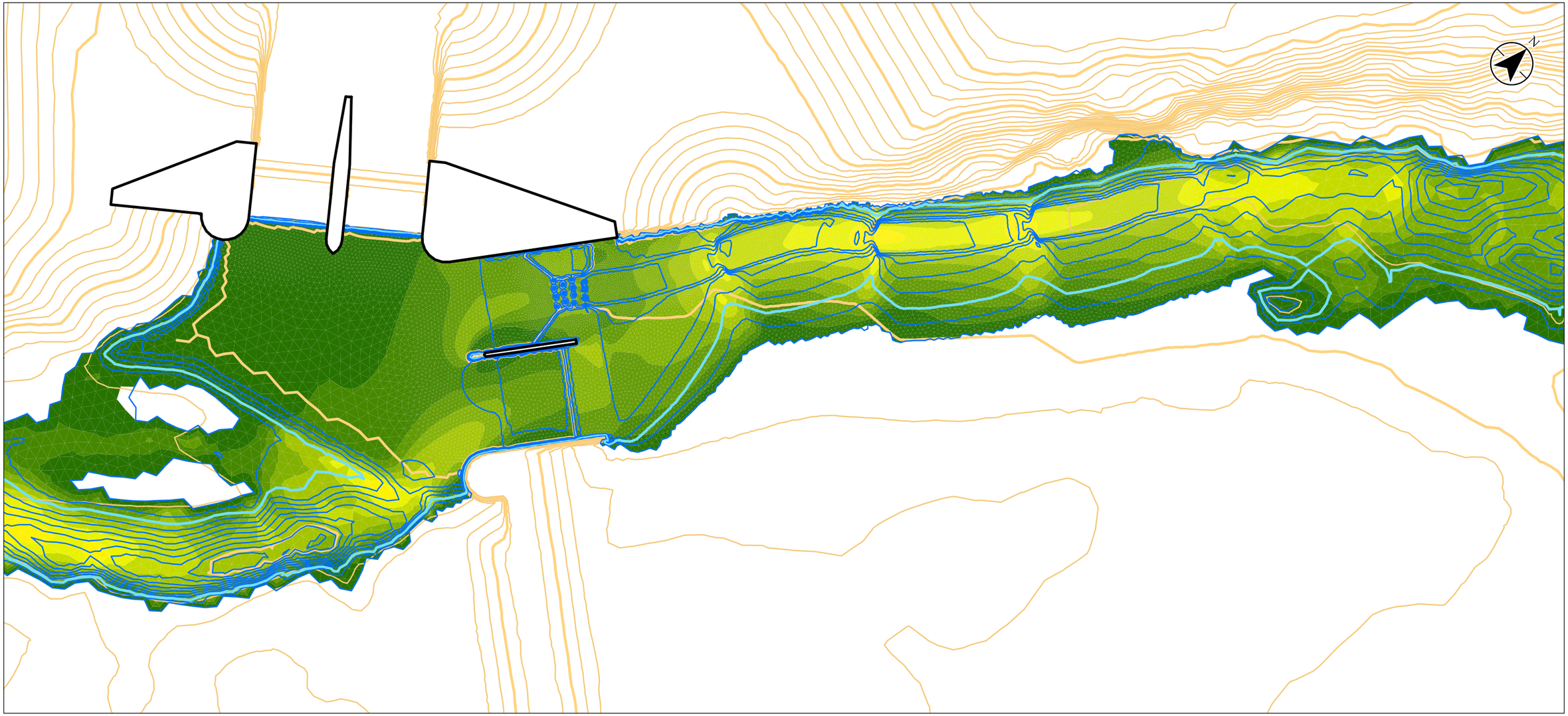
Independent Review by ABC on 2017-02-xx

Client/Project
Alberta Transportation
Springbank Off-Stream Reservoir (SR1)

Figure No.
2 of 2

Title
Fish Passage Simulation
Preliminary Design, 9.81 cms



Legend

- Model Domain Lines

Depth Contours (0.1 m interval)

- All depth contours
- 0.2 m depth contour

Bed Contours (1 m interval)

- Intermediate
- Index

Velocity (m/s)

- 3.5 - 3.75
- 3.25 - 3.5
- 3 - 3.25
- 2.75 - 3
- 2.5 - 2.75
- 2.25 - 2.5
- 2 - 2.25
- 1.75 - 2
- 1.5 - 1.75
- 1.25 - 1.5
- 1 - 1.25
- 0.75 - 1
- 0.5 - 0.75
- 0.25 - 0.5
- 0 - 0.25
- 0

0 20 40 Meters

1:1,000 (At original document size of 11x17)

Notes

1. Coordinate System: NAD 1983 3TM 114

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Client/Project
Alberta Transportation
Springbank Off-Stream Reservoir (SR1)

Figure No.
1 of 2

Title
Fish Passage Simulation
Preliminary Design, 15 cms

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Legend

Model Domain Lines

Depth Contours (0.2 m interval)

All depth contours

0.2 m depth contour

Bed Contours (1 m interval)

Intermediate

Index

Velocity (m/s)

- 3.5 - 3.75
- 3.25 - 3.5
- 3 - 3.25
- 2.75 - 3
- 2.5 - 2.75
- 2.25 - 2.5
- 2 - 2.25
- 1.75 - 2
- 1.5 - 1.75
- 1.25 - 1.5
- 1 - 1.25
- 0.75 - 1
- 0.5 - 0.75
- 0.25 - 0.5
- 0 - 0.25
- 0

0 60 120 Meters

1:3,000 (At original document size of 11x17)

Notes

1. Coordinate System: NAD 1983 3TM 114

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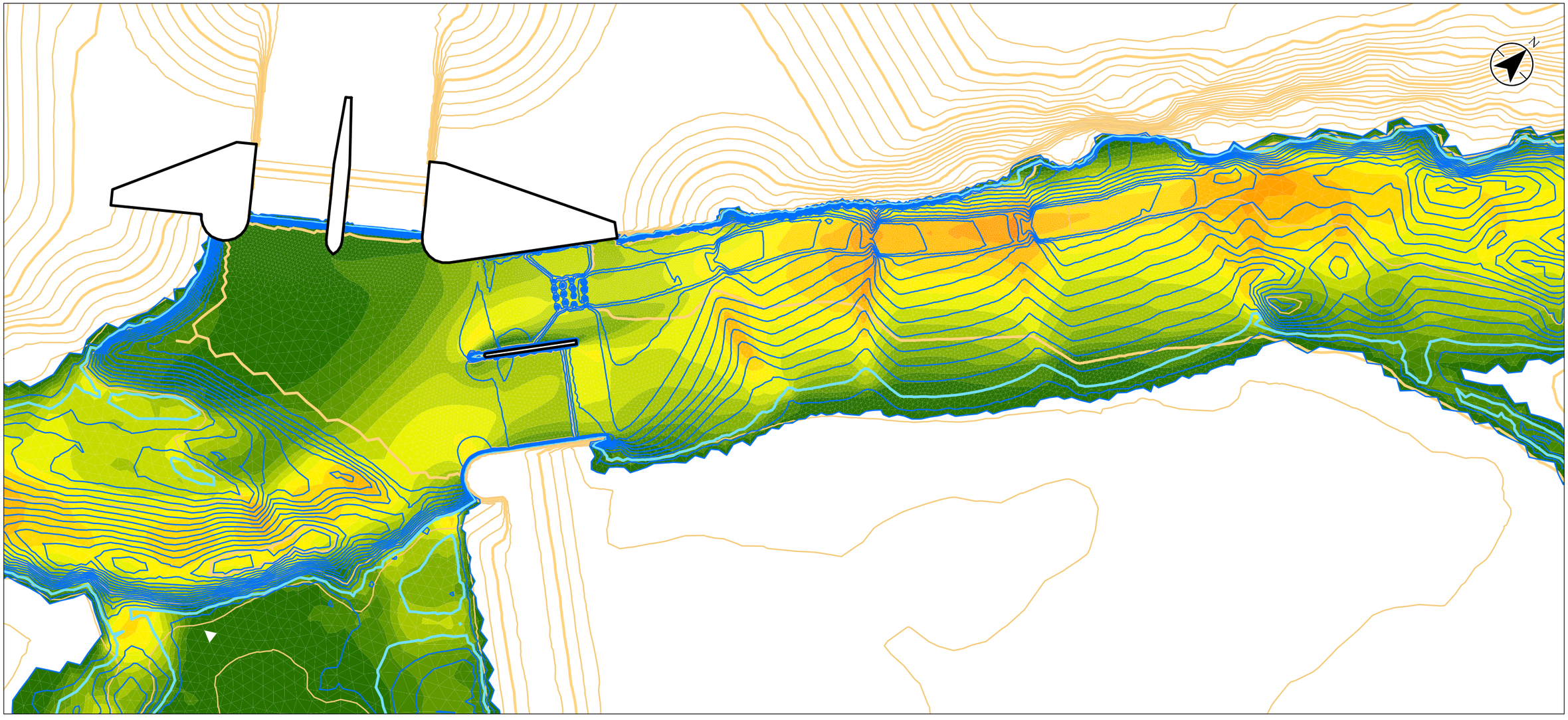
Client/Project
Alberta Transportation
Springbank Off-Stream Reservoir (SR1)

Figure No.
2 of 2

Title
Fish Passage Simulation
Preliminary Design, 15 cms



Legend

- Model Domain Lines

Depth Contours (0.1 m interval)

- All depth contours
- 0.2 m depth contour

Bed Contours (1 m interval)

- Intermediate
- Index

Velocity (m/s)

- 3.5 - 3.75
- 3.25 - 3.5
- 3 - 3.25
- 2.75 - 3
- 2.5 - 2.75
- 2.25 - 2.5
- 2 - 2.25
- 1.75 - 2
- 1.5 - 1.75
- 1.25 - 1.5
- 1 - 1.25
- 0.75 - 1
- 0.5 - 0.75
- 0.25 - 0.5
- 0 - 0.25
- 0

0 20 40 Meters

1:1,000 (At original document size of 11x17)

Notes

1. Coordinate System: NAD 1983 3TM 114

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Client/Project
Alberta Transportation
Springbank Off-Stream Reservoir (SR1)

Figure No.
1 of 2

Title
Fish Passage Simulation
Preliminary Design, 69.5 cms

Revised: 2017-08-23 By: dhoffman
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Legend

Model Domain Lines

Depth Contours (0.2 m interval)

All depth contours

0.2 m depth contour

Bed Contours (1 m interval)

Intermediate

Index

Velocity (m/s)

- 3.5 - 3.75
- 3.25 - 3.5
- 3 - 3.25
- 2.75 - 3
- 2.5 - 2.75
- 2.25 - 2.5
- 2 - 2.25
- 1.75 - 2
- 1.5 - 1.75
- 1.25 - 1.5
- 1 - 1.25
- 0.75 - 1
- 0.5 - 0.75
- 0.25 - 0.5
- 0 - 0.25
- 0

0 60 120 Meters

1:3,000 (At original document size of 11x17)

Notes

1. Coordinate System: NAD 1983 3TM 114

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Independent Review by ABC on 2017-02-xx

Client/Project
Alberta Transportation
Springbank Off-Stream Reservoir (SR1)

Figure No.
2 of 2

Title
Fish Passage Simulation
Preliminary Design, 69.5 cms

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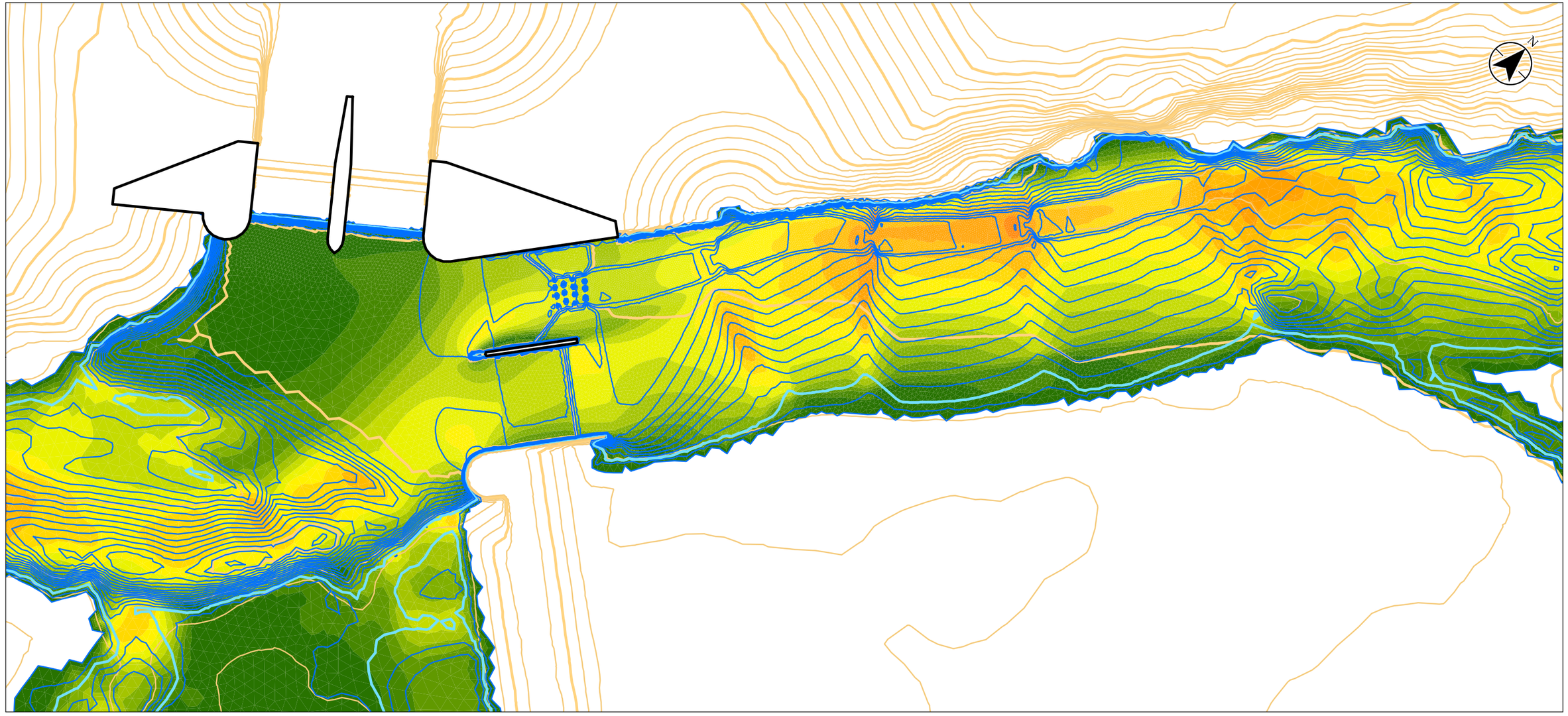

Legend

- Model Domain Lines

Depth Contours (0.1 m interval)

- All depth contours
- 0.2 m depth contour

Bed Contours (1 m interval)

- Intermediate
- Index

Velocity (m/s)

- 3.5 - 3.75
- 3.25 - 3.5
- 3 - 3.25
- 2.75 - 3
- 2.5 - 2.75
- 2.25 - 2.5
- 2 - 2.25
- 1.75 - 2
- 1.5 - 1.75
- 1.25 - 1.5
- 1 - 1.25
- 0.75 - 1
- 0.5 - 0.75
- 0.25 - 0.5
- 0 - 0.25
- 0

0 20 40 Meters

1:1,000 (At original document size of 11x17)

Notes

1. Coordinate System: NAD 1983 3TM 114

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Client/Project
Alberta Transportation
Springbank Off-Stream Reservoir (SR1)

Figure No.
1 of 2

Title
Fish Passage Simulation
Preliminary Design, 75.7 cms

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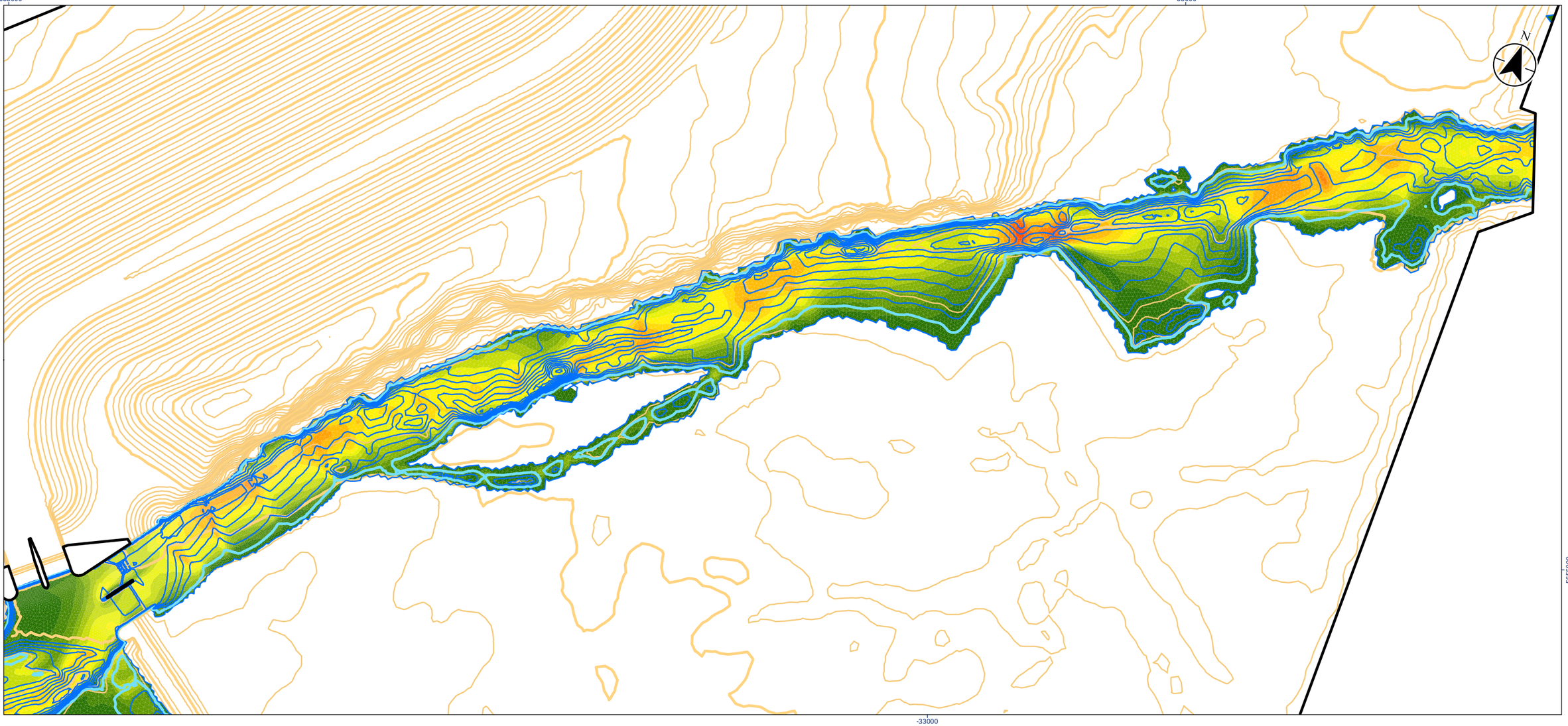

5655000

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Legend

- Model Domain Lines

Depth Contours (0.2 m interval)

- All depth contours
- 0.2 m depth contour

Bed Contours (1 m interval)

- Intermediate
- Index

Velocity (m/s)

- 3.5 - 3.75
- 3.25 - 3.5
- 3 - 3.25
- 2.75 - 3
- 2.5 - 2.75
- 2.25 - 2.5
- 2 - 2.25
- 1.75 - 2
- 1.5 - 1.75
- 1.25 - 1.5
- 1 - 1.25
- 0.75 - 1
- 0.5 - 0.75
- 0.25 - 0.5
- 0 - 0.25
- 0

0 60 120 Meters

1:3,000 (At original document size of 11x17)

Notes

1. Coordinate System: NAD 1983 3TM 114

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Independent Review by ABC on 2017-02-xx

Client/Project
Alberta Transportation
Springbank Off-Stream Reservoir (SR1)

Figure No.
2 of 2

Title
Fish Passage Simulation
Preliminary Design, 75.7 cms

To:	Matt Wood	From:	Seifu Guangul
	Stantec, Calgary		Stantec, Winnipeg
File:	110773396-302.600	Date:	September 1, 2016

Reference: SR1: Fish Passage Flows Analysis

This memo describes the data, approach and result of fish passage flow analysis for Springbank Off-Stream Reservoir. The analysis include two types of flows: 3 day, 10 year maximum daily mean flow ($3Q10_{max}$) and the 3 day, 10 year minimum daily-mean flow (minimum flow) ($3Q10_{min}$) for the Biologically Sensitive time Periods as identified below:

> **BSP-1**: from 2 April to15 June (bull trout: incubation, fry, juvenile, adult, spawning; brown trout: fry, juvenile, adult; rainbow trout: incubation, fry, juvenile, adult, migration, spawning; mountain whitefish: fry, juvenile, adult)
>
> **BSP-2**: from 16 June to 25 September (bull trout: migration, spawning, incubation, juvenile, adult; brown trout: fry, juvenile, adult; rainbow trout: incubation, fry, juvenile, adult; mountain whitefish: fry, juvenile, adult)
>
> **BSP-3**: from 26 September to 01 December (bull trout: incubation, adult, spawning; brown trout: incubation, fry, juvenile, adult, migration, spawning; rainbow trout: fry, juvenile, adult; mountain whitefish: incubation, fry, juvenile, adult, spawning)
>
> **BSP-4**: from 02 December to 01 April (bull trout: incubation, fry, adult; brown trout: incubation, fry, juvenile, adult; rainbow trout: fry, juvenile, adult; mountain whitefish: incubation, fry, juvenile, adult)

The $3Q10_{max}$ should will provide the basis for velocities and depths that fish can pass a structure during the 1:10 flows, without a 3 day delay during the relevant BSPs. Whereas, the $3Q10_{min}$ should provide velocities and depths that are suitable under extreme low flow situations for specific BSPs.

DATA AND METHOD

The key gauging stations used for analysis were Elbow River below Glenmore Dam (05BJ001), Elbow River at Bragg Creek (05BJ004), Elbow River above Glenmore Dam (05BJ005), and Elbow River at Sarcee Bridge (05BJ010). The Bragg Creek Station is located upstream of the proposed SR1 diversion site, while the remaining stations are situated downstream of the diversion site near the Glenmore Reservoir. See Table1 for a summary of the relevant hydrometric stations.

Stations on the Elbow River below Glenmore Dam, above Glenmore Dam, and at Sarcee Bridge have drainage areas 1236, 1220, and 1189 km^2, respectively. Due to the proximity of the locations and drainage areas between these stations, their data was combined and considered as one station for further analysis (hereafter referred to as the Combined Station). Therefore the Combined Station consists of data from 1908 to 1932, 1934 to 1977, and 1979 to 2013, respectively. Only natural, unregulated flow is represented in the data series. Therefore, flow

measurements up until the construction of the dam in 1934 were used at the station below Glenmore Dam. No flow data exists in 1933, 1978, and 1991 for any of the stations within the Combined Station grouping.

Table1: Relevant Hydrometric Station Summary

Station ID	Station Name	Drainage Area (km^2)	Period of Record		Percent Missing Data	Years of Acceptable Flow Data	Type of Flow	Operation Schedule
			From	To				
05BJ001	Elbow River below Glenmore Dam	1235.7	1908	2011	2%	102	Unregulated (1908 – 1932)/ Regulated	Continuous
05BJ004	Elbow River at Bragg Creek	790.8	1934	2012	25%	59	Natural	Continuous
05BJ005	Elbow River above Glenmore Dam	1220	1933	1977	0%	45	Natural	Continuous
05BJ010	Elbow River at Sarcee Bridge	1189.3	1979	2012	37%	20	Natural	Continuous

The fish passage flow analyses were carried out using the Frequency Analysis Procedure for Stormwater Design developed the City of Calgary (City of Calgary 2014). This method requires input data series from which it calculates basic, assessment, and statistical characteristics as well as conducts a frequency analysis. The frequency analysis consists of determining the best fit theoretical probability distribution function for the sample and obtaining the prediction rule from the fitted distribution. The method requires another software package called Hydrologic Frequency Analysis Plus (HYFRAN+) for fitting a statistical distribution to the data series. HYFRAN+ is a numerical tool that can be used to compare multiple frequency distributions, parameter estimation methods, and provides some goodness-of-fit and data series characteristic tests to aid in the user's judgment. Accordingly, the following probability distributions were analyzed: Normal, Log Normal, Log Normal III, Exponential, Pearson III, Log Pearson III, Gumbel, GEV, Weibull, and Gamma.

Table 2 shows the statistical properties of each fish passage flow for each BSPs using different probability distributions.

Table2: Statistical Characteristics of fish passage flows

Statistical Tests		Biologically Sensitive Period 1		Biologically Sensitive Period 2		Biologically Sensitive Period 3		Biologically Sensitive Period 4	
		$3Q10_{max}$	$3Q10_{min}$	$3Q10_{max}$	$3Q10_{min}$	$3Q10_{max}$	$3Q10_{min}$	$3Q10_{max}$	$3Q10_{min}$
Stationarity	**Spearman Rank Order Correlation Coefficient (Trend)**	no significant trend at a=0.05	no significant trend at a=0.05	no significant trend at a=0.05	no significant trend at a=0.05	no significant trend at a=0.05	trend detected at a=0.05	no significant trend at a=0.05	trend detected at a=0.05
	Mann-Whitney Test for Jump	presence of jump possible at a=0.05	presence of jump possible at a=0.05	presence of jump possible at a=0.05	presence of jump possible at a=0.05	presence of jump possible at a=0.05	presence of jump possible at a=0.05	presence of jump possible at a=0.05	presence of jump possible at a=0.05
	Wald-Wofowitz Test (Jump)	presence of jump possible at a=0.05	presence of jump possible at a=0.05	presence of jump possible at a=0.05	presence of jump possible at a=0.05	presence of jump possible at a=0.05	presence of jump possible at a=0.05	presence of jump possible at a=0.05	presence of jump possible at a=0.05
Homogeneity	**Mann-Whitney U Test**	sample is not homogeneous at 0.05 significance level	sample is not homogeneous at 0.05 significance level	sample is not homogeneous at 0.05 significance level	sample is not homogeneous at 0.05 significance level	sample is not homogeneous at 0.05 significance level	sample is not homogeneous at 0.05 significance level	sample is not homogeneous at 0.05 significance level	sample is not homogeneous at 0.05 significance level
	Terry Test	sample is not homogeneous at 0.05 significance level	sample is not homogeneous at 0.05 significance level	sample is not homogeneous at 0.05 significance level	sample is not homogeneous at 0.05 significance level	sample is not homogeneous at 0.05 significance level	sample is not homogeneous at 0.05 significance level	sample is not homogeneous at 0.05 significance level	sample is not homogeneous at 0.05 significance level
Independence	**Spearman Rank Order Correlation Coefficient**	non-independence detected at a=0.05	non-independence detected at a=0.05	non-independence detected at a=0.05	non-independence detected at a=0.05	non-independence detected at a=0.05	non-independence detected at a=0.05	non-independence detected at a=0.05	non-independence detected at a=0.05
	Wald-Wolfowitz Test for Independence	sample is independent at a=0.05	non-independence detected at a=0.05	non-independence detected at a=0.05	non-independence detected at a=0.05	non-independence detected at a=0.05	non-independence detected at a=0.05	non-independence detected at a=0.05	non-independence detected at a=0.05
	Anderson Test	sample is independent at a=0.05	non-independence detected at a=0.05	non-independence detected at a=0.05	non-independence detected at a=0.05	non-independence detected at a=0.05	non-independence detected at a=0.05	non-independence detected at a=0.05	non-independence detected at a=0.05
Outliers	**Grubbs and Beck Test**	no high outlier; low outlier may be present	no high outliers; no low outliers	no high outliers; no low outliers	high outlier may be present; no low outlier	no high outliers; no low outliers	no high outliers; no low outliers	high outlier may be present; no low outliers	high outlier may be present; no low outliers

The frequency analysis method selects an appropriate probability distribution based on numerical and visual goodness-of-fit tests. These tests are:

- **Kolmogorov-Smirnov Test:** a numerical goodness-of-fit test. To apply this test, the maximum discrepancy (D-statistic) between the empirical probability and the probability distribution for the observed values is calculated and compared to a critical statistic for the data set. If the calculated D-statistic is greater than the critical statistic, the frequency distribution does not match the data set.

- **Anderson-Darling Test:** a numerical goodness-of-fit test. Similar to the Kolmogorov-Smirnov Test, a statistic A is compared to a critical statistic calculated from the sample size and significance level to determine if the data series fits with compared probability distribution.

- **Ranking Least Squares Method:** a visual goodness-of-fit test, which compares the fit of multiple distribution s to a single data sample. For this method, the sum of squares is calculated for the differences between calculated and observed discharges. A ranking of distributions by order of least standard error based on the sum of squares reveals the ranked goodness-of-fit of each distribution.

A summary of the results of the goodness-of-fit tests for the best fit probability distribution functions for the six datasets are presented in Table 3.

Table3: Goodness-of-Fit and Best Fit Probability Distribution Functions

Dataset		Numerical Goodness-of-Fit Tests			Best Fit Probability Distributions
		Anderson-Darling Test	Kologorov-Smirnov Test	Least Squares Ranking	
Biologically Sensitive Period1	**$3Q10_{max}$**	1	1	3	GEV
	$3Q10_{min}$	1	2	6	Log Normal
Biologically Sensitive Period 2	**$3Q10_{max}$**	1	2	2	Log Normal
	$3Q10_{min}$	1	1	3	GEV
Biologically Sensitive Period 3	**$3Q10_{max}$**	2	1	4	Log Normal Type III
	$3Q10_{min}$	1	3	4	Log Normal Type III
Biologically Sensitive Period 4	**$3Q10_{max}$**	1	1	3	GEV
	$3Q10_{min}$	1	1	2	Log Pearson Type III

Summary of results for each BSPs and fish passage flows using different probability distribution is shown below. Results based on the best-fit probability distribution are highlighted in yellow.

Table 4. Results from frequency analysis for fish flow analysis.

		Normal	Log Normal	Log Normal III	Exponential	Pearson Type III	Log Pearson Type III	Gumbel	GEV	Weibull	Gamma
Biologically Sensitive Period1	**$3Q10_{max}$**	82	78.3	76.5	91.3	81.8	78.2	71.2	75.7	81.2	77.2
	$3Q10_{min}$	2.2	2.8	2.5	1.71	2.45	2.7	2.5	2.5	2.1	2.4
Biologically Sensitive Period 2	**$3Q10_{max}$**	69.7	69.5	71.5	76.3	71	69.9	65.8	70.1	70.8	68.6
	$3Q10_{min}$	N/A	3.04	3.3	2.43	2.89	4	3.13	3.47	1.11	2.4
Biologically Sensitive Period 3	**$3Q10_{max}$**	15.2	14.5	15	16.2	15	14.7	13.8	15	15.4	14.7
	$3Q10_{min}$	2.17	2.39	2.38	1.56	2.36	2.37	2.38	2.39	2.12	2.36
Biologically Sensitive Period 4	**$3Q10_{max}$**	11.9	9.93	10	11.8	11.5	10.2	9.47	9.81	11.7	10.4
	$3Q10_{min}$	0.17	0.74	0.8	0.66	0.78	0.8	1.04	0.82	0.42	0.63

The best-fit probability distributions for each of the fish passage flow are shown below. The distributions along with the raw data and the 95% confidence intervals were plotted on log scaled graphs. For some probability distribution functions and return periods, HYFRAN+ was unable to generate the 95% confidence intervals.

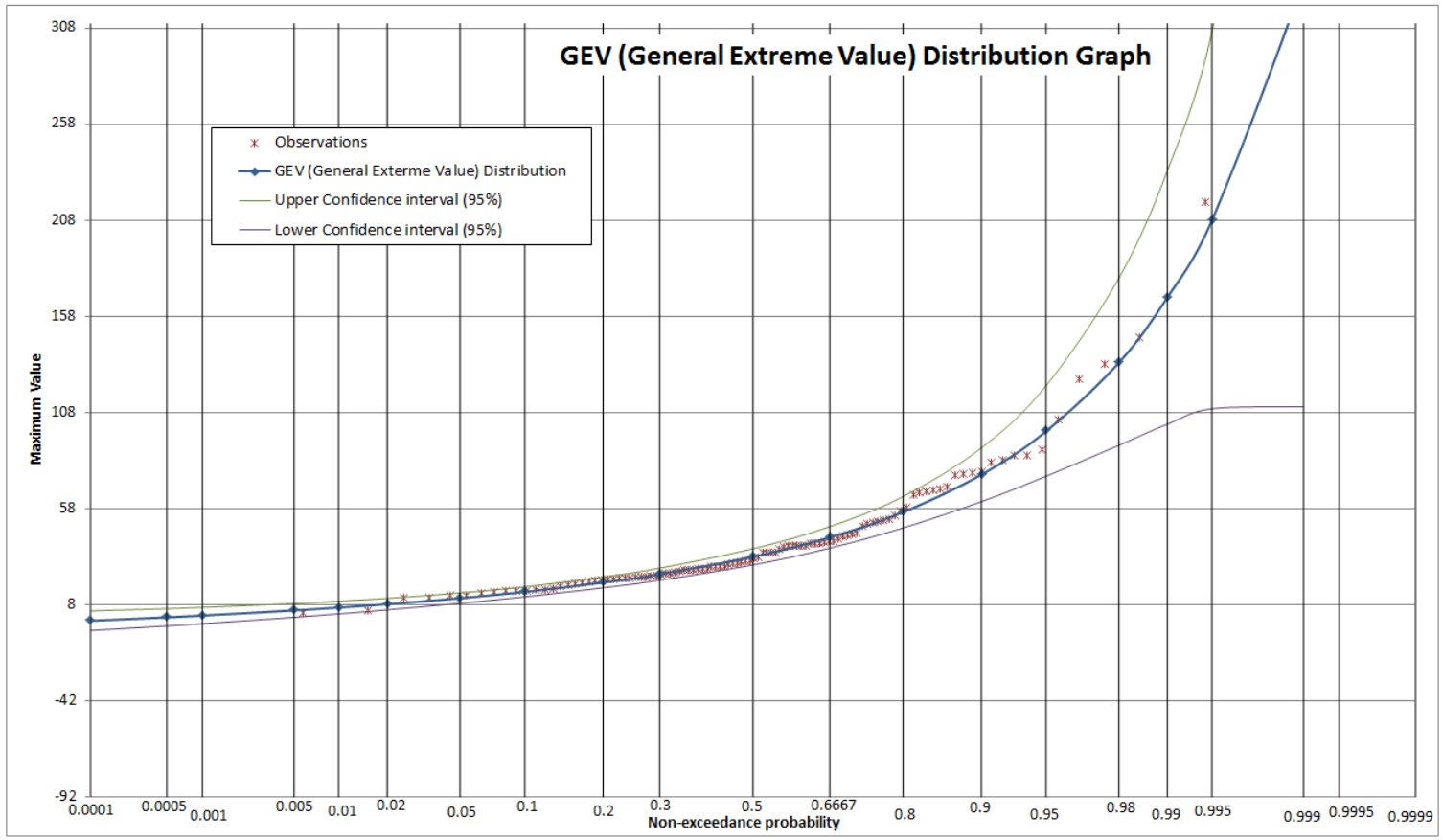

Figure 1. GEV: best fit distribution for the BSP-1, $3Q10_{max}$ flow

Reference: SR1: Fish Passage Flows Analysis

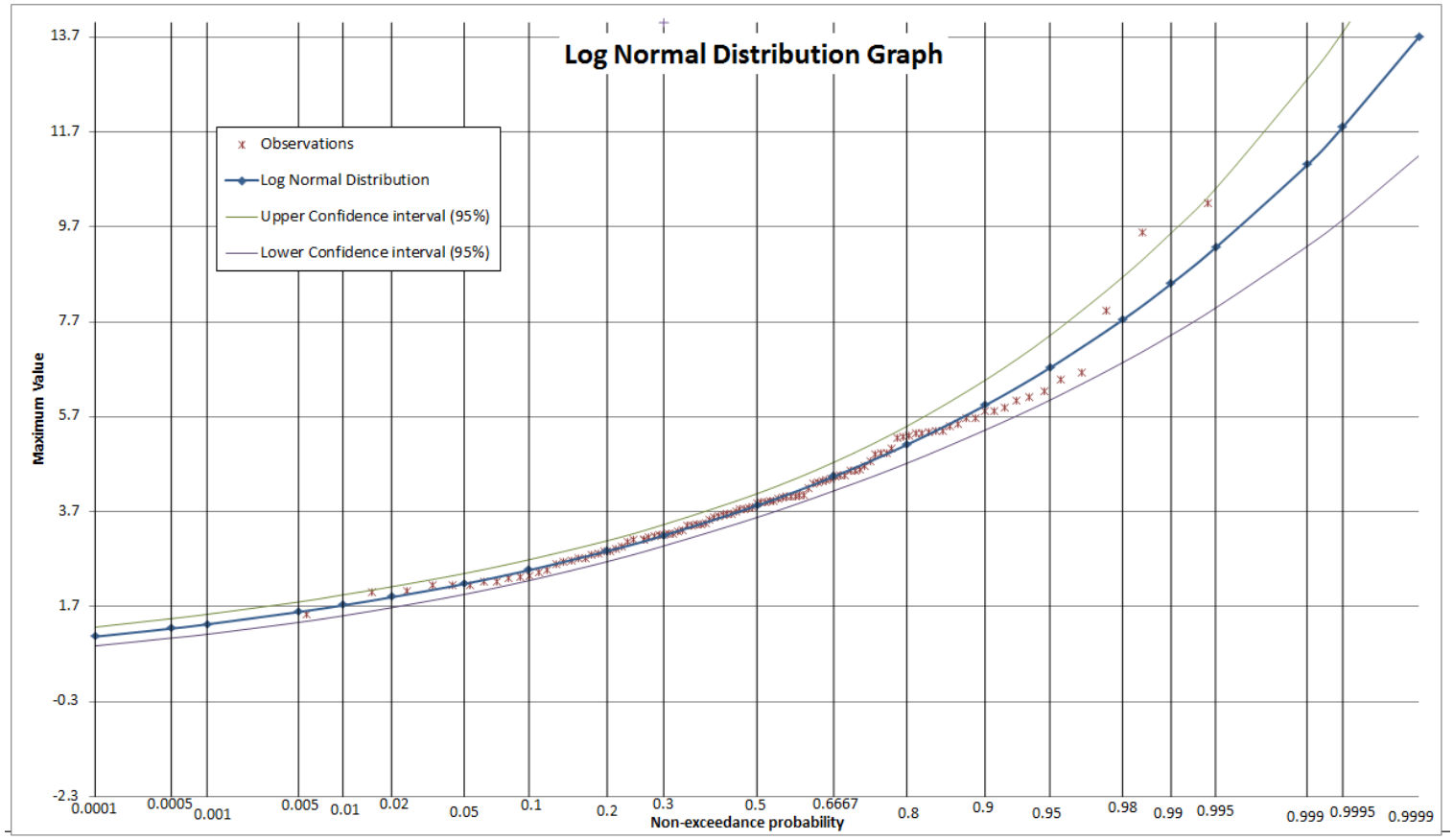

Figure 2. Log Normal: best fit distribution for the BSP-1, $3Q10_{min}$ flow

Reference: SR1: Fish Passage Flows Analysis

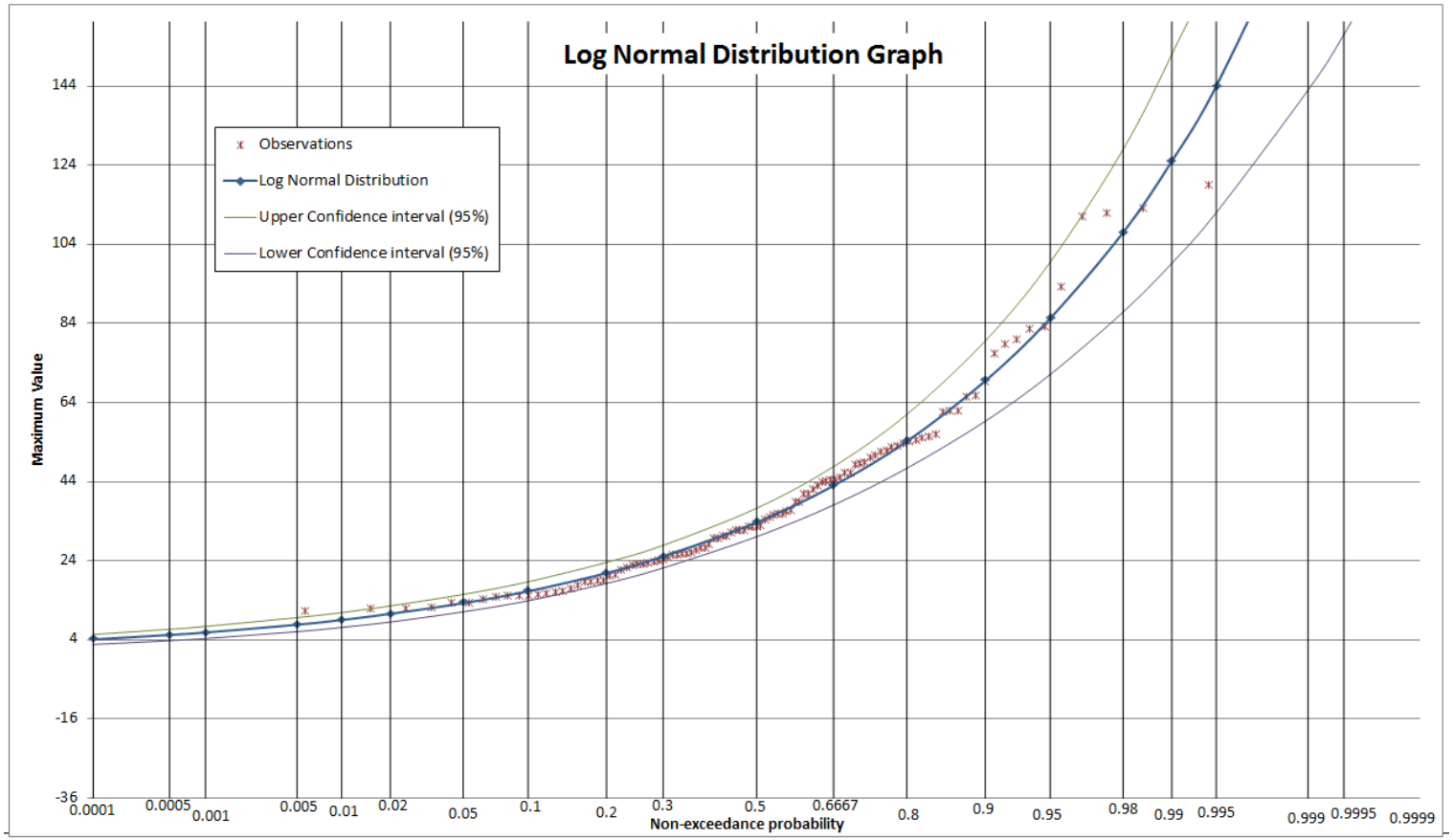

Figure 3. Log Normal: best fit distribution for the BSP-2, $3Q10_{max}$ flow

Reference: SR1: Fish Passage Flows Analysis

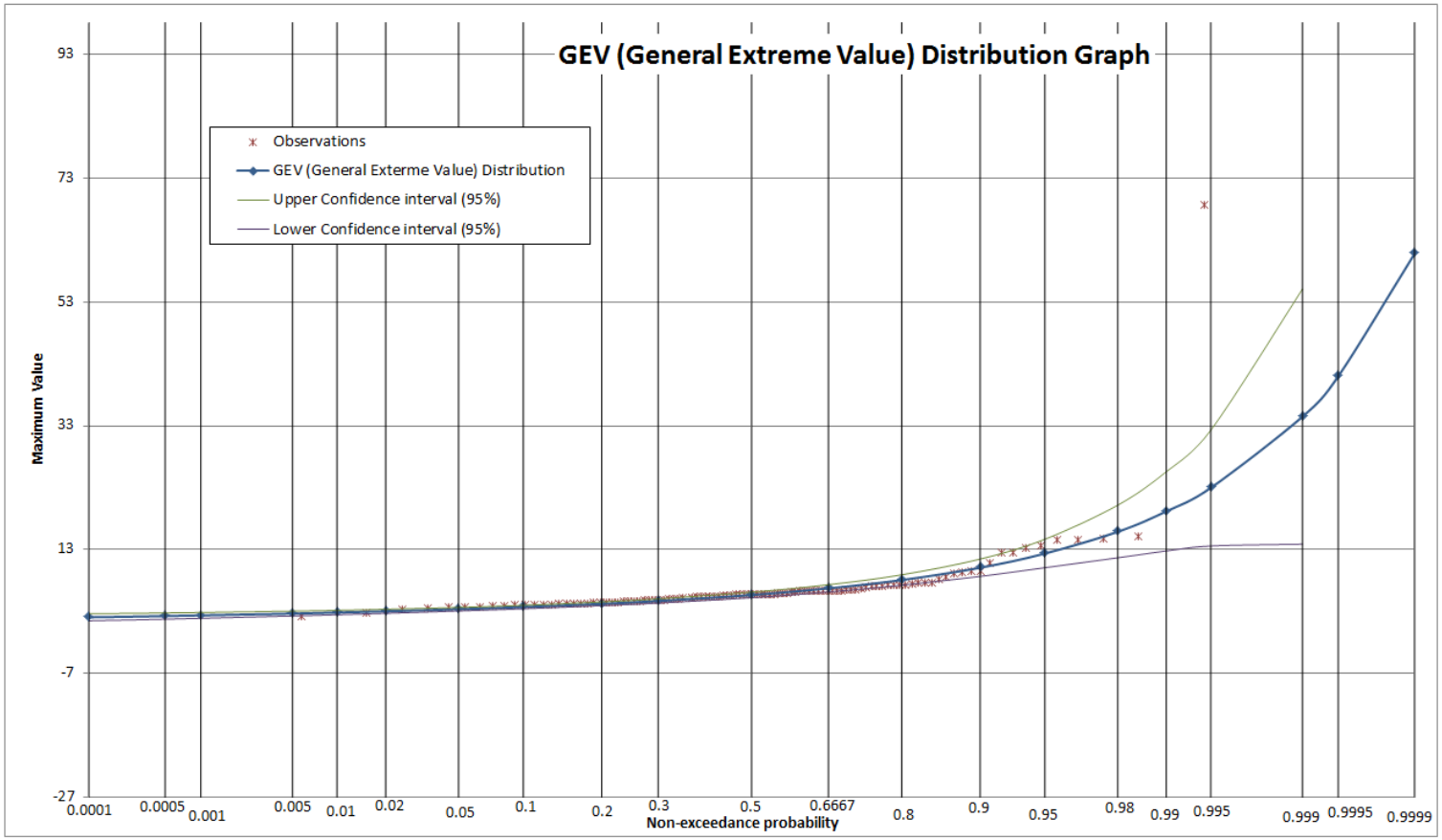

Figure 4. GEV: best fit distribution for the BSP-2, $3Q10_{min}$ flow

Reference: SR1: Fish Passage Flows Analysis

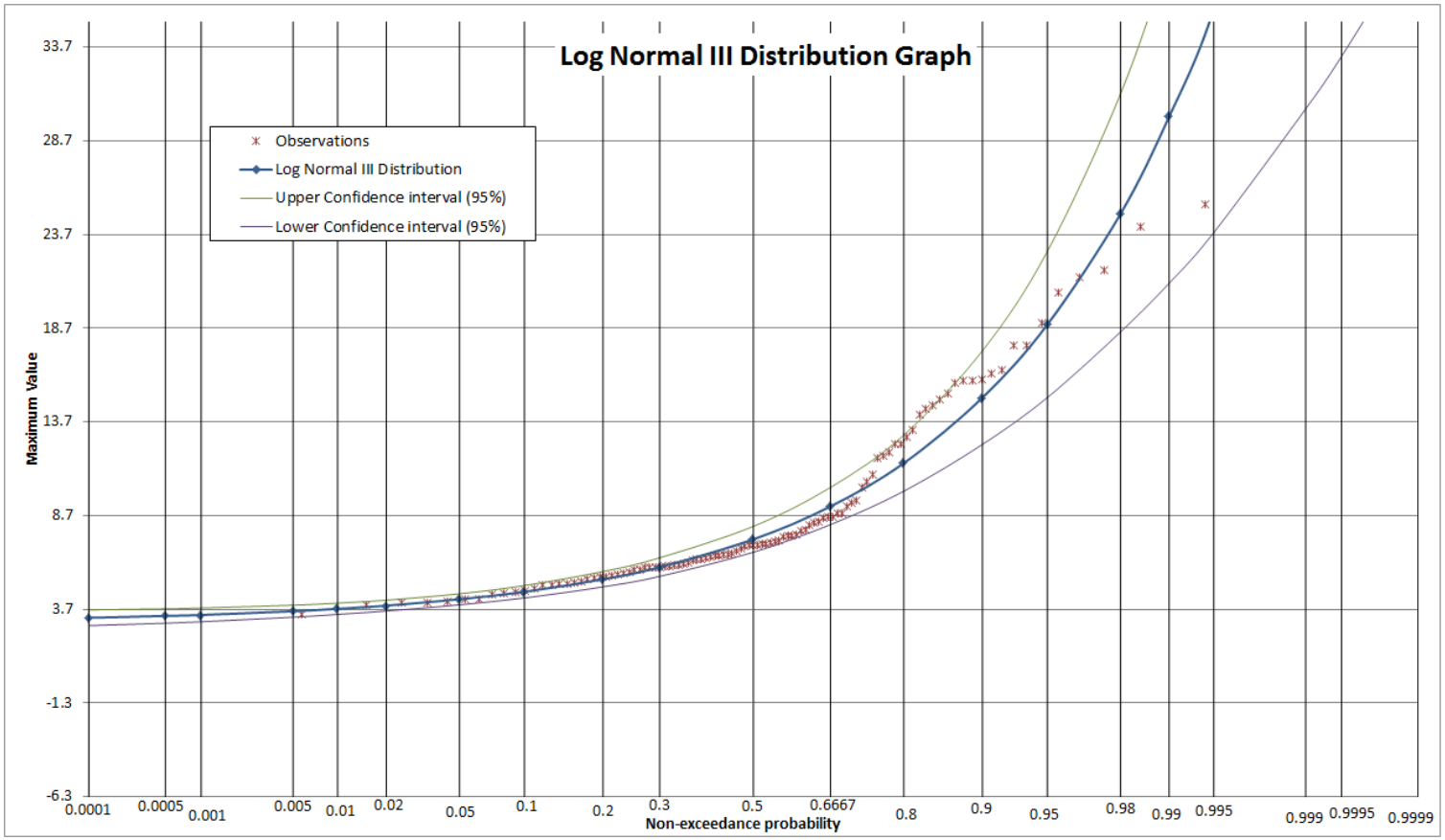

Figure 5. Log Normal III: best fit distribution for the BSP-3, $3Q10_{max}$ flow

Reference: SR1: Fish Passage Flows Analysis

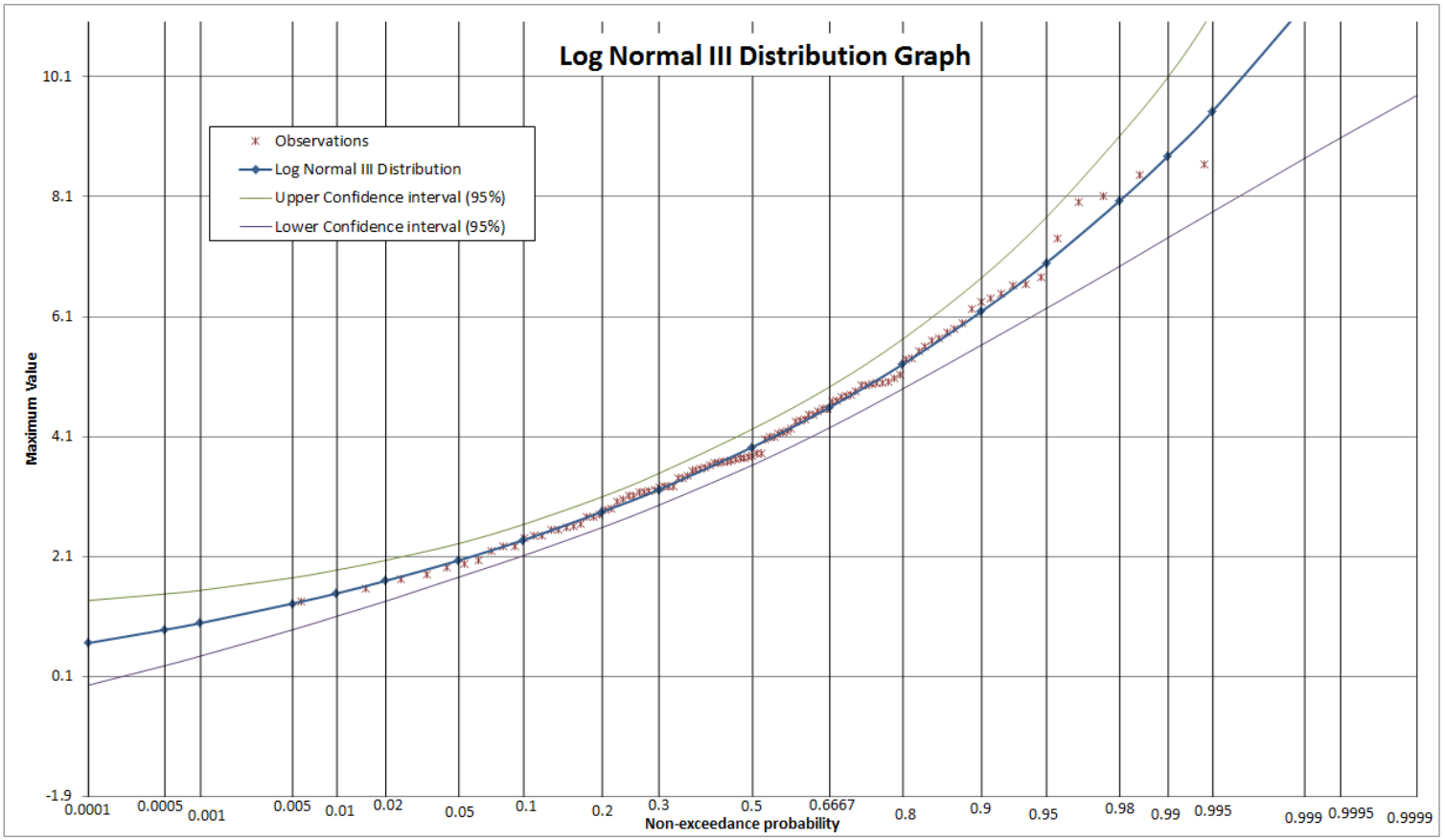

Figure 6. Log Normal III: best fit distribution for the BSP-3, $3Q10_{min}$ flow

Reference: SR1: Fish Passage Flows Analysis

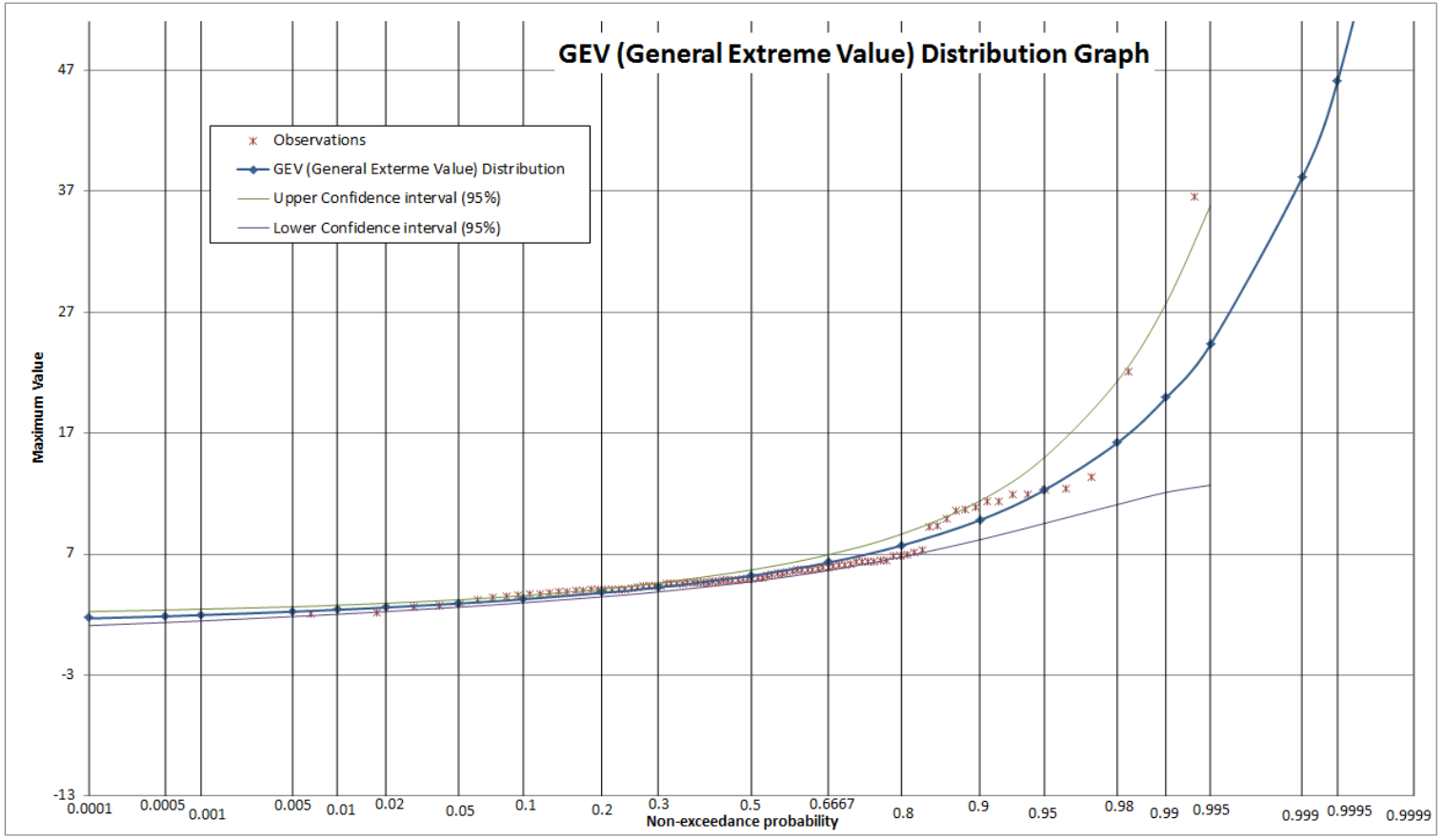

Figure 7. GEV: best fit distribution for the BSP-4, $3Q10_{max}$ flow

Reference: SR1: Fish Passage Flows Analysis

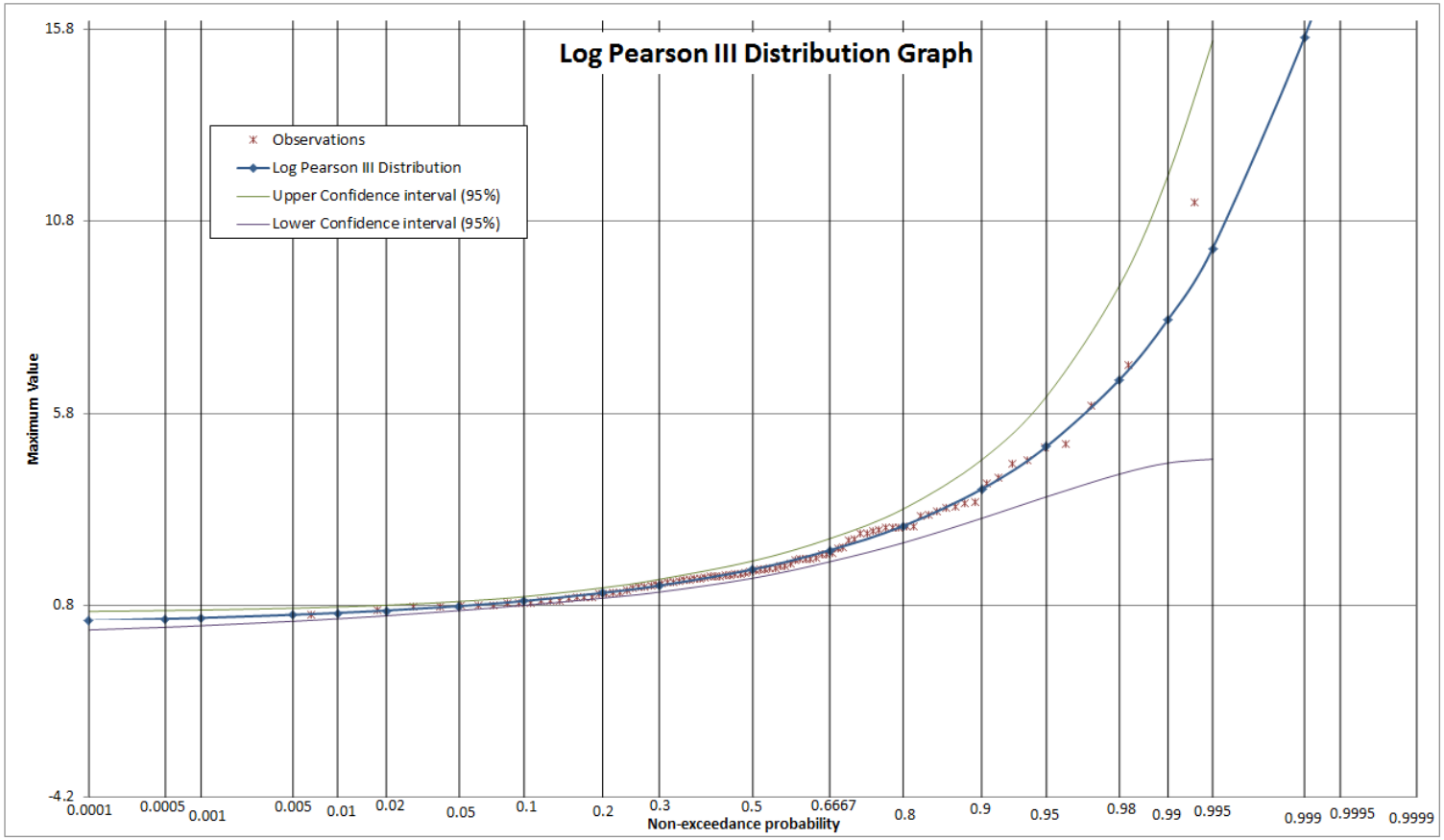

Figure 8. Log Pearson III: best fit distribution for the BSP-4, $3Q10_{min}$ flow

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Memo

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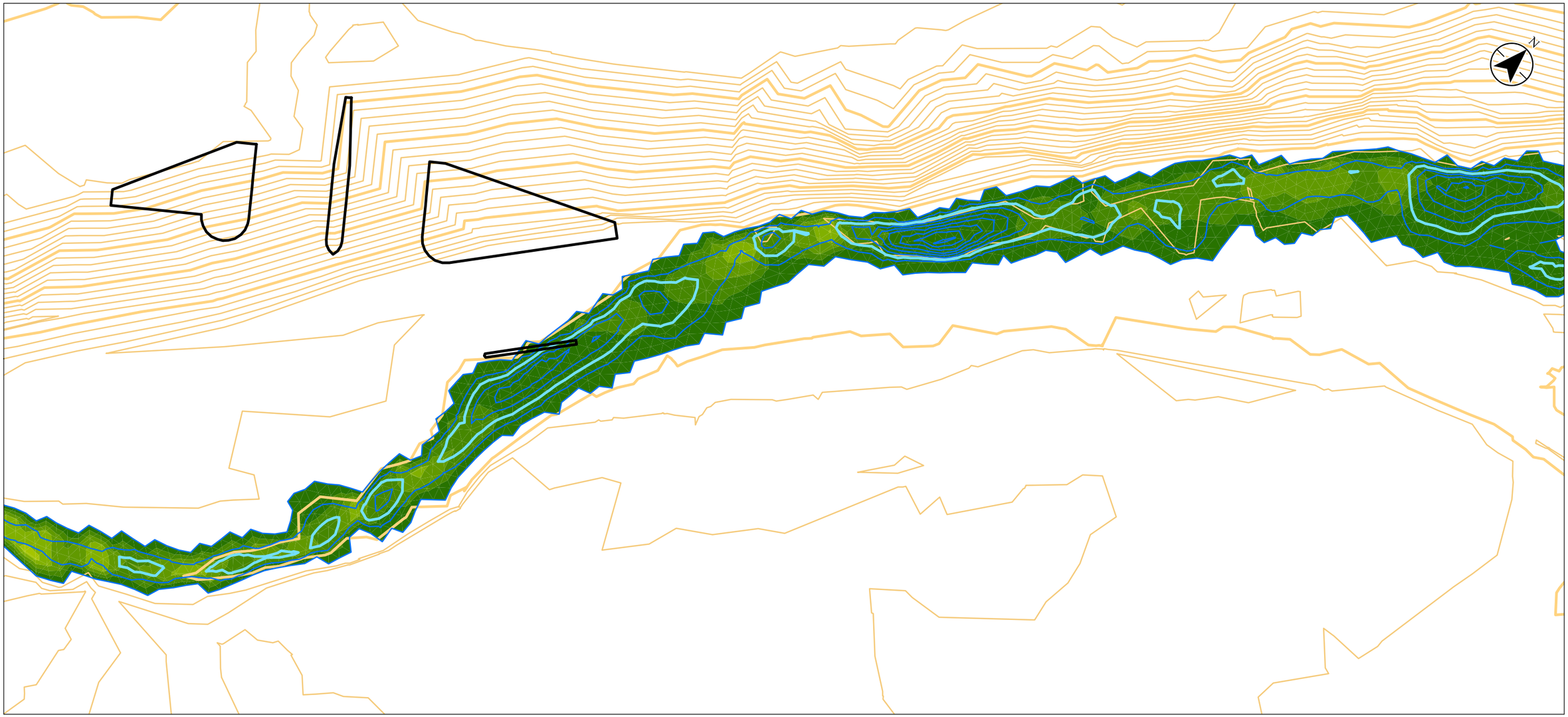

Legend

- Model Domain Lines
- **Depth Contours (0.1 m interval)**
  - All depth contours
  - 0.2 m depth contour
- **Bed Contours (1 m interval)**
  - Intermediate
  - Index

Velocity (m/s)

- 3.5 - 3.75
- 3.25 - 3.5
- 3 - 3.25
- 2.75 - 3
- 2.5 - 2.75
- 2.25 - 2.5
- 2 - 2.25
- 1.75 - 2
- 1.5 - 1.75
- 1.25 - 1.5
- 1 - 1.25
- 0.75 - 1
- 0.5 - 0.75
- 0.25 - 0.5
- 0 - 0.25
- 0

0 20 40 Meters

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Notes

1. Coordinate System: NAD 1983 3TM 114

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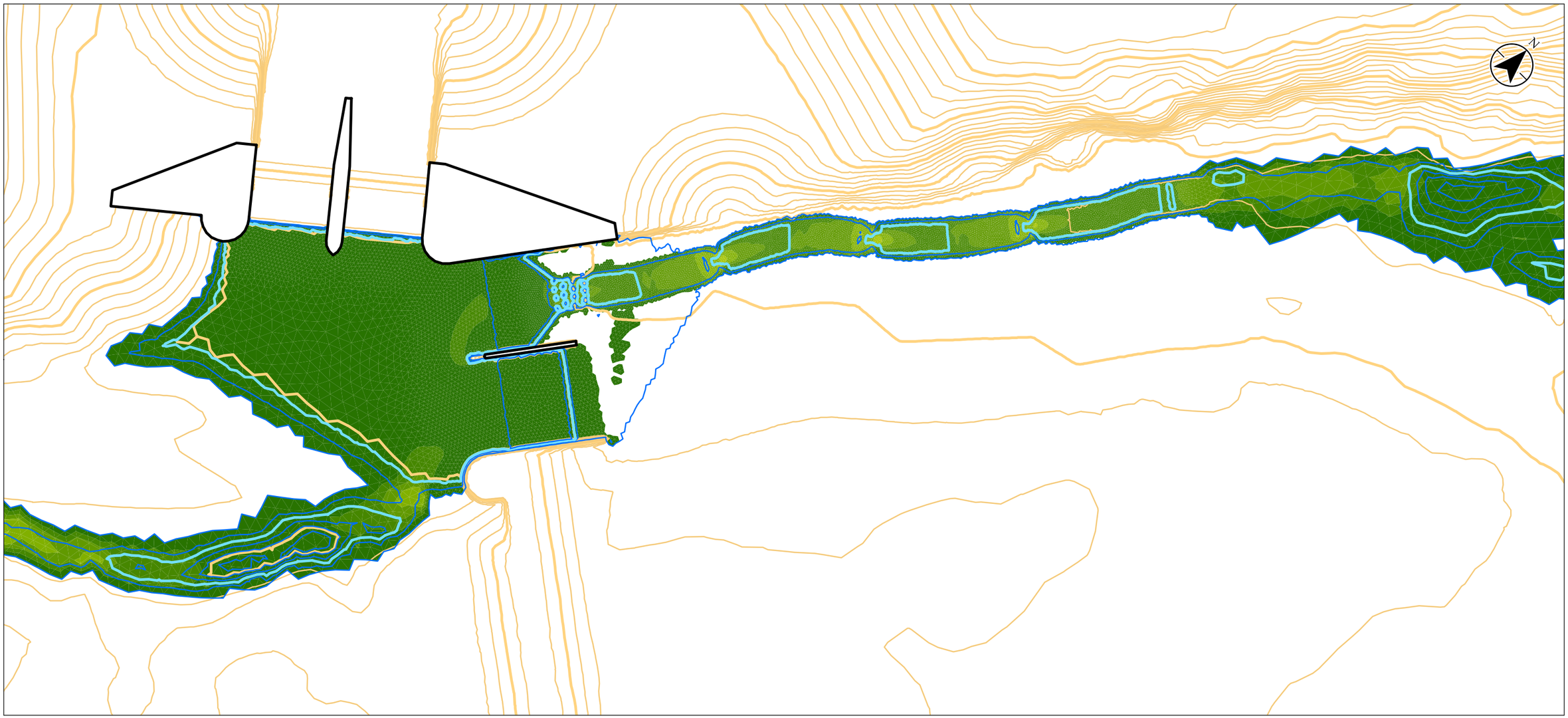
Client/Project
Alberta Transportation
Springbank Off-Stream Reservoir (SR1)

Figure No.
1 of 2

Title
Fish Passage Simulation
Existing Conditions, 0.8 cms



Legend

- Model Domain Lines

Depth Contours (0.1 m interval)

- All depth contours
- 0.2 m depth contour

Bed Contours (1 m interval)

- Intermediate
- Index

Velocity (m/s)

- 3.5 - 3.75
- 3.25 - 3.5
- 3 - 3.25
- 2.75 - 3
- 2.5 - 2.75
- 2.25 - 2.5
- 2 - 2.25
- 1.75 - 2
- 1.5 - 1.75
- 1.25 - 1.5
- 1 - 1.25
- 0.75 - 1
- 0.5 - 0.75
- 0.25 - 0.5
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Figure No.
1 of 2

Title
Fish Passage Simulation
Preliminary Design, 0.8 cms

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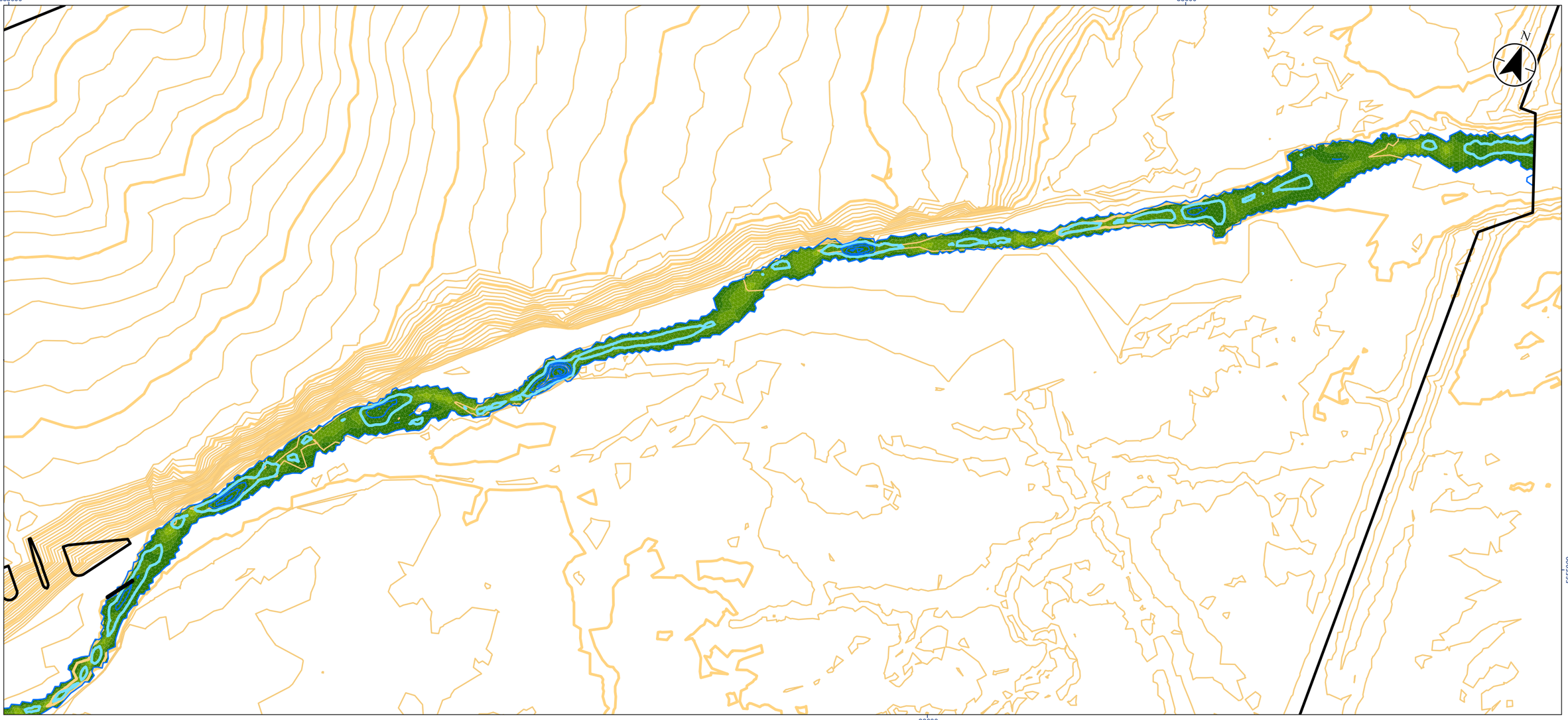

5655000

-33000

Legend

- Model Domain Lines

Depth Contours (0.2 m interval)

- All depth contours
- 0.2 m depth contour

Bed Contours (1 m interval)

- Intermediate
- Index

Velocity (m/s)

- 3.5 - 3.75
- 3.25 - 3.5
- 3 - 3.25
- 2.75 - 3
- 2.5 - 2.75
- 2.25 - 2.5
- 2 - 2.25
- 1.75 - 2
- 1.5 - 1.75
- 1.25 - 1.5
- 1 - 1.25
- 0.75 - 1
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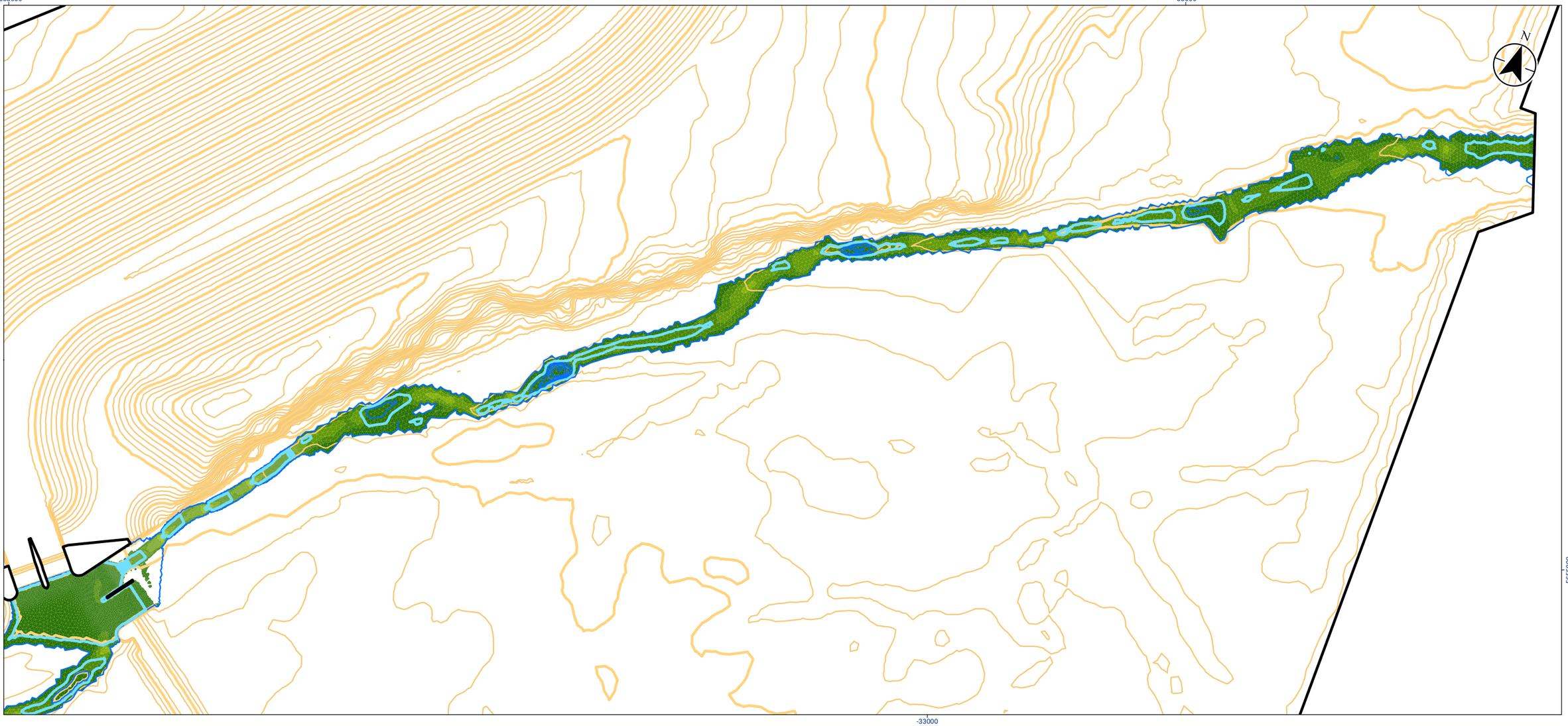
Springbank Off-Stream Reservoir (SR1)

Figure No.
2 of 2

Title
Fish Passage Simulation
Existing Conditions, 0.8 cms

5655000

-33000



5655000

-33000

Legend

- Model Domain Lines

Depth Contours (0.2 m interval)

- All depth contours
- 0.2 m depth contour

Bed Contours (1 m interval)

- Intermediate
- Index

Velocity (m/s)

- 3.5 - 3.75
- 3.25 - 3.5
- 3 - 3.25
- 2.75 - 3
- 2.5 - 2.75
- 2.25 - 2.5
- 2 - 2.25
- 1.75 - 2
- 1.5 - 1.75
- 1.25 - 1.5
- 1 - 1.25
- 0.75 - 1
- 0.5 - 0.75
- 0.25 - 0.5
- 0 - 0.25
- 0

0 60 120 Meters

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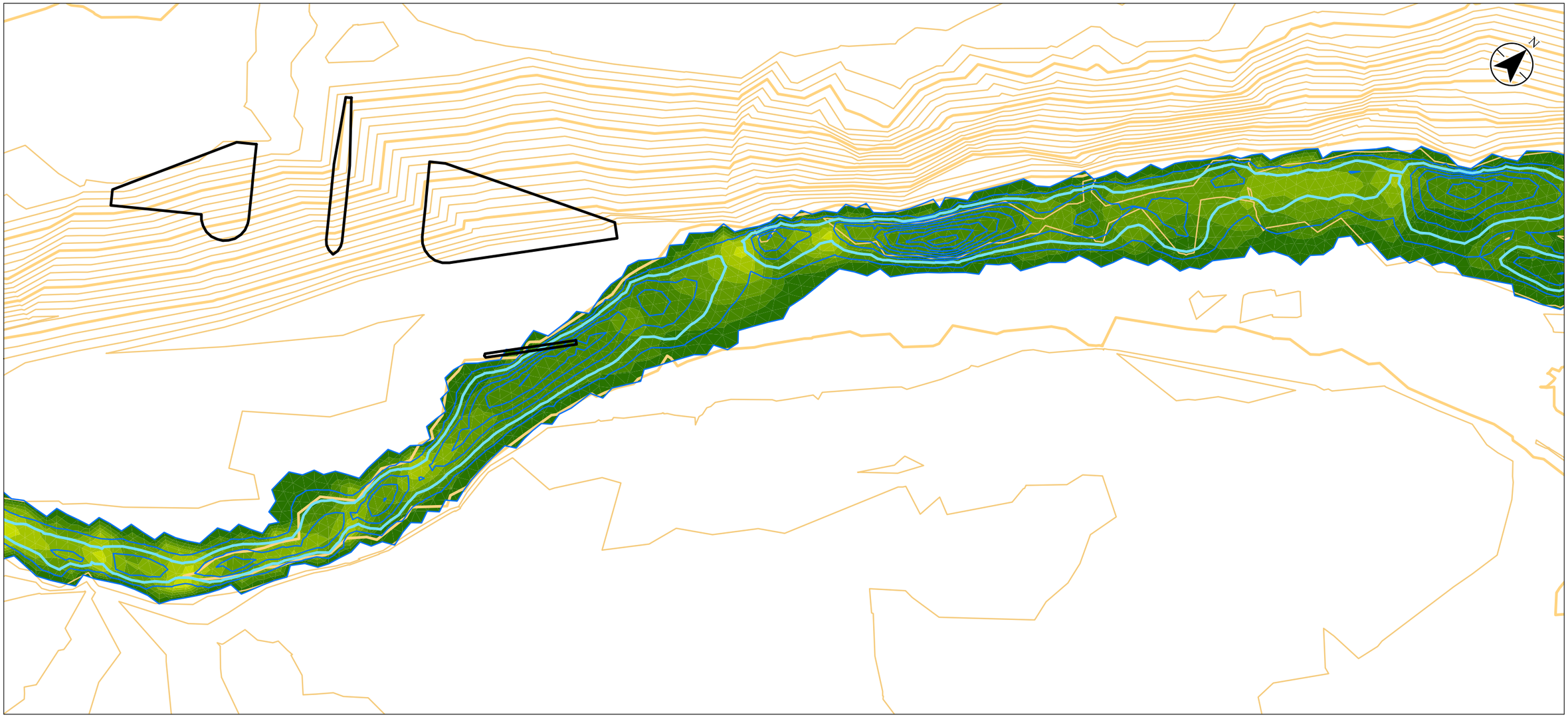
Alberta Transportation
Springbank Off-Stream Reservoir (SR1)

Figure No.
2 of 2

Title
Fish Passage Simulation
Preliminary Design, 0.8 cms



Legend

- Model Domain Lines

Depth Contours (0.1 m interval)

- All depth contours
- 0.2 m depth contour

Bed Contours (1 m interval)

- Intermediate
- Index

Velocity (m/s)

- 3.5 - 3.75
- 3.25 - 3.5
- 3 - 3.25
- 2.75 - 3
- 2.5 - 2.75
- 2.25 - 2.5
- 2 - 2.25
- 1.75 - 2
- 1.5 - 1.75
- 1.25 - 1.5
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- 0.75 - 1
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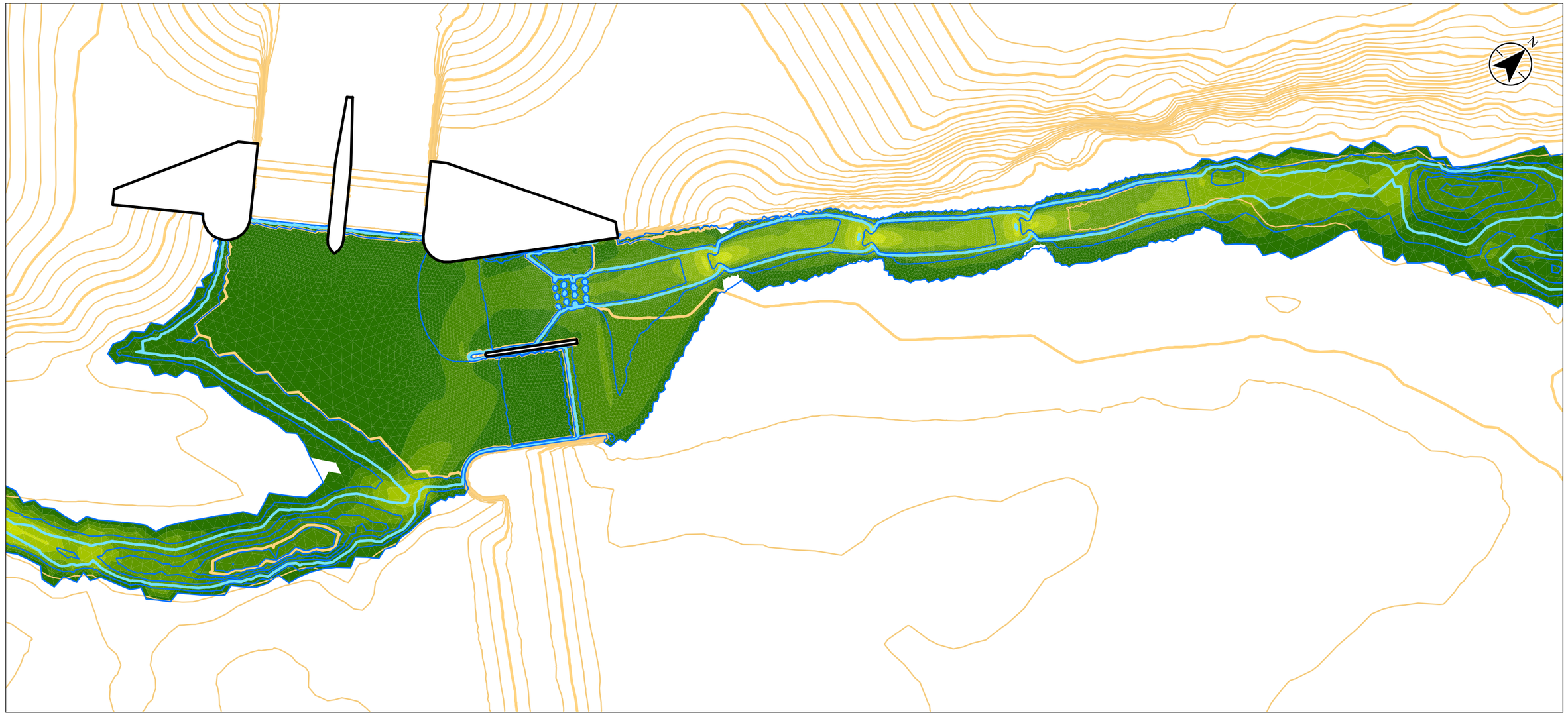
Springbank Off-Stream Reservoir (SR1)

Figure No.
1 of 2

Title
Fish Passage Simulation
Existing Conditions, 2.38 cms



Legend

- Model Domain Lines

Depth Contours (0.1 m interval)

- All depth contours
- 0.2 m depth contour

Bed Contours (1 m interval)

- Intermediate
- Index

Velocity (m/s)

- 3.5 - 3.75
- 3.25 - 3.5
- 3 - 3.25
- 2.75 - 3
- 2.5 - 2.75
- 2.25 - 2.5
- 2 - 2.25
- 1.75 - 2
- 1.5 - 1.75
- 1.25 - 1.5
- 1 - 1.25
- 0.75 - 1
- 0.5 - 0.75
- 0.25 - 0.5
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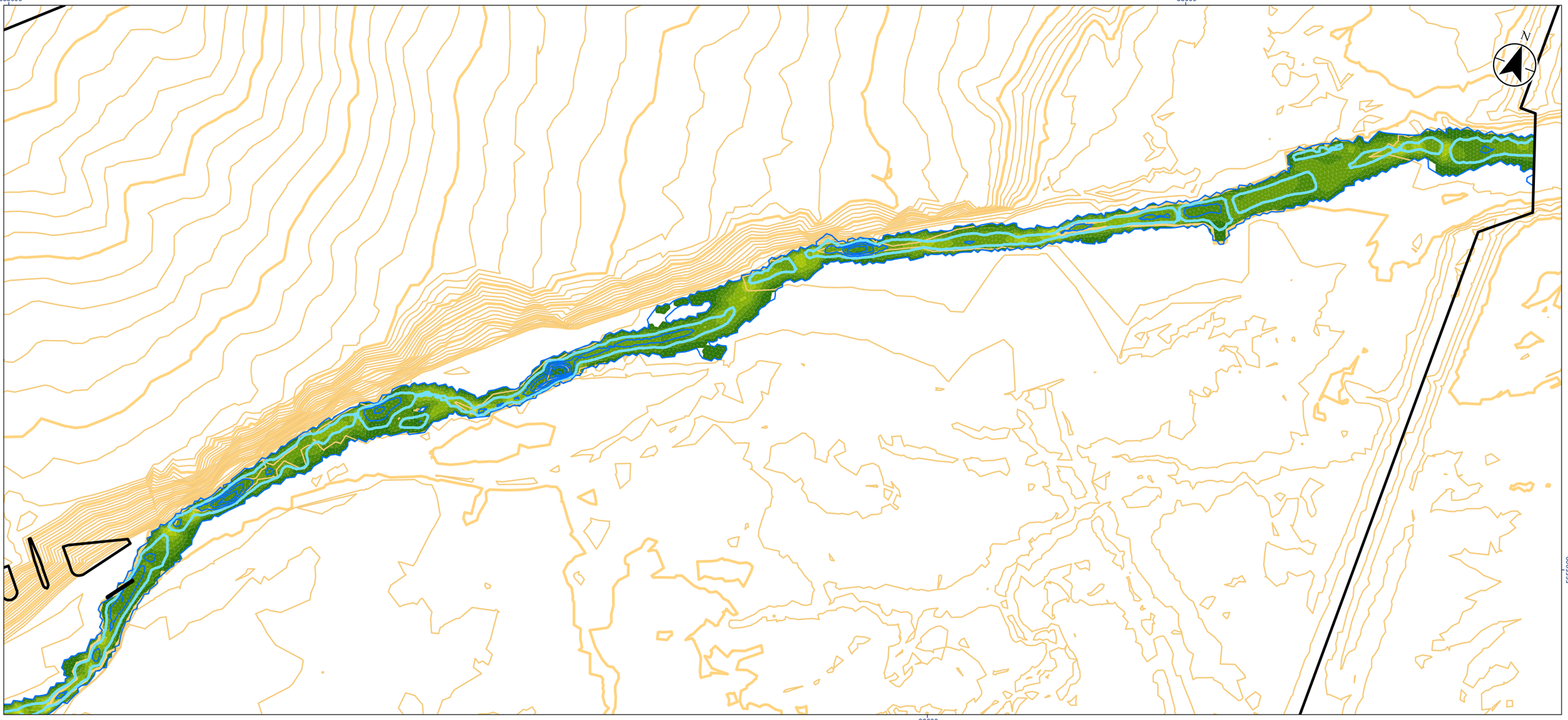
Springbank Off-Stream Reservoir (SR1)

Figure No.
1 of 2

Title
Fish Passage Simulation
Preliminary Design, 2.38 cms

5655000

-33000



-33000

5655000

Legend

- Model Domain Lines

Depth Contours (0.2 m interval)

- All depth contours
- 0.2 m depth contour

Bed Contours (1 m interval)

- Intermediate
- Index

Velocity (m/s)

- 3.5 - 3.75
- 3.25 - 3.5
- 3 - 3.25
- 2.75 - 3
- 2.5 - 2.75
- 2.25 - 2.5
- 2 - 2.25
- 1.75 - 2
- 1.5 - 1.75
- 1.25 - 1.5
- 1 - 1.25
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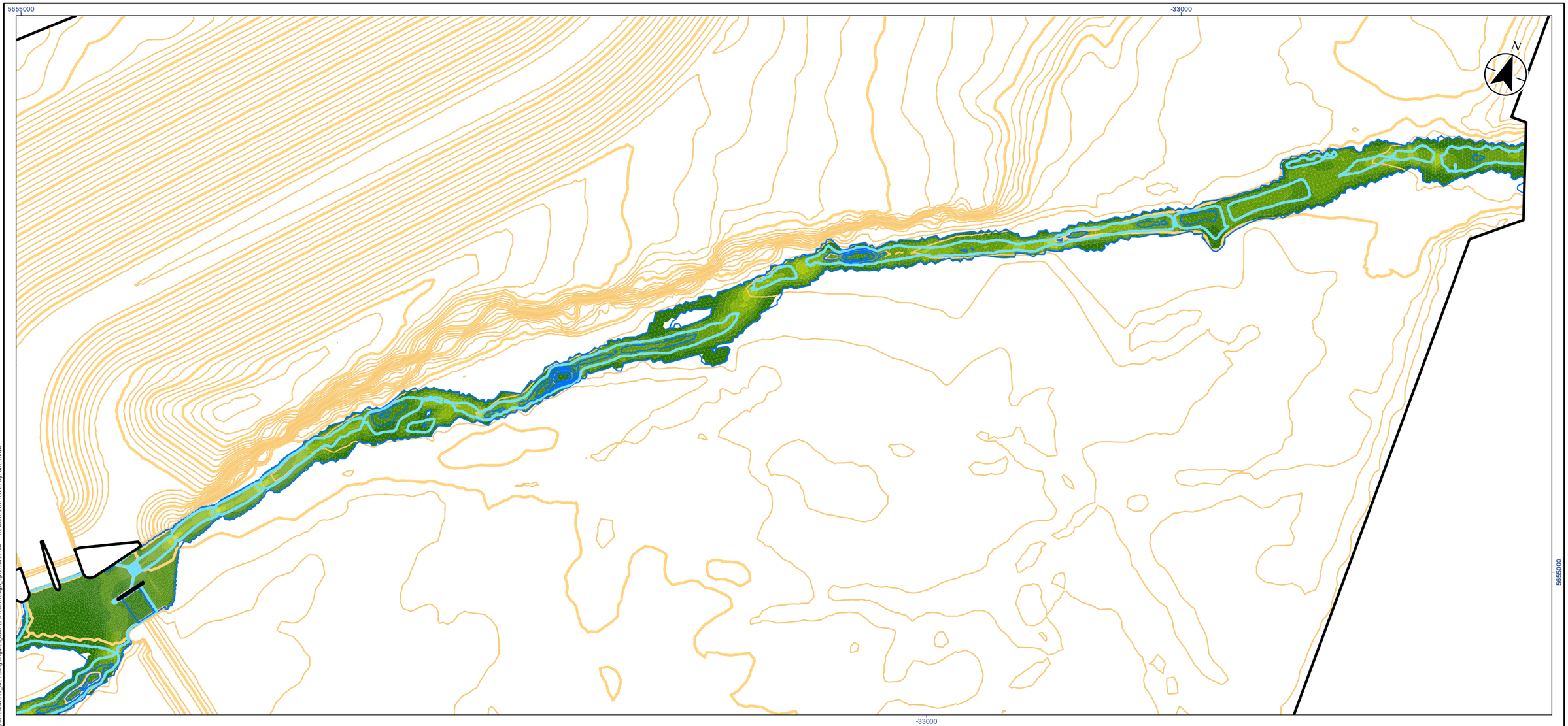
Springbank Off-Stream Reservoir (SR1)

Figure No.
2 of 2

Title
Fish Passage Simulation
Existing Conditions, 2.38 cms



Legend

- Model Domain Lines

Depth Contours (0.2 m interval)

- All depth contours
- 0.2 m depth contour

Bed Contours (1 m interval)

- Intermediate
- Index

Velocity (m/s)

- 3.5 - 3.75
- 3.25 - 3.5
- 3 - 3.25
- 2.75 - 3
- 2.5 - 2.75
- 2.25 - 2.5
- 2 - 2.25
- 1.75 - 2
- 1.5 - 1.75
- 1.25 - 1.5
- 1 - 1.25
- 0.75 - 1
- 0.5 - 0.75
- 0.25 - 0.5
- 0 - 0.25
- 0

0 60 120 Meters

1:3,000 (At original document size of 11x17)

Notes

1. Coordinate System: NAD 1983 3TM 114

Stantec

Project Location
City of Calgary
Alberta

110773396
Prepared by DEH on 2017-08-23
Technical Review by ABC on 2017-02-xx
Independent Review by ABC on 2017-02-xx

Client/Project
Alberta Transportation
Springbank Off-Stream Reservoir (SR1)

Figure No.
2 of 2

Title
Fish Passage Simulation
Preliminary Design, 2.38 cms

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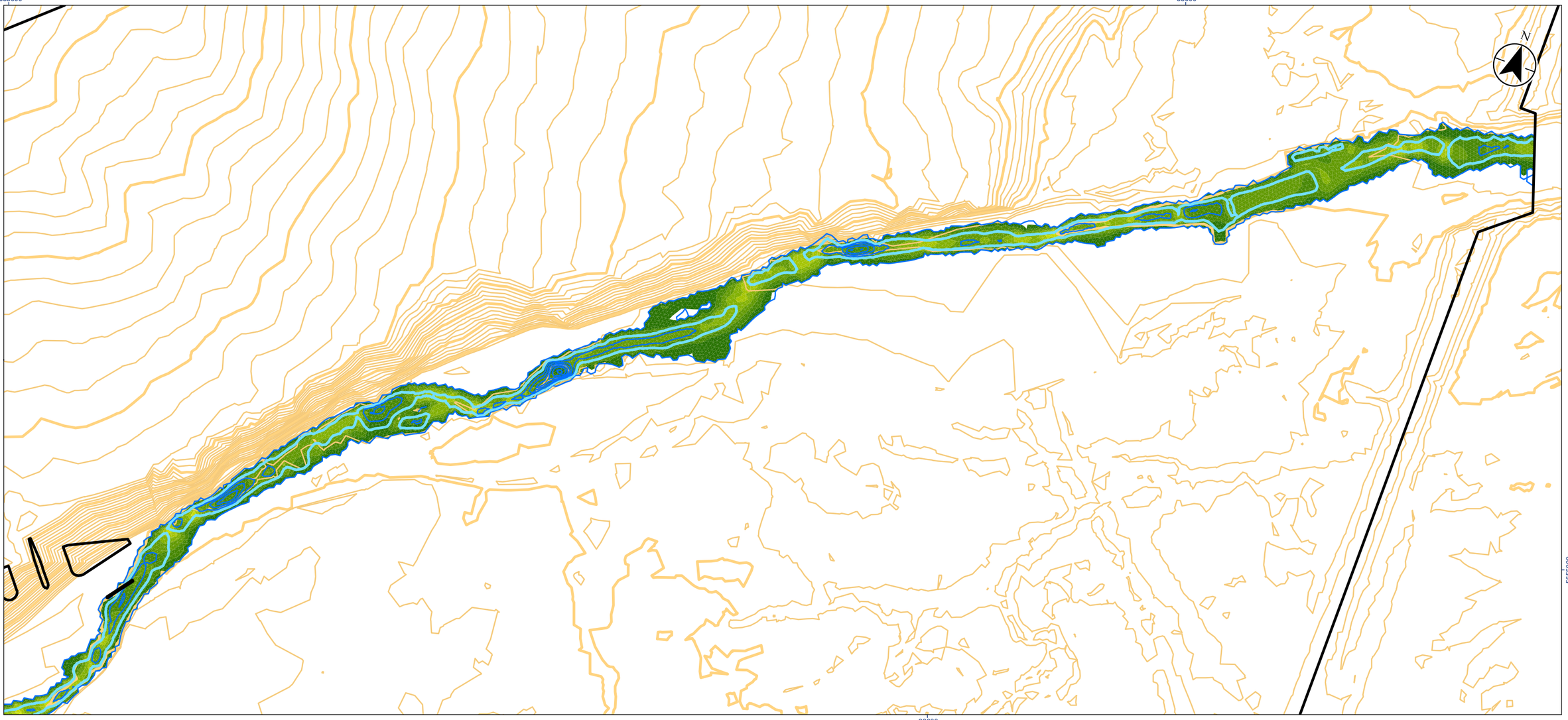

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-33000

Legend

- Model Domain Lines

Depth Contours (0.2 m interval)

- All depth contours
- 0.2 m depth contour

Bed Contours (1 m interval)

- Intermediate
- Index

Velocity (m/s)

- 3.5 - 3.75
- 3.25 - 3.5
- 3 - 3.25
- 2.75 - 3
- 2.5 - 2.75
- 2.25 - 2.5
- 2 - 2.25
- 1.75 - 2
- 1.5 - 1.75
- 1.25 - 1.5
- 1 - 1.25
- 0.75 - 1
- 0.5 - 0.75
- 0.25 - 0.5
- 0 - 0.25
- 0

0 60 120 Meters

1:3,000 (At original document size of 11x17)

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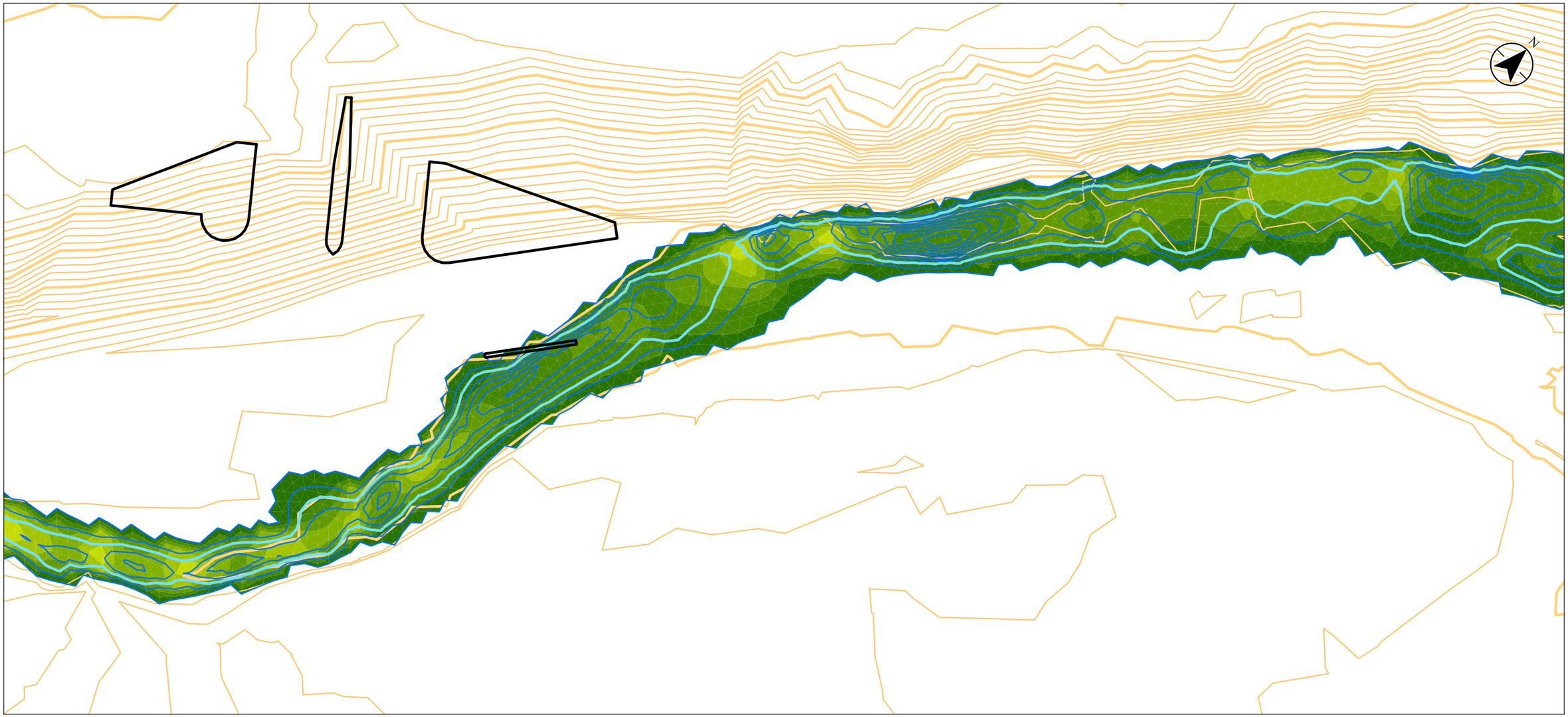
Client/Project
Alberta Transportation
Springbank Off-Stream Reservoir (SR1)

Figure No.
2 of 2

Title
Fish Passage Simulation
Existing Conditions, 2.8 cms



Legend

- Model Domain Lines

Depth Contours (0.1 m interval)

- All depth contours
- 0.2 m depth contour

Bed Contours (1 m interval)

- Intermediate
- Index

Velocity (m/s)

- 3.5 - 3.75
- 3.25 - 3.5
- 3 - 3.25
- 2.75 - 3
- 2.5 - 2.75
- 2.25 - 2.5
- 2 - 2.25
- 1.75 - 2
- 1.5 - 1.75
- 1.25 - 1.5
- 1 - 1.25
- 0.75 - 1
- 0.5 - 0.75
- 0.25 - 0.5
- 0 - 0.25
- 0

0 20 40 Meters

1:1,000 (At original document size of 11x17)

Notes

1. Coordinate System: NAD 1983 3TM 114

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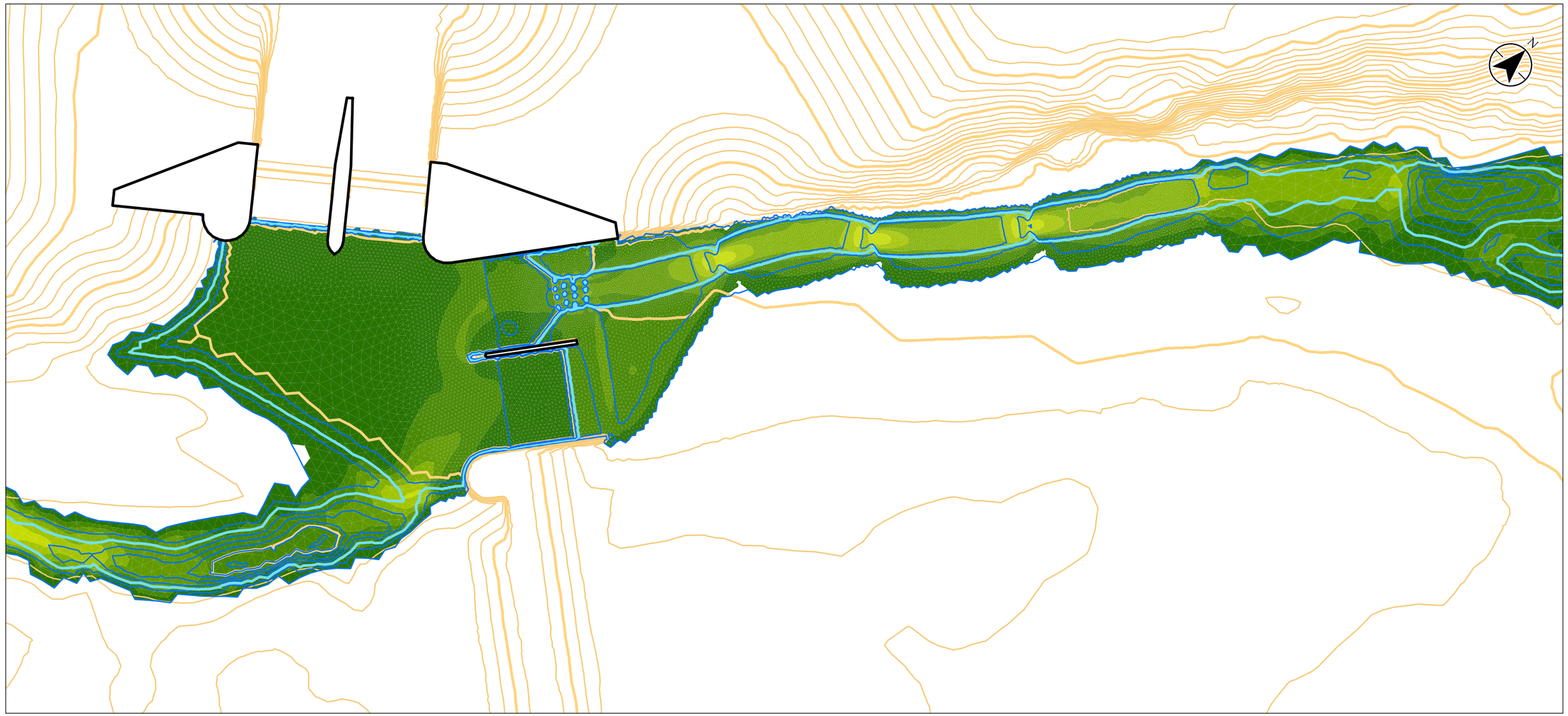
Client/Project
Alberta Transportation
Springbank Off-Stream Reservoir (SR1)

Figure No.
1 of 2

Title
Fish Passage Simulation
Existing Conditions, 2.8 cms



Legend

- Model Domain Lines

Depth Contours (0.1 m interval)

- All depth contours
- 0.2 m depth contour

Bed Contours (1 m interval)

- Intermediate
- Index

Velocity (m/s)

- 3.5 - 3.75
- 3.25 - 3.5
- 3 - 3.25
- 2.75 - 3
- 2.5 - 2.75
- 2.25 - 2.5
- 2 - 2.25
- 1.75 - 2
- 1.5 - 1.75
- 1.25 - 1.5
- 1 - 1.25
- 0.75 - 1
- 0.5 - 0.75
- 0.25 - 0.5
- 0 - 0.25
- 0

0 20 40 Meters

1:1,000 (At original document size of 11x17)

Notes

1. Coordinate System: NAD 1983 3TM 114

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Client/Project
Alberta Transportation
Springbank Off-Stream Reservoir (SR1)

Figure No.
1 of 2

Title
Fish Passage Simulation
Preliminary Design, 2.8 cms

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Legend

Model Domain Lines

Depth Contours (0.2 m interval)

All depth contours

0.2 m depth contour

Bed Contours (1 m interval)

Intermediate

Index

Velocity (m/s)

- 3.5 - 3.75
- 3.25 - 3.5
- 3 - 3.25
- 2.75 - 3
- 2.5 - 2.75
- 2.25 - 2.5
- 2 - 2.25
- 1.75 - 2
- 1.5 - 1.75
- 1.25 - 1.5
- 1 - 1.25
- 0.75 - 1
- 0.5 - 0.75
- 0.25 - 0.5
- 0 - 0.25
- 0

0 60 120 Meters

1:3,000 (At original document size of 11x17)

Notes

1. Coordinate System: NAD 1983 3TM 114

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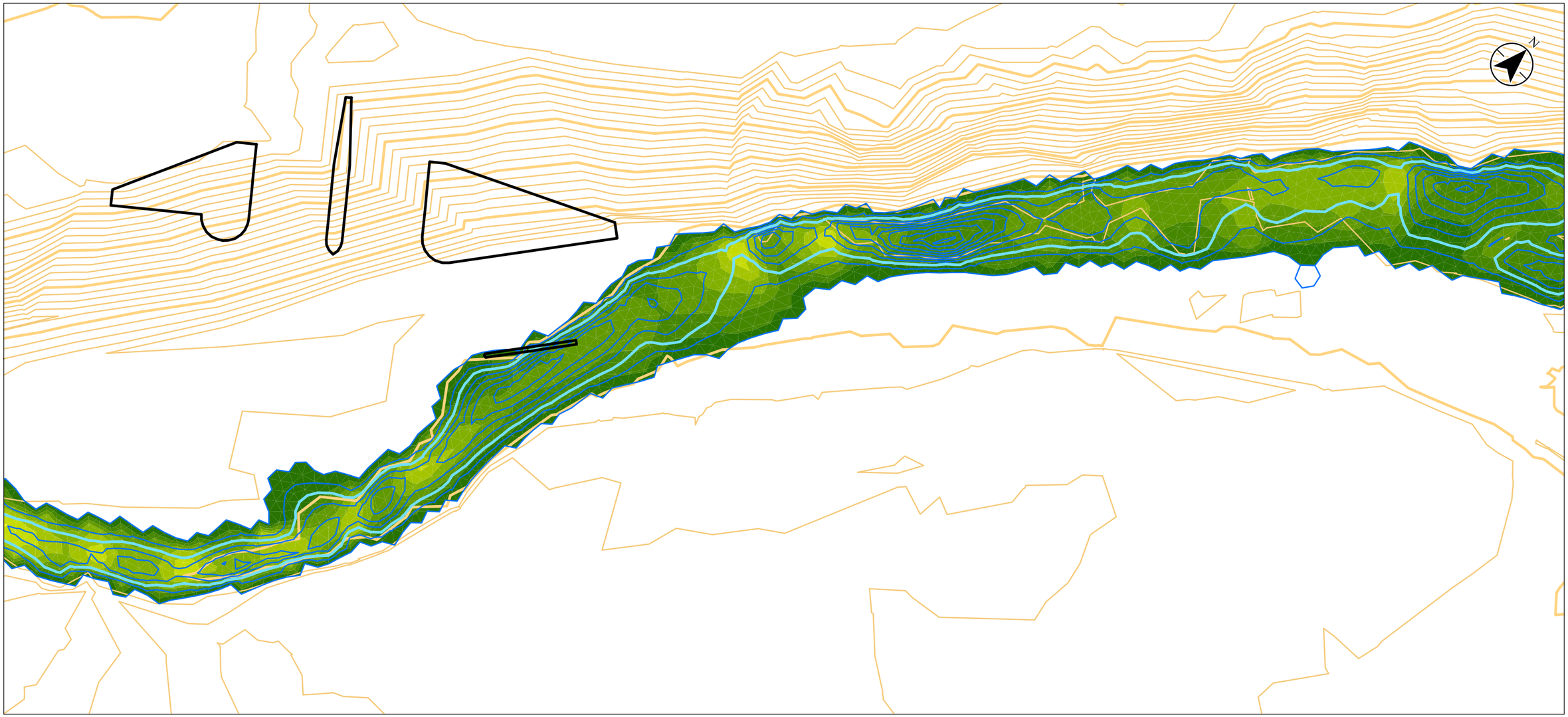
Client/Project
Alberta Transportation
Springbank Off-Stream Reservoir (SR1)

Figure No.
2 of 2

Title
Fish Passage Simulation
Preliminary Design, 2.8 cms



Legend

- Model Domain Lines

Depth Contours (0.1 m interval)

- All depth contours
- 0.2 m depth contour

Bed Contours (1 m interval)

- Intermediate
- Index

Velocity (m/s)

- 3.5 - 3.75
- 3.25 - 3.5
- 3 - 3.25
- 2.75 - 3
- 2.5 - 2.75
- 2.25 - 2.5
- 2 - 2.25
- 1.75 - 2
- 1.5 - 1.75
- 1.25 - 1.5
- 1 - 1.25
- 0.75 - 1
- 0.5 - 0.75
- 0.25 - 0.5
- 0 - 0.25
- 0

0 20 40 Meters

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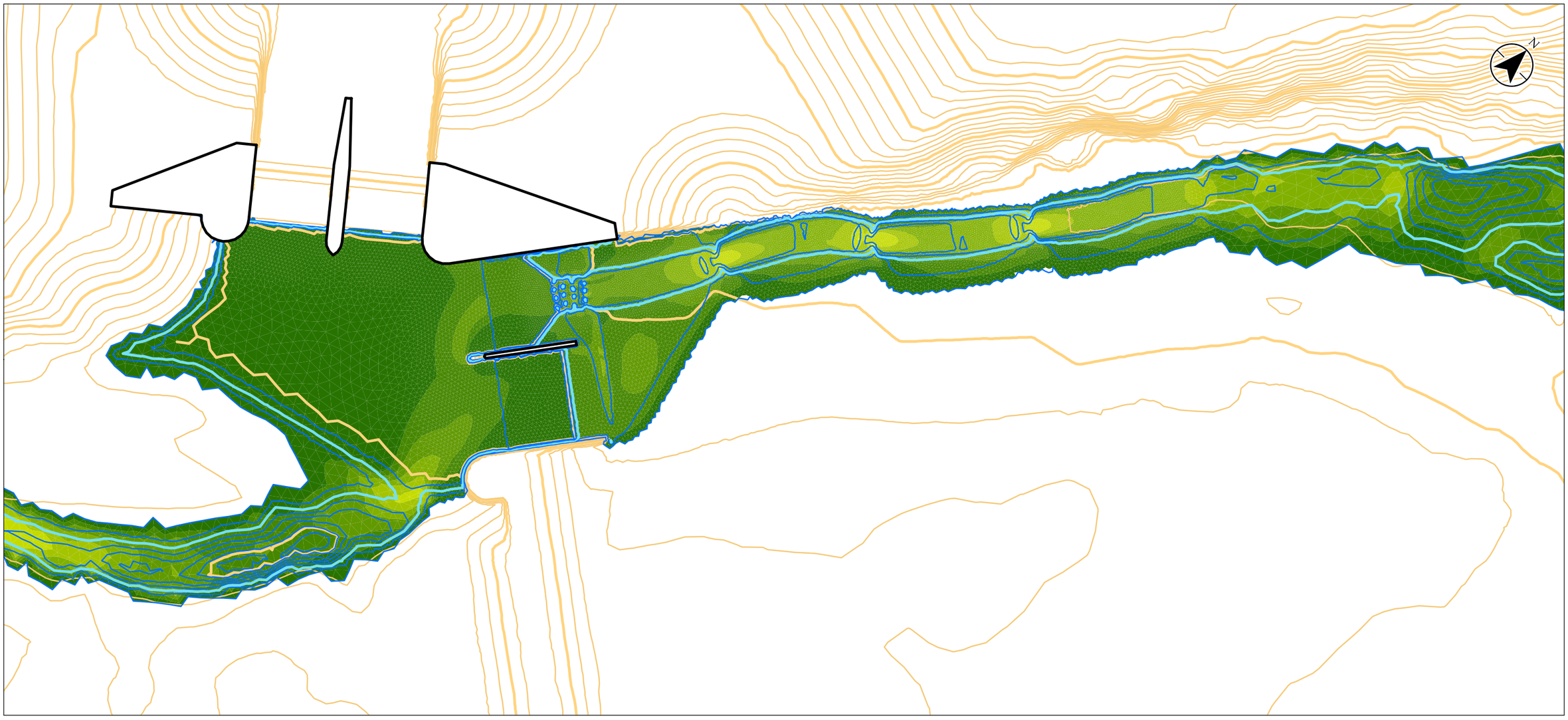
Client/Project
Alberta Transportation
Springbank Off-Stream Reservoir (SR1)

Figure No.
1 of 2

Title
Fish Passage Simulation
Existing Conditions, 3.47 cms



Legend

- Model Domain Lines

Depth Contours (0.1 m interval)

- All depth contours
- 0.2 m depth contour

Bed Contours (1 m interval)

- Intermediate
- Index

Velocity (m/s)

- 3.5 - 3.75
- 3.25 - 3.5
- 3 - 3.25
- 2.75 - 3
- 2.5 - 2.75
- 2.25 - 2.5
- 2 - 2.25
- 1.75 - 2
- 1.5 - 1.75
- 1.25 - 1.5
- 1 - 1.25
- 0.75 - 1
- 0.5 - 0.75
- 0.25 - 0.5
- 0 - 0.25
- 0

Notes

1. Coordinate System: NAD 1983 3TM 114

0 20 40 Meters

1:1,000 (At original document size of 11x17)

Stantec

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Client/Project
Alberta Transportation
Springbank Off-Stream Reservoir (SR1)

Figure No.
1 of 2

Title
Fish Passage Simulation
Preliminary Design, 3.47 cms

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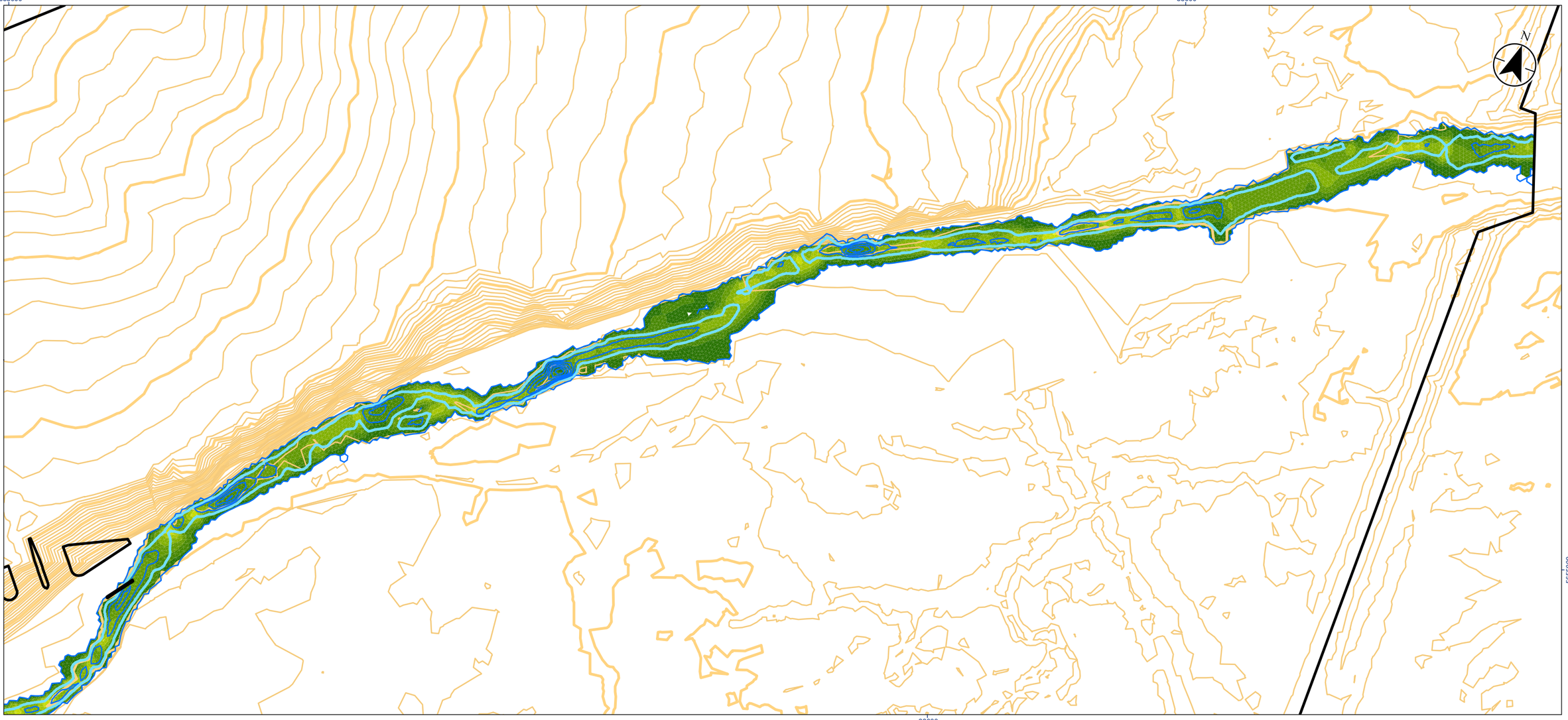

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Legend

- Model Domain Lines

Depth Contours (0.2 m interval)

- All depth contours
- 0.2 m depth contour

Bed Contours (1 m interval)

- Intermediate
- Index

Velocity (m/s)

- 3.5 - 3.75
- 3.25 - 3.5
- 3 - 3.25
- 2.75 - 3
- 2.5 - 2.75
- 2.25 - 2.5
- 2 - 2.25
- 1.75 - 2
- 1.5 - 1.75
- 1.25 - 1.5
- 1 - 1.25
- 0.75 - 1
- 0.5 - 0.75
- 0.25 - 0.5
- 0 - 0.25
- 0

0 60 120 Meters

1:3,000 (At original document size of 11x17)

Notes

1. Coordinate System: NAD 1983 3TM 114

Stantec

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Client/Project
Alberta Transportation
Springbank Off-Stream Reservoir (SR1)

Figure No.
2 of 2

Title
Fish Passage Simulation
Existing Conditions, 3.47 cms

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-33000

Legend

Model Domain Lines

Depth Contours (0.2 m interval)

All depth contours

0.2 m depth contour

Bed Contours (1 m interval)

Intermediate

Index

Velocity (m/s)

3.5 - 3.75
3.25 - 3.5
3 - 3.25
2.75 - 3
2.5 - 2.75
2.25 - 2.5
2 - 2.25
1.75 - 2
1.5 - 1.75
1.25 - 1.5
1 - 1.25
0.75 - 1
0.5 - 0.75
0.25 - 0.5
0 - 0.25
0

0 60 120 Meters

1:3,000 (At original document size of 11x17)

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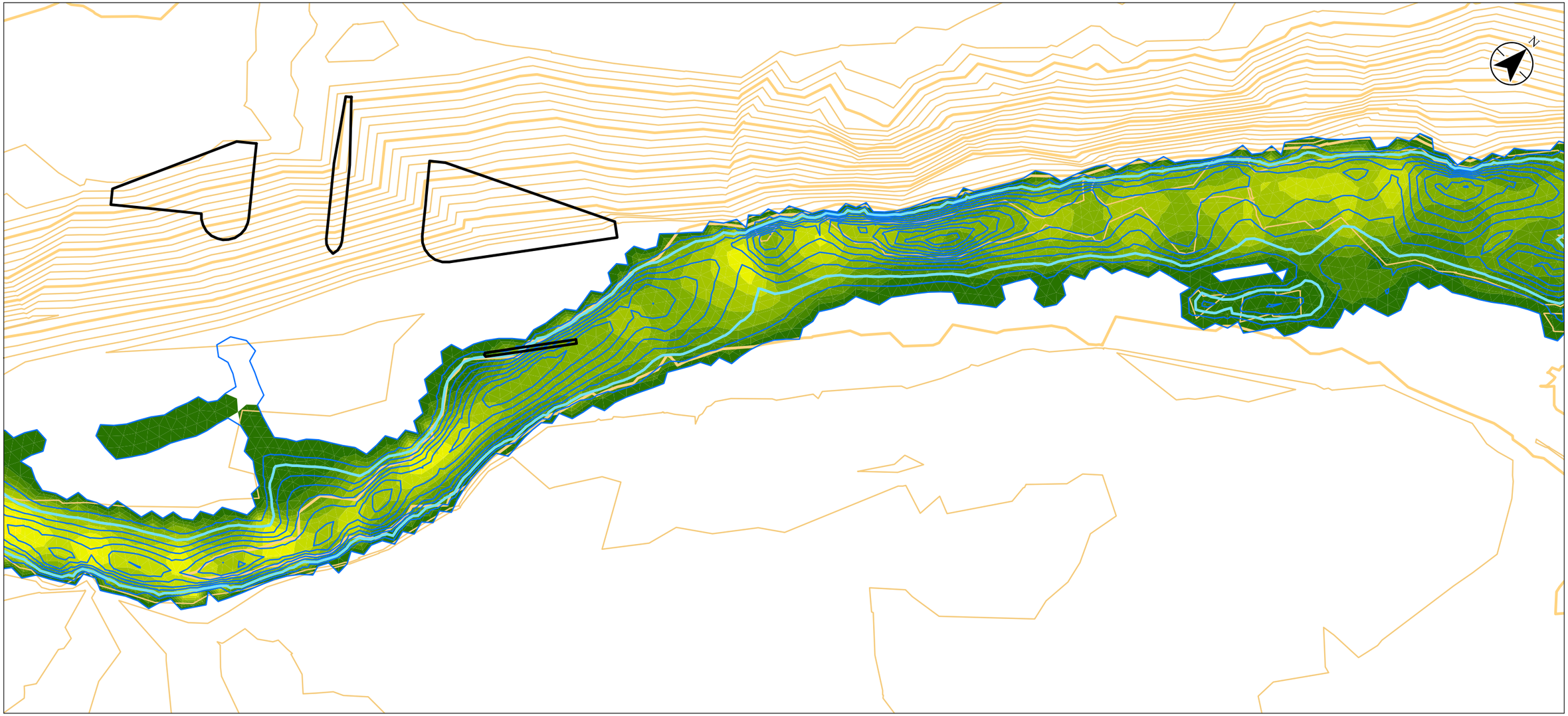
Client/Project
Alberta Transportation
Springbank Off-Stream Reservoir (SR1)

Figure No.
2 of 2

Title
Fish Passage Simulation
Preliminary Design, 3.47 cms



Legend

- Model Domain Lines

Depth Contours (0.1 m interval)

- All depth contours
- 0.2 m depth contour

Bed Contours (1 m interval)

- Intermediate
- Index

Velocity (m/s)

- 3.5 - 3.75
- 3.25 - 3.5
- 3 - 3.25
- 2.75 - 3
- 2.5 - 2.75
- 2.25 - 2.5
- 2 - 2.25
- 1.75 - 2
- 1.5 - 1.75
- 1.25 - 1.5
- 1 - 1.25
- 0.75 - 1
- 0.5 - 0.75
- 0.25 - 0.5
- 0 - 0.25
- 0

0 20 40 Meters

1:1,000 (At original document size of 11x17)

Notes

1. Coordinate System: NAD 1983 3TM 114

Stantec

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City of Calgary
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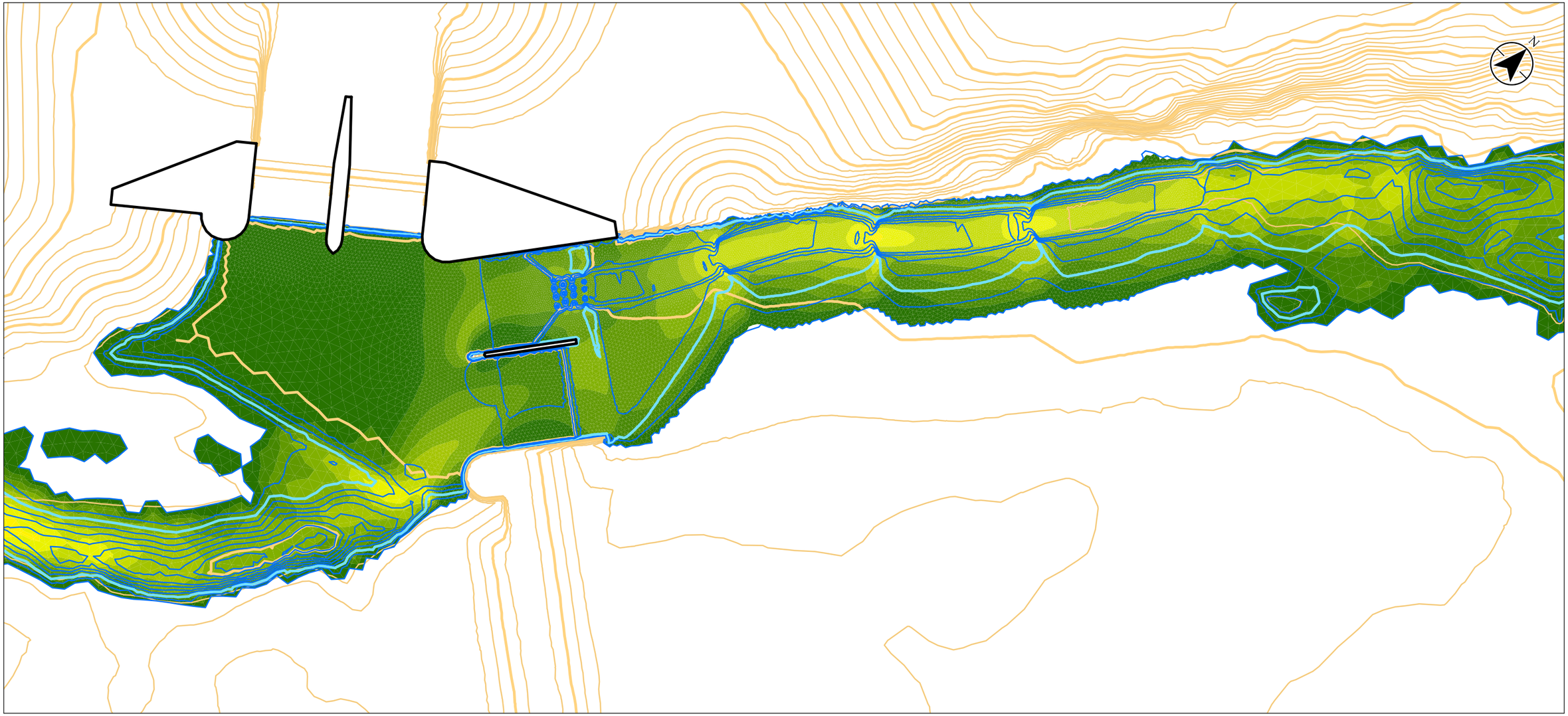
Client/Project
Alberta Transportation
Springbank Off-Stream Reservoir (SR1)

Figure No.
1 of 2

Title
Fish Passage Simulation
Existing Conditions, 9.81 cms



Legend

- Model Domain Lines

Depth Contours (0.1 m interval)

- All depth contours
- 0.2 m depth contour

Bed Contours (1 m interval)

- Intermediate
- Index

Velocity (m/s)

- 3.5 - 3.75
- 3.25 - 3.5
- 3 - 3.25
- 2.75 - 3
- 2.5 - 2.75
- 2.25 - 2.5
- 2 - 2.25
- 1.75 - 2
- 1.5 - 1.75
- 1.25 - 1.5
- 1 - 1.25
- 0.75 - 1
- 0.5 - 0.75
- 0.25 - 0.5
- 0 - 0.25
- 0

0 20 40 Meters

1:1,000 (At original document size of 11x17)

Notes

1. Coordinate System: NAD 1983 3TM 114

Stantec

Project Location
City of Calgary
Alberta

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Client/Project
Alberta Transportation
Springbank Off-Stream Reservoir (SR1)

Figure No.
1 of 2

Title
Fish Passage Simulation
Preliminary Design, 9.81 cms

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Revised: 2017-08-23 By: dhoffmann

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Legend

- Model Domain Lines

Depth Contours (0.2 m interval)

- All depth contours
- 0.2 m depth contour

Bed Contours (1 m interval)

- Intermediate
- Index

Velocity (m/s)

- 3.5 - 3.75
- 3.25 - 3.5
- 3 - 3.25
- 2.75 - 3
- 2.5 - 2.75
- 2.25 - 2.5
- 2 - 2.25
- 1.75 - 2
- 1.5 - 1.75
- 1.25 - 1.5
- 1 - 1.25
- 0.75 - 1
- 0.5 - 0.75
- 0.25 - 0.5
- 0 - 0.25
- 0

0 60 120 Meters

1:3,000 (At original document size of 11x17)

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1. Coordinate System: NAD 1983 3TM 114

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Client/Project
Alberta Transportation
Springbank Off-Stream Reservoir (SR1)

Figure No.
2 of 2

Title
Fish Passage Simulation
Existing Conditions, 9.81 cms

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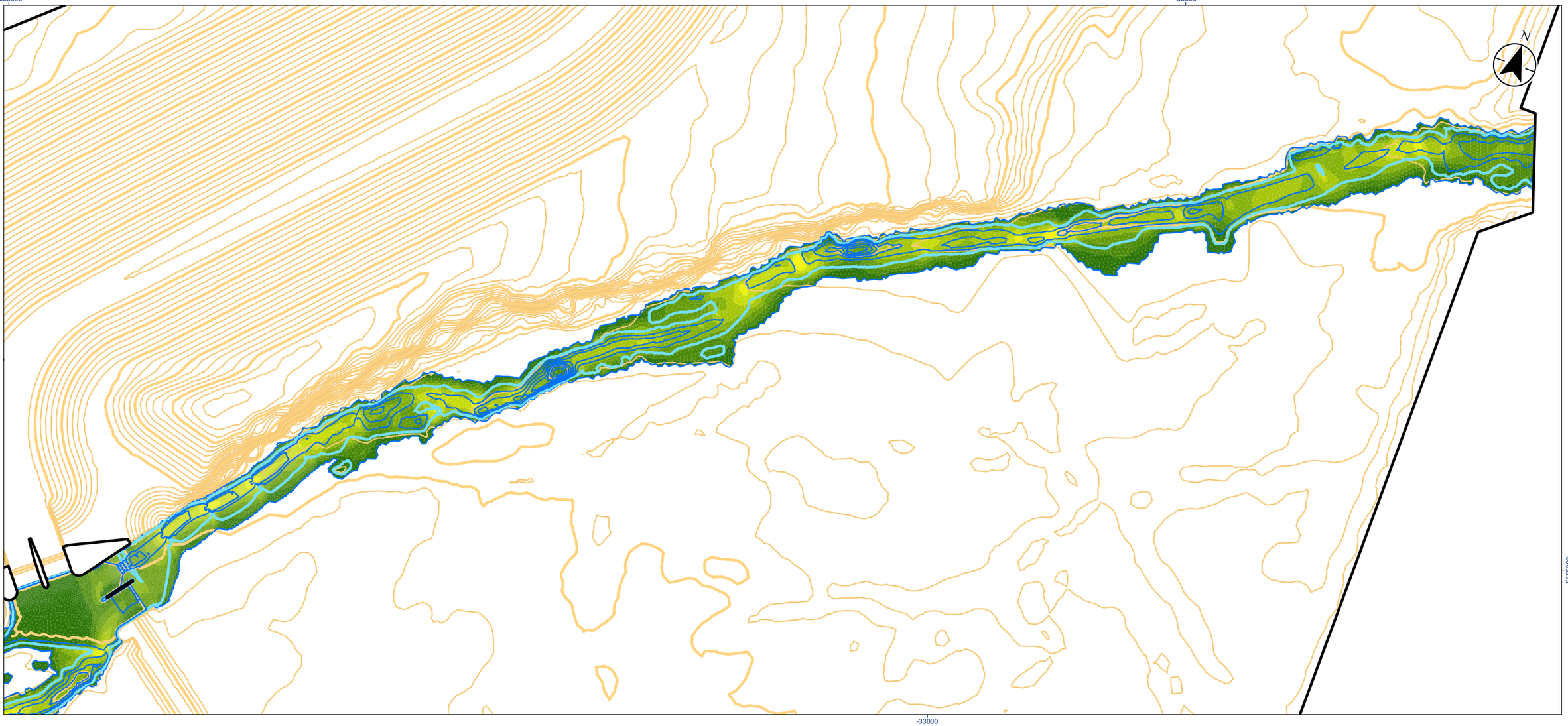

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-33000

Legend

- Model Domain Lines

Depth Contours (0.2 m interval)

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- 0.2 m depth contour

Bed Contours (1 m interval)

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Velocity (m/s)

- 3.5 - 3.75
- 3.25 - 3.5
- 3 - 3.25
- 2.75 - 3
- 2.5 - 2.75
- 2.25 - 2.5
- 2 - 2.25
- 1.75 - 2
- 1.5 - 1.75
- 1.25 - 1.5
- 1 - 1.25
- 0.75 - 1
- 0.5 - 0.75
- 0.25 - 0.5
- 0 - 0.25
- 0

0 60 120 Meters

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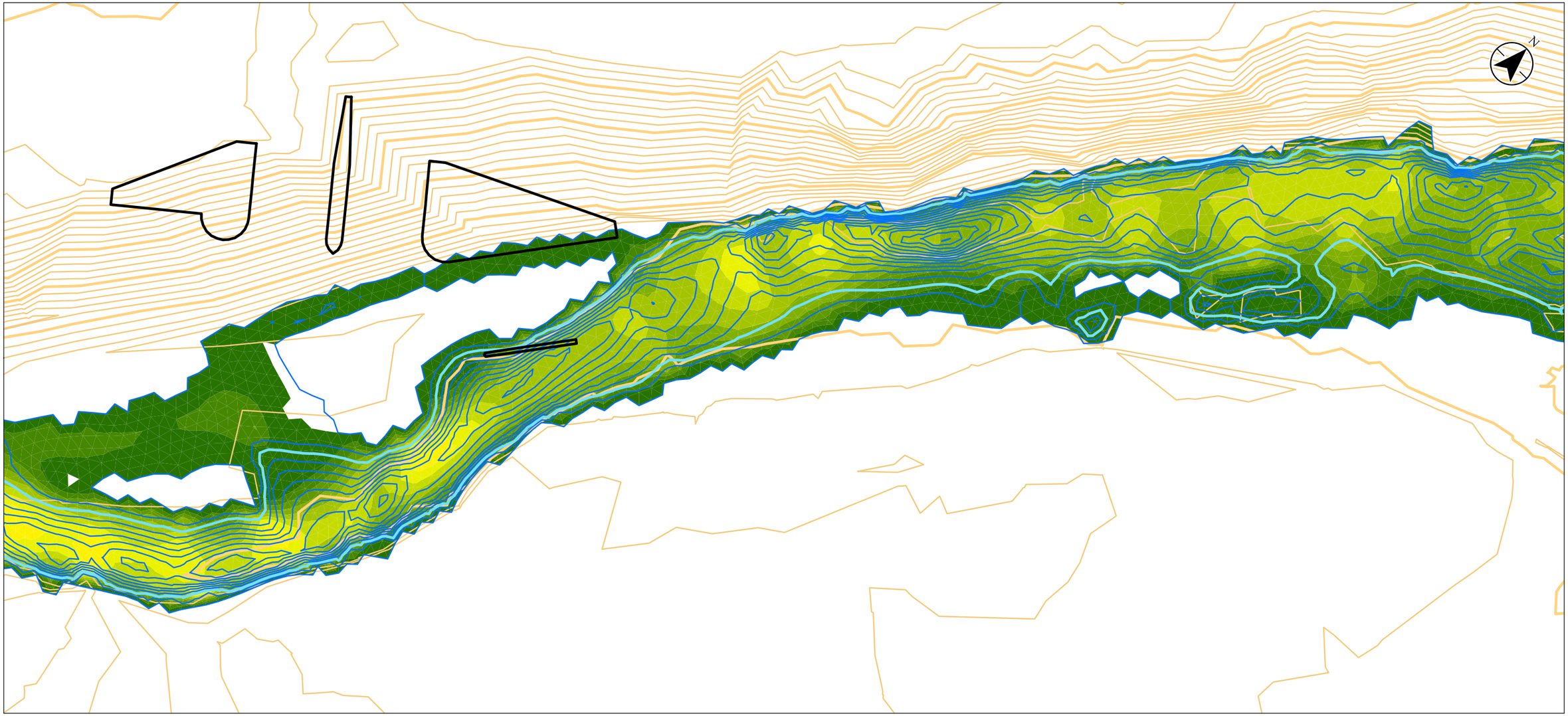
Client/Project
Alberta Transportation
Springbank Off-Stream Reservoir (SR1)

Figure No.
2 of 2

Title
Fish Passage Simulation
Preliminary Design, 9.81 cms



Legend

- Model Domain Lines

Depth Contours (0.1 m interval)

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- 0.2 m depth contour

Bed Contours (1 m interval)

- Intermediate
- Index

Velocity (m/s)

- 3.5 - 3.75
- 3.25 - 3.5
- 3 - 3.25
- 2.75 - 3
- 2.5 - 2.75
- 2.25 - 2.5
- 2 - 2.25
- 1.75 - 2
- 1.5 - 1.75
- 1.25 - 1.5
- 1 - 1.25
- 0.75 - 1
- 0.5 - 0.75
- 0.25 - 0.5
- 0 - 0.25
- 0

0 20 40 Meters

1:1,000 (At original document size of 11x17)

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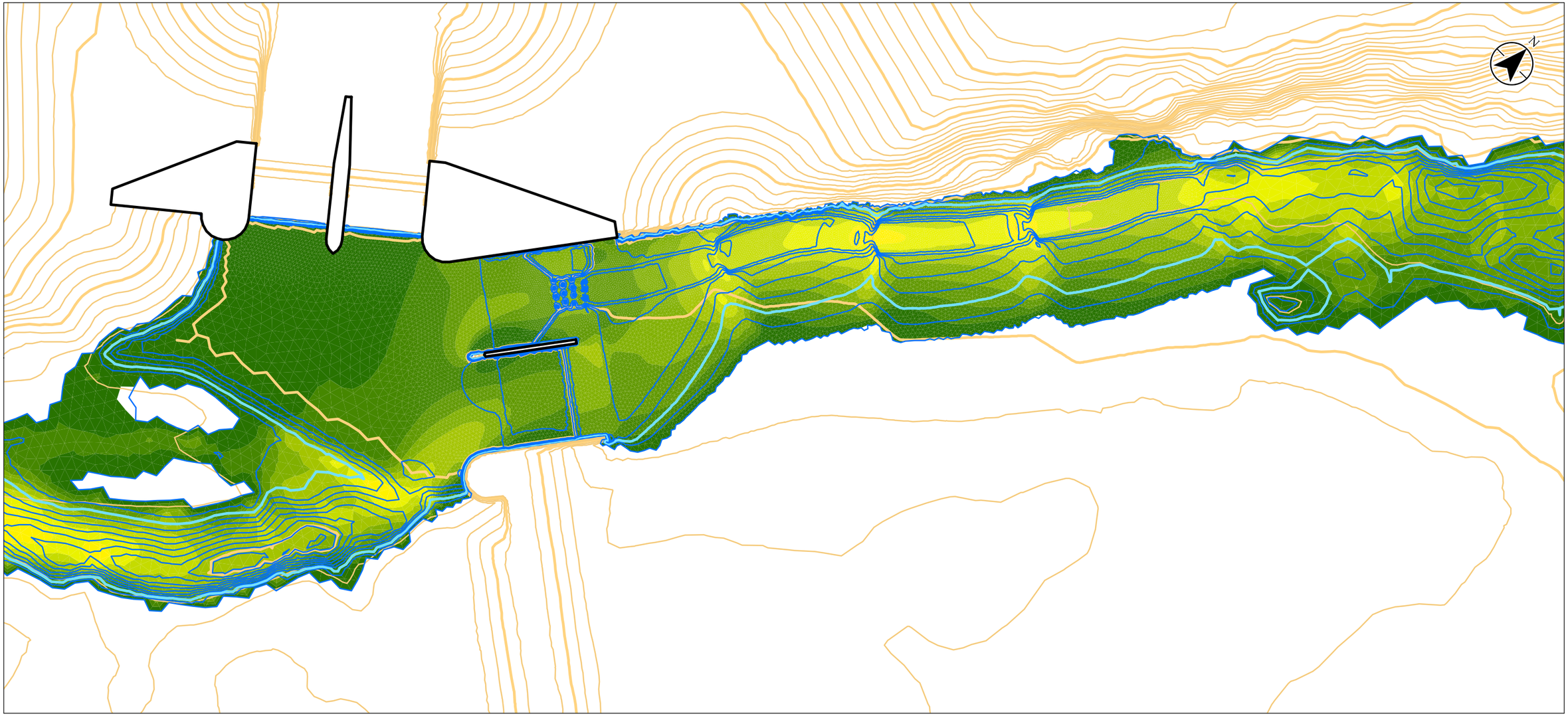
Client/Project
Alberta Transportation
Springbank Off-Stream Reservoir (SR1)

Figure No.
1 of 2

Title
Fish Passage Simulation
Existing Conditions, 15 cms



Legend

- Model Domain Lines

Depth Contours (0.1 m interval)

- All depth contours
- 0.2 m depth contour

Bed Contours (1 m interval)

- Intermediate
- Index

Velocity (m/s)

- 3.5 - 3.75
- 3.25 - 3.5
- 3 - 3.25
- 2.75 - 3
- 2.5 - 2.75
- 2.25 - 2.5
- 2 - 2.25
- 1.75 - 2
- 1.5 - 1.75
- 1.25 - 1.5
- 1 - 1.25
- 0.75 - 1
- 0.5 - 0.75
- 0.25 - 0.5
- 0 - 0.25
- 0

0 20 40 Meters

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Client/Project
Alberta Transportation
Springbank Off-Stream Reservoir (SR1)

Figure No.
1 of 2

Title
Fish Passage Simulation
Preliminary Design, 15 cms

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Legend

Model Domain Lines

Depth Contours (0.2 m interval)

All depth contours

0.2 m depth contour

Bed Contours (1 m interval)

Intermediate

Index

Velocity (m/s)

3.5 - 3.75

3.25 - 3.5

3 - 3.25

2.75 - 3

2.5 - 2.75

2.25 - 2.5

2 - 2.25

1.75 - 2

1.5 - 1.75

1.25 - 1.5

1 - 1.25

0.75 - 1

0.5 - 0.75

0.25 - 0.5

0 - 0.25

0

0 60 120 Meters

1:3,000 (At original document size of 11x17)

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Client/Project
Alberta Transportation
Springbank Off-Stream Reservoir (SR1)

Figure No.
2 of 2

Title
Fish Passage Simulation
Existing Conditions, 15 cms

5655000

-33000

N

5655000

-33000

Legend

Model Domain Lines

Depth Contours (0.2 m interval)

All depth contours

0.2 m depth contour

Bed Contours (1 m interval)

Intermediate

Index

Velocity (m/s)

- 3.5 - 3.75
- 3.25 - 3.5
- 3 - 3.25
- 2.75 - 3
- 2.5 - 2.75
- 2.25 - 2.5
- 2 - 2.25
- 1.75 - 2
- 1.5 - 1.75
- 1.25 - 1.5
- 1 - 1.25
- 0.75 - 1
- 0.5 - 0.75
- 0.25 - 0.5
- 0 - 0.25
- 0

0 60 120 Meters

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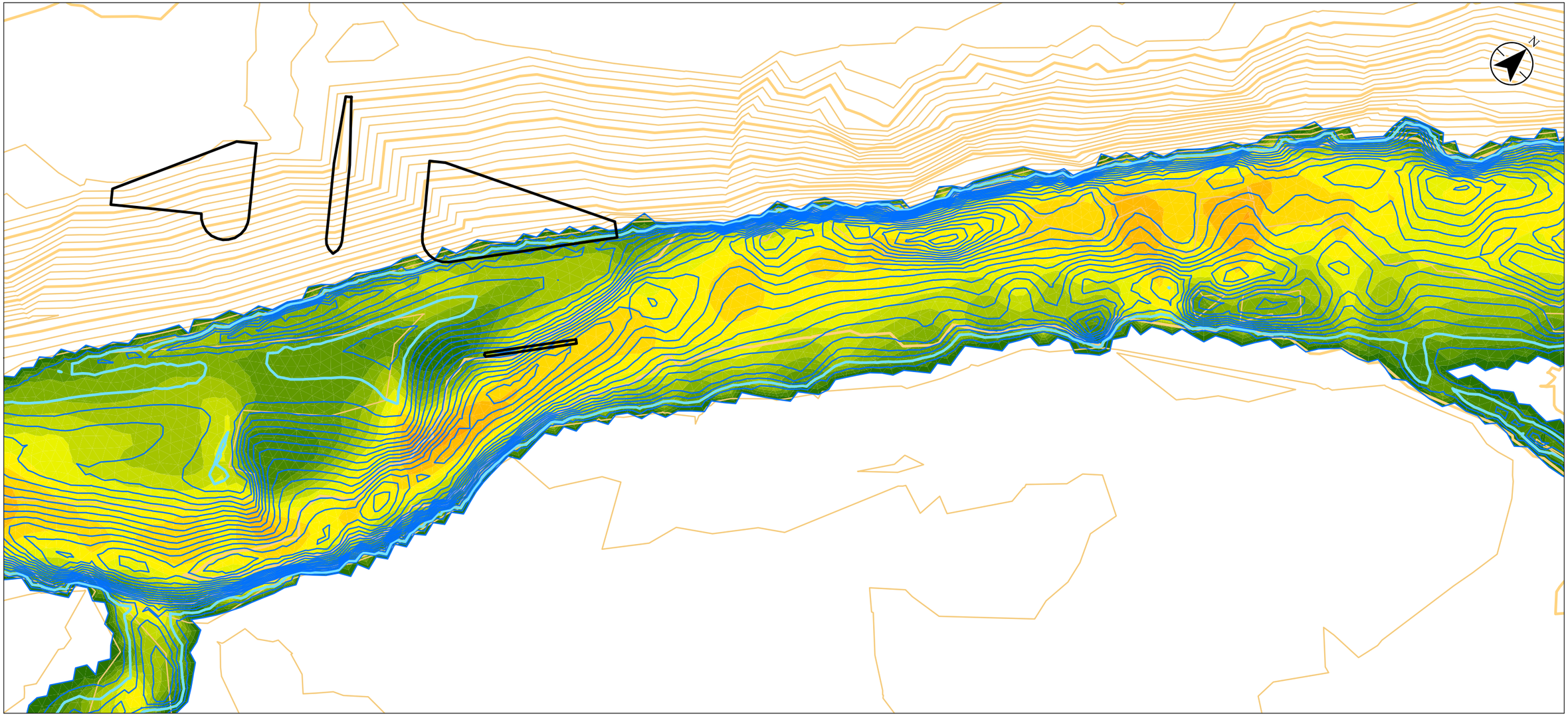
Alberta Transportation
Springbank Off-Stream Reservoir (SR1)

Figure No.
2 of 2

Title
Fish Passage Simulation
Preliminary Design, 15 cms



Legend

- Model Domain Lines

Depth Contours (0.1 m interval)

- All depth contours
- 0.2 m depth contour

Bed Contours (1 m interval)

- Intermediate
- Index

Velocity (m/s)

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Client/Project
Alberta Transportation
Springbank Off-Stream Reservoir (SR1)

Figure No.
1 of 2

Title
Fish Passage Simulation
Existing Conditions, 69.5 cms

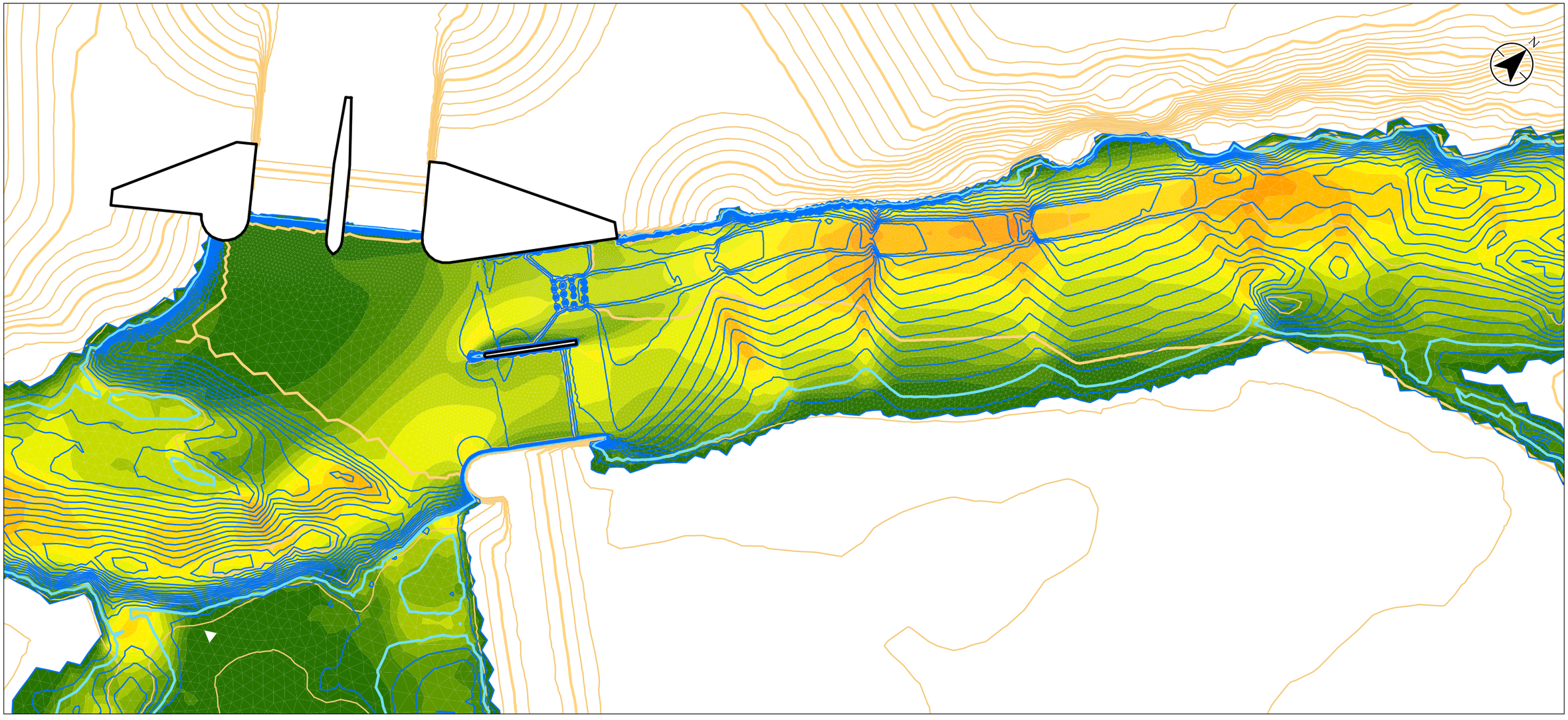

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Figure No.
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Fish Passage Simulation
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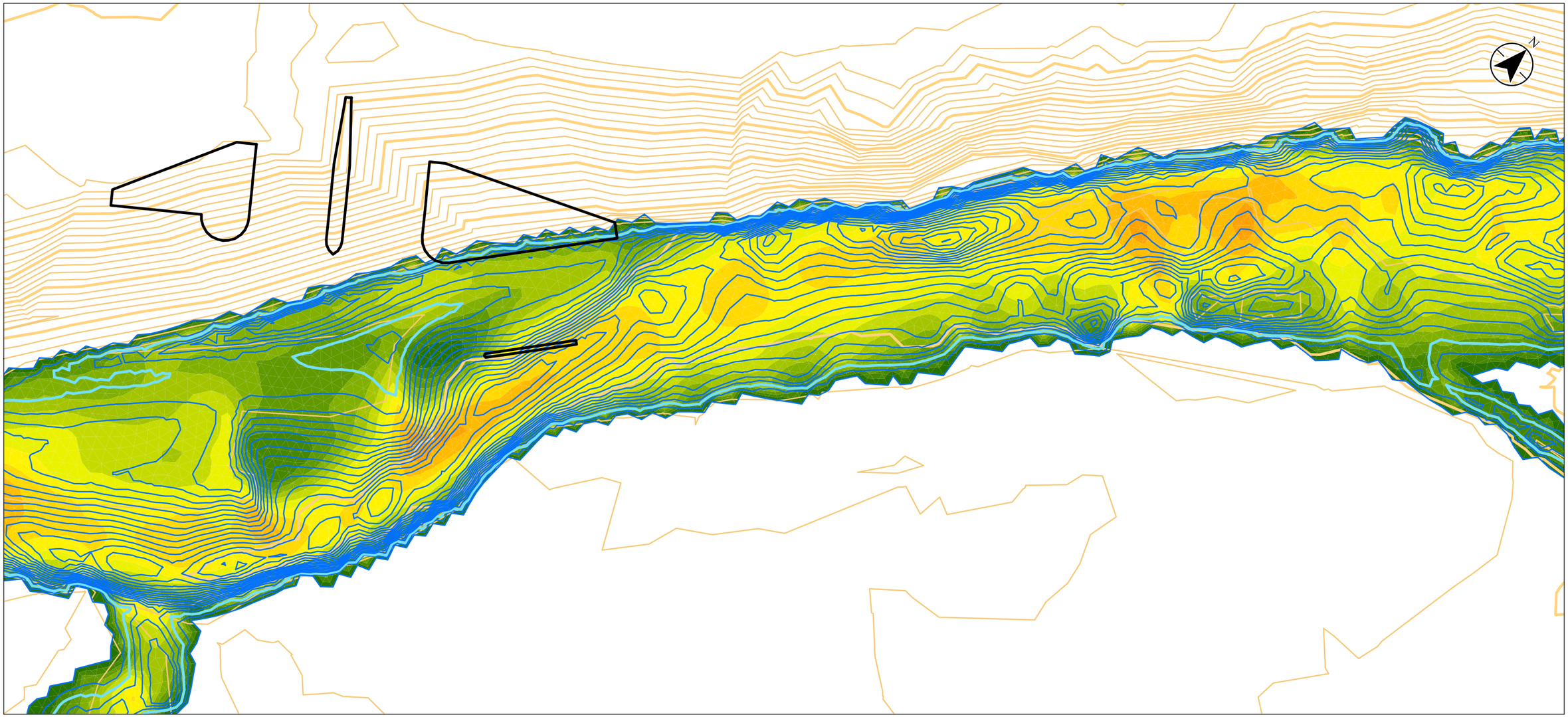

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Client/Project
Alberta Transportation
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Figure No.
1 of 2

Title
Fish Passage Simulation
Existing Conditions, 75.7 cms

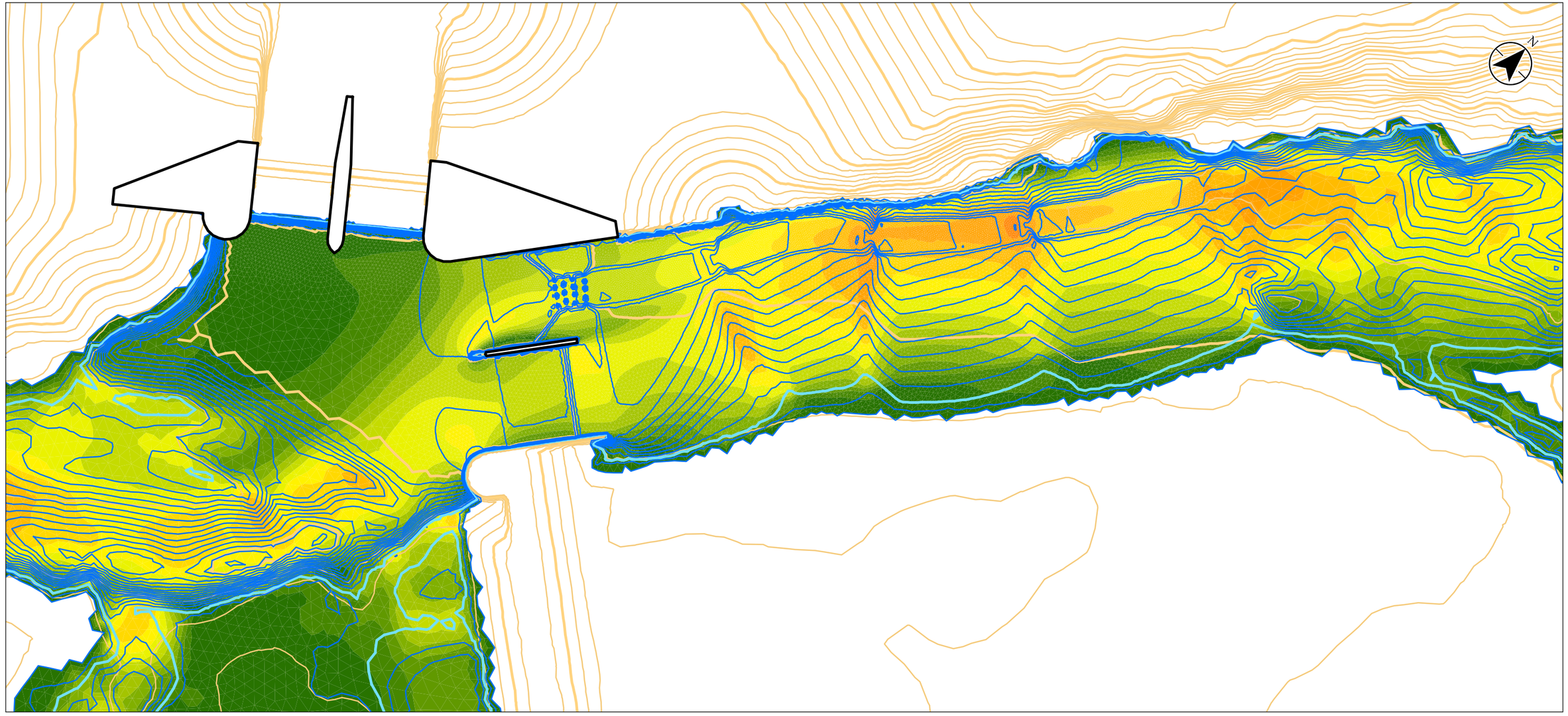

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Figure No.
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Fish Passage Simulation
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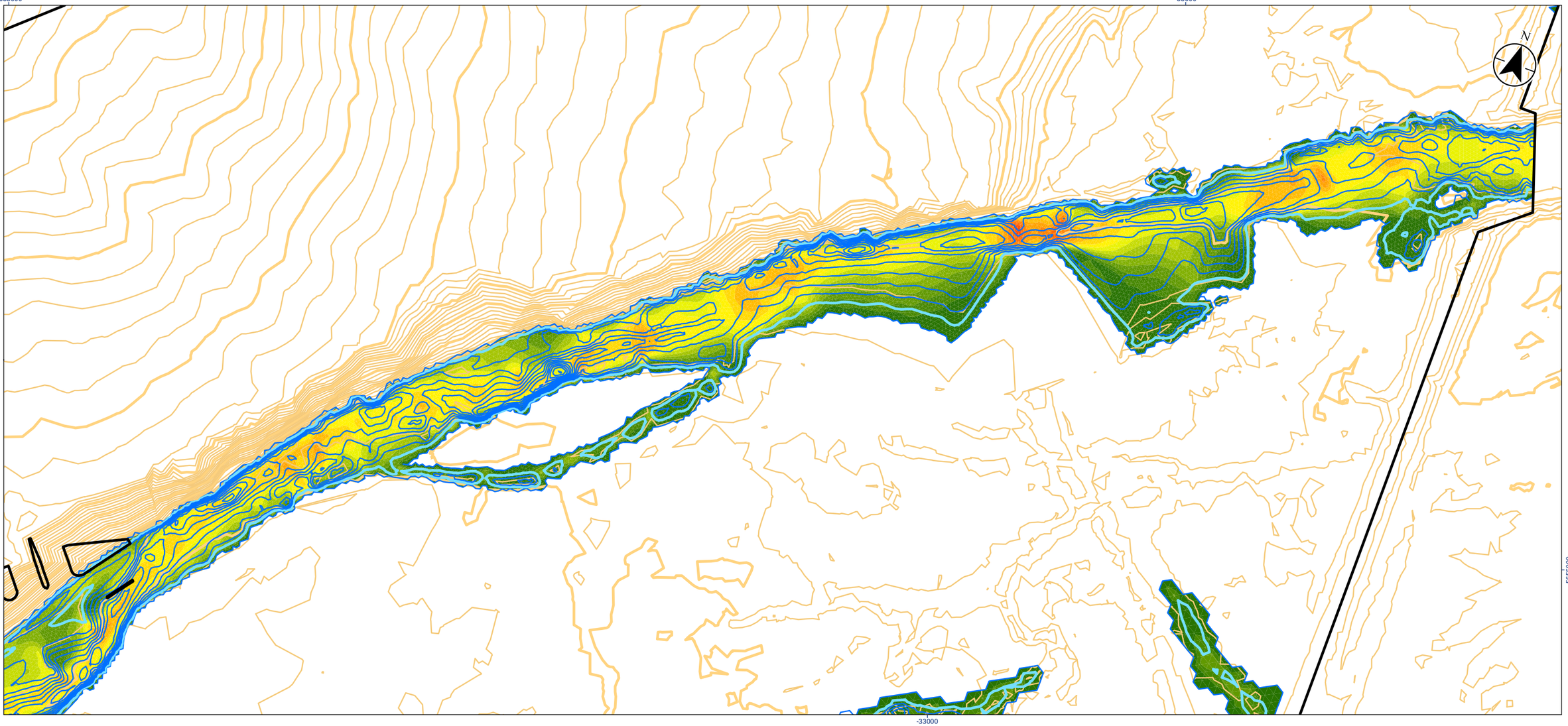

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Existing Conditions, 75.7 cms

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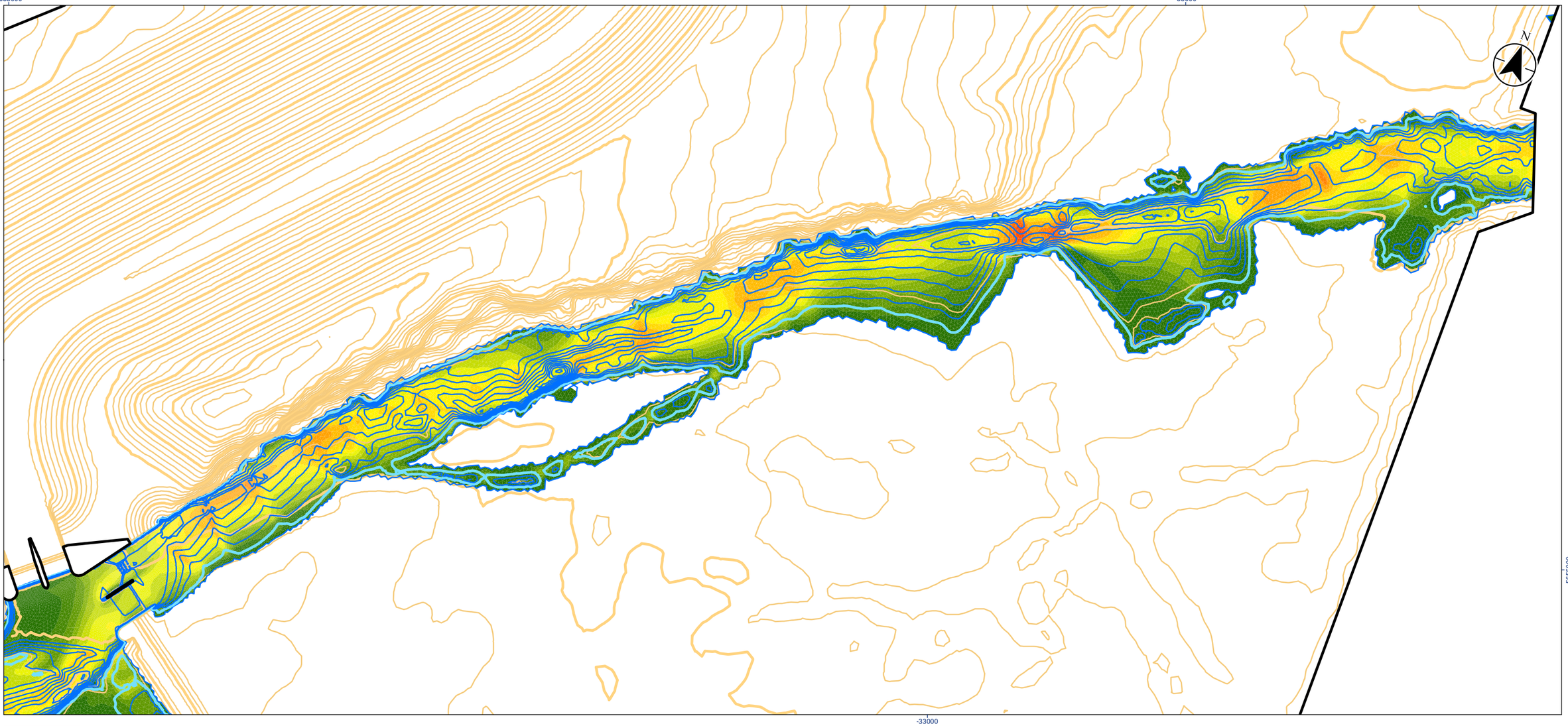

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Figure No.
2 of 2

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Fish Passage Simulation
Preliminary Design, 75.7 cms

SPRINGBANK OFF-STREAM RESERVOIR PROJECT
Environmental Impact Assessment

Volume 4: Appendices
Appendix M

Aquatic Ecology
Technical Data Report

Prepared for:
Alberta Transportation

Prepared by:
Stantec Consulting Ltd.

March 2018

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Abbreviations

AEP	Alberta Environment and Parks
COSEWIC	Committee on the Status of Endangered Wildlife in Canada
CPUE	catch per unit effort
CRA	Commercial, Recreational, and Aboriginal
DFO	Fisheries and Oceans Canada
DO	dissolved oxygen
EPT	ephemeroptera/plecoptera/trichoptera
ESRD	Alberta Environment and Sustainable Resource Development
FRL	fish research license
FWMIS	fisheries and wildlife management information system
GPS	global positioning system
LAA	local assessment area
LDB	left downstream bank
NTU	nephelometric turbidity units
QAES	qualified aquatic environment specialist
QC	quality control
SDI	Simpson's diversity index
SEI	Simpson's evenness index
SWQG	surface water quality guideline
TSS	total suspended solids

1.0 INTRODUCTION

This technical data report includes information on aquatic ecology that supports the environmental assessment for the Springbank Off-stream Reservoir Project (the Project).

2.0 METHODS

2.1 ASSESSMENT AREAS

The Local Assessment Area (LAA) for aquatic ecology assessment is based on the Project area boundaries, drainage basin characteristics, and aquatic resources in the Elbow River and tributaries that may be affected by the Project (Figure 2-1). The LAA for aquatic ecology assessment consists of the section of the Elbow River from Elbow Falls at the west edge of the area downstream to the inlet of Glenmore Reservoir. Within the LAA, 12 reaches of the Elbow River and two tributaries were identified for fisheries component of the aquatic ecology assessment based on distances from the proposed diversion structure. Ten of the twelve reaches were chosen to cover the extent of the LAA for the benthic invertebrate component of the aquatic ecology assessment. Five reaches were chosen to correspond with five Elbow River sites sampled for sediment quality. Field observations and site positions were recorded in the field using a Garmin global positioning system (GPS).

2.2 FISH AND FISH HABITAT

Desktop and field assessments were used to characterize the fish and fish habitat in the LAA. The objectives of the fish and fish habitat assessment were to:

- Document the fish community in the LAA
- Characterize the biophysical and water quality conditions of 12 reaches of the Elbow River and two unnamed tributaries to the Elbow River; and
- Determine fish habitat in 12 reaches of the Elbow River and two unnamed tributaries to the Elbow River.

2.2.1 Desktop Review

A review of historic fish and fish habitat data of the Elbow River and tributaries within the LAA was assembled using Alberta Environment and Parks' (AEP) online Fisheries and Wildlife Management Information System (FWMIS) database (AEP 2016). FWMIS is a central source of publicly available fisheries and wildlife data.

The status of fish species in the LAA was determined through a search of Species at Risk databases, including:

- Species at Risk Public Registry (GoC 2017a)
- Committee on the Status of Endangered Wildlife in Canada (COSEWIC) (GoC 2017b)
- General Status of Alberta Wild Species (ESRD 2012)

2.2.2 Field Assessment

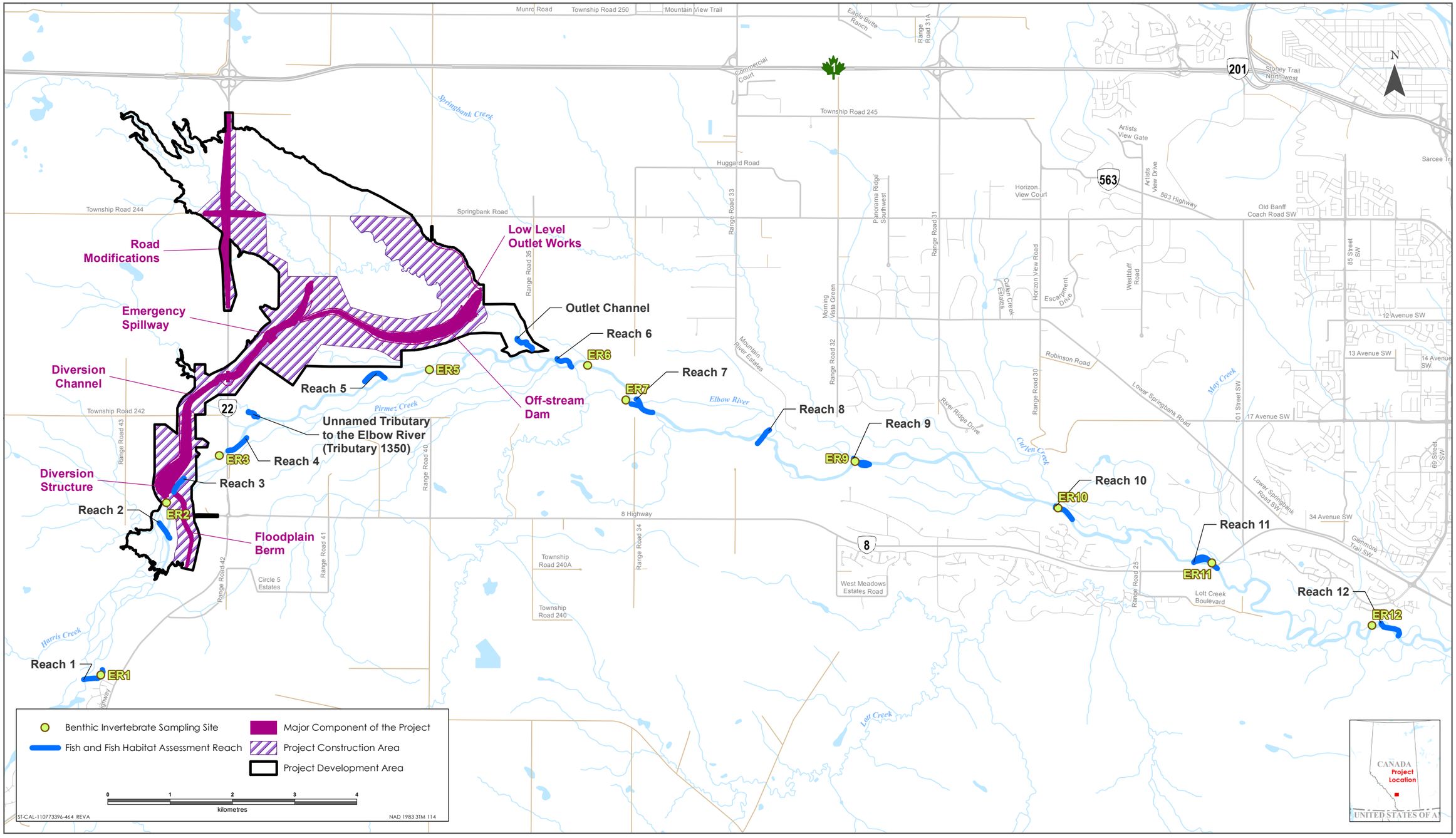
Fish and fish habitat field surveys were completed by a team of qualified aquatic environment specialists (QAES). The field assessment comprised fish inventory, fish habitat assessment, and habitat inventory at 12 reaches of the Elbow River and two tributaries (Figure 2-1).

Fish Inventory

Fish presence was sampled in watercourses using backpack electrofishing techniques. Electrofishing is a non-lethal and non-exclusive sampling method, and can capture a high diversity of species, but is generally biased towards capturing larger individuals and species that are particularly susceptible to electrical current (Portt et al. 2006). Live captured fish were placed in a holding tank for measurement, and once processed were live-released outside the sampling area to limit potential of recapture. Fish that avoided capture, but were positively identified to species in the water, were recorded as observed.

A Fish Research License (FRL) was obtained from AEP prior to the start of field surveys. Field data was collected under the authority of 16-1541 FRL, and as per the conditions of the FRL, the results were submitted to AEP for input into the Alberta provincial FWMIS database.

Fish sampling results were combined with historic fisheries data to describe the local fish community, fish species presence, and distribution.



Sources: Base Data- Government of Alberta, Government of Canada. Thematic Data - Stantec Ltd.

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ALBERTA TRANSPORTATION SPRINGBANK OFF-STREAM RESERVOIR PROJECT ENVIRONMENTAL IMPACT ASSESSMENT

Fish and Fish Habitat Assessment Reaches and Benthic Invertebrate Sampling Sites

Figure 2-1

SPRINGBANK OFF-STREAM RESERVOIR PROJECT
ENVIRONMENTAL IMPACT ASSESSMENT
AQUATIC ECOLOGY TECHNICAL DATA REPORT

Methods
March 2018

Fish Habitat Surveys

Fish habitat surveys included observations on channel characteristics, channel substrate peddle counts, water quality, fish habitat inventory, and habitat quality ratings.

Channel Characteristics

The Project used a reach-based assessment to qualify fish habitat in a segment of the surveyed watercourses. This assessment is used where there may not be an identified location or a delineated zone of Project impact. The following data were recorded within each reach:

- location (recorded with handheld GPS unit)
- reach size (length and mean width [m]) and gradient (%)
- habitat type
- channel characteristics including:
  - width (bankfull and wetted)
  - depth (at 25, 50 and 75% of wetted width, and maximum depth)
  - bank characteristics (height, slope, stability, vegetation % cover and bank materials)
  - cover (% total instream, % total overhead and % aquatic)
  - vegetation characteristics (riparian type and % crown closure)
  - substrate composition and embeddedness
  - silt cover over substrates
  - physical channel characteristics (pattern, islands, bars, coupling and confinement)
- stream stage during time of survey
- stream velocity and discharge
- photo-documentation of noted fish-habitat

Channel width, wetted width, bank height and depths were measured using a surveyor's tape, meter stick, and or range finder for larger watercourses.

Pebble Counts

A Wolman Pebble Count (Bevenger and King 1995) was used within each of the reaches to characterize substrate.

Substrate size was determined by walking across a transect and recording the substrate size at each step across the width of the river. This method included collection of at least 100 samples across a single transect. Substrate size was estimated using a modified Wentworth Scale (Wentworth 1922) (Table 2-1). Organic, fine, sand and bedrock materials were recorded using the following abbreviation. For substrate material greater than 2 mm in diameter, the diameter was measured to the nearest millimeter.

Table 2-1 Substrate Sizes and Descriptions

Class Name	Code	Size Range	Description
Organics	O	NA	Unconsolidated organic material (small sticks, leaves, decaying plant material)
Fines	F	<0.06mm	Slick or greasy feel when rubbed between fingers
Sand	S	0.6-2mm	Gritty when rubbed between fingers
Small Gravel	SG	2-16mm	Point of pen to marble size
Large Gravel	LG	17-64mm	Marble to golf ball size
Cobble	Co	65-256mm	Golf ball to head size
Boulder	BL	>256mm	Head size to car size
Bedrock	BD	NA	Unable to identify edges of rock; larger than car size
Artificial	AR	NA	Substrates such as rock baskets, gabions, bricks, trash, concrete etc.
Sludge	SL	NA	A thick layer of organic matter that is decidedly of human or animal origin. Note: sludge that originates from point sources is not included; the substrate score is based on the underlying material.

Water Quality

Surface water quality were measured at each watercourse at water depths which were sufficient to submerge the water quality probe. Water quality was measured using an YSI ProPlus multiparameter water quality instrument and a Lamotte turbidity meter. Both instruments were calibrated on site prior to use.

Water quality parameters measured in the field included:

- **Conductivity:** Conductivity is a function of water temperature and the concentration of dissolved ions. Conductivity is an indication of the concentration of dissolved ions; and can provide insight to the presence of products in the water such as road salt or fertilizers. Conductivity measurements are important in determining settings for electrofishing units for fish inventories.

- **Dissolved oxygen (DO):** DO concentration largely determines the capacity of a watercourse to sustain aquatic life. For fish, DO levels can restrict the species that could be present in a watercourse (Jackson et al. 2001). Alberta Surface Water Quality Guidelines (ESRD 2014) set out guidelines for acceptable DO concentrations for the protection of freshwater organisms, these include; 6 mg/L or greater for early life stages of cool water species, 5.5 mg/L or greater for other life stages of cool water species, 9.5 mg/L or greater for early life stages of cold water species, and 6.5 mg/L or greater for other life stages.
- **pH:** pH is the concentration of H+ ions in water in moles per liter. Water with a low pH is acidic and water with a high pH is basic (or alkaline). A pH range from 5 to 9 is not directly toxic to fish (McDonald et al. 1991). However, pH levels between 5.0 and 5.9 are considered limiting for the presence of most fish species, including fathead minnow (*Pimephales promelas*) and white sucker (*Catostomus commersoni*) (Mills et al. 2000). Although alkaline pH values are not generally as important a limiting factor in determining fish community as acidity, alkalinity can become lethal to fish if the pH is greater than 10 (Wurts and Durborow 1992).
- **Temperature:** Temperature is an important water quality parameter for all aquatic life. Aquatic organisms have specific tolerances and optimal water temperatures in which they live, reproduce, flourish or perish (Hasnain et al. 2010). Second, high water temperatures increase the metabolic rate of cold-blooded organisms. Finally, as water temperature increase, the capacity of water to hold oxygen in solution decreases and therefore limits oxygen available for fish to breath. As a result, elevated summer water temperatures can lead to fish kills as DO concentrations could drop below the tolerance of a given fish or invertebrate species.
- **Turbidity:** Turbidity is a measurement of water clarity, often measured in nephelometric turbidity units (NTU). Turbidity is a surrogate for the concentration of total suspended solids (TSS) in the water column. TSS has the potential to affect fish habitat quality and fish health. Many fish are visual predators and, therefore, high turbidity can affect a fish's ability to locate food items (Madej et al. 2007). High TSS concentrations have been shown to negatively affect fish embryo survival, and in extreme cases adult survival (Robertson et al. 2006). Sub lethal physiological responses to TSS have also been documented for aquatic species, including increased stress response, reduced respiratory function, gill damage, and reduced disease resistance (Robertson et al. 2006).

Fish Habitat Inventory

Reaches within the Elbow River and its tributaries were characterized as habitat units and measured for habitat length, channel width (average bankfull and wetted widths) and depth (maximum) of each unit (Table 2-2). Habitat units were adapted from the Alberta Transportation Fish Habitat Manual's Small River or Stream Habitat Classification and Rating System (Alberta Transportation 2009). Descriptions of the habitat units identified within the assessed reaches are provided in Table 2-2.

Table 2-2 Habitat Units and Descriptions

Habitat Unit	Unit ID	Description
Rapid	RA	High velocity; deeper than riffle, with some exposed boulders at lower flows; substrate extremely coarse (large cobble/boulder); instream cover in pocket eddies and associated with substrate. Considerable turbulence, some whitewater, fast velocity (> 0.5 m/s), 4-7% slope.
Riffle	RF	Moderate to high velocity/gradient relative to run habitat; surface agitated due to submerged or exposed coarse bed material causing moderate turbulence and ripples; shallow relative to other channel units (generally ≤0.5m deep); coarse substrate, little to no whitewater or standing waves (some whitewater at points of constriction).
Run	R	Runs are typically deep, slow to fast flowing sections with a coarse substrate, defined thalweg, moderate slope, and with little surface turbulence. Run units are differentiated into three classes, based on depth.
	R1	Deepest run habitat (> 1 m), slow to fast water velocity, coarse substrate (cobble to boulder), high instream cover from substrate and depth.
	R2	Moderate depth (0.75 - 1.0 m), slow to fast water velocity, coarse substrate (cobble to boulder), moderate instream cover from substrate and depth.
	R3	Shallowest depth (0.3 - 0.75 m), slow to fast water velocity, coarse substrate (gravel to cobble), low instream cover.
Glide	GL	Glides are shallow (< 0.3 m deep), slow flowing, non-turbulent, and lack a defined thalweg, with a U-shaped, smooth, wide bottom. Glides are extended transitional areas between fast and slow water habitats. Substrate is usually silt/sand but may sometimes consist of gravel to small cobble.
Flat	FL	Area characterized by low velocity and near-uniform flow; differentiated from pool habitat by high channel uniformity; more depositional than run habitat.
Pool	P	Reduced current velocity, often with water deeper than the surrounding areas. Usually formed by the scouring or plunging action of water. Sub-surface velocities are slow and is substrate usually composed of fines or small gravel. Pool units are differentiated into three classes, based on depth.
	P1	High quality pool habitat based on depth and size. High instream cover from instream features (i.e., logs/boulders) and depth (> 1.2 m deep), provides overwintering habitat.
	P2	Shallower than P1 (0.6 - 1.2 m deep), moderate to high instream cover, not suitable for overwintering but provides juvenile and adult fish rearing habitat during open water.
	P3	Shallow (< 0.6 m deep) and small, low instream cover. Not suitable for overwintering or adult holding habitat but may provide rearing habitat for juvenile fish during open water.
Dry Channel	DR	Channel with defined bed and banks with no water at time of survey.

Habitat Quality Ratings

Habitat characteristics were integrated into a physical habitat classification system to rate the quality of each macro-habitat type based on physical features (e.g., depth, cover, substrate). The physical habitat classification and habitat quality is linked to the life history requirements of fish species (e.g., rearing, spawning, overwintering) predicted to occur in the reach.

Fish habitat suitability for migration, spawning, rearing, and overwintering for each reach was rated (i.e., good, moderate, poor, or none) according to its capacity to support these life history requirements (Nelson and Paetz 1992; Scott and Crossman 1998). Habitat quality ratings are listed below. To determine the habitat quality rating of a reach, it must possess at least one of the criteria within each rating class:

- Good Habitat Quality
  - species present are highly sensitive to perturbations and are not resilient to change
  - presence of spawning or other habitat critical to the survival of a species
  - habitat essential to sustaining a commercial, recreational, or Aboriginal (CRA) fishery
  - permanent flowing, cold and cool water systems that cannot easily buffer temperature changes or are not resilient to disturbance especially where unique or limited within an ecozone
- Moderate Habitat Quality
  - species present are moderately resilient to change and perturbation
  - diverse fish community
  - habitat used by one or more species for feeding, growth and migration
  - typical of the fish habitat in the region. Large amount of similar habitat readily available
- Poor Habitat Quality
  - habitat with low productive capacity
  - no suitable spawning habitat for sport fish and low or nil rearing potential for sport fish
  - habitat has substantial limitations to contribute to a CRA fishery (e.g., sparse in-water and overhead cover, low flows, poor fish passage, no overwintering capacity)
  - typically supports only forage fish species which are not consider a CRA fishery species under the *Fisheries Act*
  - contributes only indirectly to a CRA fishery species

  - ephemeral watercourses that might not provide habitat for fish to complete one or more of their life processes, but might provide occasional habitat in high flows as well as flow and nutrients to downstream areas. These watercourses might also affect downstream areas through the transport of sediment and other deleterious substances.

- Not Fish Habitat
  - no direct or indirect contribution to downstream habitat

2.3 BENTHIC INVERTEBRATES

Desktop and field assessments were conducted and used to characterize the benthic invertebrate community in the LAA. The objectives of the benthic invertebrate assessment were to:

- Document the benthic invertebrate community at 10 sampling sites in proximity to the fisheries reaches, and
- Characterize the biophysical and water quality conditions of the 10 sampling sites in the Elbow River.

2.3.1 Desktop Review

Historic benthic invertebrate data for the Elbow River within the LAA was reviewed using publicly available data and reports. The status of benthic invertebrate species in the Elbow River were determined through a search of the Species at Risk Public Registry (GoC 2017a), COSEWIC (GoC 2017b), and General Status of Alberta Wild Species (ESRD 2012) databases.

2.3.2 Field Assessment

Benthic invertebrate field assessments were completed at 10 sites located in proximity to fish habitat reaches (Figure 2-1) and included collection of benthic invertebrate samples and observations of physical habitat characteristics and in-situ measurement of water quality parameters.

Physical Variables

Physical stream variables influence the occurrence and distribution of benthic invertebrates, including some key parameters like river flow conditions, water quality and physical structured habitats (Hynes 1972). The physical characteristics of benthic invertebrate sample sites were chosen for consistency among sites to limit inter-site variability. The 10 sites were selected with similar water velocities, water depths, and substrate compositions.

Three measurements of water velocity and water depth were taken at each sampling site using a Price AA current meter. Substrates were quantitatively classified using a modification of the Wentworth classification system (Cummins 1962). Loose substrates were collected from each site within a defined area and categorized by size classes using standard Tyler geologic screens. The substrates were weighed with a portable spring scale to determine percentages of each size category based on the total substrate weight. A visual estimate was made of the amount of algal growth on the substrates at each site.

Water Quality

Water quality was sampled at each site and consisted of field measurements of temperature (± 0.1°C), pH (± 0.1 unit), conductivity (± 1 µS/cm) and dissolved oxygen (± 0.1 mg/L) using a YSI ProPlus multi-parameter meter. The meter was calibrated daily. The water chemistry results were compared against the Alberta Surface Water Quality Guidelines (SWQG) for the protection of freshwater aquatic life (ESRD 2014).

Benthic Invertebrate Sampling

Benthic invertebrate samples were collected from natural river substrates following protocols established by Alberta Environment (2006). Benthic invertebrates were sampled using a modified Neill-Hess cylinder with a 210 µm mesh collection net with a collection area of 0.0892 m^2. The invertebrate sample was concentrated using a 180 µm mesh standard sieve and stored in 5 % formalin and Rose Bengal stain. Samples were labeled with project information, site, time and date with chain-of-custody and delivered to the laboratory for identification and sample processing. Three field benthic invertebrate samples were collected at each site and were used to support a precision of 20% confidence in data results (Elliott 1977; Environment Canada 2010).

2.3.3 Data Analysis

Benthic Invertebrates

Benthic invertebrate samples were separated into a coarse fraction (>1 mm) and a fine fraction (0.180 to 1 mm). A whole sort method was used on the coarse fraction and a subsampling method on the fine fraction (Environment Canada 2002). The fine fraction was subsampled using the cone subsampler described by Wrona et al. (1982). Subsamples were sorted and counted for organisms until a target of at least 300 organisms was met (Environment Canada 2002).

As part of quality control (QC), a re-sorting of randomly selected sample residues was conducted on at least 10% of the samples to determine the level of sorting efficiency. A recovery of at least 90% of organisms was required for the sorted samples (Environment Canada 2002).

Samples were identified and enumerated by a professional taxonomist (Bob Saunders). Benthic invertebrates were identified to the lowest practical taxonomic level. The portion volume of subsample sorted was used to extrapolate the counts for the whole sample.

Data and Statistics

Descriptive statistics of mean and standard deviation were calculated for number of invertebrate species at each site. The following metrics were calculated:

- total taxa richness – number of species
- total density (number/m^2) – relative abundance of organisms
- taxa richness of major groups
- density of major groups
- % ephemeroptera/plecoptera/trichoptera (EPT) – percent of the community made up of the sensitive (intolerant) EPT
- % chironomidae – percent of the community made up of the generally tolerant chironomidae
- % oligochaeta – percent of the community made up of the generally tolerant Oligochaeta
- EPT/chironomidae ratio – ratio of the abundance of intolerant EPT to the tolerant Diptera - chironomidae
- Simpson's evenness index (SEI)
- Simpson's diversity index (SDI)

The SEI expresses how evenly organisms in the community are distributed as values of 0 to 1, with 1 being complete evenness (Smith and Wilson 1996). Simpson's Evenness Index was calculated as follows:

$$SEI = 1 / \sum_{i=1}^{s} (p_i)^2 / s$$

where: p_i = the proportion of the i^{th} taxon at the site
s = the total number of taxa at the site.

The SDI uses both the abundance patterns and taxonomic diversity to estimate species richness of the invertebrate community (Krebs 1985), as follows:

$$SDI = 1 - \sum_{i=1}^{s} (p_i)^2$$

where: p_i = the proportion of the i^{th} taxon at the site
s = the total number of taxa at the site

3.0 RESULTS

3.1 FISH AND FISH HABITAT

Fish and fish habitat characteristics for the LAA are summarized in the following section using the results from the desktop review and field surveys. Habitat quality was determined in each reach for migration, spawning, rearing, and overwintering habitats for fish species expected to occur in the reach.

A summary table of the reach data is presented in Attachment A, Section A.1. Fish and fish habitat field data, including fish capture results and representative site photographs depicting habitat features at the time of the assessment, can be found in Attachment A, Section A.2.

3.1.1 Desktop Review

Existing fish and fish habitat information from the Elbow River and tributaries within the LAA was compiled using the FWMIS database on May 2016 (AEP 2016). The FWMIS data is presented in Table 3-1 and summarizes the presence and status of 19 fish species within the LAA, including key fish species: brook trout (*Salvelinus fontinalis*), brown trout (*Salmo trutta*), bull trout (*Salvelinus confluentus*), burbot (*Lota lota*), cutthroat trout (*Oncorhynchus clarkii*), mountain whitefish (Prosopium williamsoni), rainbow trout (*Oncorhynchus mykiss*), white sucker (*Catostomus commersonii*), longnose sucker (*Catostomus catostomus*), and mountain sucker (*Catostomus platyrhynchus*) (Table 3-1). The Elbow River comprises habitats potentially supporting gravel beds and scoured pools that provide high quality spawning and overwintering habitats for many of these fish species. Fish habitat has also been observed within the lower reaches of the Elbow River tributaries within the LAA.

Bull trout and westslope cutthroat trout (*Oncorhynchus clarkii lewisi)* are considered species of conservation concern in Alberta (ESRD 2012; GoC 2017a, b). Bull trout is resident to the area and is currently designated *Threatened* by COSEWIC (GoC 2017b). Provincially, bull trout is listed as *Threatened* under the *Wildlife Act* (1997) and considered a sensitive species under the General Status of Alberta Wild Species (ESRD 2012). Westslope cutthroat trout are listed as *threatened* under Alberta's *Wildlife Act* (1997) and the federal *Species at Risk Act (*GoC 2017a). It is unlikely that there are pure westslope cutthroat trout within the LAA downstream of Bragg Creek (Figure 2-1) because the closest known population of genetically pure westslope cutthroat trout is in Prairie Creek (i.e., approximately 25km upstream of the LAA) and critical habitat extends into the Elbow River at the confluence. Another population of pure westslope cutthroat trout exists in Silvester Creek, a tributary of the Elbow River that is upstream of the Prairie Creek confluence.

Sport Fish

Brook Trout

Brook trout were introduced in Alberta over 80 years ago. Despite being considered an "invasive" species because of their competition with native bull and cutthroat trout, they are a desired sport fish. Brook trout are found in the Elbow River and its tributaries in the LAA. They are opportunistic feeders that prefer a variety of aquatic invertebrates and fishes (Scott and Crossman 1998).

Brook trout spawn in early fall, normally in smaller tributaries on gravel substrates. In smaller streams, brook trout dig nests called redds over sources of groundwater upwellings. Rearing young of year and juvenile brook trout prefer extensive overhead cover and woody debris in shallow areas (Roberge et al. 2002).

Brown Trout

Brown trout are one of the most desired sport fish in the RAA and are an introduced species into the Elbow River and are not federally or provincially listed. However, brown trout are considered part of a CRA fishery under the *Fisheries Act*.

Brown trout are opportunistic drift feeders that prefer a variety of aquatic invertebrates, molluscs, fishes, and frogs (Scott and Crossman 1998). They typically prefer a moderate flow of water, with plenty of cover for ambushing prey. They are more resilient than native trout species and can flourish in warmer water temperatures than bull trout or cutthroat trout (Scott and Crossman 1998).

Spawning brown trout can be large and require deep pools in October. They will likely be spawning in the lower portion of the LAA, between Highway 22 and the Glenmore Reservoir Brown trout are known to spawn over gravels when water temperatures fall below 6-8°C, typically during October to December (Scott and Crossman 1998). Females will dig a redd and cover the eggs with gravel after fertilization; eggs will hatch around March to late April (Scott and Crossman 1998). Preferred spawning substrate size range from 0.3 – 10 cm, with water depths under 0.5 m (Raleigh et al. 1986)

After emerging, the fry will seek cover habitats (e.g. large woody debris, undercut banks) in slower water generally shallower 0.15 m deep (Raleigh et al. 1986) and feed on plankton and aquatic invertebrates until large enough to successfully ambush fishes and larger prey types. Juveniles move to deeper water. Adult brown trout prefer water close to escape cover, such as overhanging vegetation, LWD, and undercut banks.

Bull Trout

Bull trout are an important fall spawner and is being federally reviewed for listing as "threatened". Bull trout has a provincial status of *Sensitive* in the *General Status of Wild Species 2012* (ESRD 2012) and is listed as *Threatened* in the Alberta *Wildlife Act* (1997). The bull trout population in the RAA is considered part of the Saskatchewan-Nelson Rivers population, and maintains a recommended status of "Threatened" by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC 2012).

Habitat degradation and reduced habitat connectivity through fragmentation pose threats to the population of bull trout (COSEWIC 2012). The introduction of non-native species, such as the eastern brook trout, has increased competition for food and spawning resources. Bull trout are also vulnerable to hybridization with introduced brook trout in areas where both species occur (COSEWIC 2012). Activities from oil and gas development, forestry, mining, transportation infrastructure, and hydroelectric projects affect habitat by increasing siltation and water temperatures, and decreasing stream flow volumes. Overfishing may also be a threat because bull trout are easily catchable and, therefore, susceptible to catch and release mortality in many areas that are accessible to anglers (COSEWIC 2012). Due to their vulnerability, AEP has implemented a zero-possession limit on bull trout throughout the province and instated a mandatory catch and release program.

Bull trout are a coldwater species that prefer water temperatures at or below 15˚C. Fluvial and ad-fluvial life histories of bull trout reside in larger rivers or lakes and migrate to suitable habitat to spawn. Stream resident forms reside in smaller streams where they spawn and rear. Bull trout spawn between mid-August and early October in gravel and cobble areas with low levels of fine sediments. Bull trout fry move to shallow, slower water with interstitial cover, moving to deeper water as they age.

Fisheries surveys indicate that bull trout in the mid-reach of the Elbow spawn in the area upstream of Bragg Creek from Gooseberry Campground up to Elbow Falls (in Sept 2008, all redds were found above Patty's Flat). There may be spawning below this, but it hasn't been reported. Because the spawning is relatively far upstream, an earlier migration (July–September) could occur near the Project

Cutthroat Trout

There are no known populations of pure-strain westslope cutthroat trout in the LAA, and it is unlikely that migratory fluvial or adfluvial populations exist that would move to or from the area (DFO 2014) affected by the construction of the diversion inlet and service spillway. Westslope cutthroat trout are known to reside in the small headwater streams that are tributaries to the upper Elbow River: Silvester Creek upstream of the falls near the confluence with the Elbow River and Prairie Creek; and Quirk Creek upstream of Elbow Falls.

While it is unlikely that pure cutthroat trout populations are present in the LAA, hybrid cutthroat-rainbow trout are present and individuals may move downstream out of their critical habitat to the mainstem of the Elbow River.

Cutthroat trout spawn during April to June (Scott and Crossman 1998) in riffles, with gravel substrates in depths generally less than 1 m. Females will dig a redd and cover the eggs with gravel after fertilization in water temperatures around 6°C up to around 10°C. The eggs will hatch between July and August, depending on temperatures. The fry require riffles with larger stone as cover when they hatch, moving to slower backwaters where there is cover from woody debris, boulders, or overhanging vegetation. Juveniles will remain close to cover provided by substrates, woody debris, or vegetation in riffles, runs and pools. They will move to pools and, sometimes, burrow in interstitial spaces in gravel to overwinter. Juveniles will eat aquatic invertebrates and terrestrial insects, with adults switching to larger prey such as small fish when it is available. Adults require larger pools to overwinter relative to juveniles where there is cover.

Rainbow Trout

Rainbow trout in the Elbow River watershed are an introduced species and are not federally or provincially listed. However, they are considered part of a CRA fishery under the *Fisheries Act*.

Female rainbow trout select adequate substrate to dig depressions in the substrate for redds. Therefore, channel gradient, water velocity and substrate size are important for spawning. Ideal spawning substrate typically ranges from clean, coarse sand to large gravel that the female can excavate (size range from 0.04 mm to 100 mm) (Nelson and Paetz 1992). Other factors that are important for salmonid spawning include stream morphology and water quality. Clear flowing streams with minimal siltation are optimal for spawning because eggs are sensitive to perturbations and siltation.

Fry prefer shallower, slower water than adults, with depths preferred less than 15 cm. Fry will disperse immediately after emergence to slow water and cover (roots, boulders, logjams, riffles, undercuts) where they prefer, for example, pool margins and interstitial space between rocks. Cover is important for rearing rainbow trout, including shallow rocky substrate, margins of river, and the absence of larger trout. Fine materials are known to reduce the value of riffles for fry. Juveniles start to prefer velocity around 10-12 cm/s, but up to velocities of 22 cm/s if rough substrate is present for cover. Juvenile rainbow trout will overwinter in shallow margins, near woody debris.

Adult rainbow Trout velocity preferences are around 0.2 – 0.3 m/s, with variable depths, normally less than 1 m, except in winter. Adults prefer instream cover from boulders and large woody debris. Pools are important to trout as a refuge from adverse conditions during the winter.

Mountain Whitefish

Mountain whitefish are a native sport fish species and their typical high abundance supports the ecosystem in the Elbow River. They are susceptible to disturbance. Mountain whitefish are found in the Elbow River throughout the RAA. Primarily a benthic feeder, mountain whitefish feed on a variety of aquatic invertebrates that inhabit well oxygenated waters (Scott and Crossman 1998).

Mountain whitefish spawn over gravel and cobble substrates at moderate gradients in the Athabasca River (R.L. & L. Environmental Services Ltd. 1996). They prefer shallow depositional gravel areas interspaced by deep runs and pools or just downstream of cobble areas along armoured or depositional banks. Spawning occurs in late fall from September to early November (Nelson and Paetz 1992). Schools of mountain whitefish will congregate around mid-September and migrate to spawning locations when water temperatures are around 2–6°C. Because mountain whitefish do not clean redds to deposit eggs (Scott and Crossman 1998), their spawning sites may be more susceptible to sediment deposition. This species moves in schools from pool to pool during migration and feeding (AEP 2017). After emerging in March, young mountain whitefish will rear in shallow backwaters and side channel, and near large woody debris cover in shallow areas (R.L. & L. Environmental Services Ltd. 1996).

Burbot

Burbot are a native piscivore, that primarily resides in relatively larger and slower bodies of water. Burbot are a coolwater, freshwater member of the cod family that generally prefer deep lakes and deep slow moving rivers (Scott and Crossman 1998). Burbot are known to prefer cold, turbid water in deep channels. Because of the eel like shape and swimming style, Burbot have poor swimming abilities, but are known to migrate distances over 50 km to spawning sites (McPhail and Paragamian 2000).

In rivers, spawning for Burbot normally occurs in mid-winter in deep, low velocity areas over gravel, sand, or silt in main and side channels behind depositional bars. The semi-buoyant eggs are broadcast into mid-water and drift downstream before settling into interstitial spaces on the substrate. Freshly hatched burbot are pelagic and drift downstream in the river, eventually moving towards the shoreline when their swimming ability improves. Rearing habitats (nearshore daytime cover) are associated with cover such as large coarse substrates, undercuts, woody debris, and vegetation mats (Langhorne et al. 2001). As they grow into adults, they move into deeper and colder water. Adults are piscivorous and voracious feeders, actively hunting in deep areas and ambushing prey along the bed. When water temperatures drop in late fall, adult burbot are known to move towards the shoreline to feed (McPhail and Paragamian 2000).

Northern Pike

Northern pike are a coolwater species that generally prefer lakes or slow-moving, low gradient rivers. They may travel large distances to find suitable spawning areas (Scott and Crossman 1998). Northern pike are a spring spawning species often migrating at when the ice breaks up, typically before the annual peak flow in rivers. Northern pike use shallow (less than 0.5 m), heavily vegetated areas for spawning such as flooded terrestrial vegetation (Inskip 1982). As a weak swimmer, it is unlikely that they move far upstream from the Glenmore Reservoir area into the higher gradient, cobble bed dominate section of the Elbow above the Project location. Young will rear in nearshore areas of lakes and rivers, but generally require vegetation and cover, and they are almost always found near either emergent vegetation or boulders (Langhorne et al. 2001). In addition to spawning, instream vegetation is important to northern pike in providing cover from predation and as ambush cover when feeding (Inskip 1982).

Low dissolved oxygen levels in summer and winter as well as high water temperatures in the summer can be detrimental to northern pike and, in combination, influence the depths at which northern pike are commonly found (Inskip 1982). Northern pike move deeper as they age into the fall, selecting larger prey. Northern pike are opportunistic feeders and primarily piscivorous but occasionally prey on aquatic invertebrates and small mammals (Harvey et al. 2009).

Coarse Fish

Longnose Sucker

Longnose sucker broadcast spawn in riffle, run, transitions into pool habitat sections of rivers, spawning in colder temperatures closer to ice-off in early spring and as late as June. Longnose suckers will spawn over coarse substrates, while white suckers will spawn over coarse and fine substrates including sand and silt (Langhorne et al. 2001).

Longnose sucker use coarse substrates to spawn. The young typically move into nearshore areas of lakes later in the summer and use large coarse substrates and submergent and emergent vegetation as cover. They will use areas of debris and vegetation in nearshore areas as they age into the fall (Langhorne et al. 2001).

Longnose sucker are benthic feeders, ingesting plankton when young and plants, detritus, and benthic invertebrates as adults (Scott and Crossman 1998). Rearing habitat is located in areas with aquatic vegetation, woody debris, or boulder cover. Adults are rare where wetted width is less than 10 m, but almost always present where wetted widths are greater than 15m (Meyer et al. 2009). Adults overwinter in deep pools.

White Sucker

White sucker is a broadcast species that spawns between May and June within shallow, gravel-bottom sections of streams (Scott and Crossman 1998). White suckers spawn in spring over coarse and fine substrates (including sand and silt) when water temperatures reach approximately 10°C (Scott and Crossman 1998; Langhorne et al. 2001).

Juvenile white sucker typically move into areas of lower velocity (such as backwaters) later in the summer and use large coarse substrates and submergent and emergent vegetation as cover. As they develop, juvenile white sucker will also move into shoreline areas with debris and vegetation (Langhorne et al. 2001). White sucker is a benthic feeder, ingesting plankton when young. As adults, they ingest plants, detritus, and benthic invertebrates (Scott and Crossman 1998). Rearing habitat is located in areas with aquatic vegetation, woody debris, or boulder cover. Adults overwinter in deep pools.

Forage Fish

Forage fish species are defined by DFO as a species which is below the top of an aquatic food chain, is an important source of food for at least some predators, and experiences high predation mortality. In riverine ecosystems, they are important for transferring energy from lower trophic levels up the food chain to the higher levels. Because many higher trophic feeders (piscivores) such as bull trout, rainbow trout and northern pike, require a forge fish prey base, it is assumed that the presence of picsivorous fish indicates suitable habitats for forage fish. Generally, they are more adaptable to a larger range of environmental conditions and less sensitive to perturbations water quality, such as temperature and turbidity. Forage fish in the Elbow River include species in the Cyprinidae (minnows), Gasterosteidae (stickleback), and Percopsidae (trout-perch) families.

3.1.2 Field Surveys

Fish and fish habitat field surveys were completed at 12 reaches and two tributaries between September and October 2016. Field surveys were conducted on foot from the banks and instream where water depths permitted.

Survey results for individual reaches are presented in the sections below. A summary data table for each of the 12 reaches is presented in Attachment A, Section A.1. Field data, including site photographs, are found in Attachment A, Section A.2. Desktop and field surveys were integrated to assess each reach.

Table 3-1 Documented Fish Species in the LAA[1]

Species Information				Legislated Protection		Scientific Review or Recommendation	
Family[1]	**Common Name[1]**	**Scientific Name[1]**	**Species Code**	***SARA*[2] (Federal)**	***Wildlife Act*[3] (Provincial)**	**COSEWIC[4] (Federal)**	**General Status[5] (Provincial)**
Catostomidae (suckers)	longnose sucker	*Catostomus catostomus*	LNSC	No status	Not listed	Not assessed	Secure
	mountain sucker (Saskatchewan River populations)	*Catostomus platyrhynchus*	MNSC	No status	Not listed	Not at risk	Secure
	white sucker	*Catostomus commersonii*	WHSC	No status	Not listed	Not assessed	Secure
Cyprinidae (carps and minnows)	fathead minnow	*Pimephales promelas*	FTMN	No status	Not listed	Not assessed	Secure
	lake chub	*Couesius plumbeus*	LKCH	No status	Not listed	Not assessed	Secure
	longnose dace	*Rhinichthys cataractae*	LNDC	No status	Not listed	Not assessed	Secure
	pearl dace	*Margariscus margarita*	PRDC	No status	Not listed	Not assessed	Undetermined
	spottail shiner	*Notropis hudsonius*	SPSH	No status	Not listed	Not assessed	Secure
Esocidae (pikes and mudminnows)	northern pike*	*Esox lucius*	NRPK	No status	Not listed	Not assessed	Secure
Gadidae (cods)	burbot*	*Lota lota*	BURB	No status	Not listed	Not assessed	Secure
Gasterosteidae (sticklebacks)	brook stickleback	*Culaea inconstans*	BRST	No status	Not listed	Not assessed	Secure
Percidae (perches and darters)	yellow perch*	*Perca flavescens*	YLPR	No status	Not listed	Not assessed	Secure
Percopsidae (trout-perches)	trout-perch	*Percopsis omiscomaycus*	TRPR	No status	Not listed	Not assessed	Secure

Table 3-1 Documented Fish Species in the LAA[1]

Species Information				Legislated Protection		Scientific Review or Recommendation	
Family[1]	**Common Name[1]**	**Scientific Name[1]**	**Species Code**	***SARA*[2] (Federal)**	***Wildlife Act*[3] (Provincial)**	**COSEWIC[4] (Federal)**	**General Status[5] (Provincial)**
Salmonidae (trout, char, salmon and whitefish)	brook trout*	*Salvelinus fontinalis*	BKTR	No status	Not listed	Not assessed	Exotic/alien
	brown trout*	*Salmo trutta*	BNTR	No status	Not listed	Not assessed	Exotic/alien
	bull trout* (Saskatchewan - Nelson Rivers populations)	*Salvelinus confluentus*	BLTR	No status	Threatened	Threatened	Sensitive
	mountain whitefish*	*Prosopium williamsoni*	MNWH	No status	Not listed	Not assessed	Secure
	rainbow trout*	*Oncorhynchus mykiss*	RNTR	No status	Not listed	Not assessed	Secure
	westslope cutthroat trout*	*Oncorhynchus clarkii lewisi*	WSCT	Threatened	Threatened	Threatened	At risk

NOTES:
[1] Common and Scientific Names of Fishes from the United States, Canada, and Mexico (Page et al. 2013)
[2] Species at Risk Act (SARA 2002) (GoC 2017a)
[3] Wildlife Act – Wildlife Regulation (1997)
[4] Committee on the Status of Endangered Wildlife in Canada (COSEWIC) (GoC 2017b)
[5] General Status of Alberta Wild Species (ESRD 2012)
* Denotes sportfish species

3.1.3 Reach 1: Elbow River

Fish Inventory

Electrofishing was completed along a 300 m section of the Elbow River within Reach 1. Fish observations/captures include 10 fish and included brown trout [n=9], and brook trout [n=1], collected over 350 seconds with a catch per unit effort (CPUE) of 3.30 fish/100 seconds (Table 3-2). Two of the brown trout were greater than 200 mm in fork length, the remaining eight fish were smaller than 200 mm in length.

Table 3-2 Fish Inventory for Reach 1: Elbow River

ID #	Species	Length (mm)	Weight (g)	Notes
1	Brown trout	261	126	Captured - maturing, sex unknown.
2	Brown trout	330	132	Captured - maturing, sex unknown.
3	Brown trout	182	58	Captured - immature, sex unknown.
4	Brook trout	132	22	Captured - immature, sex unknown.
5	Brown trout	60	6.8	Captured - immature, sex unknown.
6	Brown trout	55	4.8	Captured - immature, sex unknown.
7	Brown trout	64	2.6	Captured - immature, sex unknown.
8	Brown trout	54	5.2	Captured - immature, sex unknown.
9	Brown trout	59	2.3	Captured - immature, sex unknown.
10	Brown trout	73	5.3	Captured - immature, sex unknown.

Fish Habitat Surveys

Reach 1 of the Elbow River channel is irregular, wandering and unconfined with no islands and braiding. Channel and wetted widths range between 26 m to 100 m and 22 m to 85 m, respectively. Channel water depths measured from the left downstream bank (LDB) at 25%, 50%, and 75%, vary from 0.1 m to 0.90 m in the survey area. The maximum channel depth recorded in Reach 1 is 0.9 m at Transect T2.

Channel substrates include: boulder (4%), cobble (39%), large gravel (41%), small gravel (12%), and fines (4%) in Reach 1. Organic and bedrock substrate materials were not observed.

Fish habitat within Reach 1 comprised braids and side channel run habitats (i.e., R3 category type at 65% of total wetted area) and riffle habitats (35%). Pools and areas of water depth greater than 0 m are absent in Reach 1.

At the time of assessment (September / October 2016), the following water quality values were recorded: water temperature (8.6°C), dissolved oxygen (9.91 mg/L), specific conductivity (400 µs/cm), pH (8.0), and turbidity (0.91 NTU). Water quality in Reach 1 is above and/or meets the Alberta SWQG minimum values for dissolved oxygen (i.e., greater than 6.5 mg/L) and pH (i.e., within 6.5 to 9.0).

Fish Habitat Inventory and Habitat Quality Rating

Reach 1 is comprised of 95% instream cover with limited <5% overhead cover. Instream cover is primarily associated with water depth (i.e., < 1.0 m) over diverse substrate types (i.e., boulder, cobble, large gravel, small gravel, and fines). Filamentous algae are observed in Reach 1 but do not provide instream fish cover. Overhead cover in Reach 1 comprises of large woody debris piles.

Spawning habitat potential is rated as "poor" for forage-fish due to limited abundance of spawning surfaces (i.e., woody debris, instream vegetation, and boulders). Spawning habitat potential is rated as "moderate" for sport-fish and coarse-fish. The moderate spawning habitat rating for these fish species was related to higher water velocities within run habitat types (i.e., predominantly R3) that are not preferred by spawning fish (broadcast spawning and/or redds) despite the presence of adequate gravels and cobbles which comprise 92% of the overall substrates.

Based on the conditions at the time of assessment (early fall) and reduced water depths and flows during the winter months, overwintering habitat potential in Reach 1 is rated as "moderate" for forage-fish and "poor-moderate" for coarse-fish and sport-fish related to low water depths (i.e., >1.0 m) used for overwintering by small-bodied fish (i.e., forage-fish species and juvenile coarse-fish, and sport-fish). Dissolved oxygen concentrations are not anticipated to limit overwintering fish potential in the Elbow River during the winter months.

Rearing habitat potential in Reach 1 is as "poor-moderate" for forage-fish, coarse-fish and sport-fish related to observed riffle/run (i.e., R3 and RF) habitat types throughout the reach with adequate holding and feeding opportunities for fish. The channel banks were observed with limited features (i.e., lacking in backwaters, steep drop offs, and boulders) to support rearing habitats. Rearing habitat is attributed to instream cover (i.e., depth, surface turbulence and woody debris) with coarse substrates (i.e., boulders and cobbles).

Migration habitat potential is rated "good" for forage-fish, coarse-fish and sport-fish related to adequate depths and flows throughout the entire year (i.e., winter, spring, summer and fall) to allow passage of the fish species present within the Elbow River. Natural and/or anthropogenic barriers to fish movement or passage are not present within Reach 1. Shallow side braids/channels and shallow areas within Reach 1 are considered to comprise limited habitat during winter related to dry or frozen-to-bottom channels.

3.1.4 Reach 2: Elbow River

Fish Inventory

Electrofishing was completed along a 300 m section of the Elbow River within Reach 2. Fish observations/captures include 9 fish comprising mountain whitefish [n=1], longnose dace [n=1] and brown trout [n=7] collected over 414 seconds for a CPUE of 2.17 fish/100 seconds (Table 3-3). Three of the brown trout were greater than 200 mm in fork length.

Table 3-3 Fish Inventory for Reach 2: Elbow River

ID #	Species	Length (mm)	Weight (g)	Notes
1	Mountain whitefish	97	6.2	Captured - immature, sex unknown.
2	Longnose dace	59	1.9	Captured - immature, sex unknown.
3	Brown trout	480	NA	Captured - mature, sex unknown.
4	Brown trout	420	NA	Captured - mature, sex unknown.
5	Brown trout	NA	NA	Observed - mature, sex unknown.
6	Brown trout	NA	NA	Observed* – immature, sex unknown.
7	Brown trout	NA	NA	Observed* – immature, sex unknown.
8	Brown trout	NA	NA	Observed* – immature, sex unknown.
9	Brown trout	NA	NA	Observed* – immature, sex unknown.

NOTES:

*individual brown trout were observed under submerged large woody debris piles in approximately 0.5 m of water.

Fish Habitat Surveys

Reach 2 of the Elbow River channel is irregular, wandering, and unconfined channel with occasional islands and mid-channel bars. Channel and wetted widths range between 13 m to 34 m and 13 m to 31 m, respectively. Water depths measured from the LDB at 25%, 50% and 75%, vary from 0.1 m to 0.8 m in the survey area. The maximum channel depth recorded in Reach 2 is 1.0 m at Transect T1.

Channel substrates include: boulders (8%), cobble (42%), large gravel (34%), small gravel (13%), and fines (3%) in Reach 2. Organic and bedrock substrate materials were not observed.

Fish habitat within Reach 2 comprise run habitats (i.e., R3 category type at 85% of total wetted area) and secondarily by deeper run habitat (i.e., R2 at 12%). Pools and areas of water depth greater than 1.0 m are absent in Reach 2. Reach 2 includes continuous run habitat, except for a small side channel near transect T6.

At the time of assessment (September / October 2016), the following water quality values were recorded: water temperature (8.8°C), dissolved oxygen (9.40 mg/L), specific conductivity (415 µs/cm), pH (8.0), and turbidity (0.31 NTU). Water quality in Reach 2 was above and/or met the Alberta SWQG minimum values for dissolved oxygen (i.e., greater than 6.5 mg/L) and pH (i.e., within 6.5 to 9.0).

Fish Habitat Inventory and Habitat Quality Rating

Reach 2 comprises 90% instream cover with limited 10% overhead cover. Instream cover is primarily associated with water depth (i.e., < 1.0 m) over diverse substrate types (i.e., boulder, cobble, large gravel, small gravel, and fines). Filamentous algae are observed in Reach 2, but do not to provide instream fish cover. Overhead cover in Reach 2 comprises large woody debris piles.

Spawning habitat potential is rated as "poor" for forage-fish due limited abundance of spawning surfaces (i.e., woody debris, instream vegetation, and boulders). Spawning habitat potential is rated as "moderate" for sport-fish and coarse-fish. The moderate spawning habitat rating for these fish species is related to higher water velocities within run habitat types (i.e., predominantly R3) that are not considered amenable for breeding pairs of fish (broadcast spawning and/or redds), despite the presence of adequate gravels and cobbles that comprised 89% of the overall substrates.

Based on the conditions at the time of assessment (early fall) and reduced water depths and flows during the winter months, overwintering habitat potential in Reach 2 was rated as "moderate" for forage-fish and "poor-moderate" for coarse-fish and sport-fish related to low water depths (i.e., >1.0 m) used for overwintering by small-bodied fish (i.e., forage-fish species and juvenile coarse-fish and sport-fish). Dissolved oxygen concentrations are not anticipated to limit overwintering fish potential in the Elbow River during the winter months.

Rearing habitat potential in Reach 2 is rated as "poor-moderate" for forage-fish, coarse-fish and sport-fish related to observed run habitat (i.e., type R2 and R3) throughout the reach with adequate for holding and feeding fish. The channel banks have limited features (i.e., lacking in backwaters, steep drop offs, and boulders) to support rearing habitats. Rearing habitat was observed attributed to instream cover (i.e., depth, surface turbulence and woody debris) with coarse substrates (i.e., boulders and cobbles) with coarse substrates (i.e., boulders and cobbles).

Migration habitat potential is rated "good" for forage-fish, coarse-fish and sport-fish related to adequate depths and flows throughout the year (i.e., winter, spring, summer, and fall) that allows fish passage. Natural and/or anthropogenic barriers to fish movement or passage are not present within Reach 2. Shallow side braids/channels and shallow areas within Reach 2 are considered to comprise limited habitat during winter related to dry or frozen-to-bottom channels. Natural and/or anthropogenic barriers to fish movement or passage were not present

within Reach 2. Shallow side channels and shallow areas within Reach 2 were considered to comprise limited habitat during winter related to dry or frozen-to-bottom channels.

3.1.5 Reach 3: Elbow River

Fish Inventory

Electrofishing was completed along a 300 m section of the Elbow River within Reach 3. Fish observations / captures include 7 fish, five brown trout and two brook trout, collected over 402 seconds for a CPUE of 1.74 fish/100 seconds (Table 3-4). The brown trout and brook trout were smaller than 200 mm in fork length.

Table 3-4 Fish Inventory for Reach 3: Elbow River

ID #	Species	Length (mm)	Weight (g)	Notes
1	Brook trout	136	27	Captured - immature, sex unknown.
2	Brown trout	84	6.1	Captured - immature, sex unknown.
3	Brown trout	85	6.5	Captured - immature, sex unknown.
4	Brown trout	64	2.9	Captured - immature, sex unknown.
5	Brown trout	86	6.5	Captured - immature, sex unknown.
6	Brown trout	79	4.9	Captured - immature, sex unknown.
7	Brook trout	127	23	Captured - immature, sex unknown.

Fish Habitat Surveys

Reach 3 of the Elbow River channel is irregular, wandering, occasionally confined with no islands or mid-channel bars. Channel and wetted widths range between 16 m to 39 m and 14 m to 37 m, respectively. Water depths measured from the LDB at 25%, 50% and 75%, vary from 0.1 m to 0.9 m in the survey area. The maximum water depth recorded in Reach 3 is 0.8 m at Transect T2.

Channel substrates include: boulders (13%), cobble (41%), large gravel (34%), small gravel (10%), and fines (2%) in Reach 3. Organic and bedrock substrate materials were not observed.

Fish habitat within Reach 3 comprises uniform and continuous run habitats (i.e., R2 category type at 45% of total wetted area) and shallow run habitats (i.e., R3 at 40%) smaller portions of riffle (10%) within small side channels and dry channels. Pools (P2 at 5%) and areas of depth >1.0 m are not present in Reach 3.

At the time of assessment (September / October 2016), the following water quality values were recorded: water temperature (8.4°C), dissolved oxygen (9.68 mg/L), specific conductivity (417 µs/cm), pH (7.9), and turbidity (0.01 NTU). Water quality in Reach 3 was above and/or met the Alberta SWQG minimum values for dissolved oxygen (i.e., greater than 6.5 mg/L) and pH (i.e., within 6.5 to 9.0).

Fish Habitat Inventory and Habitat Quality Rating

Reach 3 comprises 90% instream cover with limited 10% overhead cover. Instream cover is primarily associated with water depths (i.e., < 1.0 m) over diverse substrate types (i.e., boulder, cobble, large gravel, small gravel, and fines). Filamentous algae are observed in Reach 3, but do not provide instream fish cover. Overhead cover in Reach 3 comprises large woody debris piles.

Spawning habitat potential is rated as "moderate" for forage-fish related to spawning surfaces present in the reach (i.e., woody debris, instream vegetation, and boulders). Spawning habitat potential is rated as "moderate" for sport-fish and coarse-fish. The moderate spawning habitat rating for these fish species is related to higher water velocities within run habitat types (i.e., predominantly R3) which are not considered amenable for breeding pairs of fish (broadcast spawning and/or redds) despite the presence of adequate gravels and cobbles which comprises 85% of the overall substrates.

Based on the conditions at the time of assessment (early fall) and reduced water depths and flows during the frozen winter months, overwintering habitat potential in Reach 3 is "moderate" for forage-fish, coarse-fish, and sport-fish related to low water depths (i.e., <1.0 m) used for overwintering by small-bodied fish (i.e., forage-fish species and juvenile coarse-fish and sport-fish). The small amount of P2 pool habitats may be used as overwintering habitats by a limited number of larger sized fish. Dissolved oxygen concentrations are not anticipated to limit overwintering fish potential in the Elbow River during the winter months.

Rearing habitat potential is "good" for forage-fish, "moderate" for coarse-fish and sport-fish related to riffle, run and pool habitat types throughout the reach. Rearing habitat observed was attributed to instream cover (i.e., depth, surface turbulence and woody debris) and with coarse substrates (i.e., boulders and cobbles).

Migration habitat potential is rated "good" for forage-fish, coarse-fish and sport-fish related to adequate depths and flows throughout the entire year (i.e., winter, spring, summer and fall) to allow for the passage of all fish species present within the Elbow River. Natural and/or anthropogenic barriers to fish movement or passage are not present within Reach 3. Shallow side braids/channels and shallow areas within Reach 3 comprise limited habitat during winter related to dry or frozen-to-bottom channels.

3.1.6 Reach 4: Elbow River

Fish Inventory

Electrofishing was completed along a 375 m section of the Elbow River within Reach 4. Fish observations / captures include 7 fish and included six brown trout and one brook trout, collected over 613 seconds with a CPUE of 1.14 fish/100 seconds (Table 3-5). One of the brown trout were greater than 200 mm, the 6 fish were smaller than 200 mm in length.

Table 3-5 Fish Inventory for Reach 4: Elbow River

ID #	Species	Length (mm)	Weight (g)	Notes
1	Brown trout	238	126	Captured – maturing, sex unknown.
2	Brown trout	198	82	Captured – immature, sex unknown.
3	Brook trout	184	67	Captured – immature, sex unknown.
4	Brown trout	76	4.0	Captured – immature, sex unknown.
5	Brown trout	69	3.2	Captured – immature, sex unknown.
6	Brown trout	65	2.7	Captured – immature, sex unknown.
7	Brown trout	64	2.8	Captured – immature, sex unknown.

Fish Habitat Survey

Reach 4 of the Elbow River channel is irregular, wandering, and unconfined with no islands or mid-channel bars. Channel and wetted widths range between 28 m to 60 m and 21 m to 54 m respectively. Channel water depths measured from the LDB at 25%, 50% and 75%, vary from 0.2 m to 0.8 m in the survey area. The maximum channel depth recorded in Reach 4 is 0.8 m at transects T1, T3 and T6.

Channel substrates include: boulders (16%), cobble (36%), large gravel (21%), small gravel (16%), and fines (11%) in Reach 4. Organics and bedrock substrate materials were not observed.

Fish habitat within Reach 4 comprises run habitat (i.e., R2 category type at 70% of total wetted area) and riffle habitats (10%) and pools (P2 category type, 10%). Several backwaters and areas of increased depth (i.e., < 1.0 m) are observed in the channel associated with boulders and large woody debris in transects T1, T3 and T6.

At the time of assessment (September / October 2016), the following water quality values were recorded: water temperature (9.0°C), dissolved oxygen (10.9 mg/L), specific conductivity (370 µs/cm), pH (8.1), and turbidity (NA). Water quality in Reach 4 was above and/or met the Alberta SWQG minimum values for dissolved oxygen (i.e., greater than 6.5 mg/L) and pH (i.e., within 6.5 to 9.0).

Fish Habitat Inventory and Habitat Quality Rating

Reach 4 is comprises 95% instream cover with limited <5% overhead cover. Instream cover is primarily associated with water depths over diverse substrate types (i.e., boulder, cobble, large gravel, small gravel, and fines). Filamentous algae are observed in Reach 4 but do not provide instream cover. Overhead cover in Reach 4 comprises large woody debris piles and areas of undercut banks.

Spawning habitat potential is rated as "good" for forage-fish due the presence of boulders and large woody debris instream. Spawning habitat potential is rated as "moderate" for coarse-fish and sport-fish. The moderate habitat rating for these fish species is related to higher water velocities and within run habitat types (i.e., predominantly R2) which are not amenable for breeding pairs (broadcast spawning and/or redds) despite the presence of adequate gravels and cobbles which comprised 73% of the overall substrates.

Based on the conditions at the time of assessment (early fall) and reduced water depths and flow during the frozen winter months, overwintering habitat potential in Reach 4 is rated as "good" for forage-fish and "moderate" for coarse-fish and sport-fish related to moderate water depths used for overwintering by small-bodied fish (i.e., forage-fish species and juvenile coarse-fish and sport-fish). Pool habitats are observed which can support habitat for several larger bodied fish. Dissolved oxygen concentrations are not anticipated to limit overwintering fish potential in the Elbow River during the winter months.

Rearing habitat potential in Reach 4 is rated as "good" for forage-fish, but "moderate" for coarse-fish and sport-fish related to observed run, riffle and pool habitat types throughout the reach considered ideal for holding and feeding fish. The channel banks are observed with limited features (i.e., lacking in backwaters, steep drop offs, and boulders) to support rearing habitat. Rearing habitat is observed attributed to instream cover (i.e., depth, surface turbulence and woody debris) with coarse substrates (i.e., boulders and cobbles).

Migration habitat potential is rated as "good" for forage-fish, coarse-fish and sport-fish related to adequate depths and flows the entire year (i.e., winter, spring, summer and fall) to allow for the passage of all fish species present within the Elbow River. Natural and/or anthropogenic barriers to fish movement or passage are not present within Reach 4.

3.1.7 Reach 5: Elbow River

Fish Inventory

Electrofishing was completed along a 360 m section of the Elbow River within Reach 5. Fish observations/captures include 8 fish, 7 brown trout [n=7] and one rainbow trout [n=1], collected over 664 seconds for a CPUE of 1.2 fish/100 seconds (Table 3-6). The brown trout and rainbow trout all have fork-lengths less than 200 mm.

Table 3-6 Fish Inventory for Reach 5: Elbow River

ID #	Species	Length (mm)	Weight (g)	Notes
1	Brown trout	146	30	Captured – immature, sex unknown.
2	Brown trout	74	4.5	Captured – immature, sex unknown.
3	Brown trout	72	4.3	Captured – immature, sex unknown.
4	Brown trout	NA	NA	Observed – immature, sex unknown.
5	Brown trout	NA	NA	Observed – immature, sex unknown.
6	Brown trout	NA	NA	Observed – immature, sex unknown.
7	Brown trout	NA	NA	Observed – immature, sex unknown.
8	Rainbow trout	NA	NA	Observed – immature, sex unknown.

Fish Habitat Assessment

Reach 5 of the Elbow River is irregular, wandering and occasionally confined channel with islands and mid-channel bars. Channel and wetted widths ranged between 15 m to 39 m and 13 m to 28 m, respectively. Channel water depths measured from the LDB at 25%, 50% and 75%, vary from 0.2 m to 1.0 m in the survey area. The maximum channel depth recorded in Reach 5 is 1.0 m at transects T4 and T5.

Channel substrates include: boulders (14%), cobble (39%), large gravel (28%), and small gravel (19%) in Reach 5. Organics, fines, and bedrock substrate materials were not present.

Fish habitat within Reach 5 comprises run habitats (i.e., R2 and R3 category type measure 37% each of the total wetted area each), pool habitats (i.e., P1 at 10%) and riffle habitat (7%), located between the runs and pools. Pools with water depths greater than 1.0 m were observed in Reach 5 within transects T4 and T5.

At the time of assessment (September / October 2016), the following water quality values were recorded: water temperature (8.2°C), dissolved oxygen (10.41 mg/L), specific conductivity (326 µs/cm), pH (7.8), and turbidity (0.46 NTU). Water quality in Reach 5 was above and/or met the Alberta SWQG minimum values for dissolved oxygen (i.e., greater than 6.5 mg/L) and pH (i.e., within 6.5 to 9.0).

Fish Habitat Inventory and Habitat Quality Rating

Reach 5 is comprises 90% instream cover with limited < 10% overhead cover. Instream cover is primarily associated with water depth (i.e., 1.0 m) and large woody debris and woody debris piles. Filamentous algae are observed in Reach 5, but do not provide instream fish cover. Overhead cover in Reach 5 comprises large woody debris, woody debris piles and undercut banks.

Spawning habitat potential is rated as "good" for forage-fish due to the presence of spawning surfaces within the boulders and large woody debris instream. Spawning habitat potential is rated as "good" for coarse-fish and sport-fish. Good spawning habitat was related to as the presence of gravel and cobble substrates which comprise86% of substrates within habitats with good water velocities for breeding pairs (i.e., broadcast spawning and/or redds).

Based on conditions at the time of assessment (early fall) and reduced water depths and flows during the frozen winter month, overwintering habitat potential in Reach 5 is rated as "good" for forage-fish, coarse-fish, and sport-fish related to areas of good water depths (i.e., 1.0 m) and flows. Dissolved oxygen concentrations are not anticipated to limit overwintering fish potential in the Elbow River during the winter months.

Rearing habitat potential in Reach 5 is rated as "good" for forage-fish, coarse-fish and sport-fish related to observed riffle, run and pool habitat types throughout the reach. Reach 5 included observations of large woody debris and undercut banks distributed downstream-right-bank near transects T3 to T5 (i.e., instream and overhead cover) which are rated as ideal for holding and feeding large-bodies and small-bodied fish.

Migration habitat potential is rated "good" for forage-fish, coarse-fish and sport-fish related to adequate depths and flows throughout the entire year (i.e., winter, spring, summer and fall) to allow passage of all fish species present within the Elbow River. Natural and/or anthropogenic barriers to fish movement or passage are not present within Reach 5.

3.1.8 Reach 6: Elbow River

Fish Inventory

Electrofishing was not completed within the Elbow River in Reach 8 due to elevated water depth and velocities that were unsafe to conduct field surveys.

Fish Habitat Assessment

Reach 6 of the Elbow River is irregular, wandering, and unconfined with occasional islands and mid-channel bars. Channel widths and wetted widths range between 25 m to 38 m and 15 m to 22 m, respectively. Water depths measured from the LDB at 25%, 50% and 75%, vary from 0.30 m to 0.80 m in the survey area. The maximum depths in Reach 6 include two measurements of 1.0 m at transects T1 and T5.

Channel substrates include boulders (11%), cobble (35%), large gravel (34%), small gravel (18%), and fines (2%) in Reach 6. Organic and bedrock substrate materials were not observed.

Fish habitat within Reach 6 comprises run habitat (i.e., R2 and R3 category types at 39% and 33% of total wetted area), riffles (i.e., at 20%) and pools (8%). A small side channel is present near transects T1 and T2.

At the time of assessment (September / October 2016), the following water quality values were recorded: water temperature (9.1°C), dissolved oxygen (12.50 mg/L), specific conductivity (469 µs/cm), pH (7.7), and turbidity (0.42 NTU). Water quality in Reach 6 was above and/or met the Alberta SWQG minimum values for dissolved oxygen (i.e., greater than 6.5 mg/L) and pH (i.e., within 6.5 to 9.0).

Fish Habitat Inventory and Habitat Quality Rating

Reach 6 comprises 80% instream cover with limited (20%) overhead cover. Instream cover is primarily associated with water depths (i.e., 1.0 m) and large woody debris and woody debris piles. Filamentous algae are observed in Reach 6, but do not provide instream fish cover. Overhead cover in Reach 6 comprises large woody debris and undercut banks.

Spawning habitat potential is rated as "good" for forage-fish as adequate spawning surfaces present in the reach (i.e., boulders and large woody debris). Spawning habitat potential is rated as "good" for coarse-fish and sport-fish. The spawning habitat is related to the presence of gravels and cobbles which comprise 87% of the overall substrate located in areas with adequate water velocities for breeding pairs (i.e., broadcast spawning and/or redds).

Based on the conditions at the time of assessment (early fall) and reduced water depths and flows during the frozen winter months, overwintering habitat potential in Reach 6 is "good" for forage-fish, coarse-fish, and sport-fish related to areas of adequate water depths (i.e., <1.0 m) and flow. Dissolved oxygen concentrations are not anticipated to limit overwintering fish potential in the Elbow River during the winter months.

Rearing habitat potential is "good" for forage-fish, coarse-fish and sport-fish related to riffle, run and pool habitat types throughout the reach. Habitat in Reach 6 downstream-right-bank near transects T3 to T6, provides areas of instream and overhead cover from large woody debris and undercut banks used for holding and feeding by large-bodied and small-bodied fish species.

Migration habitat potential is rated "good" for forage-fish, coarse-fish and sport-fish related to adequate water depths and flows during the year (i.e., winter, spring, summer and fall) which allow for the passage of all fish species present within the Elbow River. Natural and/or anthropogenic barriers to fish movement or passage are not present within Reach 6. Shallow side braids/channels and shallow areas within Reach 6 comprise limited habitat during winter related to dry or frozen-to-bottom channels. Reach 7: Elbow River

Fish Inventory

Electrofishing was completed along a 370 m section of the Elbow River within Reach 7. Fish observations / captures include 3 fish, two longnose dace and one white sucker, collected over 657 seconds with a total CPUE of 0.45 fish/100 seconds (Table 3-7). The dace and sucker were smaller than 200 mm in fork length.

Table 3-7 Fish Inventory for Reach 7: Elbow River

ID #	Species	Length (mm)	Weight (g)	Notes
1	Longnose dace	47	0.9	Captured – immature, sex unknown.
2	White sucker	< 20	NA	Captured – immature, sex unknown.
3	Longnose dace	< 20	NA	Captured – immature, sex unknown.

Fish Habitat Assessment

Reach 7 of the Elbow River is irregular, wandering, occasionally confined with few islands and mid-channel bars. Channel widths and wetted widths range between 24 m to 46 m and 20 m to 30 m, respectively. Water depths measured from the LDB at 25%, 50% and 75%, vary from 0.3 m to 1.0 m in the survey area. The maximum depth recorded in Reach 7 is 1.2 m at Transect T6.

Channel substrates include: boulders (6%), cobble (38%), large gravel (33%), small gravel (17%), fines (4%), and organics (2%) in Reach 7. Organic and bedrock substrate materials were not observed.

Fish habitat within Reach 7 comprises run habitats (i.e., R1, R2, and R3 category type measure 15%, 40% and 15% of total wetted area, respectively) and riffle habitats (20%)between runs, and smaller portions of glide habitat (10%) between T4 and T5.

At the time of assessment (September / October 2016), the following water quality values were recorded: water temperature (12.5°C), dissolved oxygen (11.50 mg/L), specific conductivity (416 µs/cm), pH (8.0), and turbidity (0.56 NTU). Water quality in Reach 7 was above and/or met the Alberta SWQG minimum values for dissolved oxygen (i.e., greater than 6.5 mg/L) and pH (i.e., within 6.5 to 9.0).

Fish Habitat Inventory and Habitat Quality Rating

Reach 7 comprises 95% instream cover with limited 5% overhead cover. Instream cover is primarily associated with water depths (i.e., 1.0 m) over diverse substrate types (i.e., boulder, cobble, large gravel, small gravel, and fines). Filamentous algae are observed in Reach 7, but do not provide instream cover. Overhead cover in Reach 7 comprises undercut banks and large woody debris.

Spawning habitat potential is rated as "moderate-good" for forage-fish related to spawning surfaces present within the reach (i.e., boulders, cobbles, and large woody debris). Spawning habitat potential is rated as "good" for coarse-fish and sport-fish. This rating is related to the presence of gravels and cobbles which comprise 88% of the overall substrates with good water velocities for breeding pairs (i.e., broadcast spawning and/or redds).

Based on the conditions at the time of assessment (early fall), and reduced water depths and flows during frozen winter months, overwintering habitat potential in Reach 7 is rated as "moderate-good" for forage-fish, coarse-fish, and sport-related to deeper water depths (i.e., >1.0 m) used for overwintering by small and large bodied fish. Dissolved oxygen concentrations are not anticipated to limit overwintering fish potential in the Elbow River during the winter months.

Rearing habitat potential is rated as "moderate" for forage-fish, coarse-fish and sport-fish related to riffle/run (i.e., type R1, R2 and R3) habitat types overhanging banks (i.e. undercuts and large woody debris).

Migration habitat potential is rated as "good" for forage-fish, coarse-fish and sport-fish related to good depths and flows throughout the entire year (i.e., winter, spring, summer and fall) to allow for the passage of all fish species present within the Elbow River. Natural and/or anthropogenic barriers to fish movement or passage are not present within Reach 7.

3.1.9 Reach 8: Elbow River

Fish Inventory

Electrofishing was not completed within the Elbow River in Reach 8 due to elevated water velocities that were unsafe to conduct field surveys.

Fish Habitat Assessment

Reach 8 of the Elbow River is irregular, wandering, and unconfined with no islands and mid-channel bars. Channel widths and wetted widths range between 21 m to 36 m and 18 m to 31 m, respectively. Water depths measured from the LDB at 25%, 50% and 75%, vary from 0.1 m to 0.8 m in the survey area. The maximum depth in Reach 8 is 1.0 m found at Transect T5.

Channel substrates include: boulders (5%), cobble (53%), large gravel (30%), small gravel (10%), and fines (2%) in Reach 8. Organic and bedrock substrate materials were not observed.

Fish habitat within Reach 8 comprises run habitats (i.e., R3 category type at 68% of total wetted area), pools (P1 at 9%), glides (9%) and riffles (14%). A side channel and/or stream braiding is present at transects T1 and T2.

At the time of assessment (September / October 2016), the following water quality values were recorded: water temperature (9.8°C), dissolved oxygen (9.88 mg/L), specific conductivity (427 µs/cm), pH (8.0), and turbidity (0.03). Water quality in Reach 8 was above and/or met the Alberta SWQG minimum values for dissolved oxygen (i.e., greater than 6.5 mg/L) and pH (i.e., within 6.5 to 9.0).

Fish Habitat Inventory and Habitat Quality Rating

Reach 8 comprises 85% instream cover with limited 15% overhead cover. Instream cover is primarily associated with water depths (i.e., <1.0 m) and large woody debris and woody debris piles. Filamentous algae are observed in Reach 8, but do not provide instream fish cover. Overhead cover in Reach 8 comprises large woody debris and undercut banks.

Spawning habitat potential is rated as “moderate-good” for forage-fish related to spawning surfaces (i.e., boulders and large woody debris) present in the reach. Spawning habitat potential is rated as “good” for coarse-fish and sport-fish. This rating is related gravels and cobbles which comprised 93% of the substrates covered with adequate water velocities for breeding pairs (i.e., broadcast spawning and/or redds).

Despite an anticipated reduction in water depths and flows during the winter months compared to the conditions at the time of assessment, overwintering habitat potential in Reach 8 is "good" for forage-fish, coarse-fish, and sport-fish due to the presence of areas of adequate depth (i.e., 1.0 m) and flows. Dissolved oxygen concentrations are not anticipated to limit overwintering fish potential in the Elbow River during the winter months.

Based on the conditions at the time of assessment (early fall) and reduced water depths and flows during the frozen winter months, overwintering habitat potential in Reach 8 is rated as "moderate-good" for forage-fish, coarse-fish, and sport-fish related to the presence of riffle, run and pool habitat types in the reach. The downstream-right-bank near transects T3 to T4, provides instream and overhead cover from large woody debris and undercut banks (which support holding and feeding habitats for large and small-bodied fish.

Migration habitat potential is rated as "good" for forage-fish, coarse-fish and sport-fish related to adequate depths and flows during the entire year (i.e., winter, spring, summer and fall) to allow for the passage of all fish species present within the Elbow River. Natural and/or anthropogenic barriers to fish movement or passage are not present within Reach 8.

3.1.10 Reach 9: Elbow River

Fish Inventory

Electrofishing was not completed within the Elbow River in Reach 8 due to elevated water velocities that were unsafe to conduct field surveys.

Fish Habitat Assessment

Within Reach 9, the Elbow River is an irregular wandering unconfined channel with occasional islands and mid-channel bars. Channel widths and wetted widths ranged between 21 m to 31 m and 11 m to 29 m, respectively. Water depths measured from the LDB at 25%, 50% and 75%, varied from 0.3 m to 0.9 m throughout the assessment area. The maximum depths in Reach 9 include two measurements of 1.2 m found at transects T4 and T5.

Organics and bedrock substrate materials are not present within the assessment area; however, boulders (8%), cobble (58%), large gravel (20%), small gravel (5%), and fines (9%) are present throughout.

Fish habitat distribution within the assessment is predominantly run habitat (i.e., R3 category type at 85% of total wetted area) with an even distribution of deeper runs (i.e. R2 at 5%), riffles (5%) and rapids (5%); pool habitat is absent from the assessment area. Several backwaters and areas of increased depth (i.e., > 1.0 m) are associated with instream boulders and large woody debris present within transects T4 and T5.

At the time of assessment, the following water quality values were recorded: water temperature (11.7 °C), dissolved oxygen (11.02 mg/L), specific conductivity (429 µs/cm), pH (7.8), and turbidity (0.00 NTU). Water quality in Reach 9 was above and/or met the Alberta SWQG minimum values for dissolved oxygen (i.e., greater than 6.5 mg/L) and pH (i.e., within 6.5 to 9.0).

Fish Habitat Inventory and Habitat Quality Rating

Within the assessment area of Reach 9, instream cover is dominant (95%) with overhead cover comprising the remaining 5%. Instream cover is primarily associated with boulders, areas of water depth (i.e., >1.0 m) and occasional collections of and large woody debris. Filamentous algae are observed in Reach 9, but do not provide instream fish cover. Overhead cover, limited to the outside of river bends, consists primarily of undercut banks with occasional overhanging riparian vegetation (i.e., willow species).

Spawning habitat potential is "poor-moderate" for forage-fish, coarse-fish, and sport-fish; despite the presence of adequate spawning surfaces (i.e., cobble and gravel substrates) present throughout the assessment area, the observed water velocities throughout Reach 9 limit spawning to the margins/banks areas of the Elbow River.

Based on the conditions at the time of assessment and the anticipated reduction in water depths and flows during the winter months, overwintering habitat potential in Reach 9 is "poor-moderate" for forage-fish, coarse-fish, and sport-fish, despite the presence of adequate water depths (i.e., >1.0 m), water velocities are elevated and high for overwintering fish and habitat use. The anticipated winter conditions and elevated velocities do not provide adequate holding habitat for fish, except for a few habitat areas (i.e., undercut banks, boulder/backwater areas with transects T4 and T5, and areas of transition between the riffle into run habitats). Overwintering habitat in Reach 9 is limited in both extent and distribution.

Rearing habitat potential is "moderate" for forage-fish, coarse-fish and sport-fish as Reach 9 lacks habitat diversity and habitat complexity as it predominantly provides a shallow run habitat (i.e., type R3) with elevated water velocities. However, the right downstream bank does provide notable cover (i.e., undercut, overhanging vegetation and large woody debris) as does the boulder garden present within transects T4 and T5, thus supporting both small-bodied and large-bodied fish.

Migration habitat potential is "good" for forage-fish, coarse-fish and sport-fish as adequate depths and flows during all season (i.e., winter, spring, summer and fall) will allow for the passage of all fish species present within the Elbow River. In addition, natural and/or anthropogenic barriers to fish movement or passage are not present within the assessment area of Reach 9.

3.1.11 Reach 10: Elbow River

Fish Inventory

Electrofishing was not completed within the Elbow River in Reach 8 due to elevated water velocities that were unsafe to conduct field surveys.

Fish Habitat Assessment

Within Reach 10, the Elbow River is an irregular wandering occasionally confined channel with no islands and mid-channel bars. Channel widths and wetted widths ranged between 24 m to 52 m and 15 m to 31 m, respectively. Water depths measured from the LDB at 25%, 50% and 75%, varied from 0.2 m to 0.6 m throughout the assessment area. The maximum depth in Reach 10 is a single measurement of 1.0 m found at Transect T1.

Organics, fines, and bedrock substrate materials are not present within the assessment area; however, cobble (67%) and large gravel (30%) are present throughout the assessment area, whereas small gravel (3%) is only present near transects T5 and T6.

Fish habitat distribution within the assessment is predominantly run habitat (i.e., R3 category type at 75% of total wetted area), with a single side channel habitat extending downstream from transect T5 to T6 transect. Distinct areas of riffle habitat (i.e., RF at 20%) and occasional areas of deeper run habitat (i.e., R2 at 5 %) are also present within Reach 10.

At the time of assessment, the following water quality values were recorded: water temperature (13.2°C), dissolved oxygen (9.80 mg/L), specific conductivity (435 µs/cm), pH (7.8), and turbidity (NA). Water quality in Reach 10 was above and/or met the Alberta SWQG minimum values for dissolved oxygen (i.e., greater than 6.5 mg/L) and pH (i.e., within 6.5 to 9.0 mg/L).

Fish Habitat Inventory and Habitat Quality Rating

Within the assessment area of Reach 10, instream cover is dominant (95%) with overhead cover comprising the remaining 5%. Instream cover is only associated diverse substrate types (i.e., cobble, large gravel, small gravel, and fines). Filamentous algae are observed in Reach 10, but do not provide instream fish cover. Overhead cover, limited to the outside of river bends, consists primarily of undercut banks with occasional overhanging riparian vegetation (i.e., willow species).

Spawning habitat potential is "poor-moderate" for forage-fish, coarse-fish, and sport-fish; despite the presence of adequate spawning surfaces (i.e., cobble and gravel substrates) present throughout the assessment area, the observed water velocities throughout Reach 10 limit spawning to the margins/banks areas of the Elbow River.

Based on the conditions at the time of assessment and the anticipated reduction in water depths and flows during the winter months, overwintering habitat potential in Reach 10 is "poor-moderate" for forage-fish, coarse-fish, and sport-fish due to the lack of areas of adequate depth (i.e., >1.0 m) and appropriate water velocities. The anticipated winter conditions do not provide adequate habitat for fish to hold in, except for a few locations (i.e., undercut banks at transects T1 and T6, and areas of transition between the riffle into run habitats), thus overwintering habitat in Reach 10 is generally absent in both extent and distribution within the assessment area.

Rearing habitat potential is "poor-moderate" for forage-fish, coarse-fish and sport-fish as Reach 10 lacks habitat diversity and habitat complexity as it only provides a shallow run habitat (i.e., type R3) with elevated water velocities over uniform substrates (i.e., cobbles and gravels only). Furthermore, banks are relatively featureless (i.e., lacking in backwaters, steep drop offs, large and small woody debris, and boulders) and instream cover is limited to uniform substrates under shallow water depths.

Migration habitat potential is "good" for forage-fish, coarse-fish and sport-fish as adequate depths and flows during all season (i.e., winter, spring, summer and fall) will allow for the passage of all fish species present within the Elbow River. In addition, natural and/or anthropogenic barriers to fish movement or passage are not present within the assessment area of Reach 10.

3.1.12 Reach 11: Elbow River

Fish Inventory

Electrofishing was completed along a 330 m section of the Elbow River within Reach 11. Fish observations / captures include 3 fish and included longnose dace [n=1], longnose sucker [n=1], and brook trout [n=1] collected over 658 seconds with a CPUE of 0.45 fish/100 seconds (Table 3-8). All fish have fork-lengths less than 200 mm.

Table 3-8 Fish Inventory for Reach 11: Elbow River

ID #	Species	Length (mm)	Weight (g)	Notes
1	Longnose sucker	86	6.8	Captured – immature, sex unknown.
2	Longnose dace	70	3.2	Captured – immature, sex unknown.
3	Brook trout	183	64	Captured – immature, sex unknown.

Fish Habitat Assessment

Within Reach 11, the Elbow River is an irregular wandering unconfined channel with no islands and mid-channel bars. Channel widths and wetted widths ranged between 21 m to 31 m and 9 m to 30 m, respectively. Water depths measured from the LDB at 25%, 50% and 75%, varied from 0.1 m to >1.0 m throughout the assessment area. The maximum depth in Reach 11 is >1.0 m documented at Transect T1.

Organics and bedrock substrate materials are not present within the assessment area; however, boulders (6%), cobble (33%), large gravel (41%), small gravel (17%), and fines (3%) are present throughout.

Fish habitat distribution within the assessment is predominantly run habitat (i.e., R3 category type at 85% of total wetted area), and a single continuous pool habitat (P1 at 15%) extending downstream from the T1 transect. Distinct and/or continuous areas of riffle habitat are not present within Reach 11.

At the time of assessment, the following water quality values were recorded: water temperature (10.6°C), dissolved oxygen (9.48 mg/L), specific conductivity (435 µs/cm), pH (8.1), and turbidity (0.01 NTU). Water quality in Reach 11 was above and/or met the Alberta SWQG minimum values for dissolved oxygen (i.e., greater than 6.5 mg/L) and pH (i.e., within 6.5 to 9.0 mg/L).

Fish Habitat Inventory and Habitat Quality Rating

Within the assessment area of Reach 11, instream cover is dominant (95%) with overhead cover comprising the remaining 5%. Instream cover is primarily associated with areas of water depth (i.e., 1.0 m) and occasional collections of boulders. Filamentous algae are observed in Reach 11, but do not provide instream fish cover. Overhead cover, limited to the outside of river bends, consists primarily of undercut banks, with occasional overhanging riparian vegetation (i.e., willow species).

Spawning habitat potential is "moderate" for forage-fish, coarse-fish, and sport-fish as adequate spawning surfaces (i.e., woody debris, boulders, cobbles, and gravels) are present throughout the assessment area. However, northern pike spawning may be limited as substrates, instream vegetation, and appropriate flows (i.e., snyes, backwaters, and flats) are not anticipated to be overly abundant in Reach 11 during the spring season.

Based on the conditions at the time of assessment and the anticipated reduction in water depths and flows during the winter months, overwintering habitat potential in Reach 11 is "moderate-good" for forage-fish, coarse-fish, and sport-fish due to the presence of the large pool which provides adequate depths (i.e., >1.0 m) for fish.

Rearing habitat potential is "moderate" for forage-fish, coarse-fish and sport-fish as Reach 11 lacks habitat diversity and habitat complexity as it only provides a single pool (type P1) within an adjacent uniform run (i.e., type R3). Furthermore, banks are relatively featureless (i.e., lacking in backwaters, steep drop offs, large and small woody debris, and boulders) and instream cover is limited to areas of depth (i.e., <1.0 m).

Migration habitat potential is "good" for forage-fish, coarse-fish and sport-fish as adequate depths and flows during all season (i.e., winter, spring, summer and fall) will allow for the passage of all fish species present within the Elbow River. In addition, natural and/or anthropogenic barriers to fish movement or passage are not present within the assessment area of Reach 11.

3.1.13 Reach 12: Elbow River

Fish Inventory

Electrofishing was completed along a 375 m section of the Elbow River within Reach 12. Fish observations/captures include 6 fish and included longnose dace [n=3] and longnose sucker [n=3] collected over 367 seconds with a CPUE of 1.64 fish/100 seconds (Table 3-9).

Table 3-9 Fish Inventory for Reach 5: Elbow River

ID #	Species	Length (mm)	Weight (g)	Notes
1	Longnose dace	59	1.6	Captured – immature, sex unknown.
2	Longnose sucker	86	7.5	Captured – immature, sex unknown.
3	Longnose sucker	68	3.5	Captured – immature, sex unknown.
4	Longnose dace	89	6.4	Captured – immature, sex unknown.
5	Longnose sucker	59	2.2	Captured – immature, sex unknown.
6	Longnose dace	46	0.9	Captured – immature, sex unknown.

Fish Habitat Assessment

Within Reach 12, the Elbow River is an irregular wandering unconfined channel with occasional islands and mid-channel bars. Channel widths and wetted widths ranged between 18 m to 29 m and 15 m to 25 m, respectively. Water depths measured from the LDB at 25%, 50% and 75%, varied from 0.1 m to >1.0 m throughout the assessment area. The maximum depths in Reach 12 include four measurements of >1.0 m found at transects T1, T2, T3 and T5.

Organics and bedrock substrate materials are not present within the assessment area; however, boulders (3%), cobble (38%), large gravel (42%), small gravel (11%), and fines (6%) are present throughout.

Fish habitat distribution within the assessment is predominantly run habitat (i.e., R1, R2, and R3 category type measure 15%, 48% and 30% of total wetted area, respectively). Occasional riffle habitat (5%), present between runs, and pool habitat (P1 at 2%) limited to backwater areas immediately downstream of riffles and along steep banks, are also present.

At the time of assessment, the following water quality values were recorded: water temperature (10.9°C), dissolved oxygen (9.38 mg/L), specific conductivity (442 µs/cm), pH (8.1), and turbidity (0.14 NTU). Water quality in Reach 12 was above and/or met the Alberta SWQG minimum values for dissolved oxygen (i.e., greater than 6.5 mg/L) and pH (i.e., within 6.5 to 9.0 mg/L).

Fish Habitat Inventory and Habitat Quality Rating

Within the assessment area of Reach 12, instream cover is dominant (85%) with overhead cover comprising the remaining 15%. Instream cover is primarily associated with areas of water depth (i.e., >1.0 m) and occasional collections of boulders and large woody debris. Filamentous algae are observed in Reach 12, but do not provide instream fish cover. Overhead cover, limited to the outside of river bends, is primarily overhanging riparian vegetation (i.e., willow and conifer species) and with occasional undercut banks.

Spawning habitat potential is "moderate" for forage-fish, coarse-fish, and sport-fish as adequate spawning surfaces (i.e., woody debris, boulders, cobbles, and gravels) are provided by the diverse substrate and habitat types present throughout the assessment area. However, northern pike spawning may be limited as substrates, instream vegetation and appropriate flows (i.e., snyes, backwaters, and flats) are not anticipated to be overly abundant in Reach 12 during the spring season.

Despite an anticipated reduction in water depths and flows during the winter months compared to the conditions at the time of assessment, overwintering habitat potential in Reach 12 is "good" for forage-fish, coarse-fish, and sport-fish due to the high abundance of areas of adequate depth (i.e., >1.0 m) and flows. Dissolved oxygen concentrations are not anticipated to limit overwintering fish potential in the Elbow River during the winter months.

Rearing habitat potential is "good" for forage-fish but "moderate" for coarse-fish and sport-fish as the type and extent of instream cover and habitat types present in Reach 12 favors small-bodied fish (e.g., minnow species, juvenile sucker, and salmonid species, etc.) over large-bodied fish (e.g., adult sucker species, adult salmonid species, etc.).

Migration habitat potential is "good" for forage-fish, coarse-fish and sport-fish as adequate depths and flows during all season (i.e., winter, spring, summer and fall) will allow for the passage of all fish species present within the Elbow River. In addition, natural and/or anthropogenic barriers to fish movement or passage are not present within the assessment area of Reach 12.

3.1.14 Elbow River Tributaries: Unnamed Tributary to the Elbow River (Unnamed Tributary ID 1350) and Low-level Outlet (Unnamed Tributary ID 22259)

Fish Inventory

In the unnamed tributary (ID 1350), electrofishing was completed along several small isolated sections of the reach (50 m in total). Fish observations/captures include 3 fish (i.e., brook stickleback [n=3]) over 300 seconds with a CPUE of 0.67 fish/100 seconds (Table 3-10). All fork-lengths were less than 200 mm long.

Table 3-10 Fish Inventory for the Unnamed Tributary to the Elbow River

ID #	Species	Length (mm)	Weight (g)	Notes
1	Brook stickleback	55	1.28	Captured - mature, sex unknown.
2	Brook stickleback	57	1.26	Captured - mature, sex unknown.
3	Brook stickleback	NA	NA	Observed - mature, sex unknown.

In the low-level outlet (unnamed tributary ID 22259), electrofishing was completed within a pool and a 30 m reach (35 m in total). Fish observations/captures include 18 fish (i.e., brook stickleback [n=15] and white sucker [n=3]) over 240 seconds for a total CPUE of 7.50 fish/100 seconds. Lengths and weights were not taken; all fork-lengths were less than 200 mm long.

Fish Habitat Assessment

Both the low-level outlet and the unnamed tributary to the Elbow River are irregular wandering unconfined channels with no mid-bars or islands and are subject to season/ephemeral flows. Channel widths and wetted widths ranged between 5 m to 10 m and 0 m (i.e., dry) to 3.0 m, respectively. Where present, water depths measured from the LDB at 25%, 50% and 75%, varied from 0.1 m to 0.3 m throughout the wetted portions of the assessment area. The maximum depth in the Elbow River tributaries was a single measurement of 0.5 m within the low-level outlet

Bedrock and boulder substrate materials are not present within the assessment area; however, cobble (30%), large gravel (15%), small gravel (15%), and fines (40%) are present throughout.

Fish habitat distribution within the assessment area is predominantly isolated pockets and/or standing water habitat present at approximately15% of total channel area. It is anticipated that during peak flows (i.e., spring freshet or elevated rain events), the lower reaches of both the unnamed tributary to the Elbow River and the low-level outlet will provide run, riffle, and pool habitats throughout the assessment area.

Fish Habitat Inventory and Habitat Quality Rating

Within the tributaries of the Elbow River, instream cover is dominant (60%) with overhead cover comprising the remaining 40%. Instream cover is primarily associated with areas of water depth (i.e., less than 1.0 m) and occasional collections of large woody debris. Filamentous algae are observed in unnamed tributary, but do not provide instream fish cover. Overhead cover is diverse primarily consisting of overhanging riparian vegetation (i.e., grasses, willow, deciduous and conifer species), and occasional areas of undercut banks with large woody debris.

Despite the presence of adequate spawning surfaces (i.e., woody debris, boulders, cobbles, and gravels) provided by the diverse substrate and habitat types, there is no spawning habitat potential in the unnamed tributary or the low-level outlet for forage fish, coarse fish, or sport fish due to the ephemeral nature of the tributaries.

Based on the anticipated reduction in water depths and flows during the winter months compared to the conditions at the time of assessment, there is no overwintering habitat potential in the unnamed tributary and low-level outlet for forage fish, coarse fish, and sport fish due to the lack of areas of adequate depth (i.e., greater than .0 m) and limited channel connectivity. In addition, dissolved oxygen concentrations are anticipated to limit overwintering fish potential for all but the most tolerant fish species (e.g., brook stickleback, fathead minnow and white sucker) during the winter months.

Rearing habitat potential is classified poor for forage fish and classifies none for coarse fish and sport fish because the type and extent of instream cover and habitat types in the unnamed tributary and low-level outlet favors small-bodied fish (e.g., minnow species, juvenile sucker, and salmonid species, etc.) over large-bodied fish (e.g., adult sucker species, adult salmonid species).

Based on the observed depths and flows, lack of depth and flows, and lack of a continuous wetted channel, migration habitat potential within the Elbow River tributaries and between these tributaries and the Elbow River, is classified “poor” for forage-fish, coarse-fish and sport-fish. It is anticipated that any movement of fish within the Elbow River tributaries, and migration of fish from the Elbow River to the Elbow River tributaries (and vice versa), is limited temporally to the spring freshet and to elevated rain events (e.g., spring rains and/or summer thunderstorms). In addition, anthropogenic barriers to fish movement or passage (e.g., instream fords, dugout impoundments, misaligned/undersized culverts, etc.) further limit migration with the Elbow River tributaries.

3.2 BENTHIC INVERTEBRATES

3.2.1 Desktop Review

River and stream benthic invertebrates are used to support biomonitoring programs to assess stream and environmental condition or health (Barbour et al. 1999). Benthic invertebrate communities indicate the cumulative effects of the river's condition and complement physical and chemical results of river quality, while physical and chemical assessments indicate the river's static condition only at the time of sampling (Norris and Hawkins 2000). Benthic invertebrates are used as biological indicators that can reflect the overall condition of the aquatic environment as some benthic invertebrates tend to be tolerant of poor water quality conditions, while others are more sensitive (intolerant) to poor water quality conditions.

Based on review of existing studies and reports, benthic invertebrate monitoring studies on the Elbow River are limited in extent. However, a study in October 2015, determined whether there were water quality changes from upstream to downstream sites on the Elbow River by using benthic invertebrates as bioindicators (Benoit et al. 2016). Biotic indices (abundance, richness, evenness, percent EPT (ephemeroptera, plecoptera, and trichoptera) and Hilsenhoff Biotic Index) decreased in the Elbow River from upstream areas in Kananaskis Country downstream towards the City of Calgary, suggesting adverse effects on benthic invertebrate populations (Benoit et al. 2016). Changes in abiotic parameters (dissolved ions and nutrients, and physical parameters) and changes in land use throughout the watershed may have an influence on the invertebrate populations (Benoit et al. 2016).

3.2.2 Field Assessment

The ten benthic invertebrate sampling sites were in Reaches 1, 2, 3, 5, 6, 7, 9, 10, 11 and 12 (Figure 2-1) within the LAA (see Attachment B for the GPS locations). Reaches 4 and 8 were not sampled for benthic invertebrates. Benthic invertebrate sampling was conducted from October 11 to 17, 2016.

Physical Variables

The results of physical variables for each sampling site are provided in Attachment B, Section B.1. During sampling, mean water depth ranged from 30 to 38 cm and water velocity from 42 to 66 cm/s at sampling sites (Figure 3-1). Substrate composition at sampling sites consisted of pebbles (mean of 46 to 67%) and cobbles (mean of 25 to 44%), with small amounts of gravels (mean of 5 to 22%) and sand (less than 1.5%) (Figure 3-2).

A visual assessment at each site on the Elbow River showed that there was zero to low periphytic algae growth on the substrates in the upper reaches 1 and 2, at sites ER1 and ER2, while low to moderate algae growth was observed in the lower reaches at all sites except Site ER10 (located just downstream of the Glencoe Golf Course), which had a moderate to heavy growth of periphytic algae.

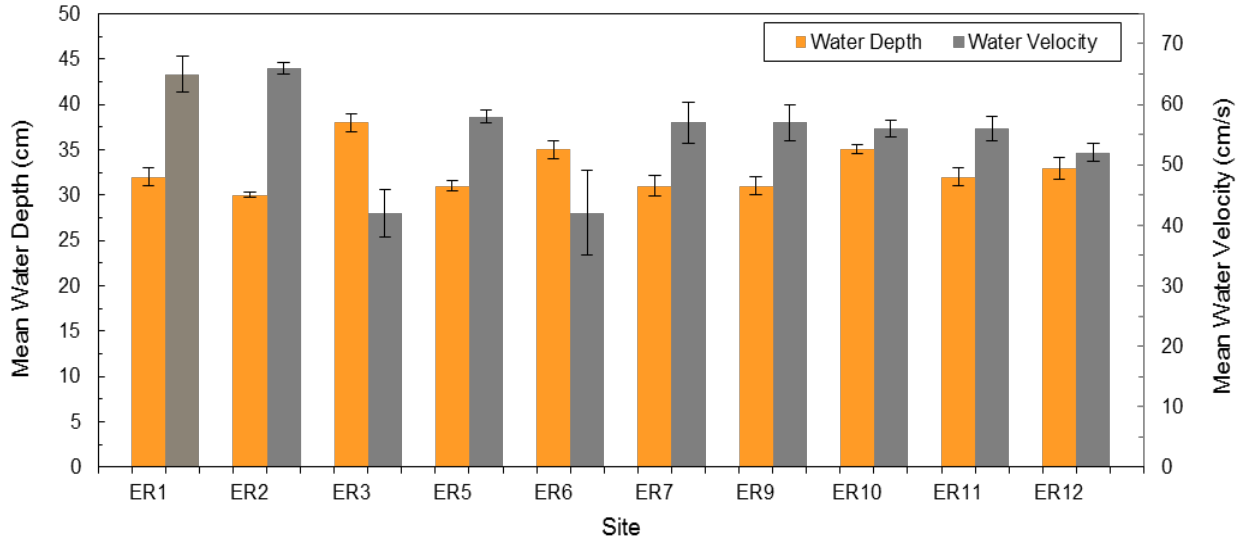

Figure 3-1 **Mean Water Depth and Velocity (with Standard Deviation) for Elbow River Sites, October 2016**

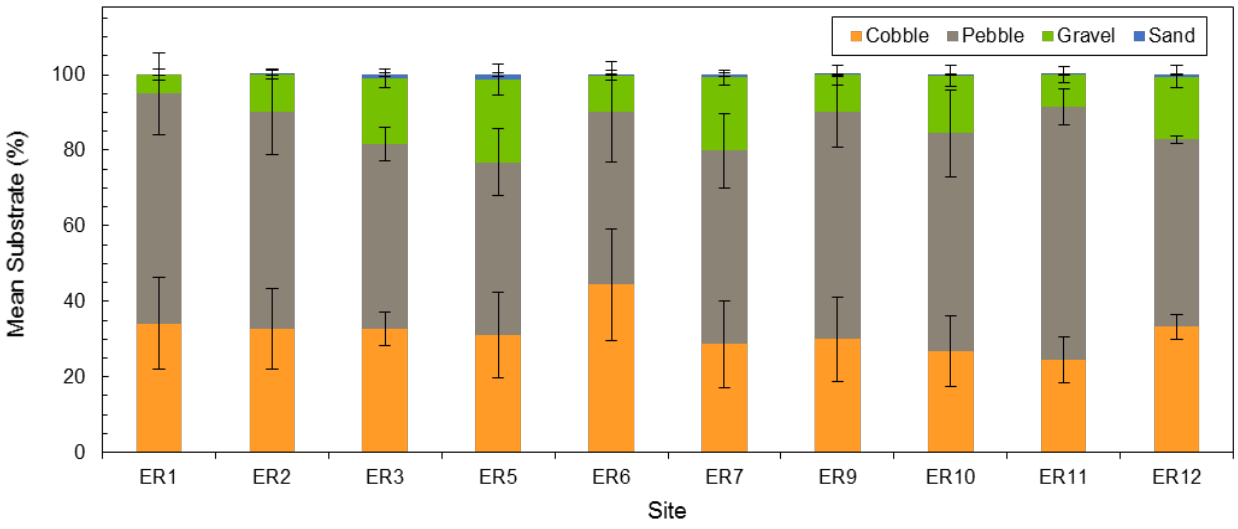

Figure 3-2 **Mean Substrate Composition (with Standard Deviation) for Elbow River Sites, October 2016**

Water Quality

The pH at Elbow River sites was consistent among sites, ranging from 8.2 to 8.4. The field measured pH was within the Alberta SWQG of 6.5 to 9.0 (Table 3-11). Specific conductivity at sites ranged from 383 to 420, with slightly higher conductivity observed in the downstream reaches compared to upstream reaches (Table 3-11). The Elbow River had dissolved oxygen concentrations at sites ranging from 12.2 to 13.1 mg/L with 98 and 104% oxygen saturation (Table 3-11). The dissolved oxygen concentrations were above the Alberta SWQG minimum of 6.5 mg/L. The water temperature ranged from 3.9 to 7.2°C with slightly higher temperatures recorded at sites sampled in the afternoons (Table 3-11).

Table 3-11 Water Chemistry for Elbow River Sites, October 2016

Site	pH (units)	Conductivity (µS/cm)	Dissolved Oxygen (mg/L) [a]	Dissolved Oxygen (% saturation)	Temperature (°C)
ER1	8.4	383	12.3	100	6.3
ER2	8.3	388	12.8	98	4.2
ER3	8.2	387	12.7	102	6.2
ER5	8.4	390	12.2	98	5.9
ER6	8.2	407	13.1	100	3.9
ER7	8.2	399	13.0	104	5.7
ER9	8.2	402	12.8	98	4.1
ER10	8.4	406	12.6	100	5.4
ER11	8.2	407	12.3	102	7.2
ER12	8.3	420	12.6	102	6.3
SWQG	6.5 – 9.0	-	>6.5 - >9.5[a]	-	-

NOTES:

a Guideline depends on the category of biota and life stage. Cold water biota - early life stage >9.5 ppm and other life stages >6.5 ppm. Warm water biota - early life stage >6.0 ppm and other life stages >5.0 ppm.

SWQG Alberta Surface Water Quality Guidelines for aquatic life (ESRD 2014)

Benthic Invertebrates

A total of 112 benthic invertebrate taxa were identified from the Elbow River sites (Attachment B, Section B.2). Most taxa were identified to the genus level (93), while 13 were identified to the family level, 4 to the order level and 2 to the phylum level. The identified taxonomic groups assessed for data presentation included the Insecta - Ephemeroptera, Plecoptera, and Trichoptera (EPT), Insecta - Diptera – Chironomidae, other Insecta, Arachnida/Crustacea, Oligochaeta/ Nematoda and other phyla (Table 3-12).

Table 3-12 Taxonomic Groups Assessed for Elbow River Sites, October 2016

Taxonomic Group	Common Name	Group Assessed
Ephemeroptera – Baetidae, Caenidae, Ephemerellidae, Heptageniidae, Leptophlebiidae, Siphlonuridae	mayflies	Insecta – EPT
Plecoptera – Capniidae, Chloroperlidae, Leuctidae, Nemouridae, Perlidae, Perlodidae, Pteronarcyidae, Taeniopterygidae	stoneflies	Insecta – EPT
Trichoptera – Brachycentridae, Glossosomatidae, Hydropyschidae, Hydroptilidae, Lepidostomatidae, Leptoceridae, Rhyacophilidae	caddisflies	Insecta – EPT
Diptera – Chironomidae	non-biting midges	Insecta – Diptera - Chironomidae
Diptera – Athericidae, Ceratopogonidae, Empididae, Psychodidae, Simuliiidae, Oreoleptidae, Tanyderidae, Tipulidae	snipe flies, biting midges, dance flies, moth flies, black flies, tabanomorph flies, primitive crane flies, crane flies	Other Insecta
Odonata – Gomphidae	dragonflies	Other Insecta
Coleoptera – Dytiscidae, Dryopidae, Elmidae, Haliplidae	predaceous beetles, long-toed beetles, riffle beetles, crawling beetles	Other Insecta
Collembola	springtails	Other Insecta
Hydracarina	water mites	Arachnida/Crustacea
Ostracoda – Podocopida – Candonidae	seed shrimps	Arachnida/Crustacea
Copepoda – Cyclopoida, Harpacticoida	copepods	Arachnida/Crustacea
Brachiopoda – Cladocera - Chydoridae	water fleas	Arachnida/Crustacea
Oligochaeta – Aeolosomatidae, Enchytraeidae, Naididae, Tubificidae, Lumbriculidae	aquatic worms	Oligochaeta/Nematoda
Nematoda	roundworms	Oligochaeta/Nematoda
Gastropoda – Lynmaeidae	snails	Other Phyla
Pelecypoda– Pisidiidae	clams	Other Phyla
Tardigrada	water bears	Other Phyla
Turbellaria – Planariidae	planarians	Other Phyla
Hydrozoa – Hydridae	hydras	Other Phyla

None of the benthic invertebrate species from the samples collected from the Elbow River were identified as being a species at risk (all species at risk are from the Mollusca phylum) (GoC 2017a, b; ESRD 2012).

As part of the sample processing QC, the level of sorting efficiency was determined for five samples. A recovery of 93 to 97% was obtained for the sorted samples which is greater than the required 90% (Environment Canada 2002).

The mean total benthic invertebrate taxa richness at Elbow River sites ranged from 42 to 60 taxa (Figure 3-3). The taxonomic groups with the highest mean richness were Insecta - EPT (17 to 23 taxa) and Diptera – Chironomidae (13 to 19 taxa), followed by the other Insecta (3 to 10 taxa) (Figure 3-3). The Arachnida/Crustacea and Oligochaeta/Nematoda groups had 2 to 4 taxa, while the other phyla had less than 3 taxa (Figure 3-3). These groups with the lower taxa richness were identified to a higher taxonomic level and therefore cannot be compared at the genus level (i.e., the number of taxa at the genus level is unknown). Sites ER1, ER5 and ER11 had slightly lower taxa richness than the other sites on the Elbow River, mainly due to a lower number of other Insecta taxa (Figure 3-3).

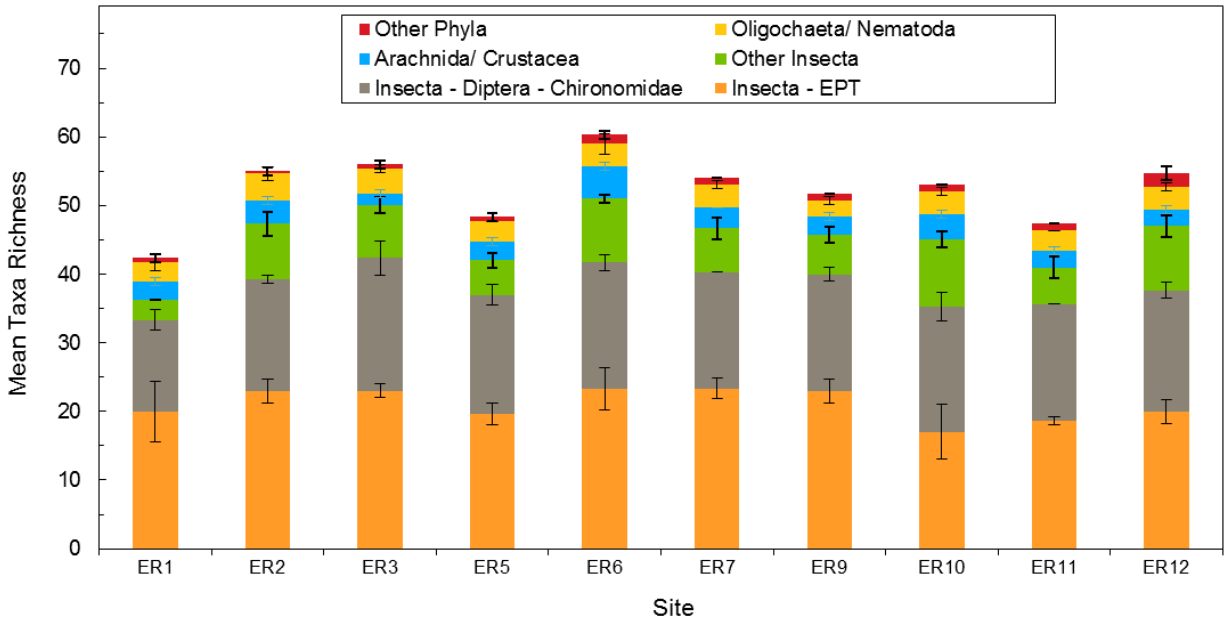

Figure 3-3 Mean Taxa Richness (with Standard Deviation) for Elbow River Sites, October 2016

The mean total benthic invertebrate density at sites on the Elbow River ranged from 28,458 to 788,356 organisms/m^2 (Figure 3-4). The highest densities were found at Sites ER6 and ER10 with intermediate densities at Sites ER3, ER7 and ER12. The taxonomic group with the highest mean density was the Diptera, Chironomidae (16,010 - 622,500 organisms/m^2) followed by the EPT (10,674 – 54,496 organisms/m^2) and Oligochaeta/Nematoda (755 – 100,415 organisms/m^2) (Figure 3-4). These three groups made up greater than 94% of the total density (Figure 3-5). Lower densities were found at sites for other Insecta (142 - 7,519 organisms/m^2), Arachnida/Crustacea (729 - 8,416 organisms/m^2) and other phyla (4 - 340 organisms/m^2) (Figure 3-4).

Diptera are considered to be one of the most abundant insect orders because of the large number of species and individuals, particularly the Chironomidae (chironomids). All larval chironomids are aquatic and are found in various types of aquatic habitats, within the bottom substrate, on aquatic plants and within algae (Clifford 1991). Most of the Chironomidae density in the Elbow River consisted of four genera, *Micropsectra* sp., *Stempellinella* sp., *Tanytarsus* sp., and *Cricotopus/Orthocladius* spp. (Figure 3-6).

EPT are common aquatic insects found in the greatest diversity in streams and can be an important food item for fish (Clifford 1991). Of the EPT, Ephemeroptera (mayflies) had the highest density in the Elbow River. Most of the Ephemeroptera density consisted of two genera, *Baetis* sp. and *Cinygmula* sp. (generally greater than 10% of the total density) (Figure 3-6).

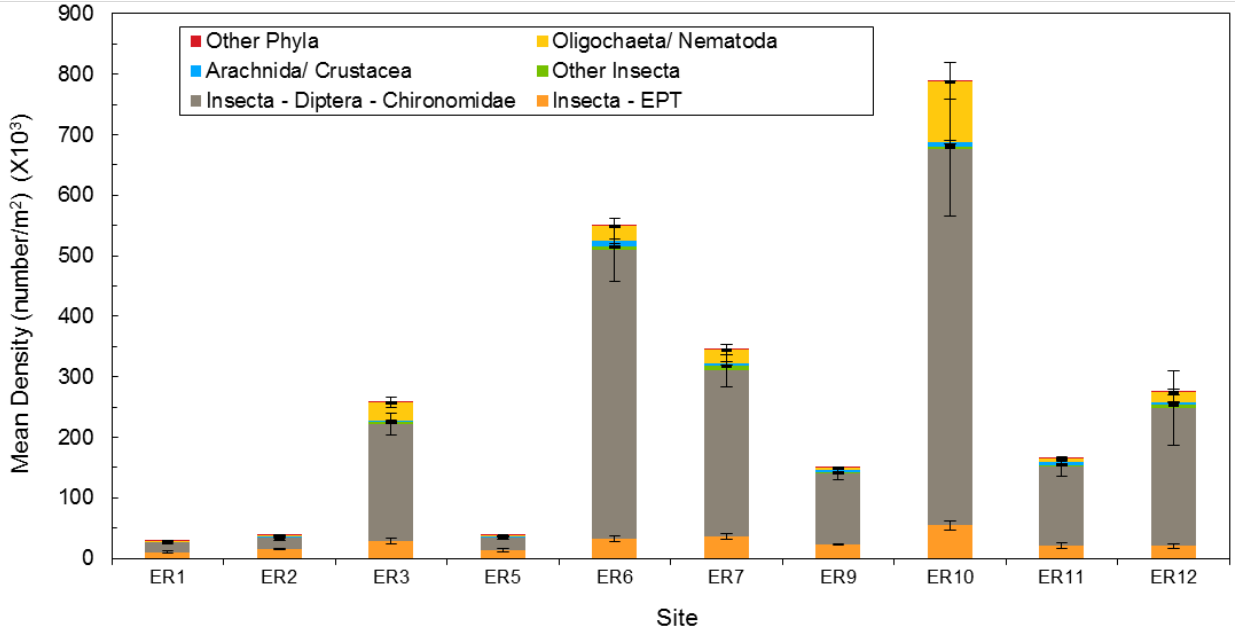

Figure 3-4 **Mean Density (with Standard Deviation) for Elbow River Sites, October 2016**

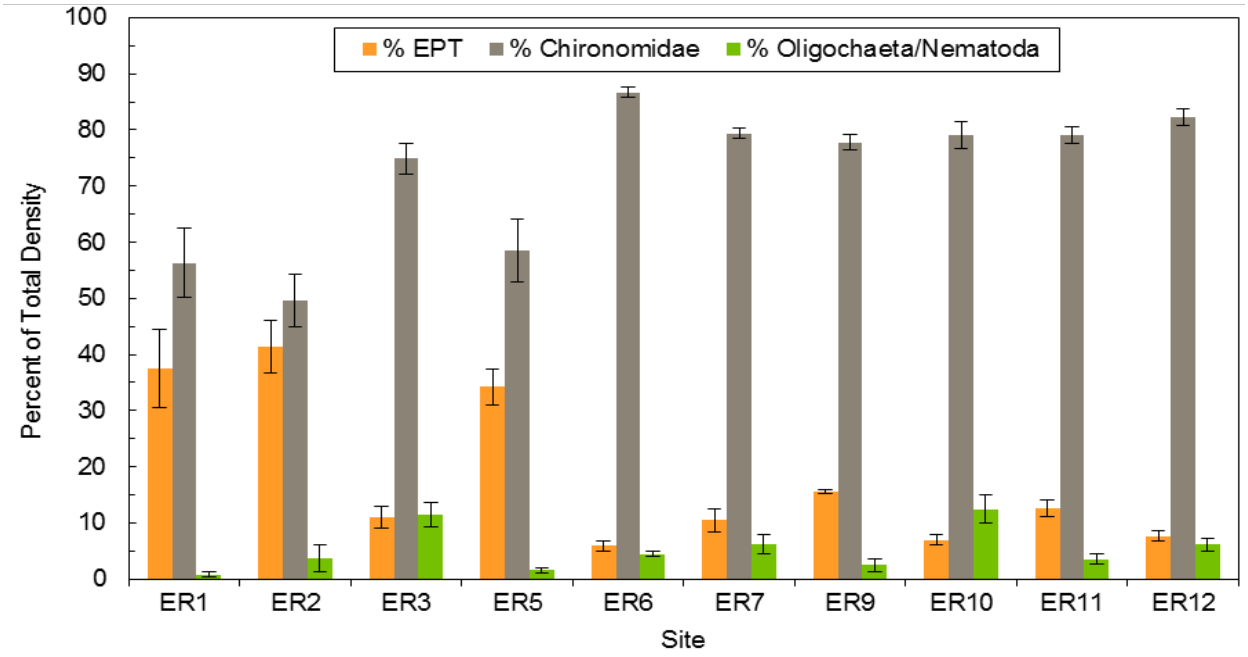

Figure 3-5 **Percent of Total Density (with Standard Deviation) of EPT, Chironomidae and Oligochaeta/Nematoda for Elbow River Sites, October 2016**

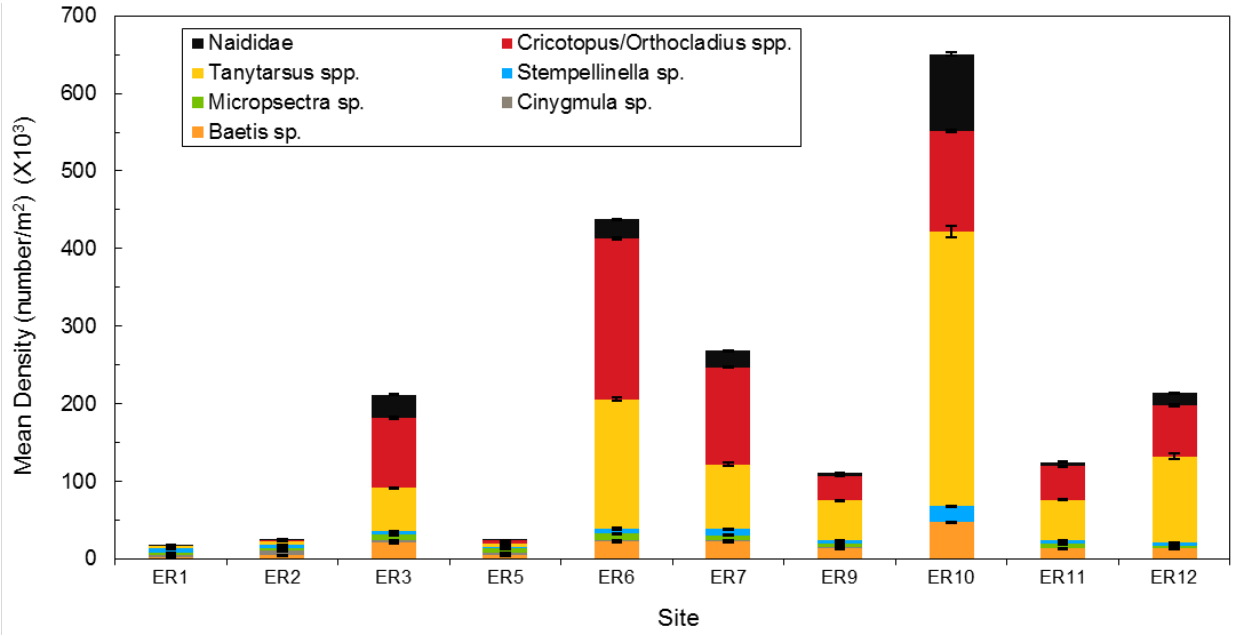

Figure 3-6 **Mean Density (with Standard Deviation) of Dominant Taxa for Elbow River Sites, October 2016**

Oligochaeta (aquatic worms) of the family Naididae and Tubificidae are common in both running and standing waters and feed on organic matter, with Tubificidae being more numerous in organically enriched streams and lakes (Clifford 1991). Most of the Oligochaeta density in the Elbow River consisted of the Naididae family (Figure 3-6).

The Simpson's Evenness Index (SEI) at sites on the Elbow River ranged from 0.07 to 0.22 (Figure 3-7). Given that an index value of 1 (maximum) indicates complete evenness, the SEI indicated that the organisms were not evenly distributed in the community at most sites. Sites ER1, ER2 and ER5 had slightly higher evenness compared to the other sites.

The Simpson's Diversity Index (SDI) at sites on the Elbow River ranged from 0.75 to 0.91 (Figure 3-7). The SDI indicated that the sites had a fairly high diverse community, as an index value of 1 (maximum) indicates high diversity. Sites ER1, ER2 and ER5 had slightly higher diversity compared to the other sites.

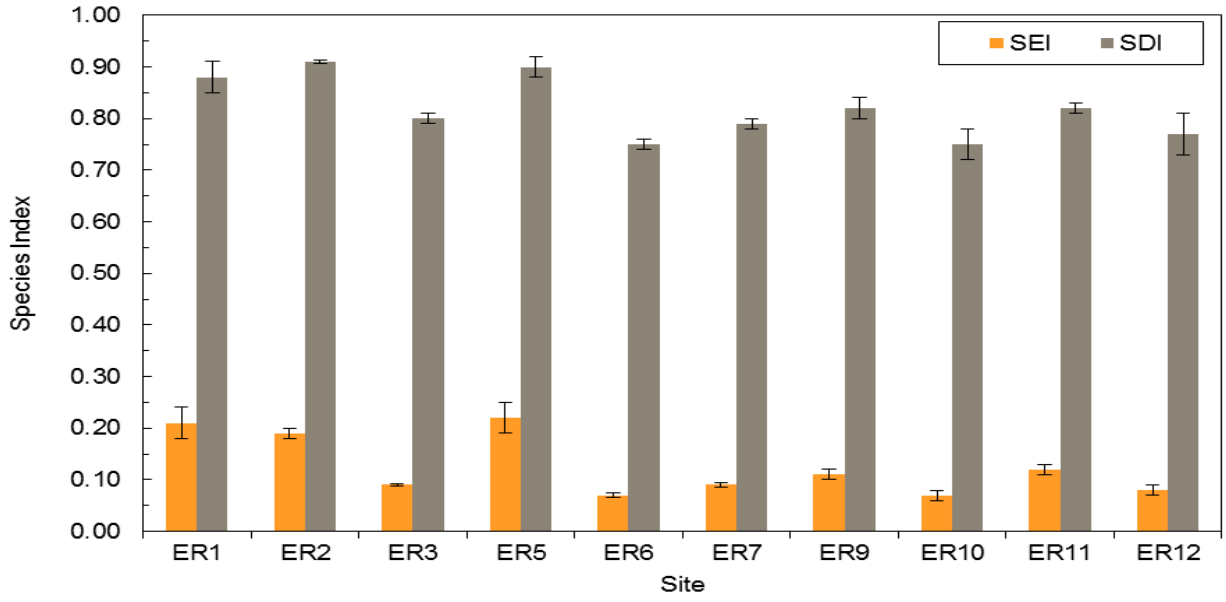

Figure 3-7 Mean Simpson's Evenness Index (SEI) and Simpson's Diversity Index (SDI) (with Standard Deviation) for Elbow River Sites, October 2016

Some benthic invertebrates such as the EPT are sensitive (less tolerant) to poor water quality conditions while Diptera and Oligochaeta tend to be tolerant of poor water quality conditions (Hynes 1972; Bothwell and Stockner 1980; Rabeni et al. 1985; Noton et al. 1989; Gazendam et al. 2011). Percent EPT can be used to evaluate environmental quality by measuring the abundance of these sensitive taxa at a site (Gazendam et al. 2011) (Figure 3-5). The lower percentage of EPT and higher percentage of Chironomidae and Oligochaeta (including Nematoda) at most Elbow River Sites, except Sites ER1, ER2 and ER5 in the upper reaches indicated that the downstream reaches had poorer water quality than upstream reaches (Figure 3-5).

The EPT/Chironomidae Index at Elbow River sites ranged from 0.06 to 0.45 (Figure 3-8). The higher index value at Sites ER1, ER2 and ER5 indicated that the benthic invertebrate community in these reaches had a higher density of sensitive(intolerant) taxa while the other downstream reaches had a higher density of tolerant taxa.

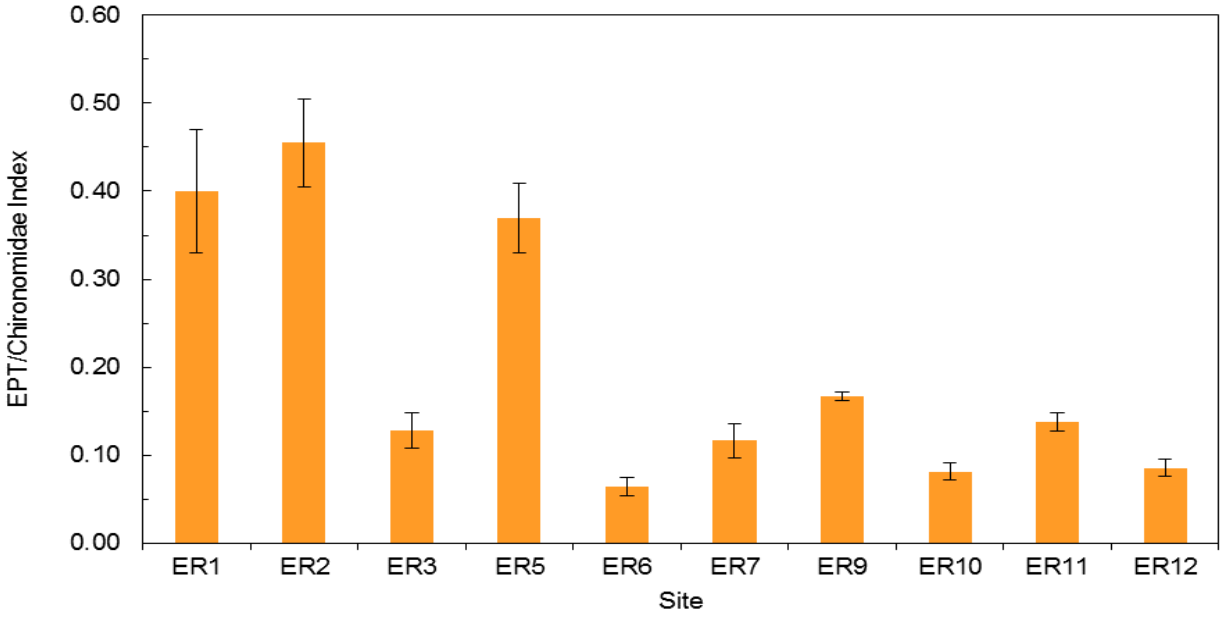

Figure 3-8 Mean EPT/Chironomidae Index (with Standard Deviation) for Elbow River Sites, October 2016

3.2.3 Discussion

In general, benthic invertebrates can be divided into two types of taxa: tolerant taxa which can survive relatively large changes in their habitat conditions, and sensitive (less tolerant – termed intolerant) taxa which can survive minor changes (Anderson 1989). Although these two types of benthic invertebrates commonly cohabit, a deterioration or improvement in water quality may result in a shift in the proportional representation of each group. Although the individual taxa from the same group tend to respond relatively uniformly, the intensity of response can vary considerably among taxa (Anderson 1989).

Increasing concentrations of nutrients (phosphorus and nitrogen) in normally low nutrient streams, often result in nutrient enrichment that increases the biomass of algae, aquatic macrophytes and benthic invertebrates (Wetzel 1983; Bowlby and Roff 1986). Nutrient inputs into streams can occur through either natural or anthropogenic sources. Natural sources of nutrients include runoff or leaching of soils and weathering of rocks from undisturbed woodlands or non-agricultural grasslands, as well as from decomposing organic matter (Hynes 1972). Anthropogenic non-point sources include drainage and leaching of soils from agricultural land and golf courses, while anthropogenic point sources include industrial effluents and sewage treatment plant effluents (Hynes 1972; Bothwell and Stockner 1980; Rabeni et al. 1985; Noton et al. 1989).

Nutrient enrichment increases the food energy available in a system and is usually accompanied by an increased oxygen demand by organisms using the additional food energy resources. In cases where nutrient enrichment does not result in a change in oxygen demand (such as for mild enrichment) or when oxygenation is maintained by water flow through a series of riffles, enrichment will tend to result in an increase in both intolerant and tolerant taxa richness and abundance, while increasing oxygen demand can decrease taxa richness and increase abundance (Pearson and Rosenberg 1978; Rabeni et al. 1985; Noton et al. 1989; Lenat et al. 1980).

Intolerant taxa such as the EPT, many of which are grazers feeding principally on algae and detrital material or are filter feeders and herbivores (Merritt and Cummins 1996), are suited to mild nutrient enrichment when oxygen is maintained in the system (Hynes 1960; Roback 1974). Plecoptera can be sensitive to low dissolved oxygen and if absent from streams can be an indication of excessive organic enrichment (Clifford 1991). The Oligochaeta (Naididae and particularly Tubificidae) and Chironomidae have been found to be reliable indicators of nutrient enrichment (Brinkhurst and Cook 1974). In low oxygen conditions, the benthic invertebrate community structure may change such that organisms tolerant of low oxygen levels dominate the community and intolerant organisms are eliminated over time (Hynes 1960).

The intolerant EPT group had the highest density of organisms at upstream reaches in the Elbow River, while the community structure shifted to the more intolerant Chironomidae and Oligochaeta at downstream reaches. The shift in the benthic invertebrate communities in the downstream reaches was likely a result of changes in land use and nutrient enrichment, particularly in the vicinity of the golf courses. However, there was no indication of low oxygen levels in the downstream reaches and along with riffle habitat maintaining these oxygen levels, the nutrient enrichment was mild to moderate.

4.0 SUMMARY

Fish and fish habitat data was collected at 12 Elbow River reaches and within local tributary sites; benthic invertebrate sampling was conducted at 10 sites located within or adjacent to fish and fish habitat surveyed reaches. Surveys observations conclude that the Elbow River provides good habitat for forage, coarse, and sport fish.

The Elbow River within the LAA was observed as an irregularly meandering channel with upstream sediment deposits observed across a wide channel and valley floor. The channel comprised infrequent islands and occasional sediment bars with channel widths ranging from 13 to 100 m, and channel water depths from 0.1 to 1.2 m. Fish habitat in the Elbow River was rated "good" for run habitats, interspersed with riffle and pool habitats. Overhead cover observed comprised undercut banks and overhanging vegetation. Instream cover comprised woody debris and large sized substrate (boulder / cobble). Filamentous algae were observed in Elbow River, but does not provide instream fish cover. Substrate composition throughout the Elbow River consisted of pebble and cobble, with smaller areas of gravel and sand.

Elbow River fish spawning, overwintering, and rearing habitats are rated as moderate-good for 8 reach areas. Habitat is rated as poor-moderate for Reach 1 and 2, located upstream of Highway 22 and downstream in Reaches 9 and 10. Lack of spawning habitat for forage fish may limit spawning potential in Reaches 1 and 2. High velocities may limit spawning habitat for species in Reaches 9 and 10. Lack of deep areas and high velocities limit overwintering habitat for all fish species in Reaches 1, 2, 9 and 10. In Reaches 1, 2 and 10, rearing habitat is limited by lack of bank cover features, habitat diversity and complexity. Migration is rated as good throughout the Elbow River with no obstructions to fish movement.

Periphytic algal density was limited at the sites sampled in the Elbow River upstream of Highway 22, but was observed at moderate densities at sites downstream of Highway 22. Site ER10 (Reach 10, located just downstream of the Glencoe Golf Course), had a moderate to heavy growth of epiphytic algae.

The intolerant EPT (mayflies, stoneflies and caddisflies) group of benthic invertebrates had the highest density of organisms at upstream reaches in the Elbow River, while the community structure shifted to the more intolerant Chironomidae (chironomids)and Oligochaeta (aquatic worms) in downstream Elbow River reaches. The shift in the benthic invertebrate communities in the downstream reaches may be linked to changes in land use and subsequent nutrient enrichment, particularly near the downstream golf courses.

Summary
March 2018

Two tributaries to the Elbow River surveyed had defined channels with standing pools of water and no flow during September / October 2016. Both tributaries were observed with poor fish habitat. Both tributaries likely provide run, riffle, and pool habitats during spring freshet or elevated rain events.

A summary table of the fish and fish habitat data collected from all reaches is presented in Attachment A, Section A.1. Fish and benthic field data, including representative site photographs showing habitat features at the time of the assessment, are provided in Attachment A, Section A.2 and Attachment B, Section B.1.

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Attachment A FISH AND FISH HABITAT FIELD DATA

A.1 REACH SUMMARY TABLE

Attachment A Fish and Fish Habitat Field Data
March 2018

Table A-1 Summary of Fisheries Reaches

Reach	Date Surveyed	Channel Width (m)	Maximum Depth (m)	Fish Captured (n)	Fish Range of Lengths (mm)	Water Quality at Time of Sampling	Spawning Habitat Rating	Overwintering Habitat Rating	Rearing Habitat Rating	Migration Habitat Rating	Comments
1: Elbow River	Sep 21, 2016	26-100	0.9	BKTR (1) BNTR (9)	132 54-330	8.6 °C 9.91 mg/L 400 µs/cm 8.0 pH 0.91 NTU	Poor - moderate	Poor - moderate	Poor - moderate	Good	Filamentous algae present. Spawning habitat limited for forage fish. Overwintering habitat limited by lack of depths. Rearing habitat is limited by lack of bank features.
2: Elbow River	Sep 22, 2016	13-34	1.0	LNDC (1) BNTR (7) MNWH (1)	59 420-480 97	8.8 °C 9.40 mg/L 415 µs/cm 8.0 pH 0.31 NTU	Poor - moderate	Poor - moderate	Poor - moderate	Good	Filamentous algae present. Spawning habitat limited for forage fish. Overwintering habitat limited by lack of depths. Rearing habitat is limited by lack of bank features.
3: Elbow River	Sep 22, 2016	16-39	0.8	BKTR (2) BNTR (5)	127-136 64-86	8.4 °C 9.68 mg/L 417 µs/cm 7.9 pH 0.01 NTU	Moderate	Moderate	Moderate - good	Good	Filamentous algae present.
4: Elbow River	Sep 21, 2016	28-60	0.8	BKTR (1) BNTR (6)	184 64-238	9.0 °C 10.86 mg/L 370 µs/cm 8.1 pH - NTU	Moderate - good	Moderate - good	Moderate - good	Good	Filamentous algae present.
5: Elbow River	Sep 26, 2016	15-39	1.0	BNTR (7) RNTR (1)	72-146 observed	8.2 °C 10.41 mg/L 326 µs/cm 7.8 pH 0.46 NTU	Good	Good	Good	Good	Filamentous algae present.
6: Elbow River	Sep 19, 2016	25-38	1.0	Not sampled due to elevated velocities	Not sampled	9.1 °C 12.50 mg/L 469 µs/cm 7.1 pH 0.42 NTU	Good	Good	Good	Good	Filamentous algae present.
7: Elbow River	Sep 19, 2016	24-46	1.2	LNDC (2) WHSC (1)	< 20 – 47 < 20	12.5 °C 11.50 mg/L 416 µs/cm 8.0 pH 0.56 NTU	Moderate - good	Moderate - good	Moderate	Good	Filamentous algae present.

Table A-1 Summary of Fisheries Reaches

Reach	Date Surveyed	Channel Width (m)	Maximum Depth (m)	Fish Captured (n)	Fish Range of Lengths (mm)	Water Quality at Time of Sampling	Spawning Habitat Rating	Overwintering Habitat Rating	Rearing Habitat Rating	Migration Habitat Rating	Comments
8: Elbow River	Sep 23, 2016	21-36	1.0	Not sampled due to elevated velocities	Not sampled	9.8 °C 9.88 mg/L 427 µs/cm 8.0 pH 0.03 NTU	Moderate - good	Good	Moderate - good	Good	Filamentous algae present.
9: Elbow River	Sep 23, 2016	21-31	1.2	Not sampled due to elevated velocities	Not sampled	11.7 °C 11.02 mg/L 429 µs/cm 7.8 pH 0.00 NTU	Poor-moderate	Poor-moderate	Moderate	Good	Filamentous algae present. High velocities limit spawning and overwintering habitat.
10: Elbow River	Sep 21, 2016	24-52	1.0	Not sampled due to elevated velocities	Not sampled	13.2 °C 9.80 mg/L 435 µs/cm 7.8 pH - NTU	Poor-moderate	Poor-moderate	Poor-moderate	Good	Filamentous algae present. High velocities limit spawning and overwintering habitat. Rearing habitat is limited by lack of habitat diversity and complexity.
11: Elbow River	Sep 22, 2016	21-31	>1.0	LNDC (2) BKTR (1)	70 – 86 183	10.6 °C 9.48 mg/L 435 µs/cm 8.1 pH 0.01 NTU	Moderate	Moderate - good	Moderate	Good	Filamentous algae present.
12: Elbow River	Sep 21, 2016	18-29	>1.0	LNDC (3) LNSC (3)	46 – 89 59 -86	10.9 °C 9.38 mg/L 442 µs/cm 8.1 pH 0.14 NTU	Moderate	Good	Moderate - good	Good	Filamentous algae present.
Unnamed tributary	Sep 20, 2016	0.5-1	0.10	BRST (2)	55-57	Not taken	None	None	None-poor	Poor	Standing pooled water with no flow.
Low-level outlet	Sep 19, 2016	5-13	0.40	WHSC (3) BRST (15)	Not measured	11.0 °C 9.50 mg/L 1,333 µs/cm 7.9 pH 5.15 NTU	None	Non-poor	None-poor	Poor	Standing pooled water with no flow.

A.2 HABITAT SURVEY SHEETS

The following data sheets provide field collected data for each fish and fish habitat assessment reach.

Springbank Off-Stream Reservoir Project

Unnamed Tributary to the Elbow River (Tributary 1350)

UTM Location:	11U 677934E 5657175N	**Survey Date:**	September 20, 2016
Legal Location:	NW-11-024-05 W5M	**Water Body Class:**	Unmapped Class C
Crew Initials:	GS, BN, LA	**Restricted Activity Period:**	May 1-July 15 & Sept 16-Apri

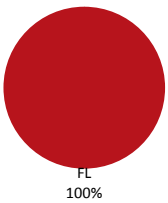
Physical Channel Transect Data

Transect # (Location)	**1 (↑100)**		**2 (↑50)**		**3 (CL)**		**4 (↓100)**		**5 (↓200)**		**6 (↓300)**	
Channel Width (m)	0.8		1.0		1.0		0.5		0.5		1.0	
Wetted Width (m)	0.5		0.5		0.8		0.3		0.3		0.5	
Depth at LDB + 25% (m)	< 0.1		≤ 0.1		0.10		< 0.1		≤ 0.1		≤ 0.1	
Depth at LDB + 50% (m)	< 0.1		≤ 0.1		0.10		< 0.1		≤ 0.1		≤ 0.1	
Depth at LDB + 75% (m)	< 0.1		≤ 0.1		0.10		< 0.1		≤ 0.1		≤ 0.1	
Max. Depth (m)	< 0.1		≤ 0.1		0.10		< 0.1		≤ 0.1		≤ 0.1	
Gradient (%)	-		-		-		-		-		-	
Dominant Habitat Unit	FL		FL		FL		FL		FL		FL	
Stream Bed												
Substrate (% of Transect Area) Organics	30		10		0		10		0		10	
Fines	55		70		100		35		100		80	
Small Gravel	5		10		0		5		0		0	
Large Gravel	5		5		0		5		0		0	
Cobble	5		5		0		40		0		5	
Boulder	0		0		0		5		0		5	
Bedrock	0		0		0		0		0		0	
Embeddedness	L		L		-		L		-		-	
Bank Measurements	**Left**	**Right**	**Left**	**Right**	**Left**	**Right**	**Left**	**Right**	**Left**	**Right**	**Left**	**Right**
Bank Height (m)	0.60		-	-	-	-	0.40		-	-	-	-
Bank Slope (°)	-	-	-	-	-	-	-	-	-	-	-	-
Bank Stability	MS	MS	MS	MS	MS	MS	MS	MS	MS	MS	-	-
Dom. Bank Material	F	F	F	F	F	F	F	F	-	-	-	-
Subdom. Bank Material	O	O	O	O	O	O	O	O	-	-	-	-
Dom. Riparian Veg.	G	G	G	G	G	G	G	G	G	G	-	-
Subdom. Riparian Veg.	D	D	D	S	S	M	D	D	S	S	-	-

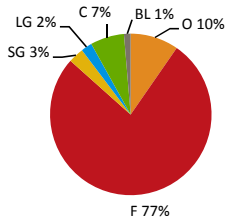
Habitat Inventory / Reach Data

Dom. Instream Cover:	-	Dom. Overhead Cover:	-
Subdom. Instream Cover:	-	Subdom. Overhead Cover:	-
Maximum Depth (m)	0.1	Dom. Aquatic Veg. Type:	-

Habitat Distribution



Substrate Composition



Water Quality Data

Time of Day (HH:MM):	-
Water Temperature (°C):	-
Dissolved Oxygen (mg/L):	-
Sp. Conductivity (µs/cm):	-
pH:	-
Turbidity (NTU):	-

Channel Characteristics

Pattern:	IM
Islands:	N
Bars:	N
Coupling:	CO
Confinement:	CO
Flow Stage:	Pooled

Fish Habitat Assessment Ratings

	Forage	**Coarse**	**Sportfish**
Spawning:	None	None	None
Overwintering:	None	None	None
Rearing:	Poor	None-Poor	None
Migration:	Poor	Poor	None

Photo 1: View upstream at T2.

Photo 2: View of wetted channel at T5.

Fish Sampling Data

Method		**Effort**	
Backpack Electrofisher (EB)		300	(s)
No Trapping		0.0	(hr)
Electrofisher Settings			
Volts	Freq. (Hz)	Duty Cycle (%)	Dist. (m)
225	30	12	50

Species	**Efish Catch** (n)	**Trap Catch** (n)	**Efish CPUE** (#fish/100s)	**Trap CPUE** (#fish/hr)	**Rel. Abundance** (% of total)
BROOK STICKLEBACK	2	-	0.67	-	100.0%
-	-	-	-	-	-
-	-	-	-	-	-
-	-	-	-	-	-
-	-	-	-	-	-

General Comments

Prepared by: KC Reviewed by: KN

Springbank Off-Stream Reservoir Project

Unnamed Tributary to the Elbow River (Tributary 1350)

UTM Location:	11U 677934E 5657175N	**Survey Date:**	September 20, 2016
Legal Location:	NW-11-024-05 W5M	**Water Body Class:**	Unmapped Class C
Crew Initials:	GS, BN, LA	**Restricted Activity Period:**	May 1-July 15 & Sept 16-Apri

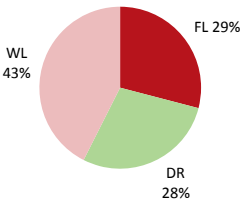
Physical Channel Transect Data

Transect # (Location)	**1 (↑300)**		**2 (↑250)**		**3 (↑175)**		**4 (↑130)**		**5 (↑80)**		**6 (↑30)**	
Channel Width (m)	1.0		0.5		0.5		1.0		1.0		0.8	
Wetted Width (m)	0.5		0.3		0.3		0.8		0.5		0.5	
Depth at LDB + 25% (m)	≤ 0.1		≤ 0.1		< 0.1		0.10		≤ 0.1		< 0.1	
Depth at LDB + 50% (m)	≤ 0.1		≤ 0.1		< 0.1		0.10		≤ 0.1		< 0.1	
Depth at LDB + 75% (m)	≤ 0.1		≤ 0.1		< 0.1		0.10		≤ 0.1		< 0.1	
Max. Depth (m)	≤ 0.1		≤ 0.1		< 0.1		0.10		≤ 0.1		< 0.1	
Gradient (%)	-		-		-		-		-		-	
Dominant Habitat Unit	WL		WL		FL		FL		DR		DR	
Stream Bed												
Substrate (% of Transect Area) Organics	10		0		10		0		10		30	
Fines	80		100		35		100		70		55	
Small Gravel	0		0		5		0		10		5	
Large Gravel	0		0		5		0		5		5	
Cobble	5		0		40		0		5		5	
Boulder	5		0		5		0		0		0	
Bedrock	0		0		0		0		0		0	
Embeddedness	-		-		L		MS		L		L	
Bank Measurements	**Left**	**Right**	**Left**	**Right**	**Left**	**Right**	**Left**	**Right**	**Left**	**Right**	**Left**	**Right**
Bank Height (m)	N/A		N/A		0.4	0.4	0.2	0.5	0.2	0.4	0.6	0.6
Bank Slope (°)	-	-	-	-	-	-	-	-	-	-	-	-
Bank Stability	MS	MS	MS	MS	MS	MS	MS	MS	MS	MS	MS	MS
Dom. Bank Material	-	-	-	-	F	F	F	F	F	F	F	F
Subdom. Bank Material	-	-	-	-	O	O	O	O	O	O	O	O
Dom. Riparian Veg.	G	G	G	G	G	G	G	G	G	G	G	G
Subdom. Riparian Veg.	S	S	S	S	D	D	S	M	D	S	D	D

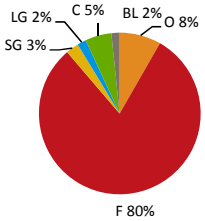
Habitat Inventory / Reach Data

Dom. Instream Cover:	DC	Dom. Overhead Cover:	UB
Subdom. Instream Cover:	BL	Subdom. Overhead Cover:	TS
Maximum Depth (m)	0.1	Dom. Aquatic Veg. Type:	N/A

Habitat Distribution



Substrate Composition



Water Quality Data

Time of Day (HH:MM):	-
Water Temperature (°C):	-
Dissolved Oxygen (mg/L):	-
Sp. Conductivity (µs/cm):	-
pH:	-
Turbidity (NTU):	-

Channel Characteristics

Pattern:	IM
Islands:	N
Bars:	N
Coupling:	CO
Confinement:	CO
Flow Stage:	Pooled

Fish Habitat Assessment Ratings

	Forage	**Coarse**	**Sportfish**
Spawning:	None	None	None
Overwintering:	None	None	None
Rearing:	Poor	None-Poor	None
Migration:	Poor	Poor	None

Photo 1: View upstream at T2.

Photo 2: View of wetted channel at T5.

Fish Sampling Data

Method		**Effort**	
Backpack Electrofisher (EB)		300	(s)
No Trapping		0.0	(hr)
Electrofisher Settings			
Volts	Freq. (Hz)	Duty Cycle (%)	Dist. (m)
225	30	12	50

Species	**Efish Catch (n)**	**Trap Catch (n)**	**Efish CPUE (#fish/100s)**	**Trap CPUE (#fish/hr)**	**Rel. Abundance (% of total)**
BROOK STICKLEBACK	2	-	0.67	-	100.0%
-	-	-	-	-	-
-	-	-	-	-	-
-	-	-	-	-	-
-	-	-	-	-	-

General Comments

Reach is a dry defined channel with areas of flat habitat which becomes a wetland area with evidence of cattle use (i.e., hummocks) approximately 250 m upstream from the confluence with the Elbow River. This channel is likely seasonally connected to the Elbow River, however, at the time of the survey there was no surface water connectivity. The lower 80 m of the channel was dry with evidence of recent flow. Approximately 150 m upstream from the mouth the channel becomes flat habitat. Approximately 250 m upstream from the mouth, the area becomes a wide wetland area with no defined channel. Fish were captured in the flat habitat approximately 200 m upstream from the mouth.

Prepared by: KC Reviewed by: KN

Springbank Off-Stream Reservoir Project

Outlet Channel, Elbow River Tributary

UTM Location:	11 682198E 5658525N	**Survey Date:**	September 19, 2016
Legal Location:	NW-18-024-05 W5M	**Water Body Class:**	Not Applicable
Crew Initials:	GS, BN, LA	**Restricted Activity Period:**	Not Applicable

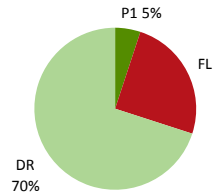
Physical Channel Transect Data

Transect # (Location)	**1 (↑425)**		**2 (↑375)**		**3 (↑300)**		**4 (↑275)**		**5 (↑200)**		**6 (↑150)**	
Channel Width (m)	5.0		13		10		8.0		10		8.0	
Wetted Width (m)	5.0		N/A		9.0		N/A		N/A		N/A	
Depth at LDB + 25% (m)	0.10		N/A		0.10		N/A		N/A		N/A	
Depth at LDB + 50% (m)	0.25		N/A		0.30		N/A		N/A		N/A	
Depth at LDB + 75% (m)	0.40		N/A		0.25		N/A		N/A		N/A	
Max. Depth (m)	0.40		N/A		0.30		N/A		N/A		N/A	
Gradient (%)	-		-		-		-		-		-	
Dominant Habitat Unit	FL		DR		FL		DR		DR		DR	
Stream Bed												
Substrate (% of Transect Area) Organics	10		20		30		10		10		N/A	
Fines	20		30		60		20		20		N/A	
Small Gravel	10		10		5		10		10		N/A	
Large Gravel	20		10		5		20		20		N/A	
Cobble	40		20		0		40		40		N/A	
Boulder	0		10		0		0		0		N/A	
Bedrock	0		0		0		0		0		N/A	
Embeddedness	VH		L		M		N		N		N	
Bank Measurements	**Left**	**Right**	**Left**	**Right**	**Left**	**Right**	**Left**	**Right**	**Left**	**Right**	**Left**	**Right**
Bank Height (m)	1.5		1.0		0.80		0.50		0.50		1.0	
Bank Slope (°)	-	-	-	-	-	-	-	-	-	-	-	-
Bank Stability	US	US	US	US	MS	MS	S	S	S	S	S	S
Dom. Bank Material	F	F	F	F	F	F	F	F	F	F	F	F
Subdom. Bank Material	O	O	SG	SG	O	O	SG	SG	SG	SG	SG	SG
Dom. Riparian Veg.	D	M	G	G	G	G	G	G	G	G	G	G
Subdom. Riparian Veg.	G	G	S	S	D	D	S	S	S	S	S	S

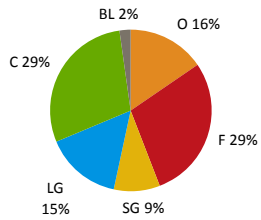
Habitat Inventory / Reach Data

Dom. Instream Cover:	WD	Dom. Overhead Cover:	WD
Subdom. Instream Cover:	AV	Subdom. Overhead Cover:	TS
Maximum Depth (m)	0.4	Dom. Aquatic Veg. Type:	FA

Habitat Distribution



Substrate Composition



Water Quality Data

Time of Day (HH:MM):	15:30
Water Temperature (°C):	11.0
Dissolved Oxygen (mg/L):	9.50
Sp. Conductivity (µs/cm):	1,333
pH:	7.87
Turbidity (NTU):	5.15

Channel Characteristics

Pattern:	IR
Islands:	N
Bars:	N
Coupling:	PC
Confinement:	FC
Flow Stage:	Pooled

Fish Habitat Assessment Ratings

	Forage	**Coarse**	**Sportfish**
Spawning:	None	None	None
Overwintering:	None	None	None
Rearing:	Poor	None-Poor	None
Migration:	Poor	Poor	Poor

Photo 1: View downstream at T5. Channel is dry.

Photo 2: View downstream at T3.

Fish Sampling Data

Method		**Effort**	
Backpack Electrofisher (EB)		300	(s)
No Trapping		-	(hr)
Electrofisher Settings			
Volts	Freq. (Hz)	Duty Cycle (%)	Dist. (m)
225	30	12	70

Species	**Efish Catch** (n)	**Trap Catch** (n)	**Efish CPUE** (#fish/100s)	**Trap CPUE** (#fish/hr)	**Rel. Abundance** (% of total)
WHITE SUCKER	3	-	1.00	-	16.7%
BROOK STICKLEBACK	15	-	5.00	-	83.3%
-	-	-	-	-	-
-	-	-	-	-	-
-	-	-	-	-	-

General Comments

Reach is a defined channel which is mainly dry with areas of standing pools of water. This channel is likely seasonaly connected to the Elbow River, however, at the time of the survey there was no surface water connectivity to the Elbow River and the confluence was blocked woody debris and substrate accumulation. The lower 200 m of the channel is primarly a dry vegetated channel with one isolated pool located 40 m upstream from the confluence. The upper 300 m is wetted with isolated areas of flat or pool habitat. Fish were captured in two isolated pools located 40 m and 300 m upstream from the confluence with the Elbow River.

Prepared by: KC Reviewed by: KN

Springbank Off-Stream Reservoir Project

Reach 1: Elbow River

UTM Location:	11U 675348E 5652594N	**Survey Date:**	September 21, 2016
Legal Location:	SE-33-023-04 W5M	**Water Body Class:**	Class C
Crew Initials:	GS, BN, JL	**Restricted Activity Period:**	May 1-July 15 & Sept 16-Apri

Physical Channel Transect Data

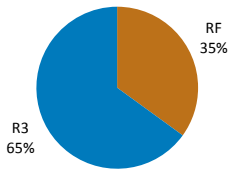
Transect # (Location)	**T1**	**T2**	**T3**	**T4**	**T5**	**T6**
Channel Width (m)	29	26	29	55	100	35
Wetted Width (m)	27	22	27	52	85	33
Depth at LDB + 25% (m)	0.4	0.9	0.1	0.4	0.2	0.2
Depth at LDB + 50% (m)	0.5	0.2	0.5	0.0	0.3	0.4
Depth at LDB + 75% (m)	0.4	0.4	0.2	0.2	0.1	0.4
Max. Depth (m)	0.5	0.9	0.5	0.4	0.3	0.4
Gradient (%)	-	-	-	-	-	-
Dominant Habitat Unit	R3	R3	R3	R3	RF	RF
Stream Bed						
Substrate (% of Transect Area) – Organics	-	-	-	-	-	-
Substrate (% of Transect Area) – Fines	-	5	5	5	5	5
Substrate (% of Transect Area) – Small Gravel	15	5	15	10	15	15
Substrate (% of Transect Area) – Large Gravel	40	35	45	60	50	20
Substrate (% of Transect Area) – Cobble	45	50	35	25	30	50
Substrate (% of Transect Area) – Boulder	10	5	-	-	-	10
Substrate (% of Transect Area) – Bedrock	-	-	-	-	-	-
Embeddedness	L	L	L	L	L	L

Bank Measurements	**Left**	**Right**	**Left**	**Right**	**Left**	**Right**	**Left**	**Right**	**Left**	**Right**	**Left**	**Right**
Bank Height (m)	0.4	0.4	0.3	0.3	0.1	0.1	0.9	0.9	0.15	0.15	0.20	0.20
Bank Slope (°)	30	05	10	15	05	80	50	50	05	40	05	40
Bank Stability	MS	S	MS	S	S	US	MS	MS	S	S	S	S
Dom. Bank Material	LG	LG	C	C	C	C	C	C	C	A	LG	A
Subdom. Bank Material	S	S	S	LG	S	F	F	F	LG	LG	C	A
Dom. Riparian Veg.	S	S	S	S	S	S	S	S	S	N	S	N
Subdom. Riparian Veg.	G	G	G	G	G	G	G	G	S	N	G	N

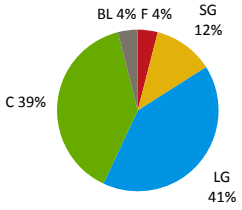
Habitat Inventory / Reach Data

Instream Cover (%):	95	Overhead Cover (%):	5
Dom. Instream Cover:	WC	Dom. Overhead Cover:	WD
Subdom. Instream Cover:	BL	Subdom. Overhead Cover:	-
Maximum Depth (m)	0.9	Dom. Aquatic Veg. Type:	FA

Habitat Distribution



Substrate Composition



Water Quality Data

Time of Day (HH:MM):	13:00
Water Temperature (°C):	8.6
Dissolved Oxygen (mg/L):	9.91
Sp. Conductivity (µs/cm):	400
pH:	8.00
Turbidity (NTU):	0.91

Channel Characteristics

Pattern:	IR
Islands:	N
Bars:	BR
Coupling:	DC
Confinement:	UN
Flow Stage:	Moderate

Fish Habitat Assessment Ratings

	Forage	**Coarse**	**Sportfish**
Spawning:	Poor	Moderate	Moderate
Overwintering:	Moderate	Poor-Moderate	Poor-Moderate
Rearing:	Poor-Moderate	Poor-Moderate	Poor-Moderate
Migration:	Good	Good	Good

Photo 1: Looking upstream from T3 at substrate and run habitat.

Photo 2: Downstream view from T2 looking at riffle run habitat.

Fish Sampling Data

Method	**Effort**	
Backpack Electrofisher (EB)	350	(s)
No Trapping	-	(hr)

Electrofisher Settings			
Volts	Freq. (Hz)	Duty Cycle (%)	Dist. (m)
225	30	12	300

Species	**Efish Catch** (n)	**Trap Catch** (n)	**Efish CPUE** (#fish/100s)	**Trap CPUE** (#fish/hr)	**Rel. Abundance** (% of total)
BROWN TROUT	9	-	2.57	-	90.0%
BROOK TROUT	1	-	0.29	-	10.0%
-	-	-	-	-	-
-	-	-	-	-	-
-	-	-	-	-	-

General Comments

Prepared by: JJ Reviewed by: LA

Springbank Off-Stream Reservoir Project

Reach 1: Elbow River

UTM Location:	11U 675494E 5652755N	**Survey Date:**	September 21, 2016
Legal Location:	SE-33-023-04 W5M	**Water Body Name:**	Elbow River
Crew Initials:	GS, BN, JL	**Project Number:**	110773996

DS UTM Start: 11U 675494E 5652755N	**US UTM Finish:** 11U 675542E 5652728N	**Embeddedness:**	Low (<25%)	**Silt Cover:**	None

Substrate Size Class

For Material greater than 2 mm in diameter, record the diameter of the intermediate axis to the nearest millimeter. For organic, fine, sand and bedrock materails record the following abbreviation:

Organics (O)		Fines (silt/clay) <0.06 mm (F)		Sand 0.06 - 2 mm (S)		Bedrock (BD)	
Diameter of Intermediate Axis (mm)							
1	F	26	18 mm	51	18 mm	76	135 mm
2	38 mm	27	19 mm	52	60 mm	77	27 mm
3	41 mm	28	230 mm	53	F	78	6 mm
4	43 mm	29	100 mm	54	F	79	19 mm
5	45 mm	30	55 mm	55	50 mm	80	27 mm
6	39 mm	31	20 mm	56	45 mm	81	42 mm
7	54 mm	32	18 mm	57	72 mm	82	20 mm
8	63 mm	33	13 mm	58	195 mm	83	48 mm
9	60 mm	34	44 mm	59	39 mm	84	8 mm
10	11 mm	35	10 mm	60	23 mm	85	16 mm
11	15 mm	36	69 mm	61	45 mm	86	17 mm
12	90 mm	37	62 mm	62	105 mm	87	34 mm
13	6 mm	38	5 mm	63	19 mm	88	27 mm
14	30 mm	39	15 mm	64	18 mm	89	36 mm
15	5 mm	40	20 mm	65	31 mm	90	55 mm
16	75 mm	41	24 mm	66	F	91	5 mm
17	19 mm	42	39 mm	67	F	92	91 mm
18	30 mm	43	29 mm	68	29 mm	93	24 mm
19	13 mm	44	18 mm	69	69 mm	94	29 mm
20	5 mm	45	17 mm	70	54 mm	95	19 mm
21	15 mm	46	65 mm	71	18 mm	96	20 mm
22	22 mm	47	48 mm	72	29 mm	97	15 mm
23	21 mm	48	122 mm	73	33 mm	98	20 mm
24	21 mm	49	38 mm	74	88 mm	99	18 mm
25	29 mm	50	10 mm	75	29 mm	100	23 mm

Side Notes

Prepared by: XX Reviewed by: XX

Springbank Off-Stream Reservoir Project

Reach 2: Elbow River

UTM Location:	11U 676741E 5655107N	**Survey Date:**	September 22, 2016
Legal Location:	NW-03-024-04 W5M	**Water Body Class:**	Class C
Crew Initials:	GS, BN, LA	**Restricted Activity Period:**	May 1-July 15 & Sept 16-Apri

Physical Channel Transect Data

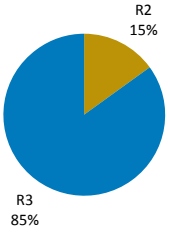
Transect # (Location)	**T1**	**T2**	**T3**	**T4**	**T5**	**T6**
Channel Width (m)	29	13	23	22	23	34
Wetted Width (m)	27	13	22	21	23	31
Depth at LDB + 25% (m)	0.6	0.4	0.4	0.1	0.4	0.3
Depth at LDB + 50% (m)	0.3	0.6	0.5	0.3	0.4	0.4
Depth at LDB + 75% (m)	0.8	0.8	0.7	0.5	0.4	0.2
Max. Depth (m)	1.0	0.8	0.7	0.7	0.5	0.5
Gradient (%)	-	-	-	-	-	-
Dominant Habitat Unit	R3	R3	R3	R3	R3	R3
Stream Bed						
Substrate (% of Transect Area) – Organics	-	-	-	-	-	-
Substrate (% of Transect Area) – Fines	10	-	5	-	-	-
Substrate (% of Transect Area) – Small Gravel	10	5	10	20	25	10
Substrate (% of Transect Area) – Large Gravel	30	30	30	45	40	30
Substrate (% of Transect Area) – Cobble	40	60	45	35	35	40
Substrate (% of Transect Area) – Boulder	10	5	10	-	-	20
Substrate (% of Transect Area) – Bedrock	-	-	-	-	-	-
Embeddedness	L	L	L	L	L	L

Bank Measurements	**Left Right**	**Left Right**	**Left Right**	**Left Right**	**Left Right**	**Left Right**
Bank Height (m)	0.4 / 0.4	0.3 / 0.3	0.3 / 0.3	0.15 / 0.15	0.15 / 0.15	0.15 / 0.15
Bank Slope (°)	30 / 70	60 / 75	05 / 90	60 / 90	70 / 70	05 / 05
Bank Stability	S / US	S / US	S / US	US / US	US / US	S / S
Dom. Bank Material	C / F	LG / F	C / F	F / F	F / F	LG /C
Subdom. Bank Material	LG / LG	C / LG	LG / LG	C / C	LG / C	C / S
Dom. Riparian Veg.	S / S	S / S	S / S	S / S	G / S	S / S
Subdom. Riparian Veg.	G / G	G / G	G / M	G / M	S / G	G / G

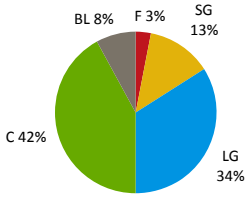
Habitat Inventory / Reach Data

Instream Cover (%):	90	Overhead Cover (%):	10
Dom. Instream Cover:	BL	Dom. Overhead Cover:	WD
Subdom. Instream Cover:	WC	Subdom. Overhead Cover:	-
Maximum Depth (m)	1.0	Dom. Aquatic Veg. Type:	FA

Habitat Distribution



Substrate Composition



Water Quality Data

Time of Day (HH:MM):	13:15
Water Temperature (°C):	8.8
Dissolved Oxygen (mg/L):	9.40
Sp. Conductivity (µs/cm):	415
pH:	8.00
Turbidity (NTU):	0.31

Channel Characteristics

Pattern:	IR
Islands:	N
Bars:	MD
Coupling:	DC
Confinement:	UN
Flow Stage:	Moderate

Fish Habitat Assessment Ratings

	Forage	**Coarse**	**Sportfish**
Spawning:	Poor	Moderate	Moderate
Overwintering:	Moderate	Poor-Moderate	Poor-Moderate
Rearing:	Moderate	Moderate	Moderate
Migration:	Good	Good	Good

Photo 1: Looking upstream from T1 at woody debris and depth cover.

Photo 2: Upstream view from T3 at run habitat found throughout the reach.

Fish Sampling Data

Method		**Effort**	
Backpack Electrofisher (EB)		414	(s)
No Trapping		-	(hr)
Electrofisher Settings			
Volts	Freq. (Hz)	Duty Cycle (%)	Dist. (m)
235	30	12	300

Species	**Efish Catch (n)**	**Trap Catch (n)**	**Efish CPUE (#fish/100s)**	**Trap CPUE (#fish/hr)**	**Rel. Abundance (% of total)**
MOUNTAIN WHITEFISH	1	-	0.24	-	11.1%
LONGNOSE DACE	1	-	0.24	-	11.1%
BROWN TROUT	7	-	1.69	-	77.8%
-	-	-	-	-	-
-	-	-	-	-	-

General Comments

Prepared by: JJ Reviewed by: LA

Springbank Off-Stream Reservoir Project

Reach 2: Elbow River

UTM Location:	11U 676554E 5655322N	**Survey Date:**	September 22, 2016
Legal Location:	NW-3-024-04 W5M	**Water Body Name:**	Elbow River
Crew Initials:	GS, BN, JL	**Project Number:**	110773996

DS UTM Start: 11U 676554E 5655322N	**US UTM Finish:** 11U 676564E 5655350N	**Embeddedness:**	None	**Silt Cover:**	None

Substrate Size Class

For Material greater than 2 mm in diameter, record the diameter of the intermediate axis to the nearest millimeter. For organic, fine, sand and bedrock materails record the following abbreviation:

Organics (O)		Fines (silt/clay) <0.06 mm (F)		Sand 0.06 - 2 mm (S)		Bedrock (BD)	
Diameter of Intermediate Axis (mm)							
1	S	26	205 mm	51	104 mm	76	64 mm
2	97 mm	27	121 mm	52	37 mm	77	52 mm
3	198 mm	28	201 mm	53	12 mm	78	141 mm
4	54 mm	29	75 mm	54	S	79	84 mm
5	41 mm	30	53 mm	55	55 mm	80	41 mm
6	131 mm	31	62 mm	56	9 mm	81	84 mm
7	10 mm	32	34 mm	57	11 mm	82	25 mm
8	115 mm	33	55 mm	58	34 mm	83	33 mm
9	49 mm	34	51 mm	59	69 mm	84	52 mm
10	54 mm	35	19 mm	60	41 mm	85	45 mm
11	113 mm	36	72 mm	61	32 mm	86	21 mm
12	35 mm	37	11 mm	62	12 mm	87	35 mm
13	23 mm	38	100 mm	63	20 mm	88	67 mm
14	21 mm	39	21 mm	64	54 mm	89	49 mm
15	195 mm	40	89 mm	65	39 mm	90	140 mm
16	9 mm	41	51 mm	66	46 mm	91	50 mm
17	77 mm	42	8 mm	67	260 mm	92	29 mm
18	58 mm	43	34 mm	68	17 mm	93	121 mm
19	111 mm	44	65 mm	69	46 mm	94	57 mm
20	175 mm	45	28 mm	70	205 mm	95	34 mm
21	182 mm	46	167 mm	71	61 mm	96	232 mm
22	104 mm	47	40 mm	72	186 mm	97	187 mm
23	34 mm	48	125 mm	73	213 mm	98	96 mm
24	88 mm	49	4 mm	74	44 mm	99	109 mm
25	62 mm	50	113 mm	75	53 mm	100	F

Side Notes

Prepared by: XX Reviewed by: XX

Springbank Off-Stream Reservoir Project

Reach 3: Elbow River

UTM Location:	11U 676779E 5655811N	**Survey Date:**	September 22, 2016
Legal Location:	SW-10-024-04 W5M	**Water Body Class:**	Class C
Crew Initials:	GS, BN, LA	**Restricted Activity Period:**	May 1-July 15 & Sept 16-Apri

Physical Channel Transect Data

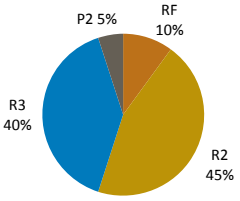
Transect # (Location)	**T1**	**T2**	**T3**	**T4**	**T5**	**T6**
Channel Width (m)	17	16	19	25	28	39
Wetted Width (m)	15	14	17	20	26	37
Depth at LDB + 25% (m)	0.1	0.7	0.6	0.5	0.5	0.3
Depth at LDB + 50% (m)	0.6	0.6	0.6	0.3	0.4	0.4
Depth at LDB + 75% (m)	0.6	0.6	0.4	0.3	0.4	0.4
Max. Depth (m)	0.7	0.8	0.7	0.6	0.5	0.5
Gradient (%)	-	-	-	-	-	-
Dominant Habitat Unit	R2	R2	R2	RF	R3	R3
Stream Bed						
Substrate (% of Transect Area) – Organics	-	-	-	-	-	-
Substrate (% of Transect Area) – Fines	-	-	5	-	8	1
Substrate (% of Transect Area) – Small Gravel	5	5	5	5	15	25
Substrate (% of Transect Area) – Large Gravel	30	25	30	40	40	40
Substrate (% of Transect Area) – Cobble	40	40	50	50	35	30
Substrate (% of Transect Area) – Boulder	25	30	10	4	2	4
Substrate (% of Transect Area) – Bedrock	-	-	-	1	-	-
Embeddedness	L	L	L	L	L	L

Bank Measurements	**Left Right**	**Left Right**	**Left Right**	**Left Right**	**Left Right**	**Left Right**
Bank Height (m)	0.2 / 0.2	0.15 / 0.15	0.40 / 0.40	0.20 / 0.20	0.35 / 0.35	0.60 / 0.60
Bank Slope (°)	05 / 40	05 / 85	10 / 80	90 / 05	85 / 10	80 / 10
Bank Stability	S / MS	S / US	S / US	US / S	US / S	US / S
Dom. Bank Material	LG / LG	C / F	LG / F	BD / C	F / LG	F / LG
Subdom. Bank Material	C / S	LG / LG	C / LG	F / LG	BD / C	C /C
Dom. Riparian Veg.	S / S	S / S	S / S	S / S	S / S	S / S
Subdom. Riparian Veg.	G / G	G / G	G / M	G / G	G / G	G / G

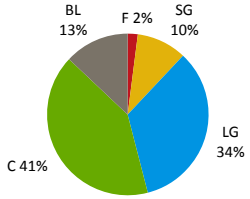
Habitat Inventory / Reach Data

Instream Cover (%):	90	Overhead Cover (%):	10
Dom. Instream Cover:	BL	Dom. Overhead Cover:	WD
Subdom. Instream Cover:	WC	Subdom. Overhead Cover:	-
Maximum Depth (m)	0.8	Dom. Aquatic Veg. Type:	FA

Habitat Distribution



Substrate Composition



Water Quality Data

Time of Day (HH:MM):	10:00
Water Temperature (°C):	8.4
Dissolved Oxygen (mg/L):	9.68
Sp. Conductivity (µs/cm):	417
pH:	7.87
Turbidity (NTU):	0.01

Channel Characteristics

Pattern:	IR
Islands:	N
Bars:	MD
Coupling:	DC
Confinement:	OC
Flow Stage:	Moderate

Fish Habitat Assessment Ratings

	Forage	**Coarse**	**Sportfish**
Spawning:	Moderate	Moderate	Moderate
Overwintering:	Moderate	Moderate	Moderate
Rearing:	Good	Moderate	Moderate
Migration:	Good	Good	Good

Photo 1: Looking downstream from T2 at run/riffle habitat and woody debris.

Photo 2: Upstream view from T3 at run habitat found throughout the reach.

Fish Sampling Data

Method	**Effort**	
Backpack Electrofisher (EB)	402	(s)
No Trapping	-	(hr)

Electrofisher Settings			
Volts	Freq. (Hz)	Duty Cycle (%)	Dist. (m)
205	30	12	300

Species	**Efish Catch** (n)	**Trap Catch** (n)	**Efish CPUE** (#fish/100s)	**Trap CPUE** (#fish/hr)	**Rel. Abundance** (% of total)
BROWN TROUT	5	-	1.24	-	71.0%
BROOK TROUT	2	-	0.50	-	29.0%
-	-	-	-	-	-
-	-	-	-	-	-
-	-	-	-	-	-

General Comments

Prepared by: JJ Reviewed by: LA

Springbank Off-Stream Reservoir Project

Reach 3: Elbow River

UTM Location:	11U 676799E 5655831N	**Survey Date:**	September 22, 2016
Legal Location:	SW-10-024-04 W5M	**Water Body Name:**	Elbow River
Crew Initials:	GS, BN, MS	**Project Number:**	110773996

DS UTM Start: 11U 676799E 5655831N	**US UTM Finish:** 11U 676792E 5655859N	**Embeddedness:** None	**Silt Cover:** None

Substrate Size Class

For Material greater than 2 mm in diameter, record the diameter of the intermediate axis to the nearest millimeter. For organic, fine, sand and bedrock materails record the following abbreviation:

Organics (O)		Fines (silt/clay) <0.06 mm (F)		Sand 0.06 - 2 mm (S)		Bedrock (BD)	
Diameter of Intermediate Axis (mm)							
1	S	26	44 mm	51	42 mm	76	69 mm
2	22 mm	27	172 mm	52	185 mm	77	63 mm
3	10 mm	28	21 mm	53	33 mm	78	31 mm
4	85 mm	29	15 mm	54	15 mm	79	12 mm
5	44 mm	30	84 mm	55	132 mm	80	40 mm
6	33 mm	31	21 mm	56	120 mm	81	44 mm
7	5 mm	32	25 mm	57	85 mm	82	26 mm
8	92 mm	33	10 mm	58	57 mm	83	34 mm
9	415 mm	34	33 mm	59	50 mm	84	37 mm
10	54 mm	35	45 mm	60	27 mm	85	9 mm
11	400 mm	36	195 mm	61	31 mm	86	25 mm
12	41 mm	37	15 mm	62	27 mm	87	22 mm
13	13 mm	38	21 mm	63	44 mm	88	86 mm
14	15 mm	39	29 mm	64	5 mm	89	40 mm
15	11 mm	40	38 mm	65	14 mm	90	38 mm
16	19 mm	41	22 mm	66	34 mm	91	F
17	29 mm	42	17 mm	67	54 mm	92	44 mm
18	75 mm	43	101 mm	68	27 mm	93	17 mm
19	31 mm	44	113 mm	69	161 mm	94	56 mm
20	13 mm	45	54 mm	70	59 mm	95	98 mm
21	35 mm	46	98 mm	71	15 mm	96	94 mm
22	95 mm	47	24 mm	72	7 mm	97	79 mm
23	82 mm	48	35 mm	73	71 mm	98	92 mm
24	27 mm	49	195 mm	74	164 mm	99	45 mm
25	36 mm	50	76 mm	75	25 mm	100	3 mm

Side Notes

Prepared by: XX Reviewed by: XX

Springbank Off-Stream Reservoir Project

Reach 4: Elbow River

UTM Location:	11U 677838E 5656664N	**Survey Date:**	September 21, 2016
Legal Location:	NW-11-024-05 W5M	**Water Body Class:**	Class C
Crew Initials:	GS, BN, LA	**Restricted Activity Period:**	May 1-July 15 & Sept 16-Apri

Physical Channel Transect Data

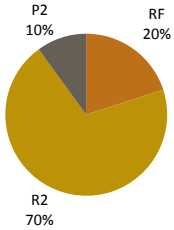
Transect # (Location)	**T1**	**T2**	**T3**	**T4**	**T5**	**T6**
Channel Width (m)	37	35	28	39	43	60
Wetted Width (m)	23	21	26	33	38	54
Depth at LDB + 25% (m)	0.7	0.6	0.4	0.3	0.5	0.6
Depth at LDB + 50% (m)	0.5	0.6	0.5	0.5	0.6	0.2
Depth at LDB + 75% (m)	0.4	0.5	0.8	0.7	0.5	0.3
Max. Depth (m)	0.8	0.7	0.8	0.7	0.6	0.8
Gradient (%)	-	-	-	-	-	-
Dominant Habitat Unit	P2	RF	R2	R2	R2	RF
Stream Bed						
Substrate (% of Transect Area) – Organics	-	-	-	-	-	-
Substrate (% of Transect Area) – Fines	-	30	20	20	-	-
Substrate (% of Transect Area) – Small Gravel	20	30	10	10	20	5
Substrate (% of Transect Area) – Large Gravel	30	30	10	10	30	15
Substrate (% of Transect Area) – Cobble	40	-	40	40	40	60
Substrate (% of Transect Area) – Boulder	10	10	20	20	10	20
Substrate (% of Transect Area) – Bedrock	-	-	-	-	-	-
Embeddedness	L	M	M	M	L	L

Bank Measurements	**Left**	**Right**	**Left**	**Right**	**Left**	**Right**	**Left**	**Right**	**Left**	**Right**	**Left**	**Right**
Bank Height (m)	0.5 / 1.0		0.3 / 0.3		0.3 / 0.3		0.4 / 0.4		0.4 / 0.4		1.0 / 0.4	
Bank Slope (°)	-		-		-		-		-		-	
Bank Stability	S / MS		S / MS		S / MS		S / S		S / S		S / S	
Dom. Bank Material	C / C		BL / BL		BL / BL		C / BL		C / C		C / C	
Subdom. Bank Material	LG / F		F / F		F / F		SG / SG		LG / LG		LG / LG	
Dom. Riparian Veg.	G / S		S / S		S / S		S / S		S / S		S / S	
Subdom. Riparian Veg.	S / G		G / G		G / G		G / G		N /N		N / N	

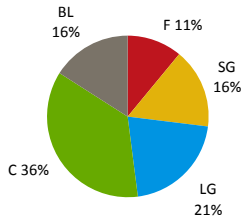
Habitat Inventory / Reach Data

Instream Cover (%):	95	Overhead Cover (%):	5
Dom. Instream Cover:	BL	Dom. Overhead Cover:	WD
Subdom. Instream Cover:	WC	Subdom. Overhead Cover:	UB
Maximum Depth (m)	0.8	Dom. Aquatic Veg. Type:	FA

Habitat Distribution



Substrate Composition



Water Quality Data

Time of Day (HH:MM):	15:30
Water Temperature (°C):	9.0
Dissolved Oxygen (mg/L):	10.86
Sp. Conductivity (µs/cm):	370
pH:	8.11
Turbidity (NTU):	NA

Channel Characteristics

Pattern:	IR
Islands:	I
Bars:	MD
Coupling:	DC
Confinement:	UN
Flow Stage:	Moderate

Fish Habitat Assessment Ratings

	Forage	**Coarse**	**Sportfish**
Spawning:	Good	Moderate	Moderate
Overwintering:	Good	Moderate	Moderate
Rearing:	Good	Moderate	Moderate
Migration:	Good	Good	Good

Photo 1: Looking upstream from T1 at the Highway 22 Bridge.

Photo 2: Downstream view of run/riffle habitat from T1.

Fish Sampling Data

Method		**Effort**	
Backpack Electrofisher (EB)		613	(s)
No Trapping		-	(hr)
Electrofisher Settings			
Volts	Freq. (Hz)	Duty Cycle (%)	Dist. (m)
205	30	12	375

Species	**Efish Catch** (n)	**Trap Catch** (n)	**Efish CPUE** (#fish/100s)	**Trap CPUE** (#fish/hr)	**Rel. Abundance** (% of total)
BROWN TROUT	6	-	0.98	-	85.7%
BROOK TROUT	1	-	0.16	-	14.3%
-	-	-	-	-	-
-	-	-	-	-	-
-	-	-	-	-	-

General Comments

Prepared by: JJ Reviewed by: LA

Springbank Off-Stream Reservoir Project

Reach 4: Elbow River

UTM Location:	11U 000000 0000000	**Survey Date:**	
Legal Location:	00-00-000-00W4M	**Water Body Name:**	Elbow River
Crew Initials:	GS, BN, MS	**Project Number:**	110773996

DS UTM Start:	11U 000000 0000000	**US UTM Finish:**	11U 000000 0000000	**Embeddedness:**	**Silt Cover:**

Substrate Size Class

For Material greater than 2 mm in diameter, record the diameter of the intermediate axis to the nearest millimeter. For organic, fine, sand and bedrock materails record the following abbreviation:

Organics (O)		Fines (silt/clay) <0.06 mm (F)		Sand 0.06 - 2 mm (S)		Bedrock (BD)	
Diameter of Intermediate Axis (mm)							
1	X mm	26	X mm	51	X mm	76	X mm
2	X mm	27	X mm	52	X mm	77	X mm
3	X mm	28	X mm	53	X mm	78	X mm
4	X mm	29	X mm	54	X mm	79	X mm
5	X mm	30	X mm	55	X mm	80	X mm
6	X mm	31	X mm	56	X mm	81	X mm
7	X mm	32	X mm	57	X mm	82	X mm
8	X mm	33	X mm	58	X mm	83	X mm
9	X mm	34	X mm	59	X mm	84	X mm
10	X mm	35	X mm	60	X mm	85	X mm
11	X mm	36	X mm	61	X mm	86	X mm
12	X mm	37	X mm	62	X mm	87	X mm
13	X mm	38	X mm	63	X mm	88	X mm
14	X mm	39	X mm	64	X mm	89	X mm
15	X mm	40	X mm	65	X mm	90	X mm
16	X mm	41	X mm	66	X mm	91	X mm
17	X mm	42	X mm	67	X mm	92	X mm
18	X mm	43	X mm	68	X mm	93	X mm
19	X mm	44	X mm	69	X mm	94	X mm
20	X mm	45	X mm	70	X mm	95	X mm
21	X mm	46	X mm	71	X mm	96	X mm
22	X mm	47	X mm	72	X mm	97	X mm
23	X mm	48	X mm	73	X mm	98	X mm
24	X mm	49	X mm	74	X mm	99	X mm
25	X mm	50	X mm	75	X mm	100	X mm

Side Notes

Prepared by: XX Reviewed by: XX

Springbank Off-Stream Reservoir Project

Reach 5: Elbow River

UTM Location:	11U 680103E 5657804N	**Survey Date:**	September 26, 2016
Legal Location:	SE-13-024-04 W5M	**Water Body Class:**	Class C
Crew Initials:	GS, BN, LA	**Restricted Activity Period:**	May 1-July 15 & Sept 16-Apri

Physical Channel Transect Data

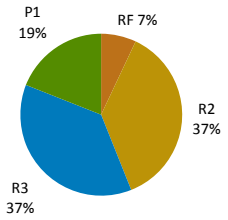
Transect # (Location)	**T1**	**T2**	**T3**	**T4**	**T5**	**T6**
Channel Width (m)	27	35	30	15	20	39
Wetted Width (m)	24	21	21	13	20	28
Depth at LDB + 25% (m)	0.5	0.6	0.4	1.0	0.5	0.2
Depth at LDB + 50% (m)	0.3	0.6	0.4	1.0	1.0	0.3
Depth at LDB + 75% (m)	0.2	0.5	0.4	1.0	1.0	0.6
Max. Depth (m)	0.8	0.7	0.5	1.0	1.0	0.8
Gradient (%)	-	-	-	-	-	-
Dominant Habitat Unit	R3	R2	RF	P1	R1	R2
Stream Bed						
Substrate (% of Transect Area) – Organics	-	-	-	-	-	-
Substrate (% of Transect Area) – Fines	-	-	-	-	-	-
Substrate (% of Transect Area) – Small Gravel	25	25	10	10	20	20
Substrate (% of Transect Area) – Large Gravel	30	30	20	30	40	20
Substrate (% of Transect Area) – Cobble	40	40	30	40	40	45
Substrate (% of Transect Area) – Boulder	5	5	40	20	-	15
Substrate (% of Transect Area) – Bedrock	-	-	-	-	-	-
Embeddedness	L	M	M	M	L	L

Bank Measurements	**Left**	**Right**	**Left**	**Right**	**Left**	**Right**	**Left**	**Right**	**Left**	**Right**	**Left**	**Right**
Bank Height (m)	1.5 / 0.4		1.0 / 0.3		1.0 / 0.4		1.75 / 0.5		2.0 / 0.5		2.0 / 2.0	
Bank Slope (°)	-		-		-		-		-		-	
Bank Stability	US / MS		US / MS		US / MS		US / MS		US / MS		US / MS	
Dom. Bank Material	C / C		C / C		C / C		C / C		C / C		C / C	
Subdom. Bank Material	LG / SG		LG / SG		LG / SG		LG / SG		LG / SG		LG / SG	
Dom. Riparian Veg.	C / G		C / G		C / G		C / G		C / G		C / G	
Subdom. Riparian Veg.	G / N		G / N		G / N		G / N		G / N		G / N	

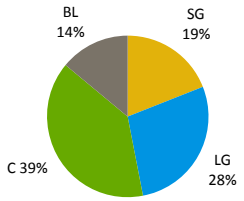
Habitat Inventory / Reach Data

Instream Cover (%):	90	Overhead Cover (%):	10
Dom. Instream Cover:	WC	Dom. Overhead Cover:	WD
Subdom. Instream Cover:	WD	Subdom. Overhead Cover:	UC
Maximum Depth (m)	1.0	Dom. Aquatic Veg. Type:	FA

Habitat Distribution



Substrate Composition



Water Quality Data

Time of Day (HH:MM):	NA
Water Temperature (°C):	8.2
Dissolved Oxygen (mg/L):	10.41
Sp. Conductivity (µs/cm):	326
pH:	7.84
Turbidity (NTU):	0.46

Channel Characteristics

Pattern:	IR
Islands:	I
Bars:	MD
Coupling:	DC
Confinement:	OC
Flow Stage:	Moderate

Fish Habitat Assessment Ratings

	Forage	**Coarse**	**Sportfish**
Spawning:	Good	Good	Good
Overwintering:	Good	Good	Good
Rearing:	Good	Good	Good
Migration:	Good	Good	Good

Photo 1: Looking downstream from T4.

Photo 2: Looking at the left downstream bank and large woody debris at T4.

Fish Sampling Data

Method		**Effort**	
Backpack Electrofisher (EB)		664	(s)
No Trapping		-	(hr)
Electrofisher Settings			
Volts	Freq. (Hz)	Duty Cycle (%)	Dist. (m)
240	30	12	360

Species	**Efish Catch** (n)	**Trap Catch** (n)	**Efish CPUE** (#fish/100s)	**Trap CPUE** (#fish/hr)	**Rel. Abundance** (% of total)
BROWN TROUT	7	-	1.05	-	87.5%
RAINBOW TROUT	1	-	0.15	-	12.5%
-	-	-	-	-	-
-	-	-	-	-	-
-	-	-	-	-	-

General Comments

Prepared by: JJ Reviewed by: LA

Springbank Off-Stream Reservoir Project

Reach 5: Elbow River

UTM Location:	11U 680103E 5657804N	**Survey Date:**	September 26, 2016
Legal Location:	SE-13-024-04 W5M	**Water Body Name:**	Elbow River
Crew Initials:	GS, BN, LA	**Project Number:**	110773996

DS UTM Start: 11U 680103E 5657804N	**US UTM Finish:** 11U 680103E 5657804N	**Embeddedness:** Low (<25%)	**Silt Cover:** None

Substrate Size Class

For Material greater than 2 mm in diameter, record the diameter of the intermediate axis to the nearest millimeter. For organic, fine, sand and bedrock materails record the following abbreviation:

Organics (O)		Fines (silt/clay) <0.06 mm (F)		Sand 0.06 - 2 mm (S)		Bedrock (BD)	
Diameter of Intermediate Axis (mm)							
1	S	26	64 mm	51	9 mm	76	36 mm
2	125 mm	27	93 mm	52	77 mm	77	69 mm
3	150 mm	28	50 mm	53	15 mm	78	92 mm
4	89 mm	29	52 mm	54	32 mm	79	27 mm
5	30 mm	30	41 mm	55	49 mm	80	58 mm
6	24 mm	31	86 mm	56	124 mm	81	80 mm
7	38 mm	32	100 mm	57	55 mm	82	11 mm
8	8 mm	33	55 mm	58	11 mm	83	21 mm
9	28 mm	34	120 mm	59	74 mm	84	75 mm
10	57 mm	35	69 mm	60	10 mm	85	46 mm
11	85 mm	36	50 mm	61	50 mm	86	66 mm
12	46 mm	37	44 mm	62	20 mm	87	69 mm
13	49 mm	38	32 mm	63	9 mm	88	56 mm
14	60 mm	39	71 mm	64	52 mm	89	38 mm
15	36 mm	40	18 mm	65	19 mm	90	18 mm
16	28 mm	41	60 mm	66	31 mm	91	35 mm
17	73 mm	42	110 mm	67	65 mm	92	66 mm
18	45 mm	43	36 mm	68	25 mm	93	59 mm
19	94 mm	44	54 mm	69	21 mm	94	24 mm
20	35 mm	45	19 mm	70	45 mm	95	71 mm
21	29 mm	46	39 mm	71	52 mm	96	134 mm
22	75 mm	47	73 mm	72	110 mm	97	21 mm
23	40 mm	48	34 mm	73	51 mm	98	33 mm
24	52 mm	49	102 mm	74	83 mm	99	50 mm
25	143 mm	50	37 mm	75	30 mm	100	131 mm

Side Notes

- Start/Stop location is the same as the depth limited pepple count sampling transects.

Prepared by: XX Reviewed by: XX

Springbank Off-Stream Reservoir Project

Reach 6: Elbow River

UTM Location:	11U 683090E 5658084N	**Survey Date:**	September 19, 2016
Legal Location:	NW-17-024-03 W5M	**Water Body Class:**	Class C
Crew Initials:	GS, BN, LA	**Restricted Activity Period:**	May 1-July 15 & Sept 16-Apri

Physical Channel Transect Data

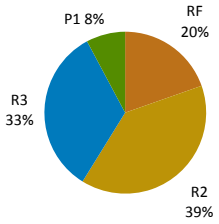
Transect # (Location)	**T1**	**T2**	**T3**	**T4**	**T5**	**T6**
Channel Width (m)	25	37	31	25	25	38
Wetted Width (m)	20	15	18	16	20	22
Depth at LDB + 25% (m)	0.5	0.3	0.3	0.3	0.5	0.4
Depth at LDB + 50% (m)	0.8	0.4	0.6	0.5	0.8	0.8
Depth at LDB + 75% (m)	0.5	0.4	0.6	0.3	0.5	0.5
Max. Depth (m)	1.0	0.5	0.8	0.5	1.0	0.9
Gradient (%)	-	-	-	-	-	-
Dominant Habitat Unit	R2	R2	P2	RF	R1	R1
Stream Bed						
Substrate (% of Transect Area) – Organics	-	-	-	-	-	-
Substrate (% of Transect Area) – Fines	-	5	5	-	-	-
Substrate (% of Transect Area) – Small Gravel	20	30	20	5	5	25
Substrate (% of Transect Area) – Large Gravel	30	30	55	20	20	45
Substrate (% of Transect Area) – Cobble	30	20	15	60	60	25
Substrate (% of Transect Area) – Boulder	20	5	5	15	15	5
Substrate (% of Transect Area) – Bedrock	-	-	-	-	-	-
Embeddedness	L	L	L	L	L	L

Bank Measurements	**Left**	**Right**	**Left**	**Right**	**Left**	**Right**	**Left**	**Right**	**Left**	**Right**	**Left**	**Right**
Bank Height (m)	0.5 / 0.75		0.5 / 0.5		0.5 / 0.5		1.0 / 0.3		0.5 / NA		0.5 / 2.0	
Bank Slope (°)	-		-		-		-		-		-	
Bank Stability	MS / US		MS / MS		MS / MS		MS / MS		MS / MS		MS / US	
Dom. Bank Material	LG / C		LG / C		LG / C		F / C		LG / F		C / F	
Subdom. Bank Material	C / LG		C / LG		C / LG		F / BL		C / C		LG /LG	
Dom. Riparian Veg.	N / G		N / N		C / G		C / G		N / N		N / G	
Subdom. Riparian Veg.	S / D		M / W		G / N		G / N		N / W		S / D	

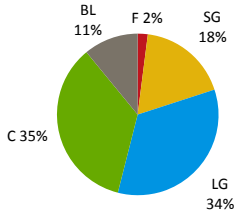
Habitat Inventory / Reach Data

Instream Cover (%):	80	Overhead Cover (%):	20
Dom. Instream Cover:	WC	Dom. Overhead Cover:	WD
Subdom. Instream Cover:	WD	Subdom. Overhead Cover:	UC
Maximum Depth (m)	1.0	Dom. Aquatic Veg. Type:	FA

Habitat Distribution



Substrate Composition



Water Quality Data

Time of Day (HH:MM):	11:15
Water Temperature (°C):	9.1
Dissolved Oxygen (mg/L):	12.50
Sp. Conductivity (µs/cm):	469
pH:	7.71
Turbidity (NTU):	0.42

Channel Characteristics

Pattern:	IR
Islands:	I
Bars:	MD
Coupling:	DC
Confinement:	UN
Flow Stage:	Moderate

Fish Habitat Assessment Ratings

	Forage	**Coarse**	**Sportfish**
Spawning:	Good	Good	Good
Overwintering:	Good	Good	Good
Rearing:	Good	Good	Good
Migration:	Good	Good	Good

Photo 1: Looking upstream from T6 at the large woody debris / logjam.

Photo 2: Upstream view of run/riffle habitat from T1.

Fish Sampling Data

Method		**Effort**	
No Electrofishing		-	(s)
No Trapping		-	(hr)
Electrofisher Settings			
Volts	Freq. (Hz)	Duty Cycle (%)	Dist. (m)
-	-	-	-

Species	**Efish Catch (n)**	**Trap Catch (n)**	**Efish CPUE (#fish/100s)**	**Trap CPUE (#fish/hr)**	**Rel. Abundance (% of total)**
-	-		-	-	-
-	-	-	-	-	-
-	-	-	-	-	-
-	-	-	-	-	-
-	-	-	-	-	-

General Comments

Prepared by: JJ Reviewed by: LA

Springbank Off-Stream Reservoir Project

Reach 6: Elbow River

UTM Location:	11U 683090E 5658102N	**Survey Date:**	September 19, 2016
Legal Location:	NW-17-024-03 W5M	**Water Body Name:**	Elbow River
Crew Initials:	GS, BN, LA	**Project Number:**	110773996

DS UTM Start: 11U 683090E 5658102N	**US UTM Finish:** 11U 682838E 5658217N	**Embeddedness:** None	**Silt Cover:** None

Substrate Size Class

For Material greater than 2 mm in diameter, record the diameter of the intermediate axis to the nearest millimeter. For organic, fine, sand and bedrock materails record the following abbreviation:

Organics (O)		Fines (silt/clay) <0.06 mm (F)		Sand 0.06 - 2 mm (S)		Bedrock (BD)	
Diameter of Intermediate Axis (mm)							
1	96 mm	26	91 mm	51	18 mm	76	24 mm
2	52 mm	27	33 mm	52	24 mm	77	21 mm
3	41 mm	28	50 mm	53	46 mm	78	6 mm
4	S	29	68 mm	54	16 mm	79	9 mm
5	28 mm	30	36 mm	55	22 mm	80	53 mm
6	52 mm	31	100 mm	56	86 mm	81	24 mm
7	84 mm	32	43 mm	57	97 mm	82	54 mm
8	178 mm	33	160 mm	58	53 mm	83	56 mm
9	123 mm	34	114 mm	59	24 mm	84	8 mm
10	189 mm	35	56 mm	60	92 mm	85	76 mm
11	19 mm	36	94 mm	61	67 mm	86	39 mm
12	210 mm	37	108 mm	62	33 mm	87	65 mm
13	41 mm	38	57 mm	63	82 mm	88	19 mm
14	79 mm	39	52 mm	64	560 mm	89	79 mm
15	21 mm	40	55 mm	65	102 mm	90	38 mm
16	17 mm	41	8 mm	66	152 mm	91	119 mm
17	76 mm	42	37 mm	67	200 mm	92	102 mm
18	55 mm	43	46 mm	68	115 mm	93	42 mm
19	14 mm	44	53 mm	69	140 mm	94	60 mm
20	44 mm	45	67 mm	70	24 mm	95	34 mm
21	72 mm	46	68 mm	71	66 mm	96	198 mm
22	S	47	64 mm	72	90 mm	97	58 mm
23	17 mm	48	45 mm	73	60 mm	98	44 mm
24	29 mm	49	100 mm	74	48 mm	99	14 mm
25	3 mm	50	92 mm	75	32 mm	100	127 mm

Side Notes

Prepared by: XX Reviewed by: XX

Springbank Off-Stream Reservoir Project

Reach 7: Elbow River

UTM Location:	11U 684282E 5657506N	**Survey Date:**	September 19, 2016
Legal Location:	SW-16-024-03 W5M	**Water Body Class:**	Class C
Crew Initials:	GS, BN, LA	**Restricted Activity Period:**	May 1-July 15 & Sept 16-Apri

Physical Channel Transect Data

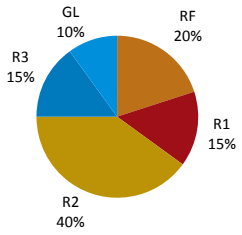
Transect # (Location)	**T1**	**T2**	**T3**	**T4**	**T5**	**T6**
Channel Width (m)	28	24	34	37	46	35
Wetted Width (m)	23	21	27	30	28	20
Depth at LDB + 25% (m)	0.3	0.4	0.4	0.4	0.3	0.6
Depth at LDB + 50% (m)	0.8	0.3	0.3	0.5	0.4	1.0
Depth at LDB + 75% (m)	0.4	0.4	0.9	0.4	0.4	0.5
Max. Depth (m)	0.9	0.7	0.9	0.6	0.4	1.2
Gradient (%)	-	-	-	-	-	-
Dominant Habitat Unit	R2	R3	R3	GL	RF	R1
Stream Bed						
Substrate (% of Transect Area) – Organics	-	5	-	5	-	-
Fines	5	-	5	10	5	-
Small Gravel	15	20	30	30	5	-
Large Gravel	30	30	40	40	30	30
Cobble	45	40	20	15	50	60
Boulder	5	5	5	-	10	10
Bedrock	-	-	-	-	-	-
Embeddedness	L	L	L	L	L	L

Bank Measurements	**Left**	**Right**	**Left**	**Right**	**Left**	**Right**	**Left**	**Right**	**Left**	**Right**	**Left**	**Right**
Bank Height (m)	0.2 / 0.5		0.2 / 0.5		0.2 / 0.5		1.0 / 0.5		0.5 / 0.5		1.0 / 0.3	
Bank Slope (°)	-		-		-		-		-		-	
Bank Stability	S / MS		S / MS		S / MS		S / MS		S / MS		MS / MS	
Dom. Bank Material	C / C		C / S		C / S		C / S		SG / S		C / S	
Subdom. Bank Material	LG / LG		LG / LG		LG / LG		SG / LG		C / SG		SG /F	
Dom. Riparian Veg.	G / S		G / S		G / S		G / S		G / S		G / S	
Subdom. Riparian Veg.	N / C		N / C		N / C		N / C		N / C		N / C	

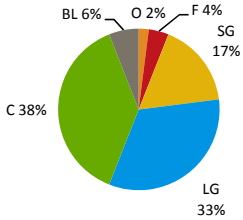
Habitat Inventory / Reach Data

Instream Cover (%):	95	Overhead Cover (%):	5
Dom. Instream Cover:	WC	Dom. Overhead Cover:	UC
Subdom. Instream Cover:	B	Subdom. Overhead Cover:	WD
Maximum Depth (m)	1.2	Dom. Aquatic Veg. Type:	FA

Habitat Distribution



Substrate Composition



Water Quality Data

Time of Day (HH:MM):	17:15
Water Temperature (°C):	12.5
Dissolved Oxygen (mg/L):	11.50
Sp. Conductivity (µs/cm):	416
pH:	8.00
Turbidity (NTU):	0.56

Channel Characteristics

Pattern:	IR
Islands:	I
Bars:	N
Coupling:	DC
Confinement:	OC
Flow Stage:	Moderate

Fish Habitat Assessment Ratings

	Forage	**Coarse**	**Sportfish**
Spawning:	Moderate-Good	Good	Good
Overwintering:	Moderate-Good	Moderate-Good	Moderate-Good
Rearing:	Moderate	Moderate	Moderate
Migration:	Good	Good	Good

Photo 1: Undercuts and largewoody debris along T3's right downstream bank.

Photo 2: Upstream view of run/riffle habitat from T1.

Fish Sampling Data

Method	**Effort**	
Backpack Electrofisher (EB)	657	(s)
No Trapping	-	(hr)

Electrofisher Settings			
Volts	Freq. (Hz)	Duty Cycle (%)	Dist. (m)
240	30	12	370

Species	**Efish Catch** (n)	**Trap Catch** (n)	**Efish CPUE** (#fish/100s)	**Trap CPUE** (#fish/hr)	**Rel. Abundance** (% of total)
LONGNOSE DACE	2	-	0.30	-	66.7%
WHITE SUCKER	1	-	0.15	-	33.3%
-	-	-	-	-	-
-	-	-	-	-	-
-	-	-	-	-	-

General Comments

Prepared by: JJ Reviewed by: LA

Springbank Off-Stream Reservoir Project

Reach 7: Elbow River

UTM Location:	11U 684415E 5657392N	**Survey Date:**	September 19, 2016
Legal Location:	SW-16-024-03 W5M	**Water Body Name:**	Elbow River
Crew Initials:	GS, BN, LA	**Project Number:**	110773996

DS UTM Start: 11U 684415E 5657392N	**US UTM Finish:** 11U 684415E 5657392N	**Embeddedness:** L ow (25%)	**Silt Cover:** None

Substrate Size Class

For Material greater than 2 mm in diameter, record the diameter of the intermediate axis to the nearest millimeter. For organic, fine, sand and bedrock materails record the following abbreviation:

Organics (O)		Fines (silt/clay) <0.06 mm (F)		Sand 0.06 - 2 mm (S)		Bedrock (BD)	
Diameter of Intermediate Axis (mm)							
1	7 mm	26	96 mm	51	110 mm	76	109 mm
2	92 mm	27	64 mm	52	32 mm	77	191 mm
3	19 mm	28	48 mm	53	215 mm	78	209 mm
4	121 mm	29	93 mm	54	151 mm	79	27 mm
5	120 mm	30	124 mm	55	56 mm	80	175 mm
6	5 mm	31	155 mm	56	120 mm	81	26 mm
7	232 mm	32	77 mm	57	36 mm	82	76 mm
8	33 mm	33	34 mm	58	63 mm	83	29 mm
9	58 mm	34	57 mm	59	97 mm	84	54 mm
10	85 mm	35	72 mm	60	73 mm	85	23 mm
11	60 mm	36	42 mm	61	55 mm	86	65 mm
12	132 mm	37	22 mm	62	48 mm	87	21 mm
13	30 mm	38	50 mm	63	80 mm	88	32 mm
14	123 mm	39	100 mm	64	102 mm	89	22 mm
15	221 mm	40	300 mm	65	S	90	71 mm
16	395 mm	41	85 mm	66	200 mm	91	14 mm
17	151 mm	42	108 mm	67	96 mm	92	74 mm
18	14 mm	43	50 mm	68	60 mm	93	29 mm
19	44 mm	44	78 mm	69	44 mm	94	64 mm
20	7 mm	45	100 mm	70	77 mm	95	53 mm
21	22 mm	46	9 mm	71	19 mm	96	41 mm
22	78 mm	47	370 mm	72	155 mm	97	6 mm
23	142 mm	48	S	73	80 mm	98	47 mm
24	25 mm	49	7 mm	74	66 mm	99	34 mm
25	128 mm	50	93 mm	75	26 mm	100	32 mm

Side Notes

- Start/Stop location is the same as the depth and water velocity limited pepple count sampling transects.

Prepared by: XX Reviewed by: XX

Springbank Off-Stream Reservoir Project

Reach 8: Elbow River

UTM Location:	11U 686209E 5657138N	**Survey Date:**	September 23, 2016
Legal Location:	NW-10-024-03 W5M	**Water Body Class:**	Class C
Crew Initials:	GS, BN, LA	**Restricted Activity Period:**	May 1-July 15 & Sept 16-Apri

Physical Channel Transect Data

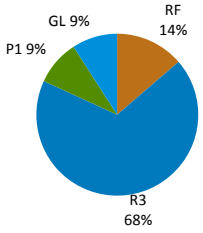
Transect # (Location)	**T1**	**T2**	**T3**	**T4**	**T5**	**T6**
Channel Width (m)	26	25	21	24	28	36
Wetted Width (m)	24	22	18	20	22	31
Depth at LDB + 25% (m)	0.6	0.5	0.6	0.7	0.8	0.5
Depth at LDB + 50% (m)	0.1	0.2	0.5	0.5	0.1	0.6
Depth at LDB + 75% (m)	0.4	0.4	0.5	0.1	0.3	0.6
Max. Depth (m)	0.6	0.6	0.6	0.8	1.0	0.6
Gradient (%)	-	-	-	-	-	-
Dominant Habitat Unit	R3	GL	P3	R3	RF	R3
Stream Bed						
Substrate (% of Transect Area) – Organics	-	-	-	-	-	-
Substrate (% of Transect Area) – Fines	5	-	5	-	-	-
Substrate (% of Transect Area) – Small Gravel	15	-	5	5	20	15
Substrate (% of Transect Area) – Large Gravel	15	30	35	40	40	20
Substrate (% of Transect Area) – Cobble	60	60	55	50	40	55
Substrate (% of Transect Area) – Boulder	5	10	-	5	-	10
Substrate (% of Transect Area) – Bedrock	-	-	-	-	-	-
Embeddedness	L	L	L	L	L	L

Bank Measurements	**Left**	**Right**	**Left**	**Right**	**Left**	**Right**	**Left**	**Right**	**Left**	**Right**	**Left**	**Right**
Bank Height (m)	0.3 / 1.2		0.5 / 2.0		0.4 / 0.2		1.2 / 0.2		1.5 / 0.2		1.5 / 0.2	
Bank Slope (°)	-		-		-		-		-		-	
Bank Stability	S / S		S / S		S / S		S / S		S / S		S / S	
Dom. Bank Material	C / C		C / C		C / C		C / C		C / C		C / C	
Subdom. Bank Material	LG / LG		LG / LG		LG / LG		LG / LG		LG / LG		LG / LG	
Dom. Riparian Veg.	S / S		S / S		S / S		S / S		S / S		S / S	
Subdom. Riparian Veg.	G / G		G / G		G / G		G / D		C / G		C / G	

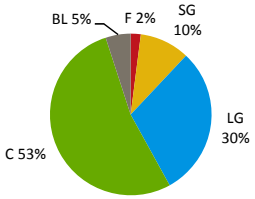
Habitat Inventory / Reach Data

Instream Cover (%):	85	Overhead Cover (%):	15
Dom. Instream Cover:	DC	Dom. Overhead Cover:	WD
Subdom. Instream Cover:	WD	Subdom. Overhead Cover:	UC
Maximum Depth (m)	1.0	Dom. Aquatic Veg. Type:	FA

Habitat Distribution



Substrate Composition



Water Quality Data

Time of Day (HH:MM):	17:15
Water Temperature (°C):	9.8
Dissolved Oxygen (mg/L):	9.88
Sp. Conductivity (µs/cm):	427
pH:	8.00
Turbidity (NTU):	0.03

Channel Characteristics

Pattern:	IR
Islands:	N
Bars:	MD
Coupling:	DC
Confinement:	UN
Flow Stage:	Moderate

Fish Habitat Assessment Ratings

	Forage	**Coarse**	**Sportfish**
Spawning:	Moderate-Good	Good	Good
Overwintering:	Good	Good	Good
Rearing:	Moderate-Good	Moderate-Good	Moderate-Good
Migration:	Good	Good	Good

Photo 1: Downstream view of assessment area from T1.

Photo 2: Updtream view from T4 at the pool and large woody debris habtiat.

Fish Sampling Data

Method	**Effort**	
No Electrofishing	-	(s)
No Trapping	-	(hr)

Electrofisher Settings			
Volts	Freq. (Hz)	Duty Cycle (%)	Dist. (m)
-	-	-	-

Species	**Efish Catch** (n)	**Trap Catch** (n)	**Efish CPUE** (#fish/100s)	**Trap CPUE** (#fish/hr)	**Rel. Abundance** (% of total)
-	-		-	-	-
-	-	-	-	-	-
-	-	-	-	-	-
-	-	-	-	-	-
-	-	-	-	-	-

General Comments

No electrofishing completed due to high depths and flows.

Prepared by: JJ Reviewed by: LA

Springbank Off-Stream Reservoir Project

Reach 8: Elbow River

UTM Location:	11U 686252E 5657178N	**Survey Date:**	September 23, 2016
Legal Location:	NW-10-024-03 W5M	**Water Body Name:**	Elbow River
Crew Initials:	GS, BN, LA	**Project Number:**	110773996

DS UTM Start: 11U 686252E 5657178N	**US UTM Finish:** 11U 686256E 5657175N	**Embeddedness:** None	**Silt Cover:** None

Substrate Size Class

For Material greater than 2 mm in diameter, record the diameter of the intermediate axis to the nearest millimeter. For organic, fine, sand and bedrock materails record the following abbreviation:

Organics (O)		Fines (silt/clay) <0.06 mm (F)		Sand 0.06 - 2 mm (S)		Bedrock (BD)	
Diameter of Intermediate Axis (mm)							
1	80 mm	26	85 mm	51	22 mm	76	41 mm
2	35 mm	27	50 mm	52	64 mm	77	50 mm
3	120 mm	28	55 mm	53	28 mm	78	47 mm
4	95 mm	29	78 mm	54	67 mm	79	64 mm
5	90 mm	30	65 mm	55	58 mm	80	56 mm
6	12 mm	31	65 mm	56	54 mm	81	55 mm
7	25 mm	32	85 mm	57	34 mm	82	46 mm
8	50 mm	33	67 mm	58	54 mm	83	95 mm
9	80 mm	34	45 mm	59	98 mm	84	130 mm
10	60 mm	35	79 mm	60	84 mm	85	54 mm
11	10 mm	36	54 mm	61	73 mm	86	76 mm
12	69 mm	37	76 mm	62	64 mm	87	60 mm
13	81 mm	38	120 mm	63	36 mm	88	79 mm
14	62 mm	39	130 mm	64	65 mm	89	58 mm
15	27 mm	40	85 mm	65	79 mm	90	60 mm
16	80 mm	41	110 mm	66	25 mm	91	75 mm
17	45 mm	42	65 mm	67	35 mm	92	50 mm
18	48 mm	43	51 mm	68	42 mm	93	53 mm
19	59 mm	44	16 mm	69	60 mm	94	58 mm
20	30 mm	45	28 mm	70	55 mm	95	67 mm
21	28 mm	46	50 mm	71	33 mm	96	63 mm
22	105 mm	47	44 mm	72	32 mm	97	76 mm
23	89 mm	48	27 mm	73	35 mm	98	84 mm
24	102 mm	49	24 mm	74	40 mm	99	49 mm
25	94 mm	50	35 mm	75	50 mm	100	50 mm

Side Notes

Prepared by: XX Reviewed by: XX

Springbank Off-Stream Reservoir Project

Reach 9: Elbow River

UTM Location:	11U 687768E 5656751N	**Survey Date:**	September 23, 2016
Legal Location:	NW-11-024-02 W5M	**Water Body Class:**	Class C
Crew Initials:	LA, JW	**Restricted Activity Period:**	May 1-July 15 & Sept 16-Apri

Physical Channel Transect Data

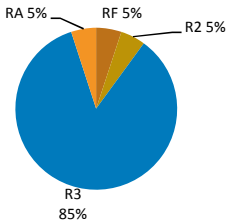
Transect # (Location)	**T1**	**T2**	**T3**	**T4**	**T5**	**T6**
Channel Width (m)	29	31	21	24	22	26
Wetted Width (m)	26	29	11	17	15	25
Depth at LDB + 25% (m)	0.6	0.6	0.7	NA	0.7	0.6
Depth at LDB + 50% (m)	0.2	0.4	0.7	NA	0.5	0.5
Depth at LDB + 75% (m)	0.5	0.3	NA	NA	0.9	0.3
Max. Depth (m)	0.6	0.6	0.7	1.2	1.2	0.6
Gradient (%)	-	-	-	-	-	-
Dominant Habitat Unit	R3	R3	R2	RA	R2	R3
Stream Bed						
Substrate (% of Transect Area): Organics	-	-	-	-	-	-
Fines	50	-	-	-	-	-
Small Gravel	-	-	-	-	20	10
Large Gravel	25	20	10	20	30	15
Cobble	25	80	80	50	40	75
Boulder	-	-	10	30	10	-
Bedrock	-	-	-	-	-	-
Embeddedness	L	L	L	L	L	L

Bank Measurements	**Left**	**Right**	**Left**	**Right**	**Left**	**Right**	**Left**	**Right**	**Left**	**Right**	**Left**	**Right**
Bank Height (m)	1.5 / 2.5		0.4 / 1.1		0.2 / 0.2		0.2 / 2.0		0.5 / 2.5		0.5 / 1.5	
Bank Slope (°)	-		-		-		-		-		-	
Bank Stability	S / MS		S / MS		S / S		S / MS		S / MS		S / MS	
Dom. Bank Material	F / F		C / C		C / C		C / F		C / F		C /F	
Subdom. Bank Material	SG / SG		SG / F		LG / LG		LG / SG		LG / SG		LG / SG	
Dom. Riparian Veg.	S / S		NA		S / S		S / D		S / D		S / D	
Subdom. Riparian Veg.	C / C		NA		S / S		NA / C		NA / C		NA / C	

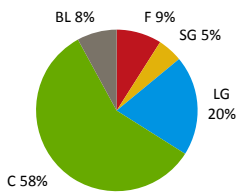
Habitat Inventory / Reach Data

Instream Cover (%):	95	Overhead Cover (%):	5
Dom. Instream Cover:	BL	Dom. Overhead Cover:	UC
Subdom. Instream Cover:	DC	Subdom. Overhead Cover:	OV
Maximum Depth (m)	1.2	Dom. Aquatic Veg. Type:	FA

Habitat Distribution



Substrate Composition



Water Quality Data

Time of Day (HH:MM):	13:30
Water Temperature (°C):	11.7
Dissolved Oxygen (mg/L):	11.02
Sp. Conductivity (µs/cm):	429
pH:	7.78
Turbidity (NTU):	0.00

Channel Characteristics

Pattern:	IR
Islands:	O
Bars:	MD
Coupling:	DC
Confinement:	UN
Flow Stage:	Moderate

Fish Habitat Assessment Ratings

	Forage	**Coarse**	**Sportfish**
Spawning:	Poor-Moderate	Poor-Moderate	Poor-Moderate
Overwintering:	Poor-Moderate	Poor-Moderate	Poor-Moderate
Rearing:	Moderate	Moderate	Moderate
Migration:	Good	Good	Good

Photo 1: View downstream from T2.

Photo 2: View of downstream right bank and rapids at T4.

Fish Sampling Data

Method	**Effort**		**Species**	**Efish Catch (n)**	**Trap Catch (n)**	**Efish CPUE (#fish/100s)**	**Trap CPUE (#fish/hr)**	**Rel. Abundance (% of total)**
No Electrofishing	-	(s)	-	-		-	-	-
No Trapping	-	(hr)	-	-	-	-	-	-
Electrofisher Settings			-	-	-	-	-	-
Volts	Freq. (Hz)	Duty Cycle (%)	Dist. (m)	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-

General Comments

No electrofishing completed due to high depths and flows.

Prepared by: JJ Reviewed by: LA

Springbank Off-Stream Reservoir Project

Reach 9: Elbow River

UTM Location:	11U 687738E 5656735N	**Survey Date:**	September 23, 2016
Legal Location:	NW-11-024-03 W5M	**Water Body Name:**	Elbow River
Crew Initials:	LA, JW	**Project Number:**	110773996

DS UTM Start: 11U 687738E 5656735N	**US UTM Finish:** 11U 687768E 5656751N	**Embeddedness:** None	**Silt Cover:** None

Substrate Size Class

For Material greater than 2 mm in diameter, record the diameter of the intermediate axis to the nearest millimeter. For organic, fine, sand and bedrock materails record the following abbreviation:

Organics (O)		Fines (silt/clay) <0.06 mm (F)		Sand 0.06 - 2 mm (S)		Bedrock (BD)	
Diameter of Intermediate Axis (mm)							
1	22 mm	26	21 mm	51	39 mm	76	57 mm
2	57 mm	27	70 mm	52	22 mm	77	55 mm
3	31 mm	28	26 mm	53	51 mm	78	30 mm
4	52 mm	29	25 mm	54	59 mm	79	53 mm
5	29 mm	30	40 mm	55	38 mm	80	85 mm
6	49 mm	31	38 mm	56	65 mm	81	86 mm
7	20 mm	32	83 mm	57	15 mm	82	39 mm
8	61 mm	33	27 mm	58	48 mm	83	40 mm
9	45 mm	34	50 mm	59	45 mm	84	49 mm
10	42 mm	35	55 mm	60	59 mm	85	82 mm
11	66 mm	36	30 mm	61	40 mm	86	45 mm
12	60 mm	37	31 mm	62	29 mm	87	60 mm
13	57 mm	38	68 mm	63	48 mm	88	110 mm
14	61 mm	39	60 mm	64	21 mm	89	41 mm
15	15 mm	40	82 mm	65	58 mm	90	20 mm
16	28 mm	41	27 mm	66	43 mm	91	30 mm
17	30 mm	42	40 mm	67	22 mm	92	53 mm
18	37 mm	43	25 mm	68	38 mm	93	54 mm
19	40 mm	44	52 mm	69	31 mm	94	50 mm
20	48 mm	45	18 mm	70	40 mm	95	55 mm
21	52 mm	46	24 mm	71	39 mm	96	132 mm
22	58 mm	47	15 mm	72	85 mm	97	98 mm
23	56 mm	48	45 mm	73	135 mm	98	82 mm
24	33 mm	49	32 mm	74	85 mm	99	37 mm
25	69 mm	50	60 mm	75	50 mm	100	54 mm

Side Notes

Prepared by: XX Reviewed by: XX

Springbank Off-Stream Reservoir Project

Reach 10: Elbow River

UTM Location:	11U 691132E 5656073N	**Survey Date:**	September 21, 2016
Legal Location:	SW-07-024-02 W5M	**Water Body Class:**	Class C
Crew Initials:	LA, JW	**Restricted Activity Period:**	May 1-July 15 & Sept 16-Apri

Physical Channel Transect Data

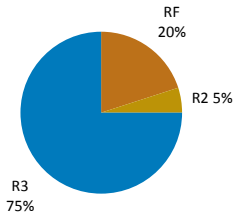
Transect # (Location)	**T1**	**T2**	**T3**	**T4**	**T5**	**T6**
Channel Width (m)	52	34	27	30	38	24
Wetted Width (m)	15	31	24	26	26	19
Depth at LDB + 25% (m)	0.2	0.4	0.5	0.3	0.3	0.3
Depth at LDB + 50% (m)	-	0.6	0.5	0.4	0.5	0.5
Depth at LDB + 75% (m)	0.2	0.3	0.5	0.3	0.5	0.6
Max. Depth (m)	1.0	0.6	0.5	0.6	0.5	0.7
Gradient (%)	-	-	-	-	-	-
Dominant Habitat Unit	RF	R3	R3	R3	RF	R3
Stream Bed						
Substrate (% of Transect Area) – Organics	-	-	-	-	-	-
Substrate (% of Transect Area) – Fines	-	-	-	-	-	-
Substrate (% of Transect Area) – Small Gravel	-	-	-	-	10	10
Substrate (% of Transect Area) – Large Gravel	60	10	10	20	40	40
Substrate (% of Transect Area) – Cobble	40	90	90	80	50	50
Substrate (% of Transect Area) – Boulder	-	-	-	-	-	-
Substrate (% of Transect Area) – Bedrock	-	-	-	-	-	-
Embeddedness	L	L	L	L	L	L

Bank Measurements	**Left**	**Right**	**Left**	**Right**	**Left**	**Right**	**Left**	**Right**	**Left**	**Right**	**Left**	**Right**
Bank Height (m)	1.0	0.75	1.5	0.2	1.8	0.2	1.8	0.2	0.5	1.5	0.2	2.7
Bank Slope (°)	-		-		-		-		-		-	
Bank Stability	MS	S	MS	S	MS	S	MS	S	S	US	S	US
Dom. Bank Material	F	LG	F	LG	F	LG	F	C	C	BD	C	F
Subdom. Bank Material	F	LG	F	LG	LG	C	SG	F	LG	F	LG	LG
Dom. Riparian Veg.	D	C	S	S	S	G	D	G	S	C	G	S
Subdom. Riparian Veg.	S	G	C	C	C	N	S	N	D	S	S	D

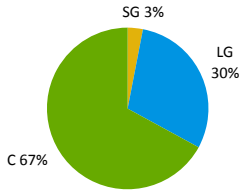
Habitat Inventory / Reach Data

Instream Cover (%):	95	Overhead Cover (%):	5
Dom. Instream Cover:	BL	Dom. Overhead Cover:	UC
Subdom. Instream Cover:	-	Subdom. Overhead Cover:	OV
Maximum Depth (m)	1.0	Dom. Aquatic Veg. Type:	FA

Habitat Distribution



Substrate Composition



Water Quality Data

Time of Day (HH:MM):	16:00
Water Temperature (°C):	13.2
Dissolved Oxygen (mg/L):	9.80
Sp. Conductivity (µs/cm):	435
pH:	7.84
Turbidity (NTU):	NA

Channel Characteristics

Pattern:	IR
Islands:	N
Bars:	MD
Coupling:	DC
Confinement:	OC
Flow Stage:	Moderate

Fish Habitat Assessment Ratings

	Forage	**Coarse**	**Sportfish**
Spawning:	Poor-Moderate	Poor-Moderate	Poor-Moderate
Overwintering:	Poor-Moderate	Poor-Moderate	Poor-Moderate
Rearing:	Poor-Moderate	Poor-Moderate	Poor-Moderate
Migration:	Good	Good	Good

Photo 1: View downstream from T6.

Photo 2: View upstream from T1 towards the riffle/run habitat.

Fish Sampling Data

Method	**Effort**		**Species**	**Efish Catch (n)**	**Trap Catch (n)**	**Efish CPUE (#fish/100s)**	**Trap CPUE (#fish/hr)**	**Rel. Abundance (% of total)**
No Electrofishing	-	(s)	-	-		-	-	-
No Trapping	-	(hr)	-	-	-	-	-	-
Electrofisher Settings			-	-	-	-	-	-
Volts	Freq. (Hz)	Duty Cycle (%)	Dist. (m)	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-

General Comments

No electrofishing completed due to high depths and flows.

Prepared by: JJ Reviewed by: LA

Springbank Off-Stream Reservoir Project

Reach 10: Elbow River

UTM Location:	11U 691202E 5656031N	**Survey Date:**	September 21, 2016
Legal Location:	SW-07-024-02 W5M	**Water Body Name:**	Elbow River
Crew Initials:	LA, JW	**Project Number:**	110773996

DS UTM Start: 11U 691202E 5656031N	**US UTM Finish:** 11U 691202E 5656031N	**Embeddedness:** None	**Silt Cover:** None

Substrate Size Class

For Material greater than 2 mm in diameter, record the diameter of the intermediate axis to the nearest millimeter. For organic, fine, sand and bedrock materails record the following abbreviation:

Organics (O)		Fines (silt/clay) <0.06 mm (F)		Sand 0.06 - 2 mm (S)		Bedrock (BD)	
Diameter of Intermediate Axis (mm)							
1	138 mm	26	15 mm	51	85 mm	76	45 mm
2	141 mm	27	30 mm	52	34 mm	77	31 mm
3	74 mm	28	50 mm	53	46 mm	78	16 mm
4	53 mm	29	41 mm	54	55 mm	79	32 mm
5	38 mm	30	24 mm	55	81 mm	80	58 mm
6	74 mm	31	29 mm	56	85 mm	81	69 mm
7	67 mm	32	31 mm	57	101 mm	82	57 mm
8	63 mm	33	18 mm	58	123 mm	83	70 mm
9	173 mm	34	20 mm	59	105 mm	84	43 mm
10	65 mm	35	38 mm	60	123 mm	85	55 mm
11	62 mm	36	10 mm	61	58 mm	86	40 mm
12	108 mm	37	26 mm	62	25 mm	87	52 mm
13	79 mm	38	88 mm	63	39 mm	88	35 mm
14	88 mm	39	62 mm	64	48 mm	89	72 mm
15	68 mm	40	64 mm	65	82 mm	90	35 mm
16	87 mm	41	35 mm	66	35 mm	91	85 mm
17	65 mm	42	21 mm	67	12 mm	92	46 mm
18	89 mm	43	170 mm	68	23 mm	93	36 mm
19	33 mm	44	67 mm	69	43 mm	94	41 mm
20	45 mm	45	48 mm	70	28 mm	95	37 mm
21	44 mm	46	141 mm	71	46 mm	96	46 mm
22	32 mm	47	28 mm	72	65 mm	97	54 mm
23	56 mm	48	85 mm	73	45 mm	98	47 mm
24	60 mm	49	95 mm	74	38 mm	99	54 mm
25	51 mm	50	44 mm	75	64 mm	100	62 mm

Side Notes

Prepared by: XX Reviewed by: XX

Springbank Off-Stream Reservoir Project

Reach 11: Elbow River

UTM Location:	11U 693267E 5655447N	**Survey Date:**	September 22, 2016
Legal Location:	NE-05-024-02 W5M	**Water Body Class:**	Class C
Crew Initials:	GS, BN, MS	**Restricted Activity Period:**	May 1-July 15 & Sept 16-Apri

Physical Channel Transect Data

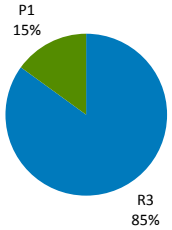
Transect # (Location)	**T1**	**T2**	**T3**	**T4**	**T5**	**T6**
Channel Width (m)	22	21	21	21	28	31
Wetted Width (m)	21	17	18	9.0	26	30
Depth at LDB + 25% (m)	0.9	0.6	0.6	0.8	0.3	0.2
Depth at LDB + 50% (m)	>1.0	0.5	0.1	0.5	0.3	0.2
Depth at LDB + 75% (m)	>1.0	0.2	0.4	0.3	0.4	0.6
Max. Depth (m)	>1.0	0.6	0.6	0.8	0.5	0.7
Gradient (%)	-	-	-	-	-	-
Dominant Habitat Unit	P1	R3	R3	R3	R3	R3
Stream Bed						
Substrate (% of Transect Area) – Organics	-	-	-	-	-	-
Substrate (% of Transect Area) – Fines	10	-	-	5	-	-
Substrate (% of Transect Area) – Small Gravel	30	15	20	15	15	10
Substrate (% of Transect Area) – Large Gravel	20	50	50	50	45	30
Substrate (% of Transect Area) – Cobble	10	35	30	30	35	60
Substrate (% of Transect Area) – Boulder	30	-	-	-	5	-
Substrate (% of Transect Area) – Bedrock	-	-	-	-	-	-
Embeddedness	L	L	L	L	L	L

Bank Measurements	**Left Right**	**Left Right**	**Left Right**	**Left Right**	**Left Right**	**Left Right**
Bank Height (m)	0.4 / 0.4	0.3 / 0.3	0.25 / 0.25	0.25 / 0.25	0.15 / 0.15	0.15 / 0.15
Bank Slope (°)	20 / 40	80 / 05	70 / 05	90 / 05	05 / 05	40 / 05
Bank Stability	S/ S	US / S	US / S	US / S	S / S	MS / S
Dom. Bank Material	LG / LG	LG / LG	LG / LG	F / LG	C /LG	F / LG
Subdom. Bank Material	SG / SG	F / C	F / C	LG / C	LG /C	LG / C
Dom. Riparian Veg.	G / G	S / G	S / G	S / G	S / S	G /G
Subdom. Riparian Veg.	S / S	G / S	G / S	G /S	G / G	S / S

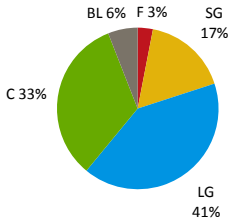
Habitat Inventory / Reach Data

Instream Cover (%):	95	Overhead Cover (%):	5
Dom. Instream Cover:	WC	Dom. Overhead Cover:	UC
Subdom. Instream Cover:	B	Subdom. Overhead Cover:	OV
Maximum Depth (m)	>1.0	Dom. Aquatic Veg. Type:	FA

Habitat Distribution



Substrate Composition



Water Quality Data

Time of Day (HH:MM):	15:00
Water Temperature (°C):	10.6
Dissolved Oxygen (mg/L):	9.48
Sp. Conductivity (µs/cm):	435
pH:	8.05
Turbidity (NTU):	0.01

Channel Characteristics

Pattern:	IR
Islands:	N
Bars:	MD
Coupling:	DC
Confinement:	UN
Flow Stage:	Moderate

Fish Habitat Assessment Ratings

	Forage	**Coarse**	**Sportfish**
Spawning:	Moderate	Moderate	Moderate
Overwintering:	Moderate-Good	Moderate-Good	Moderate-Good
Rearing:	Moderate	Moderate	Moderate
Migration:	Good	Good	Good

Photo 1: Downstream right bank from T1 with pool and artificial boulders.

Photo 2: Downstream view from T45 with shallow run and woody debris.

Fish Sampling Data

Method		**Effort**	
Backpack Electrofisher (EB)		658	(s)
No Trapping		-	(hr)
Electrofisher Settings			
Volts	Freq. (Hz)	Duty Cycle (%)	Dist. (m)
205	30	12	330

Species	**Efish Catch** (n)	**Trap Catch** (n)	**Efish CPUE** (#fish/100s)	**Trap CPUE** (#fish/hr)	**Rel. Abundance** (% of total)
LONGNOSE DACE	1		0.15	-	33.3%
LONGNOSE SUCKER	1	-	0.15	-	33.3%
BROOK TROUT	1	-	0.15	-	33.3%
-	-	-	-	-	-
-	-	-	-	-	-

General Comments

Prepared by: JJ Reviewed by: LA

Springbank Off-Stream Reservoir Project

Reach 11: Elbow River

UTM Location:	11U 693449E 5655410N	**Survey Date:**	September 22, 2016
Legal Location:	NE-05-024-02 W5M	**Water Body Name:**	Elbow River
Crew Initials:	GS, MS, BN	**Project Number:**	110773996

DS UTM Start: 11U 693449E 5655410N	**US UTM Finish:** 11U 693410E 565438N	**Embeddedness:** Low (<25%)	**Silt Cover:** None

Substrate Size Class

For Material greater than 2 mm in diameter, record the diameter of the intermediate axis to the nearest millimeter. For organic, fine, sand and bedrock materails record the following abbreviation:

Organics (O)		Fines (silt/clay) <0.06 mm (F)		Sand 0.06 - 2 mm (S)		Bedrock (BD)	
Diameter of Intermediate Axis (mm)							
1	123 mm	26	42 mm	51	13 mm	76	79 mm
2	27 mm	27	45 mm	52	77 mm	77	66 mm
3	31 mm	28	64 mm	53	99 mm	78	54 mm
4	6 mm	29	22 mm	54	21 mm	79	23 mm
5	53 mm	30	79 mm	55	54 mm	80	105 mm
6	35 mm	31	29 mm	56	65 mm	81	31 mm
7	25 mm	32	71 mm	57	102 mm	82	36 mm
8	12 mm	33	128 mm	58	121 mm	83	75 mm
9	33 mm	34	21 mm	59	54 mm	84	20 mm
10	32 mm	35	40 mm	60	72 mm	85	23 mm
11	19 mm	36	96 mm	61	149 mm	86	29 mm
12	31 mm	37	76 mm	62	175 mm	87	46 mm
13	51 mm	38	22 mm	63	41 mm	88	21 mm
14	24 mm	39	39 mm	64	68 mm	89	23 mm
15	86 mm	40	15 mm	65	97 mm	90	25 mm
16	115 mm	41	61 mm	66	34 mm	91	101 mm
17	42 mm	42	101 mm	67	40 mm	92	95 mm
18	36 mm	43	17 mm	68	48 mm	93	32 mm
19	201 mm	44	165 mm	69	136 mm	94	94 mm
20	50 mm	45	20 mm	70	45 mm	95	86 mm
21	21 mm	46	56 mm	71	149 mm	96	55 mm
22	93 mm	47	112 mm	72	44 mm	97	32 mm
23	95 mm	48	10 mm	73	35 mm	98	18 mm
24	91 mm	49	142 mm	74	61 mm	99	46 mm
25	60 mm	50	F	75	21 mm	100	68 mm

Side Notes

Prepared by: XX Reviewed by: XX

Springbank Off-Stream Reservoir Project

Reach 12: Elbow River

UTM Location:	11U 696243E 5654512N	**Survey Date:**	September 21, 2016
Legal Location:	NW-34-023-02 W5M	**Water Body Class:**	Class C
Crew Initials:	GS, BN, LA	**Restricted Activity Period:**	May 1-July 15 & Sept 16-Apri

Physical Channel Transect Data

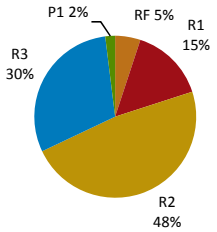
Transect # (Location)	**T1**	**T2**	**T3**	**T4**	**T5**	**T6**
Channel Width (m)	25	21	29	27	24	18
Wetted Width (m)	15	18	25	22	22	16
Depth at LDB + 25% (m)	>1.0	>1.0	>1.0	0.3	0.4	0.5
Depth at LDB + 50% (m)	>1.0	0.5	0.5	0.6	0.1	0.6
Depth at LDB + 75% (m)	0.7	0.5	0.4	0.6	>1.0	0.5
Max. Depth (m)	>1.0	>1.0	>1.0	0.7	>1.0	0.6
Gradient (%)	-	-	-	-	-	-
Dominant Habitat Unit	R1	R2	R2	R2	R2	R3
Stream Bed						
Substrate (% of Transect Area) – Organics	-	-	-	-	-	-
Fines	-	10	5	10	10	-
Small Gravel	10	20	5	15	5	10
Large Gravel	50	40	60	40	35	30
Cobble	30	30	30	35	45	60
Boulder	10	-	-	-	5	-
Bedrock	-	-	-	-	-	
Embeddedness	L	L	L	L	L	L

Bank Measurements	**Left Right**	**Left Right**	**Left Right**	**Left Right**	**Left Right**	**Left Right**
Bank Height (m)	0.4 / 0.4	0.2 / 0.2	0.35 / 0.35	0.20 / 0.20	0.25 / 0.25	0.25 / 0.25
Bank Slope (°)	40 / 05	90 / 05	05 / 05	05 / 90	05 / 90	90 / 05
Bank Stability	MS / S	US / MS	MS / MS	MS / US	S / US	US / S
Dom. Bank Material	F / LG	F / LG	LG / LG	S / F	LG /F	F / LG
Subdom. Bank Material	A / C	LG / S	S / S	LG / LG	C / LG	LG / S
Dom. Riparian Veg.	S / S	S / G	S / S	S / S	S / S	S / S
Subdom. Riparian Veg.	G / G	G / S	G / G	G / G	G / G	C / G

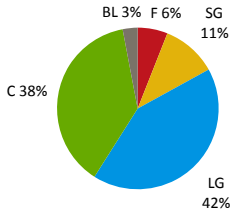
Habitat Inventory / Reach Data

Instream Cover (%):	85	Overhead Cover (%):	15
Dom. Instream Cover:	WC	Dom. Overhead Cover:	OV
Subdom. Instream Cover:	B	Subdom. Overhead Cover:	UC
Maximum Depth (m)	>1.0	Dom. Aquatic Veg. Type:	FA

Habitat Distribution



Substrate Composition



Water Quality Data

Time of Day (HH:MM):	16:00
Water Temperature (°C):	10.9
Dissolved Oxygen (mg/L):	9.38
Sp. Conductivity (µs/cm):	442
pH:	8.14
Turbidity (NTU):	0.14

Channel Characteristics

Pattern:	IR
Islands:	I
Bars:	MD
Coupling:	DC
Confinement:	UN
Flow Stage:	Moderate

Fish Habitat Assessment Ratings

	Forage	**Coarse**	**Sportfish**
Spawning:	Moderate	Moderate	Moderate
Overwintering:	Good	Good	Good
Rearing:	Good	Moderate	Moderate
Migration:	Good	Good	Good

Photo 1: Downstream left bank, deep run and boulder from T1.

Photo 2: Upstream view from T5 with run and woody debris.

Fish Sampling Data

Method		**Effort**	
Backpack Electrofisher (EB)		367	(s)
No Trapping		-	(hr)
Electrofisher Settings			
Volts	Freq. (Hz)	Duty Cycle (%)	Dist. (m)
225	30	12	375

Species	**Efish Catch (n)**	**Trap Catch (n)**	**Efish CPUE (#fish/100s)**	**Trap CPUE (#fish/hr)**	**Rel. Abundance (% of total)**
LONGNOSE DACE	3		0.82	-	50.0%
LONGNOSE SUCKER	3	-	0.82	-	50.0%
-	-	-	-	-	-
-	-	-	-	-	-
-	-	-	-	-	-

General Comments

Prepared by: JJ Reviewed by: LA

Springbank Off-Stream Reservoir Project

Reach 12: Elbow River

UTM Location:	11U 696500E 5654438N	**Survey Date:**	September 22, 2016
Legal Location:	NE-34-023-02 W5M	**Water Body Name:**	Elbow River
Crew Initials:	GS, MS, BN	**Project Number:**	110773996

DS UTM Start: 11U 696500E 5654438N	**US UTM Finish:** 11U 696424E 5654444N	**Embeddedness:** None	**Silt Cover:** None

Substrate Size Class

For Material greater than 2 mm in diameter, record the diameter of the intermediate axis to the nearest millimeter. For organic, fine, sand and bedrock materails record the following abbreviation:

Organics (O)		Fines (silt/clay) <0.06 mm (F)		Sand 0.06 - 2 mm (S)		Bedrock (BD)	
Diameter of Intermediate Axis (mm)							
1	42 mm	26	99 mm	51	62 mm	76	34 mm
2	28 mm	27	81 mm	52	11 mm	77	64 mm
3	36 mm	28	44 mm	53	54 mm	78	53 mm
4	14 mm	29	82 mm	54	58 mm	79	31 mm
5	11 mm	30	55 mm	55	42 mm	80	37 mm
6	62 mm	31	34 mm	56	54 mm	81	36 mm
7	14 mm	32	48 mm	57	17 mm	82	62 mm
8	29 mm	33	F	58	38 mm	83	56 mm
9	23 mm	34	12 mm	59	41 mm	84	33 mm
10	54 mm	35	80 mm	60	19 mm	85	34 mm
11	12 mm	36	46 mm	61	28 mm	86	53 mm
12	20 mm	37	35 mm	62	15 mm	87	102 mm
13	36 mm	38	65 mm	63	28 mm	88	64 mm
14	49 mm	39	54 mm	64	31 mm	89	71 mm
15	5 mm	40	103 mm	65	39 mm	90	91 mm
16	47 mm	41	71 mm	66	54 mm	91	52 mm
17	4 mm	42	62 mm	67	47 mm	92	33 mm
18	40 mm	43	98 mm	68	29 mm	93	54 mm
19	58 mm	44	50 mm	69	36 mm	94	F
20	135 mm	45	62 mm	70	25 mm	95	40 mm
21	69 mm	46	54 mm	71	48 mm	96	F
22	81 mm	47	66 mm	72	50 mm	97	69 mm
23	146 mm	48	25 mm	73	47 mm	98	33 mm
24	161 mm	49	63 mm	74	20 mm	99	80 mm
25	67 mm	50	35 mm	75	99 mm	100	4 mm

Side Notes

Prepared by: XX Reviewed by: XX

Attachment B BENTHIC INVERTEBRATE FIELD DATA

B.1 PHYSICAL PARAMETER AND WATER CHEMISTRY FIELD DATA

The following data sheets provide field collected data for physical parameters and water chemistry for each benthic invertebrate sampling site.

Springbank Off-Stream Reservoir Project

Reach 1: Elbow River

UTM Location:	11U 0675739E 5652852N	Survey Date:	October 11, 2016
Legal Location:	SE-33-023-04 W5M	Site Name:	ER1 (Benthic Invertebrate Site)
Crew Initials:	ML, JJ	Sampler Type:	Neill-Hess Cylinder

Sampling Location Physical Data

Depth (cm)	1	2	3	Mean
ER1-1	35	32	34	34
ER1-2	31	31	33	32
ER1-3	30	31	32	31
Site Mean				32
Site SD				1

Velocity (cm/s)	1	2	3	Mean
ER1-1	70	67	59	65
ER1-2	73	70	62	68
ER1-3	67	62	56	62
Site Mean				65
Site SD				3

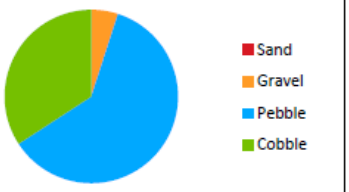
Water Chemistry Data

Time of Day (HH:MM):	15:50
Water Temperature (°C):	6.3
Dissolved Oxygen (mg/L):	12.3
Dissolved Oxygen (%)	100
Sp. Conductivity (µS/cm):	383
pH:	8.4

Substrate (%)	ER1-1	ER1-2	ER1-3	Site Mean	Site SD
Coarse Sand (1 - 2 mm)	0.0	0.0	0.0	0.0	0.0
Gravel (2 - 16 mm)	6	3	6	5	2
Pebble (16 - 64 mm)	61	50	72	61	11
Cobble (64 - 256 mm)	34	47	22	34	12

Amount of Algae on Substrates: none to minimal

Substrate Composition



General Comments

Photo 1: Site ER1 looking upstream

Photo 2. Site ER1 substrate

Reach 2: Elbow River

UTM Location:	11U 0676678E 565655N	Survey Date:	October 17, 2016
Legal Location:	SW-10-024-04 W5M	Site Name:	ER2 (Benthic Invertebrate Site)
Crew Initials:	ML, JJ	Sampler Type:	Neill-Hess Cylinder

Sampling Location Physical Data

Depth (cm)	1	2	3	Mean
ER2-1	30	29	30	30
ER2-2	29	31	30	30
ER2-3	29	31	31	30
Site Mean				30
Site SD				0.3

Velocity (cm/s)	1	2	3	Mean
ER2-1	71	71	56	66
ER2-2	57	71	67	65
ER2-3	62	65	74	67
Site Mean				66
Site SD				1.0

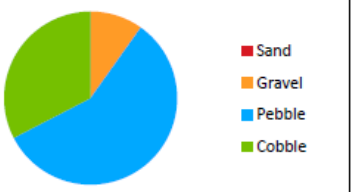
Water Chemistry Data

Time of Day (HH:MM):	11:00
Water Temperature (°C):	4.2
Dissolved Oxygen (mg/L):	12.8
Dissolved Oxygen (%)	98
Sp. Conductivity (µS/cm):	388
pH:	8.3

Substrate (%)	ER2-1	ER2-2	ER2-3	Site Mean	Site SD
Coarse Sand (1 - 2 mm)	0.0	0.1	0.1	0.1	0.0
Gravel (2 - 16 mm)	9	11	9	10	1
Pebble (16 - 64 mm)	70	47	56	58	11
Cobble (64 - 256 mm)	21	42	35	33	11

Amount of Algae on Substrates: none to minimal

Substrate Composition



General Comments

Photo 1: Site ER2 looking downstream

Photo 2. Site ER2 substrate

Springbank Off-Stream Reservoir Project

Reach 3: Elbow River

UTM Location:	11U 0677499E 5656447N	Survey Date:	October 11, 2016
Legal Location:	NE-10-024-04 W5M	Site Name:	ER3 (Benthic Invertebrate Site)
Crew Initials:	ML, JJ	Sampler Type:	Neill-Hess Cylinder

Sampling Location Physical Data

Depth (cm)	1	2	3	Mean
ER3-1	36	36	40	37
ER3-2	38	40	38	39
ER3-3	39	36	38	38
Site Mean				38
Site SD				1

Velocity (cm/s)	1	2	3	Mean
ER3-1	38	47	31	39
ER3-2	34	48	43	41
ER3-3	48	42	47	46
Site Mean				42
Site SD				4

Water Chemistry Data

Time of Day (HH:MM):	13:30
Water Temperature (°C):	6.2
Dissolved Oxygen (mg/L):	12.7
Dissolved Oxygen (%)	102
Sp. Conductivity (µS/cm):	387
pH:	8.2

Substrate (%)	ER3-1	ER3-2	ER3-3	Site Mean	Site SD
Coarse Sand (1 - 2 mm)	0.5	1.1	1.2	0.9	0.4
Gravel (2 - 16 mm)	19	19	15	18	3
Pebble (16 - 64 mm)	44	51	51	49	4
Cobble (64 - 256 mm)	37	28	33	33	4

Amount of Algae on Substrates: moderate

Substrate Composition

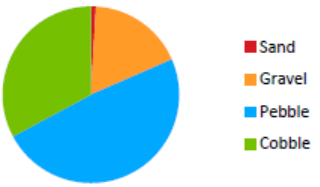


Photo 2. Site ER3 substrate

Photo 1: Site ER3 looking upstream

General Comments

Upstream of Highway 22 Bridge

Reach 5: Elbow River

UTM Location:	11U 0680813E 5657966N	Survey Date:	October 17, 2016
Legal Location:	SE-13-024-04 W5M	Site Name:	ER5 (Benthic Invertebrate Site)
Crew Initials:	ML, JJ	Sampler Type:	Neill-Hess Cylinder

Sampling Location Physical Data

Depth (cm)	1	2	3	Mean
ER5-1	29	32	31	31
ER5-2	32	30	33	32
ER5-3	33	31	31	32
Site Mean				31
Site SD				0.6

Velocity (cm/s)	1	2	3	Mean
ER5-1	58	56	58	57
ER5-2	50	62	62	58
ER5-3	49	64	65	59
Site Mean				58
Site SD				1.0

Water Chemistry Data

Time of Day (HH:MM):	13:50
Water Temperature (°C):	5.9
Dissolved Oxygen (mg/L):	12.2
Dissolved Oxygen (%)	98
Sp. Conductivity (µS/cm):	390
pH:	8.4

Substrate (%)	ER5-1	ER5-2	ER5-3	Site Mean	Site SD
Coarse Sand (1 - 2 mm)	0.8	1.0	1.8	1.2	0.5
Gravel (2 - 16 mm)	19	27	21	22	4
Pebble (16 - 64 mm)	48	53	36	46	9
Cobble (64 - 256 mm)	33	19	41	31	11

Amount of Algae on Substrates: low

Substrate Composition

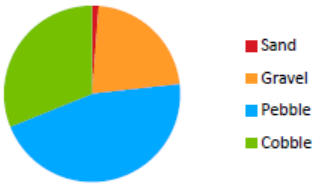


Photo 2. Site ER5 substrate

Photo 1: Site ER5 looking upstream

General Comments

Springbank Off-Stream Reservoir Project

Reach 6: Elbow River

UTM Location:	11U 0683348E 5658136N	Survey Date:	October 12, 2016
Legal Location:	NE-17-024-03 W5M	Site Name:	ER6 (Benthic Invertebrate Site)
Crew Initials:	ML, JJ	Sampler Type:	Neill-Hess Cylinder

Sampling Location Physical Data

Depth (cm)	1	2	3	Mean
ER6-1	34	34	33	34
ER6-2	35	38	36	36
ER6-3	36	33	35	35
Site Mean				35
Site SD				1

Velocity (cm/s)	1	2	3	Mean
ER6-1	33	41	30	35
ER6-2	43	52	46	47
ER6-3	49	43	43	45
Site Mean				42
Site SD				7

Water Chemistry Data

Time of Day (HH:MM):	11:00
Water Temperature (°C):	3.9
Dissolved Oxygen (mg/L):	13.1
Dissolved Oxygen (%)	100
Sp. Conductivity (µS/cm):	407
pH:	8.2

Substrate (%)	ER6-1	ER6-2	ER6-3	Site Mean	Site SD
Coarse Sand (1 - 2 mm)	0.1	0.2	0.3	0.2	0.1
Gravel (2 - 16 mm)	8	10	10	10	1
Pebble (16 - 64 mm)	33	45	60	46	13
Cobble (64 - 256 mm)	59	44	30	44	15

Amount of Algae on Substrates: moderate

Substrate Composition

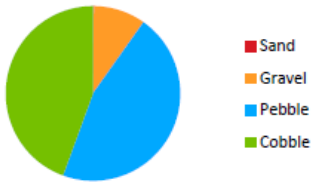


Photo 1: Site ER6 looking upstream

Photo 2. Site ER6 substrate

General Comments

Upstream end of River Spirit Golf Course

Reach 7: Elbow River

UTM Location:	11U 0683987E 5657607N	Survey Date:	October 12, 2016
Legal Location:	SE-17-024-03 W5M	Site Name:	ER7 (Benthic Invertebrate Site)
Crew Initials:	ML, JJ	Sampler Type:	Neill-Hess Cylinder

Sampling Location Physical Data

Depth (cm)	1	2	3	Mean
ER7-1	30	29	30	30
ER7-2	31	32	32	32
ER7-3	29	34	31	31
Site Mean				31
Site SD				1.1

Velocity (cm/s)	1	2	3	Mean
ER7-1	56	56	50	54
ER7-2	56	52	64	57
ER7-3	62	54	65	61
Site Mean				57
Site SD				3.4

Water Chemistry Data

Time of Day (HH:MM):	13:30
Water Temperature (°C):	5.7
Dissolved Oxygen (mg/L):	13.0
Dissolved Oxygen (%)	104
Sp. Conductivity (µS/cm):	399
pH:	8.2

Substrate (%)	ER7-1	ER7-2	ER7-3	Site Mean	Site SD
Coarse Sand (1 - 2 mm)	1.0	1.1	0.2	0.8	0.5
Gravel (2 - 16 mm)	21	17	20	19	2
Pebble (16 - 64 mm)	56	40	58	51	10
Cobble (64 - 256 mm)	22	42	22	29	12

Amount of Algae on Substrates: moderate

Substrate Composition

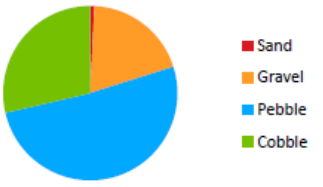


Photo 1: Site ER7 looking upstream

Photo 2. Site ER7 substrate

General Comments

Downstream end of River Spirit Golf Course

Springbank Off-Stream Reservoir Project

Reach 9: Elbow River

UTM Location:	11U 0687704E 5656774N	Survey Date:	October 13, 2016
Legal Location:	NW-11-024-03 W5M	Site Name:	ER9 (Benthic Invertebrate Site)
Crew Initials:	ML, JJ	Sampler Type:	Neill-Hess Cylinder

Sampling Location Physical Data

Depth (cm)	1	2	3	Mean
ER9-1	29	32	33	31
ER9-2	29	31	32	31
ER9-3	29	32	30	30
Site Mean				31
Site SD				1

Velocity (cm/s)	1	2	3	Mean
ER9-1	59	59	51	56
ER9-2	53	55	55	54
ER9-3	61	64	56	60
Site Mean				57
Site SD				3

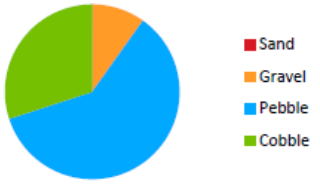
Water Chemistry Data

Time of Day (HH:MM):	10:30
Water Temperature (°C):	4.1
Dissolved Oxygen (mg/L):	12.8
Dissolved Oxygen (%)	98
Sp. Conductivity (µS/cm):	402
pH:	8.2

Substrate (%)	ER9-1	ER9-2	ER9-3	Site Mean	Site SD
Coarse Sand (1 - 2 mm)	0.1	0.1	0.0	0.1	0.1
Gravel (2 - 16 mm)	10	7	12	10	3
Pebble (16 - 64 mm)	69	50	61	60	9
Cobble (64 - 256 mm)	21	42	27	30	11

Amount of Algae on Substrates: low to moderate

Substrate Composition



General Comments

Upstream end Glencoe Golf Course

Photo 1: Site ER9 looking upstream

Photo 2. Site ER9 substrate

Reach 10: Elbow River

UTM Location:	11U 0690991E 5656152N	Survey Date:	October 13, 2016
Legal Location:	SW-07-024-02 W5M	Site Name:	ER10 (Benthic Invertebrate Site)
Crew Initials:	ML, JJ	Sampler Type:	Neill-Hess Cylinder

Sampling Location Physical Data

Depth (cm)	1	2	3	Mean
ER10-1	33	35	34	34
ER10-2	33	37	34	35
ER10-3	35	36	34	35
Site Mean				35
Site SD				0.5

Velocity (cm/s)	1	2	3	Mean
ER10-1	59	53	52	54
ER10-2	59	47	65	57
ER10-3	59	57	53	56
Site Mean				56
Site SD				1.3

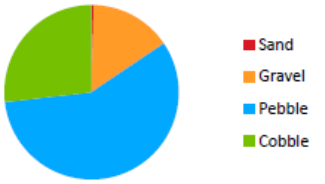
Water Chemistry Data

Time of Day (HH:MM):	13:20
Water Temperature (°C):	5.4
Dissolved Oxygen (mg/L):	12.6
Dissolved Oxygen (%)	100
Sp. Conductivity (µS/cm):	406
pH:	8.4

Substrate (%)	ER10-1	ER10-2	ER10-3	Site Mean	Site SD
Coarse Sand (1 - 2 mm)	0.1	0.5	0.6	0.4	0.3
Gravel (2 - 16 mm)	12	16	18	15	3
Pebble (16 - 64 mm)	65	63	44	58	12
Cobble (64 - 256 mm)	23	20	37	27	9

Amount of Algae on Substrates: moderate to heavy

Substrate Composition



General Comments

Downstream end of Glencoe Golf Course

Photo 1: Site ER10 looking downstream

Photo 2. Site ER10 substrate

Springbank Off-Stream Reservoir Project

Reach 11: Elbow River

UTM Location:	11U 0693496E 5655376N	**Survey Date:**	October 12, 2016
Legal Location:	NE-05-024-02 W5M	**Site Name:**	ER11 (Benthic Invertebrate Site)
Crew Initials:	ML, JJ	**Sampler Type:**	Neill-Hess Cylinder

Sampling Location Physical Data

Depth (cm)	1	2	3	Mean
ER11-1	35	32	34	34
ER11-2	30	32	34	32
ER11-3	30	31	33	31
Site Mean				32
Site SD				1

Velocity (cm/s)	1	2	3	Mean
ER11-1	59	49	56	55
ER11-2	55	51	59	55
ER11-3	62	62	53	59
Site Mean				56
Site SD				2

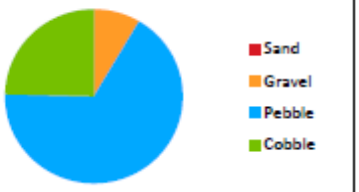
Water Chemistry Data

Time of Day (HH:MM):	15:55
Water Temperature (°C):	7.2
Dissolved Oxygen (mg/L):	12.3
Dissolved Oxygen (%)	102
Sp. Conductivity (µS/cm):	407
pH:	8.2

Substrate (%)	ER11-1	ER11-2	ER11-3	Site Mean	Site SD
Coarse Sand (1 - 2 mm)	0.1	0.0	0.0	0.0	0.1
Gravel (2 - 16 mm)	11	7	8	8	2
Pebble (16 - 64 mm)	68	61	71	67	5
Cobble (64 - 256 mm)	21	32	22	25	6

Amount of Algae on Substrates: low to moderate

Substrate Composition



General Comments

Upstream of Highway 8 Bridge
Some filamentous algae present along the shoreline

Photo 2. Site ER11 substrate

Photo 1: Site ER11 looking upstream

Reach 12: Elbow River

UTM Location:	11U 0696109E 5654473N	**Survey Date:**	October 13, 2016
Legal Location:	NW-34-023-02 W5M	**Site Name:**	ER12 (Benthic Invertebrate Site)
Crew Initials:	ML, JJ	**Sampler Type:**	Neill-Hess Cylinder

Sampling Location Physical Data

Depth (cm)	1	2	3	Mean
ER12-1	35	33	34	34
ER12-2	34	30	32	32
ER12-3	36	32	34	34
Site Mean				33
Site SD				1.2

Velocity (cm/s)	1	2	3	Mean
ER12-1	56	51	49	52
ER12-2	57	55	50	54
ER12-3	55	48	51	51
Site Mean				52
Site SD				1.5

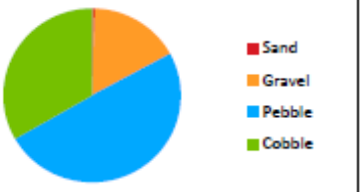
Water Chemistry Data

Time of Day (HH:MM):	15:45
Water Temperature (°C):	6.3
Dissolved Oxygen (mg/L):	12.6
Dissolved Oxygen (%)	102
Sp. Conductivity (µS/cm):	420
pH:	8.3

Substrate (%)	ER12-1	ER12-2	ER12-3	Site Mean	Site SD
Coarse Sand (1 - 2 mm)	0.6	0.7	0.3	0.5	0.2
Gravel (2 - 16 mm)	15	20	15	17	3
Pebble (16 - 64 mm)	51	50	49	50	1
Cobble (64 - 256 mm)	34	30	36	33	3

Amount of Algae on Substrates: low to moderate

Substrate Composition



General Comments

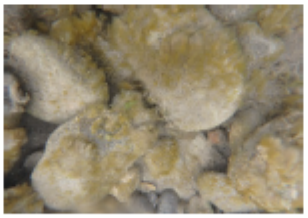


Photo 2. Site ER12 substrate

Photo 1: Site ER12 looking upstream

B.2 BENTHIC INVERTEBRATE DATA RESULTS FOR THE ELBOW RIVER

Table B-1 Benthic Invertebrate Data Results for the Elbow River

	Mean Density (number/m²)									
Site	**ER1**	**ER2**	**ER3**	**ER5**	**ER6**	**ER7**	**ER9**	**ER10**	**ER11**	**ER12**
Taxa										
Phylum: Arthropoda										
Class: Insecta										
Order: Ephemeroptera										
Family: Siphlonuridae										
Ameletus sp.	22	37	22	4	362	37	97	11	108	0
Family: Baetidae										
Acentrella sp.	0	26	4	4	0	0	11	0	0	0
Baetis sp.	1798	4667	21584	5394	22896	22859	14126	47167	13244	13464
Family: Caenidae										
Caenis sp.	0	0	0	0	0	0	0	0	0	4
Family: Ephemerellidae										
Drunella doddsi	49	30	0	0	0	0	0	0	0	0
Drunella grandis ingens	0	0	26	0	37	34	7	64	0	37
Ephemerella sp.	26	303	747	440	2747	3651	994	4462	2130	4170
Family: Heptageniidae										
Cinygmula sp.	3060	5658	2362	2475	774	1278	1001	22	583	179
Epeorus sp.	2635	504	912	358	172	471	684	153	164	19
McCaffertium sp.	0	0	0	0	7	0	0	0	15	4
Rhithrogena sp.	695	605	142	1061	277	579	774	206	561	108
Family: Leptophlebiidae										
Paraleptophlebia sp.	239	217	404	638	1809	2713	1741	1013	2194	478
Order: Trichoptera										
Family: Brachycentridae										
Brachycentrus sp.	56	120	11	78	30	120	564	183	49	362
Family: Glossosomatidae										
Glossosoma sp.	0	11	15	7	0	4	0	0	0	30
Family: Hydropsychidae										
Arctopsyche sp.	19	15	11	0	4	4	7	0	0	0

Table B-1 Benthic Invertebrate Data Results for the Elbow River

	Mean Density (number/m²)									
Site	**ER1**	**ER2**	**ER3**	**ER5**	**ER6**	**ER7**	**ER9**	**ER10**	**ER11**	**ER12**
Taxa										
Cheumatopsyche sp.	0	0	0	0	4	164	15	4	22	19
Hydropsyche sp.	463	788	101	385	164	1095	1338	105	878	994
Family: Hydroptilidae										
Hydroptila sp.	0	0	321	25	2160	643	191	340	7	19
Ochrotrichia sp.	0	4	183	0	22	11	0	4	0	0
Oxyethira sp.	0	0	0	0	4	0	0	0	0	0
Family: Lepidostomatidae										
Lepidostoma sp.	26	34	15	7	146	60	519	183	247	247
Family: Leptoceridae										
Oecetis sp.	0	0	4	0	11	0	4	7	0	64
Family: Rhyacophilidae										
Rhyacophila sp.	4	0	0	0	0	4	4	0	0	0
Order: Plecoptera										
Family: Capniidae	252	665	64	903	168	475	19	0	45	0
Family: Chloroperlidae	272	131	220	331	389	269	452	153	396	467
Sweltsa sp.	198	157	60	86	105	123	202	105	161	22
Family: Leuctridae	22	112	19	272	0	19	15	0	0	0
Family: Nemouridae	123	93	157	7	11	318	41	149	0	7
Zapada cinctipes	52	45	7	19	7	4	4	4	0	0
Family: Perlidae										
Claassenia sabulosa	15	26	19	7	93	127	116	4	168	7
Calineuria californica	0	0	0	0	0	0	0	0	4	0
Hesperoperla pacifica	56	45	149	26	26	22	7	11	4	0
Family: Perlodidae	0	0	0	0	0	0	7	0	0	4
Cultus sp.	0	0	4	0	4	0	0	0	0	0
Isoperla sp.	19	52	254	75	164	228	333	138	97	45
Skwala americana	0	0	0	15	4	0	0	0	0	4
Family: Pteronarcyidae										
Pteronarcella sp.	0	0	0	4	0	0	30	4	0	0
Pteronacys sp.	0	0	0	0	0	0	0	0	0	7

Table B-1 Benthic Invertebrate Data Results for the Elbow River

	Mean Density (number/m²)									
Site	**ER1**	**ER2**	**ER3**	**ER5**	**ER6**	**ER7**	**ER9**	**ER10**	**ER11**	**ER12**
Taxa										
Family: Taeniopterygidae										
Taenionema sp.	572	1001	602	284	11	516	15	4	4	26
Order: Diptera	0	0	0	0	0	0	0	0	0	0
Family: Athericidae										
Atherix sp.	0	15	93	15	93	45	15	209	15	22
Family: Ceratopogonidae	0	0	0	0	4	0	0	0	0	0
Family: Empididae										
Chelifera sp.	69	392	3348	578	5942	6551	1816	1368	2100	3913
Hemerodromia sp.	0	0	0	0	0	0	0	321	4	990
Wiedemannia sp.	4	4	4	0	19	344	11	325	19	71
Family: Psychodidae										
Pericoma sp.	4	7	0	4	4	149	4	4	0	0
Family: Simuliidae										
Simulium sp.	0	142	0	49	0	11	7	153	4	0
Family: Oreoleptidae										
Oreoleptis torrenticola	0	7	4	0	0	0	0	0	0	0
Family: Tanyderidae										
Protanyderus sp.	0	0	0	0	0	0	0	4	0	4
Family: Tipulidae										
Antocha sp.	25	4	93	0	7	7	0	4	0	0
Dicranota sp.	0	15	4	0	7	0	0	0	0	0
Hesperoconopa sp.	0	0	0	0	0	0	4	0	0	0
Hexatoma sp.	37	41	19	26	15	26	4	30	11	202
Limnophila sp.	4	11	4	7	19	7	15	52	11	41
Tipula sp.	0	0	0	0	4	0	0	0	0	4
Family: Chironomidae										
Subfamily: Chironominae										
Tribe: Chironomini										
Chironomus sp.	30	0	4	0	0	0	0	0	0	0
Microtendipes sp.	4	0	0	0	11	0	0	0	0	0

Table B-1 Benthic Invertebrate Data Results for the Elbow River

	Mean Density (number/m²)									
Site	**ER1**	**ER2**	**ER3**	**ER5**	**ER6**	**ER7**	**ER9**	**ER10**	**ER11**	**ER12**
Taxa										
Paracladopelma sp.	0	0	149	0	0	0	0	0	0	0
Phaenopsectra sp.	0	4	0	0	0	0	0	0	0	0
Polypedilum sp.	703	404	75	488	0	0	1536	1046	815	1106
Tribe: Tanytarsini										
Cladotanytarsus sp.	1774	1080	11502	2034	29529	8221	5437	31689	3318	11794
Micropsectra sp.	2488	4077	7915	5575	8905	6297	4372	1058	5859	2881
Paratanytarsus sp.	0	0	0	0	149	0	0	0	0	0
Rheotanytarsus sp.	140	598	1730	15	2037	904	460	0	135	149
Stempellinella sp.	6076	3804	4122	2209	6278	8221	4148	19880	4021	4036
Sublettea sp.	0	120	7164	633	17096	16162	6584	31842	6323	8251
Tanytarsus spp.	3863	5168	55579	3440	166850	83423	51480	354320	52194	111839
Subfamily: Diamesinae										
Diamesa sp.	0	34	149	32	0	598	187	153	187	303
Pagastia spp.	4	336	1883	406	12201	8143	1562	15419	2351	5217
Potthstia gaedii gp. sp.	0	0	75	0	561	676	258	1132	706	691
Potthastia longimana gp. sp.	0	0	22	0	161	157	0	329	0	336
Subfamily: Orthocladiinae	0	30	0	7	897	0	0	149	4	149
Brillia sp.	0	60	0	0	149	0	4	4	0	0
Corynoneura sp.	0	0	153	127	299	0	0	149	224	329
Cricotopus/Orthocladius spp.	230	1069	90213	5085	207814	124955	31939	128920	43262	65990
Eukiefferiella spp.	199	460	2500	132	448	2709	766	3143	628	299
Heleniella sp.	74	400	7	380	157	172	613	26	41	116
Heterotrissocladius sp.	4	0	4	0	161	0	0	0	4	0
Krenosmittia sp.	30	67	0	194	0	0	37	149	0	149
Nanocladius sp.	0	0	75	0	0	0	0	0	0	0
Parakiefferiella spp.	55	0	448	0	2018	1046	149	1943	374	1286
Parametriocnemus sp.	0	37	86	7	7	4	157	325	15	11
Rheocricotopus sp.	0	60	75	0	0	0	0	0	0	0
Synorthocladius sp.	25	30	990	198	4865	2096	1158	448	3498	1674

Table B-1 Benthic Invertebrate Data Results for the Elbow River

	Mean Density (number/m²)									
Site	**ER1**	**ER2**	**ER3**	**ER5**	**ER6**	**ER7**	**ER9**	**ER10**	**ER11**	**ER12**
Taxa										
Thienemanniella sp.	25	0	78	4	0	149	0	0	0	0
Tvetenia sp.	59	512	602	198	1794	755	800	2840	359	3558
Subfamily: Tanypodinae										
Ablabesmyia sp.	0	0	7	4	0	0	0	0	0	0
Monopelopia sp.	0	0	0	0	4	0	0	0	0	0
Thienemannimyia gp.	229	277	7526	524	13972	9727	4854	27534	6218	7055
Order: Odonata										
Family: Gomphidae										
Ophiogomphus sp.	0	0	4	0	4	0	0	11	4	19
Order: Coleoptera										
Family: Dytiscidae										
Liodessus sp.	0	0	4	0	4	0	4	0	0	7
Oreodytes sp.	0	0	4	0	0	0	0	0	0	0
Stictotarsus sp.	0	0	0	0	0	0	7	0	0	0
Family: Dryopidae										
Helichus sp.	0	0	7	0	0	0	0	0	0	4
Family: Elmidae										
Optioservus sp.	0	4	187	11	661	377	168	497	235	927
Family: Haliplidae										
Brychius sp.	0	0	0	0	37	0	0	0	0	0
Order: Collembola	0	202	4	4	0	0	0	0	0	0
Class: Arachnida										
Suborder: Hydracarina	201	531	1966	167	3330	3262	1046	2362	1039	2649
Class: Crustacea										
Subclass: Ostracoda										
Order: Podocopida										
Family: Candonidae										
Candona sp.	479	209	598	1046	1050	605	2769	2997	3629	901
Subclass: Copepoda										
Order: Cyclopoida	50	60	0	37	299	0	0	0	0	0

Table B-1 Benthic Invertebrate Data Results for the Elbow River

	Mean Density (number/m²)									
Site	**ER1**	**ER2**	**ER3**	**ER5**	**ER6**	**ER7**	**ER9**	**ER10**	**ER11**	**ER12**
Taxa										
Order: Harpacticoida	0	90	0	37	2616	897	52	1797	149	15
Subclass: Branchiopoda										
Order: Cladocera										
Family: Chydoridae	0	0	0	0	1121	299	0	747	0	0
Phylum: Oligochaeta										
Class: Clitellata										
Order: Haplotaxida										
Family: Aeolosomatidae										
Aeolosoma sp.	0	71	0	0	0	0	0	0	0	0
Family: Enchytraeidae	30	34	299	0	153	299	0	456	78	1039
Family: Naididae	197	1132	29641	501	24275	21513	3602	99324	5822	15587
Family: Tubificidae	4	202	34	93	19	26	0	0	0	0
Order: Lumbriculida										
Family: Lumbriculidae	0	0	0	0	7	0	7	15	4	37
Phylum: Nematoda	639	232	239	161	202	325	191	620	120	426
Phylum: Mollusca										
Class: Gastropoda										
Order: Basommatophora										
Family: Lymnaeidae	0	0	0	0	0	0	0	0	0	4
Class: Pelecypoda										
Order: Veneroida										
Family: Pisidiidae										
Pisidium sp.	30	0	0	0	0	0	0	0	0	0
Phylum: Tardigrada	0	0	0	0	0	0	0	0	0	239
Phylum: Platyhelminthes										
Class: Turbellaria										
Order: Tricladida										
Family: Planariidae										
Polycelis coronata	4	4	7	15	26	280	108	64	183	97
Phylum: Cnidaria										

Table B-1 Benthic Invertebrate Data Results for the Elbow River

	Mean Density (number/m²)									
Site	**ER1**	**ER2**	**ER3**	**ER5**	**ER6**	**ER7**	**ER9**	**ER10**	**ER11**	**ER12**
Taxa										
Class: Hydrozoa										
Order: Anthoathercata										
Family: Hydridae										
Hydra sp.	0	0	0	0	7	0	0	0	0	0
Total Taxa/Site	**57**	**68**	**76**	**62**	**79**	**64**	**67**	**67**	**59**	**69**
Total Density/Site	**28458**	**37380**	**258117**	**37351**	**548898**	**345269**	**149652**	**788356**	**165041**	**275206**