Ricardo Ranch
Master Drainage Plan

July 2019

DRAFT

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2197.0009.22

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1.0 INTRODUCTION

1.1 Background

Urban Systems was retained by the Ricardo Ranch Landowner Group to prepare a Stormwater Master Drainage Plan in support of the ASP process. **Figure 1** shows the location of the Ricardo Ranch ASP within the context of the City of Calgary.

The Ricardo Ranch Landowner group is comprised of the following developers and landowners:

Brookfield Residential (Carma Ltd.) - 138 hectares
Genesis Land Development – 141 hectares
Alexander Soutzo – 222 hectares

Land ownership boundaries within the ASP area are shown on **Figure 2**.

1.2 Project Scope

The project scope was developed in discussions with The City of Calgary Water Resources, Calgary Parks, and the Ricardo Ranch Landowner Group. The scope of the pre-development hydrology assessment was reduced since full pre-development analysis of the Ricardo Ranch MDP area was completed as part of the *Rangeview MDP* (Urban Systems, 2015).

The Terms of Reference are summarized below:

Information Gathering and Baseline Study

- Compile all available data, including background reports, provincial mapping, existing topographical information, watershed maps, flood maps, regional data, wetland and stream delineation maps, and other information that is required for both pre-development and post-development hydrologic analysis.
- Confirm pre-development drainage boundaries, flow directions, natural low-lying areas and water bodies, and drainage courses. The delineation of the drainage catchments includes any lands that extend beyond the boundaries of the area structure plan, if these lands are deemed relevant to the drainage patterns and boundaries of lands within the area structure plan.
- Identify any existing drainage infrastructure and confirm its capacity.
- Undertake a site inspection of the study area and take photos showing the existing wetlands and drainage pathways. Document the findings of the site inspections of existing drainage features, such as wetlands, perennial and intermittent drainage courses

including ravines, as well as man-made drainage infrastructure such as impoundments, ponds, and culverts.

Wetlands and Drainage Courses

- Using the findings of the site inspection and the approved Environmental Inventory report, identify wetlands and drainage courses that can be modelled using current approved hydrological tools (e.g., PCSWMM).
- For wetlands likely to be retained, develop water balance estimates for each, and verify water levels and extent against historical records.
- Identify the extent of ravines and drainage courses to be maintained in a natural-like state, and/or deemed important for preservation by Parks and/or Water Resources, and/or subject to the Water Act. Identify the extent of the Bow River escarpment and confirm it with Parks and Water Resources.
- Undertake a limited pre-development analysis, using continuous simulation, to determine the water balance of the wetlands that are to be retained.
- Prepare flow-frequency curves for the ravines and drainage courses, including estimates of as identified above, verify/validate with observations found in previous tasks.
- Where applicable, evaluate considerations for establishing appropriate stream setbacks, addressing the following objectives:
    - Safe flood conveyance
    - Stream movement
    - Water quality/ treatment
    - Access for maintenance
    - Habitat and wildlife movement
    - Groundwater protection
    - Geotechnical slope stability
    - Educational, interpretative and recreational functions

Post-Development Servicing Strategy

- Set post-development stormwater targets within the study area.
- Using land use planning information, develop post-development drainage servicing strategies and concepts. Locate stormwater management facilities, storm trunks, and outfalls. Clearly describe any LIDs proposed to be used within the development area and determine locations.
- Undertake the appropriate continuous and single-event hydrologic analysis using the same models used for the pre-development conditions to determine detention storage requirements and predict runoff volumes and peak flow rates. The continuous simulation

model is to use hourly data from 1960 to 2014. Consider interaction among various catchments within plan area to achieve targets.

- Identify and locate the following:
  - Overland drainage routes, including the use of ephemeral and intermittent ravines and streams as overland escape routes.
  - Approximate storm trunk alignment.
  - Stormwater management facilities.
- For ponds in the flood fringe, provide an adequate level of service, based on gravity flow conditions. The ponds are to be sized to provide a 100-year level of service with the river at a 100-year flood elevation.
- Present the results of a post-development rainfall-runoff analysis to determine preliminary pond surface area, storage capacity requirements, and runoff volumes.
- Undertake a climate change assessment to review the impacts of future 100-year storm on the level of service.
- Meet with Parks and Water Resources to discuss the results.
- Present recommendations for future analysis and/or design during the preparation of the SMDPs.
- Ensure all landowners in the area are adequately represented during the development of this MDP.
- Prepare an MDP report (draft and final).

1.3 Stakeholder Engagement Process

During preparation of the Ricardo Ranch MDP, regular biweekly meetings were held with the landowner group, and several meetings were held with the Water Resources and Parks representatives. The purpose of these meetings was to ensure that MDP is aligned with the ASP policies, and to discuss with the City the proposed servicing scenarios, methodology, climate change assessment approach, and findings. One technical memorandum, describing the pre-development hydrology and findings, was submitted in the course of the project.

The intent of the engagement process was to allow the City adequate time to provide comments on the important servicing concepts, and to resolve any potential issues that would otherwise prolong the approval process.

1.4 Watershed Context and Relevant Policies

The City of Calgary's commitment to sustainable management of its water resources is articulated within several governing documents including:

- *Total Loading Management Plan* (City of Calgary, 2008)
- *Municipal Development Plan* (City of Calgary, 2010)
- *Bow River Basin Watershed Management Plan* (Bow River Basin Council, 2008)
- *Stormwater Management Strategy* (City of Calgary 2005, update expected 2020)

A portion of the Ricardo Ranch ASP area is located within the floodway and flood fringe of the Bow River. Development in the flood fringe is governed by provincial and municipal policies and requirements for flood proofing, setbacks, and building design. The City of Calgary and provincial regulatory flood maps along with other information obtained from Water Resources department was utilized for stormwater analysis in the flood fringe.

In addition, the following policies will apply in the Bow River valley:

- *Calgary Riparian Strategy* (2014)
- *Stepping Back from the Water* (2012)
- *Bow River Access Plan*
- *City of Calgary River Access Strategy*

Several policy documents that govern wetlands and natural areas management were also considered in the development of this MDP. These include:

- *Calgary Wetland Conservation Plan* (City of Calgary, 2004)
- *Open Space Plan* (City of Calgary, 2003)
- *Natural Areas Management Plan* (City of Calgary, 1994)
- *Environmental Reserve Setback Guidelines* (2007)
- *Alberta Wetlands Policy* (2014)

1.5 Background Documents

The following background reports and information were considered in the development of the MDP:

- **Regional Policy Plan:**
    - *Southeast Planning Area Regional Policy Plan* (City of Calgary, 2004)
- **Hydrogeological studies:**
    - *Hydrogeological Assessment for Ricardo Ranch Area Structure Plan* (Waterline Resources, 2019)
    - *Rangeview Area Structure Plan - Hydrogeology Study* (Golder, 2014)

- **Environmental reports:**
  - *Ecological Inventory for Ricardo Ranch ASP Area* (Stantec, 2018)
  - *Rangeview Biophysical Impact Assessment* (Golder, 2014)
  - *Ricardo Ranch – Bow River Morphology Study* (Golder, 2019)
  - *Phase I Environmental Site Assessment for Ricardo Ranch ASP area* (Athena Environmental Consultants, 2018)
- **Geotechnical reports:**
  - *SE Sanitary Tunnel Feasibility Study Geotechnical Investigation* (Thurber Engineering, 2007)
  - *Slope Stability Analysis, Rangeview Cell E ASP* (McIntosh Lalani Engineering, 2018)
- **Stormwater reports:**
  - *Rangeview Master Drainage Plan* (Urban Systems, 2015)
  - *Rangeview Master Drainage Plan - Update* (Urban Systems, 2018)
  - *Seton Pond E - Pond Report* (Urban Systems, 2019)
- **Climate Change and Flood Assessment Reports**
  - *Bow River and Elbow River – Hydraulic Model and Flood Inundation Mapping Update* (Golder Associates, 2015)
  - *2018 and Climate Change IDF Curve Update Methodology and Results – Technical Memorandum* (Associated Engineering, 2019)

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Ricardo Ranch Landowners Group

Ricardo Ranch MDP

Location Plan

Legend

Ricardo Ranch

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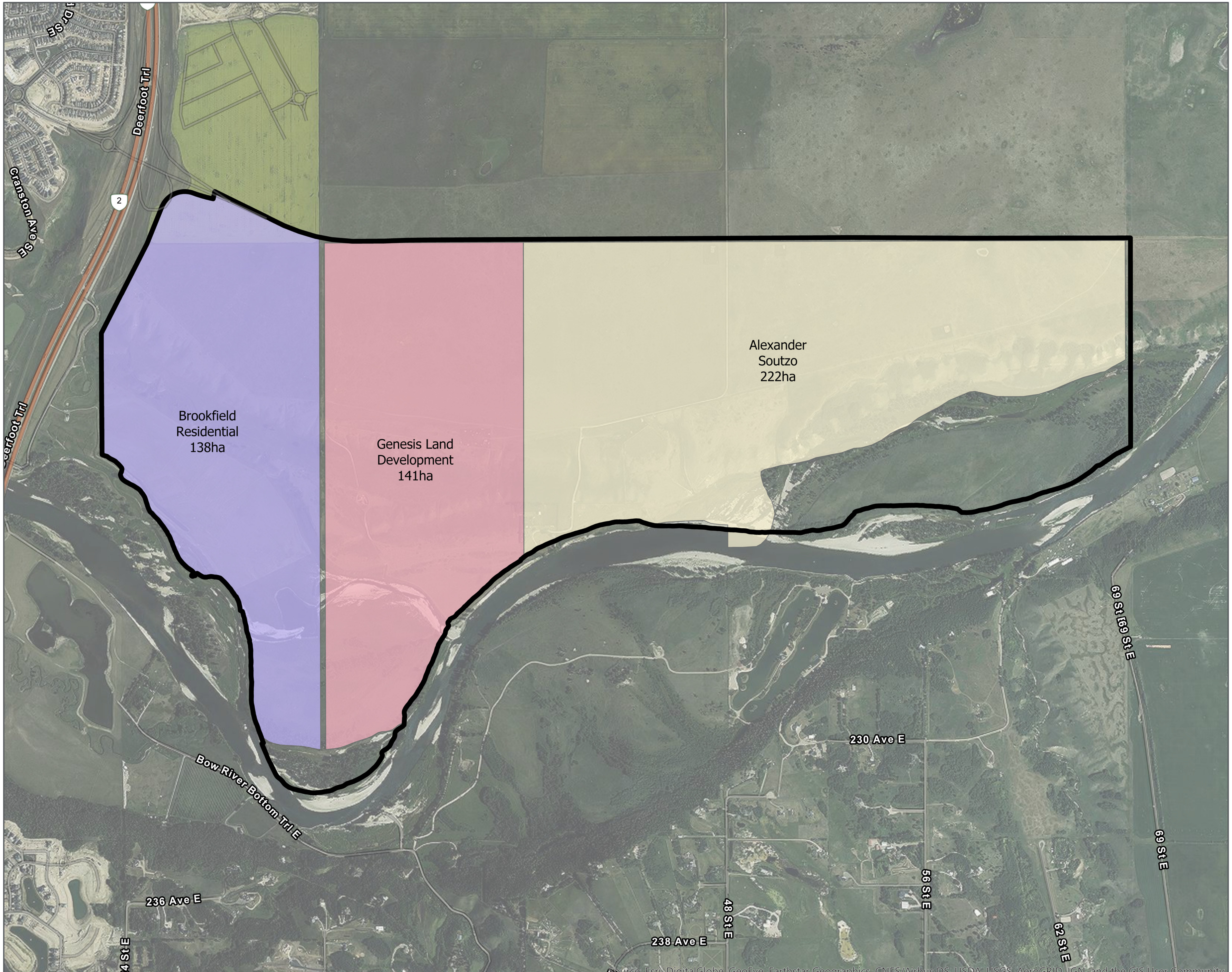
FIGURE 1



Ricardo Ranch Landowners Group

Ricardo Ranch MDP

Land Ownership

Legend

- Ricardo Ranch

Owner

- Alexander Soutzo
- Brookfield Residential
- Genesis Land Development

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FIGURE 2

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U:\Projects_CAL\2197\0009\22\D-Design\GIS\Projects\Pro_Projects\RicardoRanch\RicardoRanch_MDP_2010719.aprx\Fig 02 - Ricardo Ranch MDP - Land Ownership - 20190719

2.0 MDP PRINCIPLES

2.1 Site Description and Constraints

The Ricardo Ranch MDP study area is shown on **Figure 3**. It includes approximately 560 hectares of land within sections 9-22-29-W4M, 10-22-29-W4M, 11-22-29-W4M, 16-22-29-W4M, 4-22-29-W4M and 3-22-29-W4M in southeast Calgary. The plan area is bound by the Bow River to the south, Deerfoot Trail SE to the west, 210th Avenue alignment to the north, and the 88th Street SE to the east. It is comprised of a large plateau above the Bow River, an escarpment with steep slopes, and the valley of the Bow River.

The plateau is undulating land with an overall average slope of approximately 2.5% to the southeast. Ground elevations on the plateau range from approximately 1,025 to 1,040 metres above sea level. The land use is almost exclusively agricultural and native pasture. The overall direction of drainage is to the Bow River in the south. Numerous small depressions, some of which have been identified as Class II and Class III wetlands, dot the plateau.

The escarpment near the Bow River is steep with some unstable slopes (Mcintosh Lalani, 2018) and several small ephemeral drainage channels. There is a narrow bench (mid-slope bench) present within the escarpment on the west side of the study area at a ground elevation of approximately 1,010 m.

Below the escarpment is the Bow River Valley, with the flood hazard area, comprised of the floodway and flood fringe (**Figure 4**). Development is discouraged in the floodway. The flood fringe is considered developable under certain conditions, i.e., if the development is flood-proofed, and mitigation strategies, such as raising site grades to safe levels and riverbank armouring, are implemented.

A river morphology assessment of the Bow River at Ricardo Ranch area, completed by Golder Associates in 2018, determined the potential for channel avulsion, and identified the changes in the meander width over the short (5-10 years), medium (50-100 years) and long term (up to 200 years). The report is included in **Appendix B**. The extent of the long-term meander belt is shown on **Figure 4**. This figure also shows the slope setbacks that are determined as part of a geotechnical investigation conducted by McIntosh Lalani.

The Ricardo Ranch ASP land use concept is shown on **Figure 5**.

2.2 Environmentally Significant Areas

The Ecological Inventory Report (Stantec, 2019) has identified a number of wetlands and natural areas within the Ricardo Ranch ASP. The Environmental Open Space (EOS) Study Area is conceptually shown on **Figure 5**. These areas will be subject to further study and refinement. It is expected that at the Outline Plan and Land Use Amendment stage, these protected areas will be finalized and may be designated as Environmental Reserve (ER) or developable land. City of Calgary Parks has the authority to claim ER at the Outline Plan stage under the *Municipal Government Act and Calgary Wetland Conservation Plan* (2004).

The Ricardo Ranch ASP policies and the Calgary Open Space Plan include additional details on the EOS areas.

For the purpose of the MDP-level analyses, assumptions were made regarding the developability of certain portions of EOS areas, as well as the removal and compensation of some of the wetlands and ephemeral drainages.

2.3 General Servicing Concepts

This section briefly outlines the general stormwater planning considerations for the Ricardo Ranch ASP area:

- Drainage from Ricardo Ranch lands is to be directed south to Bow River and will be limited to the pre-development unit area release rate (UARR) for the 100-year storm event. Therefore, the post-development UARR is set at 2.78 L/s/ha. The rate was established through pre-development hydrologic assessment completed for the Rangeview MDP in 2015.
- Several stormwater management facilities are planned for the study area to reduce the discharge rate of stormwater to the pre-development UARR and to provide water quality enhancements. The locations and operating levels of these facilities have been determined in consultations with the landowners and the City, however they are considered conceptual at the MDP stage and will be finalized at the Outline Plan and SMDP stage. The post-development analyses and sizing of stormwater facilities is described in **Section 4**.
- An overland emergency spill route is provided for each stormwater facility to protect downstream properties from flooding. Where possible, open space corridors are used as preferred locations for emergency spill routes. Future climate change impacts were considered during determination of suitable overland emergency spill routes.
- The stormwater ponds are generally designed to operate as off-stream facilities. The connecting stormwater trunk between stormwater ponds and the outfall is considered a "clean water trunk" (i.e. it conveys already treated water). Direct connections of untreated stormwater to the "clean water trunk" are not permitted.
- The future Rangeview stormwater trunk and outfall in the 72^{nd}/52^{nd} Street SE RoW will be used to service a large portion of the Ricardo Ranch ASP area. One additional stormwater trunk and outfall is required to service the western portion of Ricardo Ranch. This trunk will likely follow the future 56^{th} Street SE alignment and is further referenced as 56^{th} Street Storm Trunk. This trunk and outfall will be developer funded. The location and alignment of trunks and outfalls are discussed in **Section 6**. The alignments are still conceptual at the MDP stage and will be refined upon further land use planning.

2.4 Volume Control Considerations and LID practices

The volume control targets for the Bow River are currently voluntary. Although the developments within Ricardo Ranch ASP area do not need to meet a specific volume target and large-scale stormwater reuse for irrigation is not considered in the MDP, implementation of volume reduction strategies is encouraged to reduce the overall development impacts on the Bow River. Several volume reduction strategies are both practical and cost-effective and can result in a significantly reduced runoff volume.

At a minimum, the developments are encouraged to implement the following LID measures to reduce its runoff volumes:

- Widespread implementation of resilient landscaping, with topsoil depths of 300 mm on private lots, and 500 mm on public green spaces.
- Maximum practical extent of impervious area disconnection (directing drainage from pervious surfaces to landscaped areas with deep topsoil).
- Planning practices aimed at reducing imperviousness, especially in the ecologically sensitive flood fringe areas.

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Ricardo Ranch Landowners Group

Ricardo Ranch MDP

Study Area

Legend

Study Area

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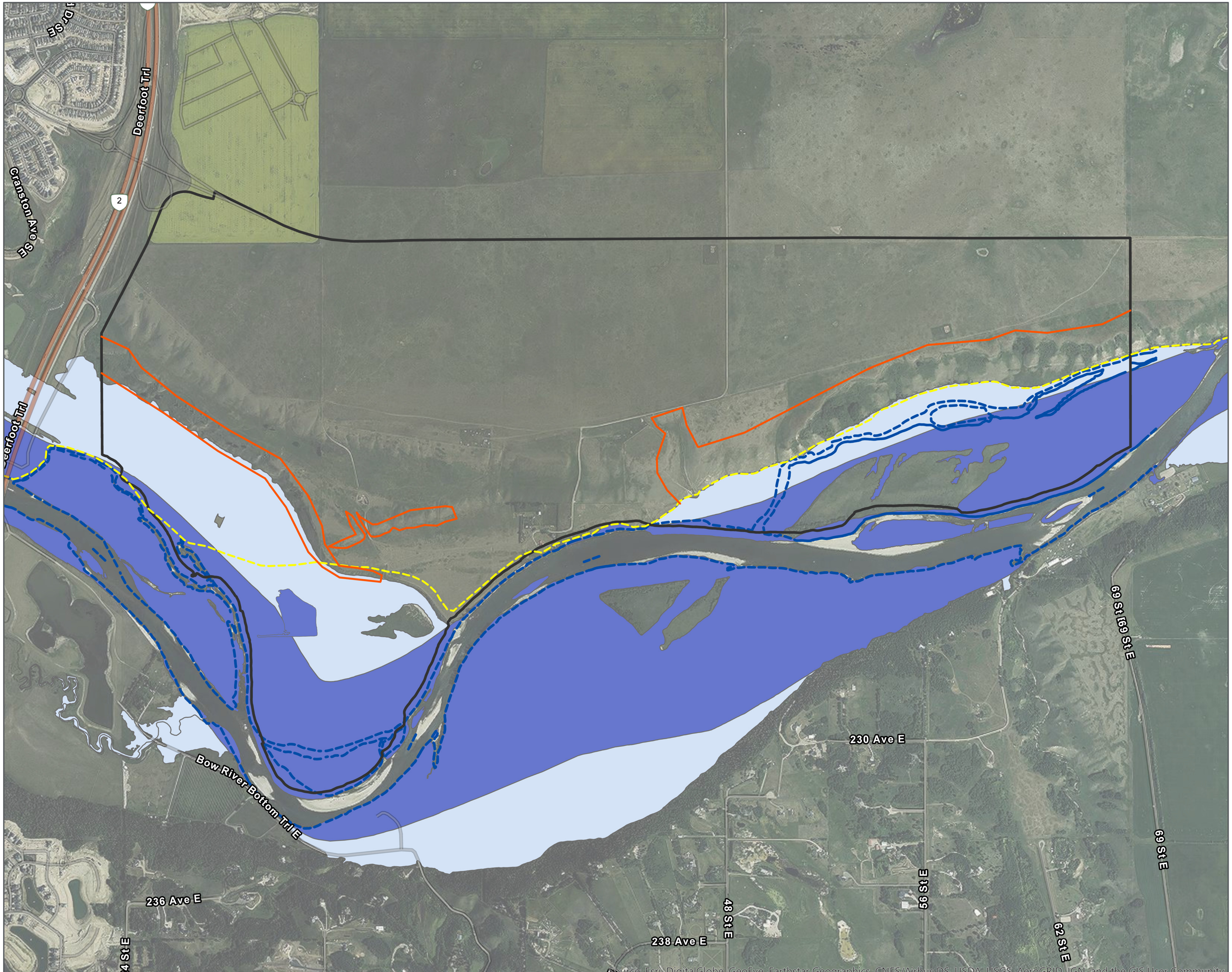
FIGURE 3



Ricardo Ranch Landowners Group

Ricardo Ranch MDP

Development Constraints

Legend

- Slope Stability Setback Line (McIntosh Lalani Engineering Ltd.)
- 200 Year Meander Belt
- Normal River Channel
- Flood Fringe
- Floodway
- Study Area

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FIGURE 4

Ricardo Ranch Landowners Group

Ricardo Ranch MDP

ASP Land Use Plan

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FIGURE 5

3.0 PRE-DEVELOPMENT HYDROLOGIC ASSESSMENT

3.1 Previous Work under Rangeview MDP

A thorough pre-development hydrological analysis of the Ricardo Ranch ASP area was completed as part of the *Rangeview Master Drainage Plan (*Urban Systems, 2015). The analysis used both WBSCC and PCSWMM rainfall-runoff modeling software:

- WBSCC was used to determine the average annual runoff volumes, since it models seasonal water balance more accurately than PCSWMM.
- PCSWMM was used to assess the hydrological importance of surface drainage connections, and to determine the 1:100-year pre-development peak flow rate.

Runoff calculation parameters used for the study were based on known site conditions including current topography, soils, geotechnical and land cover data for the study area, and are consistent with the City of Calgary guidelines. The key findings of the pre-development assessment include:

- Based on a continuous simulation using 50 years of data, the runoff is effectively captured on the plateau. The average annual runoff from the plateau was found to be in the range of 1.2 to 2.1 mm, based on the WBSCC model results.
- The estimated 1:100-year predevelopment peak runoff release rate from the plateau is 2.78 L/s/ha, based on the PCSWMM model results.

3.2 Surface Drainage Connections

The pre-development catchment delineation is shown on **Figure 6**. The ArcHydro analysis indicates that there are no apparent surface drainage connections of any hydrological significance between the depressions and wetlands on the plateau. The analysis suggests that the runoff is collected in depressions and lost to infiltration and evaporation rather than overland conveyance.

3.3 Hydrogeology

Waterline Resources completed a hydrogeological review of the Ricardo Ranch ASP area in July 2018, with final report submitted in January of 2019 (**Appendix A**). Based on Waterline's review there appear to be three groundwater systems present:

- A series of shallow, localized, small-scale perched groundwater systems present on the plateau, which may be infiltrating groundwater vertically, deeper into the Crossfield Drift. The water source in this system is from snowmelt and precipitation. It does not appear that there are subsurface drainage connections in the plateau region. The subsoil is glacial till with a low hydraulic conductivity and the wetlands appear to be perched with little likelihood of groundwater interaction.

- A deeper, intermediate-scale groundwater system present within the Crossfield Drift; the groundwater in this system is sourced from a combination of existing groundwater present upgradient in the Crossfield Drift and snowmelt/precipitation infiltrating from low lying surface depressions such as ponds and ephemeral wetlands present on the plateau;
- A regional-scale groundwater system is present in the bedrock aquifers; groundwater in this system is sourced from recharge occurring over a large region north of the study area.

The conceptual model of groundwater flow along the escarpment demonstrated that an intermediate to regional flow system controls the discharge of groundwater from inter-till aquifers which occur as springs and seeps along the escarpment, and a regional flow system controls the discharge of groundwater from the bedrock at the base of the escarpment.

Land development could potentially reduce the infiltration on the plateau, which may somewhat reduce the discharge from the associated springs and seeps along the escarpment. However, it should be noted that most of the impacts have already occurred through the development of Rangeview and Seton District areas, as well as earlier developments north of Seton district. The impacts on the intermediate or regional scale groundwater regimes from the development of Ricardo Ranch area are not anticipated.

3.4 Wetlands

One significant hydrologic feature of the plateau is the presence of a large number of shallow depressions and wetlands. In its *Ecological Inventory Report* (**Appendix C**), Stantec identified a total of forty-one (41) wetlands within the Ricardo Ranch ASP area, as shown on **Figure 7**.

Twenty of these wetlands (fourteen on the plateau and six on the slopes) are identified as Class II. These wetlands typically have a very small delineated area and only retain water for a short time after heavy precipitation. The slope wetlands may also receive some additional groundwater inputs from seepage areas along the escarpment. Despite the groundwater input, overall permanence of these wetlands was determined to be temporary.

A total of twenty-one (21) wetlands (six on the plateau, one within the flood fringe, and fourteen on the slopes) were identified as Class III wetlands, suggesting that they have some standing water during parts of the growing season. Based on ArcHydro analysis and review of aerial photographs, the following can be concluded for these wetlands:

- Of the six Class III wetlands on the plateau, none have a large enough delineated area, depth, or reasonable storage potential, to be adequately assessed through hydrologic modeling. Wetlands W01, W04 and W08 have a footprint of less than 0.1 ha and do not show any standing water on available aerial photos. Wetlands W03 (a man-made dugout), W02 and W09 have a footprint of less than 0.5 ha. These wetlands show a small wetted area on only two aerial photos (1974 and 1996), however the depth and extent of the wetted area are too small for model calibration. There are no identifiable overland drainage connections between these wetlands. The wetlands appear to act as disconnected localized depressions that receive some runoff after a major precipitation event. The runoff collected in these wetlands infiltrates or evaporates. The wetlands are heavily impacted by grazing, and unlikely to be retained post-development.

- One Class III wetland, W32, is identified within the flood fringe area at the west project boundary. The wetland is located within a heavily disturbed area, a site of former gravel excavation operation. Although identified as Class III, with a delineated surface area of 1.48 hectares, the wetland does not show any standing water or appreciable wet area in any of the aerial photos used in the assessment and could not be analysed through hydrologic modeling. As shown on **Figure 8**, this wetland may receive some overflow from the slope wetlands and ephemeral drainages on the escarpment. If the flood fringe area is developed, the wetland would likely be removed since a number of adaptive mitigation strategies would need to be implemented in the flood fringe. If the area is preserved in its natural condition, the development on the plateau is unlikely to have a significant impact on the hydrology of this wetland.
- A total of 14 Class III slope wetlands were identified along the escarpment, where seepage and groundwater discharge contribute to wetland water sources. These wetlands receive some runoff from the plateau, and the ephemeral drainages identified along the escarpment. Because of their location on the protected escarpment, the slope wetlands will not be directly impacted by the development. However, the development on the plateau may reduce the groundwater inputs to the wetlands, as well as reduce the contributing surface water catchment. The potential reduction of the wetlands' catchment area is shown on **Figure 9**.
- A large pond A03 (**Figure 9**) is an artificial water body that was constructed and used during active gravel mining operations. Prior to 2013, A03 was isolated from the Bow River; however, the 2013 flood created a new fluvial channel connecting the pond to the Bow River. The fluvial channel and the pond will be subject to development setbacks and will not be directly impacted by the development.

3.5 Drainages and Streams

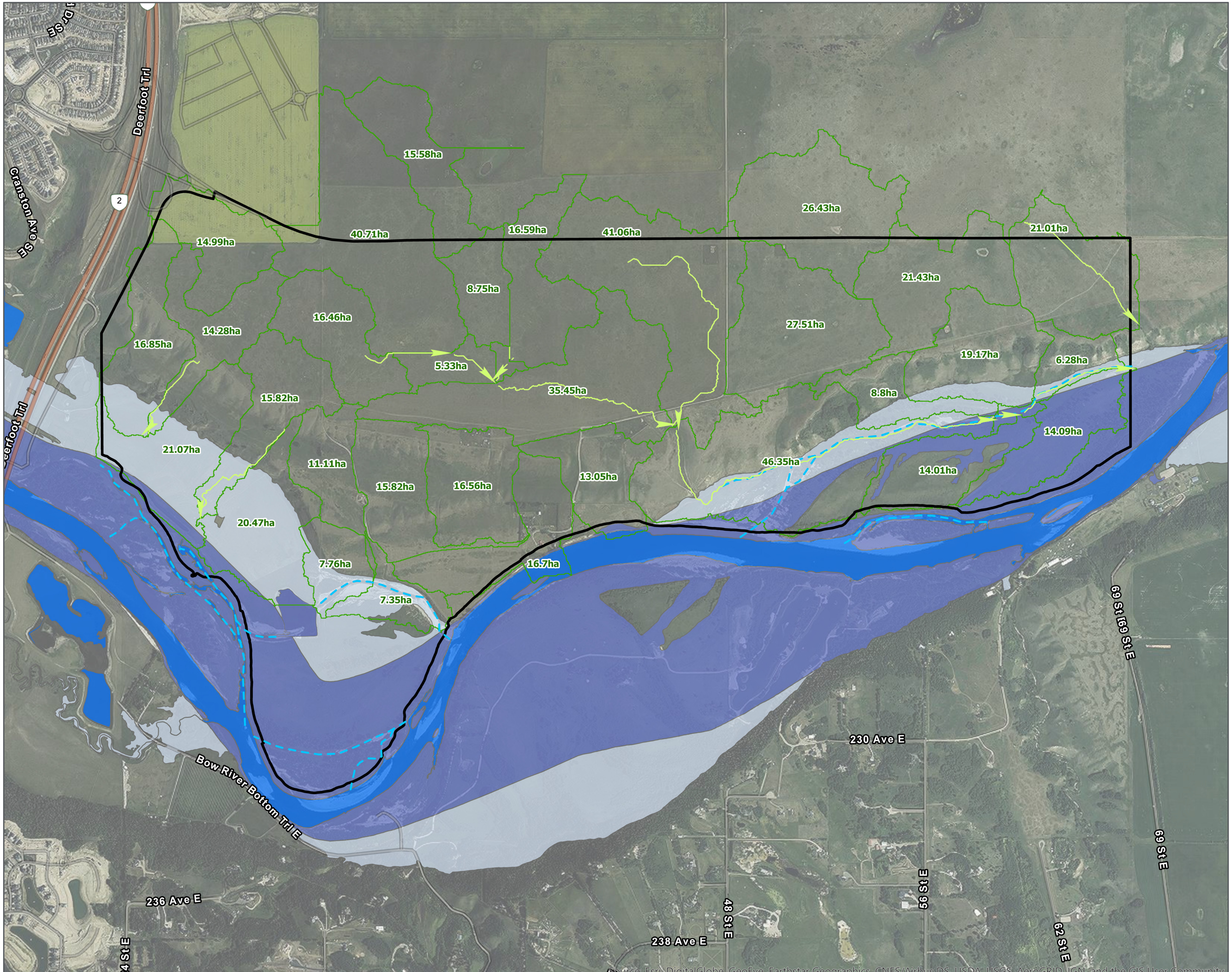
The Ecological Inventory Report (Stantec, 2018) identifies a total of fifty-six (56) ephemeral drainages and one (1) intermittent stream within the Ricardo Ranch ASP area (**Figure 7**). As stated in the report, ephemeral drainages do not have a well-defined channel and are usually situated within a topographically low area or between two topographically high points. Water found in an ephemeral drainage typically only flows during or immediately following a large precipitation event or during snowmelt. Some ephemeral drainages are associated with slope wetlands and receive some groundwater inputs. From a hydrologic perspective, the ephemeral drainages do not appear to be significant flow conveyances.

Five (5) ephemeral drainages, identified as more significant in the ArcHydro analysis, are modeled using PCSWMM. These are labeled as D1 to D5 on **Figure 10.** The resulting Flow-Duration curves are presented on **Figure 11**. The very low probability of exceedance (less than 1%) indicates that modeled ephemeral drainages will only experience flow during occasional storm events. The model results show that each of the drainages (D1 to D5) will experience intermittent overland flow, with no flow during smaller storms. The maximum peak flows for the smaller drainages (D2 to D5), are estimated at 0.3 – 1.0 m^3/s. The larger drainage, D1, has a maximum peak flow in continuous simulation of 5.2 m^3/s.

One intermittent stream was identified within the study area, as shown on **Figure 7** and **Figure 10**. Typically, an intermittent stream will have some flowing water during spring runoff and after a major precipitation event. The stream flows were modeled using PCSWMM, and the Flow-Duration curves are shown on **Figure 11**. The intermittent stream has a significant maximum peak flow, estimated at 6.9 m^3/s in the model, although it exhibits the same intermittent nature as the smaller drainages.

Land development on the plateau will significantly reduce the surface catchment areas to the modeled drainages and the intermittent stream, resulting in less frequent flow occurrences and much lower peaks. This will limit the potential for erosion and escarpment slope failure. Once the plateau is developed, replicating pre-development flow regime in the drainages and the intermittent stream is not possible or advisable, as it can potentially destabilize the steep slopes.

Several fluvial channels associated with the historical meandering of the Bow River are present in the river valley and are shown on **Figure 7**. Fluvial channels are hydrologically connected to the main river channel, particularly during significant precipitation events and during times of high-water levels in the river. The channels are within development setback areas and their connection to the river flows ensures that they will not be impacted by development.



Ricardo Ranch Landowners Group

Ricardo Ranch MDP

Catchment Areas and Major Drainage Connections

Legend

- Fluvial Channel
- Major Drainage Paths
- Catchments
- Flood Fringe
- Floodway
- Normal River Channel
- Study Area

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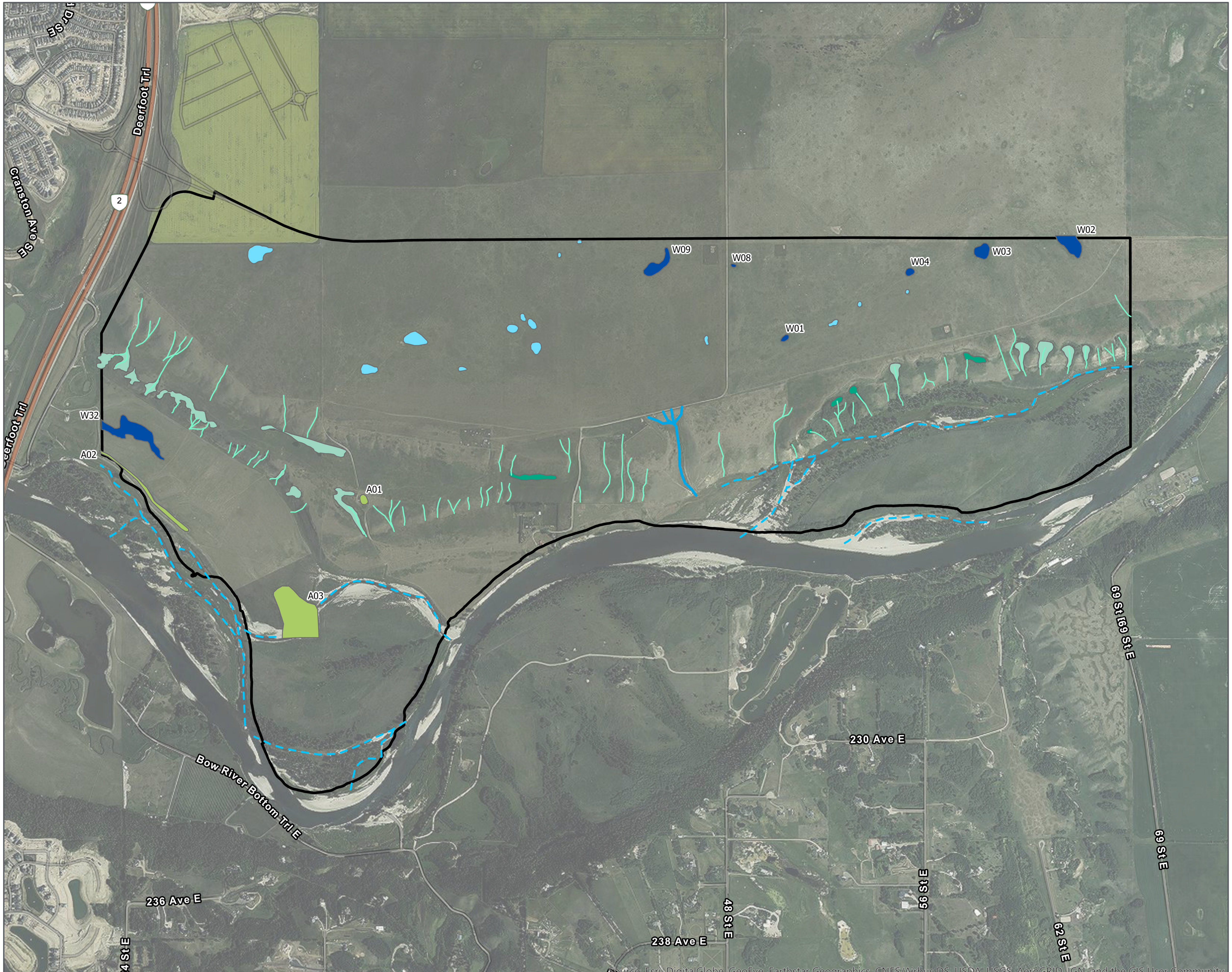
FIGURE 6



Ricardo Ranch Landowners Group

Ricardo Ranch MDP

Wetlands and Drainages

Legend

- Fluvial Channel
- Ephemeral Drainage
- Intermittent Stream
- Artificial Pond
- Class II Wetland
- Class III Wetland
- Class II Slope Wetland
- Class III Slope Wetland
- Study Area

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Meters

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FIGURE 7

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U:\Projects_CAL\2197\0009\22\D-Design\GIS\Projects\Pro_Projects\RicardoRanch\RicardoRanch_MDP_2010719.aprx\Fig 07 - Ricardo Ranch MDP - Wetlands & Drainages - 20190719

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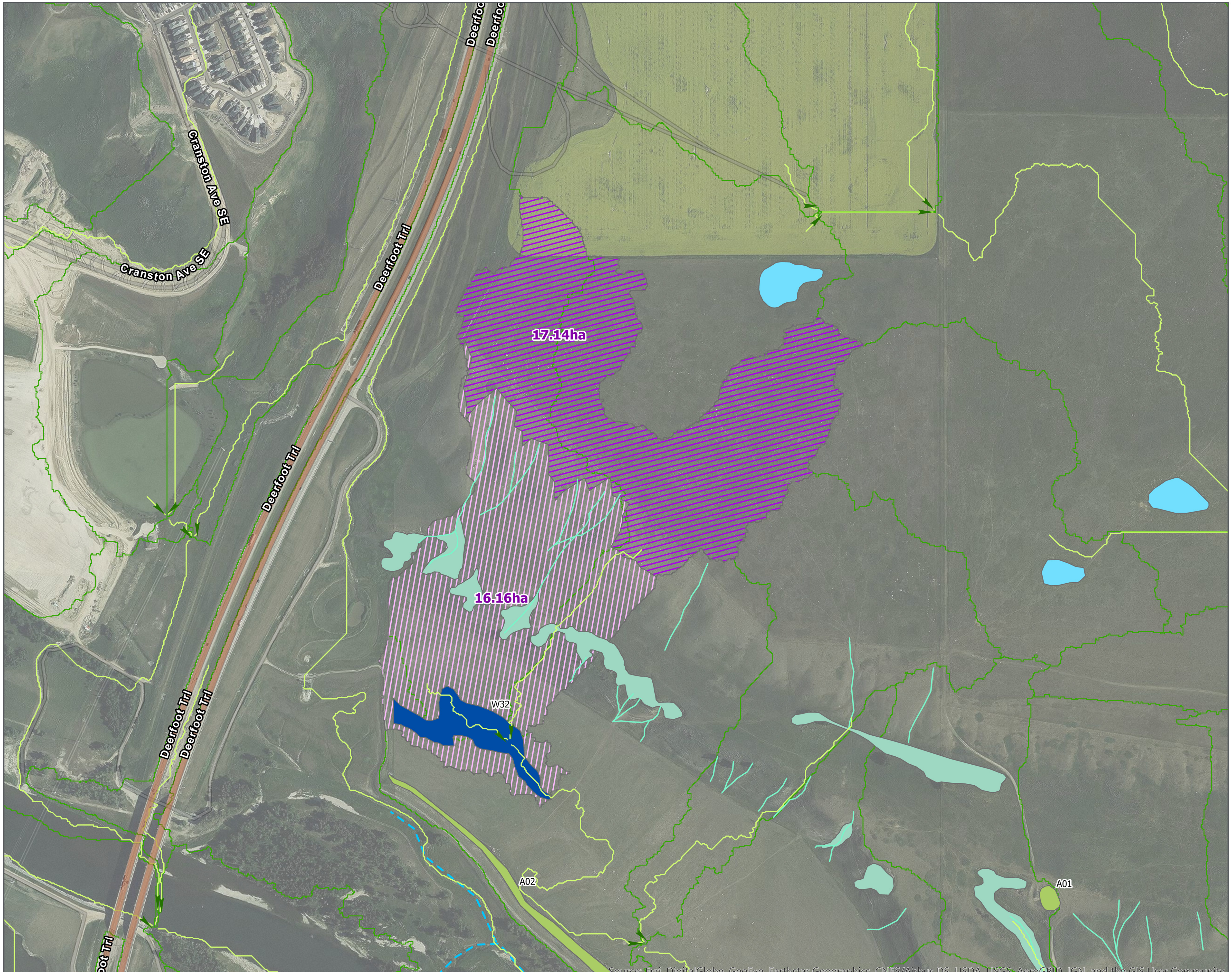
U:\Projects_CAL\2197\0009\22\D-Design\GIS\Projects\Pro_Projects\RicardoRanch_MDP_2010719.aprx\Fig 08 - Ricardo Ranch MDP - Catchment to W32 - 20190719



Ricardo Ranch Landowners Group

Ricardo Ranch MDP

Contributing Catchment to W32

Legend

- Fluvial Channel
- Ephemeral Drainage
- Intermittent Drainage
- Artificial Pond
- Class II Wetland
- Class III Wetland
- Class II Slope Wetland
- Class III Slope Wetland

Gravel Pond Catchment

- Plateau
- Escarpment & Flood Fringe

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0 100 200 300
Meters

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Coordinate System: NAD 1983 3TM 114

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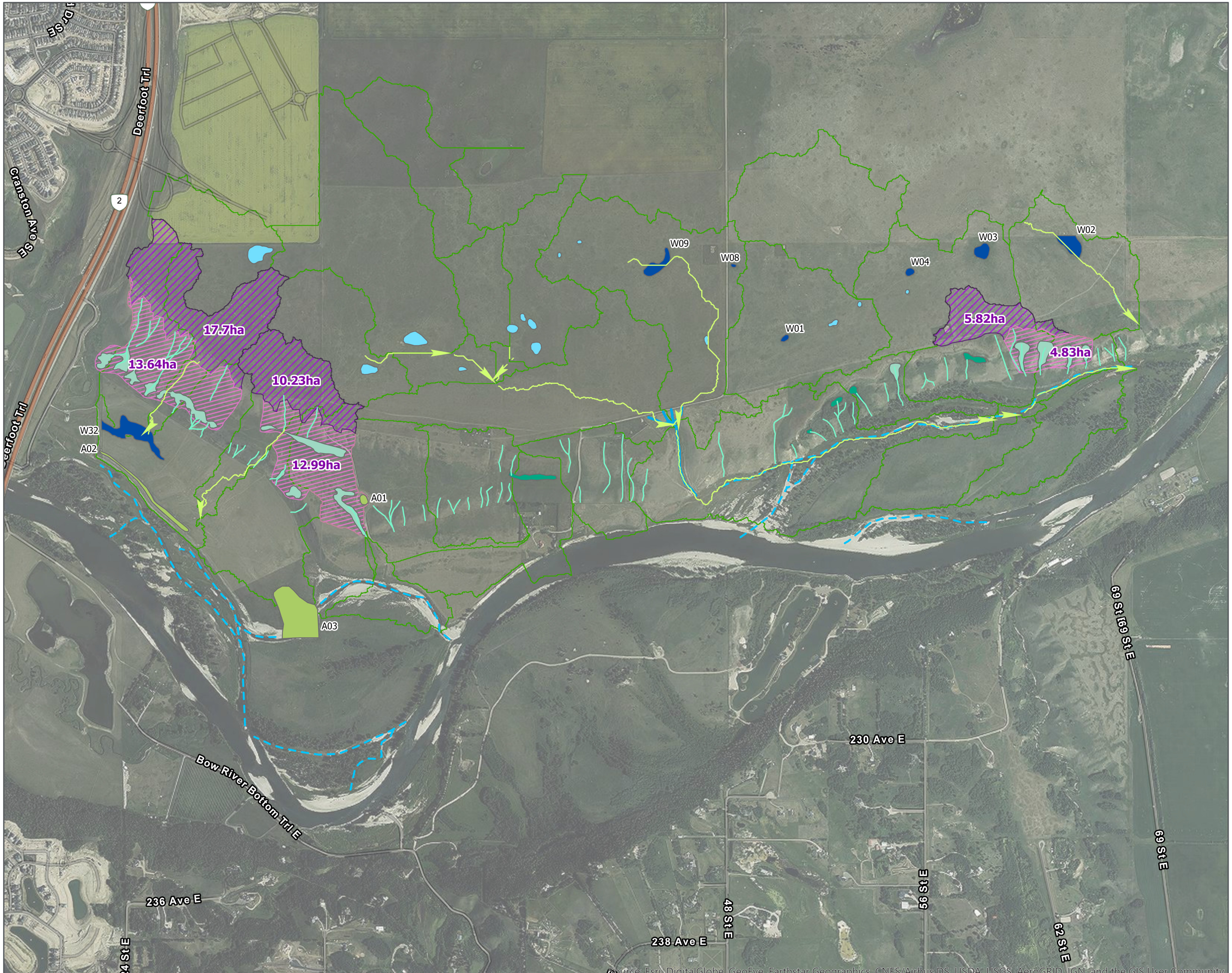
FIGURE 8



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U:\Projects_CAL\2197\0009\22\D-Design\GIS\Projects\Pro_Projects\RicardoRanch_MDP_2010719.aprx\Fig 09 - Ricardo Ranch MDP - Catchment to Class III Slope Wetlands - 20190719

Ricardo Ranch Landowners Group

Ricardo Ranch MDP

Contributing Catchments to Class III Slope Wetlands

Legend

- Major Drainage Paths
- Fluvial Channel
- Ephemeral Drainage
- Intermittent Stream
- Artificial Pond
- Class II Wetland
- Class III Wetland
- Class II Slope Wetland
- Class III Slope Wetland

Class III Slope Wetland Catchments

- Plateau
- Escarpment

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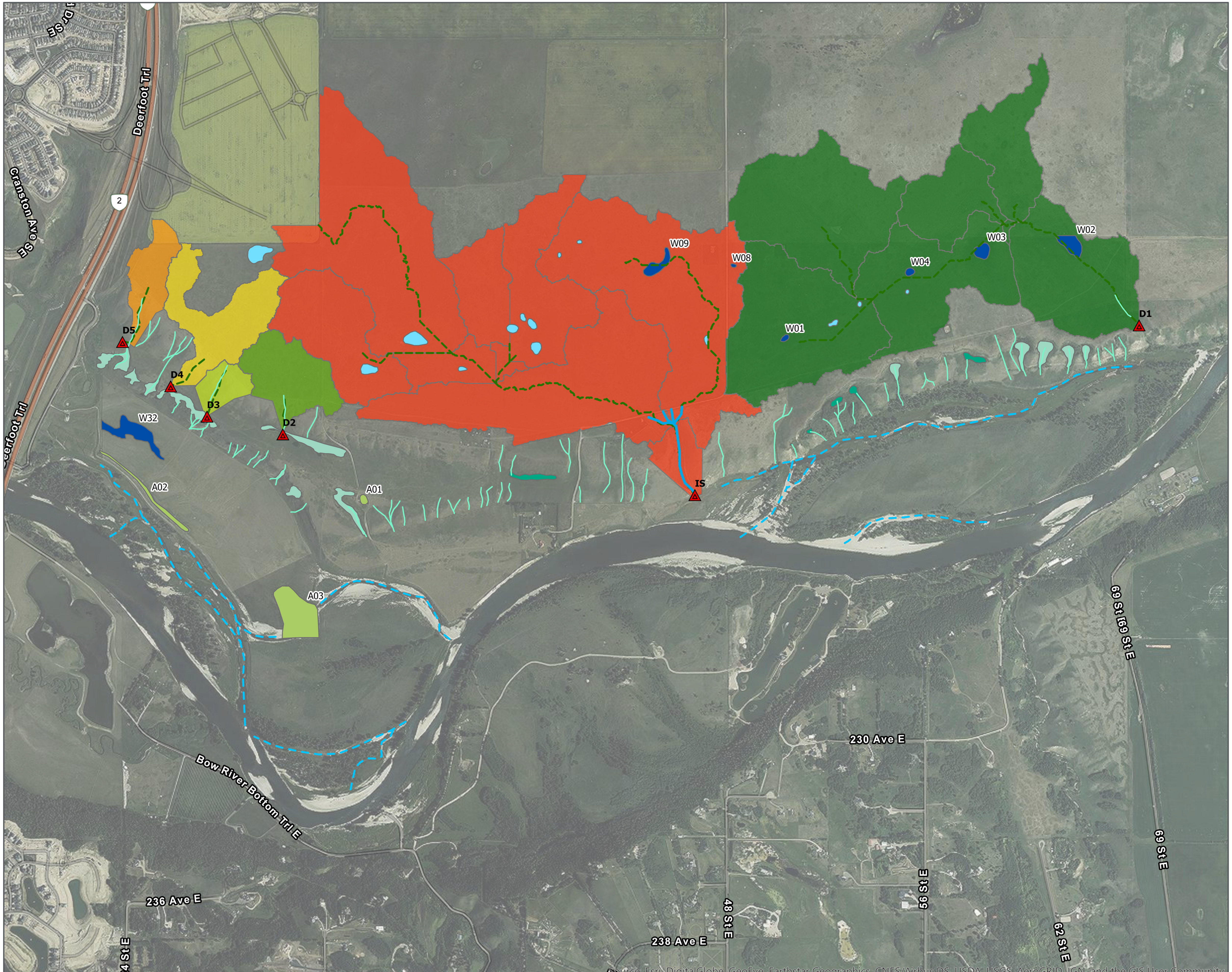
FIGURE 9



Ricardo Ranch Landowners Group

Ricardo Ranch MDP

Modelled Drainage Areas

Legend

- Outfalls
- Flow Paths
- Fluvial Channel
- Ephemeral Drainage
- Intermittent Stream
- Artificial Pond
- Class II Wetland
- Class III Wetland
- Class II Slope Wetland
- Class III Slope Wetland

Catchments

- D1
- D2
- D3
- D4
- D5
- IS

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0 100 200 300 Meters

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FIGURE 10

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U:\Projects_CAL\2197\0009\22\D-Design\GIS\Projects\RicardoRanch_MDP_2010719.aprx\Fig 10 - Ricardo Ranch MDP - Modelled Drainage Areas - 20190719

Ricardo Ranch Landowners Group

Ricardo Ranch MDP

Flow-Duration Curves For Modelled Drainage Features

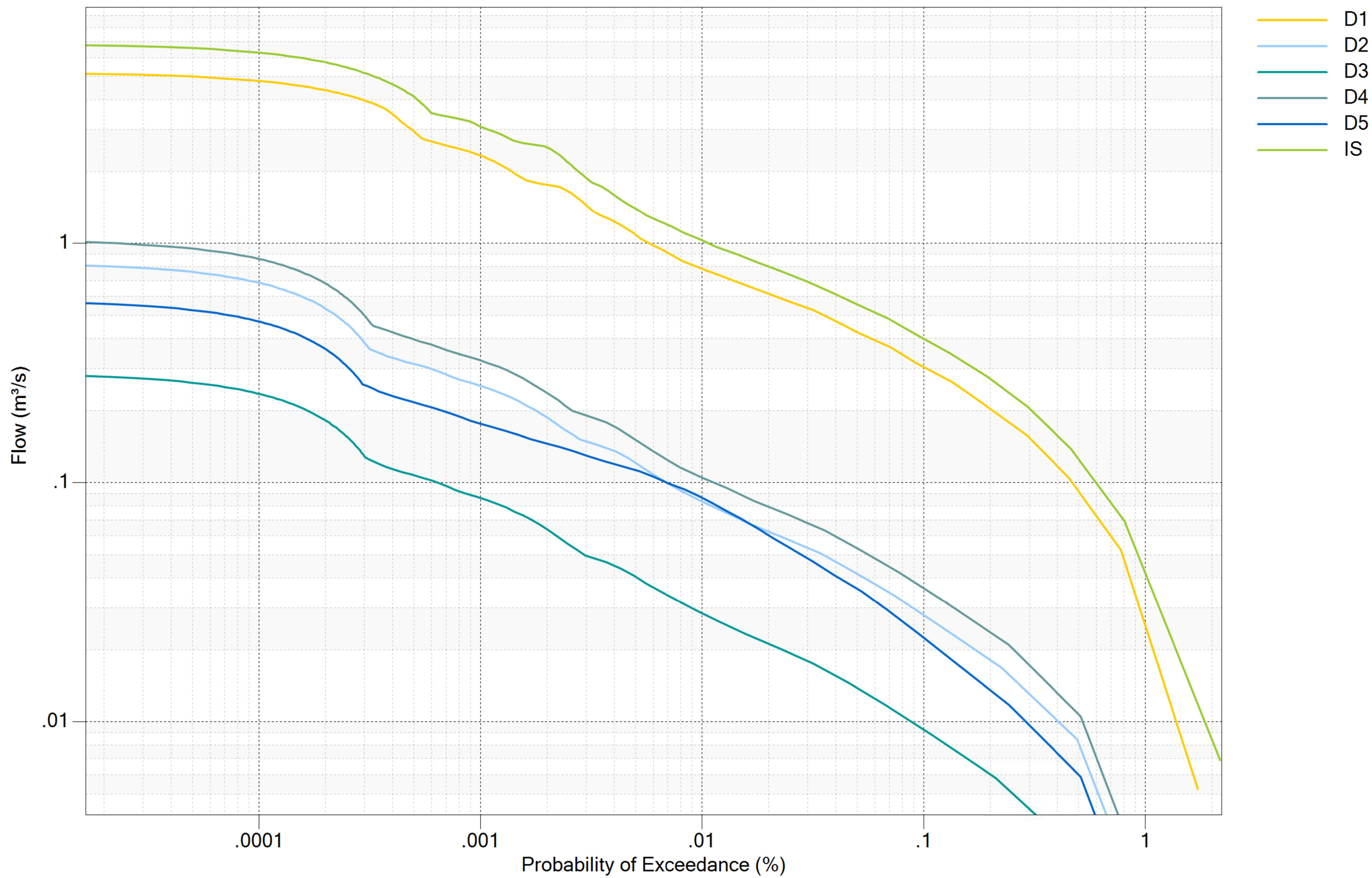

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FIGURE 11

4.0 POST-DEVELOPMENT ASSESSMENT

4.1 Stormwater Servicing Concept

4.1.1 Wetlands and Drainages

As discussed in **Section 3**, the wetlands on the plateau are disconnected localized depressions with small catchment areas and negligible storage potential. The runoff that reaches the wetlands after a major precipitation event generally infiltrates and evaporates. The wetlands show significant impacts due to grazing and agricultural practices and are unlikely to be retained post-development. For the purpose of the MDP-level stormwater analysis, these wetlands were assumed to be removed in post-development scenarios.

The Class III wetland (W32) in the flood fringe is also located within a highly disturbed area that used to be a gravel mining site. This wetland was assumed to be removed if development occurs in the flood fringe.

The Class III slope wetlands will remain undisturbed by land development since they are located within a protected escarpment area. This is reflected in the post-development model.

Land development on the plateau will significantly reduce the surface catchment areas to the modeled drainages and the intermittent stream, resulting in less frequent flow occurrences and much lower peaks. This will limit the potential for erosion and escarpment slope failure. Discharge of post-development flows to these drainages to mimic the pre-development hydrology is not recommended and was not considered in the post-development analysis, since this practice can impact the stability of steep slopes.

4.1.2 Bow River Flood Fringe

The City is currently working on the Ricardo Ranch Flood Fringe Study, a watershed analysis and planning project intended to develop alternative future land use scenarios and recommend the best and highest use for flood fringe lands. The decision framework will consider development value, environmental and social value, public safety, flood resilience and future climate change impacts.

Since the study timing lags the ASP development, its outcome is not intended to inform the MDP-level decision making process, but to help bridge the gap between the ASP and the subsequent Outline Plans for flood fringe lands. Therefore, certain conservative assumptions were made for the stormwater analysis of subject lands within this MDP:

- All the flood fringe lands, outside of setbacks related to known development constraints (**Figure 4**), are assumed to be flood-proofed and developable.
- The development type was assumed to be residential.

- The pond parameters (location, configuration, facility type) were chosen based on maximizing the development potential within flood fringe lands.

These assumptions are deemed appropriate at the MDP stage of stormwater planning. Depending on the outcome of the flood fringe study, any revisions to the stormwater concept can be addressed at the Outline Plan/SMDP stage.

4.1.3 Off-site flows

No off-site overland flows or uncontrolled minor system flows enter the Ricardo Ranch study area in the post-development situation. The flows within Deerfoot Trail ROW, west of the study boundary, are contained within the Deerfoot Trail storm system. Overland flows within Rangeview development, north of 210th Avenue, are also fully contained. The pre-development drainage direction is generally south-southeast, and pre-development flows east of the 88th Street ROW do not enter the study area.

4.1.4 Post-development Catchments and Stormwater Facilities

Post-development catchment boundaries and the location of proposed stormwater facilities are shown on **Figure 12.** The catchment boundaries are based on the best information available at the time of the MDP development and may be adjusted in future development applications. In addition to topography and land use, land ownership and likely development timing were considered in the catchment boundary delineation and the development of stormwater servicing concepts.

For the MDP level analysis, the facilities on the plateau are modelled as wet ponds, however they can also be constructed wetlands or pond/wetland hybrid systems. One dry pond option was also considered, and it is further described in the section below. The facility in the flood fringe was assumed to be a constructed wetland. The facilities' type and footprint are preliminary at the MDP stage and will be confirmed at the Outline Plan/SMDP stage.

Modelling results and preliminary pond sizing is summarized in **Section 4.2.**

4.1.4.1 Ricardo Ranch EXT

This catchment area comprises 34 hectares of future residential development. It will be serviced by Seton Pond E, which is located south of the 210th Avenue Right-of-Way and is currently under construction. Detailed description of Pond E design and operation is included in the *Seton Pond E - Pond Report* (Urban Systems, 2019), which is approved by the City of Calgary. No further analysis for Ricardo Ranch EXT catchment or Seton Pond E is included in this MDP report.

4.1.4.2 Ricardo Ranch 1

The Ricardo Ranch 1 catchment area includes approximately 73 hectares on the upper plateau, comprised of primarily single-family residential development, with two future school sites and a neighborhood activity center (NAC). One stormwater facility is proposed for servicing of this catchment. The facility will discharge to the future developer-funded stormwater trunk in the 56th Street ROW.

Two options were considered for the facility type, summarized in **Table 4.1** below.

Table 4.1 - SWMF Options for Ricardo Ranch 1 Catchment

Facility Type	Description
Wet pond	• Release rate is 2.78 L/s/ha • Located within PUL • Runoff treatment by an Oil/Grit Separator and release to 'clean' storm trunk • Provides runoff volume storage for the 100-year event
Dry pond	• Release rate is 15 L/s/ha • Located within MR/MSR site • Runoff treatment by an Oil/Grit Separator and release to 'dirty' storm trunk • Provides runoff flow attenuation. Runoff volume storage is provided by the downstream (Ricardo Ranch 4) facility

For the dry pond option, most of the contributing runoff volume is transferred to the downstream stormwater management facility in Ricardo Ranch 4 catchment. This option should only be considered if, as an outcome of the Ricardo Ranch Flood Fringe Study, large area within the flood fringe remains undeveloped and can be used for stormwater management purposes. By transferring the runoff storage requirement to the undeveloped portion of the flood fringe and using MR/MSR areas for flow attenuation, the development potential of the land on the plateau is significantly increased. However, higher flow rates will result in a larger storm trunk diameter and higher construction cost.

Table 4.2 - Ricardo Ranch 1 SWMF- Wet Pond Option - Depth-Area-Volume-Discharge

Depth (m)	Area (m^2)	Total Storage Volume (m^3)	Active Storage Volume (m^3)	Discharge (L/s)	
0.00	9,077	0	-	-	Bottom
2.50	15,275	30,911	-	0	PWL
3.00	16,800	38,927	8,016	89.3	
3.50	18,375	47,718	16,807	137.1	
4.00	20,000	57,309	26,397	172.1	
4.50	21,675	67,725	36,813	201.1	HWL
4.80	22,497	74,350	-	-	Freeboard

Table 4.3 - Ricardo Ranch 1 SWMF- Dry Pond Option - Depth-Area-Volume-Discharge

Depth (m)	Area (m^2)	Total Storage Volume (m^3)	Active Storage Volume (m^3)	Discharge (L/s)	
0	5,504	0	0	732.0	Bottom
0.30	11,534	2,501	2,501	816.9	
0.50	12,000	4,854	4,854	869.0	
1.00	13,200	11,151	11,151	987.2	
1.25	13,819	14,528	14,528	1041.3	
1.50	14,450	18,062	18,062	1092.7	HWL
1.80	15,068	22,489	-	-	Freeboard

4.1.4.3 Ricardo Ranch 2

This catchment, with a total area of approximately 114 hectares on the upper plateau, will be serviced by one wet pond. The preliminary pond location was determined based on topography and known road alignments. The pond will discharge to the future Rangeview storm trunk in the 72nd Street SE.

Table 4.4 – Ricardo Ranch 2 SWMF Depth-Area-Volume-Discharge

Depth (m)	Area (m^2)	Total Storage Volume (m^3)	Active Storage Volume (m^3)	Discharge (L/s)	
0.00	17,092	0	-	-	Bottom
2.50	25,075	53,377	0	0	PWL
3.00	27,000	66,393	13,016	134.8	
3.50	28,975	80,384	27,007	212.9	
4.00	31,000	95,375	41,998	269.3	
4.50	33,075	111,391	58,013	315.7	HWL
4.80	34,089	121,465	-	-	Freeboard

4.1.4.4 Ricardo Ranch 3

The Ricardo Ranch 3 catchment encompasses 31 hectares in the north east corner of the study area. One wet pond is planned for this area, however due to a small contributing catchment the facility does not meet the minimum size requirement of 2 ha, stipulated in the City of Calgary and provincial stormwater guidelines. At future planning stages, an option of a shared stormwater facility servicing both Ricardo Ranch 3 and Westcreek catchment in Rangeview should be investigated. The facility will discharge to the future 210th Avenue storm trunk, which is a lateral extension of the Rangeview storm trunk.

Table 4.5 – Ricardo Ranch 3 SWMF - Depth-Area-Volume-Discharge

Depth (m)	Area (m²)	Total Storage Volume (m³)	Active Storage Volume (m³)	Discharge (L/s)	
0.00	2,006	0	-	-	Bottom
2.50	5,763	9,904	0	0	PWL
3.00	6,741	13,027	3,123	39.6	
3.50	7,770	16,651	6,748	58.8	
4.00	8,848	20,803	10,899	73.1	
4.50	9,976	25,506	15,602	85.1	HWL
4.80	10,536	28,583	-	-	Freeboard

4.1.4.5 Ricardo Ranch 4

The Ricardo Ranch 4 catchment includes the escarpment with steep slopes, a narrow mid-slope bench within the escarpment, and the flood fringe of the Bow River. The total area included in the analysis is 121 hectares, of which approximately 38 hectares were considered undevelopable due to steep slopes. The future development is assumed to be primarily low-density residential.

The flood fringe is considered developable if the development is flood proofed. Flood-proofing strategies include raising site grades to safe levels and riverbank armouring. The site grades and the amount of fill required for flood-proofing will be determined based on the following specific requirements that are above the standard requirements outlined in the City of Calgary's Land Use Bylaw:

- A minimum of 1 meter of additional freeboard above the 1:200 flood level is required to be incorporated in the building, street and community design.
- The stormwater management facility must be designed with adequate storage to fully contain the 1:100-year storm while the river is at the 1:100-year flood level. No overflow from the facility is permitted under these conditions.

The catchment is proposed to be serviced by a constructed wetland with 0.5 m of dead storage and 2 m of active storage depth. The facility will discharge to the future 56th Street storm trunk and new outfall to the Bow River. As per the City of Calgary guidelines, outfalls should have invert elevations above the 1:5-year flood level of the receiving stream.

The location of the facility will be largely influenced by the outcomes of the Ricardo Ranch Flood Fringe Study. On **Figure 12**, the wetland is shown just outside of the 200-year meander belt, as requested by Water Resources. For the purposes of pond sizing, it was conservatively assumed that the flood fringe would be developed to the full extent and the pond would be placed within the meander belt. Construction of the wetland inside the meander belt would maximize development potential of the flood fringe lands, however bank armoring and raising site grades within the meander belt may require further study of potential impacts on the river channel. The final decision on the pond location should be made at the Outline Plan/SMDP stage.

The requirement to fully contain the 1:100-year storm in the facility while the river is at 1:100 flood elevation was used as a design basis to set the operating levels and bottom elevation for the facility. Further analysis and discussion on the interaction of river levels and pond elevations is provided in **Section 5.1.4. Tables 4.6 and 4.7** below show the stage-storage-discharge curves for the Ricardo Ranch 4 facility, assuming a free outlet. The analysis presented in **Section 5** explores different pond bottom elevations but does not change the facility's stage-storage relationship. Therefore, **Table 4.6** presenting the Ricardo Ranch 4 facility configuration for the wet pond option in Ricardo Ranch 1 catchment is also valid for all scenarios analyzed in **Section 5.**

Table 4.6 – Ricardo Ranch 4 SWMF - Depth-Area-Volume-Discharge (RR1 Wet Pond)

Depth (m)	Area (m^2)	Total Storage Volume (m^3)	Active Storage Volume (m^3)	Discharge (L/s)	
0.00	5,013	0	-	-	Bottom
0.50	6,916	2,974	0	0	PWL
1.00	22,458	12,039	9,065	142.7	
1.50	23,356	23,719	20,745	226.6	
2.00	26,125	36,315	33,341	286.9	
2.50	28,033	49,855	46,881	336.5	HWL
2.80	28,967	58,405	-		Freeboard

Table 4.7 shows the facility's characteristics should a dry pond option be implemented for servicing of Ricardo Ranch 1 catchment. In this scenario, the 56th Storm Trunk will first discharge into Ricardo Ranch 4 facility before release into the Bow River.

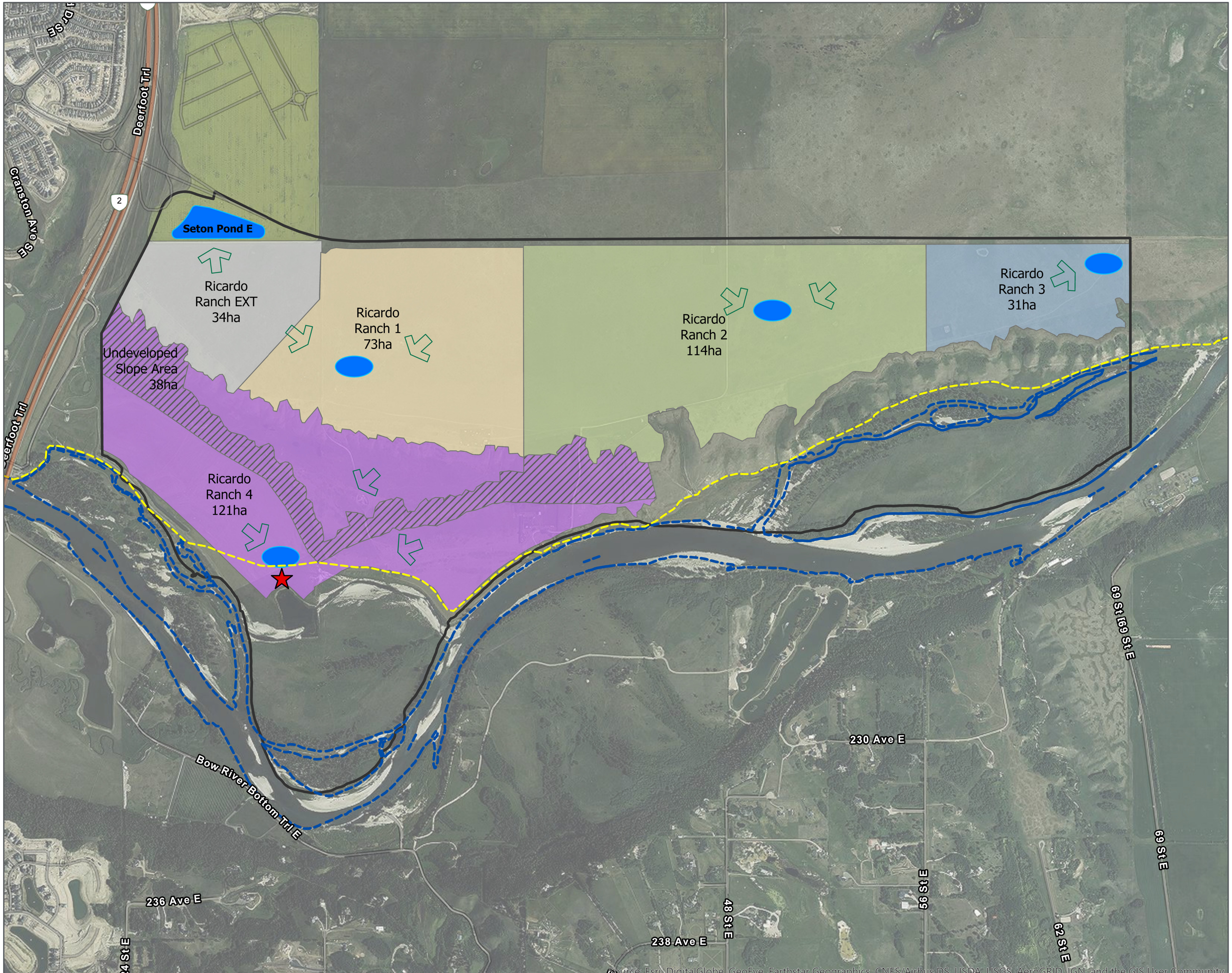
Table 4.7 - Ricardo Ranch 4 SWMF - Depth-Area-Volume-Discharge (RR1 Dry Pond)

Depth (m)	Area (m^2)	Total Storage Volume (m^3)	Active Storage Volume (m^3)	Discharge (L/s)	
0	9,238	0	-	-	Bottom
0.5	11,719	5,231	0	0	PWL
1.0	37,333	20,412	15,181	214.8	
1.5	39,642	39,654	34,423	357.6	
2.0	42,000	60,063	54,832	457.9	
2.5	44,408	81,665	76,434	539.9	HWL
2.8	45,582	95,164	-	-	Freeboard

4.1.5 Emergency Escape Routes

The general direction of the emergency escape routes for the stormwater management facilities in Ricardo Ranch is shown in **Figure 13**. The arrows indicate potential overland or piped directions of emergency spill flow, based on the existing topographic information. More precise directions should be determined at the Staged Master Drainage Plan and/or Detailed Pond Report stages, when development grading information becomes available.

The emergency escape routes should be properly planned to ensure safe conveyance to the Bow River, whether it be a piped or overland escape route. A consideration should also be made for the emergency escape routes from Rangeview development, which continue through Ricardo Ranch area to the Bow River. Design of emergency spill routes and elevations should follow the *2011 City of Calgary Stormwater Management and Design Manual*, so that impacts are minimized to downstream developments.



Ricardo Ranch Landowners Group

Ricardo Ranch MDP

Post Development Stormwater Management Concept

Legend

- 200 Year Meander Belt
- Normal River Channel
- Study Area
- Ricardo Ranch 1
- Ricardo Ranch 2
- Ricardo Ranch 3
- Ricardo Ranch 4
- Ricardo Ranch EXT
- Undeveloped Slope Area
- Drainage Direction

★ Location of Ricardo Ranch 4 stormwater facility may be considered within the 200 year meander line. Subject to further design and analysis at the outline plan/SMDP stage.

0 100 200 300
Meters

N

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FIGURE 12

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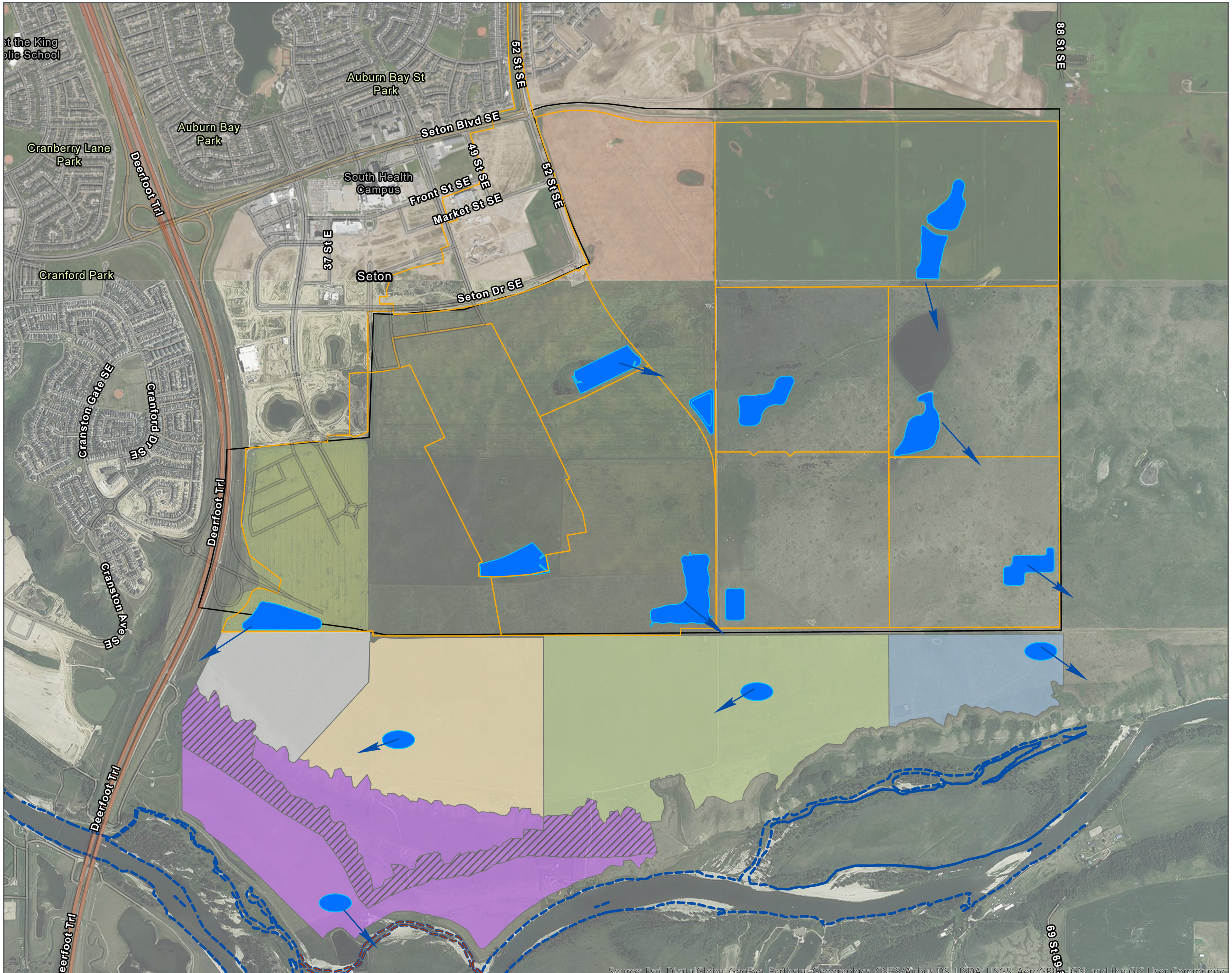
U:\Projects_CAL\2197\0009\22\D-Design\GIS\Projects\Pro_Projects\RicardoRanch_MDP_2010719.aprx\Fig 12 - Ricardo Ranch MDP - Post Development Storm Mgmt - 20190719



Ricardo Ranch Landowners Group

Ricardo Ranch MDP

Emergency Spill Routes

Legend

- Emergency Spill Routes
- Avulsed Channel
- Normal River Channel
- Ponds
- Post Development Catchments
- Rangeview
- Ricardo Ranch 1
- Ricardo Ranch 2
- Ricardo Ranch 3
- Ricardo Ranch 4
- Ricardo Ranch EXT
- Undeveloped Slope Area

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Meters

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FIGURE 13

4.2 Post-development Analysis Framework

4.2.1 Methodology

A post-development hydrologic analysis of the study area was conducted to support the proposed development of the area. The objective of the analysis was to confirm that the key stormwater management targets can be met through the land development process. Based on the results of the pre-development analysis, the maximum release rate is set at 2.78 L/s/ha for the 1:100-year storm event. As there is currently no mandatory runoff volume target for the Bow River, post-development hydrologic analysis did not consider average annual runoff volume as a stormwater management target.

Analysis of storage volumes for the planned storage facilities was carried out using the latest version of PCSWMM software:

PCSWMM Professional 2D, version 7.2.2780
Graphical Interface for EPASWWM version 5.1.013

Both the 24-hour 1:100-year single event and continuous simulation were performed. The single extreme event analysis uses the 1:100-year Chicago design storm event. The design event is based on the criteria established in the 2011 City of Calgary Stormwater Management and Design Manual. The results of the simulation provide the user with a single storage volume required to contain runoff (i.e. below pond HWL) from a 1:100-year theoretical rainfall event.

The City of Calgary precipitation and temperature dataset for the 55-year period (1960 through 2014) were used for modelling. In the simulations, the model continuously updates results for the overall water balance and its constituent processes such as precipitation, infiltration, and evapotranspiration. The simulation provides the user with maximum pond volumes in each of the years of record, 1960 through 2014. The results from the continuous simulation were further analyzed using the City of Calgary's Data and Frequency Analysis Spreadsheet (DFASCC) to determine the statistical 1:100-year storage volume.

Results from the single event simulation, continuous event simulation, and statistical 1:100-year event are then compared to determine the highest value that governs the storage volume requirements for the proposed storage facilities. Results are presented in the following section.

4.2.2 PCSWMM Model Parameters

Stormwater runoff calculation parameters used for this study area are based on known conditions at the site and are consistent with City of Calgary guidelines.

A summary of the common input parameters used in each model are:

- Green-Ampt Infiltration parameters based on the geotechnical studies completed for the development area. Parameters are summarized in **Table 4.8.**

- Abstraction Loss Parameters:
    - Pervious Surfaces = 3.2 mm
    - Impervious Surfaces = 1.6 mm
- Manning 'n' Values:
    - Pervious Areas = 0.25
    - Impervious Areas = 0.015

Table 4.8 - Green-Ampt Infiltration Parameters

Parameter	Value
Suction Head (mm)	208
Conductivity (mm/hr)	4.3
Initial Deficit	0.24

The post-development layout plan shown on **Figure 12** was used as the basis for model development. **Table 4.9** presents the post-development catchment areas, imperviousness percentages and release rates utilized for stormwater modeling.

Table 4.9 – Post-Development Catchments

Catchment ID	Total Area (ha)	Total Imperviousness (%)	Allowable Release Rate (L/s)
Ricardo Ranch 1	73	67	202
Ricardo Ranch 2	114	67	317
Ricardo Ranch 3	31	67	85
Ricardo Ranch 4	121	41	336

4.2.3 Model Results

The storage volume results are summarized in **Table 4.10** below.

Table 4.10 - Modelled Runoff Storage Volumes

SWMF	Active Storage Volume (m^3)	Single Event Storage Volume (m^3)	Continuous Event Storage Volume (m^3)	Statistical 100-year Storage Volume (m^3)
Ricardo Ranch 1 WP	36,813	29,014	**35,681**	34,389
Ricardo Ranch 2	58,013	45,532	**55,933**	53,623
Ricardo Ranch 3	15,602	12,169	**15,025**	14,496
Ricardo Ranch 4[1]	46,881	34,904	45,921	**46,326**
Ricardo Ranch 1 DP	18,062	17,432	-	-
Ricardo Ranch 4[2]	76,434	54,298	**75,248**	72,769

1) Ricardo Ranch 1 wet pond option
2) Ricardo Ranch 1 dry pond option

The dry pond option in Ricardo Ranch 1 catchment was sized based on a single event method only. Because the release rate is high (15 L/s/ha), and the pond emptying time is approximately 7 hours, this approach was considered adequate. Over the 55-year simulation period, the frequency of inundation for the dry pond can be summarized as follows:

- Ponding depth was above 1 m only once over the simulation period
- Ponding above 0.5 m occurred 14 times
- Ponding over 0.3 m occurred 25 times

This frequency of inundation was deemed acceptable for the pond location in MR/MSR area.

The storage volume requirements for the facility in the flood fringe (Ricardo Ranch 4) were estimated based on free outlet conditions. The interaction between the facility and the river levels is further analysed in **Section 5**.

5.0 CLIMATE CHANGE ASSESSMENT

5.1.1 Approach

The climate change assessment for Ricardo Ranch ASP area includes an analysis of both the stormwater system performance and the interaction between the stormwater system and the Bow River during future climate change scenarios. Therefore, there are two different climate change trends that were considered – increasing peak flows in the river and increasing intensity of design storms. A thorough study of these trends is outside the scope of this report, but potential magnitudes have been provided by the City of Calgary for use in this analysis and are provided in **Section 5.1.2**.

Different combinations of these trends have been modelled in the post-development scenario to assess the expected future level of service of the Ricardo Ranch stormwater management facilities. Because this is an exploratory analysis, the ponds have not been oversized to handle a specific climate change scenario. Rather, the ponds are sized based on the current 100-year level of service, and the output is the resulting level of service under climate change scenarios. This will help to inform discussions about how to incorporate climate change impacts into future design guidelines.

5.1.2 Climate Change Data and Assumptions

Based on preliminary analyses that have been conducted by the City of Calgary Water Resources department, the future 1:100 water level in the Bow River, considering climate change, is expected to be similar to the current 1:200-year level. Therefore, the 1:200-year levels from the *Bow River and Elbow River – Hydraulic Model and Flood Inundation Mapping Update* (Golder Associates, 2015) were used as a proxy for this climate change analysis.

Based on the most likely location for a pond outlet, river levels at Station 319 in the Golder report (**Figure 14**) were used as the backflow condition and considered valid, since this is the best available information at the time of assessment. As a cautionary note, the analysis of the river presented in the Golder's report is only a 1D model based on the main channel thalweg, and it is unknown how reflective the model is of actual flow conditions and levels in the avulsion channel (north of the main channel) where the storm outfall would be placed.

For the design storms, a future IDF curve was provided by the City of Calgary in the memo *Climate Change IDF Curve Update Methodology and Results* (Associated Engineering, 2019). This IDF curve was created using the IDF-CC Tool created by University of Western Ontario, with the following settings:

- Time period of 2050-2100.
- Using nine (9) climate models downscaled by PCIC (Pacific Climate Impacts Consortium, a climate services center at the University of Victoria).
- Single Curve, presenting the mean of the nine downscaled models

- RCP 8.5 (Representative Concentration Pathway resulting in a radiative forcing of 8.5 W/m^2; informally, the "business as usual" industrial growth scenario).
- Curve-Fitting based on the City of Calgary's 2011 Stormwater Management Guidelines (not detailed in the memo).

The resulting future IDF curve is presented in **Table 5.1** for reference:

Table 5.1 - Updated IDF Curve for the City of Calgary

	Return Period ($Years^{-1}$)								
	2	*5*	*10*	*25*	*50*	*100*	*200**	*500**	*1000**
Best-Fit Parameters									
A	379.5	652.6	880.3	1200.4	1637.8	2166.6	2332.3	2797.7	3156.8
B	4.267	5.572	6.953	8.387	10.435	13.238	12.487	13.342	13.888
C	0.732	0.758	0.777	0.795	0.813	0.83	0.829	0.837	0.841
Fitted Intensity (mm/hr)									
5 min	74.4	109.2	128.1	152.6	177.0	194.6	217.6	245.1	266.7
10 min	54.2	81.4	97.6	118.6	140.9	159.2	176.6	200.3	218.9
15 min	43.5	65.9	79.9	97.9	117.9	135.4	149.5	170.3	186.5
30 min	28.6	43.5	53.3	66.1	80.9	95.1	104.2	119.3	131.2
1 h	18.0	27.4	33.6	41.7	51.5	61.4	66.9	76.8	84.7
2 h	11.1	16.7	20.4	25.3	31.2	37.4	40.6	46.6	51.4
6 h	5.1	7.4	9.0	10.9	13.4	15.9	17.2	19.7	21.7
12 h	3.1	4.4	5.3	6.4	7.7	9.1	9.8	11.2	12.3
24 h	1.8	2.6	3.1	3.7	4.4	5.1	5.6	6.3	6.9

** projected beyond the data given by the IDF-CC tool; large confidence interval*

The climate change analysis presented here only includes the consideration of the 24-hour design storms and the increased river levels. Continuous simulation is not performed as the City of Calgary currently does not have future precipitation data in the format that can be used for this type of analysis.

5.1.3 Stormwater Facilities on the Plateau

The wet ponds on the plateau (Ricardo Ranch 1, 2 and 3) are completely independent of the river level, so the only impact of climate change will be due to the increased volume of the 24-hour design storm. For these ponds, the design storm model in PCSWMM was run using the future 24-hour 1:100-year Chicago storm based on the IDF curve presented in **Table 5.1**. The modelling was performed using lumped catchments draining to the pond, which implies that any trap-lows that are over-capacity under future climate conditions future will still overflow freely to the storm pond. This is conservative in the assessment of peak pond volumes, and in accordance with the City of Calgary standards. However, at a more detailed design level it is important to consider that individual trap-lows and drainage systems may also be over-capacity in the future.

The results of the climate change assessment for ponds on the plateau are summarized in **Tables 5.2, 5.3, and 5.4** below. Under future climate conditions, it appears that the largest storm that can be contained in the wet ponds is a 24-hour, 1:25-year event. This is a significant reduction in the stormwater level of service resulting from climate change, when compared to the 1:100-year standard commonly used today.

To evaluate the consequences of a future 1:100-year storm on pond operation, a second model was created with a typical overland escape channel based on current design requirements. The future 1:100-year storm was routed through this model, and the resulting spill rates and volumes, as well as the increased levels in the pond during spill conditions, were recorded. The resulting spill rates are significant, ranging between 1.5 – 3.8 m^3/s. Although the overflow channels at the pond perimeter can be designed to convey these high flow rates, negative impacts will likely be encountered on the downstream infrastructure., and safe conveyance of these flows down the escarpment to the Bow River will be compromised. Additionally, overland spill flows from Rangeview development area are conveyed through Ricardo Ranch further compounding the problem.

The high rates of overland spill under the future climate change scenario is clearly a concern. An additional scenario, with a two-stage pond outlet, was developed and tested as a way to potentially mitigate the risks. In this scenario, the ponds release at the pre-development rate of 2.78 L/s/ha up to their regular High-Water Level (HWL), assuming 2 m of active storage. Above this level, a second orifice with a higher release rate is placed to allow the total release rate of the pond to increase, to mimic increased pre-development runoff as a result of climate change. This scenario also provides a compromise between oversizing the pond to store the entire increased runoff volume, and oversizing trunks or overland escape routes for the significant flows calculated in the first scenario.

A rate of 7 L/s/ha was tested in this scenario, but the likely range of release rates could be between 5 and 10 L/s/ha, depending on the catchment characteristics and the level of downstream risks. For the purposes of this model, the pond was allowed to continue filling to whatever depth was required, and the overland escape channel was removed. This scenario shows promising results – for the three wet ponds tested, increasing the capacity of the downstream trunks between 140 - 500 L/s, the future 1:100 year storm can be fully captured, and the depth of active storage is increased by 0.44 – 0.57 m, for a total active storage depth of up to 2.6 m. The results are summarized in the **Tables 5.2, 5.3, and 5.4** below.

Table 5.2 - Climate Change Impacts - Ricardo Ranch 1 Wet Pond

Pond Parameters		Current Conditions	Climate Change	
			Escape Only	Two-stage Outlet
1:100 24 hr Total Inflow	(m^3)	37 380	61 760	61 760
1:100 24 hr Total Inflow	(mm)	52	86	86
Peak Water Level	(m)	1028.63	1029.22	1029.58
Peak Depth	(m)	4.13	4.72	5.08
Depth Above HWL	(m)	-0.38	0.22	0.58
Peak Volume	(m^3)	59 900	72 670	80 800
Peak Outflow Through Orifice	(L/s)	180	212	230
Total Volume Through Orifice	(m^3)	36 600	44 870	50 360
Peak Outflow Through High Level Orifice	(L/s)	-	-	325
Total Volume Through High Level Orifice	(m^3)	-	-	10 580
Peak Outflow Through Overflow Channel	(L/s)	-	2 895	-
Total Volume Through Overflow Channel	(m^3)	-	16 090	-
Required Freeboard	(m)	1029.3	1029.52	1029.88
Freeboard Height Above HWL	(m)	0.30[1]	0.52	0.88
Largest 24-Hour Event Not Causing Overflow	(1:yr)	100	25[2]	100

1. This doesn't consider the 1 m^3/s through escape channel, in reality freeboard would be higher.
2. Future (climate change) 1:25-year 24-hour storm, to be consistent with the scenario approach.

Table 5.3 - Climate Change Impacts - Ricardo Ranch 2 Wet Pond

Pond Parameters		Current Conditions	Climate Change	
			Escape Only	Two-stage Outlet
1:100 24 hr Total Inflow	(m^3)	58 530	96 670	96 670
1:100 24 hr Total Inflow	(mm)	52	86	86
Peak Water Level	(m)	1025.61	1026.27	1026.59
Peak Depth	(m)	4.11	4.77	5.09
Depth Above HWL	(m)	-0.39	0.27	0.59
Peak Volume	(m^3)	98 910	120 400	131 600
Peak Outflow Through Orifice	(L/s)	280	337	362
Total Volume Through Orifice	(m^3)	57 180	70 610	78 850
Peak Outflow Through High Level Orifice	(L/s)	-	-	506
Total Volume Through High Level Orifice	(m^3)	-	-	16 350
Peak Outflow Through Overflow Channel	(L/s)	-	3 778	-
Total Volume Through Overflow Channel	(m^3)	-	24 630	-
Required Freeboard	(m)	1029.3	1026.57	1026.89
Freeboard Height Above HWL	(m)	0.30[1]	0.57	0.89
Largest 24-Hour Event Not Causing Overflow	(1:yr)	100	25[2]	100

1. This doesn't consider the 1 m^3/s through escape channel, in reality freeboard would be higher.
2. Future (climate change) 1:25-year 24-hour storm, to be consistent with the scenario approach

Table 5.4 - Climate Change Impacts - Ricardo Ranch 3 Wet Pond

Pond Parameters		Current Conditions	Climate Change	
			Escape Only	Two-stage Outlet
1:100 24 hr Total Inflow	(m^3)	15 740	26 010	26 010
1:100 24 hr Total Inflow	(mm)	53	88	88
Peak Water Level	(m)	1022.63	1023.15	1023.52
Peak Depth	(m)	4.13	4.64	5.02
Depth Above HWL	(m)	-0.37	0.14	0.52
Peak Volume	(m^3)	22 070	27 040	30 970
Peak Outflow Through Orifice	(L/s)	76	88	96
Total Volume Through Orifice	(m^3)	15 490	19 070	21 460
Peak Outflow Through High Level Orifice	(L/s)	-	-	132
Total Volume Through High Level Orifice	(m^3)	-	-	4 267
Peak Outflow Through Overflow Channel	(L/s)	-	1 517	-
Total Volume Through Overflow Channel	(m^3)	-	6 678	-
Required Freeboard	(m)	1029.3	1023.45	1023.82
Freeboard Height Above HWL	(m)	0.30[1]	0.44	0.82
Largest 24-Hour Event Not Causing Overflow	(1:yr)	100	25[2]	100

1. This doesn't consider the 1 m^3/s through escape channel, in reality freeboard would be higher.
2. Future (climate change) 1:25-year 24-hour storm, to be consistent with the scenario approach

5.1.4 Stormwater Facility in the Flood Fringe

The climate change analysis for the stormwater facility in the flood fringe (Ricardo Ranch 4) considered five combinations of river flood levels and design storms. The five scenarios are:

1. Free-flowing Outlet – River is at the 1:5-year level, with a 1:100-year storm on the contributing catchment. The intent of this scenario is to analyze the pond performance with a free-flowing outlet (i.e., no impact from river levels).

2. Baseline Scenario – The 1:100-year level in the river happens concurrently with the 1:100-year storm on the catchment. This is the baseline design condition applied to ponds in the flood fringe. No spill from the pond is permitted under this scenario.

3. Climate Change Scenario 1 – River is at the 1:200-year level which represents potential future flood conditions. The storm on the contributing catchment is the current 1:100-year event.

4. Climate Change Scenario 2 – River is at the current 1:100-year level, the storm on the catchment is the future 24 hour, 1:100-year event

5. Climate Change Scenario 3 – River is at the 1:200-year level, and the storm on the catchment is the future 24 hour, 1:100-year event. This is the worst-case future climate change scenario.

It should be noted that in the climate change analysis, only the option with a wet pond in Ricardo Ranch 1 catchment was considered, since this would be the most likely option to be implemented if the flood fringe is fully developed.

The Baseline Scenario, which analyzes the current 24 hour 1:100-year storm concurrent with the 1:100-year river level, is considered the standard "no spill" design condition for the stormwater facilities in the flood fringe. The facility operating levels (elevations) and bottom elevation were set based on this scenario. Keeping the stage-storage curve constant, modeling was performed for different facility elevations until no overflow occurred in the model. This resulted in a pond bottom elevation at 981.60 m, and NWL at 982.10 m. When hydraulic losses are considered, the NWL corresponds roughly with the 1:20 year river level, which is 981.94 m. The resulting stage-storage curve of the pond is provided in **Table 5.5** below.

Table 5.5 - Ricardo Ranch 4 SWMF- Stage-Storage

Depth (m)	Elevation (m)	Area (m^2)	Total Storage Volume (m^3)	Active Storage Volume (m^3)	
0.00	981.60	5,013	0	-	Bottom
0.50	982.10	6,916	2,974	0	PWL
1.00	982.60	22,458	12,039	9,065	
1.50	983.10	23,356	23,719	20,745	
2.00	983.60	26,125	36,315	33,341	
2.50	984.10	28,033	49,855	46,881	HWL
3.50	985.10	28,967	79,901	-	Freeboard

After the facility elevation was determined, the remaining scenarios were analyzed to evaluate the impact of climate change. The results are presented in **Table 5.6**. For each scenario, the water level in the facility was assumed to be at the river level at the start of the simulation. This represents the case without a flap gate where the facility can back-fill from the river, or if the river is high for a sustained period and the facility filled as a result of baseflow or minor storm events. Therefore, this is a conservative scenario, as it assumes no active storage remaining below the river flood level.

During the simulation, the facility was allowed to overflow freely into the river at its HWL of 984.10 m, with flow rates and depth based on a typical overflow channel. As shown in **Table 5.6**, the resulting overflow rates are significant, with more than 11 m^3/s spilling in the Climate Change Scenario 3. However, since the facility is immediately adjacent to the river, a safe spill route to the river can be designed by keeping public access away from the spill channel or providing a pedestrian bridge over it.

Additionally, the model shows the potential extent of water levels in the facility exceeding the HWL during climate change scenarios. For instance, if a current 100-year storm were to occur while the river was at its 200-year level (Climate Change Scenario 1), the peak water level is at 984.22 m, or 0.12 m above HWL; this provides information about potential impact from HGL backup during river flooding.

Finally, the models were used to test the highest return period storm that could be contained within the pond, with minimal overland spill, during climate change scenarios. Using the previous example, during a 200-year river flood, the pond could still safely contain a 1:50-year storm.

Table 5.6 - Summary of Climate Change Scenario Results

Scenario:		**1**	**2**	**3**	**4**	**5**
24 Hour Design Storm	(1:yr)	Current 100	Current 100	Current 100	Future 100	Future 100
River Level	(1:yr)	5	100	200	100	200
Starting Water Level[1]	(m)	982.1	982.72	983.06	982.72	983.06
Starting Water Depth	(m)	0.50	1.12	1.46	1.12	1.46
Starting Volume	(m^3)	2 974	14 760	22 750	14 760	22 750
Active Storage Volume at Start of Storm	(m^3)	46 881	35 124	27 134	35 124	27 134
1:100 24 hr Total Inflow	(m^3)	45 590	45 590	45 590	84 040	84 040
1:100 24 hr Total Inflow	(mm)	38	38	38	69	69
Peak Water Level	(m)	983.66	984.08	984.22	984.56	984.65
Peak Depth	(m)	2.06	2.48	2.62	2.96	3.05
Depth Above HWL	(m)	-0.44	-0.02	0.12	0.46	0.55
Peak Volume	(m^3)	37 880	49 170	53 340	63 310	65 990
Peak Outflow Through Orifice	(L/s)	293	289	268	337	313
Total Volume Through Orifice	(m^3)	45 110	44 290	37 020	45 610	36 950
Peak Outflow Through Overflow Channel	(L/s)	-	-	1 179	8 715	11 350
Total Volume Through Overflow Channel	(m^3)	-	-	7 191	37 130	45 710
Required Freeboard	(m)	984.4	984.4	984.52	984.86	984.95
Freeboard Height Above HWL	(m)	0.30[2]	0.30[2]	0.42	0.76	0.85
Largest 24 h Event Not Causing Overflow	(1:yr)	100	100	50[3]	10[4]	10[5]

1. Water Level in the pond assumed to equal river level at the start of the storm event, in case there is no flap gate

2. This doesn't consider the 1 m3/s through escape channel, in reality freeboard would be 0.5-0.6 m

3. Peak water level reaches 4 cm above HWL in the 50-year event

4. Future (climate change) 10-year 24 hour storm

5. Future (climate change) 10-year 24 hour storm, peak level reaches 5 cm above HWL

6.0 STORM TRUNKS AND OUTFALLS

6.1 Storm Trunks

The future Rangeview storm trunk, located within the 72nd Street ROW, will provide stormwater servicing for Ricardo Ranch 2 and Ricardo Ranch 3 catchments. The conceptual trunk design (alignment, sizing, pipe slope and depth, and outfall location) was presented in the *Rangeview MDP Update* (Urban Systems, 2018). Ricardo Ranch 2 catchment will have a direct connection to the 72nd Street trunk, while Ricardo Ranch 3 will connect to the lateral trunk extension in 210th Avenue (**Figure 15)**. Both trunks (72nd Street trunk and 210th Avenue trunk) meet the criteria for City-funded infrastructure. The detailed trunk design is currently underway by the City of Calgary, with construction completion expected in 2021.

The Rangeview trunk design summary is presented in **Table 6.1.** The Rangeview MDP Update report can be referenced for more information.

Table 6.1 - Rangeview (72nd St) Trunk Design Summary

FROM	TO	Q (L/s)	SLOPE (%)	PIPE (mm)	PIPE CAPACITY (L/s)	PERCENT FULL CAPACITY (%)
Genstar North Pond	Genstar South Pond	775	0.10	1050 CON	900	86
Genstar South Pond	Seton Pond D	980	0.10	1200 CON	1286	76
Seton Pond D	212 Ave SE	1560	0.10	1350 CON	1760	89
210 Ave.	Ricardo Ranch 2	2006	0.15	1500 CON	2855	70
Ricardo Ranch 2	Escarpment	2323	0.15	1500 CON	2855	82
Escarpment	Outfall	2323	25	600 HDPE	3578	65
210 Ave. Trunk						
Ricardo Ranch 3	72nd St.	446.0	0.10	900 CON	602	75

The western portion of the study area, comprised of Ricardo Ranch 1 and Ricardo Ranch 4 catchments, will be serviced by a new stormwater trunk in the 56th Street alignment. This trunk does not meet the criteria for City-funded infrastructure and the construction cost will be borne by the benefiting landowners (Brookfield and Genesis). The final trunk alignment, size, slope and depth will be determined at the Outline Plan/SMDP stage, since it will largely depend on the development layout, the floodproofing strategies within Ricardo Ranch 4 catchment, and the extent of the development within flood fringe.

Both trunks will need to be installed down the escarpment of the Bow River. Detailed design should account for high velocities and the construction practices need to consider impacts to sensitive escarpment area. The City of Calgary design standards should be followed at detailed design stages.

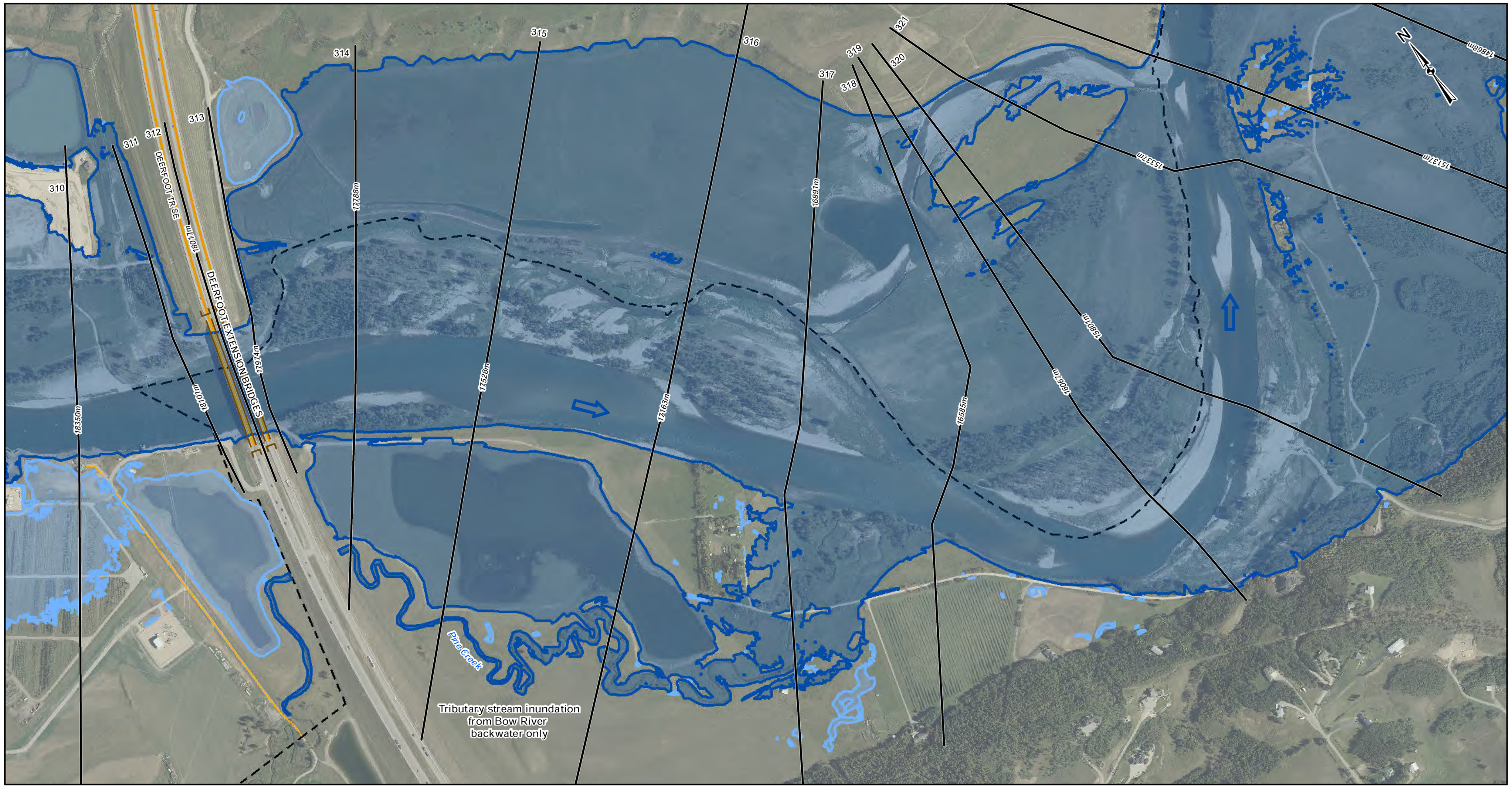
6.2 Outfalls

Two new stormwater outfalls will service Ricardo Ranch ASP area; one at the Bow River at 72nd Street alignment, and second at the Bow River avulsion channel (Transect 319 as shown on **Figure 14**). Proposed outfall locations are also shown on **Figure 15.** Due to very steep slopes and elevation change from the plateau down the escarpment to the river, energy dissipation options and erosion protection will be required for outfalls. The City of Calgary Stormwater Management Guidelines (2011) should be consulted for details on the design of outfall structures. The outfalls will need approval and registration under the Water Act.

Ricardo Ranch Landowners Group

Ricardo Ranch MDP

Bow River Flood Elevation



Transect 319 Flood Elevations:
1:200 - 983.06 m
1:100 - 982.72 m
1:50 - 982.36 m
1:20 - 981.94 m
1:10 - 981.66 m
1:5 - 981.26 m

The accuracy & completeness of information shown on this drawing is not guaranteed. It will be the responsibility of the user of the information shown on this drawing to locate & establish the precise location of all existing information whether shown or not.

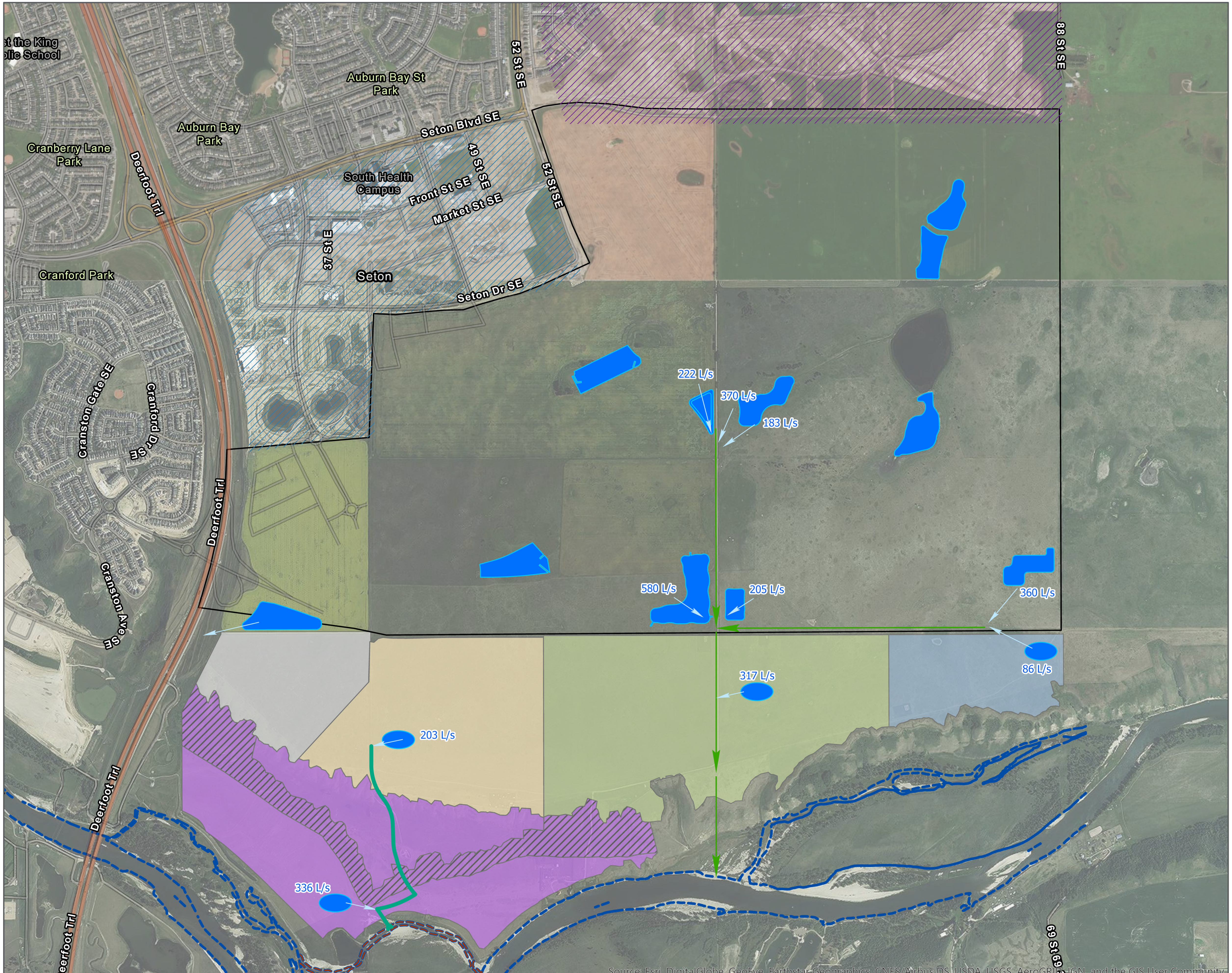
Data Sources:

- Data provided by the Government of Alberta

Project #:	2197.0009.22
Author:	JW
Checked:	LB
Status:	Review
Revision:	A
Date:	2019 / 7 / 24

URBAN systems

FIGURE 14



Ricardo Ranch Landowners Group

Ricardo Ranch MDP

Storm Trunks

Legend

- 72nd St. Storm Trunk
- 56th St. Storm Trunk
- Normal River Channel
- Avulsed Channel
- Ponds
- Ricardo Ranch 1
- Ricardo Ranch 2
- Ricardo Ranch 3
- Ricardo Ranch 4
- Ricardo Ranch EXT
- Undeveloped Slope Area

56th Street Release Rates:
Ricardo Ranch 1 - 203 L/s
Ricardo Ranch 4 - 336 L/s

72nd Street Release Rates:
Danube - 222 L/s
Section 23 - 370 L/s
Genstar North - 183 L/s
Genstar South - 205 L/s
Seton - 580 L/s
Westcreek - 360 L/s
Ricardo Ranch 2 - 317 L/s
Ricardo Ranch 3 - 86 L/s

The accuracy & completeness of information shown on this drawing is not guaranteed. It will be the responsibility of the user of the information shown on this drawing to locate & establish the precise location of all existing information whether shown or not.

0 100 200 300
Meters

Coordinate System: NAD 1983 3TM 114

Scale: 1:17,500 (When plotted at 11"x17")

Data Sources:

- Data provided by Stantec

Project #: 2197.0009.22
Author: JW
Checked: LB
Status: Review
Revision: A
Date: 2019 / 7 / 24

URBAN systems

FIGURE 15

7.0 STORMWATER SERVICING STRATEGIES

7.1 Stormwater System Planning Considerations

This section provides a summary of important stormwater design and planning considerations for Ricardo Ranch MDP area, and it should be referenced for future development planning (Staged Master Drainage Plans, Pond Reports, Stormwater Management Reports, Development Site Servicing Plans).

7.1.1 Stormwater Targets

The stormwater rate target for Ricardo Ranch was established in the Rangeview MDP and it is 2.78 L/s/ha. This unit area release rate is to be used for sizing of stormwater facilities, "clean water" stormwater trunks, and outfalls. Review of other stormwater studies and MDPs in the area indicate that this rate is within a reasonable range and appropriate for a site defined by a plateau and escarpment adjacent to the Bow River.

Because Ricardo Ranch discharges directly to the Bow River, the development is not subject to a discharge volume target. Should this change in the future, additional volume control strategies, such as irrigation with stormwater, can be considered at the Outline Plan and SMDP stage.

7.1.2 LID Implementation

Use of LID to reduce the volume of stormwater discharges to the Bow River is encouraged. At a minimum, the use of resilient landscaping with varying topsoil depths on both private lots and public open spaces, and routing of impervious areas over pervious areas should be considered.

Additional LID features (i.e. biofilters, better planning practices to reduce imperviousness, etc.) can be proposed at the Outline Plan and SMDP stage, especially in the development areas within the Bow River flood fringe. These features should be designed in accordance with the City's LID Technical Guidance documents.

7.1.3 Minor System and Overland Drainage

The minor and major systems design should follow the guidelines specified in the City of Calgary Stormwater Management and Design Manual (2011). Typically, minor system UARRs of 70 L/s/ha for single family residential development, 100-120 L/s/ha for commercial and multi-family residential developments and 120 L/s/ha for roadways are acceptable in the City of Calgary. In some cases, the UARR can be reduced if widespread LID is implemented; however, this should be discussed with Water Resources and calculations to support the lower UARR will be required.

7.1.4 Water Quality Considerations

The City's Stormwater Management Guidelines specify that new developments are required to remove 85% of Total Suspended Solids for particle size of 50 µm or greater. In recent amendments to the Guidelines, the City requires an off-line oil/grit separator to be installed in lieu of a forebay and skimming weirs/skimming manholes. The oil/grit separator is to be installed prior to any pipes with standing water and designed to remove 85% of TSS particles 150 microns or greater if the stormwater facility is a wet pond. Design options to divide the storm pond into smaller cells that can be individually operated and dewatered can be considered during the preparation of the Staged Master Drainage Plan. Smaller cells will reduce the potential of remobilization of deposited sediments and can potentially minimize impacts on existing sensitive wetland areas within the context of a larger stormwater management system.

If the facility is a constructed wetland, the runoff entering the facility must be treated to a higher standard to prevent adverse impacts to wetland health. At a minimum, an oil/grit separator upstream of the wetland must be sized to remove 85% TSS for particles 75 microns or greater. Additional water quality opportunities, such as installation of buffers, biofilters along overland flow paths to the wetland, and increased plantings, should be also considered.

If a dry pond option is implemented for Ricardo Ranch 1 catchment, the pre-treatment will be especially important since the discharge from the dry pond will be conveyed to the wetland in the flood fringe (Ricardo Ranch 4 catchment). An oversized oil/grit separator placed upstream of the dry pond and sized to remove 85% of TSS particles 75 microns or greater is a minimum treatment requirement in this case. High treatment levels will also prevent silting up of the multi-purpose area where the dry pond will be located.

Prior to detailed design, the City of Calgary Stormwater Guidelines should be consulted for any updates to water quality requirements, and updated targets for various pollutants of concern and treatment options.

7.1.5 Stormwater Facility Considerations

Detailed design of stormwater management facilities should follow the City of Calgary Stormwater Management and Design Manual (2011) and the applicable AEP requirements. Preliminary volume requirements have been presented in this document, and all supporting design parameters and considerations have been included. Future reporting should be consistent with the design concepts presented in this report, unless there is information available at the time to support changes.

All stormwater management facilities, whether temporary or permanent, will need approvals under the Water Act and Environmental Protection and Enhancement Act (EPEA).

7.2 Development Staging Considerations

The neighborhood plan and likely development staging for the Ricardo Ranch ASP area are shown on **Figures 16 and 17**. Generally, the development is expected to follow servicing and occur in a sequence from west to east and from north to south.

From the stormwater servicing perspective, it is preferable to construct permanent stormwater management facilities in conjunction with or prior to the first phase of development. For Ricardo Ranch area, the servicing will largely depend on the timing of stormwater infrastructure construction (outfalls and stormwater trunks), which would need to be in place before the stormwater facilities can connect and release at approved discharge rates. **Table 7.1** below describes stormwater servicing considerations for each Ricardo Ranch neighborhood.

Table 7.1 - Potential Development Staging Considerations

Neighborhood/ Outline Plan	Staging of Stormwater Servicing
1	Stormwater servicing through Seton Pond E is readily available for the western 34 hectares (catchment Ricardo Ranch EXT). The remainder of Neighborhood 1 is in Ricardo Ranch 1 catchment and will require one stormwater pond and the construction of a developer-funded storm trunk and outfall in the 56th Street alignment. The type of stormwater facility (dry or wet pond) and trunk size will be influenced by land development decisions in the Neighborhood 4 (flood fringe area). Refer to Section 4 for details. Considering the development pressures in this area and the developer-funder infrastructure, interim servicing is unlikely to be required.
2	The servicing for western portion of Neighborhood 2 (in Genesis ownership) is to Ricardo Ranch 1 pond and the future 56th Street storm sewer. This trunk is developer-funded infrastructure and it is expected to be in place in advance of the first stages of development in Neighborhoods 1 and 2. The remaining area will be serviced through Ricardo Ranch 2 wet pond and future Rangeview (72nd Street) storm trunk. The 72nd Street storm trunk is currently in the detailed design stage, with construction expected to be completed by 2021. Given the short timeframe for trunk and outfall construction, interim servicing is unlikely.
3	The western portion will be serviced through Ricardo Ranch 2 pond and Rangeview (72nd Street) storm trunk, which will be constructed by 2021. The eastern portion will drain to Ricardo Ranch 3 pond and to the future 210th Ave storm trunk, which is intended to also service the Westcreek development in Rangeview. The development timing will depend on the construction of 210th Ave storm trunk. There is a potential to construct the storm trunk at the same time as the 210th Avenue sanitary trunk, as they follow the same alignment. If the trunk construction is delayed, interim storm servicing may be considered for this development area. Two potential interim options would be to pump to Ricardo Ranch 2 pond, or a zero-release system.

4	This is the final neighborhood development in Ricardo Ranch. The entire area is in the Bow River Valley and it includes flood fringe lands as well as the lower bench which is fully developable. The optimal use of flood fringe lands will be determined in the Ricardo Ranch Flood Fringe Study. The stormwater servicing will be provided by Ricardo Ranch 4 stormwater facility and the 56th Street storm trunk and outfall. From a timing perspective, the stormwater infrastructure will be constructed as part of Neighborhood 1 development. Interim servicing for this area is unlikely, and it would not be feasible due to complexities of flood fringe development.

Interim stormwater servicing concepts may be proposed to allow the development to proceed prior to the construction of permanent facilities. Interim servicing scenarios may include temporary stormwater facilities, off-peak discharges to already constructed stormwater facilities and trunks, or other site-specific options. Some important considerations for interim servicing scenarios are presented below:

- Interim servicing concepts (including grades, elevations, minor system design, etc.) must be in accordance with the approved permanent servicing scenarios to allow for seamless connection to the permanent facilities once they become available.
- Temporary stormwater facilities must be fully contained within the corresponding Outline Plan boundary.
- The recommended discharge options for temporary stormwater facilities would be a discharge off-peak to existing stormwater infrastructure servicing other catchment areas. If irrigation is used as means of stormwater disposal, the irrigated area should be located either within the Outline Plan boundary, or in the same land ownership as the Outline Plan area. Evaporation ponds are discouraged within residential development.
- If the Outline Plan boundary contains a permanent stormwater facility, the facility should be constructed for the ultimate servicing concept even if downstream infrastructure (trunk and outfall) are not in place and the connection is not possible. In this case, the facility can be used as an interim (temporary) pond. Area that can be serviced by this pond in the interim must be delineated in the SMDP.
- If the temporary facility discharges off-peak to the existing trunk, the operational details of such system must be clearly described in the corresponding SMDP and may include flow rates, any potential impacts, delay period prior to pumping after a major rainfall event, etc.
- Any interim servicing strategies will not be taken over by the City, as is their policy. They will remain the responsibility of the proponent until the ultimate system is in place.

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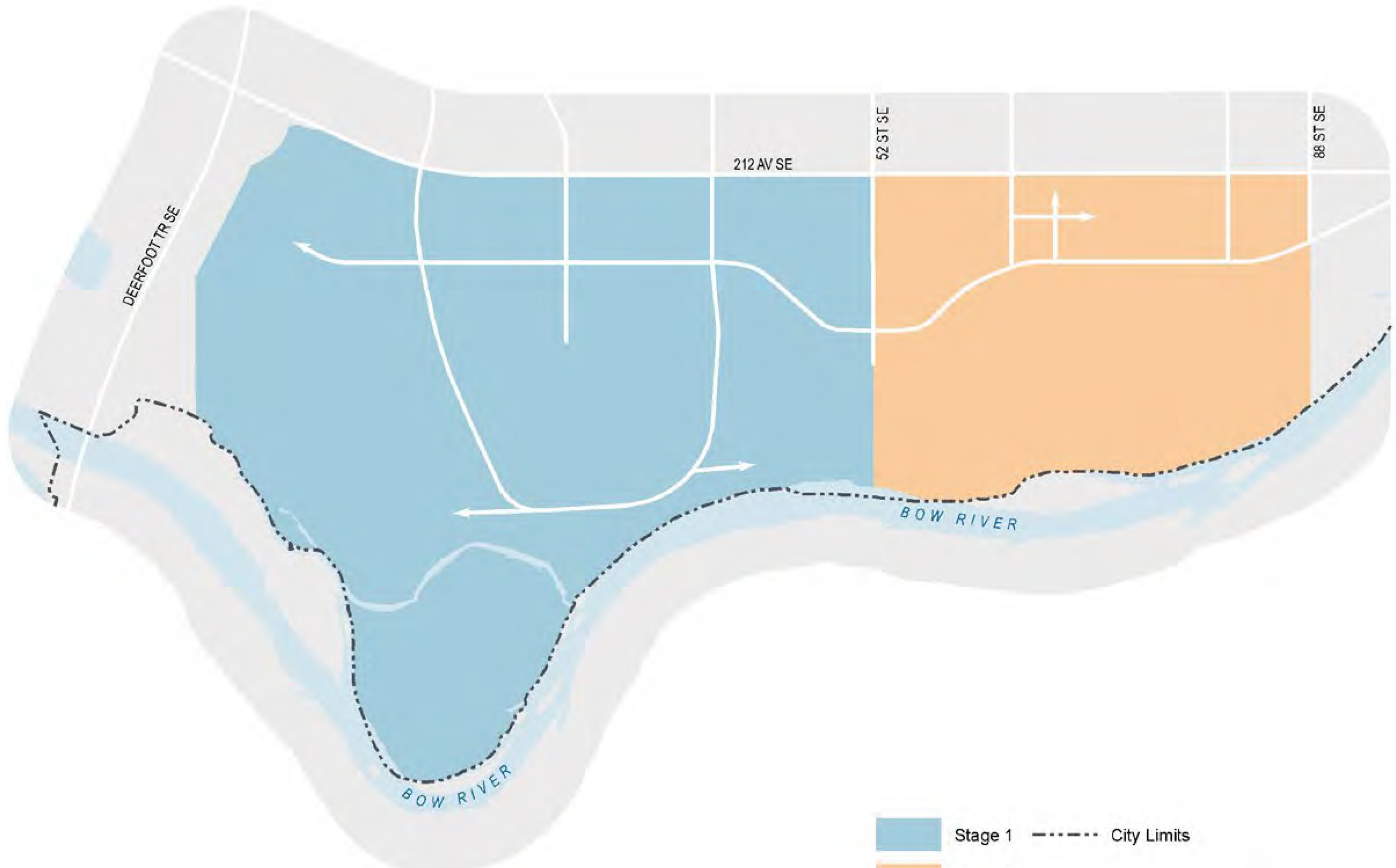
U:\Projects_CAL\2197\0009\22\D-Design\GIS\Projects\Pro_Projects\RicardoRanch_MDP_2010719.aprx\Fig 16 - Ricardo Ranch MDP - Development Staging - 20190719



Ricardo Ranch Landowners Group

Ricardo Ranch MDP

ASP Development Staging

The accuracy & completeness of information shown on this drawing is not guaranteed. It will be the responsibility of the user of the information shown on this drawing to locate & establish the precise location of all existing information whether shown or not.

Data Sources:

- Data provided by the City of Calgary

Project #:	2197.0009.22
Author:	JW
Checked:	LB
Status:	Review
Revision:	A
Date:	2019 / 7 / 24

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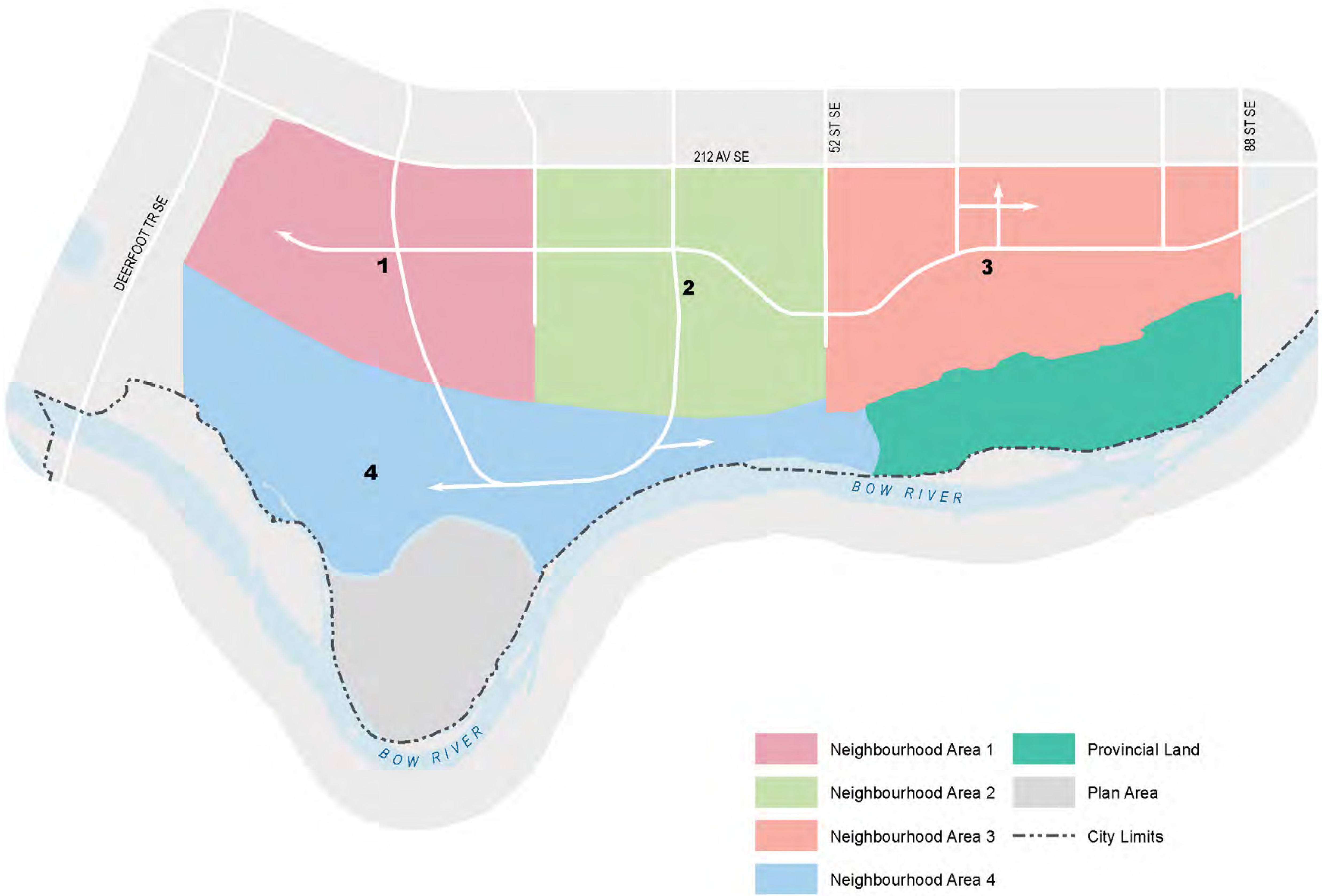
FIGURE 16



Ricardo Ranch Landowners Group

Ricardo Ranch MDP

ASP Community and Neighbourhoods

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Data Sources:

- Data provided by the City of Calgary

Project #: 2197.0009.22
Author: JW
Checked: LB
Status: **Review**
Revision: A
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FIGURE 17

8.0 CONCLUSIONS AND RECOMMENDATIONS

8.1 Conclusions

The post-development stormwater management servicing concept for Ricardo Ranch utilizes a conventional approach with stormwater management facilities discharging to the Bow River via two new stormwater trunks and outfalls. A unit area release rate of 2.78 L/s/ha for the 1:100-year storm event was established in *Rangeview MDP* (Urban Systems, 2015), and applies to the entire Ricardo Ranch area. There are no off-site catchment areas serviced through Ricardo Ranch stormwater infrastructure.

A specific volume control target does not currently apply to Ricardo Ranch. Volume reduction strategies such as resilient landscaping and impervious area disconnection are recommended to reduce the impact of post-development runoff volumes on the Bow River, but practices such as stormwater irrigation were not included in the servicing concept and analysis.

A thorough pre-development hydrological analysis of the Ricardo Ranch ASP area was completed as part of the Rangeview Master Drainage Plan. The analysis used both WBSCC and PCSWMM rainfall-runoff modeling software and established the pre-development flow rate and discharge volumes. Additional pre-development assessment of the Ricardo Ranch area, completed as part of this study, focused on new, more detailed information around wetlands and drainages. The following are the major findings of the pre-development hydrology assessment:

- Majority of the stormwater runoff is contained on the plateau and lost to evaporation and infiltration. The average annual runoff from the plateau was found to be only in the range of 1.2 mm to 2.1 mm. This is based on the WBSCC modeling completed as part of the Rangeview MDP analysis, and confirmed through this assessment.
- The maximum 1:100-year pre-development peak runoff release rate from the plateau area is 2.78 L/s/ha. This was established using a calibrated PCSWMM model, as part of the Rangeview MDP analysis.
- A total of fourteen (14) Class II and six (6) Class III wetlands were identified on the plateau area. The wetlands appear to act as disconnected localized depressions that receive some runoff after a major precipitation event. The runoff collected in these wetlands infiltrates or evaporates. The delineated area, depth and storage potential of these wetlands are too small to be adequately represented in a hydrologic model. The wetlands show significant impacts due to grazing and agricultural practices and are unlikely to be retained post-development.
- One Class III wetland W32 is located within the flood fringe. The wetland does not show any standing water or appreciable wet area in any of the areal photos used in the assessment and could not be analysed through hydrologic modeling. The wetland is located within a highly disturbed area and will likely be removed if land development occurs in the flood fringe.
- A total of fourteen (14) Class III slope wetlands are identified along the escarpment area. Water sources to the slope wetlands include both surface runoff and groundwater. Surface

runoff to the slope wetlands is limited while groundwater flow is predominant and determined to be the main water source that sustains the vegetation observed in the slope wetlands. Accurate estimation of potential impacts to water sources of these wetlands is not possible without long-term data monitoring and analysis. However, the preliminary hydrogeological investigation established that the development on the plateau will likely have no impact on groundwater regime along the escarpment.

- The modeled ephemeral drainages have intermittent flows about 1% of the time. The intermittent stream experiences flow about 2% of the time. Land development on the plateau will reduce the surface catchment areas to the modeled drainages and the intermittent stream, resulting in less frequent flow occurrences and much lower peaks. This will limit the potential for erosion and escarpment slope failure. Mimicking the pre-development hydrology of the ephemeral drainages and the intermittent stream is not recommended, since it can impact the stability of steep slopes.
- There are no pre-development offsite drainage areas coming into the site unaccounted for. The Deerfoot is on the west boundary and has its own stormwater management system. The Rangeview ASP area north of 210th Avenue is currently under development and the flows are controlled within each development cell.
- To limit the potential for erosion and failure of the unstable slopes on the escarpment, it is recommended that runoff be piped to the bottom of the escarpment and towards the Bow River.

Environmentally sensitive areas, including escarpment, wetlands and drainages, and the flood fringe lands are shown as EOS areas in the Ricardo Ranch ASP. Final status of the EOS areas will be determined at the Outline Plan stage. A Water Act application is required for all wetlands that are slated for removal as part of the development process.

The City of Calgary is currently working on the Ricardo Ranch Flood Fringe Study which will recommend optimal land use scenarios within the flood fringe. The study outcome may result in stormwater concept changes in the flood fringe. A conservative approach of full development within the flood fringe was assumed in this report.

The proposed post-development servicing concept is shown on **Figure 12**. The major findings of post-development analysis are summarized below:

- Stormwater management facilities are used to attenuate post-development flows from Ricardo Ranch area to 2.78 L/s/ha. The pre-development release rate to the Bow River is achieved from the entire ASP area.
- Stormwater runoff is controlled for all future development areas. Areas in the Bow River valley that will not be developed (development setback areas, Crown lands, etc.) will continue to discharge at existing (pre-development) rates to the river.
- Two options for servicing of Ricardo Ranch 1 were considered – a wet pond and a dry pond option. The dry pond is proposed to be placed within MR/MSR sites. Both options meet the expected

level of service. The extent of development in the flood fringe will ultimately decide the feasibility of a dry pond option.

- Ricardo Ranch 2 and 3 catchment areas are proposed to be serviced by conventional wet ponds. The pond in Ricardo Ranch 3 catchment does not meet the minimum footprint requirement. However, without any information on future Westcreek development in Rangeview, it was not possible to find an alternative solution for this catchment.
- Ricardo Ranch 4 facility is proposed to be a constructed wetland in the flood fringe. The facility was sized based on full development of the flood fringe lands, outside of development setbacks. The operating levels and elevations were determined based on the requirement that adequate storage be provided to fully contain the 1:100-year storm while the river is at 1:100-year flood level. No overflow from the facility is permitted under these conditions.
- Future climate change impacts were investigated using the updated IDF curves provided by the City of Calgary. The climate change analysis was based on the single-event approach. The results indicate that climate change impacts to stormwater level of service can be considerable. For the facilities on the plateau that are not impacted by river levels, the largest storm that can be contained in the facilities is a 24-hour, 1:25 year event. This is a significant reduction in the level of service resulting from climate change, when compared to the 1:100-year standard commonly used today. For the future 1:100 year storm, spill rates are significant, ranging between 1.5 – 3.8 m3/s. These flow rates would likely result in negative downstream impacts. A potential solution with a two-stage outlet was tested and found to be effective in reducing the risks, however it should be noted that this is a very preliminary and high-level assessment. A more detailed assessment and development of climate change mitigation strategies is outside of the scope of this report.
- Three climate change scenarios were investigated for the facility in the flood fringe, using different combinations of river levels and future design storms. The results are summarized in **Table 5.6**. The level of service is significantly reduced for each climate change scenario, with maximum spill rate reaching 11 m^3/s. Since the facility is immediately adjacent to the river, a safe spill route to the river can be designed by keeping public access away from the spill channel or providing a pedestrian bridge over it.
- The controlled discharges from the stormwater facilities are to the Rangeview (72nd) and 56th Street stormwater trunks and new outfalls to the Bow River. Both trunks are expected to be constructed by 2021. The 56th Street trunk will be developer-funded.

The development within the ASP area is expected to occur in a sequence from west to east and from north to south. Given the development staging and the timing for stormwater trunks and outfalls, interim stormwater servicing may not be required. Potential staging scenarios are described in **Table 6.1**.

8.2 Recommendations

The following is a summary of recommendations that should be considered at the time of Outline Plan and Staged Master Drainage Plan submission:

- The pond locations, types, catchment areas, analysis and model results presented in this report are preliminary and subject to refinement at the Outline Plan and Staged Master Drainage Plan stage.
- Proposed post-development servicing concepts may have to be revised as an outcome of Ricardo Ranch Flood Fringe Study, and the land use decisions for EOS areas. This should be considered at the future Outline Plan and SMDP stages.
- If a dry pond option is chosen for Ricardo Ranch 1 catchment, the facility should be designed in a way that maximizes the use of sports fields and other MR, such as placing areas of frequent inundation outside of high use areas. Pond outlet should be designed to facilitate shorter emptying time.
- The facility in the flood fringe will be a constructed wetland. Opportunities to designate the facility as ER should be investigated at the Outline Plan stage. The facility location within the meander belt of the Bow river should also be considered, depending on the outcome of the Ricardo Ranch Flood fringe Study.
- At future planning stages, an option of a shared stormwater facility servicing both Ricardo Ranch 3 and Westcreek catchment in Rangeview should be investigated.
- Designs of stormwater facilities and any LID features should follow the current City guidelines to ensure proper operation of the facilities post-construction.
- Detailed design of stormwater trunks and outfalls should follow City of Calgary guidelines. Outfall inverts are currently assumed to be at the 1:5-year Bow River elevations. Adjustments may need to be made during the SMDP and detailed design stage. The proposed location of the 56th Street outfall should be confirmed at the Outline Plan stage. Any change in this outfall location may change the Ricardo ranch 4 SWMF's elevation, and therefore the fill requirements for the development in the flood fringe.
- The results of climate change assessment indicate that future level of service could be compromised. A preliminary discussion on impacts and potential mitigation approaches are provided, however a more detailed risk assessment is outside of the scope of this report and future Ricardo Ranch SMDPs. The severity of impacts identified in this report, however, emphasise the importance of a comprehensive assessment of future risks to City's stormwater infrastructure, and the need for a City-wide mitigation strategy.

CORPORATE AUTHORIZATION

This report, titled *Ricardo Ranch Master Drainage Plan*, was prepared for the Ricardo Ranch Landowners Group. The material in this report reflects the best judgement of Urban Systems Ltd. based on the information available at the time of preparation. Any use that the third party makes of this report, or reliance on or decisions made based on it, is the responsibility of the third party. Urban Systems Ltd. accepts no responsibility for damages, if any, suffered by a third party as a result of decisions made or actions taken based on this report.

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Appendix A

HYDROGEOLOGICAL ASSESSMENT OF RICARDO RANCH (WATERLINE RESOURCES, 2019)

Appendix B

BOW RIVER MORPHOLOGY STUDY AT RICARDO RANCH (GOLDER ASSOCIATES, 2014)

Appendix C

ECOLOGICAL INVENTORY REPORT FOR RICARDO RANCH ASP AREA (STANTEC, 2018)

Appendix D

PRE-DEVELOPMENT PCSWMM MODEL FILES

Appendix E

HISTORICAL AERIAL IMAGERY FOR PRE-DEVELOPMENT WETLAND ANALYSIS

Appendix F

POST-DEVELOPMENT PCSWMM CONTINUOUS SIMULATION MODEL FILES

Appendix G

POST DEVELOPMENT PCSWMM SINGLE EVENT MODEL FILES

Appendix G

DATA AND FREQUENCY ANALYSIS SPREADSHEET FOR THE CITY OF CALGARY (DFASCC) FILES