

# Wetland 06 Water Monitoring Plan Southwest Calgary Ring Road Project Calgary, Alberta

**Prepared for:**

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Project No. 102604-01

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## 1.0 INTRODUCTION

The Southwest Calgary Ring Road (SWCRR) Project (the Project) includes the design and construction of approximately 31 kilometers of new six and eight lane divided freeway, 14 interchanges, as well as three watercourse realignments and associated crossing structures. The Project corridor is located along the western limit of the City of Calgary south of Highway 8 and includes sections of Highways 8 and 22. The Project has been awarded by Alberta Transportation to Mountain View Partnership, which in turn has engaged KGL Constructors (KGL) to develop the Project.

On August 11, 2017, the Project received *Water Act* Approval No.: 00388473-00-00 (the Approval) to impact twenty-four (24) wetlands, including Wetland 06. Subsequently, an Environmental Appeal was filed (*Brockman and Tulick v. Director, South Saskatchewan Region, AEP*; Appeal Nos.: 17-047 and 17-050-R. 2017) affecting KGL's ability to impact the wetlands, as described in the Approval.

As a result of the Environmental Appeal, the Minister of Environment and Parks issued a Ministerial Order 06/2018 (the Order), on January 29, 2018, that amended the previously received Approval to include conditions to address water quality and quantity impacts to Wetland 06 (see conditions 6.2 to 6.6). To address these conditions, KGL Constructors retained Hemmera Envirochem Inc. (Hemmera) to develop a monitoring plan (the Plan) that includes:

- monitoring of the flow of water flow into Wetland 06 in the spring and fall of each year that the plan is in effect;
- monitoring of the water quality in Wetland 06 in the spring and fall of each year that the plan is in effect, including total dissolved solids, salts, dissolved metals, and other parameters consistent with a stormwater sampling program;
- the monitoring data shall be provided to the Director within one month from the date the data were collected;
- the results of the monitoring and an analysis of the monitoring shall be provided to the Director in an annual report by March 31 of the year following the calendar year in which the data were collected; and
- the monitoring plan shall come into effect as soon as the Director approves the plan and shall remain in effect for a period of five years after the road is officially opened to the public.

### 1.1 Monitoring Objectives

Wetlands consist of land that has been saturated for sufficient time to promote the formation of water altered soils, growth of water tolerant vegetation, and various kinds of biological activity, adapted to wet environments (ESRD 2013). They play an important role on the landscape and are ecologically and economically significant by maintaining water quality and supply in watersheds, providing flood protection and erosion control, as well as providing habitat for various fish and wildlife species. Wetland health is reflective of numerous physical, chemical, and biological components. We acknowledge that there are numerous indicators of wetland health; however, the monitoring plan has been developed specifically to reflect requirements of the Order. As a result, monitoring elements of this Plan were prioritized to surface water quality and flow exclusively.

The objectives of the Plan include:

- monitoring surface water quality in Wetland 06 and flow into Wetland 06,
- monitoring surface water flow out of Wetland 06,
- monitoring surface water quality in waterbodies/drainages that provide surface water flow into Wetland 06, and
- monitoring surface water quality in an adjacent reference wetland.

It is expected that by monitoring Wetland 06 as well as other nearby wetlands and waterbodies, the Plan will result in a suitable comparative analysis about the potential influences or lack thereof of the Project on surface water quality and flow in Wetland 06.

## 2.0 DESCRIPTION OF WETLAND 06

Wetland 06 is located in the Weaselhead Natural Area, a natural environmental park that borders the west end of Glenmore Reservoir (**Figure 1**) within the City of Calgary. A small portion of Wetland 06 is located within the Transportation Utility Corridor (TUC). Wetland 06 is a historical oxbow channel to the Elbow River that is over 500 m in length with wetted widths that are generally less than 30 m. A pedestrian/bike bridge associated with the Glenmore Reservoir Regional Pathway network crosses Wetland 06. Wetland 06 drains generally east through the Weaselhead Natural Area and eventually discharges into the Glenmore Reservoir, which provides approximately half of the City of Calgary's drinking water supply.

Wetlands 07, 08, and 09 are located upslope of Wetland 06 and are the source of surface water flow into Wetland 06 (**Figure 1**). Wetland 08 and 07 are located to the southwest of Wetland 06. Surface flow from Wetland 08 and 07 are conveyed into Wetland 06 by an undefined channel that becomes defined downstream of the TUC near Wetland 06 as the slope gradient increases. A bypass drainage culvert will be installed during the construction phase of the Project to convey water from Wetland 07 and 08 through the Project area. Wetland 09 is located south of Wetland 06. Surface flow from Wetland 09 is conveyed by an undefined channel first flowing easterly through the Project and then northerly from the TUC boundary through a defined channel to Wetland 06. A bypass drainage system has been installed as part of the Project to maintain flow from Wetland 09 to Wetland 06.

During the construction phase of the Project, surface run-off from the work area will be managed through temporary erosion and sediment control (ESC) measures and will be redirected away from Wetland 06. During the operational phase of the Project, the natural flow of surface water (i.e., from the west side of the TUC) into Wetland 06 will be maintained via the bypass drainage systems described above. Further, during the operational phase, Project-impacted water will not be discharged into Wetland 06. All Project-impacted water in the vicinity of Wetland 06 has been designed to flow north into a stormwater pond.

### 3.0 MONITORING SCHEDULE

The monitoring schedule, including field sampling visits, seasonal data summaries, and annual reports is provided in **Table 1**. Field sampling visits to monitor surface water quality and flow will occur during the spring and fall of each year of the Plan. Additional details on sampling frequency are provided in **Section 4.2**.

Following each season of monitoring, data summaries (i.e., surface water quality and flow) will be made publicly available by KGL within one month of the seasonal field sampling visits. The annual report will be made publicly available by March 31 of the year following the field sampling visits.

**Table 1 Monitoring Schedule**

Task	Monitoring Year <sup>a</sup>											
	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar
1. Water Quality Monitoring <sup>b</sup>												
2. Water Flow Monitoring <sup>b</sup>												
3. Seasonal Data Summary <sup>c</sup>												
4. Annual Report <sup>d</sup>												

<sup>a</sup> Plan year includes construction phase and first five years of the operational phase.

<sup>b</sup> Surface water quality and flow field sampling visits are proposed in May and October of each year of the Plan; however, annual variability in ambient air temperature, snow/ice cover, and precipitation events may impact the exact date of sampling.

<sup>c</sup> Surface water quality and flow data summaries will be made publicly available within one month of each seasonal monitoring visit.

<sup>d</sup>The Annual Report will be made publicly available by March 31 of the year following the field sampling visits (e.g., the 2018 Annual Report will be posted by March 30, 2019).

## 4.0 METHODOLOGY

### 4.1 Sample locations

The locations for surface water quality and flow monitoring are provided in **Figure 2**. The sites have been selected strategically for appropriate reference and comparison site considerations, in order to allow for a comparative analysis. An enhanced view of the sampling sites in and near Wetland 06 is provided in **Figure 3**. Suitability of these locations has been field verified during a reconnaissance survey in early spring 2018, however, the locations of these sites are subject to change pending potential subsequent annual and seasonal variability in site conditions.

#### 4.1.1 Surface Water Quality

Surface water quality will be monitored at eight site locations (**Table 2**).

One surface water quality reference site (WQ-01) is identified for the Plan. The reference site is located north of Wetland 06 in an adjacent wetland that is outside the TUC. This site was selected as there are no identified or known pathways from the Project that could potentially direct Project-affected water into the adjacent wetland.

Based on a desktop assessment and a field reconnaissance, Hemmera identified two pathways in which Project-influenced water could potentially flow into Wetland 06 (see **Figure 1**). The two identified pathways are described below. For each of the respective pathways, comparison samples will be collected from a series of sample sites (i.e., background vs. comparison) (see **Figure 2**).

- Pathway 1 is an undefined channel that diagonally bisects the Project footprint. From the west side of the TUC boundary, water flows northeast through Wetland 08 into Wetland 07 where it then flows past the east side of the TUC boundary and then into a defined channel (approximately 400 m) that ultimately drains into Wetland 06 (see **Figure 1**). The sample sites associated with Pathway 1 are; WQ-04a, WQ-04b, and WQ-02 (see **Figure 2**). WQ-04a has been selected as a background site, as it is located upstream of potential influences from the Project.
- Pathway 2 is an undefined channel that flows east through Wetland 09 where it then enters a recently construction stormwater drainage system (see **Figure 1**). The drainage system outlets into a constructed riprap lined drainage ditch that flows north towards the eastern TUC boundary. In addition, a constructed drainage ditches channels water west where it converges with flows in the aforementioned constructed riprap lined drainage ditch. From the eastern TUC water meanders north through a defined channel (approximately 1,000 m) that eventually drains into Wetland 06 (see **Figure 1**). The samples sites associated with Pathway 2 are; WQ-05a, WQ-05b, WQ-05c, and WQ-03 (see **Figure 2**).

Surface water quality monitoring sites are subject to change due to seasonality and site conditions. Additional or alternative surface water quality monitoring sites may be identified if field crews observe abnormal site conditions or contaminant indicators, more information is provided in **Section 4.3**.

**Table 2 Surface Water Quality Sample Locations**

Site Name	Universal Transverse Mercator (Zone 11U)		Site Description	Reference or Comparison Site
	Easting	Northing		
WQ-01	699168	5652375	Reference wetland to the north of Wetland 06	Reference
WQ-02	699186	5652164	West (upslope) side of Wetland 06	Comparison
WQ-03	699432	5652159	East (downslope) side of Wetland 06	Comparison
WQ-04a	698898	5651725	Wetland 08, upslope of SWCRR Project	Background
WQ-04b	699113	5651956	Wetland 07, downslope of SWCRR Project and Wetland 08	Comparison
WQ-05a	699060	5650929	Upslope of Wetland 09 and SWCRR Project	Background
WQ-5b	699788	5651289	Watercourse 01 downslope of Wetland 09 and SWCRR Project	Comparison
WQ-05c	700061	5651274	Catchment basin to the east of SWCRR Project and upslope of the confluence with Watercourse 01	Comparison

**4.1.2 Surface Water Flow**

Surface water flow will be monitored at four locations around Wetland 06 (**Table 3**). Each of these locations are expected to provide conveyance of surface flow (inflow or outflow) year-round during normal surface flow conditions. Given the higher than average snowfall and later than normal lowland melt in 2018, sampling locations for surface water flow may need to be reconsidered in subsequent sampling visits.

Surface water inflows have been identified at FL-01, FL-02, and FL-03. The sampling location FL-01 occurs where surface water inflow is associated with drainage from Wetland 07 and 08. Site FL-02 is where the surface water inflow is conveyed from Wetland 09. Site FL-03 is where the surface water inflow associated with drainage from the reference wetland to the north of Wetland 06. Surface water outflow monitoring will occur at FL-04 at the Glenmore Pathway bridge crossing approximately 75 m downslope from Wetland 06.

**Table 3 Surface Water Flow Sample Locations**

Site Name	Universal Transverse Mercator (Zone 11U)		Inflow or Outflow
	Easting	Northing	
FL-01	699156	5652166	Inflow
FL-02	699406	5652115	Inflow
FL-03	699075	5652326	Inflow
FL-04	699644	5652343	Outflow

Surface flow in undefined channels (i.e., lacking defined bed and banks) may be present at the surface water flow monitoring locations pending flow conditions during each field sampling visit and are expected to be influenced by natural events (e.g., precipitation levels) within and between monitoring years. Monitoring flow in waterbodies lacking defined bed and banks can also have reduced accuracy as compared to a defined channel. Therefore, field crews may be required to adjust the surface water flow monitoring sites

during each field sampling visit to a location where channel characteristics are most appropriate for flow measurements. If additional surface water inflow or outflow locations are identified during the field sampling visits due to variability in hydrological connectivity, contingency surface water flow monitoring sites will be added.

## 4.2 Frequency of sampling

Surface water quality and flow monitoring will occur twice annually, once in the spring and once in the fall. The spring field sampling visit is proposed to occur in May and the fall field sampling visit is proposed to occur in October of each year of the Plan. The exact timing of the spring and fall field sampling visits are dependent on environmental conditions including ambient air temperatures, snow/ice cover, and precipitation events. Sampling will not occur during or within 72 hours of a substantial precipitation event to reduce any temporal variation (short-term pulse response) associated with extreme disturbances resulting in water and flow sampling that is more representative of the wetland conditions.

## 4.3 Water Quality Monitoring

Surface water quality samples will be taken from the banks of at the sample sites provided in **Tables 2** and discussed in **Section 4.1.1**. Site conditions (e.g., weather) will be recorded by the field crew. At each sampling site, five photos will be taken in a north, south, east, west, and ground direction.

Discrete profile lake water sampling and composite integrated water sampling methodologies (Alberta Environment 2006) have been determined to be inappropriate sampling methodologies for this Plan as water depths at the sampling sites are not deep enough to require spatial characterization over a horizontal or depth profile. The protocol provided by Canadian Council of Ministers of the Environment (CCME) (2011) for shore sampling will be followed and is summarized below. A certified Canadian Association for Laboratory Accreditation (CALA) laboratory will complete the laboratory analysis of water samples.

Samples will be labeled using a water-proof marker for accurate identification by the field crews and the laboratory. A chain of custody form will be completed, and any transfers of custody will be noted on the form by the authorized personnel including transfer to the CALA laboratory. Field crews will wear unpowdered latex or polyethylene disposable gloves and refrain from smoking or eating while collecting water samples (Alberta Government 2006).

An extension pole will be used to collect a “grab sample” from each sampling site and to avoid disturbing the site during collection of the water samples (CCME 2011). At each sampling location, the extension pole and clamp will be rinsed prior to collecting the water samples to reduce possible contamination between sites. Laboratory protocols for sample bottle rinsing will be followed and any rinsing of sample bottles or collection equipment will be completed slightly downslope of the sampling location to prevent cross contamination.

Water samples will be collected facing upstream if flow is present (CCME 2011). Water bottles will be uncapped immediately prior to filling. Water samples will be collected one at a time ensuring the lid is immediately capped once the bottle is filled. Water samples will be collected at approximately 60% water depth to avoid surface scum and film, and to collect a representative water sample. Algae, sediment, and organic matter will be avoided in the water sample.

Laboratory protocols for preservatives, storage, and transportation of water samples will be followed. Water samples will be kept in coolers containing enough ice packs or warm water bottles to keep the samples at approximately 4°C. All water samples will be sealed and packed in the coolers as to prevent spillage or breakage. Water samples will be delivered to the laboratory as soon as possible after collection, preferably the same day and hold times will be followed so analysis will occur within the appropriate hold periods.

Water sample parameters to be monitored during the Plan include those identified as potential sources or indicators of sources of pollutants or contaminants that may result from the construction and operations phases of the Project. Previous studies have shown sediment transport and deposition pose the greatest risk to the construction phase of highway projects, resulting from excavation and earthworks (Barrett et. al., 1995). Eroded soil can also transport nutrients, ions, and metals (Barrett et. al., 1995). During the operations phase of highway projects, sedimentation remains a concern along with transportation of pollutants from vehicles operating on the highway through run-off (Barrett et. al., 1995).

Water samples will be collected at all eight sampling (**Table 2**) for the parameters provided in **Table 4**. All samples collected from Wetland 06 and the reference wetland (i.e., WQ-01, WQ-02, and WQ-03) will be submitted for analysis for all parameters immediately after collection, with regular turn around time of 7-days requested. For remaining sample locations (i.e., WQ-04a,b; WQ-05a,b,c), all samples will be submitted, however, only those samples which have a holding time of less than 7 days will be immediately analysed (i.e., biological oxygen demand, nitrate, nitrite, sulfate, total dissolved solids, and total suspended solids. Samples not immediately analysed will be kept at the laboratory, pending the results from WQ-01 to WQ-03, and will be stored at the laboratory in accordance with CALA standards. If an exceedance value is identified at WQ- 01, WQ-02, or WQ-03, additional laboratory analysis for the exceedance parameter(s) will be conducted for the remaining sample sites (i.e., WQ-04a,b; WQ-05a,b,c), to determine if the exceedance is Project related or generated offsite.

The parameters provided in **Table 4** are reflective of those included in the City of Calgary Stormwater Management and Design Manual (2011). Project activities associated with the construction and operations phase of the Project are unlikely to have effects on microbiological indicators; as such they have been excluded from the Plan.

**Table 4 Water Quality Parameters Monitored During the Plan**

Sediment & Physical	
<ul style="list-style-type: none"> <li>• Total Suspended Solids (TSS)</li> <li>• Total Dissolved Solids (TDS)</li> <li>• Turbidity</li> </ul>	<ul style="list-style-type: none"> <li>• Conductivity (EC)</li> <li>• pH</li> <li>• Dissolved Oxygen (DO)</li> </ul>
Nutrients and Others (mg/L)	
<ul style="list-style-type: none"> <li>• Biochemical Oxygen Demand (BOD)</li> <li>• Chemical Oxygen Demand (COD)</li> <li>• Nitrate (NO<sub>3</sub>)</li> <li>• Nitrite (NO<sub>2</sub>)</li> </ul>	<ul style="list-style-type: none"> <li>• Total Kjelaht Nitrogen (TKN)</li> <li>• Ammonia-Nitrogen (NH<sub>3</sub>-N)</li> <li>• Total Phosphorus (TP)</li> <li>• Dissolved Reactive Phosphorus (TDP)</li> <li>• Ortho-Phosphate</li> </ul>

Dissolved Metals & Metals (mg/L)			
• Silver (Ag)	• Cobalt (Co)	• Molybdenum (Mo)	• Tin (Sn)
• Aluminum (Al)	• Chromium (Cr)	• Nickel (Ni)	• Strontium (Sr)
• Arsenic (As)	• Copper (Cu)	• Lead (P)	• Sodium (Na)
• Boron (B)	• Iron (Fe)	• Lead (Pb)	• Titanium (Ti)
• Barium (Ba)	• Potassium (K)	• Sulfur (S)	• Thallium (Tl)
• Beryllium (Be)	• Lithium (Li)	• Antimony (Sb)	• Uranium (U)
• Calcium (Ca)	• Magnesium (Mg)	• Selenium (Se)	• Vanadium (V)
• Cadmium (Cd)	• Manganese (Mn)	• Silicon (Si)	• Zinc (Zn)
Major Ions & Salts			
• Sodium (Na <sup>2+</sup> )		• Calcium (Ca <sup>2+</sup> )	
• Potassium (K <sup>+</sup> )		• Chloride (Cl <sup>-</sup> )	
• Potassium (K <sup>+</sup> )		• Sulfate (SO <sup>4-</sup> )	

Sediment and physical parameters provided in the first section of **Table 4** (i.e., TSS, TDS, turbidity, conductivity, dissolved oxygen, and pH) will be measured at all water quality monitoring sites listed in **Table 2**. In addition, water temperature, conductivity, pH, and dissolved oxygen which will be measured in-situ at all water quality monitoring sites provided in **Table 2**. These measurements will be taken below the water surface at approximately 60% water depth. Manufacturers instructions for calibration and measuring parameters will be followed.

In-situ measurements will be used as field indicators for any supplemental water quality sampling, if required. Field crews may collect additional water samples for analysis at the existing water sampling locations or at additional locations not included in **Table 2** if abnormal site conditions are observed or in-situ measurements indicate potential water quality abnormalities. Field indicators of potential hydrocarbons (e.g., oil sheen, odor) will be noted by field crews and a potential observation will trigger further water quality analysis for hydrocarbons.

#### 4.4 Water Flow Monitoring

The proposed locations for surface water flow monitoring have been discussed in **Section 4.1**. Surface flow will be measured at each monitoring site using a HACH® velocity flow meter (or comparable model) and using the velocity-area method (Government of Alberta 2009). Using the surface water inflows and outflows of Wetland 06, a modified water balance will be completed. The sum of all surface water inflow and sum of all outflows will be compared for each seasonal sampling visit and between years of the Plan.

In addition to flow monitoring, field crews will deploy a water level staff gauge in both Wetland 06 and the reference wetland. Water depths will be recorded during each field sampling visit. Wetted widths will also be measured at four transects across Wetland 06 and the reference wetland. Transect locations will be recorded using a global positioning system (GPS) device and natural landmarks will be recorded for replicability in the transect location from each seasonal field sampling visit during the Plan.

A comparison of the wetted widths and water depths of Wetland 06 and the reference wetland will be used to assess if the wetted perimeter of Wetland 06 is being reduced while accounting for natural fluctuations resulting in annual variability through comparison to the reference wetland.

## 4.5 Reporting

Surface water quality and flow results for each monitoring field visit will be made publicly available by KGL within one month of the seasonal field sampling event. The annual report, incorporating both seasonal field sampling visits will be made publicly available by KGL by March 31 of the year following the seasonal field sampling visits.

The annual report will include analysis of the surface water quality and flow results for both seasonal field visits. Surface water quality results will be compared relative the Environmental Quality Guidelines for Alberta Surface Waters (Government of Alberta 2014). Select surface water quality parameters (i.e., turbidity, temperature, pH, conductivity, dissolved oxygen, phosphate, and chloride) will also be compared to water quality parameters collected by the Weaselhead /Glenmore Park Preservation Society in 2016 within Wetland 06 as part of a baseline conditions environmental monitoring study (Porto 2017). This study will provide baseline conditions (i.e., prior to construction activities on the Project) in Wetland 06 with the limitation that not all water quality parameters measured in this Plan were included in the 2016 baseline study.

The annual report will also compare wetted width measurements and water depths in Wetland 06 versus the reference wetland to the north. Any change in wetted width or water depth recorded during prescribed sampling times (i.e., May and October) will be compared in the reference wetland to identify if changes in the wetland are due to Project effects or natural environmental conditions (e.g., drought). Following the first annual report, subsequent annual reports will also include a trend analysis through comparison of surface water quality and flow between years of the Plan.

## 5.0 CLOSURE

This Monitoring Plan has been developed to meet the monitoring requirements described in Condition 6.2 and other additional monitoring components that will enable identification of potential impacts to the surface water quality and flow of Wetland 06. Alternatively, the Plan may also identify and inform on other potential impacts that are not related to the Project.

In developing this Plan, Hemmera has relied in good faith on information provided by others and has assumed that the information provided by those individuals is both complete and accurate. This Plan was developed to current industry standard practice for similar environmental work, within the relevant jurisdiction and same locale, but with specific reference to the Order. The Plan presented herein should be considered within the context of the scope of work and project terms of reference; further, the Plan is time sensitive and should be considered valid only during the timeline included in this Plan. This Plan is based upon the applicable guidelines, regulations, and legislation existing at the time the Plan was produced.

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## 6.0 REFERENCES

Environment and Sustainable Resource Development (ESRD) 2013. Alberta Wetland Policy. Prepared by ESRD, September 2013. ISBN: 978-4601-1286-1.

Barrett, Michael E., Joseph F. Malina, Randall J. Harbeneau, and George H. Ward. 1995. Effects of Highway Construction and Operation on Water Quality and Quantity in an Ephemeral Stream in the Austin, Texas Area. Available at:  
[https://repositories.lib.utexas.edu/bitstream/handle/2152/6739/crwr\\_onlinereport95-7.pdf](https://repositories.lib.utexas.edu/bitstream/handle/2152/6739/crwr_onlinereport95-7.pdf).

Canadian Council of Ministers of the Environment. 2011. Protocols Manual for Water Quality Sampling in Canada. Available at:  
[https://www.ccme.ca/files/Resources/water/water\\_quality/protocols\\_document\\_e\\_final\\_101.pdf](https://www.ccme.ca/files/Resources/water/water_quality/protocols_document_e_final_101.pdf)

City of Calgary. 2011. Stormwater Management and Design Manual. Water Resources Division. Available at:  
[www.calgary.ca/\\_layouts/cocis/DirectDownload.aspx?target=http%3a%2f%2fwww.calgary.ca%2fPDA%2fpd%2fDocuments%2furban\\_development%2fbulletins%2f2011-stormwater-management-and-Design.pdf&noredirect=1&sf=1](http://www.calgary.ca/_layouts/cocis/DirectDownload.aspx?target=http%3a%2f%2fwww.calgary.ca%2fPDA%2fpd%2fDocuments%2furban_development%2fbulletins%2f2011-stormwater-management-and-Design.pdf&noredirect=1&sf=1)

Government of Alberta. 2009. Water Measurement Guidebook. Available at:  
<http://aep.alberta.ca/water/reports-data/water-use-reporting-system/documents/WUR-WaterMeasurementGuidebook-2009.pdf>

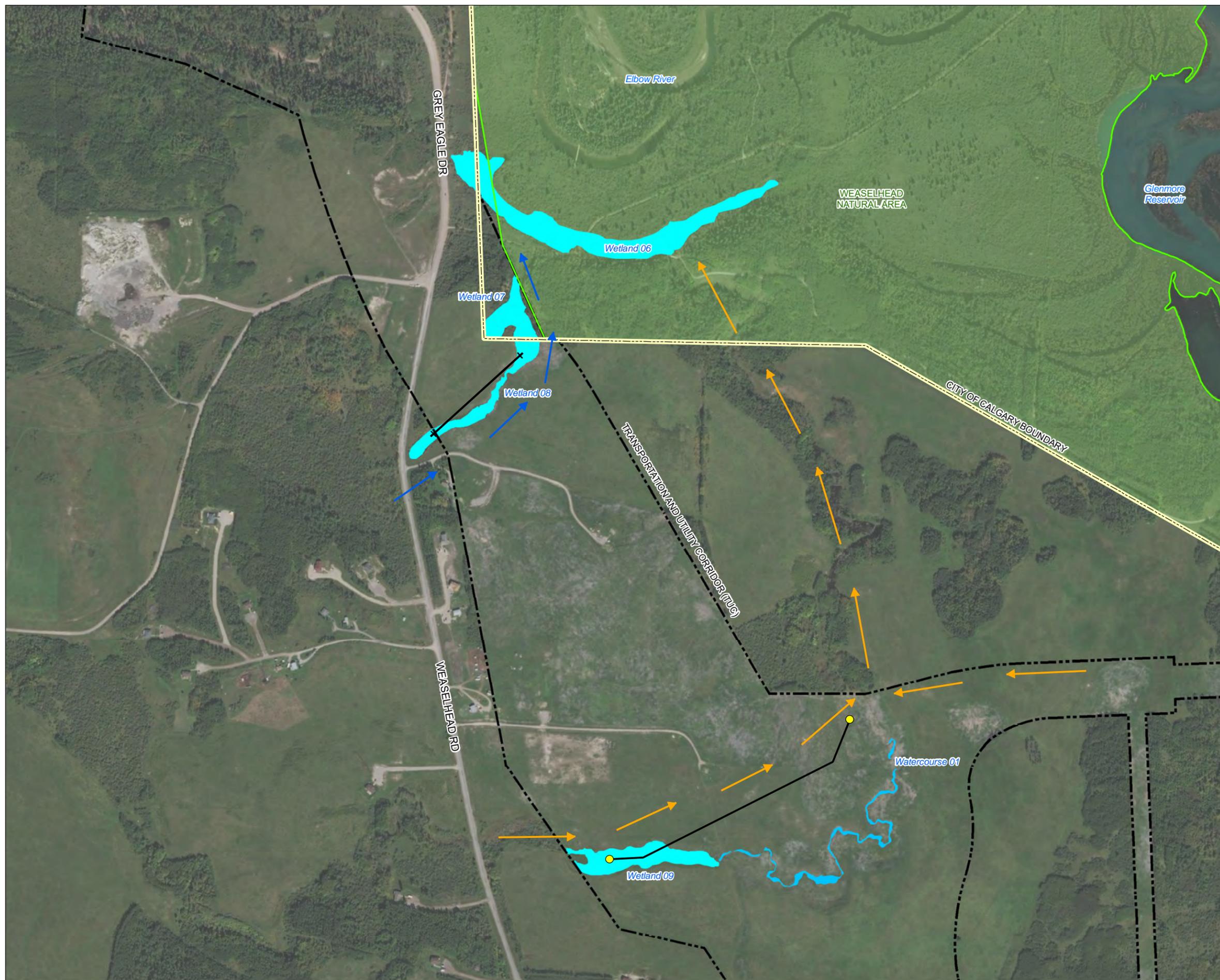
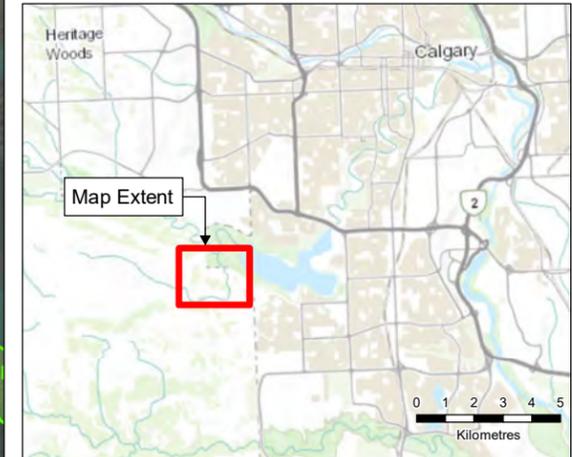
Government of Alberta. 2014. Environmental Quality Guidelines for Alberta Surface Waters. Alberta Environment and Sustainable Resource Development, Water Policy Branch, Policy Division. Edmonton, 48 pp.

Porto, Cassiano. 2017. Weaselhead/Glenmore Park SWCRR Impact Study Environmental Monitoring Report 2016: baseline conditions. Wetland Monitoring Component.

# FIGURES

- Figure 1 Wetland Locations
- Figure 2 Water Flow and Quality Sampling Locations
- Figure 3 Water Flow and Quality Sampling Location Details

**Wetland Locations**



**Legend**

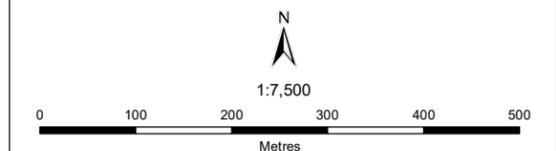
- Bypass Culvert
- Pathway #1 Approximate Direction of Flow
- Pathway #2 Approximate Direction of Flow
- Stormwater Drainage Line
- City of Calgary Boundary
- Natural Area
- Transportation and Utility Corridor (TUC)
- Watercourse
- Wetland

**Notes**

1. All mapped features are approximate and should be used for discussion purposes only.
2. This map is not intended to be a "stand-alone" document, but a visual aid of the information contained within the referenced Report. It is intended to be used in conjunction with the scope of services and limitations described therein.

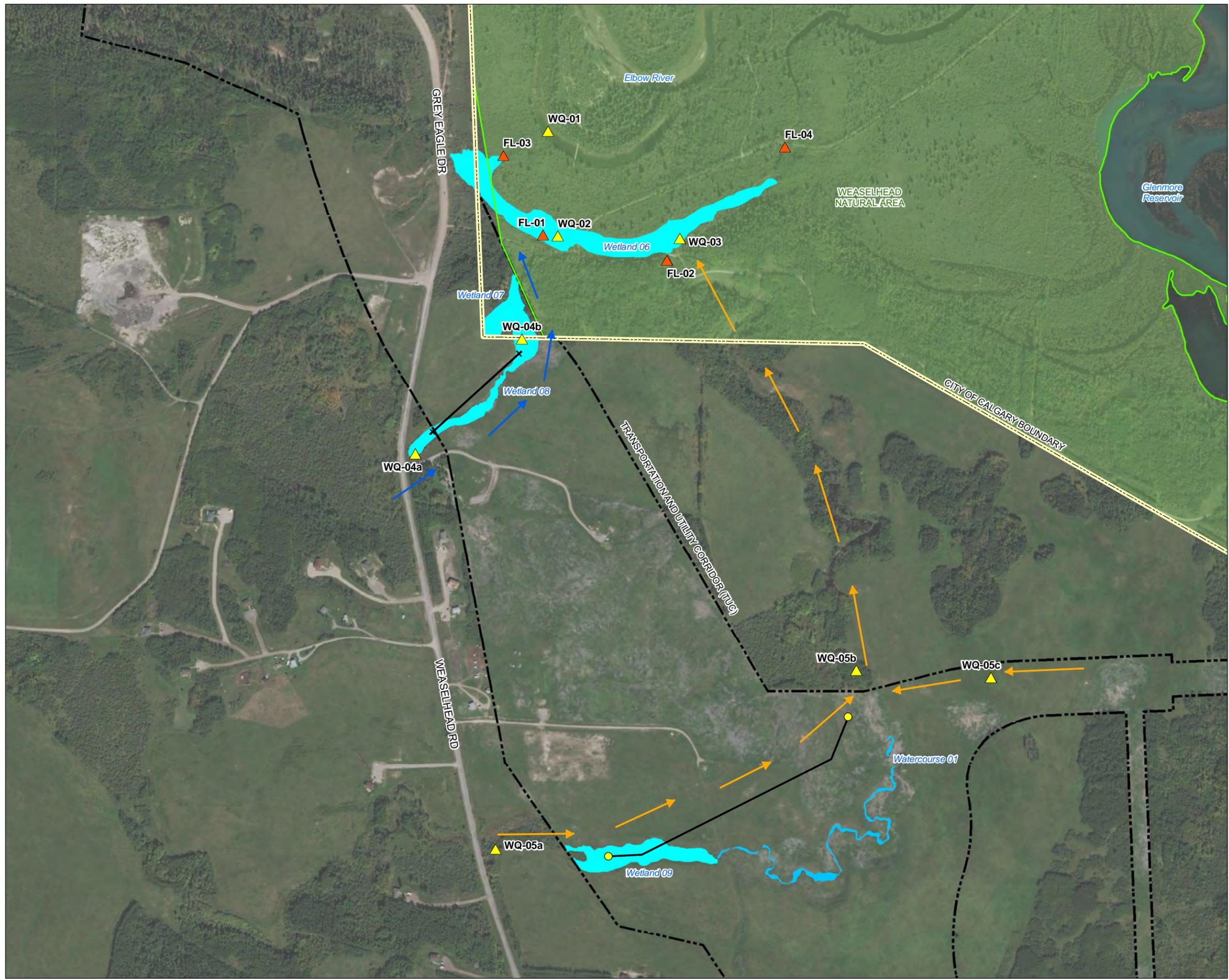
**Sources**

- Aerial Image: ESRI World Imagery, 2016
- Inset Basemap: ESRI World Topographic Map



NAD 1983 UTM Zone 11N  
Page Size: 11" x 17"

**Water Flow and Quality  
Sampling Locations**



**Legend**

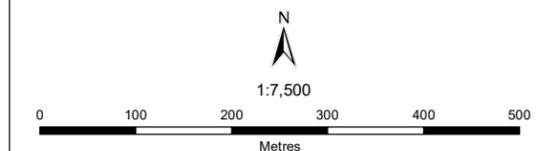
- ▲ Water Flow Sample Location (Hemmera, 2018)
- ▲ Water Quality Sample Location (Hemmera, 2018)
- Bypass Culvert
- Pathway #1 Approximate Direction of Flow
- Pathway #2 Approximate Direction of Flow
- Stormwater Drainage Line
- City of Calgary Boundary
- Natural Area
- Transportation and Utility Corridor (TUC)
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- Wetland

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**Sources**

- Aerial Image: ESRI World Imagery, 2016



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**Water Flow and Quality  
Sampling Location Details**

**Legend**

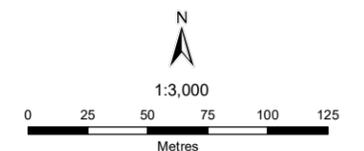
- ▲ Water Flow Sample Location (Hemmera, 2018)
- ▲ Water Quality Sample Location (Hemmera, 2018)
- Bypass Culvert
- ➔ Pathway #1 Approximate Direction of Flow
- ➔ Pathway #2 Approximate Direction of Flow
- City of Calgary Boundary
- Natural Area
- Transportation and Utility Corridor (TUC)
- Wetland

**Notes**

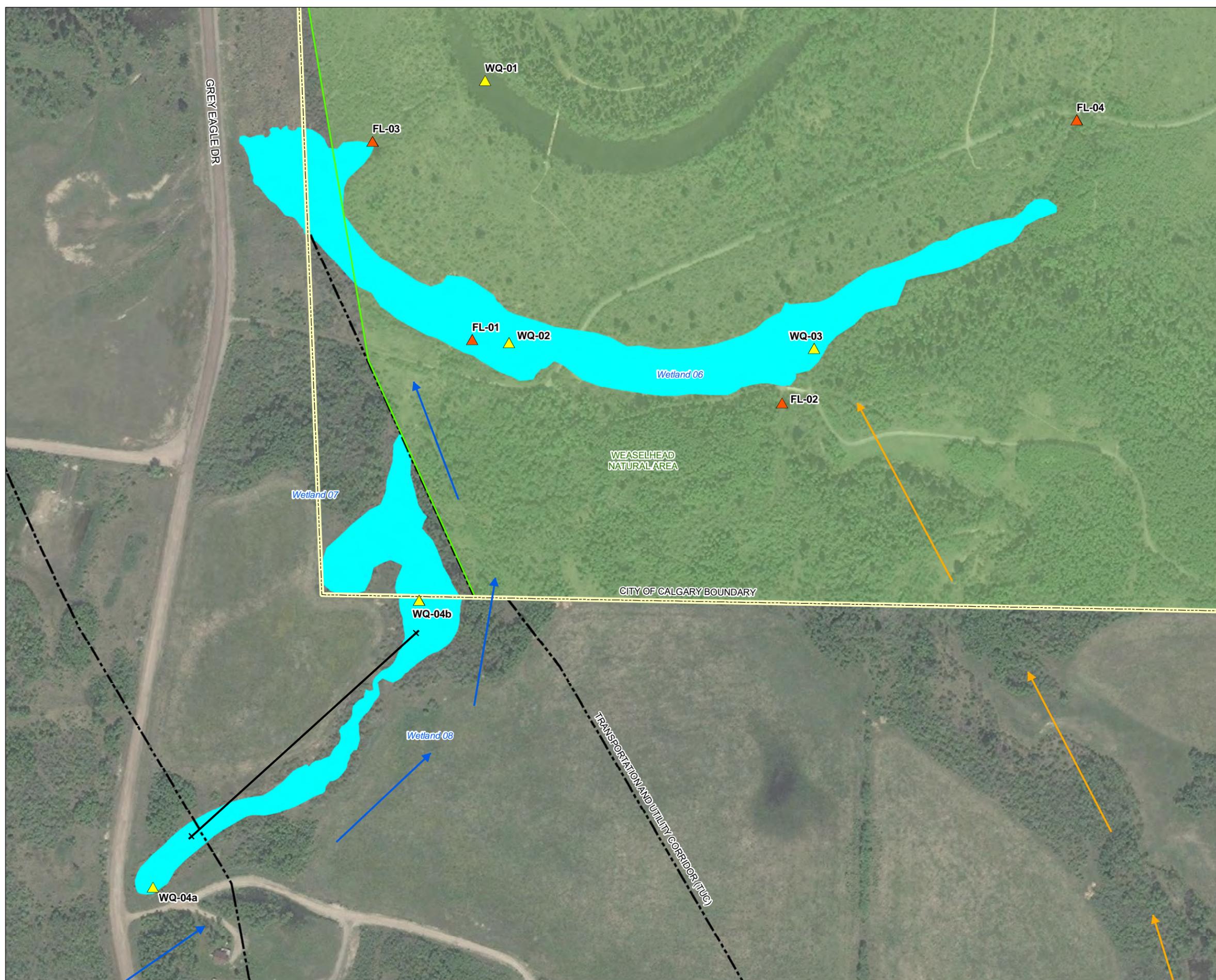
1. All mapped features are approximate and should be used for discussion purposes only.
2. This map is not intended to be a "stand-alone" document, but a visual aid of the information contained within the referenced Report. It is intended to be used in conjunction with the scope of services and limitations described therein.

**Sources**

- Aerial Image: ESRI World Imagery, 2016



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