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Sheep River Intake Feasibility Assessment

Final Revision 0

Project No. 142001

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1 INTRODUCTION

Sheep River Regional Utility Corporation (SRRUC) owns and operates a raw water system located in SE 06-20-02 W5M and SW 01-20-02 W5M[1], approximately one kilometer southeast of the Town of Diamond Valley. SRRUC's water supply system consists of four main producing water wells, a seasonal river water intake, a stilling basin, and a raw water reservoir, which supplies the water treatment plant (WTP) for distribution to the Town of Diamond Valley, and Foothills County. The location of the water supply infrastructure is highlighted in **Figure 1**.

While the four wells can produce water throughout the year, operation of the seasonal river water intake (the "Temporary Intake") is typically limited to the summer and fall months. Operations during winter and spring are limited by river ice cover and elevated turbidity levels, respectively. SRRUC is exploring options to replace the Temporary Intake with a new permanent river water intake that can be utilized continuously throughout the year and requires less operational effort. SRRUC's preferred location for the intake is directly south of the raw water reservoir, where the pipeline and power source are currently located for the Temporary Intake.

Through MPE a Division of Englobe (MPE), SRRUC has retained Boreal Water Resources Ltd. (Boreal) to prepare an Intake Feasibility Assessment that explores alternative intake types and locations for use on the Sheep River. The Study Area for this Intake Feasibility Assessment ranges from the present location of the Temporary Intake downstream to the bridge crossing at Decalta Drive. The results of the Intake Feasibility Assessment are summarized in this report

1.1 Scope of Work

In completing this Intake Feasibility Assessment for SRRUC, Boreal has undertaken the following tasks:

- Review of available background information.
- Field assessment, including a review of watercourse conditions and planform, assessment of relevant hydraulic features and identification of locations that may be suitable for different types of water intakes.
- Geomorphic assessment, including identification of potential geomorphic risks, such as avulsion, lateral erosion, channel migration, and scour.
- Hydraulic assessment to both inform the geomorphic assessment and to evaluate typical flow conditions in the Sheep River.
- Review of typical design requirements for several types of water intakes and evaluation of their suitability for use in the Study Area.
- Preparation of this summary report, including recommendations for SRRUC to consider in deciding on a future intake.

1.2 Available information

The following information was made available to Boreal for this Intake Feasibility Assessment:

- Historical air photos for the years 1950, 1962, 1987, 2005, 2013, 2020. Data Source: Alberta Air Photos Library (provided by MPE).
- LIDAR-based digital elevation model (DEM) with a 1.0 m resolution per pixel. Data source: AltaLis (survey dates: July 27, 2010; April 17, 2015).
- *Technical Memorandum 01: SRRUC River Intake*. Prepared by MPE Engineering Ltd. September 9, 2022. 12 p.

[1] Locations are presented in Alberta Township System format.

- *Sheep River Direct Intake Geotechnical Evaluation*. Prepared by MPE a Division of Englobe. November 24, 2023. 33 p.
- *Town of Turner Valley, Water Supply Infiltration Gallery Site Selection and Design River Engineering Assessment*. Prepared by Northwest Hydraulic Consultants. June 15, 1998. 20 p.
- *Town of Turner Valley Stage 2 Raw Water Direct Intake Civil Stilling Basin Plan*. Prepared by MPE Engineering Ltd. September 09, 2019.
- *Plan Showing Topographic Survey SE ¼ Sec 1-20-3W.5M. Turner Valley, AB*. Prepared by Measurement Sciences Inc, on June 9, 2022.
- *Turner Valley Municipal Groundwater Supply Evaluation – High-Level Review of Regional Geology and Hydrogeology Information.* Prepared by Stantec, June 22, 2016.
- *Stage 2 Water Supply Exploration Program Update – June 24, 2016 for Discussion Purposes Only*. Prepared by Stantec, June 24, 2016.

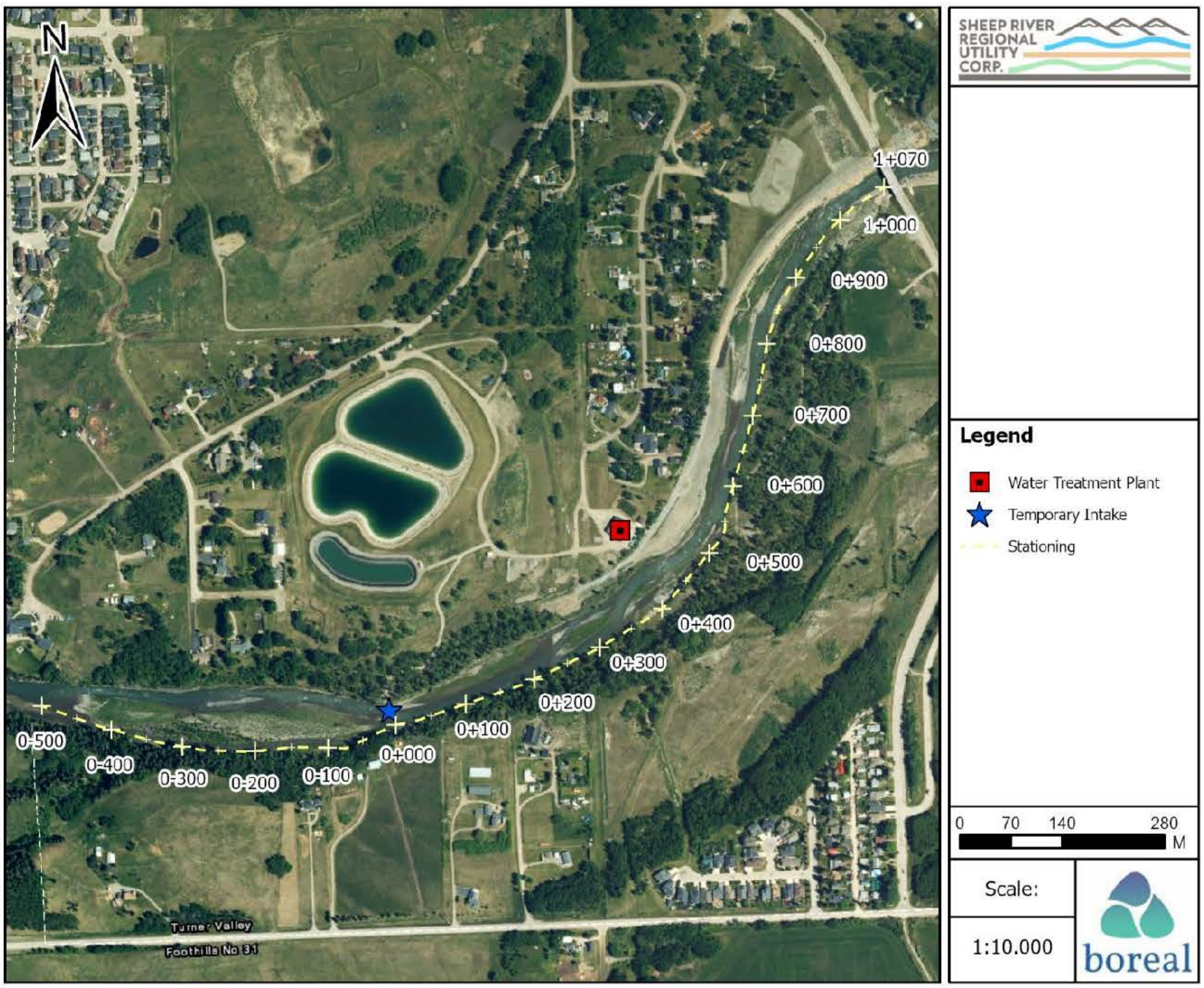

Figure 1: Project location.

2 BACKGROUND

2.1 Project History

The following presents a chronology of activities that have occurred on the project site as may be relevant to selecting a permanent intake option and/or location:

- In 1998, Northwest Hydraulic Consultants (NHC, 1998) was retained to evaluate potential locations for a direct infiltration intake style of raw water intake on the Sheep River. The study reach extended from the present-day WTP location downstream to the Decalta Road bridge crossing. In their study, NHC highlighted the benefits and risks associated with a direct infiltration intake, along with potential operational considerations related to management of sediment accumulation in the filtration media. NHC identified two potential locations for direct infiltration intake: one just upstream of the Decalta Road bridge crossing and the other directly across from the present-day WTP. The former location was coincident with the location of a previous direct infiltration intake that was noted for not performing very well; therefore, the location directly across from the WTP was selected. However, NHC emphasized caution in the use of a direct infiltration intake given high sediment loadings in the Sheep River.
- Prior to 1998, potable water for Turner Valley and neighbouring jurisdictions was obtained from several water wells situated adjacent to the north (left) abutment of the Decalta Road bridge crossing (NHC, 1998). These included Wells 2 through 5 and Well 7. In 2013 and 2014, MPE assisted Quad Regional Water Partnership with upgrades to this system, which included the installation of Well VW5 to convey water to the WTP. The present system consists of Vault Well 5 (VW5), Well 5A, Culvert Well 8 (CW8), and Well 7, with Well 4 available as a back-up water source.
- In 2016, Stantec Consulting Ltd. (Stantec) was retained to investigate the potential to augment the existing potable water supply with additional groundwater sources. Stantec (2016a) focused their assessment on potential groundwater locations that were near the WTP, upstream of the Turner Valley Gas Plant and within direct influence of surface water from the Sheep River. Several locations having some groundwater potential were identified within 2.9 km of the WTP; however, locations were noted as requiring multiple well installations to obtain the production rates required by SRRUC. Potential aquifer targets identified by Stantec are shown in **Appendix D**. Stantec had identified that an investigative drilling program at these locations would help to characterize aquifer potential; such a program was undertaken in 2016 (Stantec, 2016b), which confirmed that the Youth with a Mission (YWAM) site as the only viable option for groundwater extraction of those sites that were assessed. This site, however, has potential environmental liabilities related to an upslope septic field and potential for a former landfill site.
- As reported in MPE (2022), in 2017 Stantec had identified hydrocarbon contamination in the vicinity of the newly constructed stilling basin immediately upslope of the Temporary Intake. As the extents of the hydrocarbon plume was not fully delineated, the risk remained that the plume could extend to shallow soils or groundwater in the floodplain area. Therefore, further investigation may be required for any options under consideration to verify the presence (or lack thereof) of hydrocarbons.
- Around this same time, SRRUC proceeded with the installation of the Temporary Intake, which is described in detail in Section 2.3, below.
- In 2022, MPE was retained to complete a high-level intake options assessment for potential application at the Temporary Intake location. Alternative intake types that were considered

included a direct infiltration intake, water wells and a lateral (side) intake. Considering factors such as water quality, capacity, maintenance, and constructability, the report converged on a direct infiltration intake as the best suited for the conditions present at the Temporary Intake. This assessment was followed up with a bathymetric survey of Sheep River over a total length of 350 m centered at the Temporary Intake Location.

- A limited geotechnical investigation was completed by MPE in 2023 approximately 30 m upslope from the riverbank. This investigation identified a shallow depth to shale bedrock (approximately 2.2 to 2.5 meter below ground surface). However, the shale was noted as being extremely weak, which may allow for ease of excavation in the case of an infiltration intake trench.

2.2 Water Licencing

SRRUC's existing water supply is provided by four water wells located on the left bank of the Sheep River in river gravel deposits downstream of the existing WTP. Additionally, there is a seasonal river water intake (Temporary Intake) located upstream of the WTP, directly south of the raw water reservoir. Relevant water licenses associated with these water sources are summarized in **Table 1**.

Table 1: Active water licences held by SRRUC.

Licence / Amendment No.	Licence owner[1]	Well ID	Total gross diversion (m^3/yr)	Maximum Rate of Diversion	
				m^3/d	LPS
00032890-00-04	DV	TW5A	121,835	655	7.6
00032891-00-03	DV	TV7	117,181	2750	31.8
00032889-00-03	DV	Intake	93,745	982	11.4
00076672-00-04	DV	CW8	145,700	888	10.3 (9.8*)
00368807-00-00	DV	VW5	527,790	2062	23.9
00396077-00-00	DV	Intake	426,925	2074	67.0 (24.0)
00396081-00-00	DV	Intake	36,367	346	4.0
00404595-00-00	FC	Intake	10,430	346	4.0

Source: MPE (2022).
Note 1: DV = Diamond Valley; FC = Foothills County.

As noted in **Table 1**, SRRUC holds seven licences to divert water: four associated with the groundwater wells, and four with the existing Temporary Intake (Licence nos. 00032889-00-03, 00396077-00-00, 00396081-00-00, and 00404595-00-00). The combined volumes and rates that are associated with diversion from the Sheep River via the Temporary Intake are as follows[2]:

- Annual diversion volume: 567,467 cubic meters per year (m^3/yr),
- Maximum daily rate of diversion: 3,748 cubic meters per day (m^3/d), and

[2] Note that the licences themselves have not been reviewed as part of this Intake Feasibility Assessment.

- Maximum instantaneous rate of diversion: 86.4 liters per second (LPS).

SRRUC is seeking to replace the Temporary Intake with a permanent, less operationally intensive option. At this present time, it is understood that SRRUC is not seeking an increase to the allowable diversion rates identified above; rather, reliability of year-round operation is the primary purpose for this permanent intake solution.

2.3 Existing Temporary Intake

MPE (2022) describes the existing Temporary Intake as follows:

> *The seasonal intake consists of an irrigation pump and river screen which allows water to be pumped during non-frozen conditions or a submersible pump that can be placed directly in the river. Raw water is pumped through a buried 200 mm diameter HDPE pipeline to the stilling basin. The lower bank of the Sheep River is in the flood plain, as such the intake site at the river consists solely of a concrete pad, chain link fence, piping connection and a small control panel. The main controls for the pumps themselves are in the stilling basin pump station out of the flood plain.*
>
> *As there is an existing pipeline and power supply in this area, this location provides advantages for a permanent intake. To further assess this location, various background documents have been assembled and reviewed to determine available information for the area.*

During Boreal's site visit completed on June 26, 2024, the Temporary Intake was deployed in the water but was not in operation (see **Figure 2**). The description provided above is consistent with Boreal's observations.

It is understood that, to the extent practicable, SRRUC would prefer to utilize the existing infrastructure at the Temporary Intake. As such, the location of the Temporary Intake presents some advantages over relocating a new, permanent intake to other locations along the study reach.

Figure 2: Temporary Intake on the Sheep River (June 26, 2024).

3 SITE DESCRIPTION

The Study Reach for this Intake Feasibility Assessment is nearly 1,070 meters in length, extending from the location of the Temporary Intake downstream to the Decalta Road bridge crossing. In the vicinity of the study reach, the channel planform is considered to be meandering with numerous medial and point bars indicative of the elevated bed load in the channel. However, meandering weakens within the Study Reach itself as a result of the confining nature of the right bank and engineered bank stabilizations on the left bank, downstream, both features being situated on the outside of bends in the river.

The following site description is organized by river reach, with a stationing of 0+000 representing the location of the Temporary Intake.

3.1 Upstream of Study Reach – 0-500 to 0+000

The Temporary Intake is located across from the downstream toe of a large medial bar. Upstream of this bar, flow divides into a north (left) channel and a south (right) channel, with the former receiving most of the flow. This has not always been the case: aerial photographs suggest that in the 1950s and early 1960s, the south channel was the dominant flow path. A reasonable hypothesis for this channel shift is that a significant flow event caused sediment aggradation to partially block the south channel, thereby pushing the flow to the north. Regardless of the cause, this shift has resulted in erosion along the left bank, including in the vicinity of the Temporary Intake. During the floods of 2013, the left bank immediately upstream of the Temporary Intake eroded approximately 35 to 40 meters forming the present bank-line, which is characterized by a 1.8 m vertical drop that is highly susceptible to future erosion. Given the scale of channel change during the 2013 flood event, it is reasonable to expected that the Temporary Intake is vulnerable to washing out during the next extreme flood event (see **Figure 3**).

As for the medial bar itself, it appears to be relatively stable and fully vegetated with shrubs and small trees. There is even some mature tree growth along the southern edge of the bar. At the time of Boreal's site visit, the tail of the bar was submerged though was noted as extending slightly downstream of the Temporary Intake location. Through a review of aerial photographs, this bar does not appear to have migrated downstream since the 2013 event, although the image quality is rather poor.

Figure 3: Location of the Temporary Intake.
Red squares indicate the location of the Temporary Intake. Image dates: left: July 20, 2012; right: October 9, 2014. Image source: Google Earth.

3.2 Temporary Intake to Upstream of Powerline – 0+000 to 0+300

Across from and immediately downstream of the Temporary Intake, the south (right) bank is steep and unstable with a 10 to 12 m high vertical face, the remnant scarp from a historical cut bank. The soil along this face is dominated by fines, though gravel and cobble inclusions are visible from the opposite side of the river. The bank begins to soften at approximately 200 meters downstream of the Temporary Intake, where it lowers to river elevation and is well-vegetated with a canopy of mature Aspen and Spruce.

The north (left) bank in this area is characteristic of a depositional point bar with low-lying accumulations of gravels and cobbles (less than 8-inches in diameter) within a matrix of fine sands and silts. This bar is approximately 225 meters long and 25 meters wide and is moderately vegetated with a mix of shrubbery (silverberry and wolf willow), balsam, and poplar with some red willow and clover. On the upslope side of this bar is a two-meter-high vertical rise to the adjacent terrain, likely formed in 2013 during the extreme flood event that impacted the river.

The river channel itself is straight and appears to be relatively stable. The 2013 extreme flood event appears to have re-distributed bedload accumulations within the channel, though this appears to have stabilized since that time. Bathymetric survey procured by MPE indicates that the channel is relatively flat and wide, with depths approaching one meter over a 20-to-25-meter wetted width. The channel thalweg appears to be marginally deeper on the right side of the channel as one might expect given the trajectory of the slight bend in the river at this location.

Figure 4 Segment 0+000 to 0+300 of the assessed reach.
Red squares indicate the location of the Temporary Intake. Image dates: left: July 20, 2012; right: October 9, 2014. Image source: Google Earth.

3.3 Powerline to Water Treatment Plant – 0+300 to 0+600

Approximately 300 meters downstream of the Temporary Intake and at the downstream end of the depositional bar, the river becomes wandering as it flows around several midstream gravel deposits. At the upstream end of this reach, the braiding has resulted in shallower flow depths and, consequently, accumulations of large woody debris. A fining of the bed materials was observed with fewer cobbles present in the sediments along with a higher concentration of clays and silts (as opposed to sands).

Towards the downstream end of this reach, the main channel steepens slightly and the velocity increases. In this area, the substrate within the channel was noted as being larger (cobbles and boulders) as fines were more likely to be washed from the interstices. The left bank was comprised of sandy clay, transitioning to the alluvial deposits from the 2013 flood. The left bank is bounded by riprap flood protection works that were installed in recent years to protect the WTP and neighbouring properties from future flood events. This latter feature will protect the left side of the channel from future mobility.

Vegetation in this reach is generally consistent with the reach immediately upstream, except that the left floodplain is clear of vegetation as it is a fresh gravel/cobble deposit. Several of the channel braids are clearly artefacts of hydraulics during flood conditions and do not represent significant flow paths otherwise. Nonetheless, they are indicative of the potential for future channel mobility

As noted in Section 2.1, NHC (1998) had proposed a location for a direct infiltration intake to the south of the present-day WTP. This location is shown in **Figure 5**, which highlights the significant movement that had occurred during the 2013 flood event. It can be seen that prior to the 2013 event, the dominant channel flowed along the left bank adjacent to the WTP, which then flipped to the right side after the event. Had a direct infiltration intake been constructed at this location, it is likely that a major maintenance program would have been required to re-establish the filtration media and to ensure that the intake's pipes remain wetted.

Figure 5: Location of direct infiltration intake proposed by NHC (1998).
Red ovals indicate the approximate location of the proposed intake. Image dates: left: July 20, 2012; right: October 9, 2014. Image source: Google Earth.

3.4 Water Treatment Plant to Decalta Road Bridge – 0+600 to 1+070

Downstream of the WTP, the river is generally confined to a single, shallow channel; however, a small gravel bar has developed at 0+620 that directs a small portion of the flow to the left through a riffle feature. The channel gradient is steeper than the upstream portions of the study reach and there are boulders throughout the main channel, including a hydraulic control section at approximately 0+800. Through this reach the sediments particle size continue to increase downstream to the vicinity of Decalta Road Bridge and are smaller close to the WTP.

From approximately 0+700 to 0+790, the channel narrows, which would imply that the velocity is generally higher than the adjacent river reaches. This may help to mitigate the accumulation of fine materials that would otherwise clog the filtration media of a direct infiltration intake.

As shown in the **Figure 6,** significant changes occurred on both the inner and outer sides of the reach near the bridge between 2012 and 2014. The outer bend was stabilized with riprap, halting erosion and preventing further migration. As a result of these stabilization efforts, the alignment of the main channel has remained relatively constant since 2014, with large deposits of fine and coarse materials on both banks of the river.

Figure 6 Segment 0+450 to 1+070 of the assessed reach.
Image source: Google Earth.

4 GEOMORPHIC ASSESSMENT

A desktop geomorphic assessment was completed for the purpose of evaluating the potential for changes in the assessed reach that may affect a future water intake. This assessment included a review of historical aerial photographs, terrain via the LIDAR-based DEM, and spatial data from the Alberta Land Inventory (ALI) and Canada Land Inventory (CLI) Landform.

Channel geomorphological assessment facilitates the understanding the river dynamics and aids in prediction of future river behavior. To do so, the stream classification technique proposed by Rosgen (USDA, 2007), was employed to gain a stronger appreciation of the potential for channel features to influence the stability of a channel and the potential risk of future channel changes. Key parameters used in this assessment include the following:

- *Entrenchment Ratio:* The entrenchment ratio is a key geomorphological parameter used to assess the confining characteristics of river or stream channels within the floodplain. In other words, the entrenchment ratio is the interrelationship of the river to its valley or landform. It provides insight into the degree to which a river or stream is incised into its floodplain and is calculated by directly comparing the width of the floodplain to the width of the channel at bankfull stage (Rosgen, 1994).
- *Width-Depth Ratio:* The width/depth ratio is a dimensionless measure that describes the geometry of a river or channel cross-section (Rosgen, 1994).
- *Sinuosity:* The sinuosity of a channel is a measure used to describe the degree to which a river or stream meanders across its floodplain or landscape compared to the straight-line distance from its source to its mouth, is the ratio of stream length to valley length. Sinuosity is an important aspect in geomorphology and hydrology as it influences various river characteristics and behaviors (Rosgen, 1994).
- *Slope:* The slope provides insight into various physical characteristics and processes of the landscape. The slope indicates the gradient or steepness of the land surface, is expressed as a ratio of vertical elevation change to horizontal distance (Rosgen, 1994).
- *Melton Ratio:* While not included in the Rosgen system, the Melton Ratio (per Wilford *et* al., 2004) is a commonly used indicator of the potential for a flood regime to be clear water in nature or to be dominated by debris, as in debris flood or debris flow events. Understanding the flood regime helps to determine the potential for entrained materials to influence flood dynamics in a stream.

The reach assessed is located in the Rocky Mountain Foothills physiographic region, specifically in the Southern Foothills. This area lies in the transition zone between Cordilleran and plains landforms. The Sheep River is in a geomorphic region characterized by morainal and colluvial veneers, which originated from debris source from to glacial activity. These sediments generally consist of well-compacted, non-stratified material containing a heterogeneous mixture of particle sizes, including sand, silt, and clay, that has been transported beneath, beside, on, within, and in front of a glacier, and not modified by any intermediate agent (Government of Canada, 1998).

Regarding the Sheep River itself, this channel generally features well-defined and steep banks, a well-defined channel despite frequent braiding, and a reasonably confined floodplain. As the Study Reach lies within a transition zone (Foothills), the predominant pattern is wandering. The Sheep River's deposition mainly consists of sand, gravel, cobbles, and boulders ranging from fine to coarse in size.

The sediments and river pattern suggest a dynamic stream behavior. The predominance of sands and gravels in the soil composition indicates that the creek may have a moderate to high flow velocity and sediment transport capacity, leading to frequent changes in its channel morphology. This is evidenced by several hydraulic structures designed for stabilization and containment of the river.

4.1 Morphometric Characteristics

A cursory review of historical aerial photographs and the LiDAR-based DEM indicates that the Sheep River exhibits several key features, including a wandering channel and a planform characterized by depositional point bars, riffle-pools, and an alluvial channel. The floodplain is narrow and well-defined within the Study Reach from the Temporary Intake to the Decalta Road bridge crossing, after which the floodplain widens considerably. Moreover, the terraces are clearly identifiable and feature steep slopes. These terraces are accompanied by alluvial soils. Despite the narrow floodplain, the assessed reach is not entrenched and exhibits a well-defined riffle-pool bed morphology. The watercourse shows evidence of lateral migration within its floodplain, constant changes in its point bars, and several abandoned branches. There is no evidence of historical beaver activity or woody debris.

A morphometric analysis was completed for Sheep River as described earlier in this section, the results of which are summarized in **Table 2**.

Table 2: Morphometric characteristics of Sheep River.

Parameter	Value	Interpretation
Entrenchment Ratio	3.27	The entrenchment ratio indicates that Sheep River is not entrenched, meaning the stream is highly likely to overtop its banks. The high width/depth ratio suggests a broad shallow channel, which when coupled with a low slope suggest a low to moderate erosion rate. The Melton Ratio is strongly indicative of Sheep River having a clear water flood regime, not debris floods or debris flows. These latter processes can exacerbate flooding as debris accumulations settle within the floodway.
Width/Depth Ratio	21.5	
Sinuosity	1	
Slope	0.54%	
Melton Ratio	0.06	
Dominant Flood Regime	Clear Water Floods	

Based on the results presented in **Table 2**, this reach of Sheep River can be classified as Stream Type C according to the Rosgen classification (see **Figure 7**). Per Rosgen (1994), such streams are typically characterized by broad valleys with well-defined terraces, gentle gradients, meandering paths, point bars, riffle and pool sequences, alluvial soils and channels, and well-defined floodplains.

This river exhibits a high degree of sediment dynamics, as observed during the site visit. Sediment deposition includes a wide range of particle sizes, attributed to the river's riffle-pool morphology and variable flows. Large boulders and riverbank protection works suggest strong erosive forces during high-stage conditions, while the presence of fine sediments along the banks indicates significant fine sediment deposition during lower flows.

From the geomorphological assessment, it is evident that Sheep River is prone to flooding due to the low entrenchment of the channel. The Temporary Intake is located 10 meters away from the main channel on a terraced floodplain; however, due to its proximity to the river the likelihood of this location to experience flooding is high. Similarly, erosion near the Temporary Intake is very likely and can be expected to compromise this location after a significant flood event.

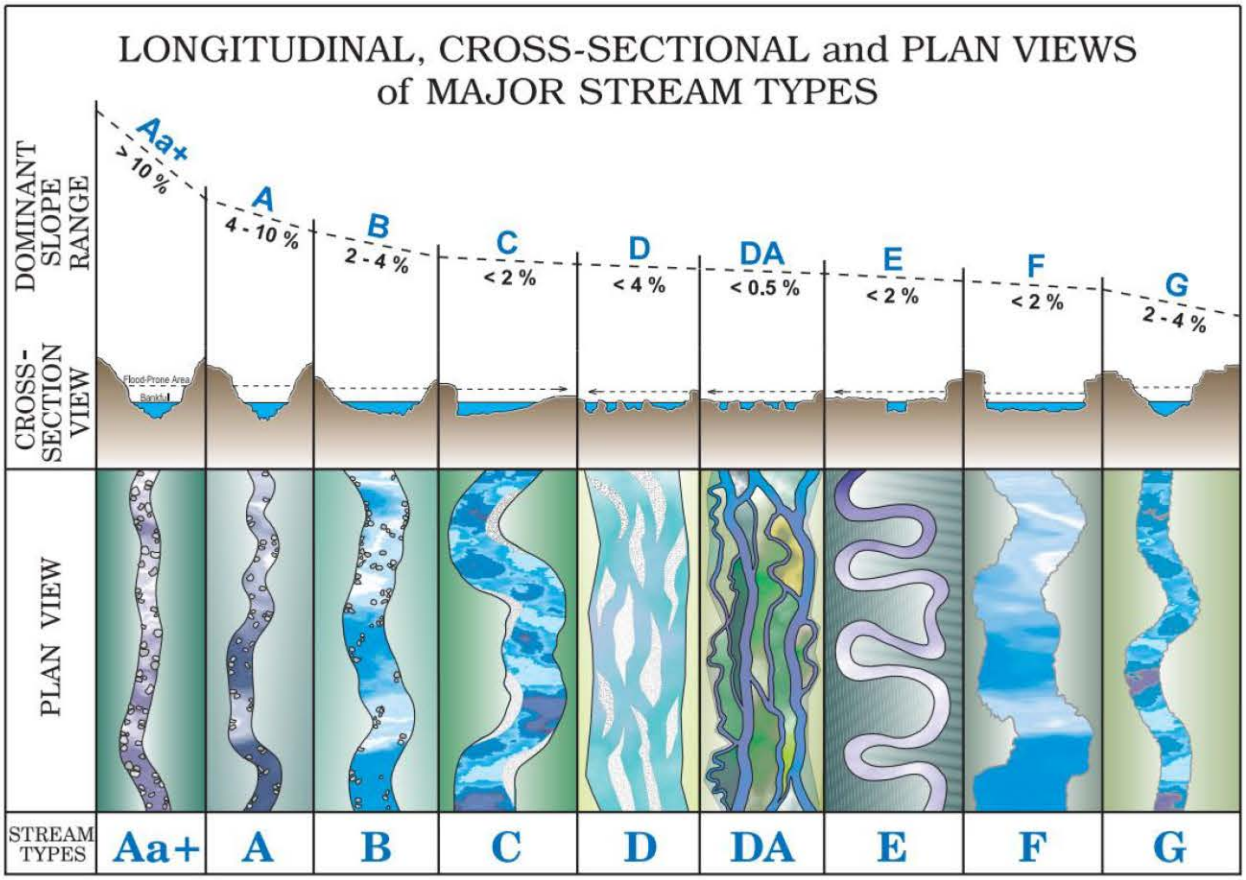

Figure 7: Schematic stream types (Rosgen, 1994).

4.2 Channel Dynamics

A multitemporal analysis was performed with aerial images from 1950 through 2020. These images reveal the high dynamism of this reach. The observed behavior of the reach aligns with its classification, as highly dynamic environments are common for wandering rivers in foothill regions (see **Figure 8**). **Appendix A** provides more detail each year with the corresponding aerial imagery.

Figure 9 shows the bed forms within the study reach, such as: point bars, branches, abandoned channels, riffles, runs, pools and glides. The most notable example of river dynamics can be observed approximately 20 meters upstream from the Temporary Intake. Here, the main channel of the river has experienced significant lateral migration to the north, with a displacement of approximately 30 meters. Currently, the left bank of the river at this point shows significant signs of erosion.

The flow characteristics of a river are important to understanding the sediment transport dynamics and for assessing a suitable location for a future water intake. These flow characteristics were compared to the sediments observed during the site visit (see **Figure 10**) to help identify where sediment distribution may present challenges. The finest sediments were found in the vicinity of the Temporary Intake, just 10 meters downstream of a wandering segment. In contrast, the reach downstream of the WTP, which features a straight alignment and a run-and-riffle profile, has coarser sediment distribution. This is because, the higher velocities impart higher turbulence and shear on the bed allowing for suspension of finer materials. This contrasts with low energy environments, such as pools, where deposition and aggradation occur, leading to the accumulation of fine sediments.

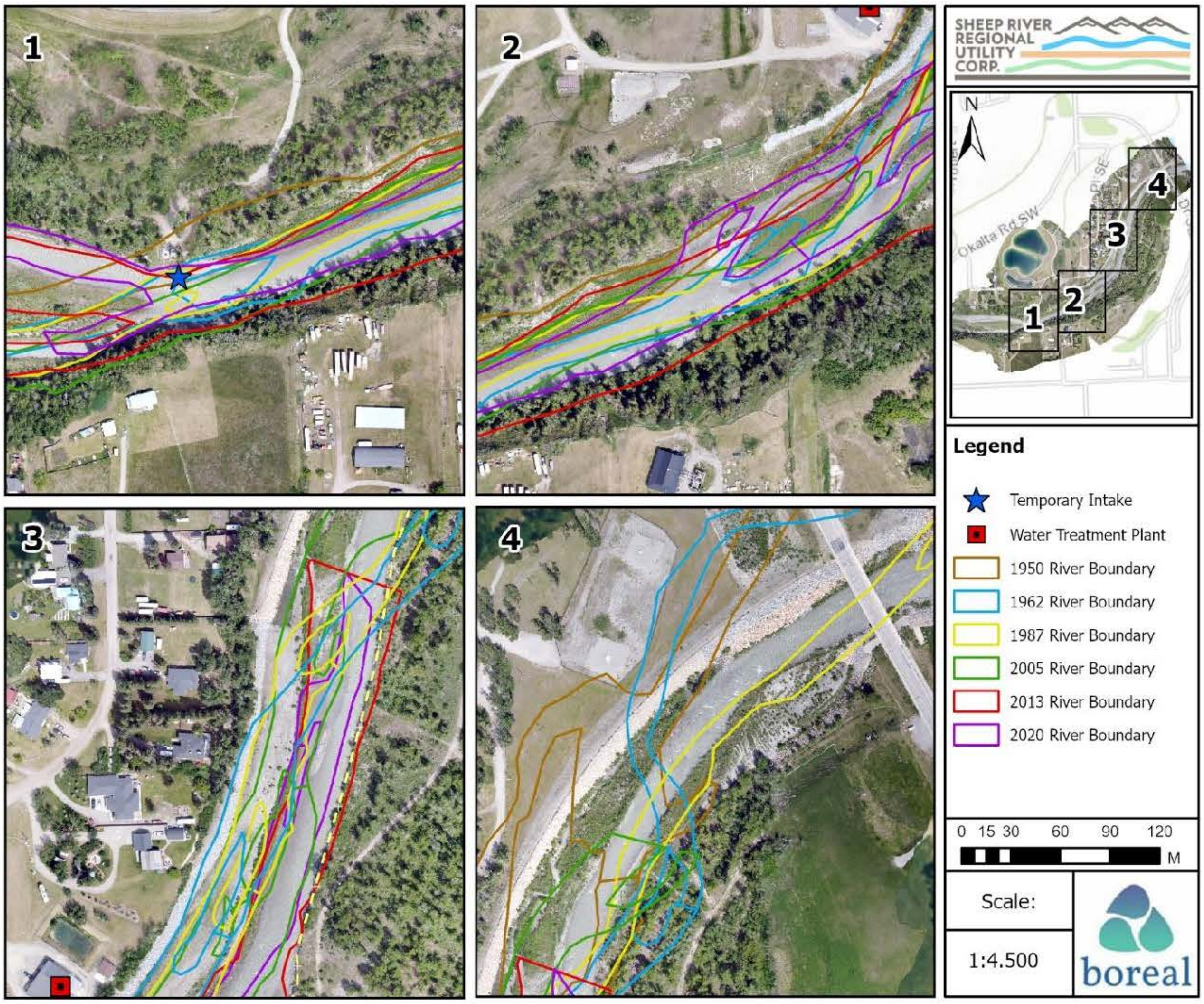

Figure 8: Multi-Temporal Analysis with Every Year.

4.3 Summary – Geomorphic Assessment

The Sheep River is very dynamic within the Study Reach, with a high potential for lateral migration and frequent channel changes, particularly in its wandering reaches. The wandering nature makes the river prone to flooding, especially in the reach between 0+750 and 1+000, where the entrenchment ratio is notably low. The multitemporal analysis illustrates the high dynamism of the reaches from 0-500 to 0+000 and 0+250 to 0+550 in its wandering segments, typical of a wandering river in a foothill region. Despite the significant dynamism of the river, since 2014 the reach has maintained the same alignment.

Regarding erosion in the assessed reach, the right bank generally exhibits several areas with cut and eroded sections. Notably, between 0+000 and 0+225, the bank is high and very steep, which if it were to fail would impact a water intake installed in this area. Additionally, upstream of the Temporary Intake, erosion along the left bank, including near the Temporary Intake itself, has been significant. During the 2013 floods, the left bank immediately upstream of the Temporary Intake eroded by approximately 35 to 40 meters, forming the current bankline. This bankline is characterized by a 1.8-meter vertical scarp, making it highly susceptible to future erosion.

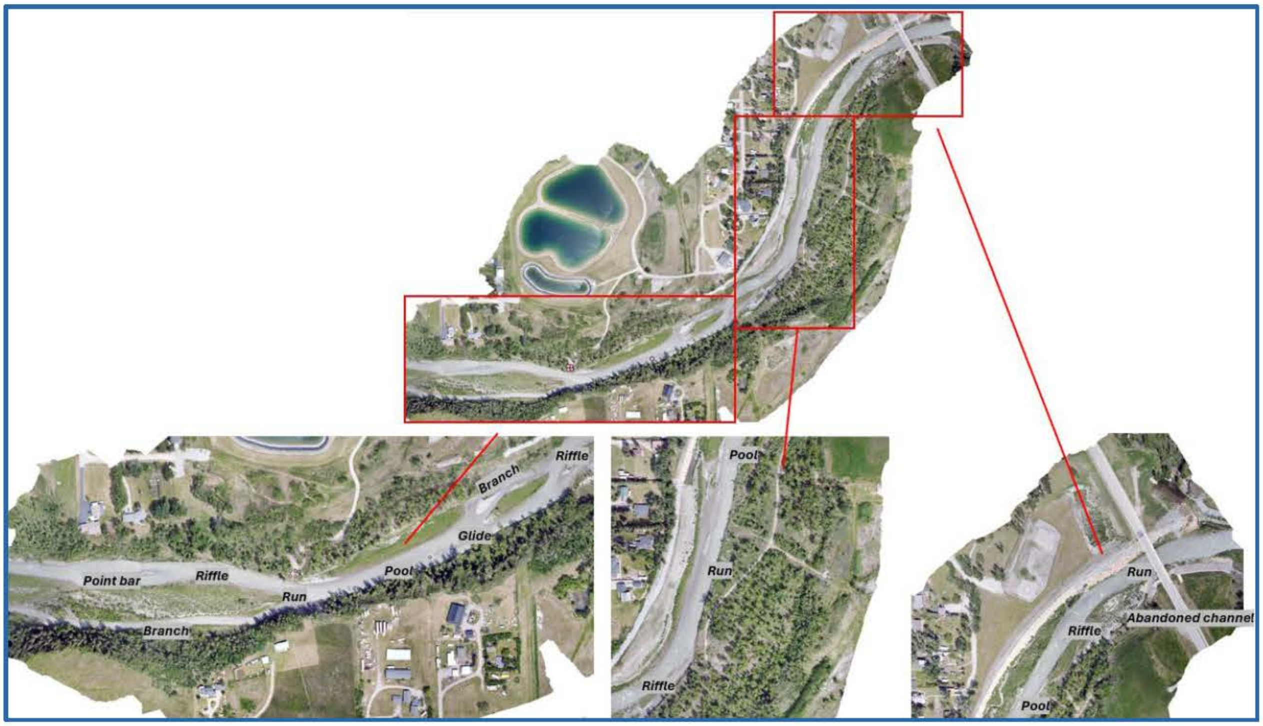

Figure 9: Assessed reach flow habits.

Based on the geomorphic assessment, the Study Reach appears to be in equilibrium from a sediment transport point-of-view. The banks have remained stable since the 2014 event with no notable increases in sediment accumulation and/or scour. This is significant because the river in this area transports large amounts of sediment, particularly during high flow events. The more significant geomorphic feature of this river is the ability of peak flood events to fundamentally alter the channel. The historical aerial photographs have identified several notable changes in the channel alignment and banks, which must be considered in the future placement of intake infrastructure.

Figure 10: Typical sediments encountered during the site visit.

5 HYDROLOGICAL AND HYDRAULIC ASSESSMENT

5.1 Watershed

Sheep River is a tributary of Highwood River and encompasses a total watershed area, as measured at the confluence, of approximately 1,555 square kilometers (km^2). Sheep River originates in the Rocky Mountains at an elevation of 2,300 meters above sea level (masl) and, therefore, a significant portion of its flow is sourced from late-season snowmelt and summer glacial melt. This river supplies several industrial activities and serves several communities, including Diamond Valley and Okotoks.

The watershed area upstream of the Study Area is 553 km^2. The land cover within this watershed is varied and includes mature mountains, forests, meadows, agricultural lands, and developed industrial areas. Development within the watershed is scattered and includes access roads, small pits and quarries and some rural residential development. Due to the glaciofluvial environment and the type of valley, the alluvial terraces and floodplains are predominantly depositional landforms, which can become significant sources of sediment supply during high flow events.

5.2 Hydrological Characterization

Flows in Sheep River are monitored by the Water Survey of Canada (WSC) at several locations, as summarized in **Table 3**. Given the proximity of WSC Station no. *05BL014: Sheep River at Black Diamond* to the Study Area, flows monitored at this location were deemed to adequately represent flows that have historically occurred at the proposed permanent water intake location. Data from this hydrometric monitoring station range from 1909 to 1916 (seasonal) and 1969 to present day (continuous).

Table 3: Hydrometric Monitoring Locations on Sheep River.

ID	Name of Station	Years of Record	Catchment Area (km^2)
05BL014	Sheep River at Black Diamond	1909 - 2024	592
05BL018	Sheep River at Buck Ranch	1950 – 1969	454
05BL012	Sheep River at Okotoks	1908 – 2024	1,490
05BL020	Sheep River near Aldersyde	1957 – 1965	1,570

Since a permanent water intake would, ideally, be operable on a year-round basis, it is important to understand typical river flows, including temporal distribution and key parameters, such as low flow statistics, Mean Annual Discharge (MAD) and peak flows. To provide this understanding, the continuous measured flow dataset published for WSC Station no. 05BL014 (1969 to present) was evaluated after transposition to the study area on the basis of direct areal proration.

A Flow Duration Curve (FDC) (see **Figure 11**) and box-and-whiskers plot (see **Figure 12,** and **Figure 13**) were developed to visualize the flow regime in Sheep River at the *Sheep River at Black Diamond* station. A key parameter utilized in this assessment is the annual Q95 estimate, which represents the river flow that is met or exceeded for 95% of the year. This metric was deemed appropriate for evaluating permanent intake options from the context of year-round operability.

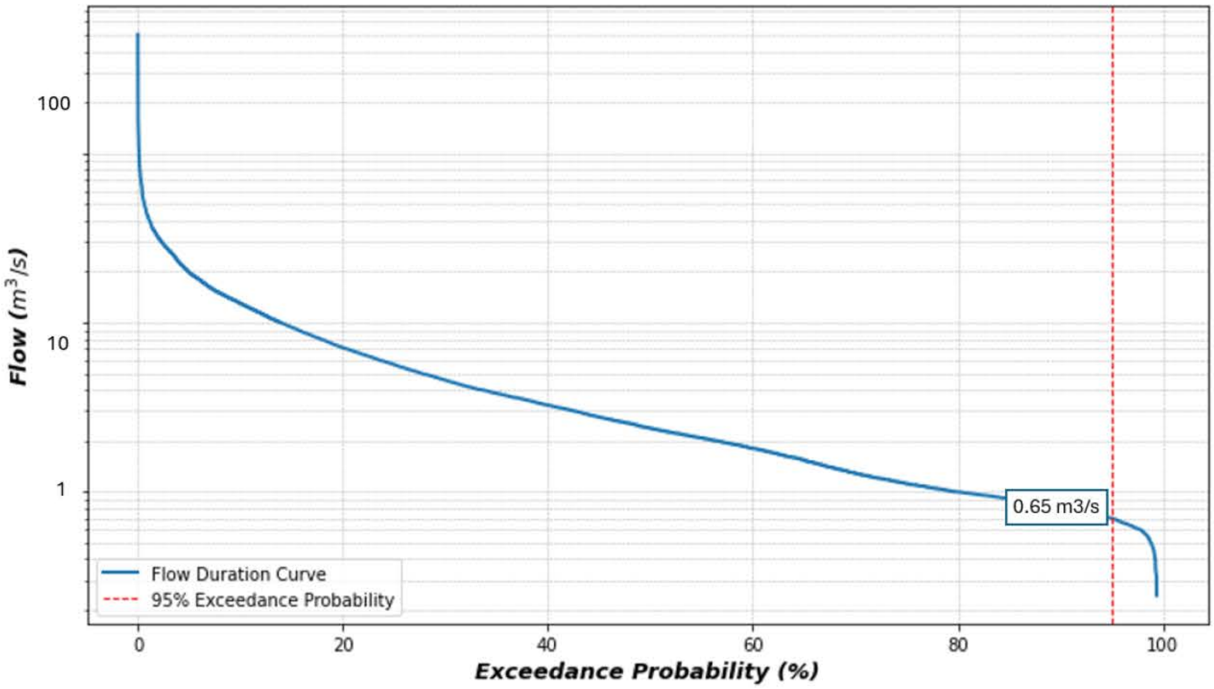

Figure 11: Annual flow duration curve for Sheep River at the Study Reach.

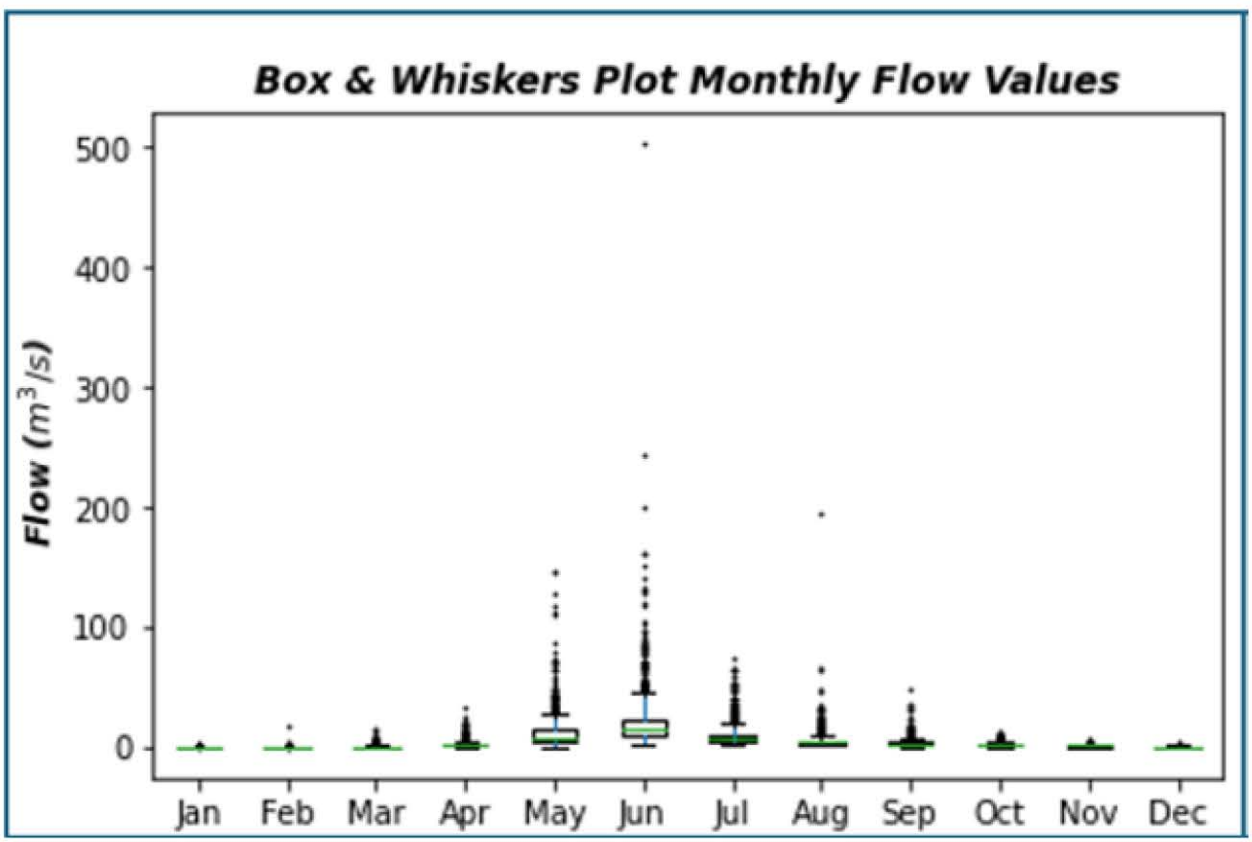

Figure 12: Box-and-whiskers plot of monthly flows at the Study Reach.

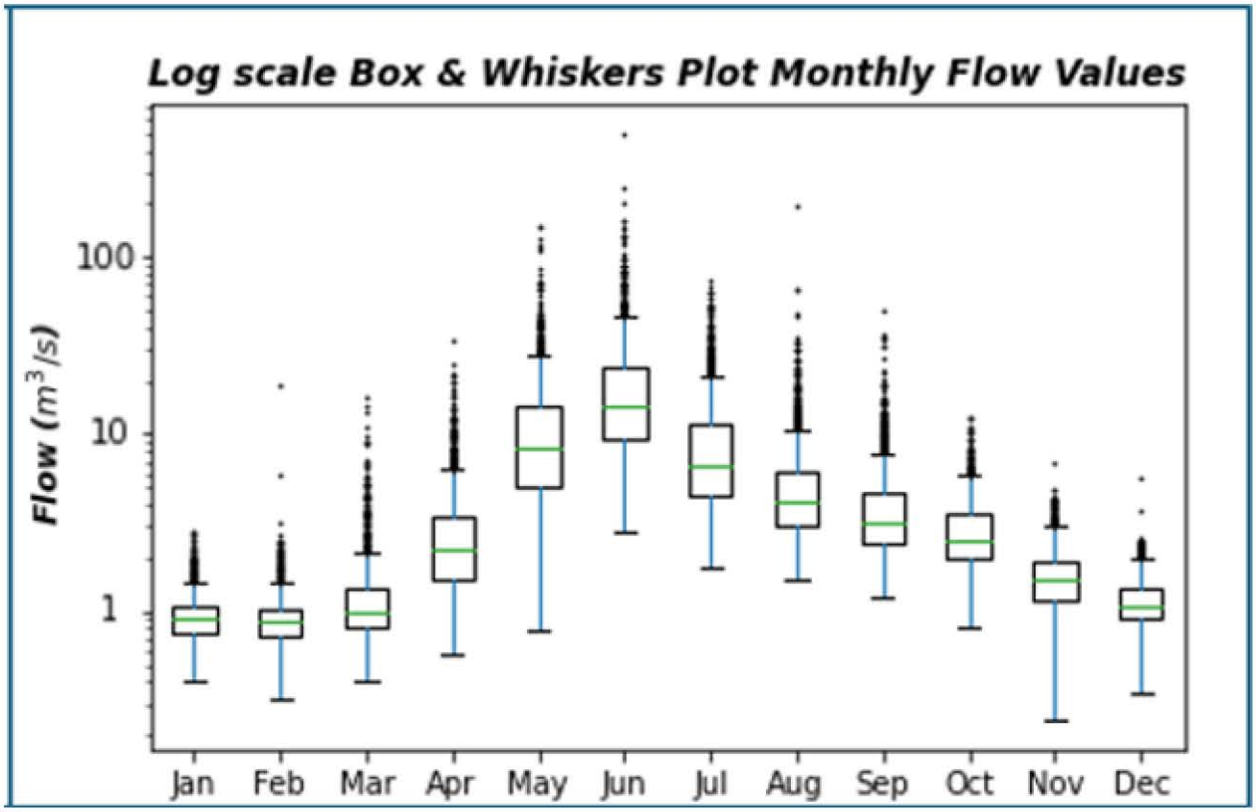

Figure 13: Box-and-whiskers plot of monthly flows in logarithmic scale at the Study Reach.

Lastly, a cursory peak flow analysis was completed by fitting a Log Pearson Type III (LP3) distribution to the transposed annual maxima series for the Sheep River dataset. This was not an in-depth exercise and was merely for the purpose of benchmarking high flow estimates to help inform hydraulic and geomorphic features of the river within the Study Area. These results are presented in **Table 4**.

Table 4: Key flow statistics (m^3/s) for Sheep River at the Study Area.

5th-Percentile Flow, Q95	$Q_{1.25}$	Q_2	Q_5	Q_{10}	Q_{20}	Q_{50}	Q_{100}
0.65	42	92	142	210	288	462	669

5.3 Hydraulic Modelling

To obtain a better understanding of the hydraulics in the assessed reach, a two-dimensional hydrodynamic model was developed using HEC-RAS software (HEC, 2024). Two analyses were performed: first, the low flow corresponding to the Q95 flow, or 0.65 m^3/s, was evaluated to determine the wetted channel area during low flow conditions; second, several key peak flows were modelled to inform conclusions regarding inundation extents, erosion potential and channel mobility.

The model was constructed from the LIDAR-based DEM and adjusted as necessary for features such as bank break lines and changes in the actual topography. The LIDAR provided to Boreal for this assessment appears to be compiled from two separate survey flights: one before and one after the extreme flood event of 2013. Hence, there is an obvious lateral shift in the flow results presented in **Appendix B** located approximately 500 m east of the Temporary Intake. However, despite the discrepancy in LIDAR collection date, the hydraulic results provide a good indication into the river behavior and dynamics.

Additional inputs to the HEC-RAS model included surface roughness, which was determined based on land surface coverage defined by orthophoto image classification (photograph data: June 26, 2024). The boundary conditions were set as a combination of normal depth and critical depth, as appropriate.

The results from the normal low-stage analysis indicate relatively shallow depths throughout most of the reach (0.4 m or less), as shown in **Appendix B** (**Figure B-1**). Velocities of approximately 0.25 m/s are observed in throughout much of the Study Reach (**Figure B-5**) indicating a strong likelihood of sediment deposition. The exception to this is in the straight, narrow, non-braided reaches where velocities increase and in the riffle segments where the velocities can reach 1.0 m/s. This corroborates the findings of the geomorphic assessment that finer materials are less likely to accumulate in these areas. This latter feature would be beneficial in the context of a direct infiltration intake, where fines have a tendency to clog the interstices of the filtration media.

The shallow depths, high velocities in high flow/stage conditions, and wetted surface area shown in **Figure B-1** and **Figure B-5** also highlight the vulnerability of fixed points of diversion (e.g., submerged screen, side intake) to changing river conditions. The wetted surface area is dependent on the present-day channel alignment. This suggests that a modest scour event, as may occur during a flooding event, raises the risk that a fixed point of diversion becomes stranded outside of the wetted surface area. Further, the shallow depths effectively limit permanent intake options to direct infiltration intakes or bottom intakes. To mitigate against these two issues within the Study Reach would require that a diversion weir and head pond (small reservoir) be created.

Figure B-2 through **Figure B-4** and **Figure B-6** through **Figure B-8** illustrate the extents of flood inundation for different return period peak flow events. Important to consider here is the placement of any required onshore works safely outside of the 100-year floodplain and adjacent risk areas.

6 INTAKE FEASIBILITY ASSESSMENT

The purpose of the Intake Feasibility Assessment is to identify viable water intake options for implementation in the Study Reach that will generally satisfy the goals of SRRUC, which are understood to include the following:

- SRRUC is not seeking an increase in capacity to satisfy additional demand; rather, SRRUC wishes to replace the temporary river intake with a permanent option that is less operationally-intensive and is consistent throughout the year;
- As such, the design flow rate for a new, permanent intake option will be the same as for the present, Temporary Intake at 86.4 L/s.; and
- Ideally, SRRUC would like to utilize existing infrastructure, including the HDPE water pipeline that conveys water from the Temporary Intake to the reservoir, although alternative intake locations that are better suited to a long-term solution will be considered.

Several water intake options were assessed, including temporary and permanent solutions (Section 6.1), as summarized. The benefits and drawbacks of these various options were evaluated then ranked using a multiple accounts assessment to identify a preferred option(s) (Section 6.16.2). Lastly, potential locations for the installation of preferred options were identified (Section 6.3).

6.1 Intake Options

The various water intake alternatives that were considered in this assessment are summarized in **Table 5**. Brief descriptions are provided, along with a summary of the benefits and drawbacks provided in **Table 6**.

Table 5: Intake options considered for the Sheep River at the Study Area.

Temporary Intake Solutions	Permanent Intake Solutions
• Existing Temporary Intake • Infiltration Ponds	• Direct Infiltration Intake • Water Wells • Lateral Intake • Submerged Screen • Bottom Intake • Coanda Screen

6.1.1 Temporary Intake Solutions

In the context of this analysis, a temporary water intake is intended to be deployed on a seasonal or as-required basis, typically during the open-water season. They can require more operational effort since they are periodically removed from the river and are less reliable given their lack of sophisticated infrastructure. Two temporary options identified for SRRUC's consideration are (1) the existing Temporary Intake set-up, and (2) infiltration pits, the latter of which has previously been utilized by SRRUC.

6.1.1.1 Existing Temporary Intake

The existing Temporary Intake (see **Figure 14**) consists of a submerged intake screen within a buoyant protection structure that can be deployed or removed as operations require. Presently, SRRUC deploys the intake in the early-summer and removes it prior to freeze up. It is understood that operations staff try not to use the intake during the freshet to minimize the amount of entrained sediment that is pumped to the retention ponds; instead, the intake is used more frequently in the late-summer and fall periods when the river water is clearer.

Figure 14: SRRUC's Temporary Intake on the Sheep River.
Image source: MPE, 2022.

6.1.1.2 Infiltration Pits

In the mid-2010s, and as an emergency measure, SRRUC had installed a series of temporary infiltration pits within the gravel and sand deposited on the left bank of the Sheep River immediately adjacent to the WTP (**Figure 15**). Water from the river infiltrated through the alluvial deposits and into the pits, where it was collected and pumped off to the water reservoir. It is understood that this set-up worked fairly well, though it required frequent maintenance.

The infiltration would act as a primary filtration process, allowing for some clarification of the river water, thus potentially allowing for allowing for operation during the turbid freshet months. Provided the pits were of a sufficient depth, winter operation is also likely.

The obvious drawback to using temporary infiltration pits is that the river will inundate this area during the mean annual flood, or possibly during lesser flood events (see **Figure B-2** in **Appendix B**). Inundation will result in infilling of the pits with debris and sediment and may altogether alter the topography of the of the left bank. These factors would result in additional maintenance requirements to maintain the pit structure.

Figure 15: SRRUC's former infiltration pits on the Sheep River.
Image source: Google Earth, 2014/10/09.

6.1.2 Permanent Intake Solutions

The permanent intake solutions identified below would provide year-round access to water through the construction of permanent infrastructure.

6.1.2.1 Direct Infiltration Intake

A direct infiltration intake is a subsurface water intake structure designed to collect water from a river, lake, or groundwater through a natural filtration process. It consists of a network of perforated pipes or conduits buried in a gravel and sand bedding beneath the water source (Fetter, 2001). The bedding provides for a progressively finer filtration media that helps to remove particulate, organics and other materials prior to diversion through the intake pipes, thereby improving water quality delivered to a treatment plant. Being buried below the riverbed, this type of water intake has a minimal surface expression, which helps to protect the intake pipes and mitigates entrainment of fish and aquatic organisms.

However, experience with direct infiltration intakes in Alberta rivers is mixed, specifically when deployed in rivers with high sediment loadings. As the concept relies on infiltration, finer sediments are removed in the filtration media. This results in clogging of the filtration media, which requires either media backflush using air or water, mechanical agitation (e.g. with an excavator) or complete replacement of filtration media. None of these maintenance activities are particularly straight-forward. Further, in rivers that are highly active, changes in channel alignment may re-route a river away from the filtration media resulting in an off-channel system that may not function as effectively as one directly below a watercourse. However, the above issues can be attenuated by oversizing the systems.

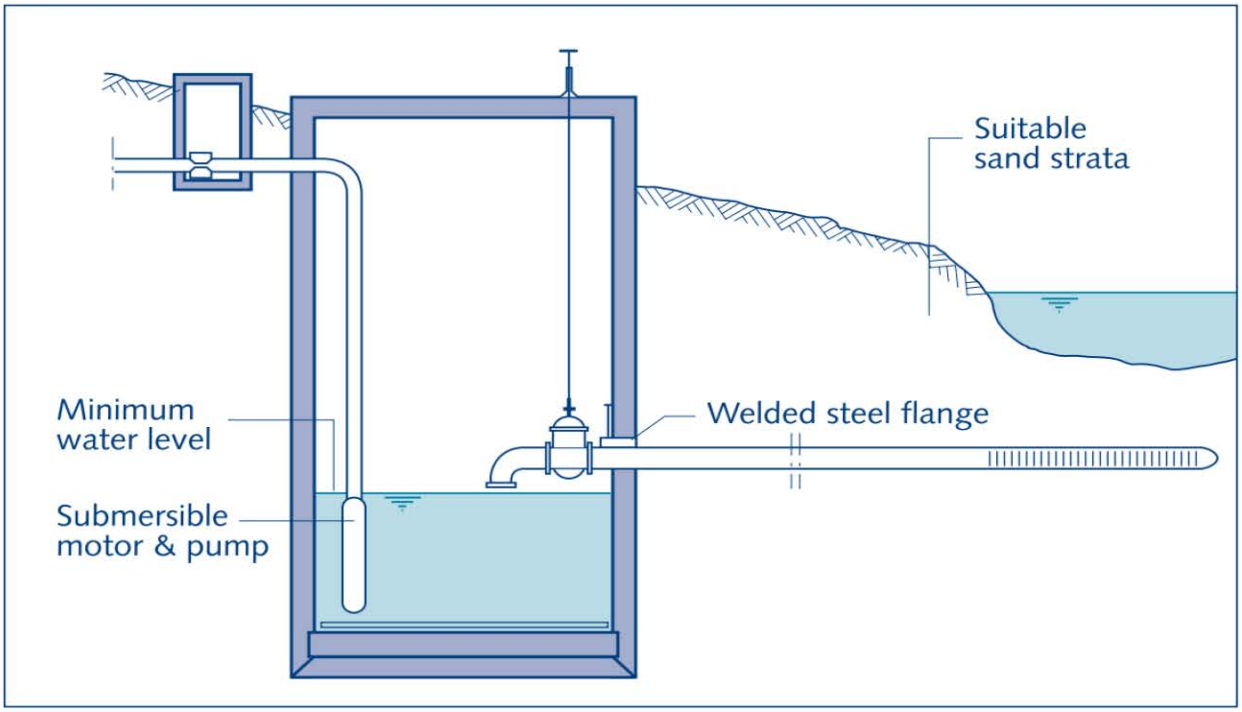

Figure 16: Direct Infiltration Intake schematic.
Image source: https://sswm.info/sites/default/files/reference_attachments/SMET%202002%20Surface%20Water%20Chapter%2011.pdf [accessed August 1, 2024].

6.1.2.2 Water Wells

In a review of local hydrogeological potential, Stantec (2016a, 2016b) identified several locations for potential groundwater well development. These locations are within 2.9 km of the WTP but are not situated in the immediate study reach. Investigative drilling identified only one location that was potentially suitable for well development, the YWAM site located approximately 600 m upstream of the Temporary Intake location. Despite suitable depths of saturated sands and gravels, the potential capacity of this location has yet to be determined. Pumping tests will be required to confirm the viability of this location for well installation.

Further, Stantec (2016b) identified several potential environmental liabilities that may impact groundwater quality at this location: an upslope septic field and, potentially, a former landfill associated with the hospital. It is unclear if these issues have been investigated.

It is suspected that an array of several wells will be required at this location to deliver the desired capacity of 86.4 L/s. An additional 600 m of pipeline will be necessary to convey water to the current Temporary Intake location, from where water would be pumped to the retention ponds. This will require land agreements and/or purchase, in addition to the capital costs for the construction of the pipeline and wells.

6.1.2.3 Lateral Intakes

A lateral water intake, also called a ‘side intake’ or a ‘conventional intake’, withdraws water from a river, typically through gated opening and into an intake forebay or stilling basin. These types of intakes require a concrete intake structure to be constructed in the bank and the inlets are typically screened to exclude fish and debris. On larger rivers, these types of intakes can be standalone features; on smaller rivers, however, a diversion weir is often required to raise the water level to create a head pond or reservoir, which is used to mitigate issues related to sediment ingestion and ice effects.

The operation and maintenance of a lateral water intake involves regular cleaning of intake screens, inspection and removal of debris, and occasional removal of sediment accumulation within the forebay.

Figure 17: Example of a lateral water intake behind a diversion weir.
Image source: Image source: https://www.cidhma.edu.pe/que-es-una-toma-lateral/ [accessed August 1, 2024].

6.1.2.4 Submerged Screens

A submerged screen intake is a water intake structure designed to withdraw water through a screen located below the water surface, often positioned near the bed of the river. This structure prevents large debris and aquatic life from entering the intake, ensuring cleaner water collection.

The operation of submerged screen intakes requires routine maintenance to avoid blockages caused by sediment buildup, debris, or aquatic growth. Regular inspections and cleaning are essential to maintain efficient flow and prevent clogging, which can reduce water intake performance.

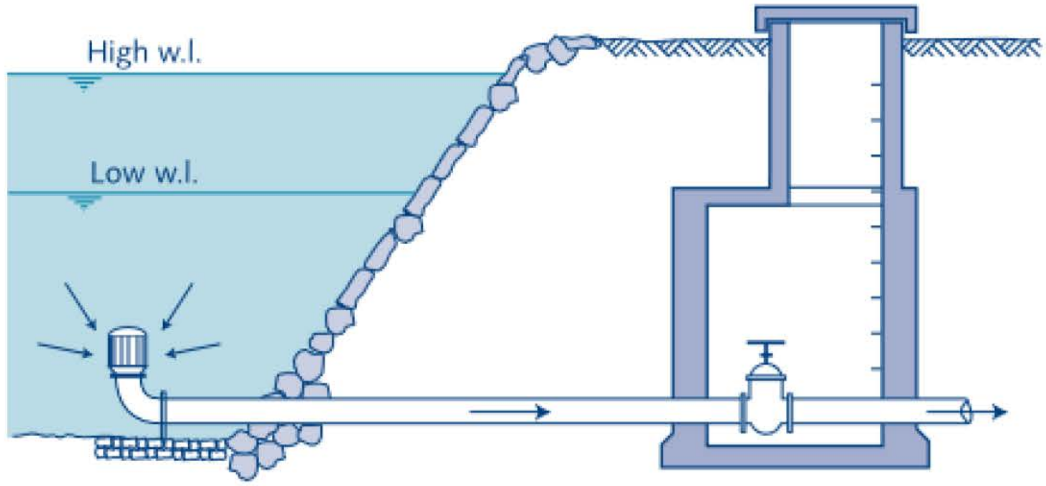

Figure 18: Schematic of a submerged intake screen.
Image source: https://sswm.info/sites/default/files/reference_attachments/SMET%202002%20Surface%20Water%20Chapter%2011.pdf [accessed August 1, 2024].

6.1.2.5 Bottom Intake

Bottom intakes, also known as Tyrolean intakes, are designed to withdraw water from the bottom of a river. A low weir spanning the river is constructed to direct water over a short, screened section. After passing through the screen, water drops into a collection chamber that is sunk into the riverbed. From here, water is conveyed to an onshore stilling basin where it could be pumped to the end user.

Since the bottom intake is installed in the riverbed, it is susceptible to accumulation of sediment and debris. For this reason, bottom intakes are typically reserved for use in steep, mountainous terrain, where sediment loading is reduced and limited to larger particle sizes that can be effectively screened. Where sediment can be ingested through the coarse screen, this is often removed using a gated flushing chamber; however, utilization of these requires sufficient head/gradient to facilitate effective flushing, a characteristic that the Sheep River does not posses in the Study Reach.

6.1.2.6 Coanda Intake

A Coanda intake is a specialized design that excludes sediments greater than 1 mm to 2 mm from becoming ingested. A Coanda intake is similar to a bottom intake in that water flows overtop of the screen and drops into a collection chamber; however, the Coanda screen pulls in water via a shearing effect through a wedgewire screen. Coanda screens are often referred to as fish-friendly since the opening sizes are less than typical fish protection requirements.

For a Coanda screen to function properly, the water surface must be raised behind a low diversion weir to form a in a small head pond. This pond has two main purposes: first, it helps to facilitate proper flow conditions over the Coanda screen to ensure maximum performance; second, it acts as a sediment trap, which is primarily to minimize wear of the screen wires. A flushing (sluice) gate is often incorporated into the diversion weir design to regulate water levels and flush sediments from the headpond.

Coanda screens are often marketed as 'self-cleaning' and low-maintenance; however, this is generally only true under specific circumstances. In high-sediment environments, erosion of the wedgewire screens reduces performance, thereby necessitating effective sediment management protocols. Also, tree leaves and needles can clog or blind screen openings if not effectively managed.

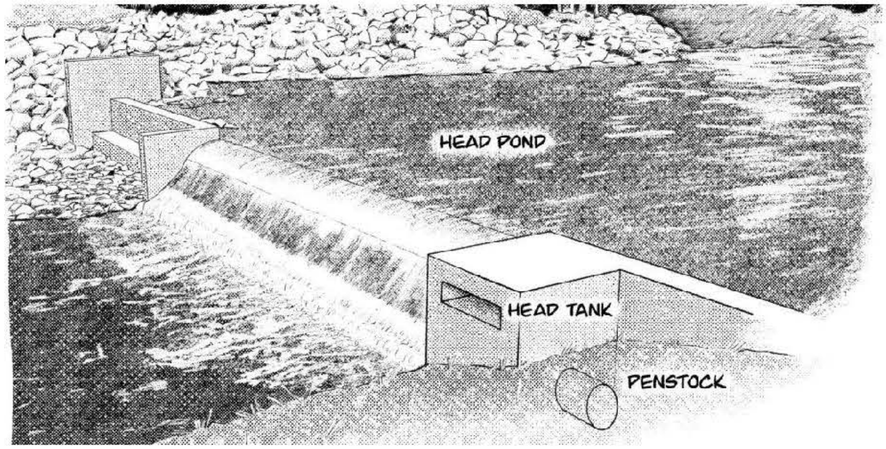

Figure 19: Schematic of a Coanda water intake.
Image source: https://elginseparationsolutions.com/coanda-screens/ [accessed August 4, 2024].

Table 6: Advantages and disadvantages of various intake options.

Intake Type	Advantages	Disadvantages
Temporary Intake Solutions		
Existing Temporary Intake	The infrastructure is already in place meaning that capital costs are effectively nil. SRRUC is familiar with its equipment and operations.	The Temporary Intake can not be used in the winter due to ice cover on the river surface. It is only functional during the open-water season and is, therefore, not a secure year-round water source. Operation during the freshet entrains significant amounts of sediments that accumulate in the reservoir. To avoid the high maintenance costs associated with sediment removal, the intake is not operated during this time. Erosion of the left bank is encroaching on the deployment boom and concrete pad at the Temporary Intake. Should this erosion continue to occur, the entire Temporary Intake is at risk of becoming compromised. Should this occur, alternate locations to re-deploy this equipment were not identified during the site visit.
Infiltration Pits	Relatively easy to construct and low capital cost. Some natural filtration capacity provided by the river sands and gravels.	Maintenance required after each flood event and possibly between events. Potential for fish standing in pits after flood events. Future erosion and changes to river alignments may prohibit this option in the future.
Permanent Intake Solutions		
Direct Infiltration Intake	Conceptually simple design and operation. Filtration capacity provided by the filtration media. No fish protection requirements since the collector pipes are buried. Collector pipes are buried and not exposed to public interface, ice, or other vectors.	Instream construction requiring channel diversion. Regular maintenance using backflush systems and/or in-stream works. Backflush systems are often prone to poor performance via preferentially air pathways (short-circuiting). Future erosion and changes to river alignments may necessitate an oversized structure.

Intake Type	Advantages	Disadvantages
Water Wells	Natural filtration capacity provided by the river sands and gravels. Infrastructure would be similar to existing water wells, facilitating ease of maintenance.	As yet, capacity of YWAM site is unknown. Potential environmental liabilities related to septic field and possible landfill. Multiple wells likely required. Additional land tenure required to install wells, pipeline.
Lateral Intake	Typically robust, long-term infrastructure. Relatively simple operation and maintenance.	Instream construction requiring channel diversion. Requires diversion weir in shallow rivers. Without this, changes to river alignment could strand the intake relative to the channel. May require mitigations related to fish entrainment, ice effects. Periodic cleaning of intake screens.
Submerged Screens	Limited instream infrastructure. Fish friendly screen.	Requires sufficient depth to mitigate against ice effects, and impacts to recreational users. Changes to river alignment could strand the intake relative to the channel.
Bottom Intake	Low profile reduces need to raise water levels.	Instream construction requiring channel diversion. Requires low diversion weir. Flushing of accumulated sediments may be challenging in low gradient environment. May require mitigations related to fish entrainment, ice effects. Periodic cleaning of intake screens.
Coanda Screen	Excludes sediments greater than 2 mm. Fish friendly screen.	Instream construction requiring channel diversion. Requires diversion weir and collection chamber. Winter operation can require additional attention to manage ice. Periodic cleaning and replacement of screen panels. Management of sediments < 2 mm still required.

6.2 Intake Comparison

The advantages and disadvantages of the various intake types described in **Table 6** were evaluated in a multiple accounts style of analysis. In this analysis, different features were compared and assigned a score from 0 (worst) to 3 (best). These various features were then assigned a weighting factor to gauge their relative importance (for example, if fish protection was deemed a higher priority than costs, it was given a higher weighting). The categories evaluated in this analysis included the following with the rational for the lowest and highest scores provided:

1. Does the option require the use of a dam or diversion weir?
    - 0 – Large structure required.
    - 3 – No structure required.
2. Does the option provide natural filtration?
    - 0 – None provided.
    - 3 – Excellent filtration provided.
3. Does the option exclude fish?
    - 0 – No fish protection measures are provided.
    - 3 – Fish are adequately excluded as required by DFO's Interim Code of Practice.
4. Maintenance considerations:
    - 0 – Low maintenance requirements.
    - 3 – Maintenance intensive installation.
5. General Cost:
    - 0 – Minimal costs, infrastructure largely exists.
    - 3 – Major capital works program required.
6. Intake Capacity:
    - 0 – Flow is limited in terms of quantity or seasonality.
    - 3 – Flows are generally unlimited in terms of quantity or seasonality.

The results of this multiple accounts assessment are shown in **Table 7**. In this analysis, the direct infiltration intake style of intake scored the highest. This was followed by new infiltration wells, though it must be emphasized that further exploration on groundwater availability would need to be performed to confirm this as a viable water source. Because the other permanent intake solutions will require a dam (including associated capital costs) these all scored low and were deemed less preferable than maintaining one of the two temporary options.

The relative weightings and individual criteria scores are subjective to the authors and could be adjusted based on the preferences of SRRUC. However, a brief sensitivity completed by Boreal (not shown herein) returned similar results to those presented below.

Based on these results, a direct infiltration intake is recommended. Potential locations for a direct infiltration intake deployment are discussed in the following section. However, it must be re-iterated that clogging of the filtration media presents a significant operational challenge for the Study Reach. This will require some operational and maintenance efforts on the part of SRRUC, including potentially having to replace the filtration media at some point. If such maintenance activities are beyond what SRRUC is willing to take on. Exploration for new water wells would be the next highest ranked option for a permanent intake solution.

Lastly, while the temporary intake options do not meet the goal of providing year-round access to water, they did score higher than those permanent intake options that require a dam. It is reasonable that SRRUC continue to operate the existing Temporary Intake, although if water security in a post-flood event is important, this may not be a viable solution.

Table 7: Evalution of various intake options.

Criteria	Weighting	Temporary Intake		Infiltration Pits		Infiltration Gallery		Water Well		Side Intake		Submerged Screen		Bottom Intake		Coanda Intake	
Dam / Diversion Weir Required?	30%	No dam required.	3	No dam required.	3	No dam required.	3	No dam required.	3	Dam required - large.	0	Dam required - large.	0	Dam required - small.	2	Dam required - medium.	1
Natural Filtration	20%	None provided.	0	Provides some filtration.	2	Provides natural filtration.	3	Provides natural filtration, consistent water quality.	3	None provided.	0	None provided.	0	None provided.	0	Coarse sand and greater removed.	1
Fish Protection	10%	Provided by intake protection screen.	2	Provided by intake protection screen. Potential for fish stranding in pits.	0	Not required.	3	Not required.	3	Intake protection screens required.	1	Provided by intake protection screen.	2	Not possible.	0	Coanda screen is fish-friendly.	2
Operation & Maintenance	10%	Easily accessible for maintenance but longer term likelihood for river to compromise intake.	1	Likelihood of annual reconstruction. Pit stability issues.	0	High likelihood that fine materials clog filtration media. Backflushing is typically not successful.	1	Regular pump maintenance and inspections, cleaning or redevelopment of the well if performance declines	2	Regular intake screen cleanings, gate maintenance. Flushing or removal of upstream sediments required.	2	Cleaning generally by air backflush. Potential for sediment accumulation to block intake. Difficult to access for maintenance.Flushing or removal of upstream sediments required.	1	Blockage by sediment is likely. River geometry is not favourable for sediment flushing. Difficult to access for maintenance.	0	Flushing of fine materials will be required. Occassional screen replacements required. Flushing or removal of upstream sediments required.	2
General Cost	15%	Option is existing. No capital cost requirement.	3	Relatively cheap to construct. Pipeline to be moved.	2	High costs related to instream works and onshore works.	1	Costs related to well development and piping infrastructure. Risk capital required for potential exploration program.	1	High capital related to development and construction.	0	High capital related to development and construction.	0	High capital related to development and construction.	0	High capital related to development and construction.	0
Capacity	15%	Pump capacity is scalable but would need to be large to achieve desired volume. Water availability limited by winter ice cover.	1	Pump capacity is scalable but would need to be large to achieve desired volume. Water availability in winter possible with proper pump. No operation during floods. installation.	2	System can be easily sized for required flow rates. System can operate throughout the winter.	3	Potential well yields have not been confirmed - further exploration required. If resource exists, water available year-round.	2	With dam, option is scalable and appropriate for winter use.	3	With dam, option is scalable and appropriate for winter use.	3	With dam, option is scalable and appropriate for winter use. Possible limitations related to sediment accumulations.	2	With dam, option is scalable and appropriate for winter use. Ice management can be relevant for winter operation.	2
Total Score	**100%**	**1.80**		**1.90**		**2.50**		**2.45**		**0.75**		**0.75**		**0.90**		**1.20**	

6.3 Intake Location Analysis

The following section describes potential locations for the installation of a new direct infiltration intake. The Study Reach was evaluated from the Temporary Intake to the Decalta Road bridge crossing. Potential intake sites were initially identified based on terrain and locational considerations, including:

- Proximity to the existing Temporary Intake and associated infrastructure;
- Channel gradient (slope);
- Location relative to flood inundation footprint(s); and
- Infrastructure requirements to support installation at the location of interest.

Additional site constraints were considered (see **Figure E-2** in **Appendix E**), as may affect placement of either onshore infrastructure (i.e., pump stations) or instream works (i.e., collection pipes). Lastly, intake hydraulic requirements were taken into account, including those shown in the **Table 8**. The Study Reach is broken down by segments that were individually assessed, as is summarized in **Table 9** and **Figure 20**.

Potential locations for groundwater well development were identified by Stantec (2016) and are shown in **Appendix D**.

Table 8: Water intake hydraulic requirements.

Criteria	Direct Infiltration Intake
Gradient	Requires gentle slopes.
River location	Preferable in areas with stable banks and minimal sediment movement.
Bed load	Minimal bed load to prevent clogging
Minimum Depth	Moderate depth, with the intake buried below the riverbed
Maximum Velocity	Enough velocity to reduce the risk of clogging and ensure consistent infiltration

Table 9: Intake locations analysis.

Location / River Stationing	Concept	Intake Suitability
1 0+000 to 0+225	This location features a maximum velocity of 0.7 m/s, with a gradient above 1%, and glide bed form. This location is in the vicinity of the Temporary Intake, allowing the use of existing infrastructure for the new intake. The drawback of this segment is that it is in the immediate vicinity of the significant erosional event that occurred in 2013 – it is possible that a similar event dramatically alters the reach alignment, including potential destabilization of the right (south) bank.	While suitable in its present form, this location presents a high risk of future channel change that may compromise an intake installation. Additionally, the lower velocity in this location may promote additional deposition of fine materials leading to clogging of filtration media.
2 0+225 to 0+350	This segment features a maximum velocity of 0.8 m/s and a shallow depth, with a gradient above 1%. This location is close enough to the Temporary Intake to utilize the existing infrastructure. The river in this segment is wandering and is prone to future channel alignment changes. There is significant debris and fines deposition at the upstream end of this segment.	This location is unsuitable for a direct infiltration intake.
3 0+350 to 0+550	This segment features a maximum velocity of 0.8 m/s and a shallow depth, with a gradient above 1%. This reach is close to the WTP, within a distance of 40 meters upstream. However, the drawback of this location is that it is situated in a reach that is actively braiding and has seen significant channel change in recent years. Situated on the outside of a bend, there is a high potential that the river migrates to the east, which would leave intake infrastructure stranded on a new left bank.	This location is unsuitable for a direct infiltration intake.
4 0+550 to 0+800	This segment features a maximum velocity of 0.7 m/s and a shallow depth, with a gradient above 1%. This location is close to the WTP, within a distance of 100 meters downstream, and is situated in a reasonably stable, straight reach. This reach corresponds to a run bedform. The low velocities may encourage some deposition of fine materials.	A direct infiltration intake may suffice in this location.
5 0+800 to 0+950	The fifth location assessed features a maximum velocity of 1 m/s and a shallow depth, with a gradient above 1%. This reach has the highest velocity but is located near the existing water well infrastructure, which may be leveraging for conveyance to the WTP or reservoirs. This location is stable and straight, situated in a riffle habitat of the river. The higher velocities would suggest lesser deposition of fines materials as compared to other segments that have been evaluated.	This would appear to be the best location to site a direct infiltration intake.
6 0+950 to 1+070	This segment features a maximum velocity of 0.8 m/s and a shallow depth, with a gradient above 1%. An installation in this segment could also leverage the existing water well infrastructure. This location is stable and is located in a slight bend of the river and corresponds to a riffle bedform. However, proximity to the bridge may induce excessive scour and debris accumulation.	It is not recommended to place a direct infiltration intake in this location due to the proximity to the bridge, where relatively high bed scour may occur.

Note 1: The maximum velocities mentioned above corresponds to the values obtained under low normal conditions Q95.

According to the analysis in the **Table 9**, the best location for the installation of a direct infiltration intake appears to be Location #5, followed by the Location #4. This location provides the most appropriate combination of features, such as river hydraulics, geomorphological conditions, sediment behavior, and terrain advantages.

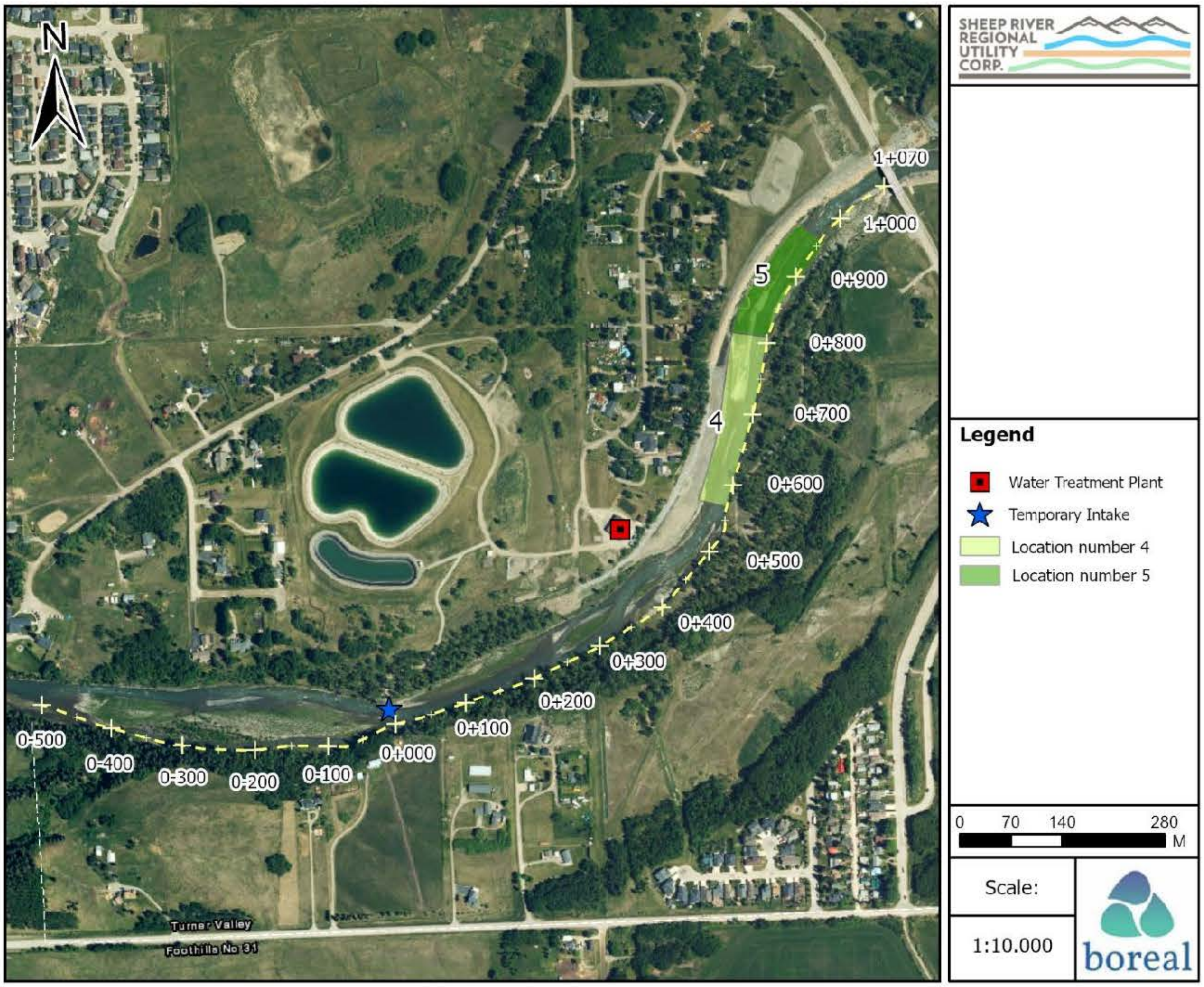

Figure 20: Selected reaches for a potential direct infiltration intake.

7 CONCLUSIONS

The results of this intake Feasibility Assessment suggest that a direct infiltration intake may be the most appropriate solution for a permanent water intake to be installed in the Study Reach. This conclusion was based on a qualitative assessment of a number of factors, including year-round operation, natural filtration capabilities, and hydraulic and geomorphological characteristics. Despite this recommendation, two key factors must be considered prior to selecting a direct infiltration intake as the preferred option. First, Sheep River is a highly active watercourse that carries an abundance of sediment, both fine and coarse. Deposition of fine sediments in particular present an issue related to potential clogging of filtration media. Were this to occur, major reconstruction of the filtration media may be required.

Second, as evidenced in historical aerial photographs and in the aftermath of the 2013 extreme flood event, the main channel of Sheep River has a tendency to shift alignment in response to erosion, scour and bedload re-distribution. While the channel appears to have remained generally stable since approximately 2014, there remains a risk that another major flood event realigns the channel, which could strand a new intake installation if care is not taken in selecting an appropriate location.

Both of these issues can be attenuated by oversizing a direct infiltration intake. A collector pipe that spans the majority of the river width would help to ensure that channel re-alignment does not significantly affect water withdrawal. Further, designing for a capacity that is significantly higher than is required would provide an additional allowance for clogging of the filtration media. However, oversizing the direct infiltration intake would also necessitate oversizing of the backflush systems, adding additional costs and maintenance.

Should SRRUC wish to pursue an option other than a direct infiltration intake, options such as water wells or a Coanda intake may be viable choices. To prove the viability of the potential groundwater locations identified in Stantec (2016), test wells will need to be installed and monitored. If the resource itself proves viable, then issues such as land tenure (for a possible pipeline and utility route) would need to be considered.

If the use of a dam structure is an option at this location, several additional intake types would be possible from a technical standpoint. However, none of these additional options address the ingestion of highly-turbid water at certain times of the year. Among these options, the Coanda intake was ranked the highest due to the potential to exclude sediment particles larger than 2 mm in diameter and the potential for a lower profile dam structure. However, there would be challenges with winter operations for a Coanda screen, requiring occasional clearing of ice and screen cleaning. Lastly, raising of a head pond behind a dam may increase the phreatic surface in the adjacent banks, which could pose an issue for the steep vertical bank immediately downstream of the Temporary Intake location.

8 RECOMMENDATIONS

Should SRRUC wish to proceed with a direct infiltration intake, it is recommended that additional bathymetric survey be completed in the vicinity of the locations identified in Section 6.3. During this survey, additional characterization of bed materials, including a limited sampling and testing program, should be completed to fully evaluate the potential for fines deposition over the filtration media such that appropriate design precautions can be considered.

Alternatively, SRRUC may wish to explore the potential groundwater resource targets identified in Stantec (2016). Doing so would require initiation of an exploration program and a better understanding of potential pipeline conveyance from the new well locations to the storage reservoir.

Dam construction is a major undertaking and, considering the relatively low flow rates under consideration, is likely cost-prohibitive. Further, none of the intake options that require dams provide a fully year-round solution given likely shutdown requirements during periods of higher turbidity. Sediment management behind a dam would also present a challenge in that a sluicing system or other means of sediment removal will be required. For these reasons, it is likely that an intake alternative requiring a dam is not worth pursuing at this time.

Should SRRUC wish to defer development of any permanent intake solutions and proceed using the existing Temporary Intake, it is advisable that SRRUC explore options to stabilize the left (north) bank immediately upstream of the boom in the event of another extreme flooding event. Potential stabilization solutions would need to consider the effect that potential protection works would have on the flood hydraulics and, specifically, directly additional flow to the right (south) bank.

9 CLOSURE

The recommendations presented in this report are based on Boreal Water Resources Ltd.'s interpretation of existing conditions as provided to us for this review. The information and recommendations presented in this report are for the exclusive use of MPE a Division of Englobe and Sheep River Regional Utility Corporation. Use or reliance on the information and recommendations presented in this report by any other party requires the express written consent of Boreal Water Resources Ltd. Boreal Water Resources Ltd. accepts no responsibility for damage suffered through unauthorized use of the information presented in this report.

If you have any questions, or require additional details, please contact the undersigned.

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APEGA Permit Number P14150

[redacted]

2024-12-10

APEGA I.D. # 77428

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APPENDIX A: GEOMORPHIC ASSESSMENT

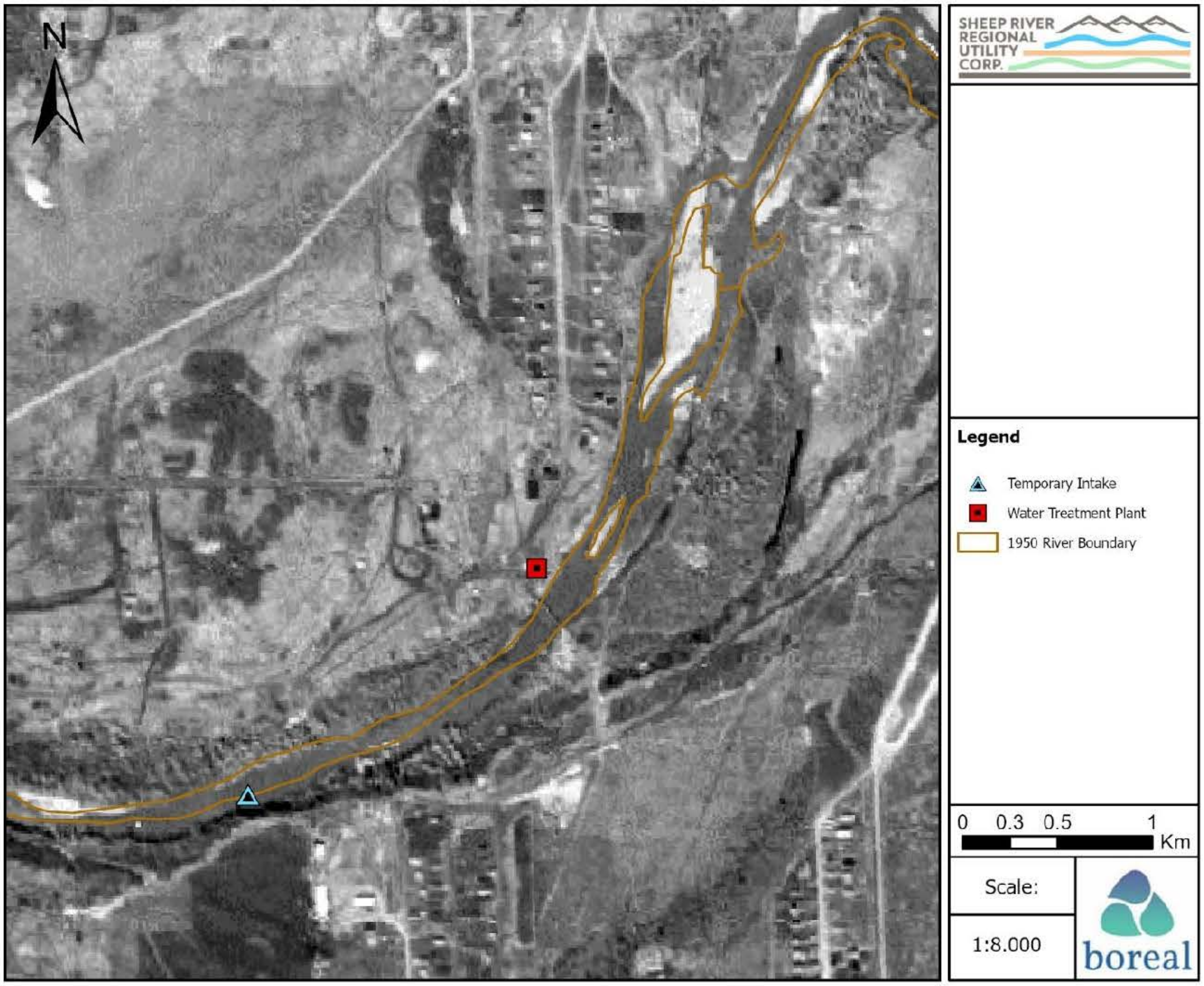

Figure A-1: Channel alignment in 1950.

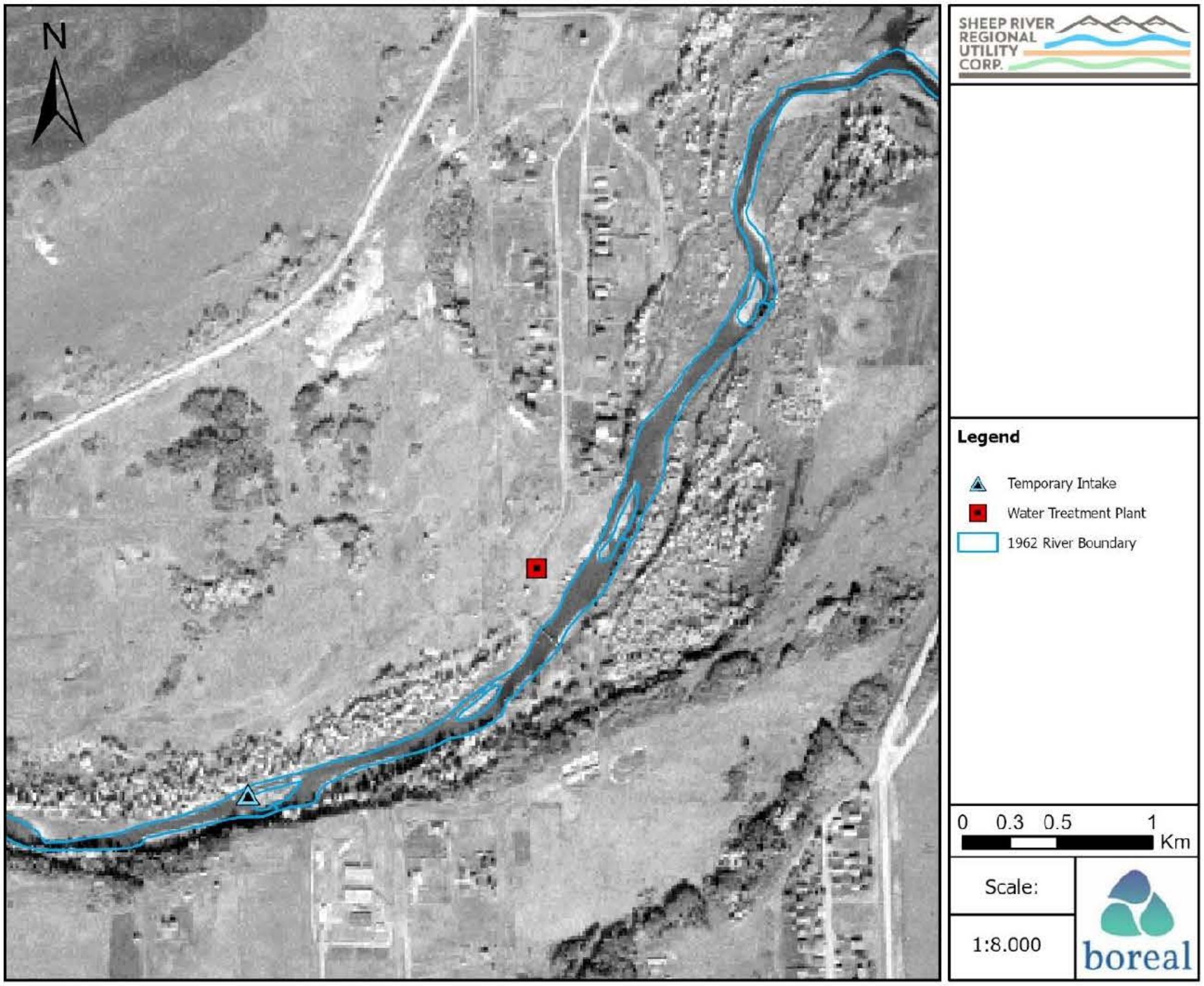

Figure A-2: Channel alignment in 1962.

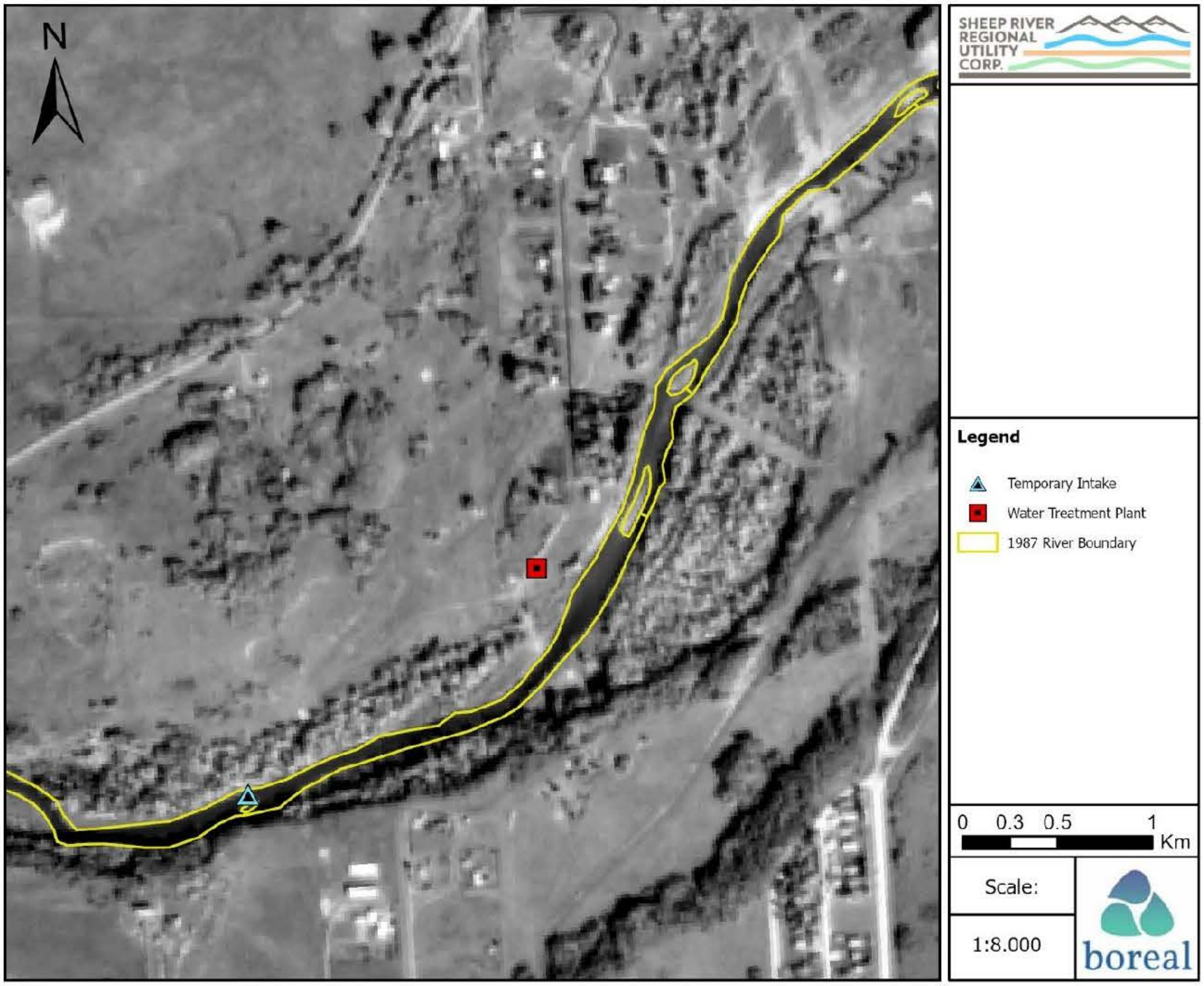

Figure A-3: Channel alignment in 1987.

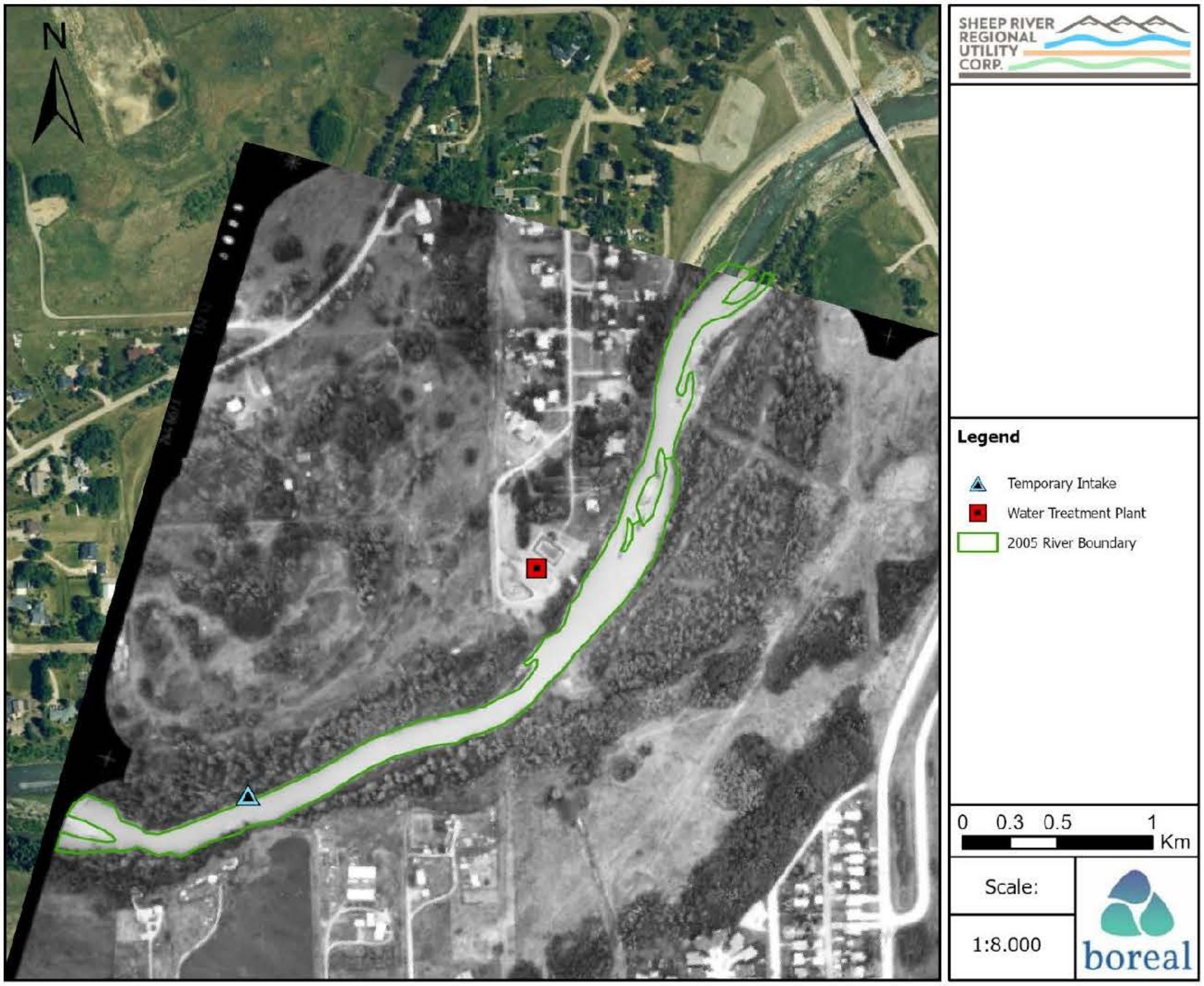

Figure A-4: Channel alignment in 2005.

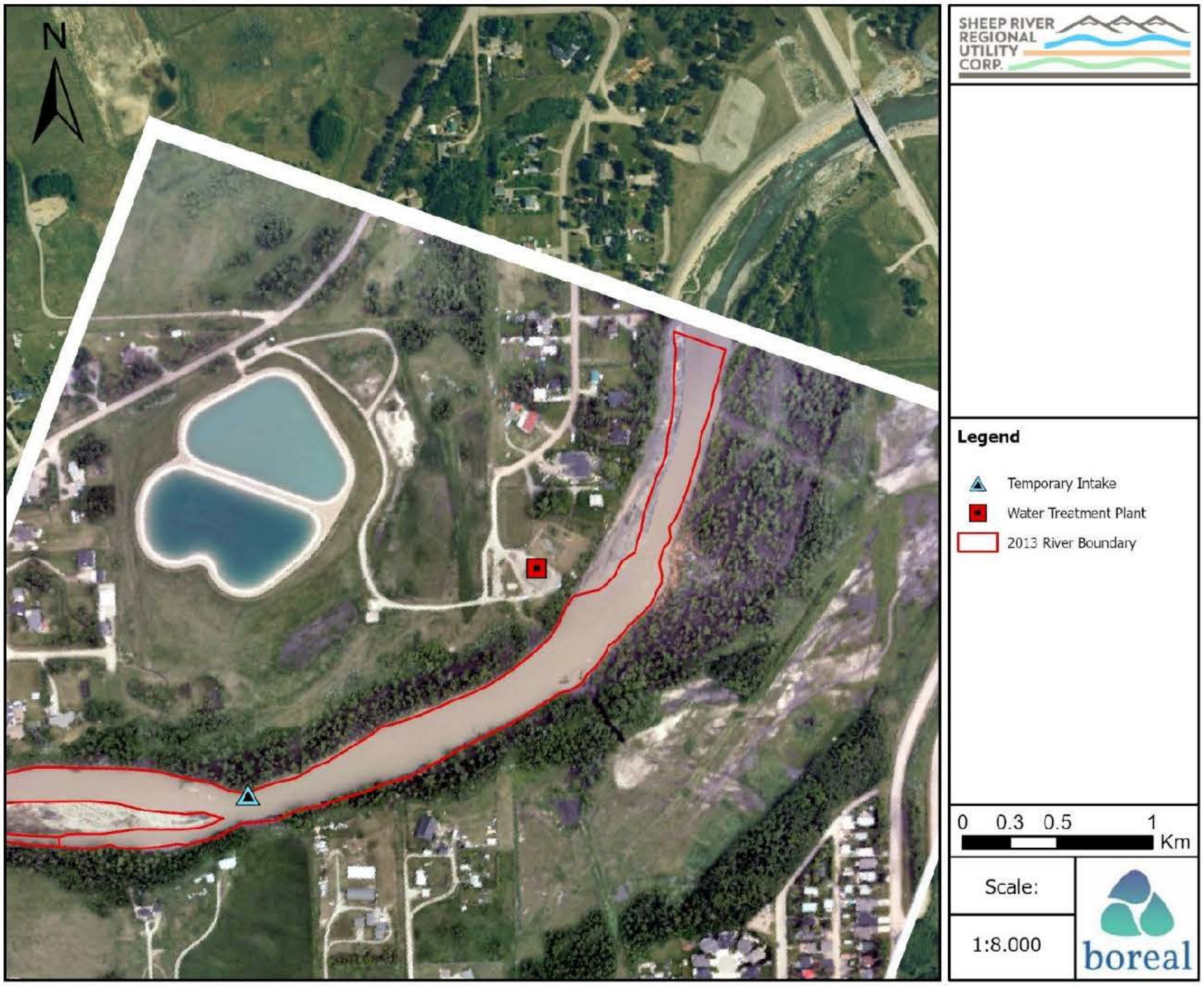

Figure A-5: Channel alignment in 2013.

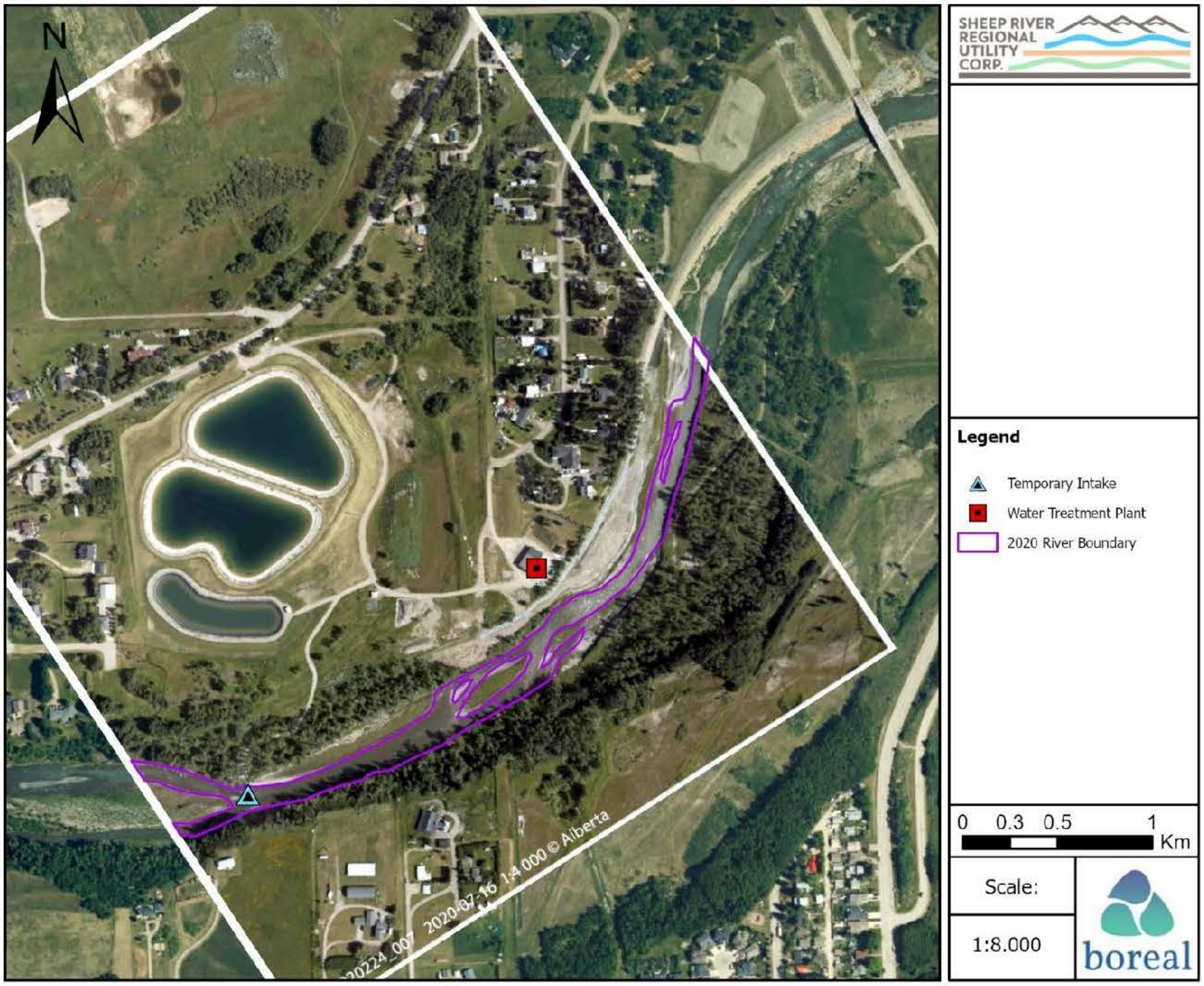

Figure A-6: Channel alignment in 2020.

Figure A-7: Orthophoto mosaic of assessed reach at Sheep River.

APPENDIX B: RESULTS OF HYDRODYNAMIC MODEL

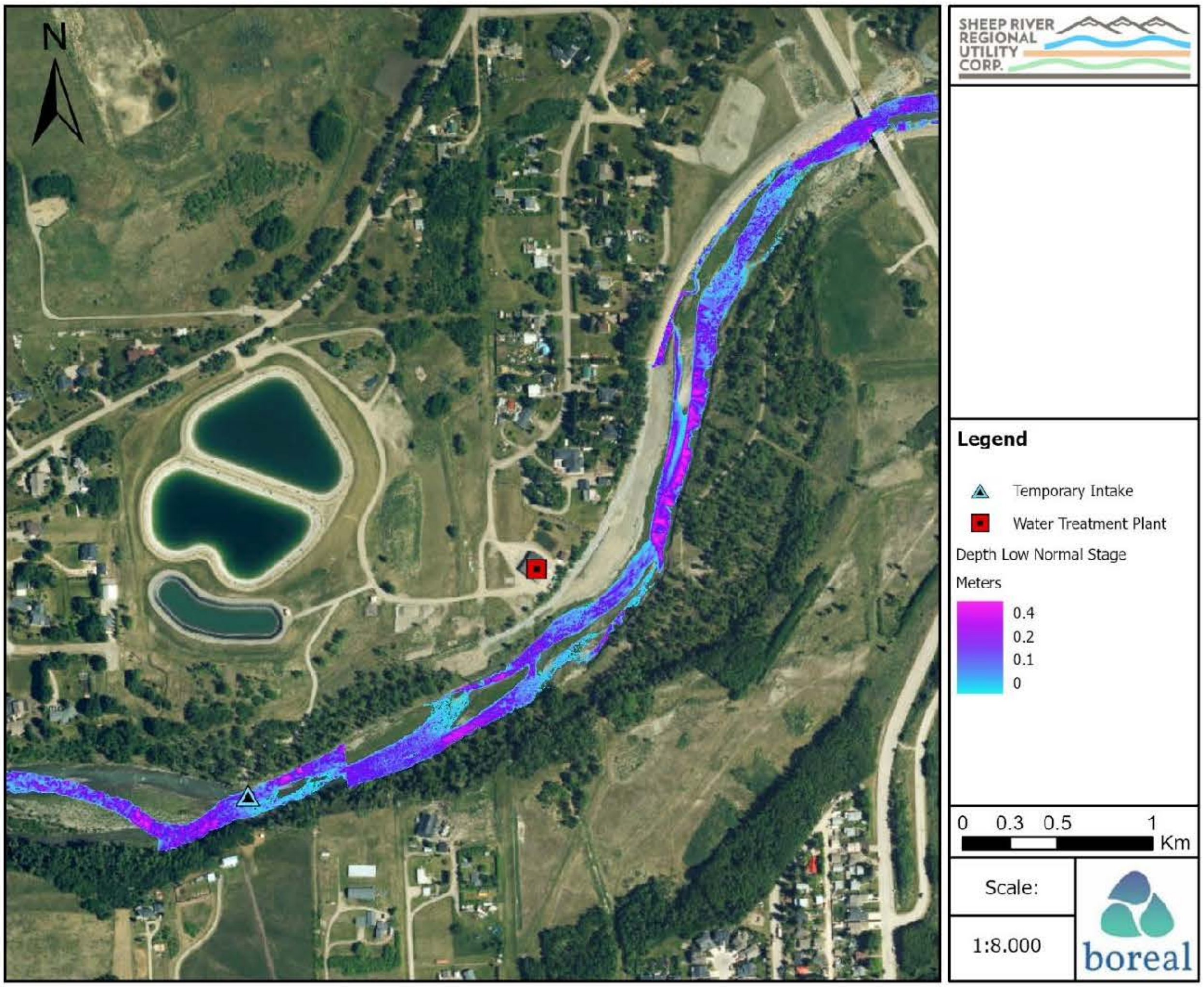

Figure B-1: Low-flow hydrodynamic model results, depth – Q_{95} (0.65 m^3/s).

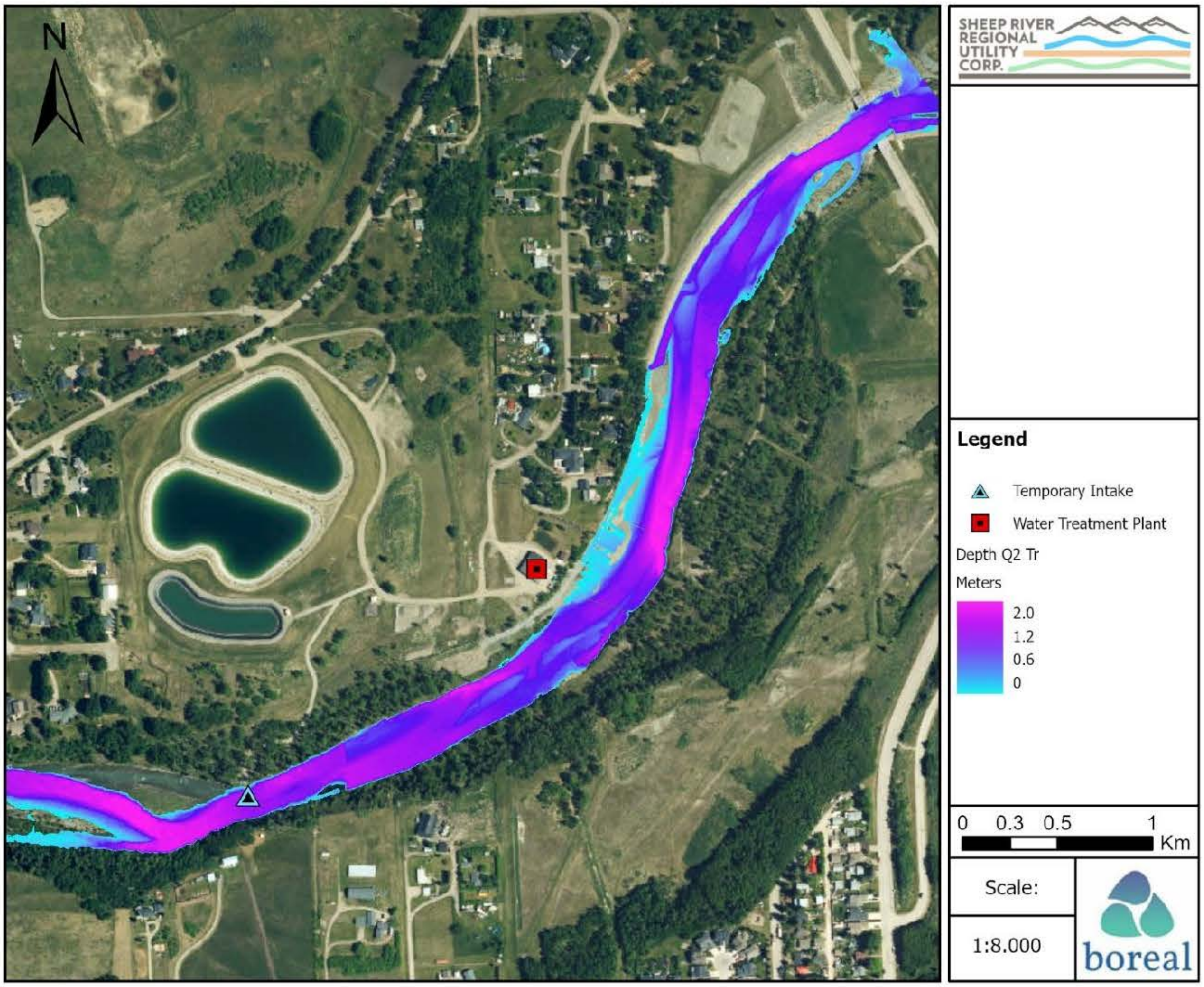

Figure B-2: Peak flow hydrodynamic model results, depth – Q_2 (92 m^3/s).

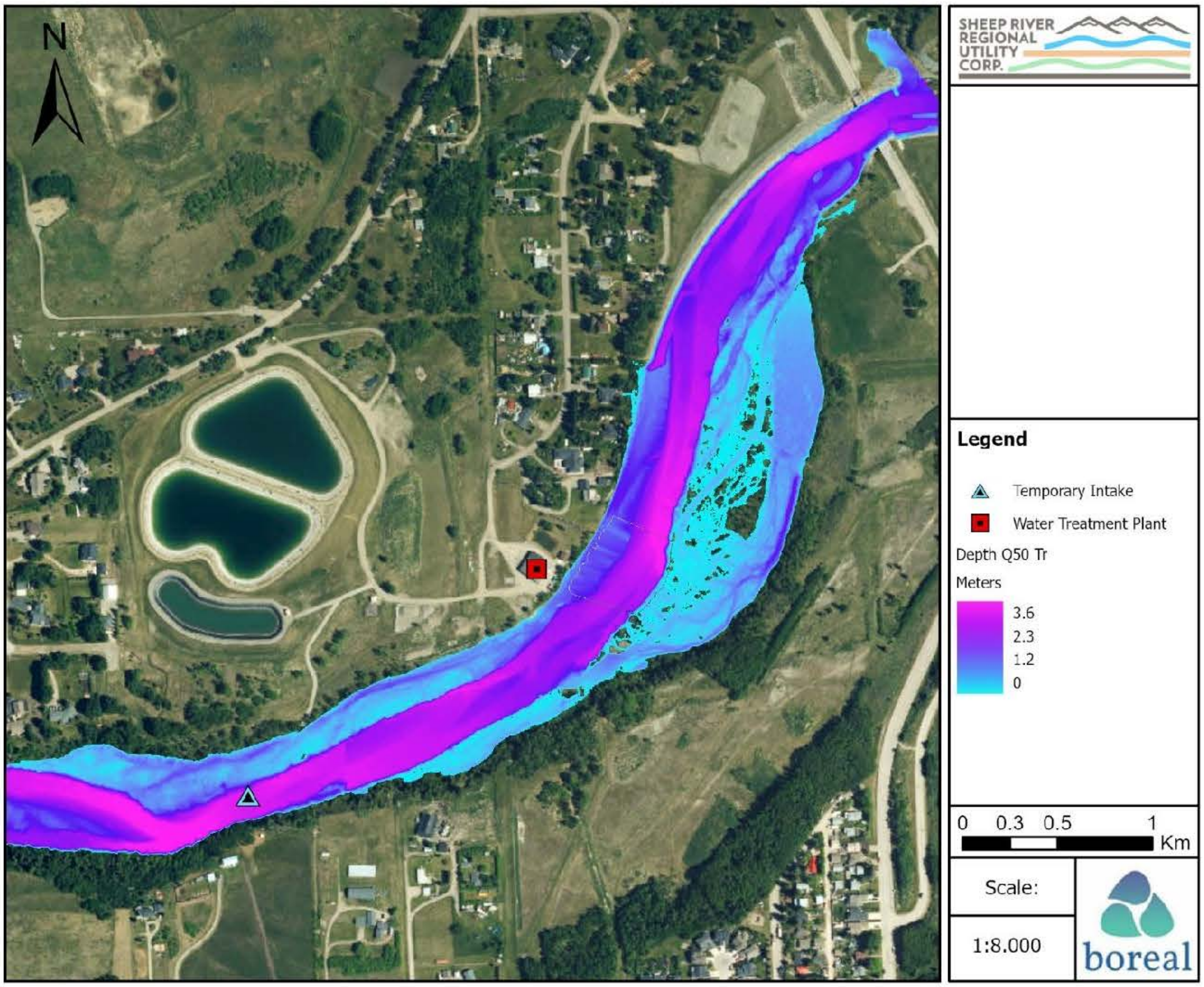

Figure B-3: Peak flow hydrodynamic model results, depth – Q_{50} (462 m^3/s).

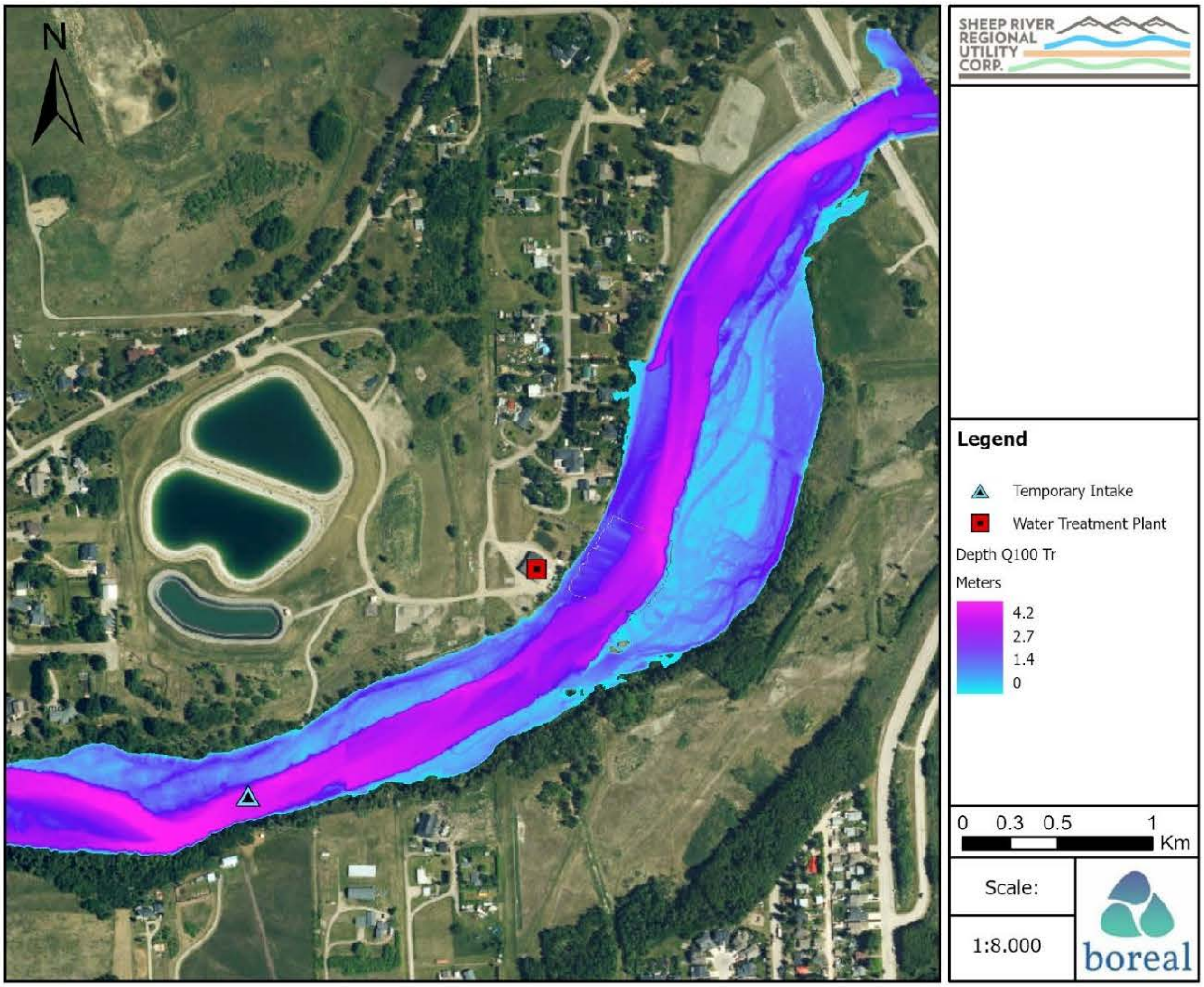

Figure B-4: Peak flow hydrodynamic model results, depth – Q_{100} (669 m^3/s).

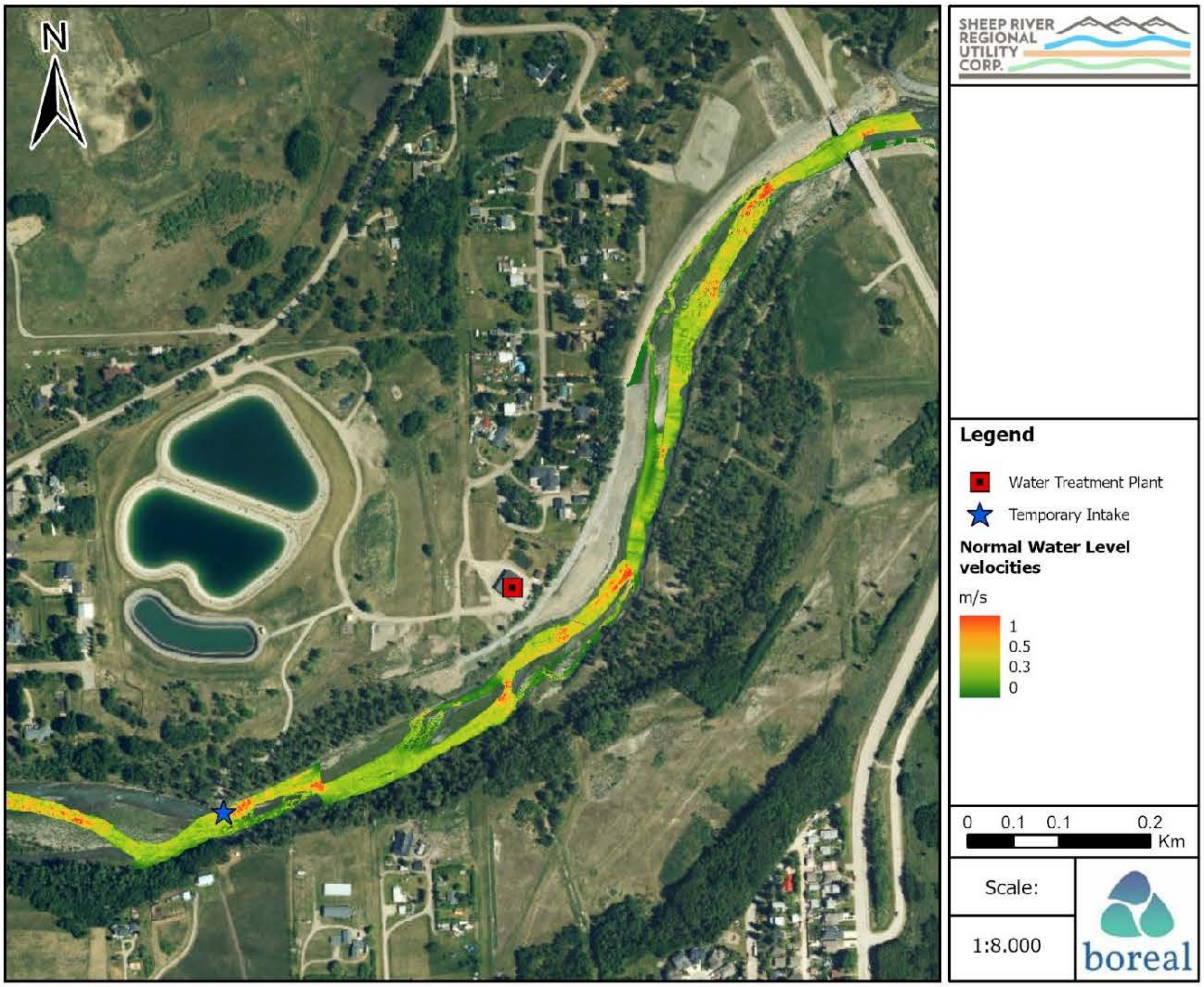

Figure B-5: Low-flow hydrodynamic model results, velocity – Q_{95} (0.65 m^3/s).

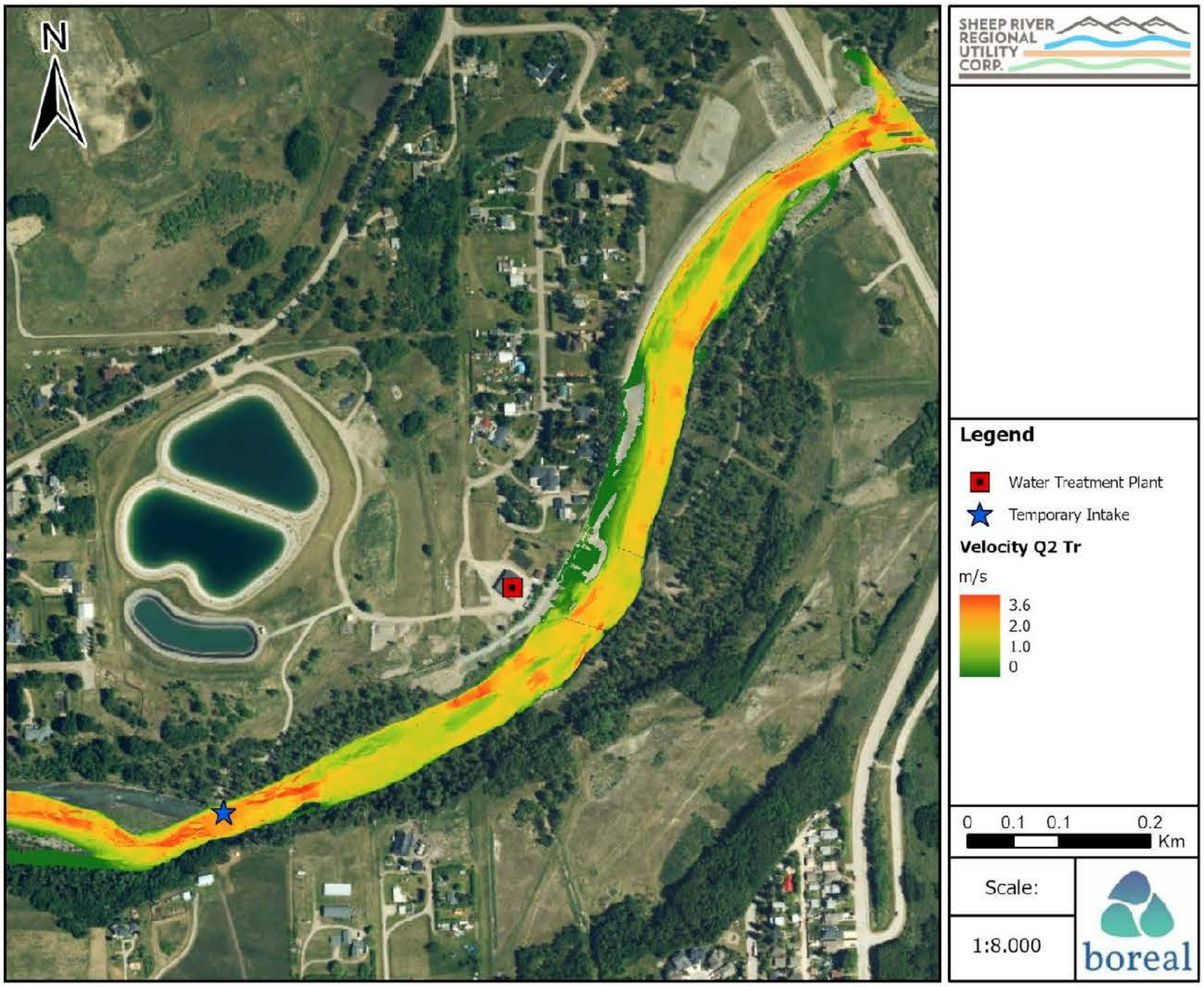

Figure B-6: Peak flow hydrodynamic model results, velocity – Q_2 (92 m^3/s).

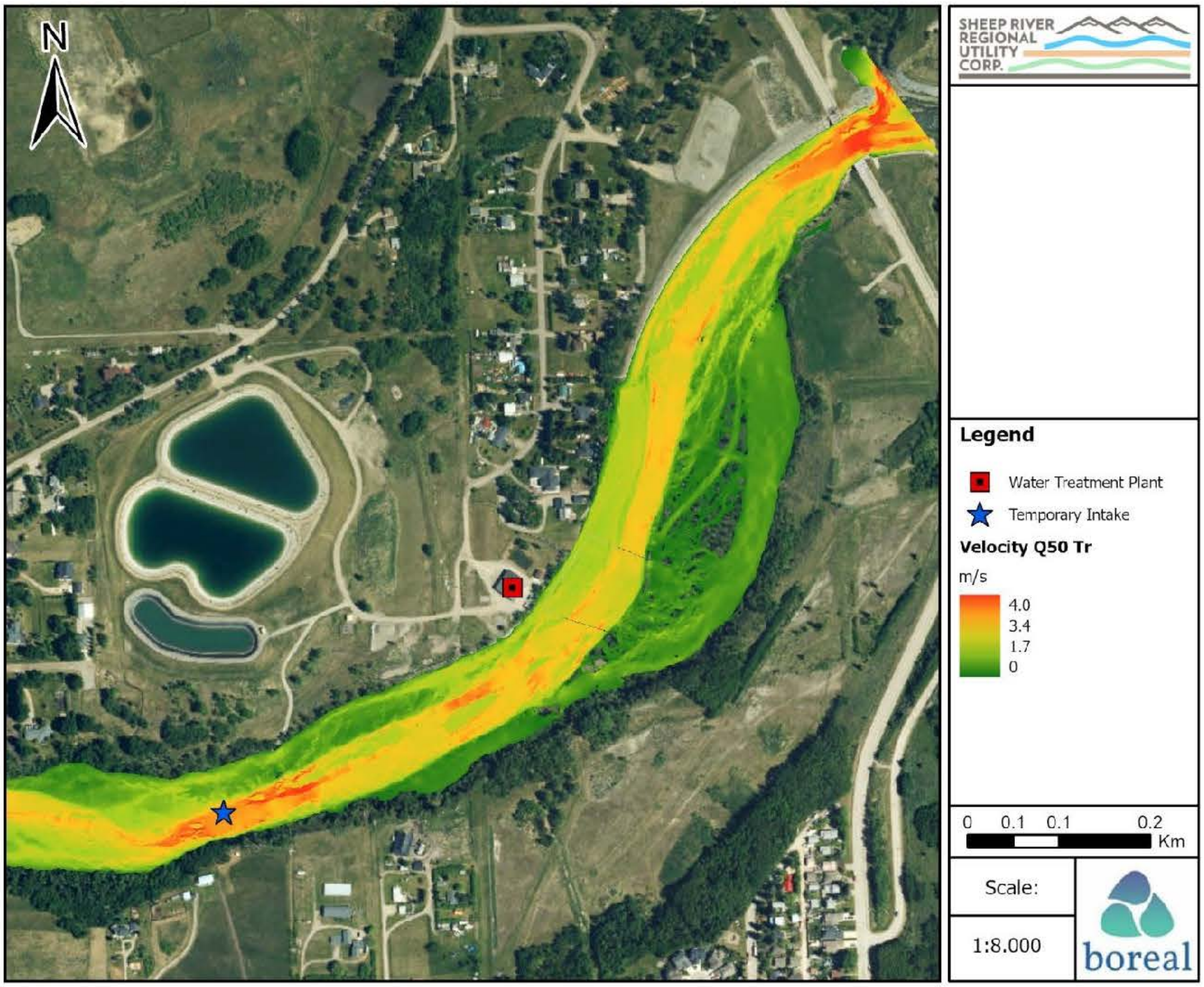

Figure B-7: Peak flow hydrodynamic model results, velocity – Q_{50} (462 m^3/s).

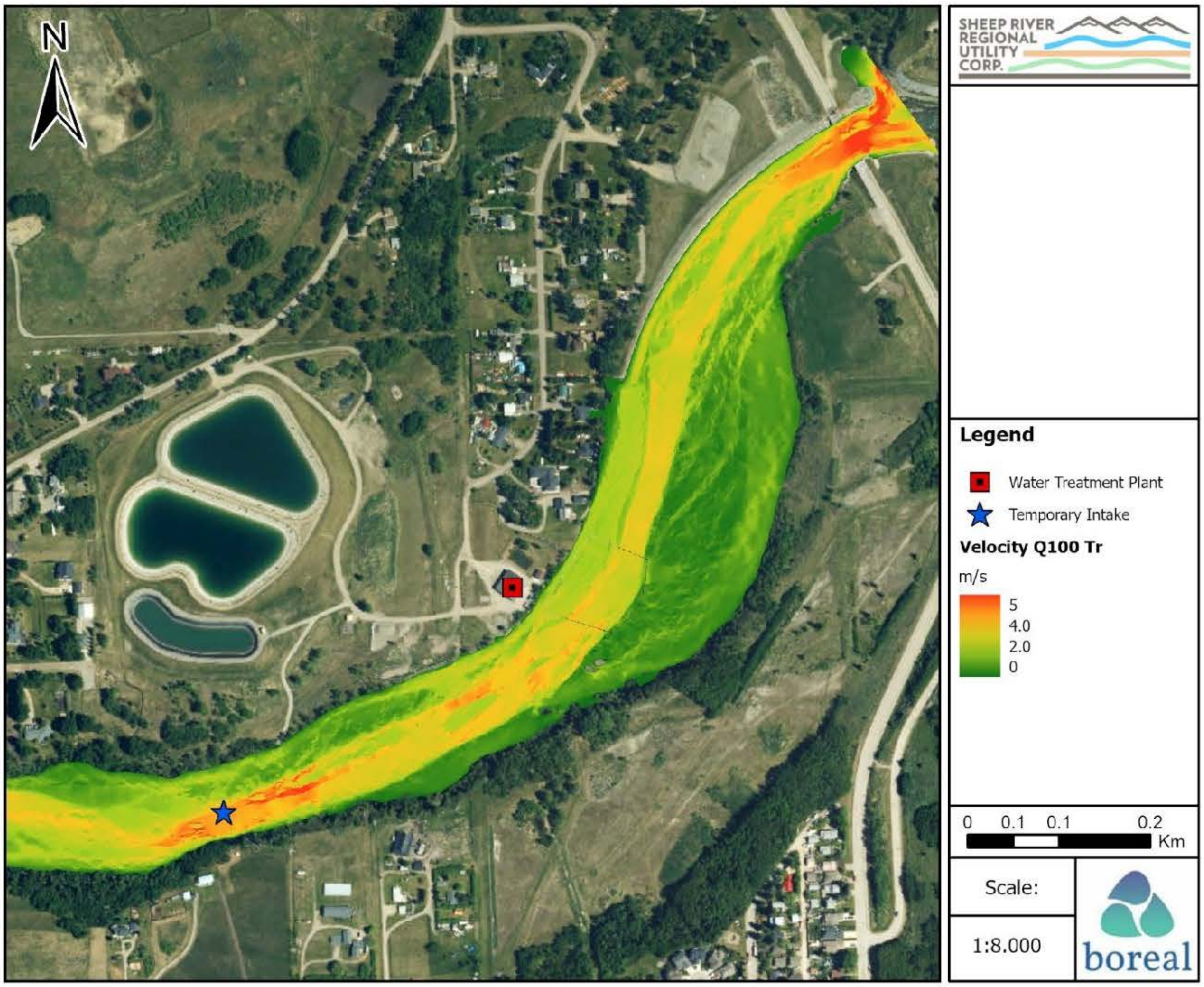

Figure B-8: Peak flow hydrodynamic model results, velocity – Q_{100} (669 m^3/s).

APPENDIX C: SITE VISIT PHOTOGRAPHS

Figure C-1: Sheep River, downstream of the Temporary Intake looking upstream from left bank.

Figure C-2: Sheep River, looking downstream from left bank, wandering reach.

Figure C-3: Flood protection berm at the left side of the Sheep River floodplain.

Figure C-4: Sheep River, photo from left bank looking wood debris at the right bank.

Figure C-5: Sheep River, photo at the left bank looking downstream.

Figure C-6: Sheep River, 100 m upstream of the Decalta Road bridge.

APPENDIX D: POTENTIAL PRODUCTIVE AQUIFER TARGETS (STANTEC, 2016)

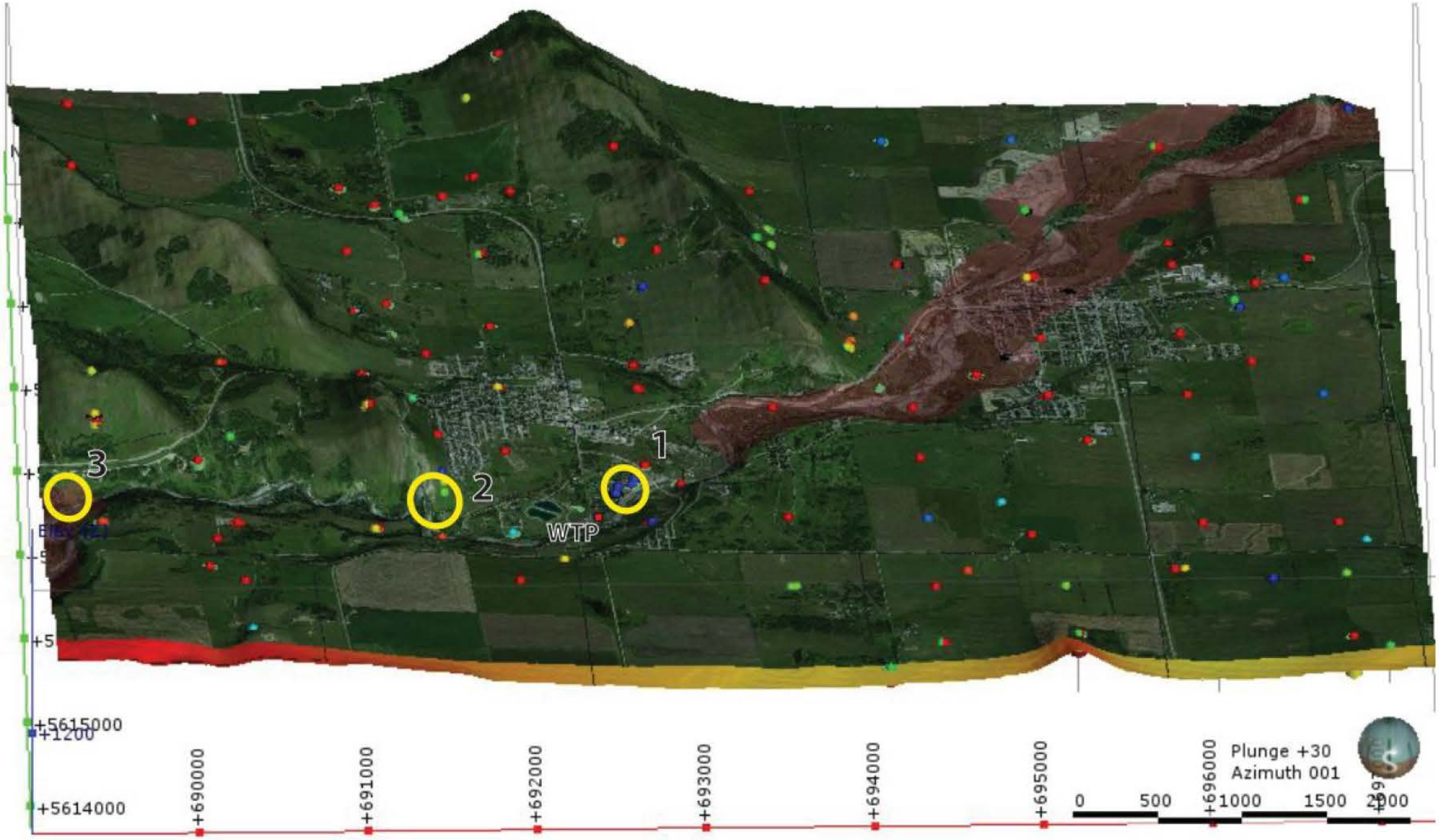

Figure D-1: 3D Geological model domain areas of potential productive aquifer targets (Stantec, 2016).

APPENDIX E: INTAKE SUITABILITY ANALYSIS

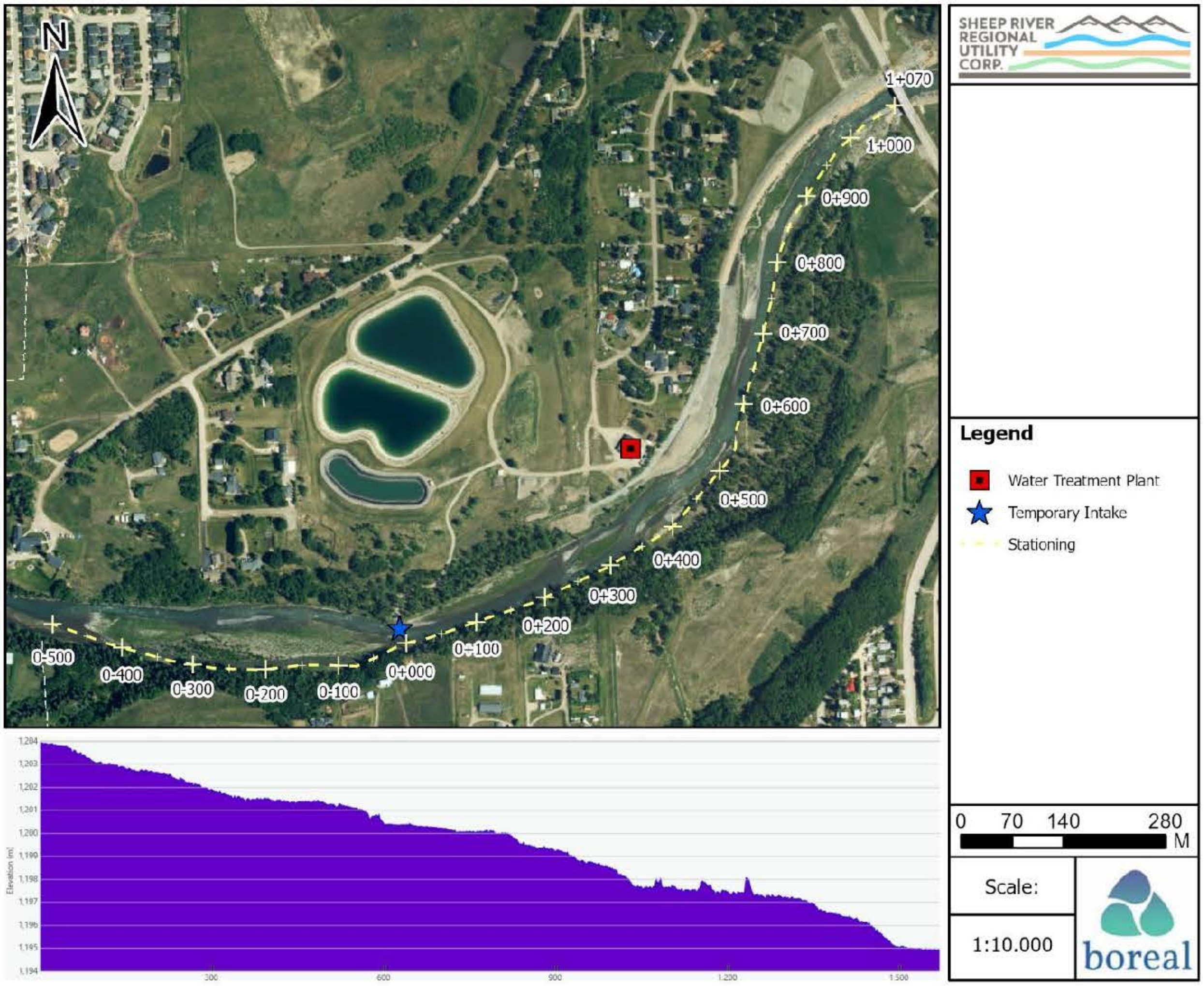

Figure E-1: Reach elevation profile.

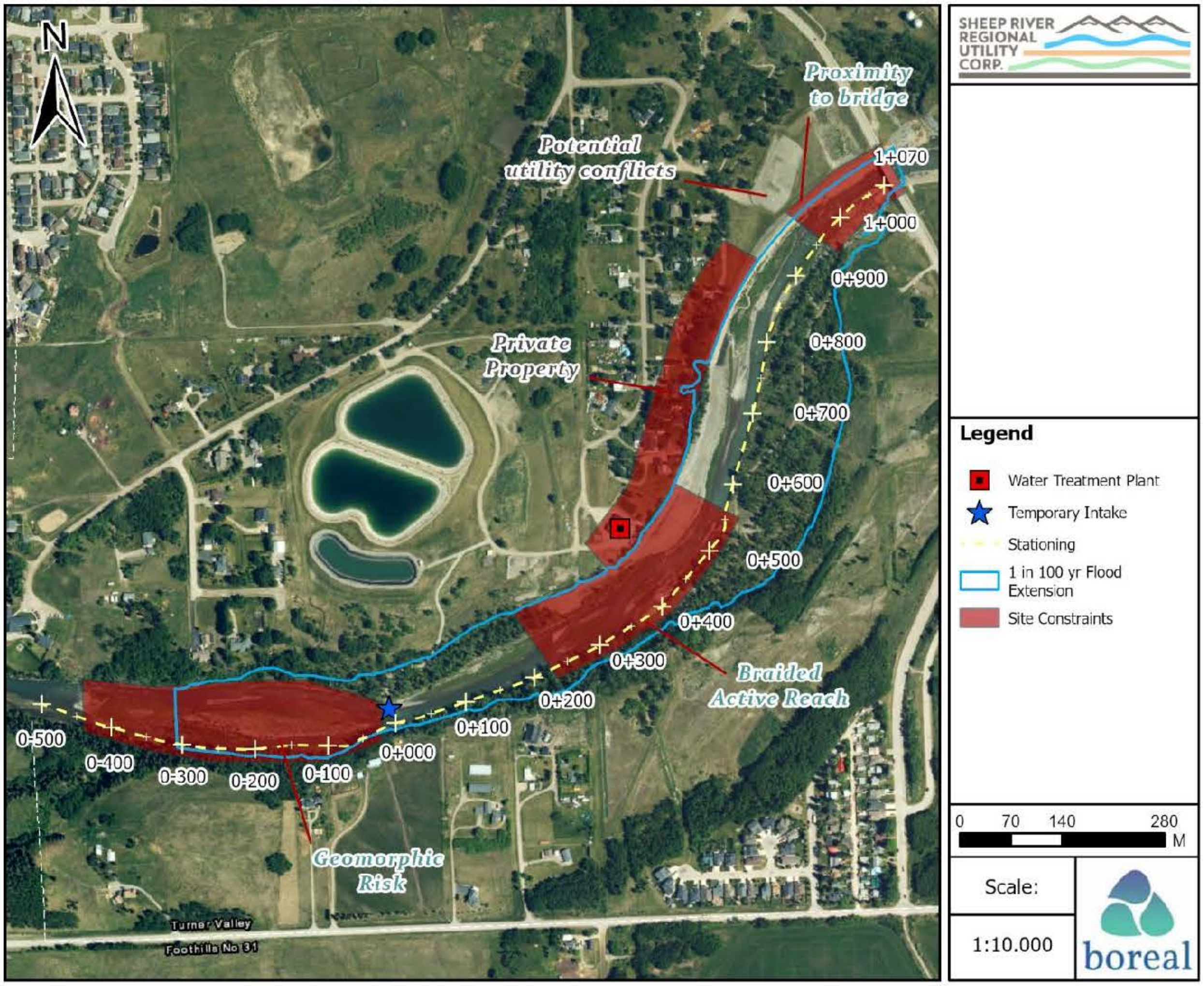

Figure E-2: Site constraints.