

**Calgary**



# Glenmore Trail East Interchanges Functional Planning Study

Appendix G - Stormwater Drainage Plan

Prepared By:

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**ISL**

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and Land Services**

# Functional Drainage Plan Highway 560 Expansion

Calgary



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Appendix A – CSP Culvert Nomograph

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# 1. Introduction

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## 1.1. General

McElhanney Consulting Services Ltd. has been retained by Parsons Corporation for the City of Calgary to complete a Master Drainage Plan for the future expansion of Highway 560. This expansion involves the future construction of approximately 6 km of new four and five-lane divided highway. The project limits extend from Stoney Trail SE at the west end, to Range Road 282 at the east end, as shown in Figure 1.2. The expansion will include three new intersections at the highway crossings with Range Road 285 (Garden Road), Range Road 284 and Range Road 283 (Rainbow Road).

## 1.2. Background Information

In 2006, AECOM completed a Master Drainage Plan for the proposed widening of Highway 560 from 84<sup>th</sup> Street SE to Highway 797 that included three new intersections at Range Road 284, Range Road 283 and Highway 791. Although the design and limits of the proposed highway expansion differs from the 2006-proposed widening, this study was used as a reference for the completion of the new master drainage plan.

Other background documents reviewed as part of this study include:

- Sheppard Industrial Area Structure Plan – Proposed; City of Calgary, 2009
- Stormwater Management and Design Manual; City of Calgary, 2011
- Proposed Edgewater Crossing Area Structure Plan; Town of Chestermere, 2013
- Janet – Area Structure Plan; Rocky View County, 2014
- Frequency Analysis Procedure for Stormwater Design; AMEC Environment & Infrastructure, 2014
- Geotechnical Input into Functional Planning Study for Glenmore Trail SE & 100<sup>th</sup> Street SE Interchange and Glenmore Trail SE & Conrich Road Interchange, Parsons, 2016

The City of Calgary Stormwater Management and Design Guidelines (2011) has been adopted as the primary source for design criteria.

## 1.3. Design Objectives

The purpose of this report is to outline a preliminary drainage design for the proposed highway expansion which has been developed by Parsons. The drainage design builds upon the Master Drainage Plan prepared by AECOM in 2006 and proposes an overall concept for the project, while also assessing the preliminary sizes of culverts and ponds.

## 1.4. Site Description

Highway 560, also known as Glenmore Trail, is a single lane road within the limits of Rocky View County. It connects the City of Calgary with the Hamlet of Langdon. The overall drainage area of the proposed expansion is located within the Shepard Regional Drainage Basin. The land use is mainly agricultural. The project area also includes the Heatherglenn Golf Course and the Prairie Schooner Estates residential development. Highway 560 crosses the Western Irrigation District (WID) Canal immediately east of 84 St SE.

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Highway 560 Expansion

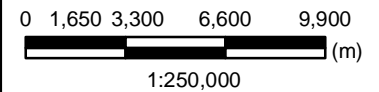


Legend

— Proposed Highway Expansion



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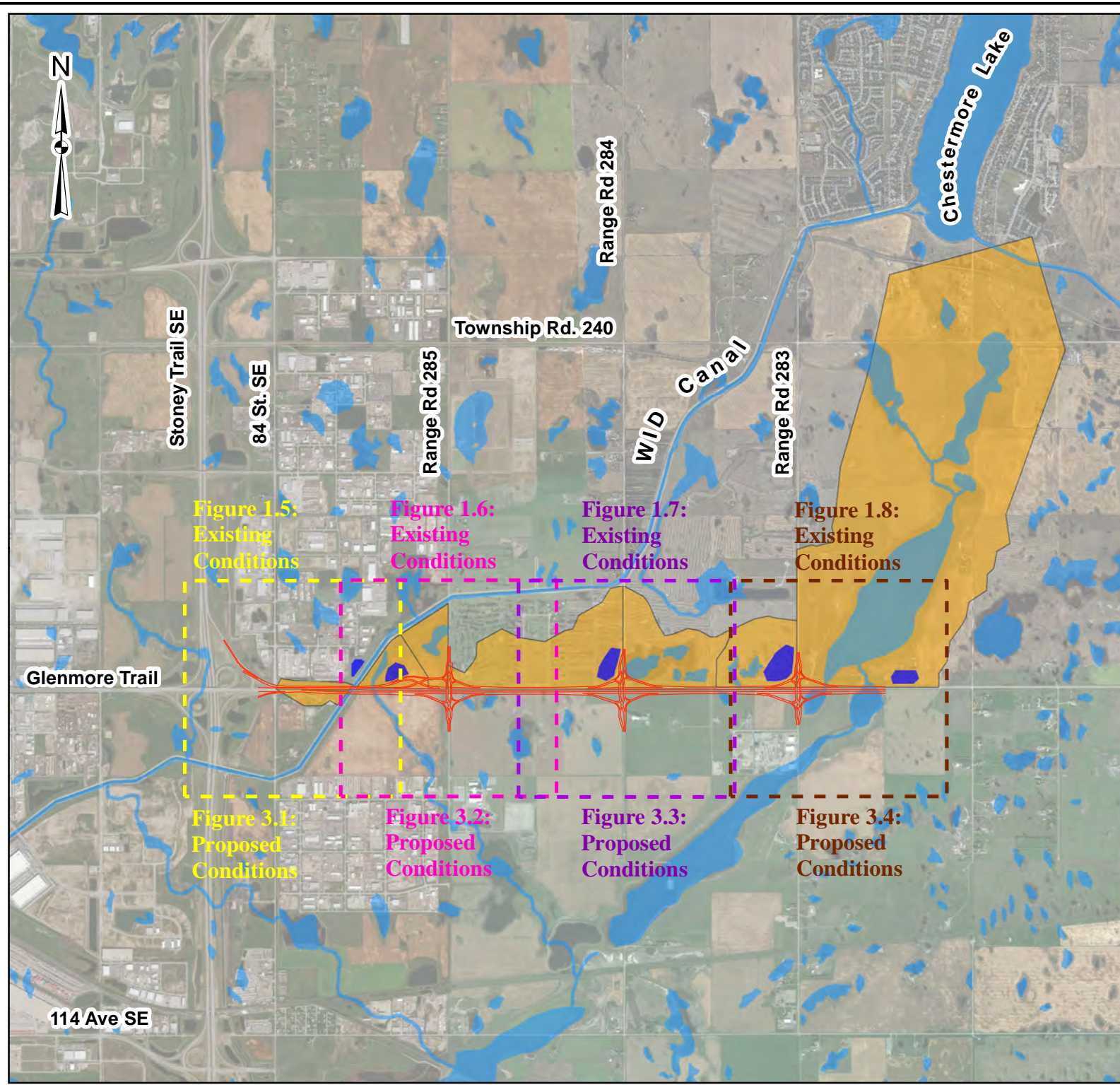
Location Map

Figure 1.1



Legend

- Proposed Highway Expansion
- Ponds
- Waterbody
- Existing Sub-catchments



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Location Map

Figure 1.2

Several wetlands exist in the catchment area, with the largest being the Shepard Slough east of Range Road 283, as shown in Figure 1.2. The Shepard Slough is part of the Shepard Wetland Complex that extends from Chestermere Lake in the northeast to Ralph Klein Park in the southwest.

### 1.4.1 Existing Sub-Catchments

Existing topographic information was obtained from LiDAR data supplied by Parsons Corporation in two sections, with the on the the 8<sup>th</sup> of February and the 8<sup>th</sup> of June, 2017. The LiDAR data was used to outline the boundaries of the existing sub-catchments. These sub-catchments are depicted in Figure 1.5 to Figure 1.8.

Figure 1.5 shows the existing sub-catchments east of Stoney Trail (EC-01 and EC-02). The runoff from these sub-catchments flows east until it is intercepted by a ditch paralleling the WID canal. The runoff pools in that ditch and then overflows into the canal through two CSP 300mm culverts. The culvert inlets are shown in the Figure 1.3 and Figure 1.4. The approximate location of those culverts is shown in Figure 1.5.



*Figure 1.3: Southern canal culvert looking east*

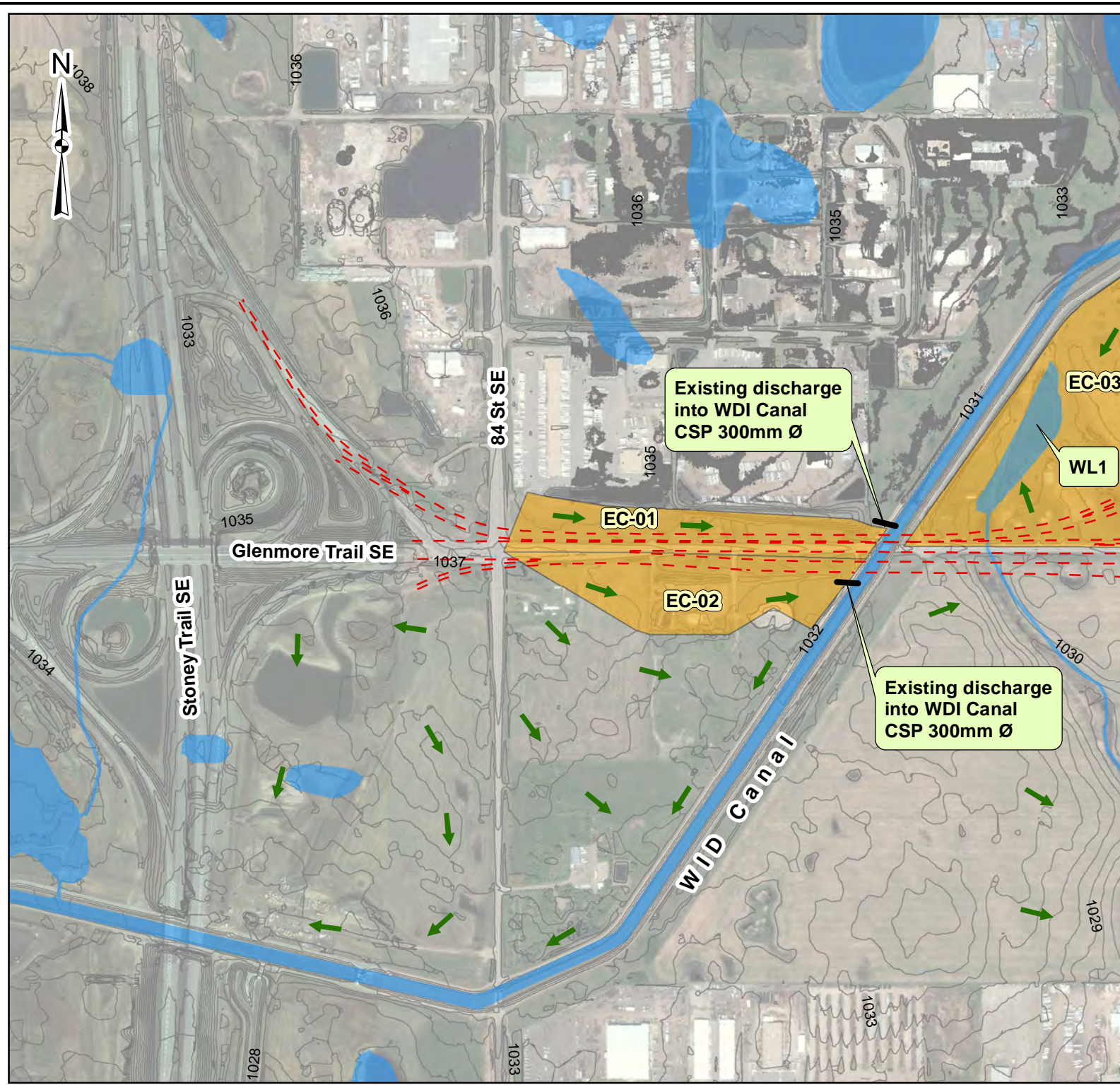


*Figure 1.4: Northern canal culvert looking east*

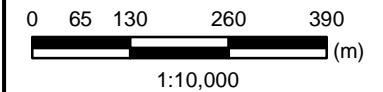


**Legend**

- Proposed Highway Expansion
- Overland flow arrows
- Waterbody
- Existing Sub-catchments
- Existing Culvert



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**Existing Conditions**

West of WID Canal

**Figure 1.5**

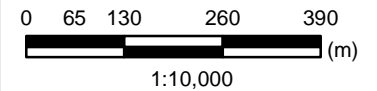


Legend

- Proposed Highway Expansion
- Overland flow arrows
- Waterbody
- Existing Sub-catchments

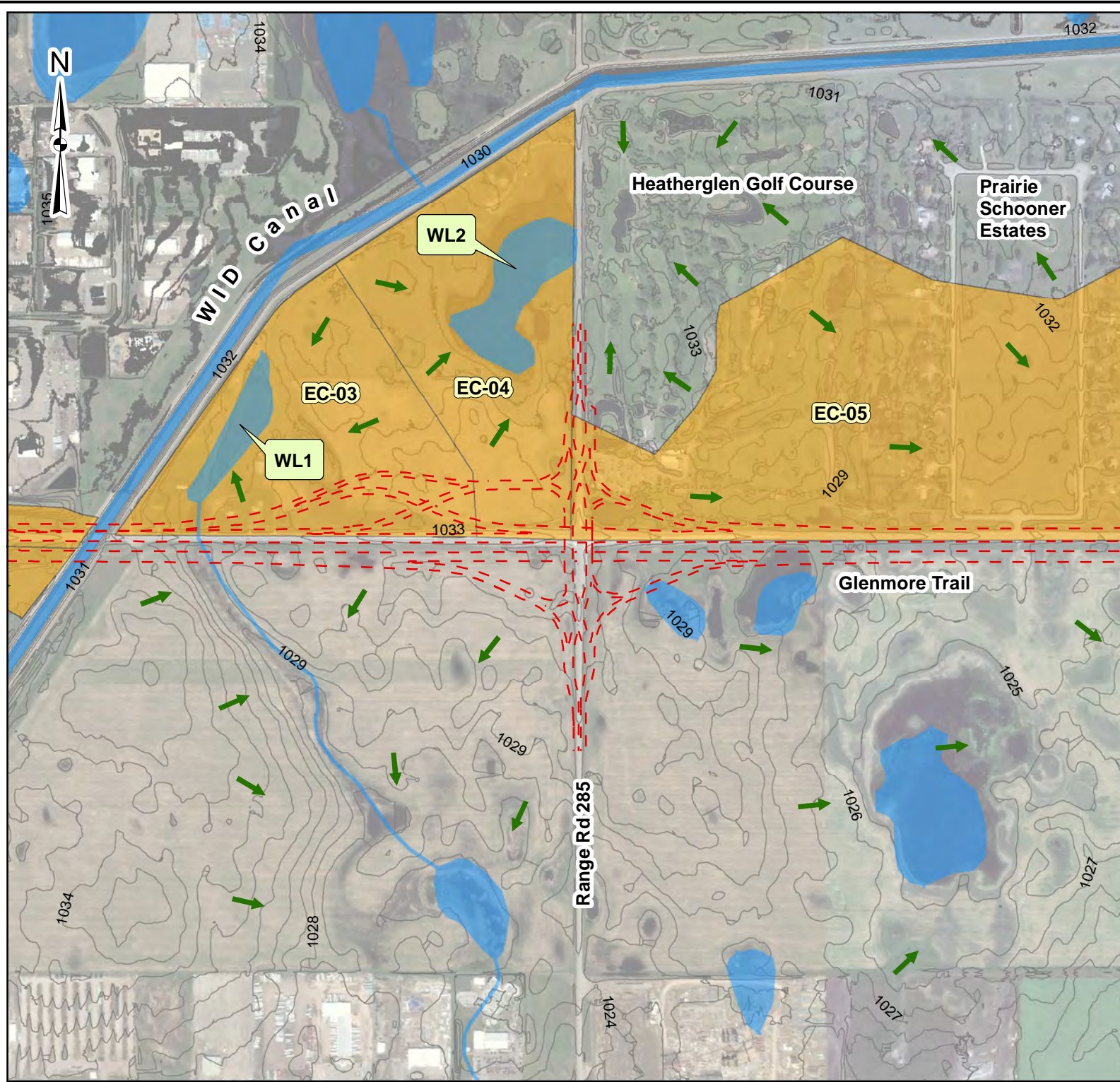


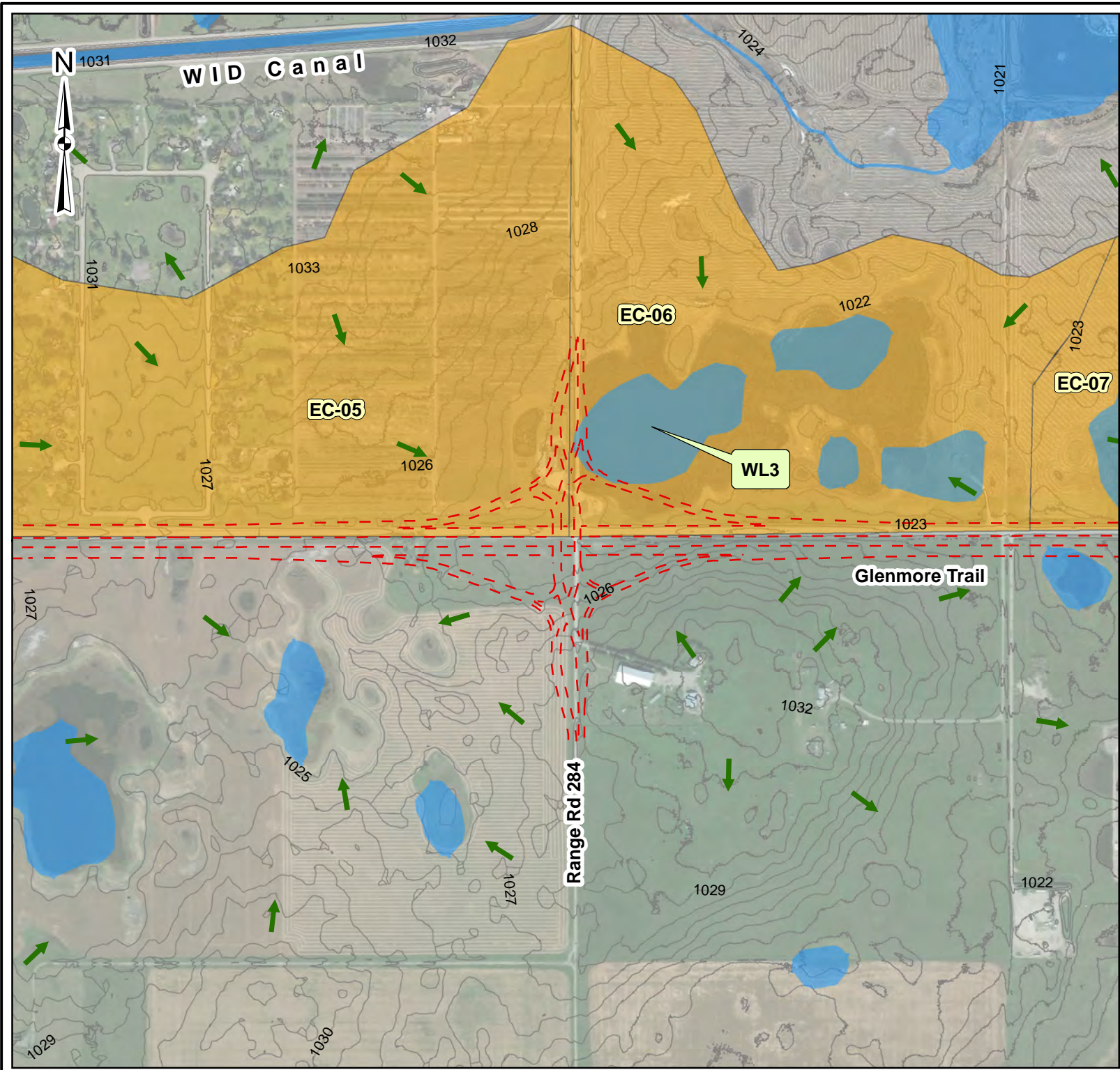
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**Existing Conditions**  
**Range Road 285**  
**Intersection**  
**Figure 1.6**





Highway 560 Expansion

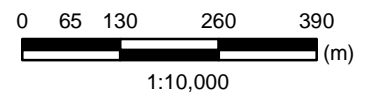


Legend

- Proposed Highway Expansion
- Overland flow arrows
- Waterbody
- Existing Sub-catchments



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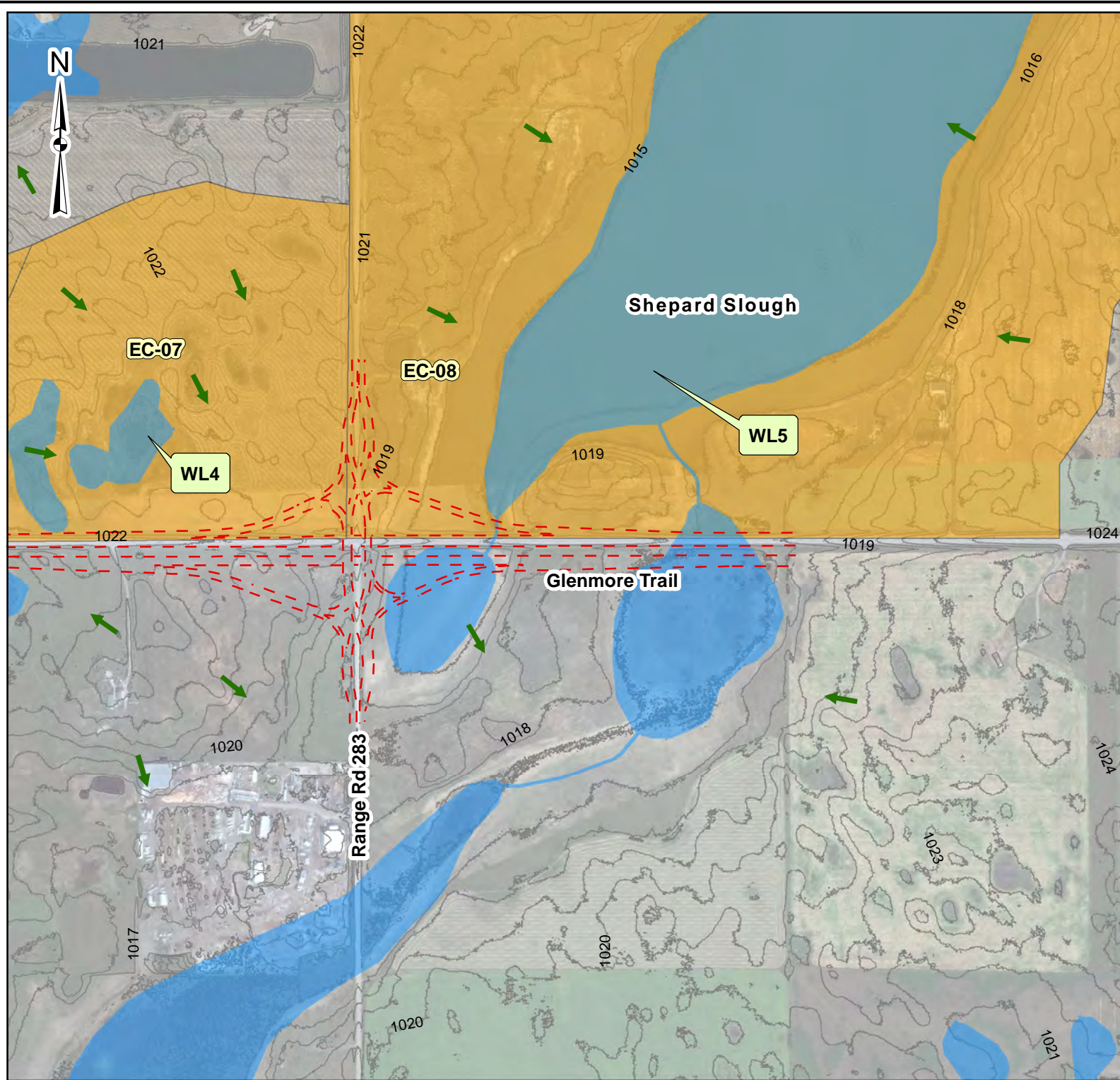


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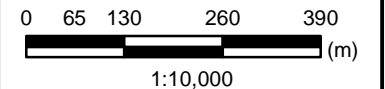
**Existing Conditions**  
**Range Road 284**  
**Intersection**  
**Figure 1.7**

**Legend**

- Proposed Highway Expansion
- Overland flow arrows
- Waterbody
- Existing Sub-catchments



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**Existing Conditions**  
**Range Road 283**  
**Intersection**  
**Figure 1.8**

The overland flow from the sub-catchments located east of the WID canal and west of Range Road 285 (EC-03 and EC-04) discharge into Wetlands WL1 and WL2, as shown in Figure 1.6. Sub-catchment EC-05, situated north of Glenmore Trail between Range Roads 285 and 284, generally drains south-east (see Figure 1.6 and Figure 1.7). The runoff ponds in the ditch along Range Road 284, as shown in the photo below. There are no visible connections between this standing water and the wetland east of Range Road 284 (wetland WL3 in Figure 1.7).



*Figure 1.9: Western drainage ditch parallel to Road 284 looking north*

Figure 1.7 and Figure 1.8 show that between Range Roads 284 and 283 there is drainage divide that separates the basin into two sub-catchments: EC-06 and EC-07. Sub-catchment EC-06 generally drains to the south-west towards the wetland complex identified as WL3. Sub-catchment EC-07 slopes to the south-east towards wetland WL4.

West of Range Road 283, sub-catchment EC-08 encompasses the drainage basin of Shepard Slough (wetland WL-5 in Figure 1.8). The extent of this sub-catchment is depicted in Figure 1.2.

## 2. Methodology

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### 2.1. General Concepts

The analysis and design of the proposed drainage system was conducted using PCSWMM (v. 7.0.2330) hydraulic modeling software. A single event simulation was conducted to estimate a unit discharge for the post-development conditions during the 100-year event. This unit discharge was used to size the drainage culvert conveyance system for the highway expansion. The design storm even representing the 100-year return period 4-hour Chicago synthetic storm were obtained from the City of Calgary Stormwater Management and Design Guidelines (pg. 90, 2011). A separate single event simulation was completed to size the stormwater management facility (SWMF) west of the WID canal. It employed the using a 100-year-24 hour Chicago synthetic storm. The pond to the west of the WID canal was modelled using a continuous simulation to confirm the footprint size. This facility will attenuate post-development discharges into the WID canal to the pre-development conditions.

For the sub-catchment areas draining into a wetland, a continuous simulation was carried out to estimate the annual maximum water elevations under existing conditions. These maximum values were used to conduct a frequency analysis and estimate the water elevation for the 100-year return period. The continuous simulation was run again for the post development conditions with the SWMFs receiving run-off from the subcatchments prior to the stormwater being released to the existing wetlands. The results were used to size the proposed SWMFs with the objective of not exceeding, and maintaining as close as possible, the 100-year pre-development water depths in the existing wetlands. The SWMFs have been designed to maintain the water levels in the respective connecting wetland. To verify this, a new frequency analysis was conducted with the annual maximum water elevations at the wetlands under proposed conditions.

### 2.2. Hydrologic Data

The hydrologic data used for the continuous simulation includes the following:

- Hourly rainfall data recorded at the Calgary International Airport for the period January 1, 1960 to December 31, 2014.
- Hourly temperature data recorded at the Calgary International Airport for the months November to May for the period 1960 to 2014.
- Average monthly evaporation values for the City of Calgary obtained from the Environment Canada weather station at the Calgary International Airport.

### 2.3. Modeling Parameters

The infiltration method which was adopted for use in the PCSWMM analysis followed the same approach as what was used in the AECOM Master Drainage Plan to ensure consistency between the results. The method involves the use of Curve Numbers (CN) to infer parameters which relate to the areas predominant soil type,

ground cover and antecedent moisture conditions (AMCs). The recommendation from the City’s design criteria for the curve number was adopted for this assignment. It is consistent with the CN used in the previous AECOM Master Drainage Plan.

The design parameters employed in the PCSWMM model are summarised in Table 2.1.

*Table 2.1: Design Parameters*

Design Parameter	Unit	Value
Sub-catchment Soil Curve Number	CN	72
Impervious Depression Storage	mm	1.6
Pervious Depression Storage	mm	7.5

## 2.4. Model Development

The topography employed in the hydraulic model was based on the LiDAR data. A digital elevation model (DEM) was derived from the LiDAR using AutoCAD Civil 3D (C3D) software. Sub-catchment boundaries were delineated based on the DEM. The catchments were imported into PCSWMM along with catchment attributes including slope and flow length. Aerial imagery for the area was used to assign the impervious areas for each sub-catchment.

The PCSWMM model was compiled using the existing catchment areas and storage nodes were included to represent the five wetlands within the project limit. The footprint area of each wetland was measured from the aerial imagery and a depth-storage volume curve was developed and applied to each wetland. No information relating to the depth of each wetland was available. An initial water depth of 0.0m was adopted for each wetland. Given the preliminary nature of this assessment, infiltration in the wetlands was ignored and only evaporation was considered. Snowmelt was accounted for using the suggested parameters in the PCSWMM manual.

This procedure was replicated for the post-development conditions and used to design the necessary stormwater infrastructure including detention ponds and the conveyance network. This will be further described in Section 3.

## 3. Analysis and Proposed Design

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### 3.1. Proposed Conditions

Detention ponds will not be positioned south of Glenmore Trail to allow for future development within this area. Surface water from catchments south of Glenmore Trail will therefore be conveyed to proposed detention ponds north of the proposed road. Cross-sections of the proposed finished road prism were provided by Parsons and a surface model was created in C3D to locate and design culverts to convey water through the road. We note that the finished ground model is preliminary and incomplete. As a result, the location and elevations of the culvert inlets and outlets are approximations and must be refined during detailed design.

A maximum spacing of 600m was assumed for the culverts which convey water from the median ditch. Where the road surface elevations were unknown, a minimum slope of 0.2% was adopted. Proposed sub-catchments were developed for each culvert based on their assumed location. These catchments are presented in Figure 3.1 to Figure 3.4.

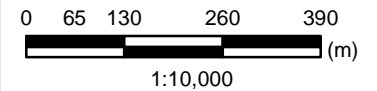


**Legend**

- Proposed Highway Expansion
- Ditches
- Overland flow arrows
- Ponds
- Waterbody
- Proposed Subcatchments
- Proposed Culverts



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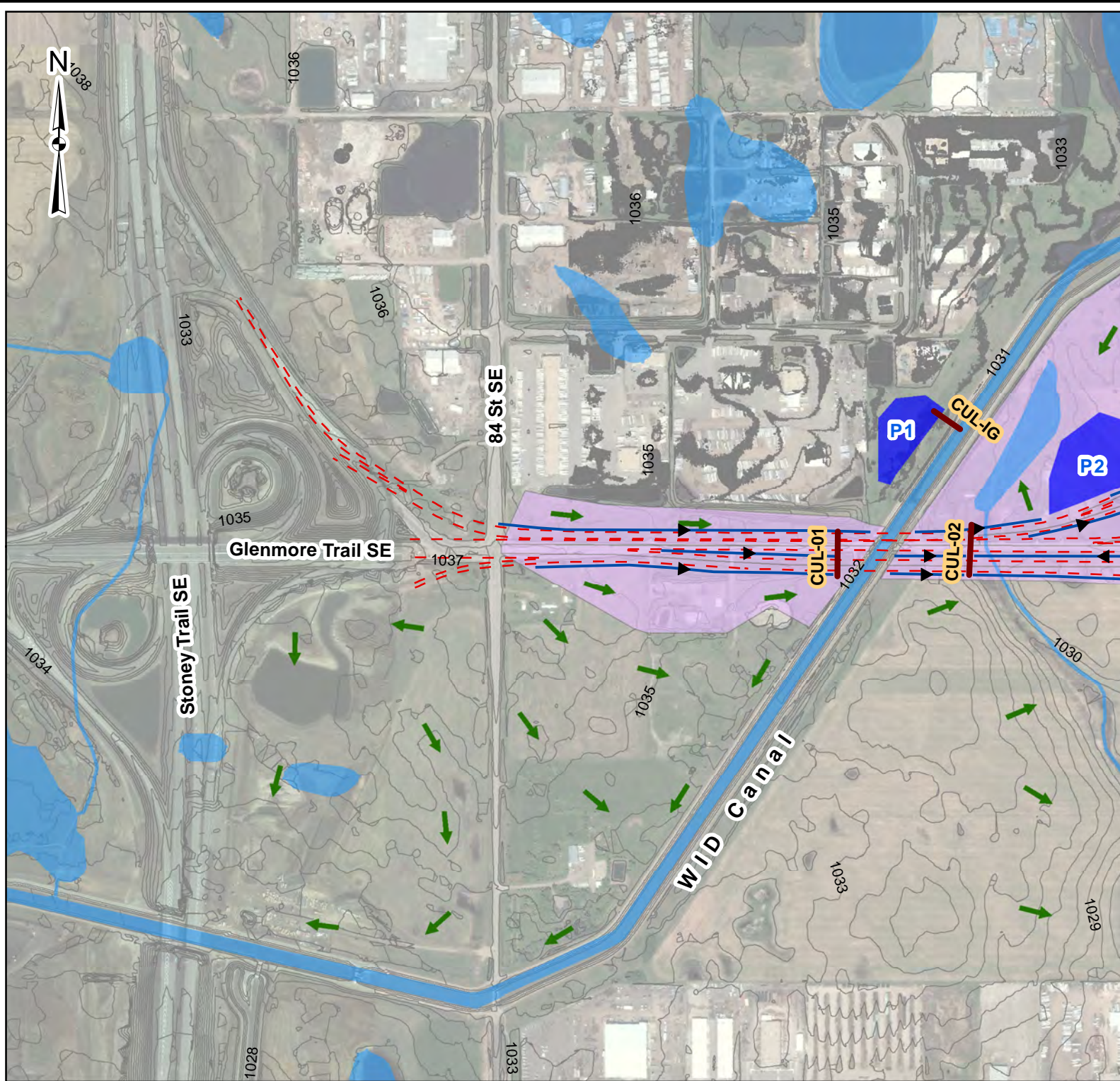


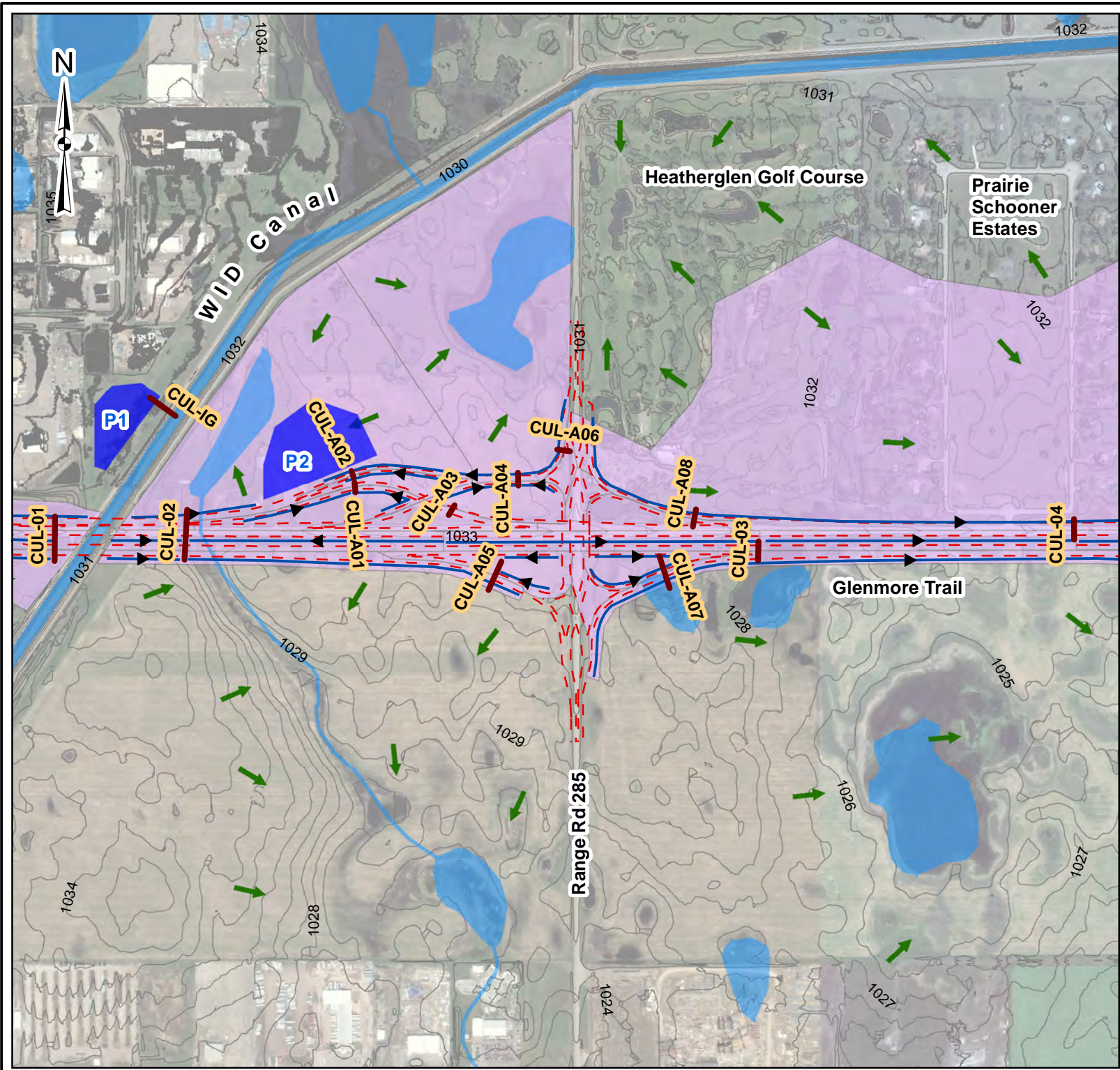
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**Proposed Conditions**

West of WID Canal

**Figure 3.1**





Highway 560 Expansion

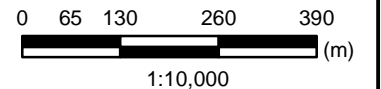


Legend

- Proposed Highway Expansion
- ← Ditches
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- ▬ Proposed Culverts



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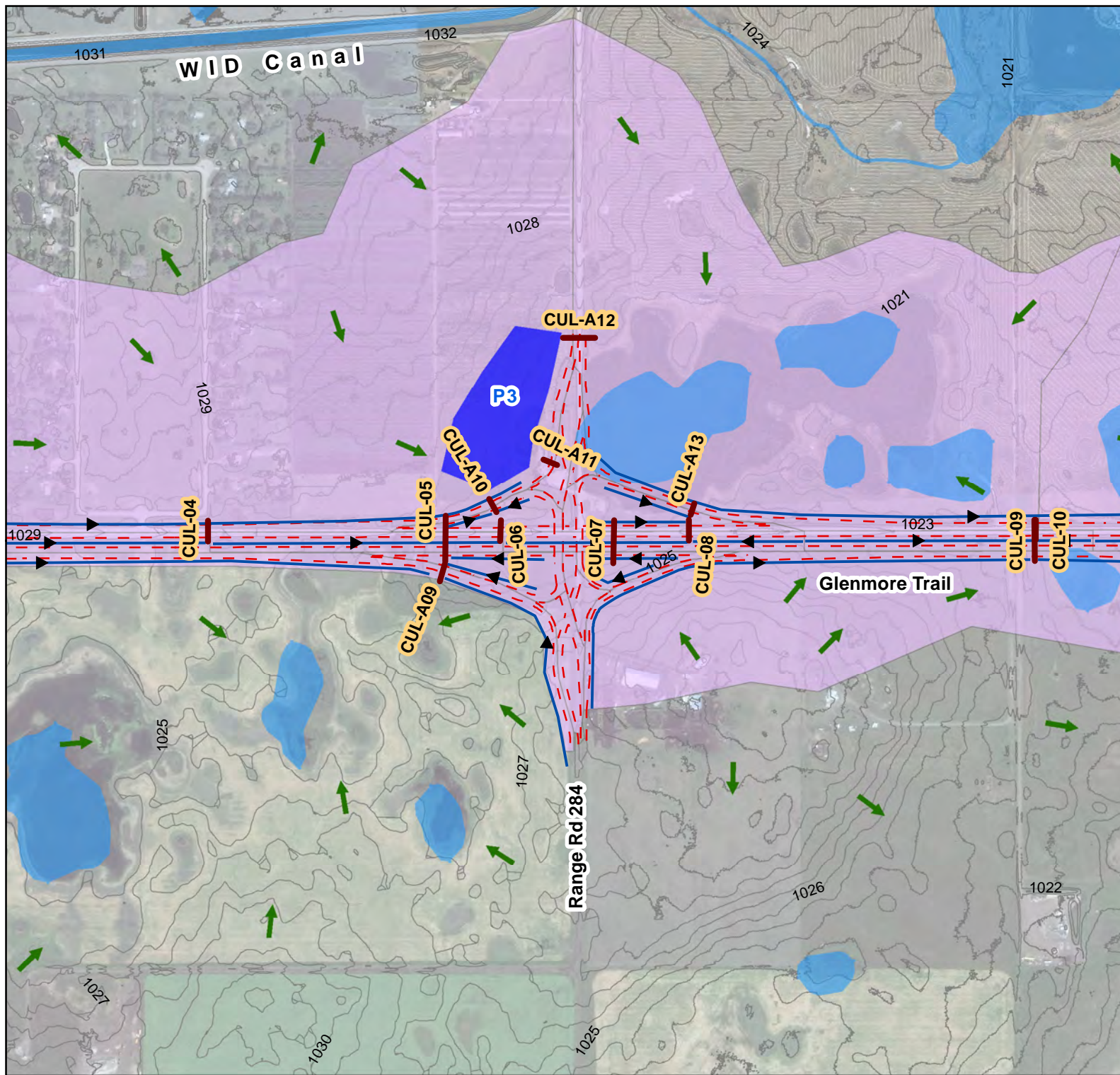
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**Proposed Conditions**  
**Range Road 285**  
**Intersection**  
**Figure 3.2**

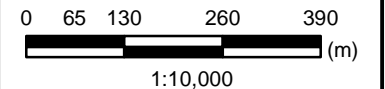


**Legend**

- Proposed Highway Expansion
- Ditches
- Overland flow arrows
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- Waterbody
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- Proposed Culverts

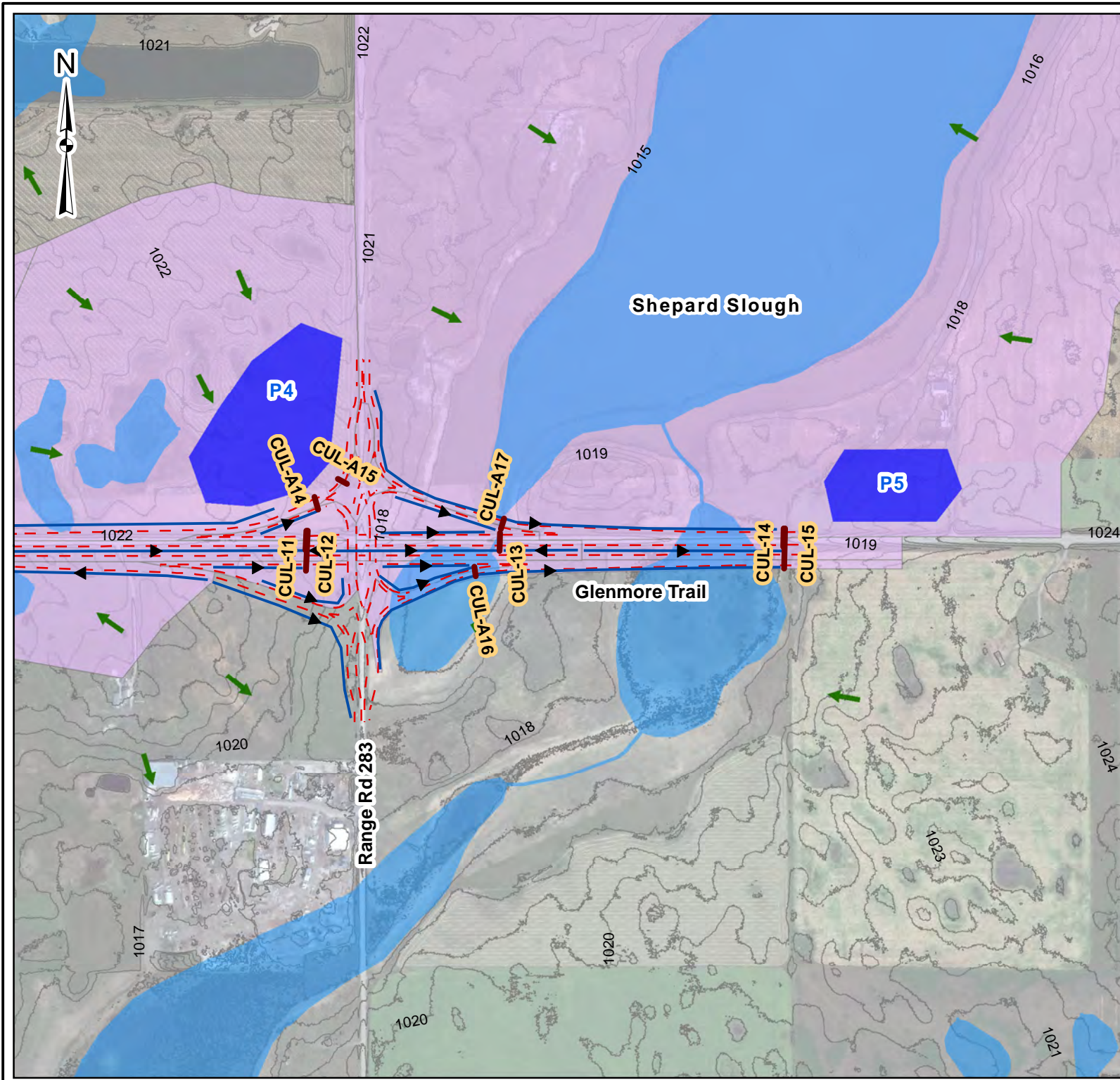


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**Proposed Conditions**  
**Range Road 284**  
**Intersection**  
**Figure 3.3**



Highway 560 Expansion

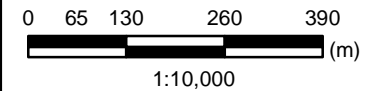


Legend

- Proposed Highway Expansion
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**Proposed Conditions**  
**Range Road 283**  
**Intersection**  
**Figure 3.4**

## 3.2. Conveyance

To design the culverts along Glenmore Trail and beneath the approach ramps, a PCSWMM model was developed to estimate the total run-off from catchments upstream of each proposed culvert. A 100-year 4-hour design storm was employed in the model. The total run-off was converted to a unit discharge rate ( $\text{m}^3/\text{s}/\text{ha}$ ) and this rate was applied to the catchment area for each individual culvert to predict the design flow for each structure. The model results are summarised in Table 3.1.

*Table 3.1 Culvert unit discharge*

Parameter	
Run-off rate	9.325 $\text{m}^3/\text{s}$
Catchment area	95.670 ha
Peak unit discharge	0.097 $\text{m}^3/\text{s}/\text{ha}$

Since it is anticipated that CSP will be selected as the preferred material for all culverts, the inlet and outlet control nomographs in the Handbook of Steel Drainage & Highway Construction Products (CSPI, 2007) were used to determine culvert sizes and the nomographs can be found in Appendix A. Details of the culverts can be seen in Table 3.2. The culvert sizes should be checked with more rigorous computational simulation methods during the concept design phase of the project.

Table 3.2 Culvert Design

Culvert	Tributary Area (ha)	Peak Discharge (m <sup>3</sup> /s)	Culvert Diameter (m)	Length (m)	Slope (%)	HW/D	Comment
CUL-01	6.27	0.61	1.2	73.00	0.20	0.66	
CUL-02	6.24	0.60	1.0	94.00	0.60	0.70	
CUL-03	2.27	0.22	0.7	36.00	0.70	0.57	
CUL-04	2.26	0.22	0.7	39.00	2.00	0.57	
CUL-05	9.07	0.88	1.2	86.00	0.30	0.75	
CUL-06	2.06	0.20	0.7	39.00	2.10	0.57	
CUL-07	1.09	0.11	0.7	80.00	0.20	0.69	
CUL-08	2.12	0.20	0.7	39.00	1.40	0.57	
CUL-09	26.38	2.55	1.6	78.00	0.30	0.81	
CUL-10	2.07	0.20	0.7	38.00	1.30	0.57	
CUL-11	2.29	0.22	0.7	37.00	0.80	0.57	
CUL-12	1.77	0.17	0.7	76.00	0.40	0.57	
CUL-13	1.85	0.18	0.7	33.00	3.90	0.57	
CUL-14	2.47	0.24	0.7	35.00	2.60	0.57	

Culvert	Tributary Area (ha)	Peak Discharge (m <sup>3</sup> /s)	Culvert Diameter (m)	Length (m)	Slope (%)	HW/D	Comment
CUL-15	3.39	0.33	0.8	76.00	0.50	0.63	
CUL-A01	1.84	0.18	0.8	20.00	0.20	0.76	Assumed slope
CUL-A02	2.76	0.27	0.9	15.00	0.20	0.74	Assumed slope
CUL-A03	1.18	0.11	0.8	21.00	0.20	0.75	Assumed slope
CUL-A04	2.76	0.27	0.9	25.00	0.20	0.72	Assumed slope
CUL-A05	1.62	0.16	0.8	17.00	0.20	0.76	Assumed slope
CUL-A06	0.37	0.04	0.7	60.00	0.20	0.61	Assumed slope
CUL-A07	1.25	0.12	0.7	64.00	0.30	0.75	
CUL-A08	1.34	0.13	0.6	34.00	2.20	0.50	
CUL-A09	6.39	0.62	1.2	24.00	0.20	0.64	
CUL-A10	3.31	0.32	0.9	27.00	0.30	0.68	
CUL-A11	0.88	0.08	0.7	27.00	0.20	0.70	Assumed slope
CUL-A12	Pond 3	0.09	0.7	61.00	0.20	0.60	Assumed slope
CUL-A13	4.43	0.43	0.9	23.00	3.40	0.67	
CUL-A14	5.18	0.50	1.0	25.00	0.40	0.69	
CUL-A15	0.66	0.06	0.7	20.00	0.50	0.66	

Culvert	Tributary Area (ha)	Peak Discharge (m <sup>3</sup> /s)	Culvert Diameter (m)	Length (m)	Slope (%)	HW/D	Comment
CUL-A16	1.16	0.11	0.7	18.00	0.20	0.73	Assumed slope
CUL-A17	3.75	0.36	0.9	21.00	0.20	0.73	Assumed slope

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### 3.3. Stormwater Management Facilities

Runoff from the highway expansion will be conveyed to the SWMFs before discharging into the WID canal or the existing wetlands. The criteria for sizing these facilities is as follows:

- For the SWMF discharging into the WID canal, the design objective is to match pre-development and post-development discharge rates. The SWMFs will attenuate the flow. The SWMFs will typically be dry between storm events.
- For the SWMFs discharging into the wetlands, the pre-development, 100-year return period water surface elevation will not be exceeded under post-development conditions. These facilities will have large surface areas to promote the evaporation (i.e. evaporation ponds).
- A sediment forebay or oil and grit separator will be required for each pond to allow for filtration of the stormwater prior to discharging to the existing wetlands. The design target for the removal of Total Suspended Solids (TSS) should be 85%.

#### 3.3.1 100 Year Depth in Existing Wetlands

To determine the effect of increased impervious area due to the proposed road surface on run-off volumes, a frequency analysis was completed to estimate the 100-year water levels in each wetland under the pre- and post-development conditions. The predicted water level data was exported from PCSWMM and decorrelated using the procedure outlined in *City of Calgary’s Frequency Analysis Procedure for Stormwater Design (2014)*. The maximum annual depths were analysed using HYFRAN+ statistical software to extrapolate the 100-year water level depths. The data was then re-correlated and a summary of the results for each wetland is presented in Table 3.3.

Table 3.3: Wetland Water Level Depth Summary

Wetland	Existing 100 Year Water Depth (m)	Proposed 100 Year Water Depth (m)
WL 1	0.86	0.61
WL 2	0.37	0.29
WL 3	0.77	0.48
WL 4	0.97	0.62
WL 5	0.41	0.4

### 3.3.2 Evaporation Ponds

The evaporation ponds were designed so that the existing 100-year maximum depths in the wetlands were not exceeded under the post-development conditions. An initial size for each pond was assumed and their performance assessed using the post-development, continuous simulation model. Multiple iterations were required to refine the size of each pond in order to achieve the performance criterion. The post-development model results were subjected to the frequency analysis previously described, and the 100-year maximum water level depth in each wetland.

The predicted 100-year water depths for the pre-development and post-development conditions were compared; all ponds met the design criterion. The preliminary pond sizes are summarised below in Table 3.4.

*Table 3.4. Preliminary Pond Sizes*

Pond	Footprint (m <sup>2</sup> )	Depth (m)
1	12,000	1.2
2	20,000	1.5
3	15,000	1.2
4	40,000	1.2
5	30,000	1.0

## 4. Summary

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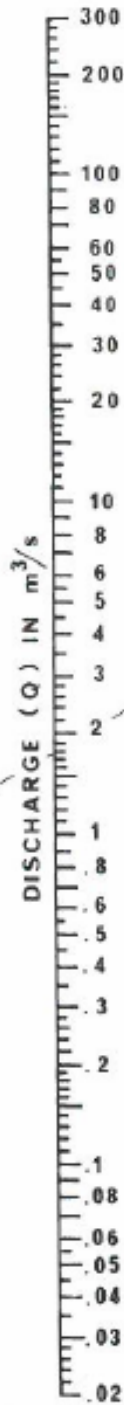
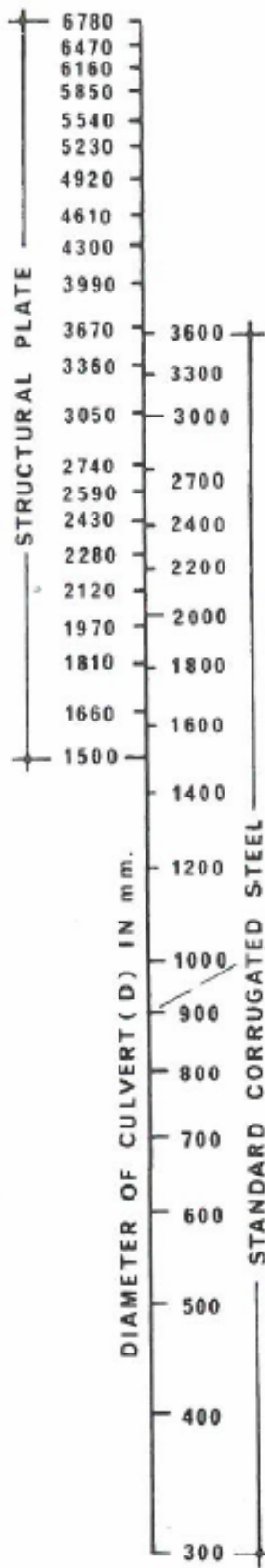
As the design of the Glenmore Trail Interchange progresses and details for the three (3) interchanges are confirmed, the design outlined in this report should be reviewed and updated accordingly given the incomplete nature of the information which was supplied.

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## Appendix A – CSP Culvert Nomograph

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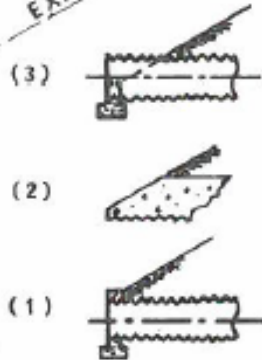


**LOSS COEFFICIENT  $K_e$  (1)  
FOR VARIOUS ENTRANCE  
TYPES**

HW/D SCALE	ENTRANCE TYPE	COEFFICIENT
(1)	Headwall, sq. edge, or End Section conforming to fill slope	0.5
(2)	Mitered to conform to slope	0.7
(3)	Projecting from fill	0.9

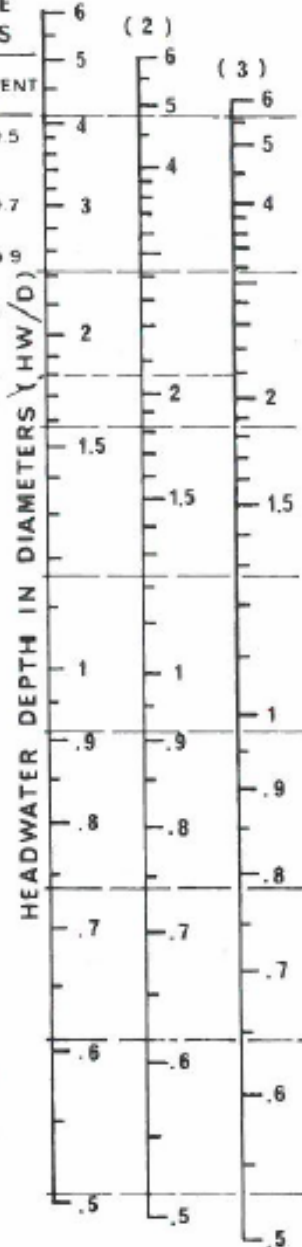
To use scale (2) or (3) project horizontally to scale (1), then use straight inclined line through D and Q scales, or reverse as illustrated.

EXAMPLE



EXAMPLE  
DIA.(D) = 900 mm  
Q = 1.8 m<sup>3</sup>/sec.

SCALE	HW/D	HW
(1)	1.8	1620
(2)	2.1	1890
(3)	2.2	1980



**INLET CONTROL  
HEADWATER DEPTH  
ROUND CSP & SPCSP**