Glenmore Trail East Interchanges Functional Planning Study

Appendix G - Stormwater Drainage Plan

Prepared By:

PARSONS

ISL Engineering and Land Services

June 2018

Prepared for:

Functional Drainage Plan

Highway 560 Expansion

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2511-00527-00

McElhanney

[2018/06/08]

Parsons
318 11 Ave SE, Calgary, AB T2G 0Y2
Attention: Haribol Sharma

Highway 560 Expansion – Master Drainage Plan

Dear Mr. Sharma:

McElhanney Consulting Services Ltd. is pleased to submit our Functional Drainage Plan for Highway 560 Expansion Final Design Report for your review.

Included in the Design Report is a discussion of the methodology which was used to determine the drainage requirements for the area, preliminary sizing for the culverts and preliminary sizes for Stormwater Management Facilities.

We trust you will find our submission acceptable. Please contact the undersigned should you have any immediate questions or concerns.

Yours truly,
McELHANNEY CONSULTING SERVICES LTD.

Nav Sandhu, P.Eng.

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Report Signature

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Please direct any questions or clarification regarding the contents of this report to the following team members who prepared this report.

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8 June 2018

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1. Introduction

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 84th 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 & 100th Street SE Interchange and Glenmore Trail SE & Conrich Road Interchange, Parsons, 2016

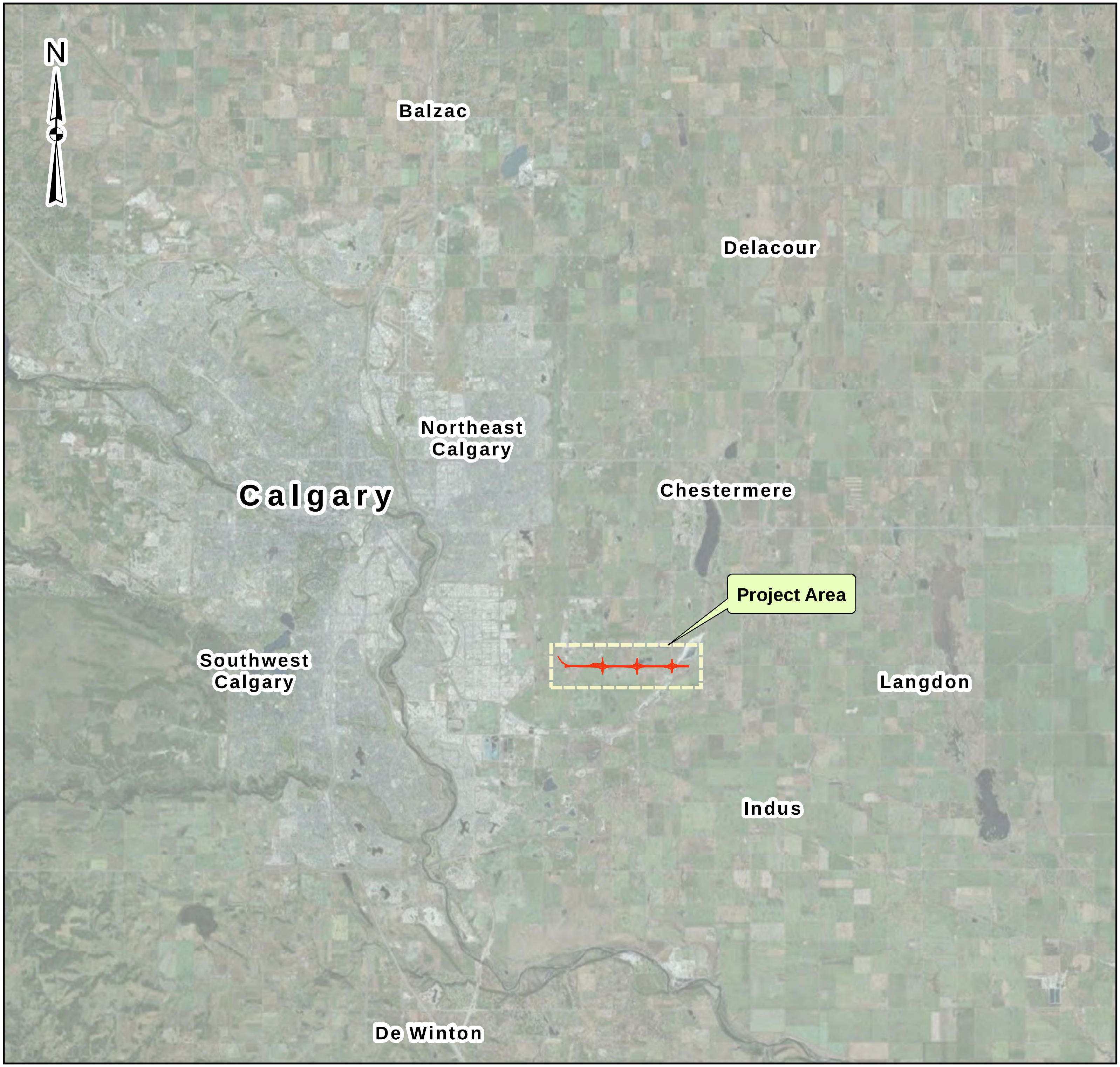
The City of Calgary Stormwater Management and Design Guidelines (2011) has been adopted as the primary source for design criteria.

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 Heatherglen Golf Course and the Prairie Schooner Estates residential development. Highway 560 crosses the Western Irrigation District (WID) Canal immediately east of 84 St SE.



Highway 560 Expansion

Legend

Proposed Highway Expansion

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Project No.	Date
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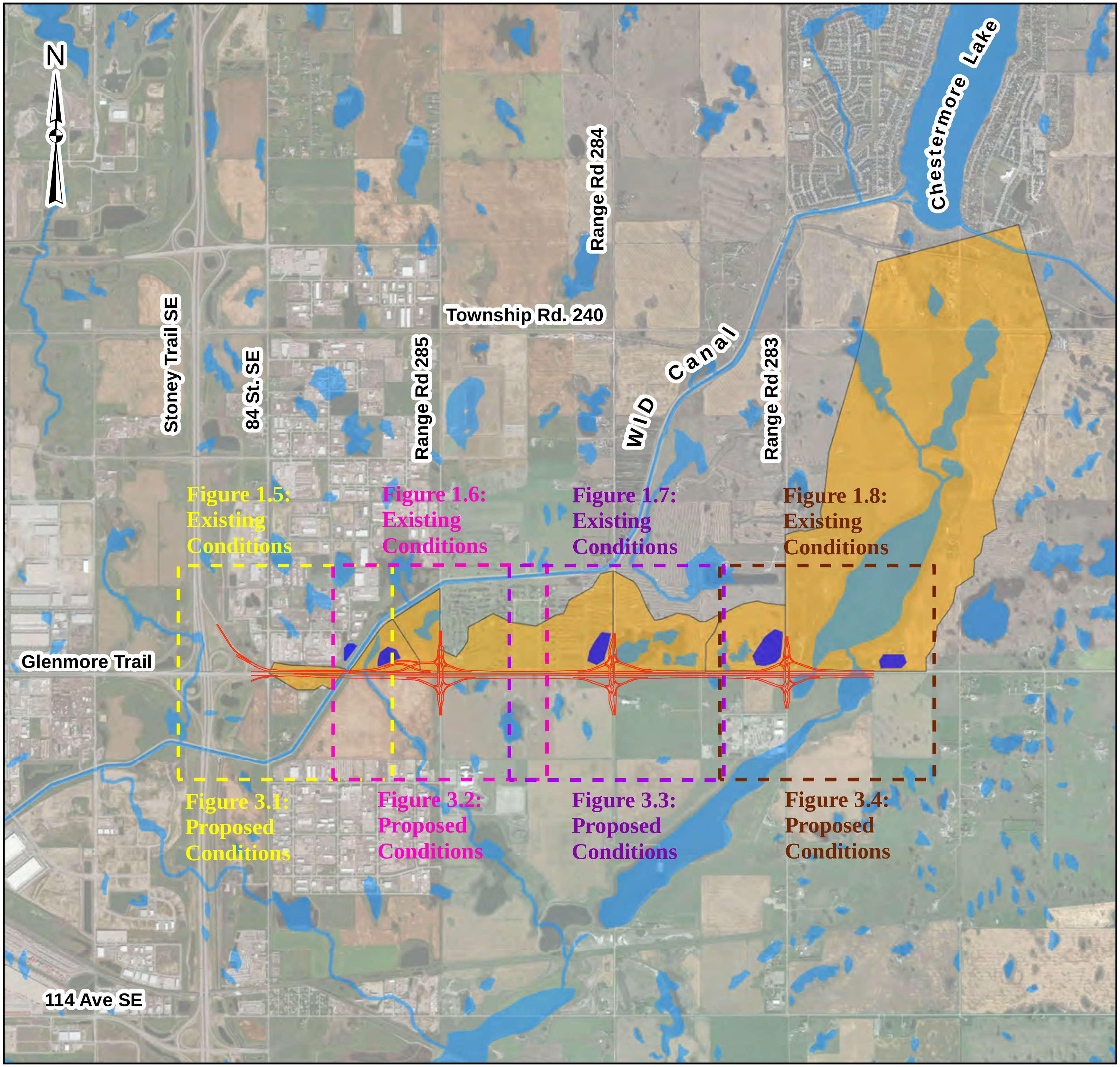
Location Map

Figure 1.1



Highway 560 Expansion

Calgary

Legend

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

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0 335 670 1,340 2,010 (m)

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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.

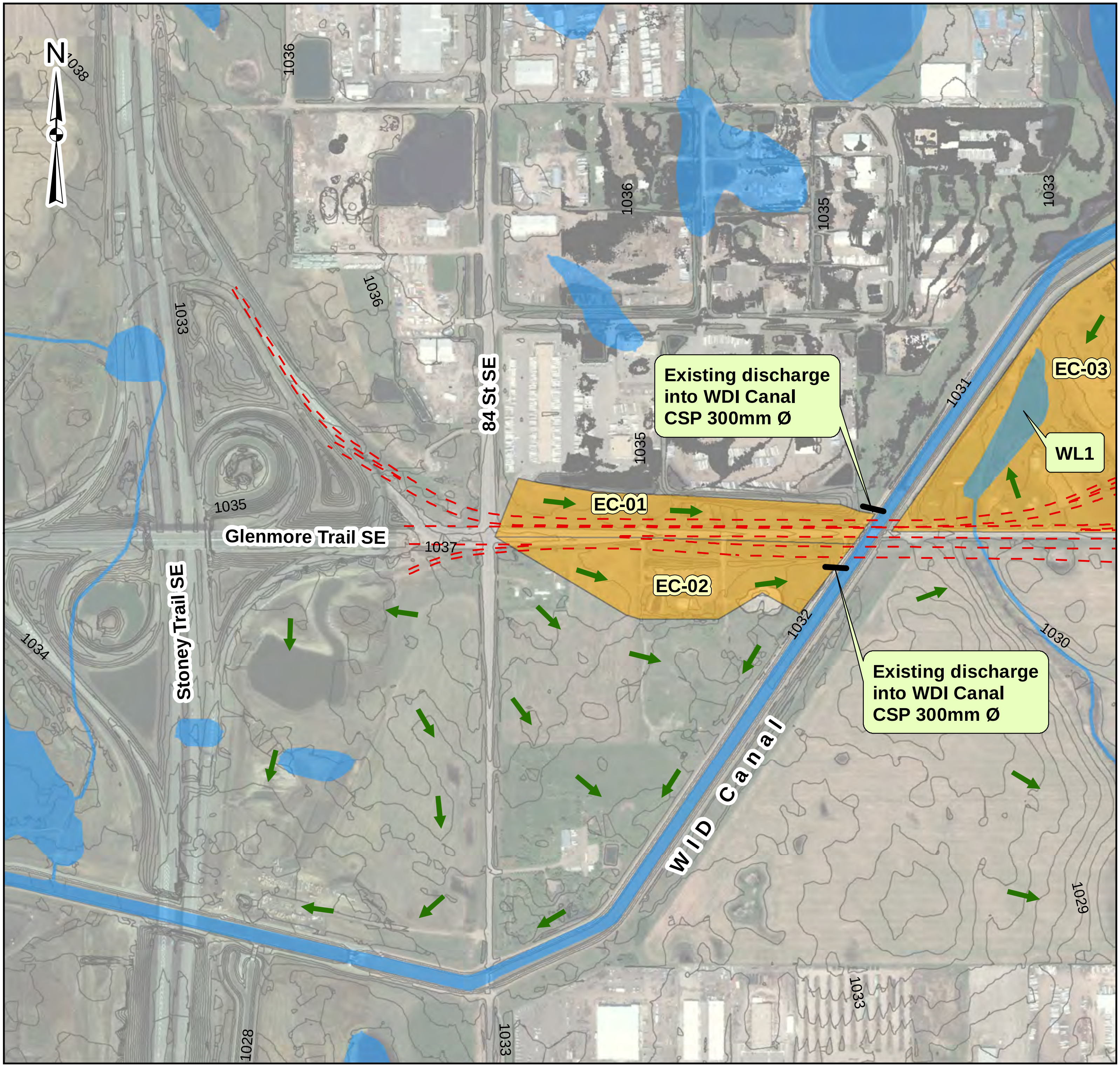
1.4.1 Existing Sub-Catchments

Existing topographic information was obtained from LiDAR data supplied by Parsons Corporation in two sections. 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 west 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 **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



Highway 560 Expansion

Calgary

Legend

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

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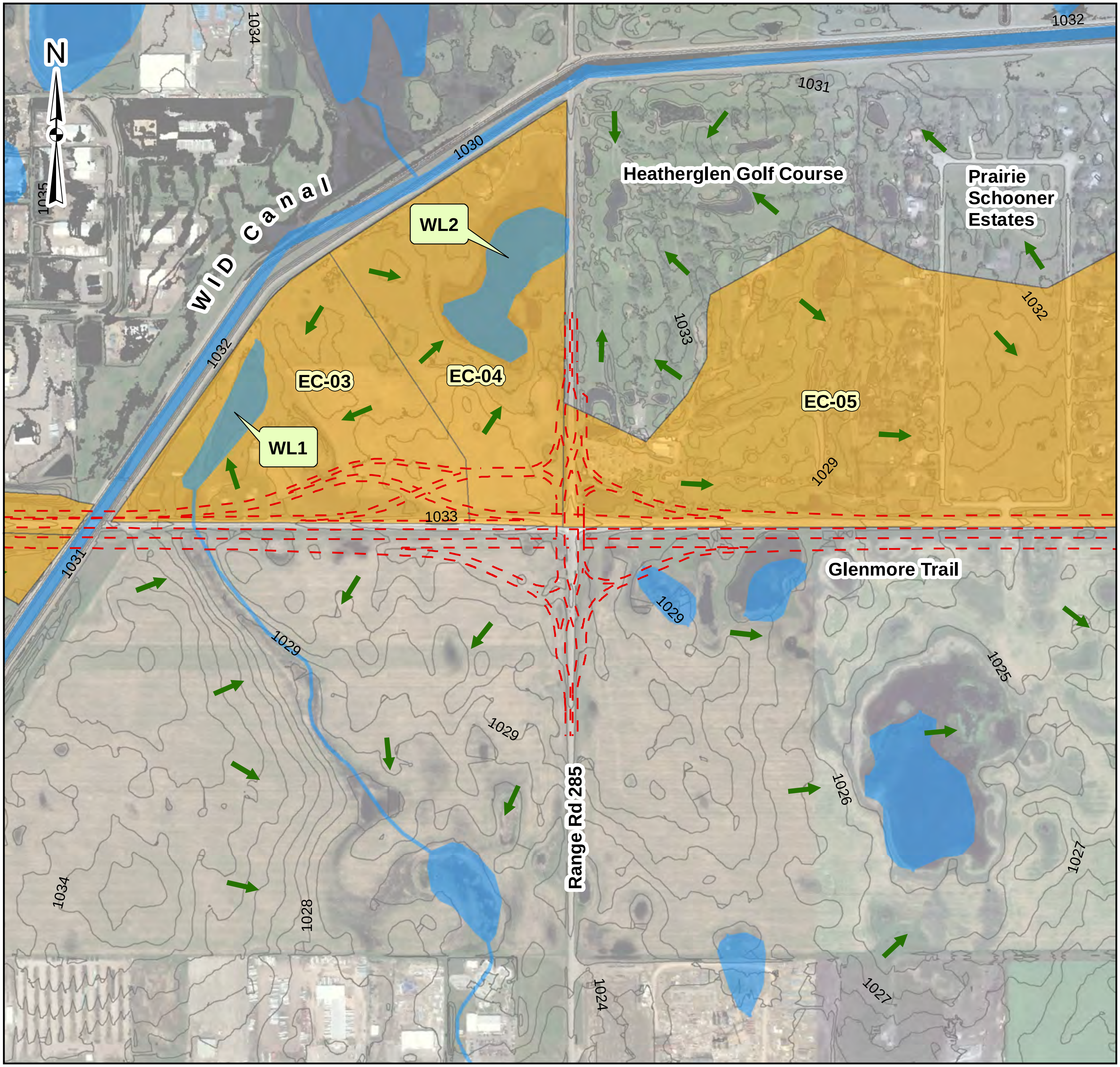
Existing Conditions

West of WID Canal

Figure 1.5



Highway 560 Expansion

Calgary

Legend

Proposed Highway Expansion

Overland flow arrows

Waterbody

Existing Sub-catchments

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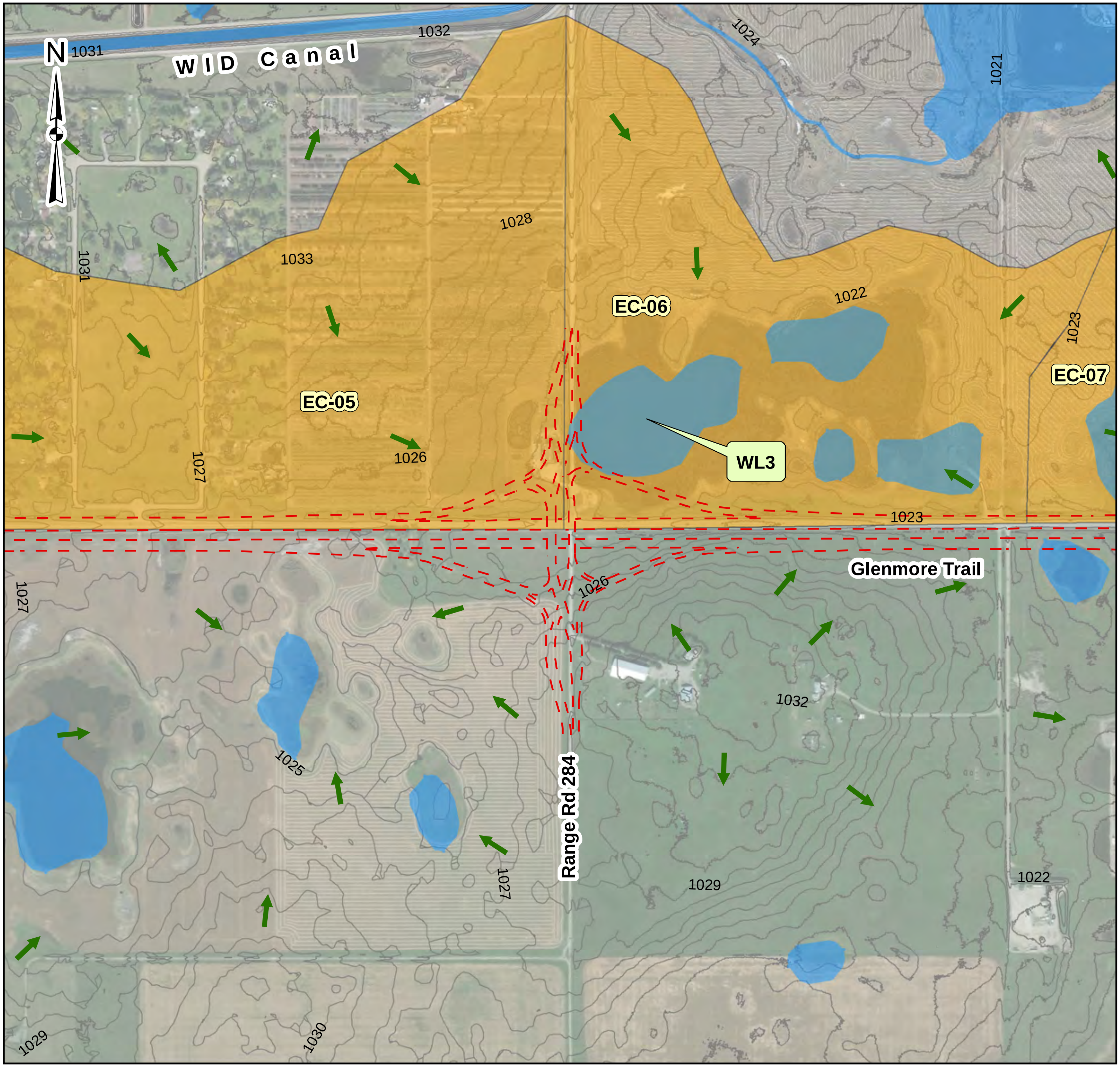
Existing Conditions

Range Road 285 Intersection

Figure 1.6

Highway 560 Expansion

Calgary



Legend

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

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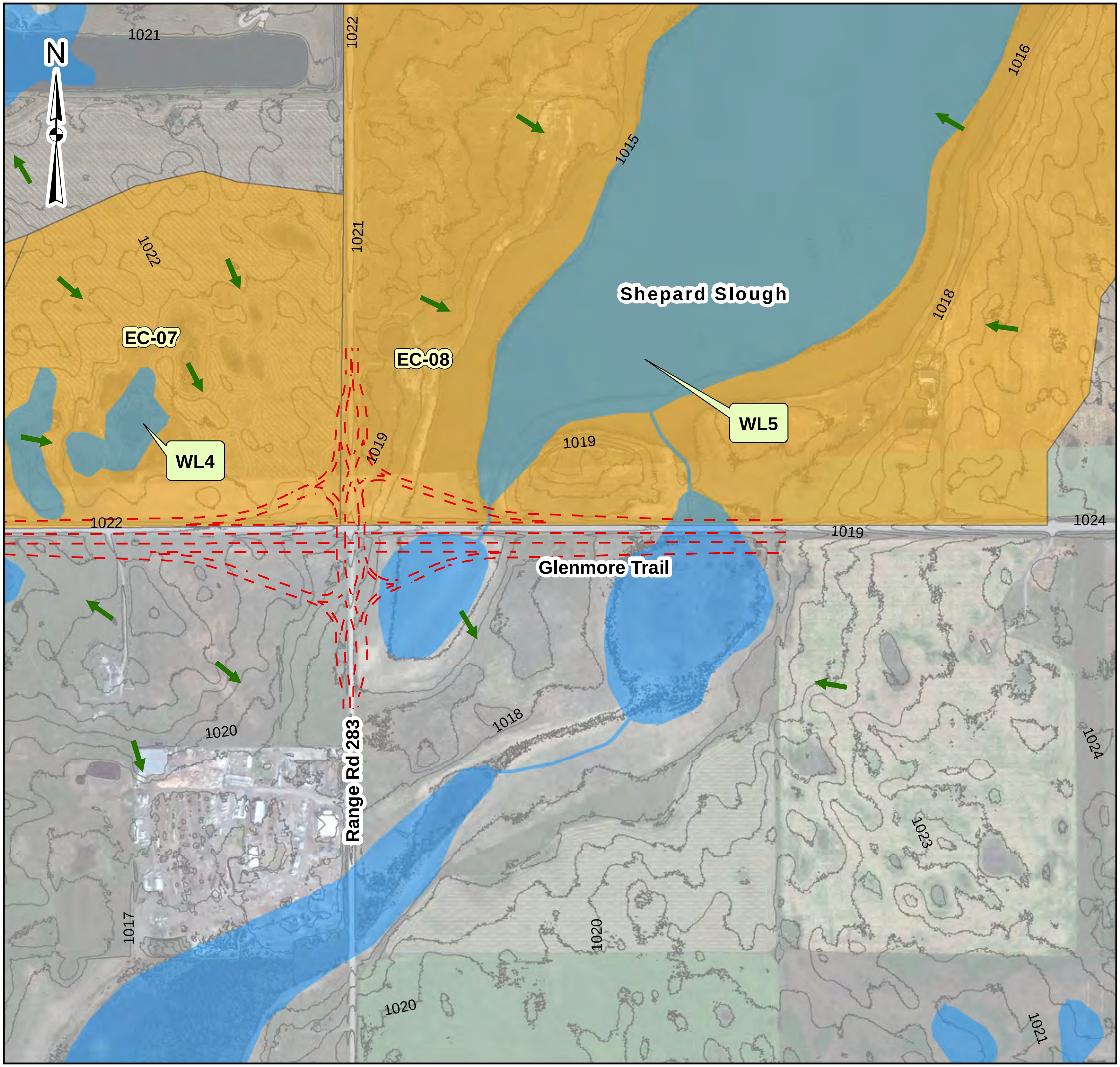
Project No.	Date
2511-00527-00	Jun 2017

Existing Conditions

Range Road 284 Intersection

Figure 1.7



Highway 560 Expansion

Legend

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

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2511-00527-00	Jun 2017

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 pools 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**).

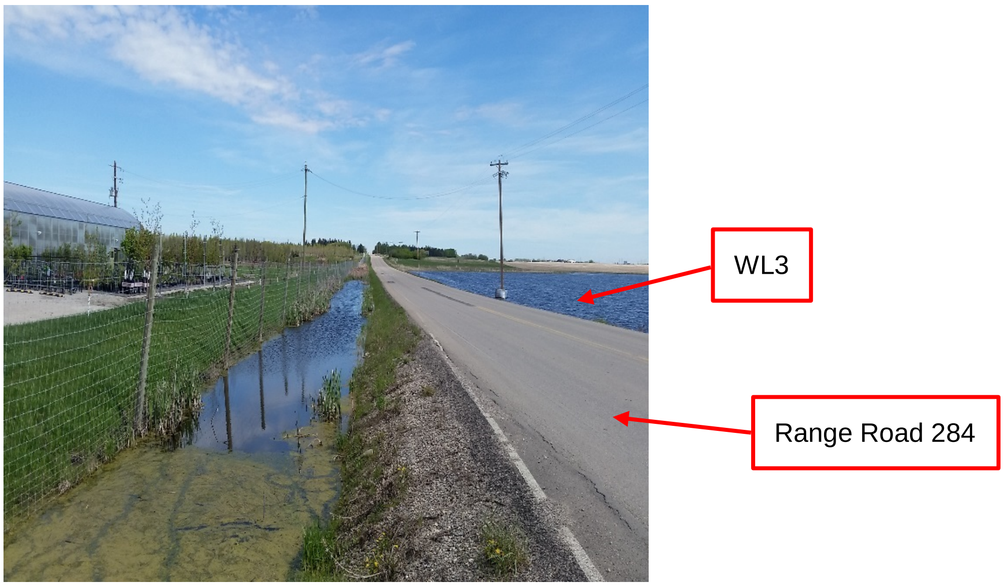


Figure 1.9: Western drainage ditch parallel to Range Road 284 looking north

Figure 1.7 and **Figure 1.8** show that between Range Roads 284 and 283 there is a 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

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 parameters representing the 100-year return period 24-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 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 is designed to function as an evaporation pond since it will attenuate post-development run-off from the roadway without discharging to an outlet. The two 300mmØ CSP culverts which currently convey flows from EC-01 and EC-02 to the WID Canal will be decommissioned and capped as part of this drainage design to allow for flows to be directed to P1.

For the sub-catchment areas draining into a wetland, a continuous simulation was carried out to estimate the annual maximum water depths under existing conditions. These values were used to conduct a frequency analysis to estimate the maximum water depth in the wetlands 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 depths 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 CN 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. Because no information relating to the depth of each wetland was available, an assumed depth of 2.0m was applied for all locations. An initial water depth of 0.0m was adopted for each wetland since the sensitivity analysis showed that the simulation was not dependent on the initial depth. 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.

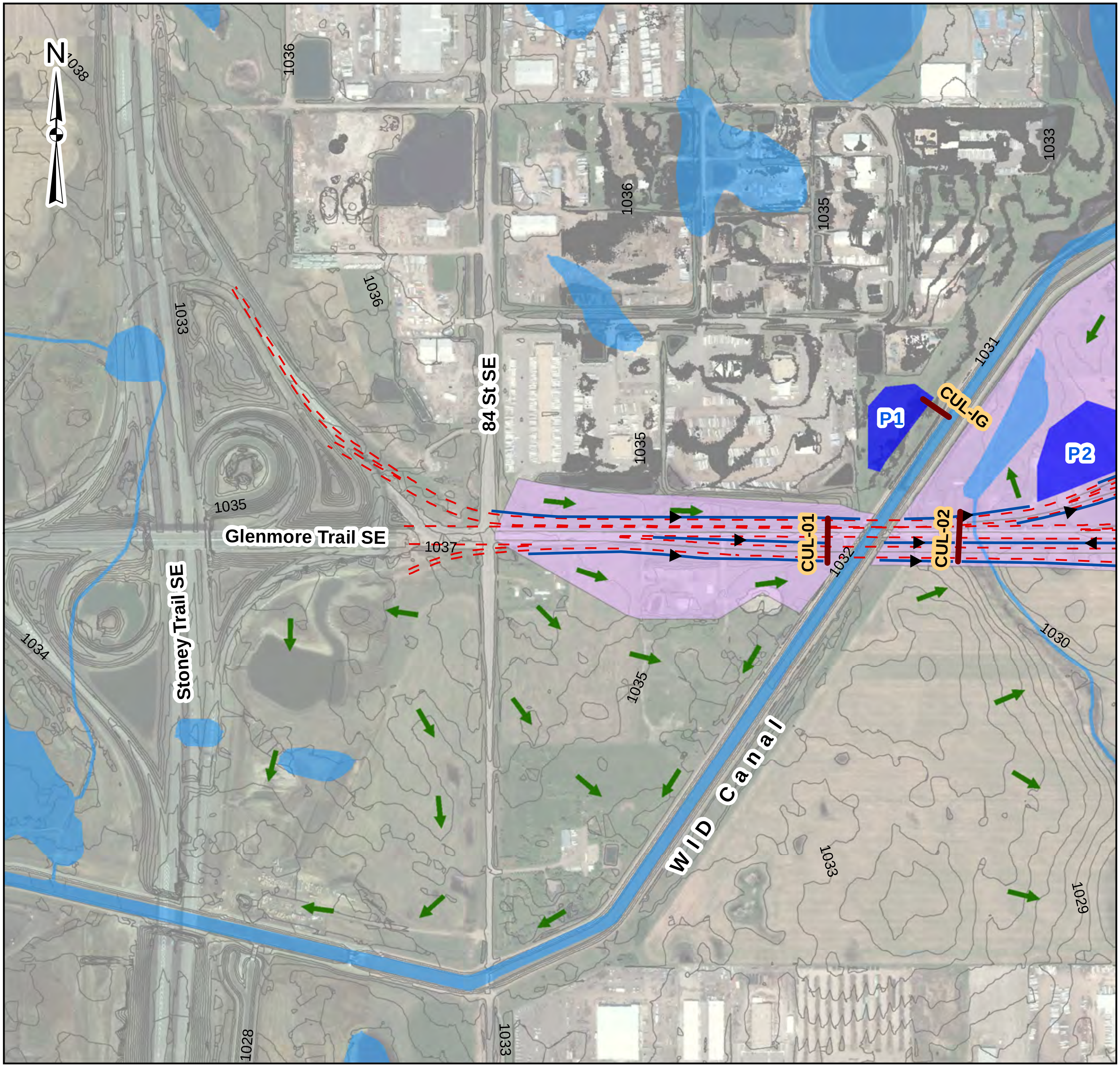
This procedure was replicated for the post-development conditions and used to design the necessary stormwater infrastructure including detention ponds and the conveyance network. This will be further discussed in Section 3.

3. Analysis and Proposed Design

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. Parsons provided a surface model of the proposed finished road corridor and this was imported into C3D to enable the culverts to be positioned and designed to convey water to the ponds. We note that the location and elevations of the culvert inlets and outlets are preliminary and must be confirmed and refined, if necessary, 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 defined for each culvert based on their assumed location. These catchments are presented in **Figure 3.1** to **Figure 3.4**.



Highway 560 Expansion

Calgary

Legend

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

McElhanney

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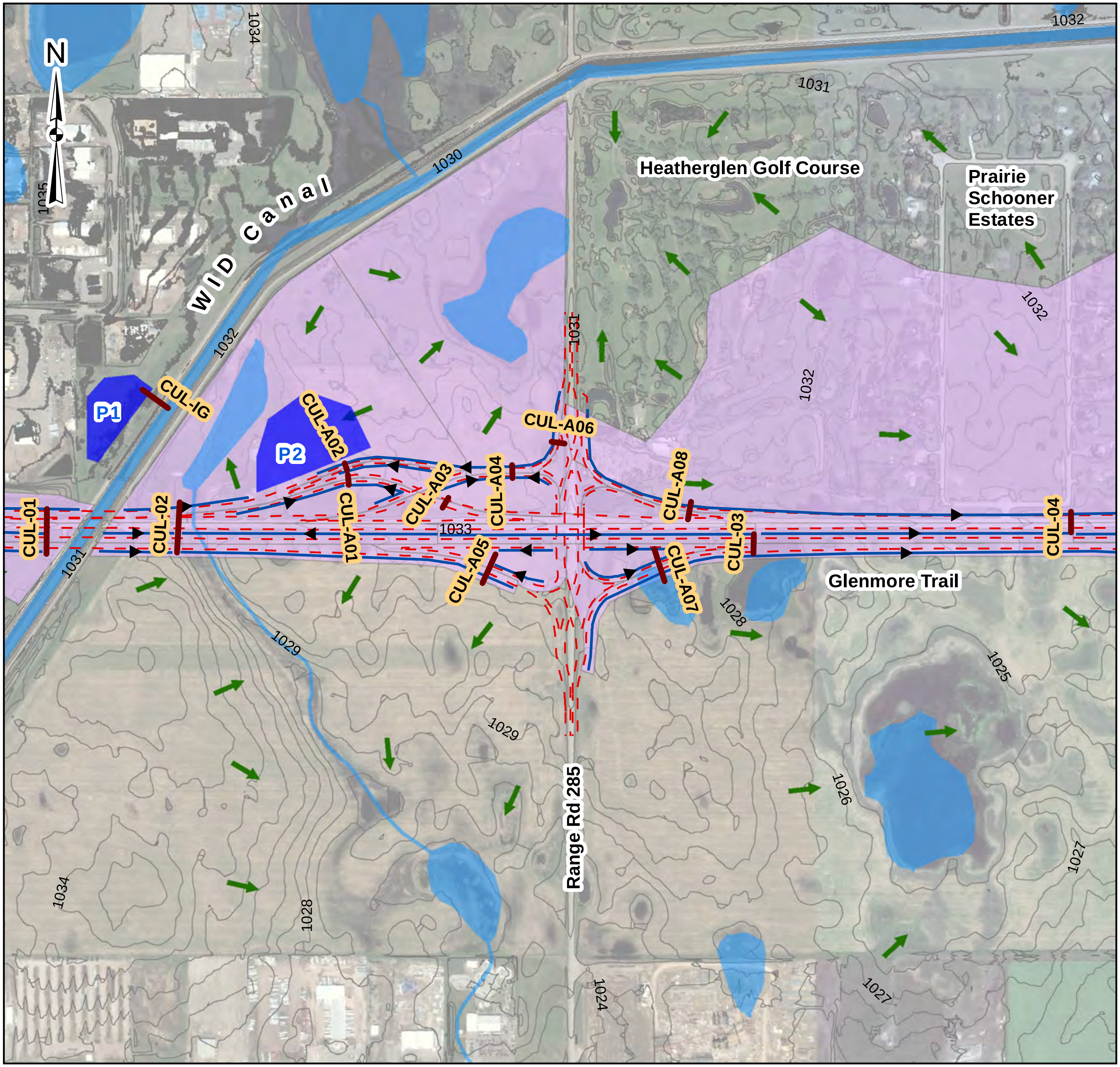
Project No.	Date
2511-00527-00	Jun 2017

Proposed Conditions

West of WID Canal

Figure 3.1



Highway 560 Expansion

Calgary

Legend

- Proposed Highway Expansion
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- Proposed Subcatchments
- Proposed Culverts

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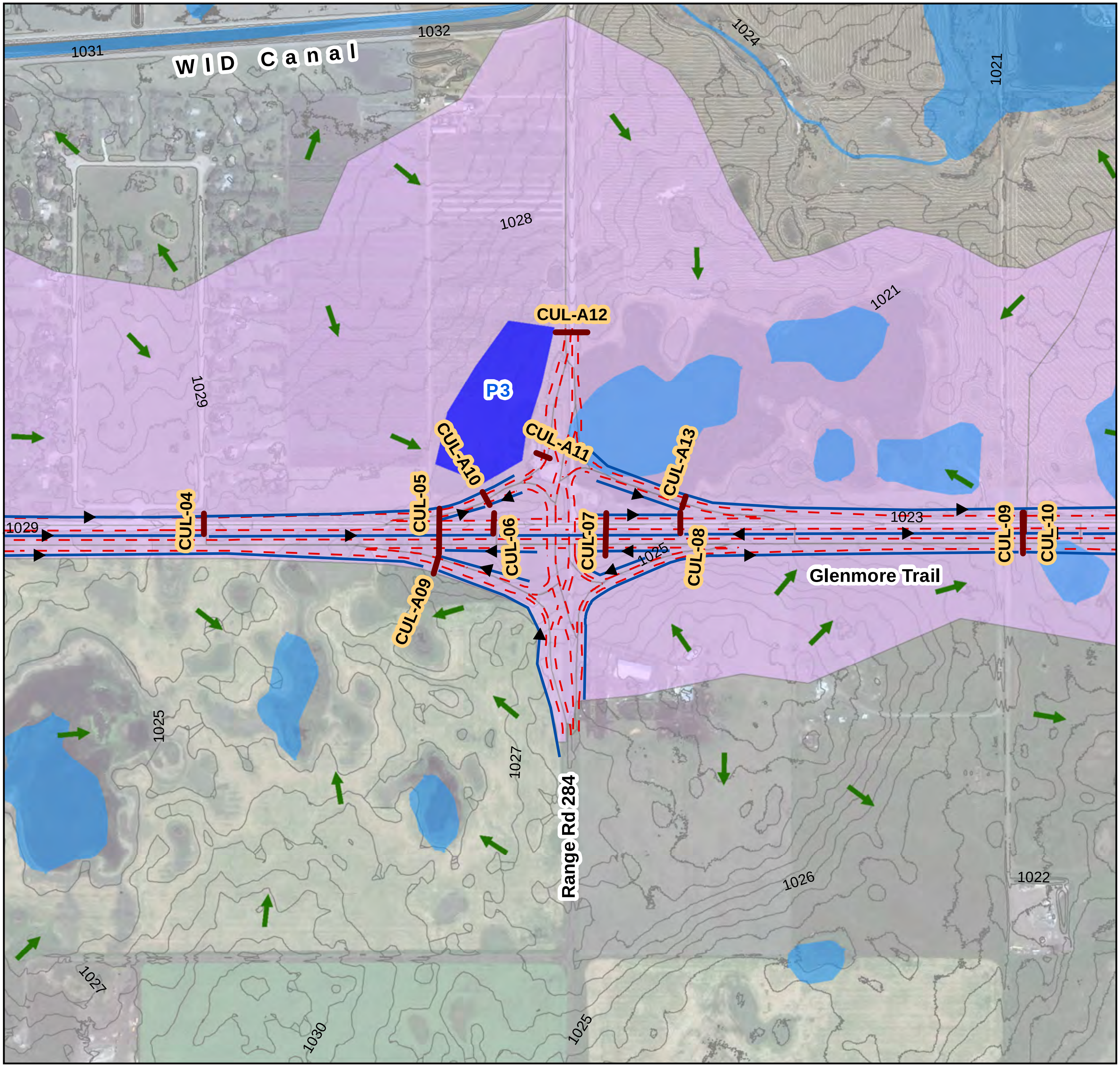
Project No.	Date
2511-00527-00	Jun 2017

Proposed Conditions

Range Road 285 Intersection

Figure 3.2



Highway 560 Expansion

Legend

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

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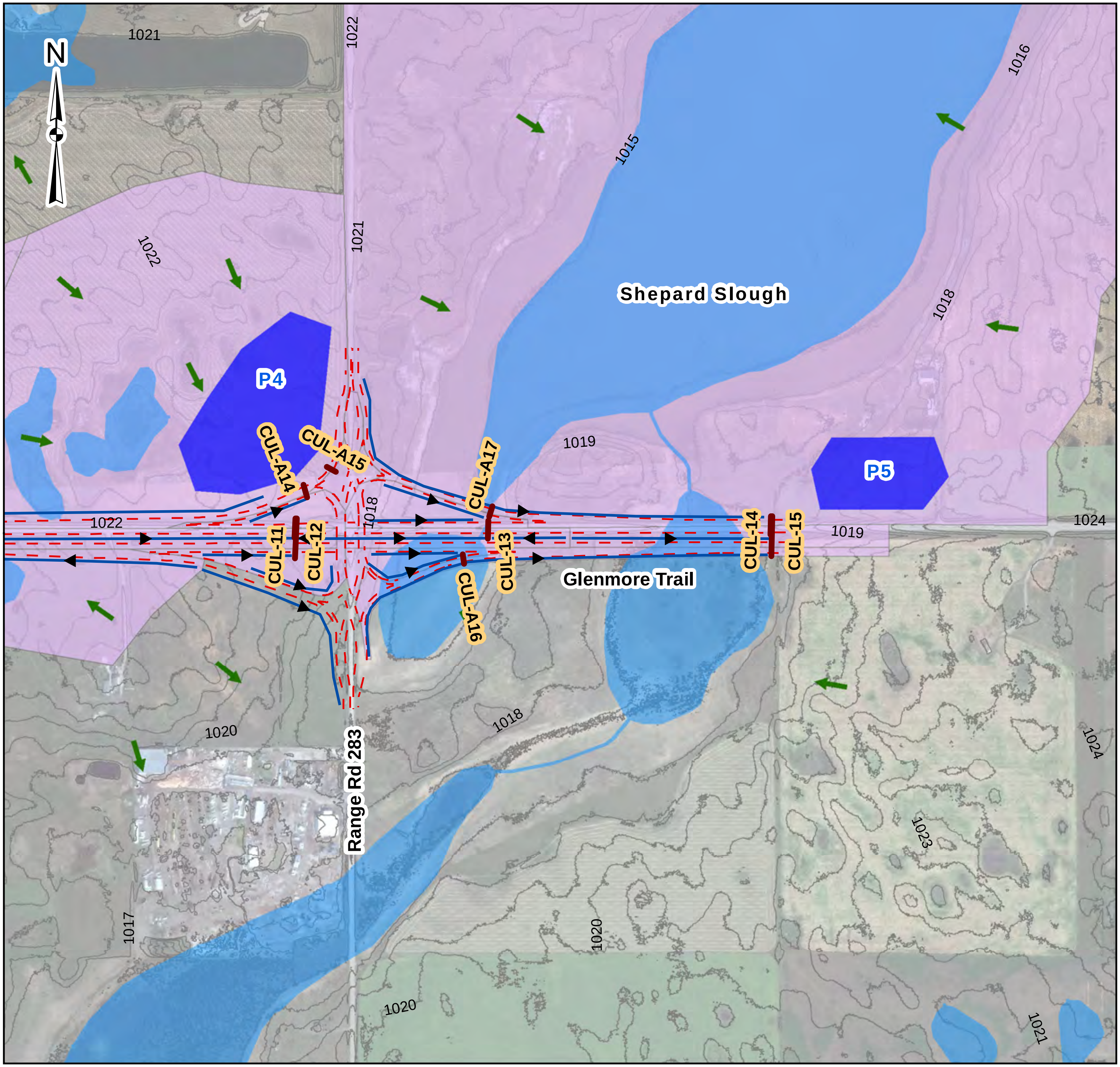
Project No.	Date
2511-00527-00	Jun 2017

Proposed Conditions

Range Road 284 Intersection

Figure 3.3



Highway 560 Expansion

Calgary

Legend

- Proposed Highway Expansion
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Project No.	Date
2511-00527-00	Jun 2017

Proposed Conditions

Range Road 283 Intersection

Figure 3.4

3.2. Conveyance

The culverts along Glenmore Trail were designed using a PCSWMM model which was developed to estimate the total run-off from all subcatchments for a 100-year 4-hour design storm. The total run-off was converted to a unit discharge rate ($m^3/s/ha$) and this rate was applied to the contributing subcatchment 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 m^3/s
Catchment area	95.670 ha
Peak unit discharge	0.097 $m^3/s/ha$

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 preliminary culvert sizes. The nomographs can be found in **Appendix A** and details of the culverts can be seen in **Table 3.2**. Because of the simplifications made by nomographs, it is recommended that the culvert sizes 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^3/s)	Culvert Diameter (mm)	Length (m)	Slope (%)	HW/D
CUL-01	6.27	0.61	1200	90	0.21%	0.82
CUL-02	6.24	0.60	1050	97	0.28%	0.70
CUL-03	2.27	0.22	750	54	0.44%	0.57
CUL-04	2.26	0.22	750	42	0.19%	0.57
CUL-05	9.07	0.88	1200	75	0.73%	0.75
CUL-06	2.06	0.20	750	39	1.64%	0.57
CUL-07	1.09	0.11	750	80	0.20%	0.82
CUL-08	2.12	0.20	750	39	0.54%	0.57
CUL-09	26.38	2.55	150	112	0.24%	0.81
CUL-10	2.07	0.20	750	59	0.80%	0.57
CUL-11	2.29	0.22	750	42	0.69%	0.57
CUL-12	1.77	0.17	750	81	0.29%	0.57
CUL-13	2.38	0.23	750	43	0.25%	0.57
CUL-14	2.87	0.28	750	94	0.37%	0.57

Culvert	Tributary Area (ha)	Peak Discharge (m^3/s)	Culvert Diameter (mm)	Length (m)	Slope (%)	HW/D
CUL-15	2.47	0.24	750	49	3.00%	0.57
CUL-A01	2.10	0.20	900	61	0.25%	0.76
CUL-A04	1.58	0.15	900	88	0.47%	0.76
CUL-A05	1.62	0.16	900	65	0.20%	0.76
CUL-A07	1.25	0.12	750	67	0.31%	0.92
CUL-A08	1.34	0.13	600	47	0.66%	0.50
CUL-A09	6.39	0.62	1200	19	1.29%	0.71
CUL-A10	12.38	1.20	1500	43	0.21%	0.95
CUL-A12	Pond 3	0.09	750	88	0.45%	0.72
CUL-A13	5.52	0.53	900	25	0.43%	0.67
CUL-A14	5.18	0.50	1050	48	0.19%	0.79
CUL-A16	1.22	0.12	750	38	1.12%	0.72
CUL-A17	4.28	0.41	900	37	0.44%	0.75
CUL-A18	0.38	0.04	600	121	0.29%	0.81

3.3. Stormwater Management Facilities

Runoff from the road surface and the subcatchments surrounding the highway expansion will be conveyed to the SWMFs before discharging into the existing wetlands. The criteria for sizing these facilities is as follows:

- The SWMF to the west of the WID canal will function as an evaporation pond with the design objective being to attenuate the run-off flow from the contributing subcatchments. The SWMF 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	0.40

3.3.2 Evaporation Ponds

The evaporation ponds were designed so that the existing 100-year maximum water depths in the wetlands were not exceeded under the post-development conditions. Top of bank surface elevations for the wetlands were obtained from LiDAR imagery supplied by Parsons, and since bathymetry survey data was not available, the average invert of each wetland was assumed to be 2.0m below the top of bank surface. The modelled invert of each pond was selected to match that of the connecting wetland to provide continuity between the two water bodies.

An initial footprint size was assumed for each pond and their performance was assessed using the post-development, continuous simulation model. Multiple iterations were required to refine the size of each pond to achieve the performance criterion. The post-development model results were subjected to the frequency analysis previously described to determine the 100-year maximum water depth in each wetland.

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

Table 3.4. Preliminary Pond Sizes

Pond	Footprint (m^2)	Depth (m)
1	12,000	2.0
2	20,000	2.0
3	15,000	2.0
4	40,000	2.0
5	25,000	2.0

4. Summary

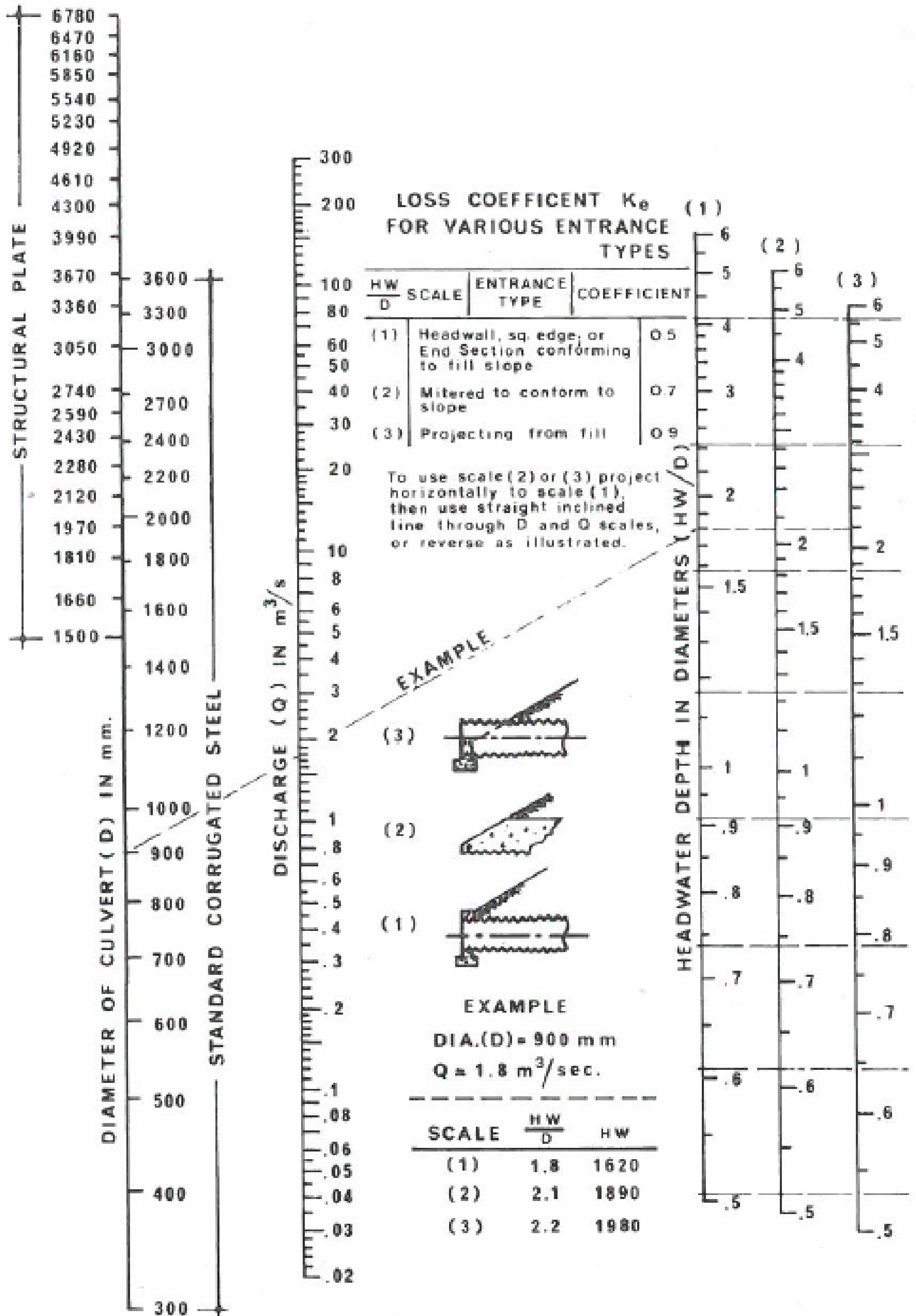
As the design of the Glenmore Trail Interchange progresses, and details for the three interchanges are confirmed, the design outlined in this report should be reviewed and updated accordingly.

The culverts have been aligned and positioned using revised roadway surface corridor models provided by Parsons on the 31st of August 2017, and ISL on the 1st of September 2017. Preliminary culvert sizes have been determined using inlet and outlet nomographs from the Handbook of Steel Drainage & Highway Construction Products (CSPI, 2007) and should be analysed using more rigorous computational methods in the following concept and detailed design phases of the project.

The two 300mmØ CSP culverts which currently convey flows from EC-01 and EC-02 to the WID Canal must be decommissioned and capped as part of this drainage design to allow for flows to be directed to P1.

The SWMFs have been positioned at locations which enables the treated run-off to be conveyed to each respective connecting wetland. The proposed PCSWMM model has applied the assumed wetland depth of 2.0m for each SWMF. Bathymetry survey should be completed for each wetland to determine the average invert. The design of each SWMF should reviewed, and refined as necessary, to reflect the surveyed invert of the wetland which the SWMF will be conveying flows to.

Appendix A – CSP Culvert Nomographs



PIPE

INLET CONTROL
HEADWATER DEPTH
ROUND CSP & SPCSP