TOWN OF BLACK DIAMOND

MASTER DRAINAGE PLAN | SEPTEMBER 2021

URBAN SYSTEMS
#101 134-11TH AVENUE SE
CALGARY AB T2G 0X5

CONTENTS

1.0 INTRODUCTION

1.1 STUDY OBJECTIVES

Urban Systems was retained by the Town of Black Diamond (Town) to prepare a Master Drainage Plan (MDP). The purpose of the MDP is to address drainage problems in the existing areas and set the stormwater management framework to guide future infrastructure design, whether for infill development or greenfield development in the new annexation areas. Specifically, the study intent is to:

- Provide a general explanation of common stormwater management principles from the City of Calgary Guidelines, which have been adopted by the Town of Black Diamond.
- Set expectations for future development and development review, whether for infill or annexation areas.
- Clarify the Town's preferences for certain aspects of stormwater design where the Town differs from the City of Calgary.

This study has been completed in three parts:

- Stormwater Management Principles
- Existing System Analysis
- Future Development Areas Analysis

This study and the planning exercises within it are not limited to the municipal boundary. Rather, existing drainage boundaries within the watershed are considered based on constraints imposed by topography, existing and proposed land uses, and other site-specific considerations. However, it is limited to an assessment of the drainage areas which contribute directly to the Town's system and the future annexation areas. Additionally, this study is focussed on stormwater management considerations, and does not include specialized studies such as biophysical or geotechnical assessments.

1.2 STUDY AREA

The Town of Black Diamond is located in the Sheep River watershed. Existing stormwater servicing is a mix of ditch drainage and limited pipe networks. During heavy precipitation events, localized ponding and flooding occasionally occurs, often requiring action by the Town's emergency services. Stormwater runoff from the existing developed area either directly to the Sheep River, or to the drainage course that transects the east part of the Town and from there flows to the Sheep River.

The Town has recently annexed five quarter-sections of land from Foothills County. Anticipated development in these areas is mostly residential, with some commercial and industrial. Stormwater from this future development will discharge to the drainage course, directly to the Sheep River, or will flow east into an ephemeral drainage course, and will need to be attenuated in stormwater facilities.

The Town has experienced problems in the past with flooding from the Sheep River which led to the construction of several flood mitigation measures. A study of the Sheep River floodplain is not part of the scope of this MDP as it is already the subject of an external study commissioned by the provincial government.

1.3 EXISTING SYSTEM ANALYSIS

The goals of the existing drainage system study are to:

- Delineate the existing drainage system, including catchments, flow paths, and depressions.
- Understand the characteristics of the existing system and current level of service.
- Identify any problem areas in the existing system, and propose drainage improvement options for them.
- Create a reference that can be used when discussing any future Municipal Improvement Programs or as a baseline to respond to any proposed infill developments.

1.4 FUTURE DEVELOPMENT DRAINAGE PLANNING

The goals of the drainage planning for future development areas are to:

- Develop Stormwater Servicing Strategies, including:
  - recommendations for stormwater targets for rate, volume, and quality;
  - recommendations for integration of sustainable stormwater practices with land use planning;
  - considerations for stormwater facilities design,
  - considerations and impacts of land use planning decisions on stormwater facility sizing;
  - requirements for regional infrastructure;
  - considerations for any interim servicing options; and
  - recommendations pertaining to wetlands.
- Align planning process and expectations with stormwater management principles; and
- Ensure an acceptable level of service can be provided while meeting watershed objectives and development constraints.

2.0 STORMWATER MANAGEMENT PRINCIPLES

Stormwater management in Alberta is regulated by the Province under both the Environmental Protection and Enhancement Act (EPEA) and the Water Act. There are provincial guidelines available via the Stormwater Management Guidelines for the Province of Alberta (January 1999), which establishes a minimum standard to which any development in the province must adhere. Any future stormwater servicing in Black Diamond must meet Provincial guidelines for peak rate control and water quality. Additionally, the Town of Black Diamond has adopted the more detailed City of Calgary Stormwater Management and Design Manual (2011) (See Engineering and Construction Standards Policy ADMIN-021) to guide the design and construction of stormwater infrastructure.

The City of Calgary Manual discusses the level of service, major and minor system component design, design of stormwater ponds and wetlands, water quality, and other items related to stormwater planning and infrastructure in detail. This section is not meant to replace the Manual, but rather to provide a convenient and brief summary of specific aspects of Calgary's stormwater design, which commonly relate to development in Black Diamond.

2.1 DUAL DRAINAGE CONCEPT

Stormwater drainage consists of an underground network of pipes and associated structures (the minor system) and overland drainage paths (the major system). The minor system is intended to provide a basic level of service by conveying flows from common low intensity rain events. Higher intensity rainstorms are conveyed by the major system once the minor system becomes overwhelmed. As such, the major and minor systems must be designed to work together to prevent overland flooding.

The major system is always present on the landscape, as water will always drain somewhere whether specific major system elements are planned or not.

Components of the dual drainage concept are listed in Table 2.1.1.

Table 2.1.1: Components of the Dual Drainage Concept

Minor System	Major System
• Catchbasins • Underground pipe system • Manholes • Outfalls to receiving waters	• Gutters • Lot drainage • Swales and ditches • Roads • Trap-lows • Escape routes • Storage facilities (ponds)

2.1.1 COMPARISON OF DUAL DRAINAGE APPROACHES

The division between flows entering the minor system and the major system can be managed in different ways.

The primary option is whether or not to control the rate at which water can enter the minor system:

- In the City of Calgary, the capture rate at every catchbasin is limited by Inlet Control Devices (ICD's); this ensures that the minor system is not surcharged (i.e. that the pipe is free-flowing and not full). ICD sizes are determined using Unit Area Release Rates (UARR's). The primary motivation for preventing surcharge is to allow individual homes and buildings to drain into the minor system, without risking back-up and basement flooding, and to explicitly control flow rates and velocities within the minor system. A secondary motivation is to simplify the integration of future development areas, since the impact on the storm system can be defined in advance.
- For comparison, many other western Canadian cities, such as Edmonton, use a surcharge approach, without any deliberate restriction to the rate of flow entering the minor system. Because the capacity of catchbasins to intercept water at the surface is typically many times higher than the capacity of the storm main, this results in surcharged pipes throughout the system, with storm mains flowing under pressure in some locations. This makes the minor system less expensive to construct, but does not provide any service to individual buildings, which must use sump pumps instead to drain any water back to surface. Additionally, flow may surcharge back to surface out of catchbasin grates or manhole lids during very large storms, and the major system may be more expensive as it must accommodate the extra flow.

The management of the major system is typically designed in one of two ways, corresponding to whether the capture rate is being limited:

- If the capture rate is limited, for example with ICD's, the major system is typically designed with trap-lows, localized areas of ponding around catchbasins that hold water temporarily while it is being slowly drained into the minor system. This allows for the required storage to be distributed around the catchment. Trap-lows are designed not to spill (or to only spill locally in managed locations) during the 1:100 year storm event, so that there are no significant overland flows during large storm events. This provides a larger degree of safety and can reduce the costs of the major system to accommodate the same size of storm.
- Cities which use a surcharge approach often allow a greater degree of overland spill during storm events as well, due to the design difficulties of balancing trap-low storage in a surcharged system (i.e. since flow is allowed to surcharge back to surface, trap-lows need to accommodate flow from the whole system, not just their local catchments). Although there may still be local low spots, the overall grades are designed to provide a continuous spill path down to a stormwater facility or final discharge point. This is simpler to design but can limit the maximum size of storm the system can safely accommodate, as overland flows can accumulate rapidly and exceed the flow-depth-velocity limits described in Provincial guidelines.

The majority of Canadian municipalities follow one of two design paradigms: ICD's and trap-lows, or surcharged pipes and continuous overland spill paths. Both methods must rely on a drainage system which is properly designed and respects flow-depth-velocity limits as detailed in provincial guidelines. Velocities in overland channels should be minimized to prevent a risk to public safety. A comparison of both methods and some key design implications are presented in Table 2.1.2.

Table 2.1.2: Comparison of Main Dual Drainage Approaches

ICD Plates and Surface Trap-lows	Surcharged Pipes
• Allows for open-channel flow in underground pipes, even during a high intensity, low frequency storm (i.e., a 1:100 year storm event) • Weeping tile around foundations of homes connects directly to storm sewers. The use of ICDs limits flows into the pipe system in order to reduce the risk of basement flooding. • Can simplify development requirements and review for private sites or future development areas. • Stormwater pipes must be deep enough in the road (roughly 3 meters) to allow for weeping tile connections, which makes their construction slightly more expensive, and maintenance slightly more difficult. • Stormwater ponds must be set at a lower elevation to avoid high water level hydraulic grade line interception with weeping tile connections in the basement of homes. • Surface trap-lows are designed to spill down roadways rather than into private lots, although the maximum extents of a trap-low may encroach on private property. • Elevation at the lowest top of footing (LTF) may be registered on lots to avoid interception with hydraulic grade line (HGL) from the storm system. • Depending on the ICD design, they can provide pre-screening for debris, which is a secondary benefit. • ICDs distribute surface storage throughout the catchment.	• The pipe network is designed to convey a design storm (1:5 year event) in open channel flow conditions, and events greater than that will surcharge the pipes, during more extreme events, potentially to surface. • Weeping tile in homes are connected to sump pumps; any direct connections will result in backup and basement flooding. Sump pumps may discharge to surface, or may connect to the storm service with backflow protection. • Stormwater pipes can be installed at a shallower depth (1.2-1.5 meters) • Stormwater ponds can be set at a higher elevation. This allows for less backsloping adjacent to the ponds. • Trap-lows in roads may still exist, but the road profile must be designed to provide a continuous spill route to the pond. • Surcharged pipes may become pressurized and introduce variables related to head pressure, suction, water hammer, and rising hydraulic grade lines. • Rising hydraulic grade lines may push the lids on stormwater manholes upwards in extreme cases. • Uncontrolled inflow to storm sewers can result in greater flooding downstream, where the likelihood of surface discharge is higher.

2.1.2 DUAL DRAINAGE IN BLACK DIAMOND

The Town of Black Diamond has adopted the City of Calgary's dual drainage approach, with minor system sizing based on UARRs. For new neighbourhoods, UARRs can be determined by the developer, as long as they meet City of Calgary standards. The following UARRs are recommended for consideration:

- 70 L/s/ha in relatively flat residential areas where trap-low storage can be provided.
- 80-90 L/s/ha for areas with moderate slopes where trap-low storage may be limited.
- 100-120 L/s/ha for areas with steep slopes where trap-low storage is limited, or areas with high densities and/or imperviousness (e.g. multi-family sites, industrial sites).
- > 120 L/s/ha for major roads or in areas where trap-low ponding is undesirable. For specific, small catchments where surface water must be minimized due to safety concerns, the UARR may need to be as high as 250 L/s/ha.

Lower release rates than the recommendations above may be considered on a case-by-case basis, but must be approved by the Town. Low rates may only be considered if there is enough available storage to minimize overland spill.

Individual lots within the established area of Black Diamond are primarily drained overland to the street, and the capture rate to the minor system is only controlled by catchbasins and ICD's in the public road. For any infill redevelopment, the developer must demonstrate that the proposed-condition runoff is less than or equal to the existing-condition runoff. For redevelopment lots which require a new minor system connection to existing infrastructure, the Town will provide an allowable release rate based on the capacity of the existing minor system and any site-specific constraints.

Future development areas should define UARR's to be consistent and provide clear allowable flow targets across the development. Trap-lows and ICD's should be used to control runoff locally, and trap-low spill or overland flow should be minimized wherever practicable. The requirement for an easement on title will be considered in new neighbourhoods to cover the trap-low extents if they encroach on private property. Allowable release rates should also be defined individually for any planned industrial, commercial, and institutional lots which would require minor system connections.

Educational information should be considered for residents to explain the purpose and locations of trap-lows, as residents are often not aware that the ponding is intentional.

2.1.3 LEVEL OF SERVICE OF THE DUAL DRAINAGE SYSTEM

Level of Service (LOS) refers to the behaviour of the major and minor systems during design storm events, and the return periods that they are designed to accommodate. The Town of Black Diamond has adopted the City of Calgary Stormwater Management and Design Manual to direct the design standard for stormwater management. The manual establishes that a basic level of service is provided by the minor system sized to convey the 1:5 year storm event, and the major system designed for the 1:100 year storm event to provide a reasonable level of flood protection.

The likelihood that a 1:100 year storm can occur in any given year is 1%. The likelihood that a 1:5 year storm can occur in any given year is 20%.

2.2 STORMWATER FACILITIES (PONDS)

In modern drainage design, stormwater facilities are used at the downstream end of conveyance systems, to provide temporary storage of stormwater runoff before releasing it to the receiving water body. This allows for rate control, releasing runoff into the downstream water body at predevelopment rates to reduce concerns about the increased runoff from a development causing flooding downstream. Stormwater facilities also provide water quality treatment of urban runoff before discharge to a downstream system. Additionally, some types of facilities offer benefits as recreational amenities, source of natural habitat, and opportunities for water re-use.

There are three main types of stormwater facilities - dry ponds, wet ponds and constructed wetlands. These are further described below.

2.2.1 DRY PONDS

Dry ponds are temporary storage areas, and do not typically have a permanent pool. The Riverwood pond is a dry pond. The advantage of dry ponds is that they are relatively simple to build and maintain, and the land area can be utilized for other activities, such as recreational playing fields, during dry periods. The disadvantage is that they provide no water quality improvement and can have difficulty drying out completely. Dry ponds cannot be used in areas where the downstream release rate is lower than 10 L/s/ha as the frequency of inundation is higher at low release rates and the facility cannot function as a dry pond within multi-use open space.

2.2.2 WET PONDS

Wet ponds have a permanent water pool which is maintained at a set elevation, and a large depth of freeboard above this level to provide temporary runoff storage during storms. Compared to dry ponds, wet ponds are more expensive to build and operate as they require more elaborate inlet and outlet structures, and may require an impervious liner to ensure water does not infiltrate from the permanent pool. However, wet ponds provide enhanced water quality due to settlement which occurs in the permanent pool and can accommodate much lower release rates. Additionally, they can be a valuable community amenity when integrated with park space or pathways. Wet ponds can also be sized to store irrigation water for nearby park spaces, to reduce the reliance on potable water.

2.2.3 CONSTRUCTED STORMWATER WETLANDS

There are many different configurations of wetlands used in stormwater management, depending on the goals of the system. Generally, constructed stormwater wetlands function similarly to wet ponds from a stormwater perspective, but have a greater focus on ecological functions. The differences depend on site-specific considerations and the balance between stormwater management and ecological factors:

- If a greater emphasis on stormwater management utility is desired, constructed wetlands are built similarly to wet ponds, but with accommodation for large planting zones around the pond. These plants help to treat nutrients such as Nitrogen and Phosphorus, which can cause algal blooms and odor issues on wet ponds. However, these water quality issues can still occur in constructed wetlands, particularly if the amount of vegetation is small compared to the size of the water area.
- If greater emphasis is placed on ecological function, constructed wetlands are often built with shallower and wider pools, to accommodate a greater range of vegetation and mimic a natural

wetland. This results in a larger facility than wet ponds for the same level of storage and flood protection, but provides much greater water quality benefit (e.g., are less likely to experience algal blooms and odor issues which can occur in wet ponds) and habitat benefit. They are often integrated into parks or natural areas and can be a major community amenity.

- In less common cases, natural wetlands are re-used as stormwater facilities. This has a significant advantage of maintaining the natural wetland soils and vegetation which have been established over a long period of time, as well as providing the best habitat value. However, implementation can be difficult depending on the natural topography and the pre-development characteristics of the wetland.

2.2.4 WATER QUALITY

There are two common methods to handle primary water quality treatment in stormwater ponds:

- Forebay: a permanent pool of water at the inlet of a pond; even dry ponds can have forebays, in which case the forebay is the only permanent water. This acts as a large sedimentation tank to remove suspended solids and grit. They can also protect the pond from erosion at the inlet. During a large storm event, the forebay spills over into the main body of the pond to utilize the pond's full storage volume. Forebays can be very effective in removing sediment. The primary disadvantage of forebays is that they are expensive to maintain in the future, as the sediment must be removed through either dredging or emptying the pond and regrading the bottom. They also do not provide any treatment of oil or floatables, so additional measures must be considered if this is a risk. The City of Calgary guidelines state that forebays should be sized for 25 years of sediment storage to reduce the frequency of this cleaning operation.
- Oil-Grit Separators (OGS's): OGS units are separation units built into manholes to treat flow dynamically as it passes through. There are several commercial manufacturers of OGS units with different configurations; all of them consist of some form of dynamic separation, sediment storage tank, and skimming weir to capture oil and floatables. Because of the smaller size of the units, they must be cleaned much more frequently (typically sized for a single year of sediment storage). However, the cleaning process is significantly easier, requiring only a single vacuum truck from the top of the manhole instead of the larger grading equipment required to dredge forebays. Additionally, OGS units require a much smaller footprint, and because they are in manholes they can be placed along the inlet pipe rather than in the pond itself, which allows for more flexibility on access options for servicing. The City of Calgary requires OGS units on all ponds in lieu of forebays, as per the December 2013 industry bulletin.

The City of Calgary guidelines set the following targets with respect to water quality, which should be used in the design of OGS units in Black Diamond:

- Removal of 85% of Total Suspended Solids (TSS) for particles 150 microns or greater when the OGS is upstream of a dry pond or wet pond.
- Removal of 85% of TSS for particles 75 microns or greater when the OGS is upstream of a stormwater wetland.

2.2.5 STORMWATER FACILITIES IN BLACK DIAMOND

There are currently two existing ponds in Black Diamond, the Willow Ridge dry pond, which has an OGS unit, and the Industrial Area dry pond, which has a forebay. All future development areas will require a stormwater pond to meet current Provincial and municipal standards.

For areas where the allowable release rate is greater than 10 L/s/ha, a dry pond is generally recommended due to the simplicity of operation and maintenance. For areas with lower release rates, wet ponds or stormwater wetlands are necessary.

The primary water quality treatment to reduce sediment loading should be through the use of Oil-Grit Separators (OGS's) as per the current City of Calgary standards, rather than forebays. OGS units must be placed at the inlets to stormwater facilities, to protect the facility from silting and contamination as well as meet Provincial regulation.

It will be up to the developer to propose the exact type and design of facility; these must be reviewed and approved by the Town. The design of ponds in Black Diamond must follow all City of Calgary standards with respect to safety, operation, access, maintenance, and other details, unless a specific relaxation is granted by the Town. The developer is also responsible to seek appropriate authorization from the Province, including EPEA, Water Act, DLO, and any other requirements for the pond and outfall.

2.3 EXISTING WETLANDS

Wetlands provide many critical functions and benefits, such as water filtration, groundwater recharge, drought and flood reduction, biodiversity support, and opportunities for tourism, boating, bird watching, nature photography, hunting and fishing. Many of the future development areas around Black Diamond contain existing prairie wetlands, and these must be considered in any development application.

All water in Alberta, including wetlands, is managed by the Crown and therefore is under provincial jurisdiction. The Public Lands Act, Section 3 provides the Government of Alberta with ownership to the beds and shores of most permanent and naturally occurring water bodies, even if the current land title is silent regarding ownership of a body of water. Public ownership must be determined prior to initiating any project. Additionally, any activity that affects or has the potential to affect (including cumulative effects) a water body, its catchment area and/or the aquatic environment (Water Act: Section 36) requires a Water Act approval. This includes draining, excavation, water control structures, and disturbing vegetation. It is the landowner's responsibility to ensure all regulatory requirements are met prior to commencing work in or near a wetland.

In 2014, Alberta released an updated Wetlands Policy which places heightened emphasis on wetland preservation, particularly in the southern region of the Province where historically over 90% of naturally occurring wetlands have been lost due to human activities. Under the Policy, wetland hierarchy is defines as:

- Preservation of natural wetlands should be the first choice, if possible
- If preservation is not possible due to the nature of project or activity, then mitigation of impacts should be considered
- Replacement/compensation is the "last resort" option if impact mitigation cannot be achieved.

Land development within a catchment of a natural wetland will impact wetland hydrology by taking the drainage away from the wetland. Recognizing that wetland preservation is not achievable in a post-development situation, the Province has developed a Guide to Wetland Construction in Stormwater Management Facilities (2018), which supports the Wetlands Policy. Where wetland impacts cannot be avoided, wetland reconstruction in accordance with the guidelines can maintain wetland area and relative wetland value, and can reduce or eliminate compensation costs. If reconstructed wetlands are intended to qualify as replacement wetlands under the Policy, the province typically asks for a Wetland Management Plan and a minimum of 5 years of monitoring to ensure that wetland health and function are maintained.

2.4 OUTFALLS AND RELEASE RATES

2.4.1 METHODOLOGY

In an urban setting, to control post-development runoff, the pre-development peak flow rate must be known to allow adequate sizing of storage facilities. The predevelopment release rates below were determined using regional analysis of Water Survey of Canada (WSC) flow gauges provided in the HYDAT database.

The normalized 1:100-year flow rate was estimated using the standard techniques found in *Federal Hydrologic and Hydraulic Procedures for Floodplain Delineation* (NRCan, 2019), and *Hydrology of Floods in Canada: A Guide to Planning and Design* (NRCC, 1989). The methodology to calculate the normalized 1:100-year rate is as follows:

- Based on observed historical flows, find the annual maximum series (AMS), the highest instantaneous flow that occurred each year. If instantaneous flows are not available, the highest daily average flow is scaled up by the average instantaneous peak to daily average flow ratio. This ratio is calculated using available data
- Filter the data to only those stations which have at least 25 "complete" years, as determined by the Water Survey of Canada
- Sort the AMS from smallest to largest and assign plotting positions (initial estimates of flood return period) based on the method of Cunnane (1978)
- Test the AMS for independence and stationarity
- Fit the AMS to a variety of distributions. Suggested distributions vary between guidelines, so this analysis included most of the commonly used ones:
    - Exponential
    - Generalized Extreme Value (GEV)
    - Gumbel
    - Weibull
    - Normal
    - Lognormal
    - 3-Parameter Lognormal
    - Gamma
    - Pearson III
    - Log-Pearson III
- There is no consensus between the guidelines regarding which frequency distribution is most suitable or which fitting method should be used to fit each distribution to the observed data. For this analysis, fitting was performed using maximum likelihood estimation (selecting the

distribution parameters which make the observed data most probable) because all of the stations analyzed have relatively long flow records. As a sensitivity check, other fitting methods such as the method of moments (setting population moments equal to sample moments) were also used to fit some of the distributions, but the differences in projected 100-year flow due to fitting methods were small compared to the differences due to distribution type

- Select the best fitting distribution. For the regional stations, this was automated by using the Kolmogorov-Smirnov (KS) Test, which compared the largest deviation between observed data and the best-fit prediction. The KS test was chosen in this case because it is the least likely to select extreme outliers when fitting multiple stations. For the Sheep River station at Black Diamond, the choice of best fitting distribution also considered the Akaike Information Criterion (AIC) and Bayesian Information Criterion (BIC) tests. Selected distributions were also checked visually to ensure they were appropriate
- Calculate the 100-year flow based on the selected distribution
- Normalize the 100-year rate by gross catchment area, as listed in HYDAT

For allowable release rates from a development within a particular sub-watershed, the accepted practice is to determine the rate based on the total sub-watershed area, rather than the effective catchment area. This ensures that each development parcel within a sub-watershed will have the same release rate target, and individual landowners or development areas do not get penalized based on their site-specific hydrology.

2.4.2 SHEEP RIVER WATERSHED

The Sheep River watershed is shown in Figure 2.4.1. The total watershed area draining to station 05BL014, which is the flow gauge on the Highway 22 bridge in Black Diamond, is 592.2 km^2.

Based on the methodology above, the 1:100 year flow in the Sheep River was estimated to be 750 m^3/s, or 12.7 L/s/ha over the total catchment area. For comparison, the *Bow, Elbow, Highwood and Sheep River Hydrology Assessment* (Golder Associated, 2017) calculated a slightly higher 1:100 year flow of 787 m^3/s, or 13.3 L/s/ha; the two estimates are very close in context. In order to be conservative when sizing ponds and outfalls, it is recommended to use the smaller of the calculated rates, 12.7 L/s/ha, for any infrastructure which drains directly to the Sheep River.

2.4.3 REGIONAL HYDROLOGIC ANALYSIS

Black Diamond is situated between two different hydrologic zones with very different runoff characteristics. To the west of the Town, the hydrology is dominated by the steep mountains and foothills in Kananaskis Country & Sheep River Provincial Park. In contrast, the area to the east of the Town is more characteristic of the prairies, with much more gentle topography which is used primarily as agricultural or ranch land.

This means that the characteristics, notably peak flow rates, of drainage courses in the area can vary significantly. The Sheep River, which starts in the mountains, has a high 1:100 year flow rate of 12.7 L/s/ha, as per Section 2.4.2; similarly high rates are found in most of the creeks and rivers which have headwaters in the mountains.

However, drainage courses starting around the Town, and to the East, are expected to have much lower flow rates. For example, the East Drainage Ditch, as discussed in Section 3.4, has a modelled 1:100 year rate of 8.0 L/s/ha where it first enters the Town. This is comparable to stations which are similarly at the edge of the prairies, such as Stimson Creek and Pekisko Creek near Longview south of Black Diamond, or Little Red Deer River and Beaverdam Creek near Cochrane to the north.

To illustrate the East-West gradient of peak flow rates in the transition from the foothills to the prairies, the methodology above was used to calculate a 1:100 year flow rate for every station available in the HYDAT database with more than 10 years of data.

The resulting 1:100 year flow rates, normalized by total catchment area, are presented in Figure 2.4.2. These flow rates should be used with caution, as individual stations' data was not examined for quality, nor were natural flows back-calculated for managed rivers. However, spot checks of the data showed that the HYDAT data and resulting projections were consistent overall.

Figure 2.4.2 illustrates the wide range and general gradient of peak flow rates across the region. Flow rates in the mountains, or streams with mountain headwaters, range from approximately 8-18 L/s/ha (for smaller rivers; larger rivers such as the Bow and Oldman have lower area-normalized flows which is expected). Flow rates in the foothills rivers and creeks at about the same distance from the mountains as Black Diamond are in the range of 7-9 L/s/ha. Further east, by High River and Aldersyde, flow rates decrease to around 4-5 L/s/ha. In the prairies, flow rates as low as 1-2 L/s/ha are common.

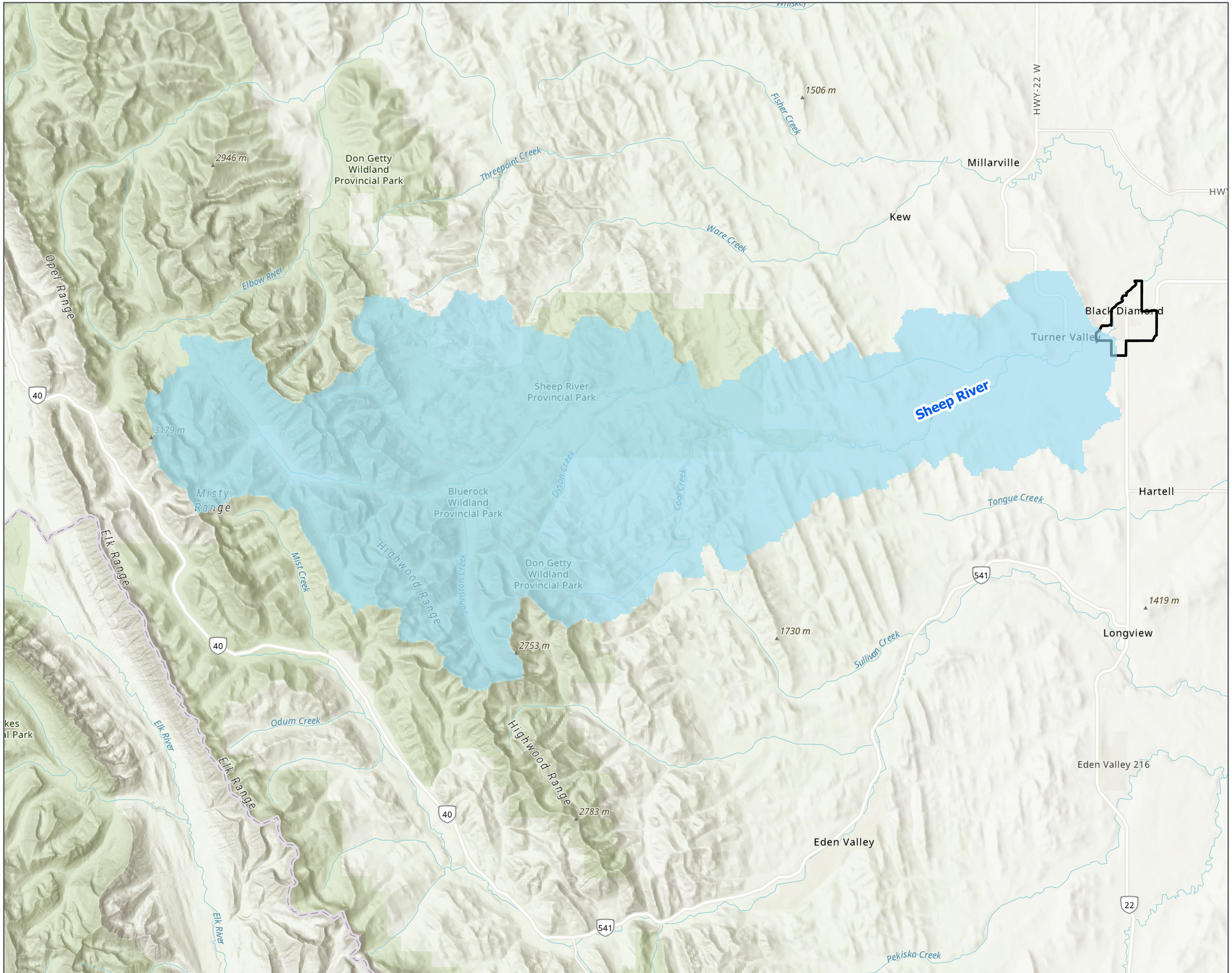
2.4.4 RECOMMENDED RELEASE RATES

Because of the east-west gradient shown in the regional analysis, it is recommended to vary the allowable release rate based on outfall location, to match estimated predevelopment flows:

Table 2.4.1: Release Rates by Outfall

Outfall Location	*Allowable 1:100 Year Release Rate*
Sheep River (Directly)	12.7 L/s/ha
Riverwood Energy Dissipation Structure and East Drainage Channel	8.0 L/s/ha
East Ephemeral Flow Path	2 - 4.0 L/s/ha

- For any outfalls directly to the Sheep River, the projected flow rate of 12.7 L/s/ha can be used.
- For outfalls to the east drainage channel, the modelled flow rate of 8.0 L/s/ha would match predevelopment flows. Note that this ditch does not appear to have capacity for the 1:100 year storm in the existing conditions, but with such a large catchment area limiting post-development flow provides relatively little benefit. This is discussed further in Section 3.4.
- For outfalls that will discharge to ephemeral drainage courses to the East, a lower release rate of 2-4.0 L/s/ha is determined based on the regional analysis. However, additional considerations for discharge to this drainage course should apply. This is further discussed in Section 4. Higher release rates could be considered if the developer can demonstrate downstream channel capacity.



Town of Black Diamond

Master Drainage Plan

Sheep River Watershed

Legend

- Sheep River Catchment
- Town Boundary

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 2 4 6 Kilometers

Coordinate System: NAD 1983 3TM 114

Scale: 1:200,000 (When plotted at 11"x17")

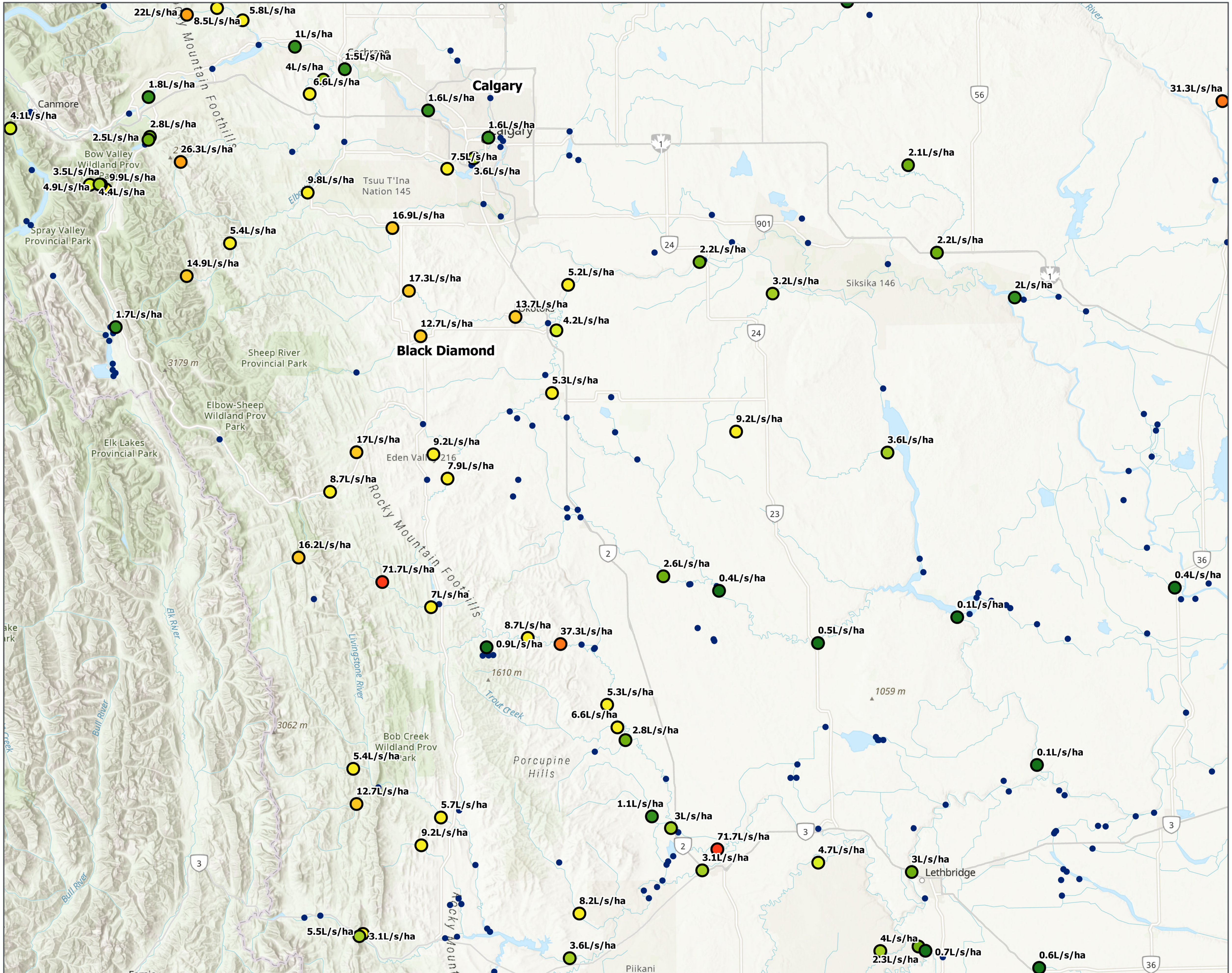
Data Sources:

- Data provided by Town of Black Diamond and AEP.

Project #:	0925.0036.01
Author:	JW
Checked:	BR
Status:	Final
Revision:	A
Date:	2021 / 4 / 19

URBAN systems

FIGURE 2.4.1



Town of Black Diamond

Master Drainage Plan

Preliminary Regional Comparison of 1:100 Year Flow Rates

Legend

Hydat Stations (Mid-Long Recrod)

100 Year Flow (L/s/ha)

- ≤1
- 1 - 2
- 2 - 3
- 3 - 4
- 4 - 5
- 5 - 10
- 10 - 20
- 20 - 30
- 20 - 50
- 50 - 72
- Hydat Stations (Short Record)

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 5 10 15 Kilometers

Coordinate System: NAD 1983 3TM 114

Scale: 1:750,000 (When plotted at 11"x17")

Data Sources:

- Data provided by Town of Black Diamond and AEP.

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URBAN systems

FIGURE 2.4.2

3.0 EXISTING SYSTEM ANALYSIS

3.1 METHODOLOGY

For the existing conditions, catchments, flow paths, and surface ponding areas were delineated primarily using LiDAR:

- High resolution (1 m) LiDAR was used for the Town site and immediate vicinity.
- 15 m LiDAR was used for the wider watershed (south of Township Road 200).

The LiDAR information was supplemented by GIS and record information for the drainage system within the Town itself, including:

- GIS Database available from the Oldman River Regional Services Commission;
- Town of Black Diamond Black Map Book Drawings (Created by BSEI prior to 2013);
- Riverwood Estates Phase 2 Tentative Plan;
- Diamond Valley Industrial Stormwater Management Plan; and
- Willow Ridge Master Drainage Plan, May 1999, Jubilee Engineering Consultants Ltd.

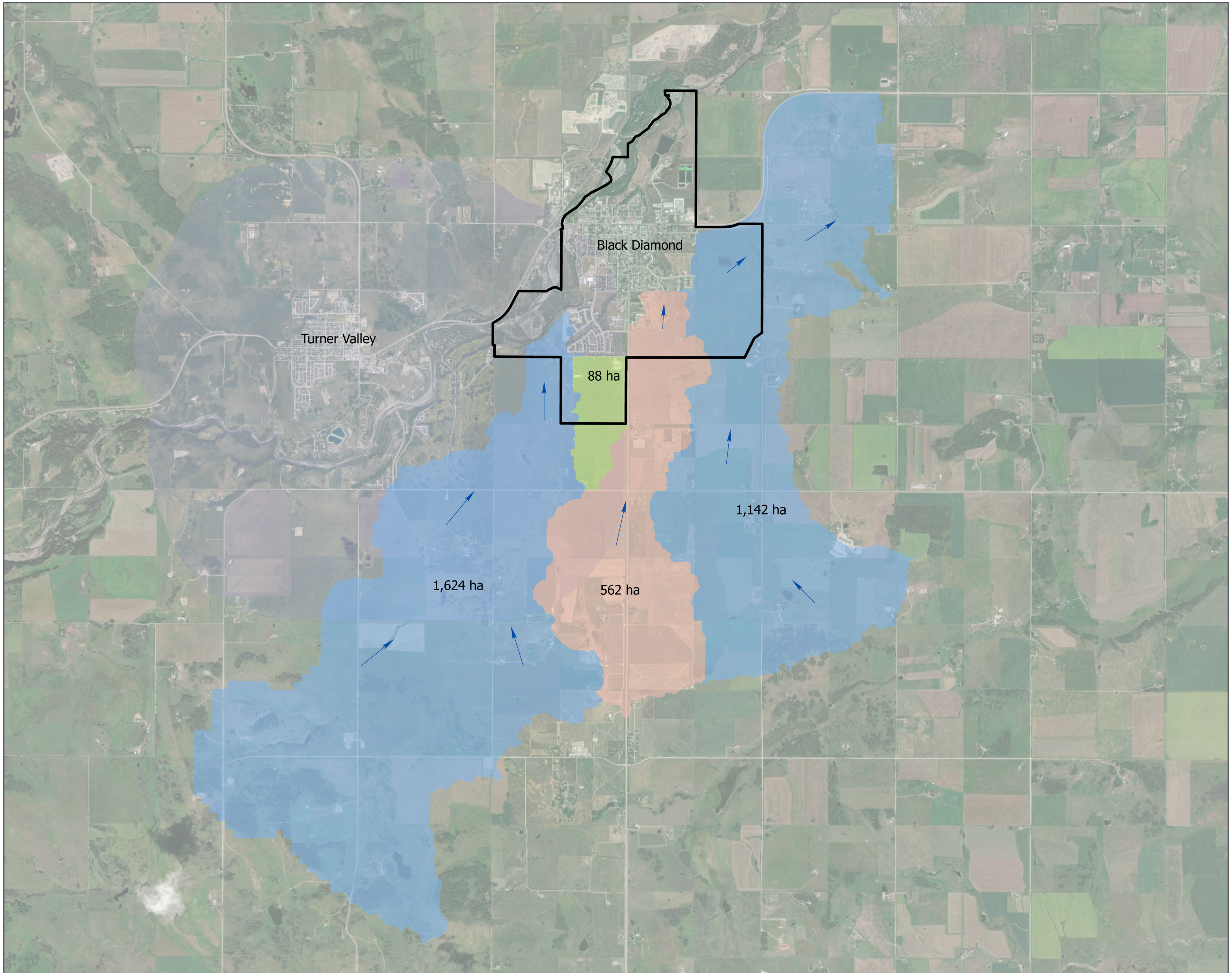
The entire catchment area of the Town, including the new annexation areas, was modelled using PCSWMM. Upstream wetlands and natural depression storages were modelled explicitly as storage nodes connected by conduits representing flow paths. Volumes and spill elevations were calculated from the LiDAR information, to allow surface depressions to fill up during small storm events, and spill downstream only in larger events or after antecedent rainfall.

For the catchment areas within the town, trap-lows and major system flow paths were calculated based on LiDAR, and the minor system was input manually into the model based on the information sources above. Trap-low spill points were modelled as conduits to allow the model to account for any runoff that overwhelmed the minor system. Inlet control devices were included in the model based on design drawings, although no survey information was available to confirm current ICD configurations.

3.2 CATCHMENTS, FLOW PATHS, AND DEPRESSIONS

The overall watersheds contributing to the Town are shown in Figure 3.2.1, and infrastructure and catchments within the Town are shown in Figures 3.2.2 and 3.2.3. There are five main catchment areas:

- The area to the southwest, in blue in Figure 3.2.1, drains through the constructed channel on the west side of Willow Ridge, and through the energy dissipator.
- A small area, in green, drains to the ditch system along Highway 22, and eventually makes its way to the Willow Ridge Dry pond. The Willow Ridge/Riverwood neighbourhood, hospital, and Lodge are part of this system.
- The catchment area upstream of the Kaiser ASP area is shown in orange, this drains through the existing drainage channel and to the Sheep River north of Town. The existing area around downtown drains into this channel on the north side of Highway 7.
- The northeast corner of the Town drains directly to the Sheep River via a series of local outfalls
- The catchment area on the east side of the Town, in blue, drains to an ephemeral channel which heads east and then north, eventually joining the Sheep River by Range Road 15.



Town of Black Diamond

Master Drainage Plan

Regional Catchment Plan

Legend

Catchments

- Catchment Areas
- Catchment Areas - Kaiser
- Catchment Areas - Riverwood
- Town Boundary

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.

0 500 1,000 1,500
Meters

Coordinate System: NAD 1983 3TM 114

Scale: 1:45,000 (When plotted at 11"x17")

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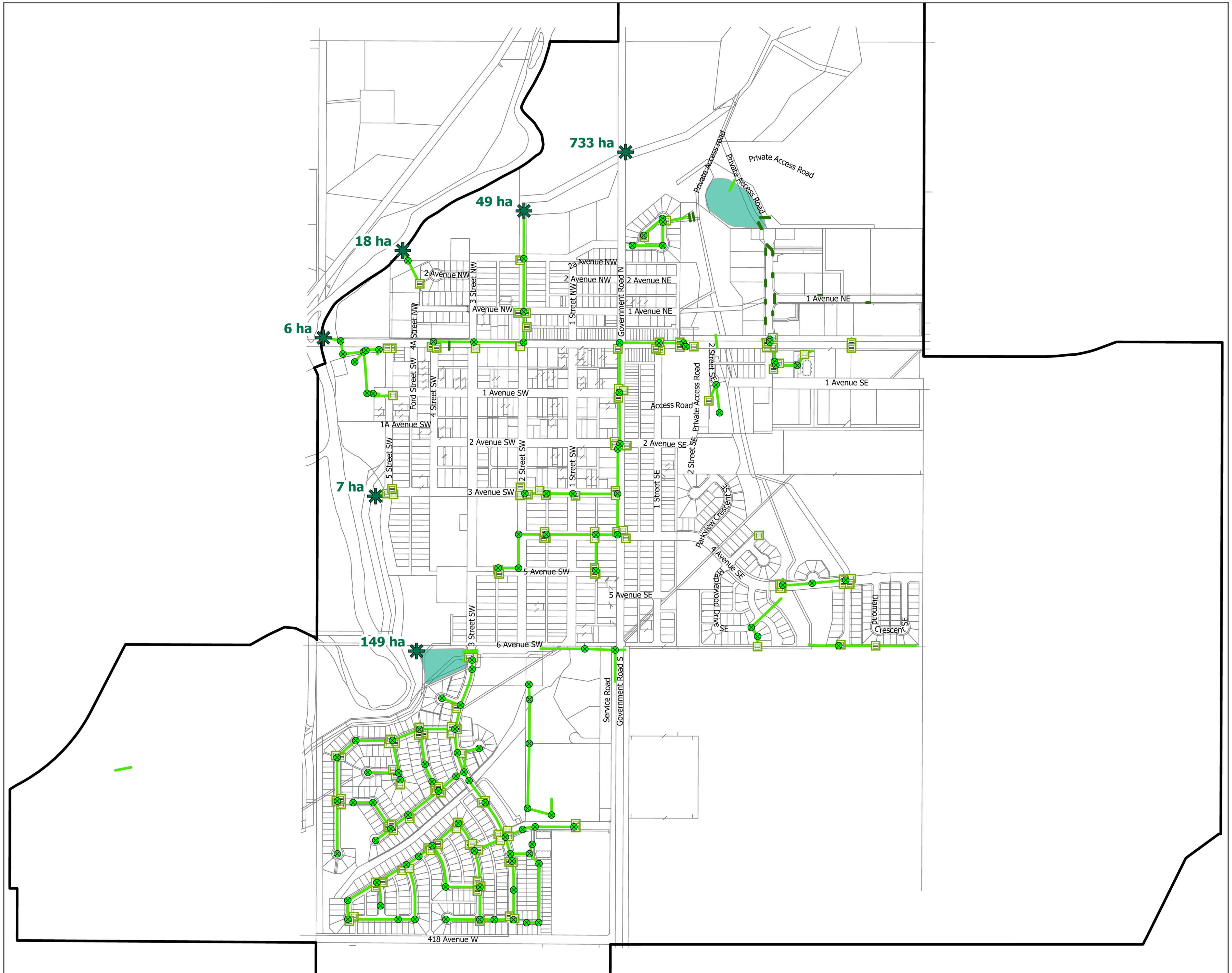
URBAN systems

FIGURE 3.2.1



Town of Black Diamond

Master Drainage Plan

Existing Infrastructure

Legend

- Manhole
- Catch Basin
- Storm System Outlets
- Storm Main
- Culvert
- Storm Pond
- Town Boundary

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0 100 200 300
Meters

Coordinate System: NAD 1983 3TM 114

Scale: 1:10,000 (When plotted at 11"x17")

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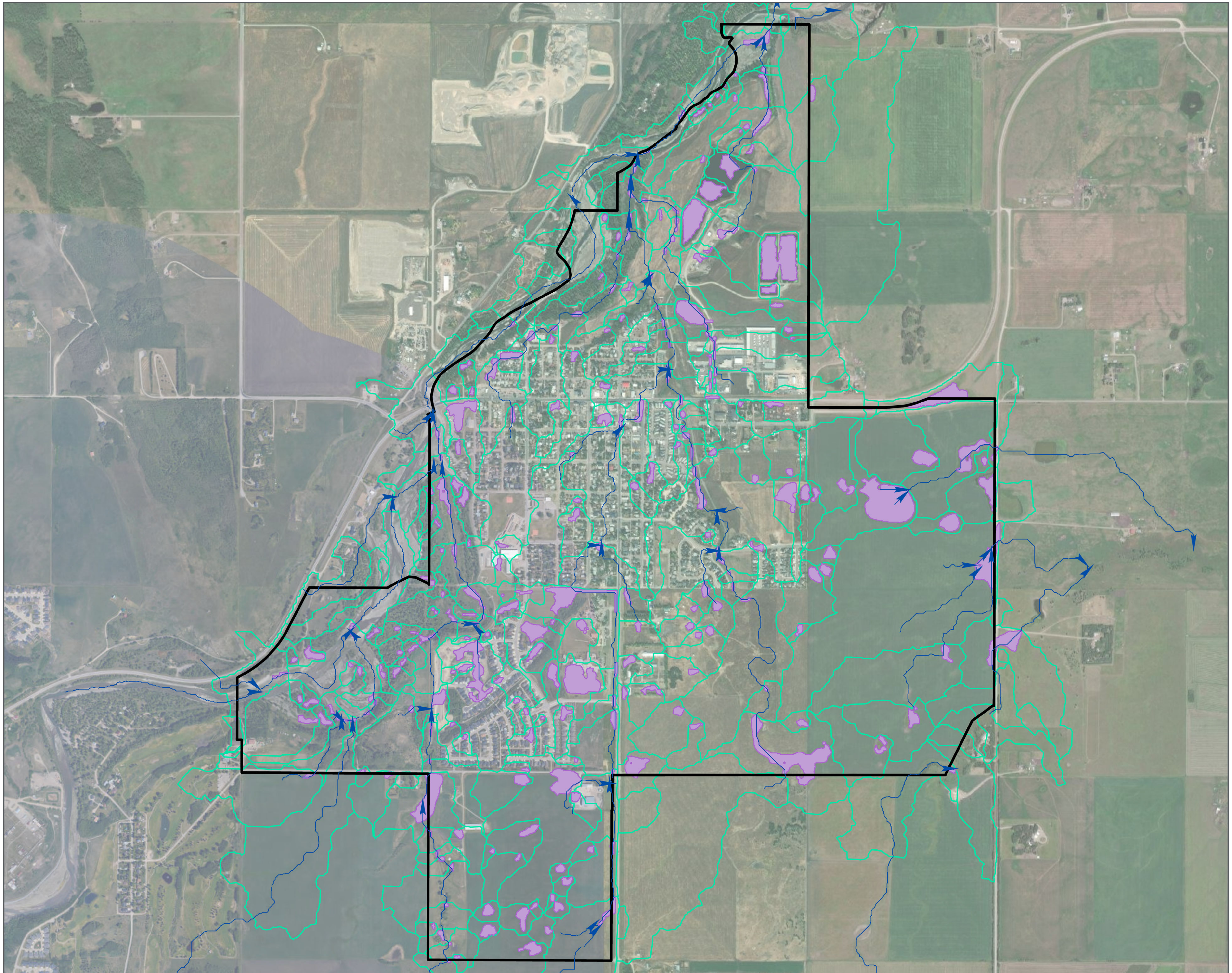
URBAN systems

FIGURE 3.2.2



Town of Black Diamond

Master Drainage Plan

Catchment Plan

Legend

- Major Flow Path
- Catchments
- Depression Storage
- Town Boundary

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0 100 200 300
Meters

N

Coordinate System: NAD 1983 3TM 114

Scale: 1:16,000 (When plotted at 11"x17")

Data Sources:

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URBAN systems

FIGURE 3.2.3

3.3 ANALYSIS

Stormwater management analysis was carried out using the PCSWMM computer simulation. The model simulated a single event at the 2, 5, 100, and 200 year return period levels, in order to establish an estimate of the performance of the piped system under its design return period (5 year) and an extreme event (100 year). The 200 year return period event was provided to illustrate the effects of an extremely unlikely rainfall event.

The single event analysis makes use of a theoretical design storm event. In this case, the design events are based on a Chicago design storm for a 24 hour duration, 5 minute time steps and based on the criteria established in the City of Calgary Stormwater Management and Design Guidelines (2011).

The return period design storm results are presented in Appendix A. The following figures from Appendix A demonstrate modeled pipe capacity and level of service for each return period. In general, flow paths are well defined, and although many pipes within older segments of the Town indicate that they are surcharged during a 1:2 year return period event, the major system (overland flows) is sufficient to transport flows. This is not unexpected, as stormwater drainage systems were previously designed to convey 1:2 year flows and surcharge to surface using the method described in Table 1.1 above. Most development in Alberta that is older than 1960 was designed using these standards.

- Figure A-1 – Level of Service 1:2 Year Return Period
- Figure A-2 – Level of Service 1:5 Year Return Period
- Figure A-3 – Level of Service 1:100 Year Return Period
- Figure A-4 – Level of Service 1:200 Year Return Period

The pipe capacity figures indicate that the reach of the stormwater pipe along Government Road and 4th Avenue SW is over capacity in as little as a 1:2 year return period design storm. This length of pipe is undersized and surcharges to surface in several locations. During a rain event, the pipes and catchbasins fill up which results in water flooding (surcharge) to the road surface. For the most part, surcharge to surface is conveyed by road gutters and does not present a risk to flooding private property. However, the catchbasin at Government Road and 1st Ave SW has been identified as a problem area and recommended solutions are discussed in Section 5.0 Problem Areas.

The catchbasins at the intersection of Government Road and 4th Avenue SW capture a large catchment area (12 hectares) on the east half of Government Road that extends south as far as the Hospital entrance. During more extreme events, the pipe reach is surcharged and runoff from this catchment area causes flow in the pipe along 4th Avenue SW to reverse. Catchbasins along 4th Avenue SW will have water bubbling to surface that is coming from Government road south of 4th Avenue SW. Given the surface information provided in the LiDAR, the surcharge to surface along 4th Avenue is conveyed west and joins the overland flow paths that flow north along 3rd Street SW.

3.4 DRAINAGE CHANNEL

The drainage channel that conveys stormwater flows on the east side of Town has a total catchment area of 733 hectares at its outfall to the Sheep River. The catchment area comprises a mix of upstream undeveloped and agricultural land uses and urban development within Town.

The channel was modelled under a 1:100 year, 24 hour design storm to assess capacity and peak flow runoff from catchment areas. In the model, the storm is assumed to be applied to the entire catchment area simultaneously. While high-intensity Alberta storms tend to be more concentrated in one location, a moving storm may have the same impact across a catchment of this size over a 24 hour duration.

The channel intersects the limit of the developed Town at 6th Avenue SE with an upstream catchment area of 562 hectares to this point. Catchment areas within the Town bring the total catchment area at Centre Avenue to be 606 hectares. The channel within the Town is well defined, with modelled flow rates at key culverts presented in Table 3.4.1.

Table 3.4.1: Modelled Flow Rates in East Ditch

Location	***Culvert Type***	***Catchment Area***	***Catchment Characteristics***	***Peak Flow Rate***
4th Avenue SE	1600 mm CSP & 800 mm CSP	562 ha	flows from the undeveloped agricultural catchments, meandering vegetated channel and attenuation in wetlands.	4.5 m^3/s
Centre Avenue	Concrete Box Culvert 2.134 x 2.134 m	606 ha	undeveloped catchments upstream of the Town as well as urban areas discharging to the ditch	4.6 m^3/s

The hydrograph in the channel at Centre Avenue has a double peak. The first peak is 2.9 m^3/s from 48 hectares of urban catchments within the Town, but the second peak is higher at 4.6 m^3/s, due to upstream catchments. This indicates that flows from the upstream catchment areas are attenuated such that the channel is able to convey the peak from urban runoff first prior to the peak from rural drainage passing through.

The upstream catchments south of Town generally have agricultural land uses with intermittently defined flow paths and frequent depressions and wetlands. Model results indicate that the peak flowrate within the upstream channel is 8 m^3/s and occurs near 434 Ave. By the time flows reach the Town, this flowrate has been attenuated almost in half to 4.5 m^3/s. This attenuation is significant. During a rainfall event, depressions in the landscape from very small (puddles) to very large (wetlands) fill up with water and spill downstream. During small rainfall events, not many depressions spill to each other, creating a small amount of runoff and a small effective catchment area. During extreme rainfall events, each depression slows down the peak of the runoff.

Elevation of the channel at Centre Avenue south of the box culvert is 1078.84m and it is spilling over Highway 7. An escape route cuts across the intersection at 2nd Street SE, and the flow path may impact properties on the southwest corner of the intersection.

Figure 3.4.1 shows the current spill path of the drainage channel. Blue areas indicate the extent of ponding at spill (not necessarily the same as the extent of ponding during a 1:100 year storm). When the drainage channel backs up at Highway 7, it first spills to the West into the parking lot of Kid's Stop. It then spills across 2nd St SE into the mobile homes and continues West following the sidewalk until spilling over the Highway at 1st St SE.

Based on the model results, it is recommended that the culvert capacity at Highway 7 should be increased to handle the 1:100 year event, and that the overland flow path over the Highway 7 should be regraded to mitigate risk of flooding to private properties, and maintain the spill path on roadways.

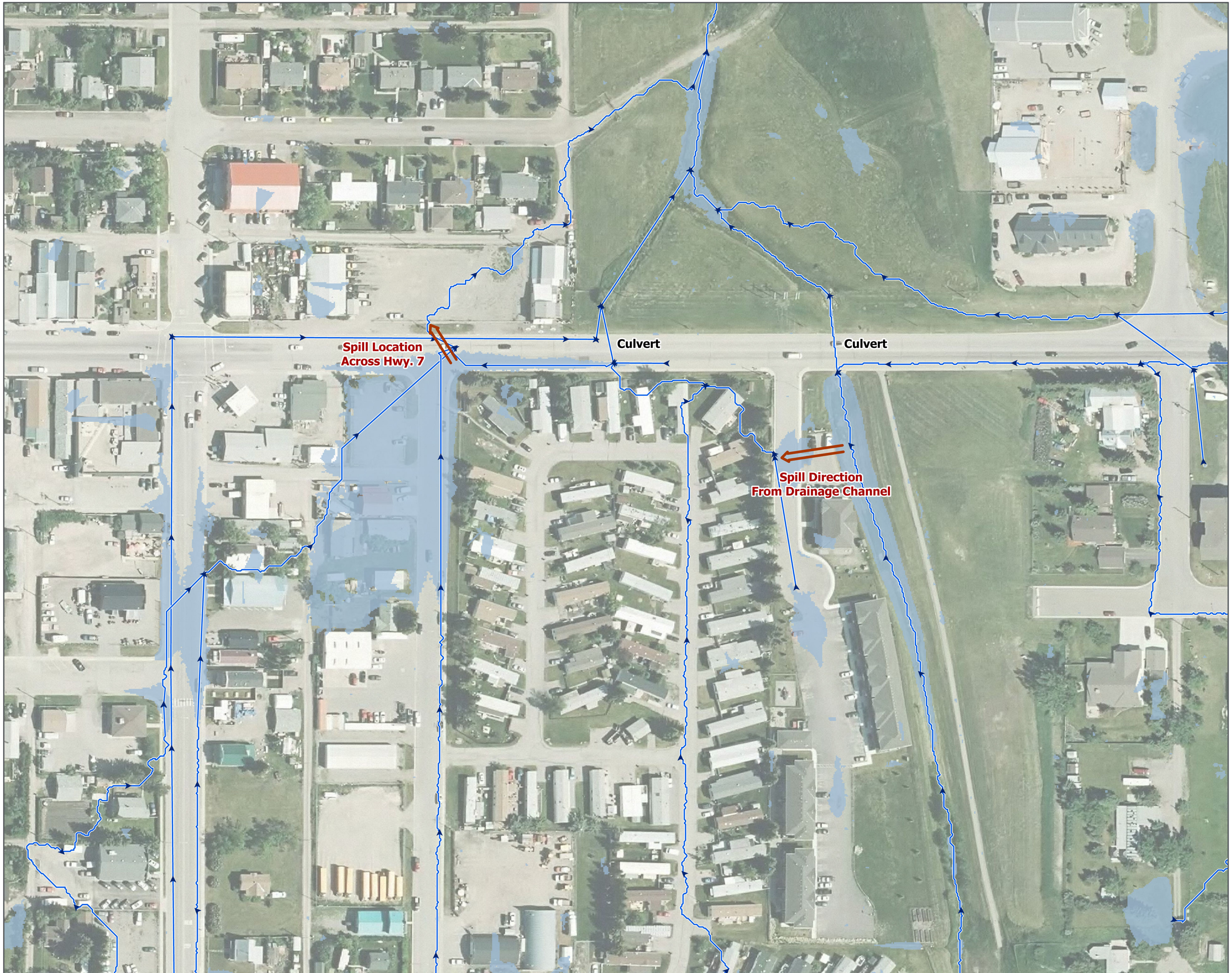
However, in discussions with the Town, this ditch has not experienced flooding problems in the past. There has not been a 1:100 year storm recorded recently in this area, so the true performance of the culverts during a 100 year storm is unknown. However, the model may be conservative with respect to peak flows or the shape of the hydrograph for large rural catchments. Given the relatively low risk of flooding (only in an extreme storm event) and the significant challenges with upgrading infrastructure within the Provincial Highway right-of-way (outside of the jurisdiction of Black Diamond), another option is to monitor the culvert and channel in the short term (2-3 years), rather than seeking to upgrade it immediately. By installing a flow monitor in the culvert, the existing system model would be calibrated more specifically to the flow in this channel, rather than relying on regional averages. This would provide a more precise prediction of the performance and resulting level of risk during an extreme event. If the calibrated model still supports the conclusion that a culvert upgrade is required, it would provide stronger evidence for the Town to engage with Alberta Transportation.

3.5 PROBLEM AREAS AND RECOMMENDATIONS

The Town staff has identified areas where, during heavy precipitation events, localized ponding and flooding require action by the Town's emergency services. These locations were combined with observations based on the depression and flow path analysis to identify specific problem areas through the existing system, as shown on Figure 3.5.1.

A detailed table is provided in Appendix B which describes each problem area, the likely cause of the problem, and current level of servicing based on the existing system analysis, and recommendations for amelioration.

Additionally, the flooding issues at Government Road and 1st Ave SW were identified as being a particularly high priority, and several different options were proposed to reduce the flooding risk. These are presented in Appendix C.



Town of Black Diamond

Master Drainage Plan

Escape Route for Flow in Drainage Channel

Legend

- Flow Path
- Depressions
- Town Boundary

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0 20 40 60
Meters

Coordinate System: NAD 1983 3TM 114

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

Data Sources:

- Data provided by Town of Black Diamond and AEP.

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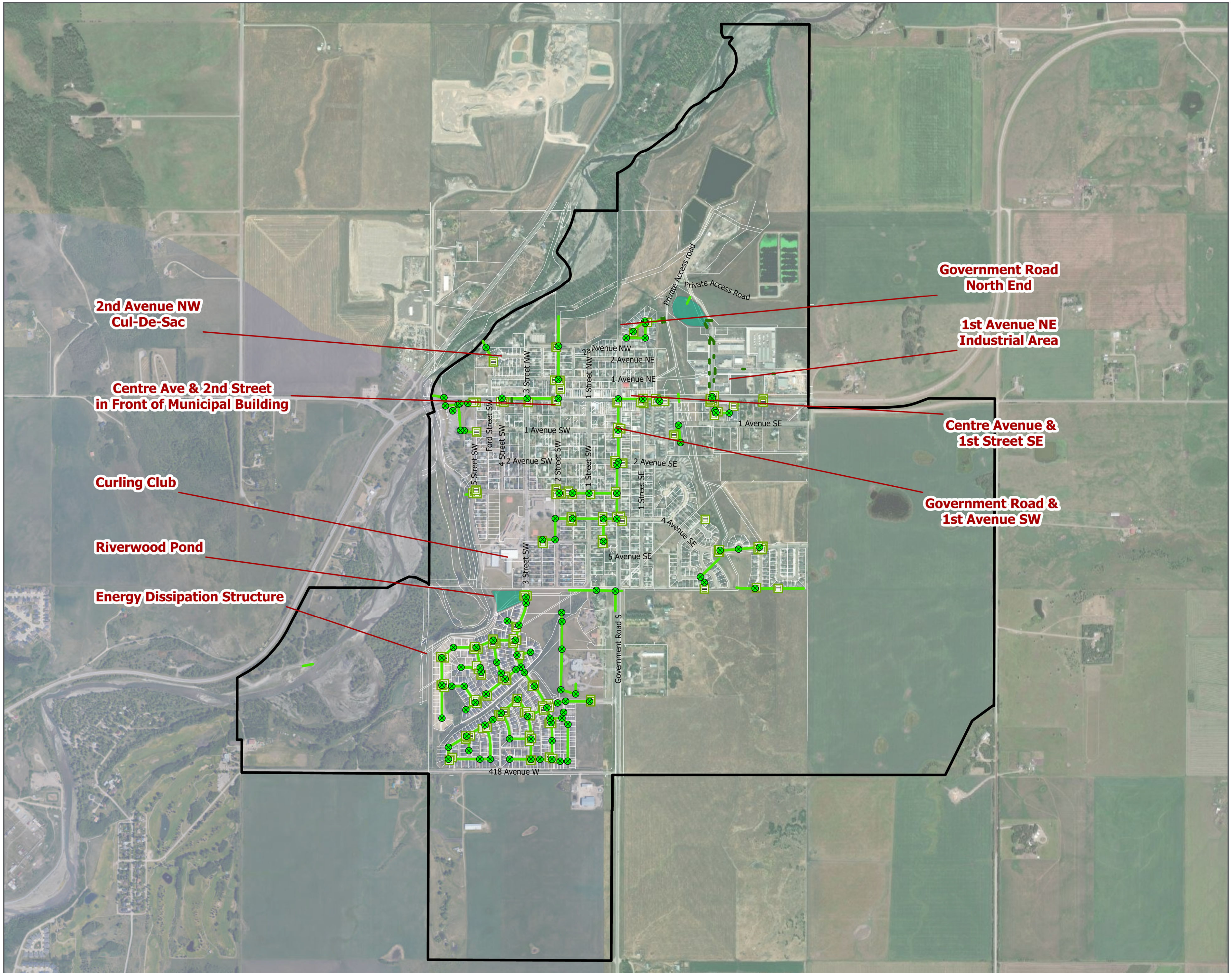
URBAN systems

FIGURE 3.4.1



Town of Black Diamond

Master Drainage Plan

Known Problem Areas

Legend

- Manhole
- Catch Basin
- Storm Main
- Culvert
- Storm Pond
- Town Boundary

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0 100 200 300
Meters

Coordinate System: NAD 1983 3TM 114

Scale: 1:16,000 (When plotted at 11"x17")

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URBAN systems

FIGURE 3.5.1

4.0 FUTURE DEVELOPMENT

The future servicing strategy is informed by the Stormwater Management Guidelines for the Province of Alberta (January 1999) and the City of Calgary Stormwater Management and Design Guidelines (2011) adopted by the Town of Black Diamond. Although the guidelines provide practical and specific guidance, there must be flexibility to account for site specific conditions. No single stormwater management technique should be universally recommended, and the guidance discussed in this document is intended to capture the preferences and style of stormwater management expected in future growth of Black Diamond.

4.1 SYSTEM PLANNING CONSIDERATIONS

The information in this section builds on the existing guidelines and provides additional information on key regulatory, planning and design aspects.

4.1.1 REGULATORY CONSIDERATIONS

Alberta Environment and Parks (AEP) is the main regulatory body that regulates stormwater discharges and surface water management. Two provincial legislations govern the quality, quantity and use of water - the *Environmental Protection and Enhancement Act* (EPEA) and the *Water Act*.

The purpose of EPEA is to "support and promote the protection, enhancement and wise use of the environment". This Act focuses more on quality-based outcomes. In general, EPEA authorization is required for the construction and operation of a storm drainage system including the stormwater management facilities (SWMF), the sewer system, any other appurtenances used to collect storm drainage. Water quality and treatment standards and requirements are regulated by EPEA.

The Water Act is primarily focused on water quantity and water use. The purpose of the Water Act is to "support and promote the conservation and management of water, including the wise allocation of water". The diversion and use of all surface water in Alberta, including stormwater, requires a licence under the Water Act. An approval under the Water Act is required for outfalls to receiving water bodies, and any impacts to existing drainage channels and wetlands. Removal and compensation for removed wetlands is managed under the Water Act. In the case of preserved wetlands (i.e. wetlands that are not impacted by land development, are usually taken as Environmental Reserve (ER) and are not subject to compensation), the water regime of the wetlands and evaporative losses may not be changed, otherwise a water licence requirement may be triggered.

An application for approval and registration under the EPEA and Water Act is required for each new development. For EPEA, a design level of detail at Staged Master Drainage Plan level is required. For Water Act, in addition to a Master Drainage Plan or a Staged Master Drainage Plan, environmental studies are required, and may include a Wetland Inventory, Wetland Permanence Assessment, Biophysical Impact Assessment, and a Wetland Classification Report.

4.1.2 WETLAND MANAGEMENT

The future development areas in Black Diamond contain a number of existing wetlands and drainage. Wetlands are hydrologically valuable as they play a significant role in watershed protection through their capacity to improve water quality, reduce flooding and erosion, and maintain habitat and biodiversity. As discussed in Section 2.3, the 2014 Alberta Wetlands Policy strongly supports the preservation of existing wetlands. While every effort should be made to preserve environmentally significant wetlands, development impacts are unavoidable. The following general guidelines are provided to ensure better decision about preservation or integration of wetlands and stormwater management during land development process:

- An Ecological Inventory (EI) or Biophysical Impact Assessment (BIA) should be completed at the Area Structure Plan or Outline Plan stage and should identify wetlands that will be preserved, wetlands that will be reconstructed and integrated with stormwater concept, and wetlands that will be compensated.
- Decision about which wetlands to preserve and how they can be integrated in the stormwater system should also consider long-term operational and maintenance costs for the Town.
- Preserved wetlands are fully protected in their natural state and are not a part of post-development stormwater management system. However, development will impact these wetlands by reducing or eliminating their catchment area, even if an environmental setback is maintained. Within current regulatory framework, stormwater cannot be pumped into these wetlands to preserve their hydroperiod, without requiring a license under the Water Act.
- Reconstructed wetlands that qualify as replacement wetlands under the Wetlands Policy must be constructed in accordance with the 2018 Provincial Guidelines for Wetland Construction in Stormwater Facilities. The Guidelines specify the side slopes, depths in various wetland zones, , placement of inlets and outlets, water quality and pre-treatment requirements, vegetation, and most importantly, duration of inundation within wetland zones. Wetland design and compliance with provincial design guidelines must be included in the SMDP report.
- Reconstructed wetlands that meet design guidelines will have a primary biological, and secondary stormwater function. These wetlands will qualify for ER designation and will have a monitoring requirement which will be specified by the Province during Water Act approval process.
- Preserved and reconstructed wetlands require a Wetland Management Plan (WMP) that can be included as part of a Pond Report or be a stand-alone document. The WMP must include monitoring plan, and vegetation and habitat management plans.
- Only highly treated stormwater may be discharged to reconstructed wetlands. The type and level of treatment and expected inflow water quality should be described in the SMDP report. In addition to treatment provided by an upstream OGS unit, often a mechanical or biological filter system may need to be considered to ensure adequate level of pollutant and nutrient removal.

4.1.3 STORMWATER DESIGN TARGETS AND LEVEL OF SERVICE

Stormwater design in new development areas upstream of stormwater management facilities will be based on a dual drainage system with UARRs as described in Section 2.1.2. Trap-lows should be used to minimize overland spill wherever practical. For all new development, the minor system should be sized for a 1:5 year level of service and the major system should be sized for a 1:100 year level of service.

The release rate from stormwater facilities to the downstream system will depend be based on the pre-development flow rate established for the receiving water body, as presented in Table 2.4.1 in Section 2.4.4.

Currently, there are no discharge volume restrictions specified for the Sheep River Watershed, and specific volume control targets have not been set for future development areas. However, it is strongly recommended that all new developments incorporate volume reduction strategies into stormwater planning process. Significant volume reduction can be achieved by mandating and encouraging LID practices such as absorbent landscaping, impervious area disconnection, and better site planning. These practices are further described in the following section.

4.1.4 SUSTAINABLE STORMWATER MANAGEMENT AND LID IMPLEMENTATION

Integration of Low Impact development (LID) practices in land development projects is supported by high level planning policies; however, it is not a mandatory design requirement. Usually, it is the responsibility of developers and their design teams to determine whether to include LID into site planning and which practices would be appropriate.

The LID implementation is recommended to reduce runoff volumes and improve overall discharge water quality. The Town should set minimum requirements for LID implementation in all new developments, that include:

- Absorbent landscaping - a minimum of 300 mm of topsoil depth should be standard for all landscaped areas, both on private and public property. At a minimum, 70% of pervious surfaces should have absorbent landscaping. The only area that should be exempt is the area immediately adjacent to buildings, to prevent water seepage to basements and foundations.
- Better site planning - practices that reduce overall imperviousness and increase impervious area disconnection should be encouraged through the planning process. Overall, a new development area should have 50% of impervious surface disconnected (i.e., draining onto pervious surface with a flow path of at least 1 m), to promote runoff infiltration and reduce the storage volume requirements in the stormwater facility.

It is recommended that these be implemented through the creation of a drainage bylaw or as part of a wider subdivision servicing bylaw.

Of note, LID implementation does not eliminate (or significantly decrease) the need for conventional stormwater infrastructure, as LID practices are only effective for smaller rainfall events and do not provide adequate stormwater control for 1:100 year event.

4.1.5 STORMWATER FACILITY CONSIDERATIONS

It is standard practice for new developments to construct stormwater facilities for both peak flow attenuation and water quality treatment. The types of stormwater facilities (dry pond, wet pond, and constructed stormwater wetland) appropriate for use in Black Diamond are described in Section 2.2.

During development planning stage, opportunities to incorporate larger, regional wet ponds with a footprint of at least 2 hectares and situated to complement parks and open spaces should be considered. Larger wet ponds have several advantages:

- Facilities are more efficient in terms of construction costs and land requirements.
- Water quality performance is better.
- Operational and maintenance costs are decreased, and there are less concerns with odor and algal blooms.

Dry ponds should have a minimum footprint of 1.5 hectares. Since dry ponds do not provide water quality enhancement, an OGS unit sized to remove 85% of sediment particles larger than 75 microns should be placed upstream of ponds. The frequency of inundation and drawdown time of dry ponds should be addressed in the SMDP report; ponds that hold water more frequently (i.e., more than 2 times in a spring/summer season) should not be placed within high use areas such as sports fields.

Stormwater wetlands do not have a minimum footprint requirement; however, wetland design must consider the biophysical function of the facility (vegetation, habitat, duration of inundation in various wetland zones) and ensure adequate runoff pre-treatment.

4.2 SERVICING OPTIONS FOR NEW DEVELOPMENT AREAS

The design and layout of new neighbourhoods, and the associated storm drainage systems, are ultimately up to the individual developers, with approval from the Town. However, the preliminary locations and drainage direction of the stormwater ponds are assessed in this study, to evaluate the need for regional infrastructure and set release rate targets for each area.

A map of the future development areas is presented in Figure 4.3.1, along with the notations that are used for this discussion. The proposed locations of stormwater facilities and associated outlet locations are shown on Figures 4.3.2 and 4.3.3.

The future development areas fall into three main categories, depending on receiving water body or drainage direction, which impacts their servicing challenges and allowable release rates targets:

- Directly to the Sheep River: either through one of the existing outfalls for the established areas in town, or through the creation of a new outfall directly in the Sheep River Channel.
- East Drainage Channel or Riverwood Energy Dissipator: The East Drainage Channel refers to the natural ephemeral stream course which runs South to North on the east side of Government Road, between the downtown area and the industrial area. The Riverwood channel and energy dissipator refers to the natural drainage course which runs South to North along the west edge of the Willow Ridge / Riverwood neighbourhood. The existing energy dissipator at the north edge of this channel carries flow down the steep riverbank at the edge of Riverwood Cr. This energy dissipator has known problems with icing in the winter, which are discussed in the existing systems analysis. However, this is the natural flow path for most of the area and the energy dissipator is already receiving predevelopment drainage from these areas.
- East Ephemeral Stream: This is an existing ephemeral flow path which flows East from the Town boundary, before turning North and joining the Sheep River at Range Road 15. This has not been used for Town drainage in the past, but is a potential option for the areas of Town which drain to it in a predevelopment condition, pending regulatory approval and regional engagement.

An overview of future development areas is provided in Table 4.2.1.

Table 4.2.1: Future Development Areas

Future Development Area	Location	Approximate Catchment Area[1] (ha)	Drainage Direction	Allowable Release Rate[2] (L/s/ha)
Area 7	SE 8-20-2-W5M	13	Sheep River, through the Riverwood Energy Dissipator	8.0
Area 5	NE 5-20-2-W5M	60	Sheep River, through the Riverwood Energy Dissipator	8.0
Area 3	SW 9-20-2-W5M	46[3]	East Drainage Channel	8.0
Kaiser ASP Area	NW 9-20-2-W5m	21	East Drainage Channel	8.0
Area 2	NE 9-20-2-W5M	64	East Ephemeral Flow Path (Option 1) or East Drainage Channel (Option 2)	4.0 (Option 1) or 8.0 (Option 2)
Area 6	SE 9-20-2-W5M	70	East Ephemeral Flow Path (Option 1) or East Drainage Channel (Option 2)	4.0 (Option 1) or 8.0 (Option 2)

1. *Areas as shown on Figure 4.3.2 for planning purposes; exact areas will depend on proposed development layout at Outline Plan Stage.*
2. *See Section 2.4 for more details.*
3. *The Eastern portion of Area 3 is recommended to drain towards the Area 6 pond, see below for a discussion.*

4.2.1 AREA 7

Area 7 is the Westernmost quarter-section in the Town, West of the Riverwood/Willow Ridge neighbourhood. The majority of Area 7 is within the Sheep River floodplain and oxbows. No development can be undertaken in the floodplain area, aside from recreational uses such as nature trails.

The Southern and Eastern edges of Area 7 are approximately 10 m above the river on the plateau. The Southwest portion of Area 7 is occupied by the driving range and buildings of the Turner Valley Golf Club, leaving the Southeast corner as the future development area, shown on Figure 4.3.2. There is currently no residential or industrial development planned for this area. Possible future uses may include recreational trails and parks, as well as a potential campground. Additional environmental studies are required to determine potential development area.

This area currently drains overland to the Riverwood drainage ditch, immediately upstream of the energy dissipator. The natural topography is very flat, with a slight overall slope of less than 1% from south to north. Because the land currently drains to the Riverwood ditch, it is recommended to maintain the same outfall location for any future development. This means that the allowable flow rate must match the predevelopment average rate of 8.0 L/s/ha for this area. There is no volume target for this area, although an OGS unit must be used prior to any stormwater facilities. Maintaining the existing flow path to the Riverwood ditch avoids the complications associated with construction of a new outfall.

4.2.2 AREA 5

Area 5 is the Southernmost area of the Town, south of the Willow Ridge neighbourhood. This area is entirely agricultural, with the exception of the existing Alberta Transportation facility in the Northeast corner. In the future development scenario, this area is expected to be primarily residential, with a small commercial area in the Northeast corner (the Provincial Highways facility).

Flow in this catchment is split, with the western portion draining to the natural channel on the West Town boundary, which eventually drains to the Riverwood energy dissipator. The eastern portion drains overland to the intersection of 418 Ave. and Highway 22 (Government Road), where it is eventually picked up in the drainage ditch that runs along the West side of Government Road. This ditch continues in front of the hospital and lodge, then West along 6^{th} Ave SW until it ultimately reaches the Willow Ridge Dry Pond. The average slope across the catchment is just over 1%.

Based on a preliminary review, this area can be drained to the natural drainage course on the west side, with a pond placed along the north side of the development area. The current drainage course, along the Government Road ditch, is at an elevation too high for gravity discharge from a pond. Backsloping at the edge of development immediately adjacent to 418 Ave. and Government Road intersection is permitted to drain at predevelopment rates into the Government Road ditch, to accommodate grading of the area.

The exact catchment area will be determined based on the proposed development layout and is subject to Town approval. Based on the estimated predevelopment rate for this channel, Area 5 has an allowable release rate of 8.0 L/s/ha. The future land use in this area is anticipated to be residential. A stormwater pond with an OGS unit is required to manage the runoff to predevelopment rates prior to discharging into the drainage course.

Area 5 has an upstream predevelopment area of approximately 36 ha to the south, which must be accommodated at a predevelopment rate (8 L/s/ha) in the design of the Area 5 drainage system. This flow can either be accommodated as a flow-through condition in the stormwater facility, or can be redirected as overland flow at the south edge of the subdivision, to the Highway 22 ditch. The drainage strategy for the upstream area is at the preference of the developer, as it depends on the development layout and grading plan. The Highway 22 ditch must be maintained as a continuous overland flow route regardless of which strategy is chosen for the upstream flow.

4.2.3 AREA 3

Area 3 is East of Government Road and South of Maplewood. There are two existing lots along Government Road, but the area is otherwise undeveloped; the Southwest corner of this area has been cultivated. In the future development scenario, there will be commercial lots along Government Road, with the rest of the area being residential.

The East Drainage Channel, on the upstream end of the Town, runs South to North through the East side of the quarter-section. A small portion of Area 3 immediately adjacent to Government Road drains towards the road, while the rest of this area is sloped at 1-2% towards the channel. The East drainage channel itself is very well defined in this area, with a bottom elevation approximately 3 m lower than the surrounding land, which allows for a standard pond with a gravity outfall.

The allowable release rate for this area is 8.0 L/s/ha, with no volume control. This area requires a wet pond or constructed wetland to manage stormwater flow prior to discharge into the drainage channel, as the release rate is too low for effective use of dry ponds. An OGS unit is required upstream of the stormwater facility. Landscaped areas at the back of lots immediately adjacent to the drainage channel may drain overland into the channel to accommodate grading at the interface between the channel and the developed area. No minor system flow or runoff from roads or private sites is permitted to drain directly into the channel, and must be accommodated in the stormwater facility first.

Additionally, the stormwater facility in this area must be an off-line facility (outside of the natural drainage channel). Ponds which rely on backing up the natural drainage channel itself will not be permitted.

The East Drainage Channel complicates the stormwater drainage of Area 3, because it splits the area into two natural drainage catchments, as indicated on Figure 4.3.2. The West side of the area has a natural post-development catchment area of approximately 46 ha, which can be accommodated in a wet pond or constructed wetland.

There are no significant natural upstream catchment areas flowing through Area 3, as all drainage to the south natural flows towards the main drainage channel prior to reaching the future development area. A small upstream area of approximately 3 ha drains into the Government Road ditch at the Southwest corner of Area 3, so the existing capacity and flow path in the Government Road ditch must be maintained in the post-development scenario through the use of culverts under any access roads. This area does not need to be accommodated into the Area 3 pond.

The east side of the drainage channel is a catchment area of approximately 12 ha. The predevelopment flow in this area is split, with a portion going towards the East Drainage Channel, and a portion draining overland to Area 6. This area is too small to be accommodated in a standard wet pond, as a wet pond sized based on the catchment area and release rate would be less than 0.4 ha in area, which is significantly smaller than the minimum allowable pond size. Therefore, a separate wet pond dedicated to this portion of Area 3 is not recommended due to operational concerns.

For efficiency and to simplify future operations and maintenance, it is recommended that this catchment area be accommodated in the minor system and pond of Area 6. The resulting catchment of Area 6 is shown in Table 4.2.1 and Figure 4.3.2. Town levies or an endeavour to assist should be agreed to between landowners to compensate for any oversize provided in Area 6. If Area 3 develops prior to Area 6, interim drainage solutions such as pumping or evaporation ponds will be considered. Alternately, the developer may propose a constructed wetland below the minimum size, subject to Town approval, if it is designed primarily for water quality and biophysical function, and can minimize the risks of algal blooms and odor problems.

4.2.4 KAISER ASP AREA

The Kaiser ASP area is bounded by 1st Ave SE to the north, 4th Ave SE to the south, the East drainage channel to the west, and the Area 2 to the East. This area currently consists of country residential houses and some industrial/commercial use along 1st Ave SE. In the future development, it is anticipated that this catchment will be a mix of commercial and industrial uses in the north, and residential uses in the south. The natural drainage of this area is East to West towards the drainage channel. There is no natural upstream catchment to this area. The drainage channel in this area is very well defined, approximately 5 m deep at the midway point in the ASP area. This allows for flexibility in locating stormwater drainage infrastructure and a pond.

Drainage planning for this catchment is complicated because there are many small parcels within the area; therefore, the ultimate solution will require an agreement between landowners. The allowable release rate for this area, based on the predevelopment rate in the drainage channel, is 8.0 L/s/ha. No volume target is applicable to this development area. This area must be drained through a stormwater management facility to attenuate the flows to the required release rate. One pond is planned for this area, individual ponds for each parcel will not be permitted. Therefore, cost-sharing must be agreed to between landowners to compensate for the pond costs and oversize costs on storm infrastructure.

It is recommended that a wet pond be located midway along the channel (opposite from Parkview Crescent SE) based on the natural drainage paths in the area, although this is subject to agreement between landowners. Based on the release rate, this should be a wet pond or constructed wetland. However, due to the small total area, it is understood that the required pond size will likely be 0.6-0.8 ha, significantly less than the 2 ha minimum size. This will be permitted for this area, as long as the pond is designed to manage runoff from the entire developable area and does not exclude any landowners from future development. The stormwater facility in this area must be an off-line facility (outside of the natural drainage channel). Ponds which rely on backing up the natural drainage channel itself will not be permitted. An OGS unit must be supplied upstream of the pond.

4.2.5 AREA 2

Area 2 is the quarter-section along the Eastern Town boundary, on the south side of Highway 7. This area is entirely agricultural, with no existing development or homes. In the future development scenario, it is anticipated that the north portion of this area, adjacent to the highway and 402 Ave., will be industrial, while the remainder will be residential.

This area has several wetlands. The largest central wetland has an area of approximately 2.5 ha, with a smaller wetland along the west boundary, and a wetland complex along the east boundary. The developer must evaluate these wetlands and consider options for preservation or reconstruction of any high-value wetlands, in accordance with Section 4.1 and Provincial Guidelines. The Town's preference is to preserve wetlands and integrate them into community natural spaces, but the exact impacts to these wetlands and feasibility of preservation will depend on the proposed development layout.

The natural drainage in this area is directly West to East, with a slope of 1% in the North and 0.6% in the South. Approximately 16 ha along the West boundary drains to the large central wetland, while the rest drains to the wetland complex and ditch along 144 St SW (Range Road 23). The 144th St SW wetland complex drains into the ephemeral flow path which drains to the East and North, and rejoins the Sheep River near Range Road 15. This flow path is shown on Figure 4.3.3.

There are no significant predevelopment upstream areas that would be required to be accommodated by Area 2, although consideration should be given for capturing runoff from 402nd Ave. and the area between 402nd Ave. and Highway 7, if it is desired to upgrade this road for increased traffic accommodation. The area from the Highway to 402nd Ave. spills south into Area 2, but in the current conditions does not spill in the 1:100 year storm.

The upstream predevelopment catchment to Area 2 is minimal. A small area of approximately 2 ha, consisting of back of lots and adjacent agricultural land along Diamond Crescent SE, currently spills into Area 2, and needs to be considered in the future stormwater design.

Area 2 will require a wet pond or a constructed wetland to accommodate drainage; it is recommended that this be placed adjacent to 144th St SW, adjacent to the wetland complex, for the most efficient drainage within the neighbourhood. An OGS unit must be placed upstream of this facility.

There are two options for discharge locations for Area 2, depending on the desired balance between up-front costs, ongoing operations and maintenance requirements, and development timing. These options are at a high level described below. A more detailed options analysis in included in the Appendix D.

Option 1

The first option is to create an outfall into the ephemeral flow path to the east. This has the advantage of following the natural flow direction, which provides the lowest ultimate impact and allows the pond to discharge by gravity. However, this option presents some challenges, as it requires engagement with regional stakeholders (downstream landowners and potentially Foothills County) which is outside of the scope of this study.

Based on a regional analysis, the estimated release rate for these areas in the predevelopment condition is 4.0 L/s/ha, with an average annual volume estimated to be 30 mm. These numbers can be used for conceptual planning purposes, but must be confirmed through a further detailed study and stakeholder engagement before they can be used for design, as there are significant challenges associated with draining into a small flow path outside of the Town boundary.

Although the channel is topographically well-defined, there are several downstream landowners with houses very close to the channel, and existing houses may have historically encroached on the channel's natural floodplain. If this is the case, the allowable release rate may need to be reduced to lower than the original predevelopment rate to ameliorate the flooding risk to downstream landowners as much as possible.

Additionally, a post-development release, even with the implementation of volume control measures, will likely change the hydrology of the channel, and will therefore require engagement with downstream landowners and regional stakeholders, as well as regulatory approval. Establishing a planned stormwater drainage system and discharge point would require creating a new outfall into the ephemeral flow path, which requires approval through Water Act and EPEA.

Finally, because the upstream end of the flow path is relatively shallow, this option presents challenges with grading to ensure that HGL in the storm system will be lower than home foundations, while still allowing gravity discharge from the pond into the channel. This may require raising the east edge of the site, which is low relative to the flow path, which can increase development costs significantly.

Option 2

A second option for draining Area 2 is to discharge into the East Drainage Channel through the Kaiser ASP area. This is also challenging, due to the topography, as the likely pond location along 144th St W is only 5.5 m higher than the East Drainage Channel culvert which is 1.5 km to the West. However, it is significantly easier from a regulatory perspective as it does not require engagement with regional stakeholders or downstream landowners.

Accounting for standard depth of basements, freeboard to footings, and active storage depth in the pond according to City of Calgary standards results in a pipe which is below minimum allowable slope. However, some of the same challenges are present when draining into the east channel, meaning that the East side of Area 2 would likely require a significant amount of fill in either scenario to allow gravity discharge from the pond. If Area 2 were graded to the same level that would be required to drain to the ephemeral flow path, the average trunk slope could be as high as 0.2%, depending on where the outfall was located in the East Drainage Channel.

If a storm trunk were established to drain the Area 2 pond to the West via gravity, it would be required to drain into the East Drainage Channel as close to the Highway 7 culvert as possible to achieve enough slope. This would likely require adding a deep storm trunk under 1st Ave SE, which could be a significant cost, and potentially harder to maintain. Either approach would require significant coordination with the Kaiser ASP process and existing landowners in the Kaiser ASP area.

Another possible option would be to drain Area 2 towards the East Drainage Channel using a pumped system. This would allow the storm trunk to sit much closer to the surface to reduce costs, as well as allowing it to connect at any point along the drainage channel. Most importantly, this would eliminate the requirement for a significant amount of fill along 144th St W, as the pond could be situated lower than the original ground to allow easier integration with the surrounding area.

With this option, the coordination with landowners and the Kaiser ASP is much simpler and the development costs would be lower. However, stormwater pumps can be a large ongoing cost for both energy and maintenance, and the Town would have to consider whether they are willing to take on this system indefinitely after the development has been completed.

Either option which drains into the East Drainage Channel would eliminate the need for volume control measures and allow discharge at the higher rate of 8.0 L/s/ha, as there would no longer be concern about erosion in the natural flow path East of Town.

4.2.6 AREA 6

Area 6 is the quarter-section in the Southeast corner of the Town, along 144th St SW. The area is entirely cultivated. There are several small wetlands in the south part of this area, and a natural flow path in the Southeast corner. An existing acreage is located in the Southwest corner of this quarter-section; this lot was not included in the annexation, and sits outside of the Town boundary.

In the future development scenario, this area is entirely residential, with no industrial or commercial areas planned at this point.

The natural drainage in this area, outside of the immediate banks of the natural flow path, all drains towards the Northeast corner, and eventually joins the 144th St SW wetland complex in Area 2, before ultimately spilling to the east along the ephemeral drainage path identified in the Area 2 servicing options. The area is very flat, with an average slope of 0.5%.

There are several predevelopment areas upstream of Area 6. To the South, most of the upstream land drains into the ephemeral drainage channel in the Southeast corner of Area 6. This channel should be maintained in a predevelopment condition, and not redirected at the Town boundary. At the Southwest corner of Area 6, there is a small predevelopment catchment of approximately 5 ha that drains north to Area 6 before ultimately draining to the East Drainage Channel; this can be redirected overland to the drainage channel.

Additionally, as discussed in the Servicing options for Area 3, it is recommended that the storm drainage system in Area 6 be oversized to accommodate the approximately 12 ha Eastern portion of Area 3, to create more efficient regional drainage.

It is recommended that Area 6 be serviced by a wet pond or wetland in the northeast corner, which then discharges into the Area 2 pond. Connecting these ponds simplifies the regional infrastructure and regulatory requirements, as only a single outfall would be required. Additionally, if it is decided to drain Area 2 to the West, a single larger trunk and/or pump system will be significantly more efficient than having two parallel systems.

Because Area 6 is connected to Area 2, it would have the same allowable release rate.

4.3 STORMWATER MANAGEMENT AND LAND USE PLANNING PROCESS

This section is intended to provide a clear understanding of stormwater requirements at various planning levels, as a guidance to Town staff as well as area developers.

There are three main levels within the Town's planning process that have specific stormwater requirements – Area Structure Plans, Outline Plans, and Subdivision/Development Permit.

4.3.1 AREA STRUCTURE PLANS

An Area Structure Plan (ASP) outlines detailed mix of land uses, open space plans, population densities and housing types, stormwater and utility servicing concepts, and phasing for future outline plans.

The stormwater requirement for this planning document would be a Master Drainage Plan (MDP) report. The drainage area for an MDP should be based on topography, and not only consider the ASP or land ownership boundaries. Typical requirements for an MDP include:

- Delineation of catchment boundaries beyond the ASP boundaries and quantification of off-site inflows that need to be accommodated through the ASP area.
- Description of how off-site inflows would be managed through the ASP area.
- Receiving water body and/or outfalls and confirmation of stormwater discharge targets.
- Quantification of off-site flow releases with a letter of permission from downstream landowners and /or jurisdictions, if the flows cross private property or jurisdictional boundary.
- Description of the existing characteristics of the site, including wetlands, drainages, etc.
- Proposed general servicing concept, including preliminary location and sizing of stormwater infrastructure (ponds and storm trunks) for each servicing option, with discharge locations.
- Requirement for regional infrastructure, if any.
- Water quality enhancements and effectiveness of proposed stormwater concept to meet water quality requirements.
- If wetlands were identified in the environmental assessments, identification of wetlands that will be preserved or reconstructed, and description how this will be achieved.
- Description of any interim servicing options and development staging.
- Relevant correspondence and approvals from regulators and project stakeholders pertaining to infrastructure location.

The MDP should also identify environmental studies and reports (Biophysical Impact Assessment, Biophysical Inventory, Wetland Assessments, Hydrogeological and Geotechnical reports) appropriate to the ASP area and discuss any items that have to be addressed prior to report approval.

4.3.2 OUTLINE PLAN

The Outline Plan provides information necessary to support a Land Use Redesignation application and includes detailed site design, road networks and utility servicing plans. To align with the Municipal Development Plan requirements for an Outline Plan, a Staged Master Drainage Plan (SMDP) is required.

The SMDP should include:

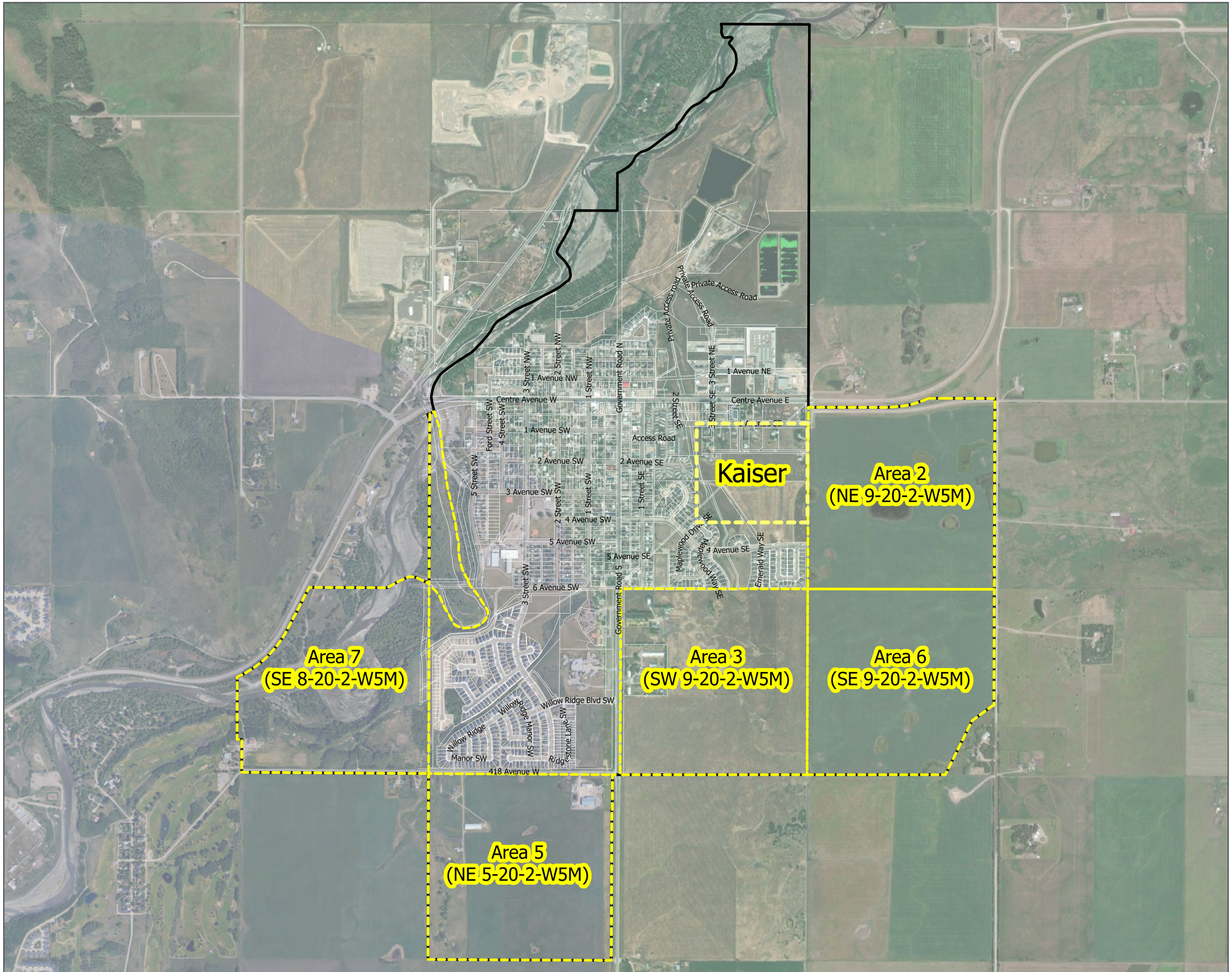
- Overall site description and location with respect to adjacent MDP or SMDP reports.
- All overland flows crossing boundary limits (inflows as well as outflows) and their locations with reference to related previous reports, as well as detailed strategy about how these flows will be managed through the development.
- Permitted release rate for storm trunks, discharge points with capacities, approximate pipe sizes and alignments.
- Location, size, volume, and land requirements for stormwater ponds. Use PCSWMM modeling software for pond sizing, and perform both single event and continuous simulations.
- Preliminary design of ponds with operating levels and elevations.
- Water quality enhancement options and their effectiveness to meet Provincial requirements.
- Type, location and land requirements for LID practices, their estimated effectiveness for meeting stormwater objectives (i.e. depth of topsoil, disconnection strategy).
- Delineation of ER areas, including wetlands and drainages, and appropriate development setbacks.
- If wetlands are to be reconstructed with a stormwater function, describe how they will be included in the post-development stormwater servicing. Include inflow rates, frequency of inundation, vegetation, and habitat management. Show that provincial guidelines for wetland reconstruction are met.
- For preserved wetlands, describe how impacts will be avoided, or mitigated.
- If there are multiple landowners within the Plan area, enclosed statement of agreement with affected owners for location of stormwater facilities (unless this was secured at the MDP stage).

4.3.3 SUBDIVISION/DEVELOPMENT PERMIT

The subdivision application is the last step in creating a new community. The stormwater requirements include a detailed Stormwater Management Report (SWMR) for each subdivision phase. If a pond is proposed, design details of the pond must be part of the SWMR for the first phase of development. The location, size, and overall design of the pond should align with the SMDP; significant changes may require a revised SMDP. The information is to be presented with technical details in construction drawing packages. This may include major and minor system design and pond design elements such as inlet and outlet control structure, landscape design, etc.

The SWMR should include:

- Reference to relevant MDP and SMDP reports, and supplemental information that rationalizes any changes to the approved reports.
- Infrastructure oversize requirements.
- Clearly labeled and quantified overland flows and/or minor system flows that cross phase boundary limits, and downstream impact assessment if the flows are increased.
- Criteria for sizing of minor system (UARR) and minor system sizing table.
- Description of computer model, methodology, design storm parameters, catchment parameters, catchbasin/invert curves, manhole losses, and/or storage curves.
- Overland flows, velocities and depths for all critical segments within phase boundaries, and overland escape routes.
- Trap low location, depth, spill information; and ICDs and catchbasin information.
- Design details for stormwater facilities, including final grading and contouring, cross-sections, inlet and outlet control structure design, erosion protection, direction of overland spill, etc.
- Modelling to confirm pond sizing and operation as per detailed pond design.
- Surcharge (HGL) analysis on a site-specific basis for areas impacted by the High Water Level (HWL) from stormwater ponds or other conditions. Tabulate HGL results.



Town of Black Diamond

Master Drainage Plan

Future Development Areas

Legend

- Future Development Areas
- Town Boundary

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: 1:16,000 (When plotted at 11"x17")

Data Sources:

- Data provided by Town of Black Diamond and AEP.

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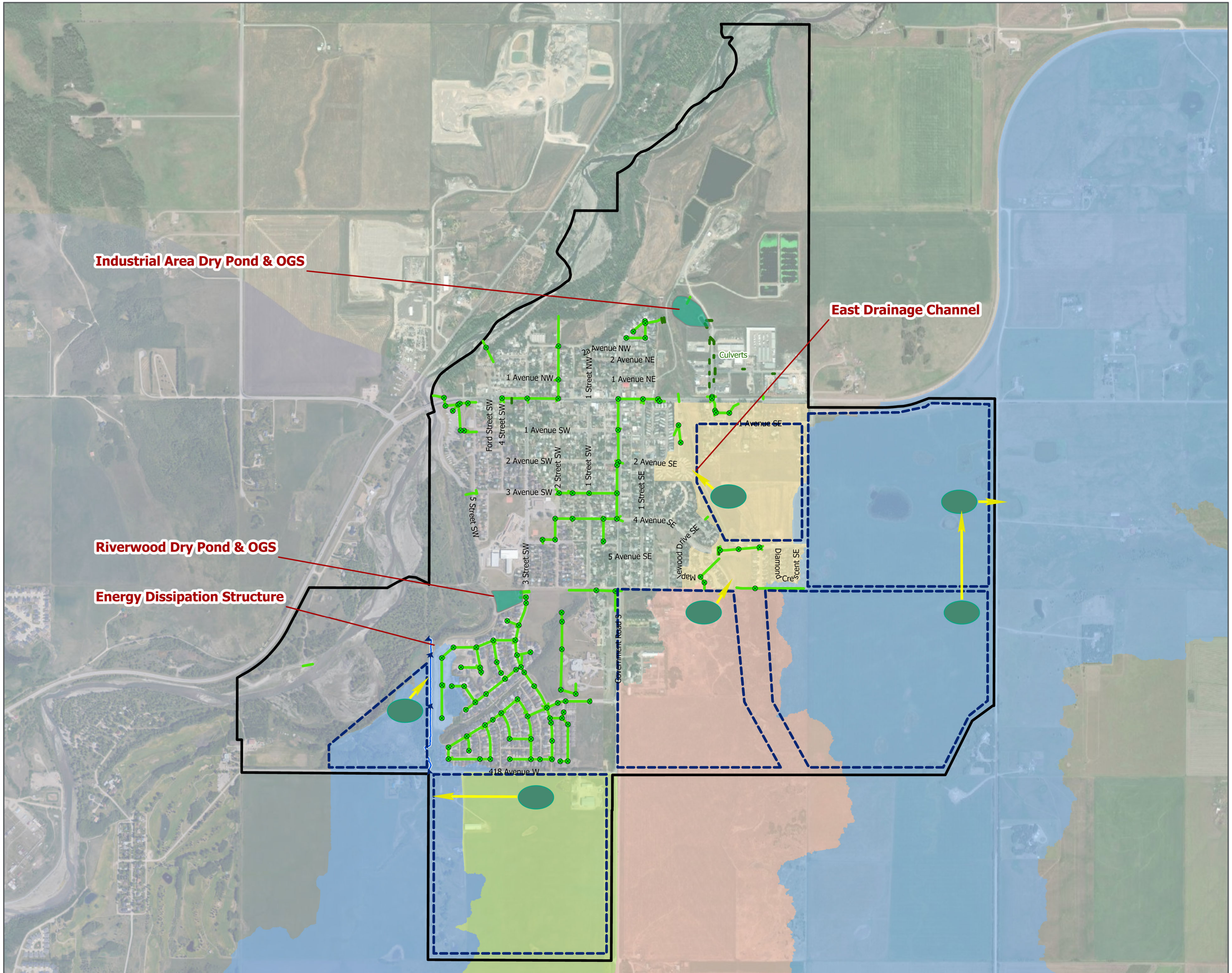
Date:	2021 / 4 / 19

URBAN systems

FIGURE 4.3.1



Town of Black Diamond

Master Drainage Plan

Future Catchment Plan

Legend

Catchments

- External Catchment Areas
- External Catchment Areas - Kaiser
- External Catchment Areas - Riverwood
- Kaiser ASP
- Manhole
- Storm Main
- Culvert
- Flow Path
- Pond Locations (Existing)
- Outfall Locations (Recommended)
- Pond Locations (Recommended)
- Pond Catchments (Recommended)
- Town Boundary

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Meters

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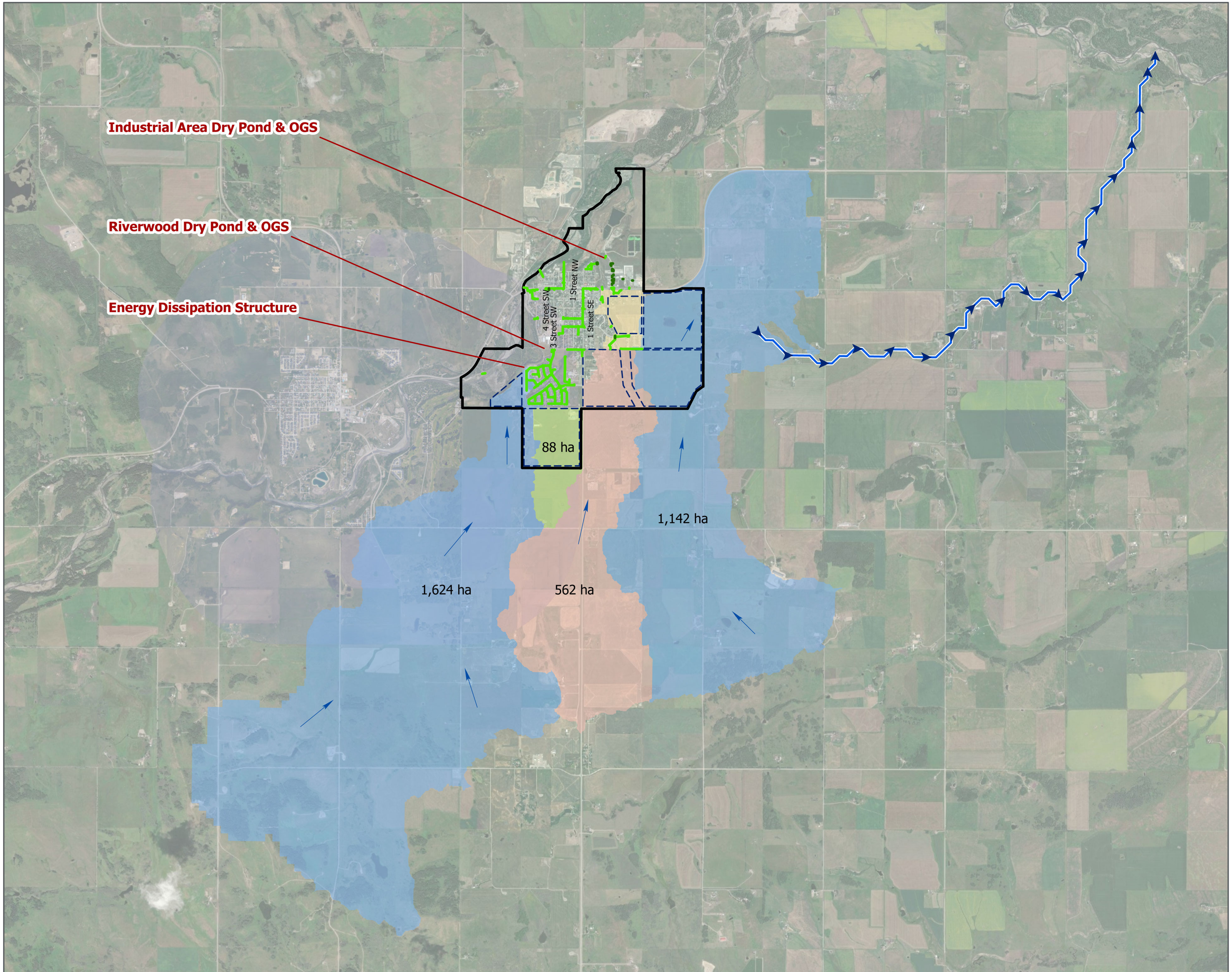
FIGURE 4.3.2



Town of Black Diamond

Master Drainage Plan

Future Catchment Plan

Legend

Catchments

- External Catchment Areas
- External Catchment Areas - Kaiser
- External Catchment Areas - Riverwood
- Kaiser ASP
- Storm Main
- Culvert
- Flow Path (To Sheep River)
- Pond Catchments (Recommended)
- Town Boundary

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Meters

Coordinate System: NAD 1983 3TM 114

Scale: 1:50,000 (When plotted at 11"x17")

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URBAN systems

FIGURE 4.3.3

URBAN SYSTEMS

5.0 SUMMARY AND RECOMMENDATIONS

5.1 EXISTING AREAS

The drainage system within existing developed areas was assessed to understand the current level of service, identify areas with flooding and capacity limitations, and develop recommendations for drainage improvements. The assessment is summarized in Section 3 and details are included in Appendix C. Key recommendations from the existing system assessment:

- Upgrade the highway culvert in the East Drainage Ditch, and establish a safe overland spill path to facilitate spill across the Highway 7 in extreme events without impacting private property, or establish a flow-monitoring plan to calibrate the model and confirm sizing recommendations. An engagement with AT is required prior to culvert upgrade.
- Consider educational campaign (mail-out pamphlets, website resources) to ensure residents are aware of the design intent and functioning of trap-lows located in front of their property. This can reduce the burden on public works and/or emergency responders.
- Create an overland flow path and consider the options presented in Appendix C to reduce surcharge to surface at Government Road and 1st Ave SW.
- Register a drainage easement on the gravel lot at 1st St SE and Centre Ave, or establish an alternative overland flow route.
- Twin the catchbasin in the 2nd Ave NW cul-de-sac to increase capture capacity and reduce the ponding depth during extreme storms.
- Regrade the parking lot in front of the Municipal Building to reduce localized ponding.
- Consider modifying the orifice size in the Riverwood pond to account for a larger drainage area, if the original design parameters cannot be confirmed.
- Revise the Diamond Valley Industrial Stormwater Plan to match the current catchment boundaries. Provide recommendations for future developments to deepen the shallow ditches.
- Reconstruct the pathway at the north end of Government Road with a dedicated rip-rap channel to withstand erosion, and consider additional erosion protection at the bottom of the slope.
- Conduct a hydrogeological assessment to understand the local water table and groundwater gradients.
- Conduct a cost analysis comparing the costs of heat-tracing catchbasins against ongoing maintenance costs associated with steaming and flushing.
- Request record drawings from the developer for the Riverwood energy dissipation structure, and review if it was constructed as designed. Study retrofit options once more information is known.
- Inspect the catchbasins at the curling club, and consider regrading the parking lot if not overland flow path is currently available.

5.2 FUTURE DEVELOPMENT

Stormwater planning considerations and servicing options for each future development area are presented in Section 4. Key recommendations are summarized below:

- Consider adding drainage easements to land title in future subdivisions, to cover trap-low extents.
- Require future development areas to provide stormwater servicing via regional ponds, using the layout shown in Figures 4.3.2 and 4.3.3 as a guiding example. The detailed community and pond design will be determined by developers, but servicing should follow City of Calgary standards wherever possible.
- Require developers to ensure all regulatory requirements are met, including Public Lands, EPEA, and Water Act, at the Outline Plan stage.
- Engage AEP and regional stakeholders (downstream property owners, Foothills County) to determine the appropriate discharge targets to East ephemeral drainage pathway, if this is a preferred servicing option for Area 2.
- To enable future development of Area 3 and the Kaiser ASP area, upgrade the highway culvert in the East Drainage Ditch, and/or establish a safe overland spill path which would allow spill across the highway in extreme events without impacting private property.
- To enable future development of Areas 5 and 7, request additional information regarding capacities of the Riverwood / Willow Ridge ditch and dry pond from the developer, or prepare additional analysis to assess capacity for a release of 12.7 L/s/ha.
- Consider creating a drainage or subdivision servicing bylaw to accommodate the recommendations in this report, including LID implementations such as absorbent landscaping and disconnection.

5.3 CLIMATE CHANGE ADAPTATION

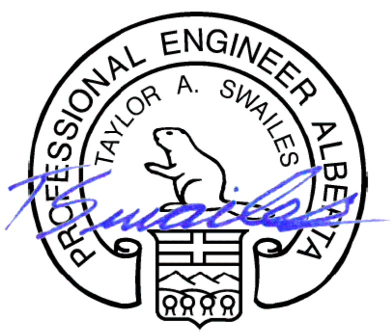
Climate change adaptation planning is being recognized as a priority for many municipalities in Alberta, as climate models predict that higher temperatures are expected and may result in more extreme events such as floods and droughts. The drainage system in the existing areas was assessed and drainage improvements were recommended for current climate conditions. Moving forward, it would be beneficial to undertake an assessment of drainage improvement options under climate change scenarios and use this information in the overall options assessment and capital improvements program development. Climate change impacts should also be considered for new developments, to understand the potential changes in the level of service and identify ways to increase infrastructure resiliency to future conditions. Key outcomes of the climate change assessment should include:

- Updated IDF curves
- Response to climate change scenarios of storm system in existing areas
- Assessment of climate change impacts for a representative new development area
- Climate change adaptation plan for stormwater infrastructure, with a risk management plan
- Infrastructure upgrade prioritization plan, based on short, mid, and long-term climate change impacts

6.0 CORPORATE AUTHORIZATION

This report, titled *Black Diamond Master Drainage Plan Update*, was prepared for the Town of Black Diamond. The material in this report reflects the best judgement of Urban Systems Ltd. based on the information available at the time of report 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.

Urban Systems Ltd.



ID #128551
2021-09-17

PERMIT TO PRACTICE
URBAN SYSTEMS LTD.

RM SIGNATURE: ____________

RM APEGA ID #: 88922

DATE: 2021-09-17

PERMIT NUMBER: P003836

The Association of Professional Engineers and Geoscientists of Alberta (APEGA)

Taylor Swailes, P.Eng.
Hydrologic Engineer

7.0 REFERENCES

Stormwater Management Guidelines for the Province of Alberta, Alberta Environmental Protection (Alberta Environment and Parks), 1999

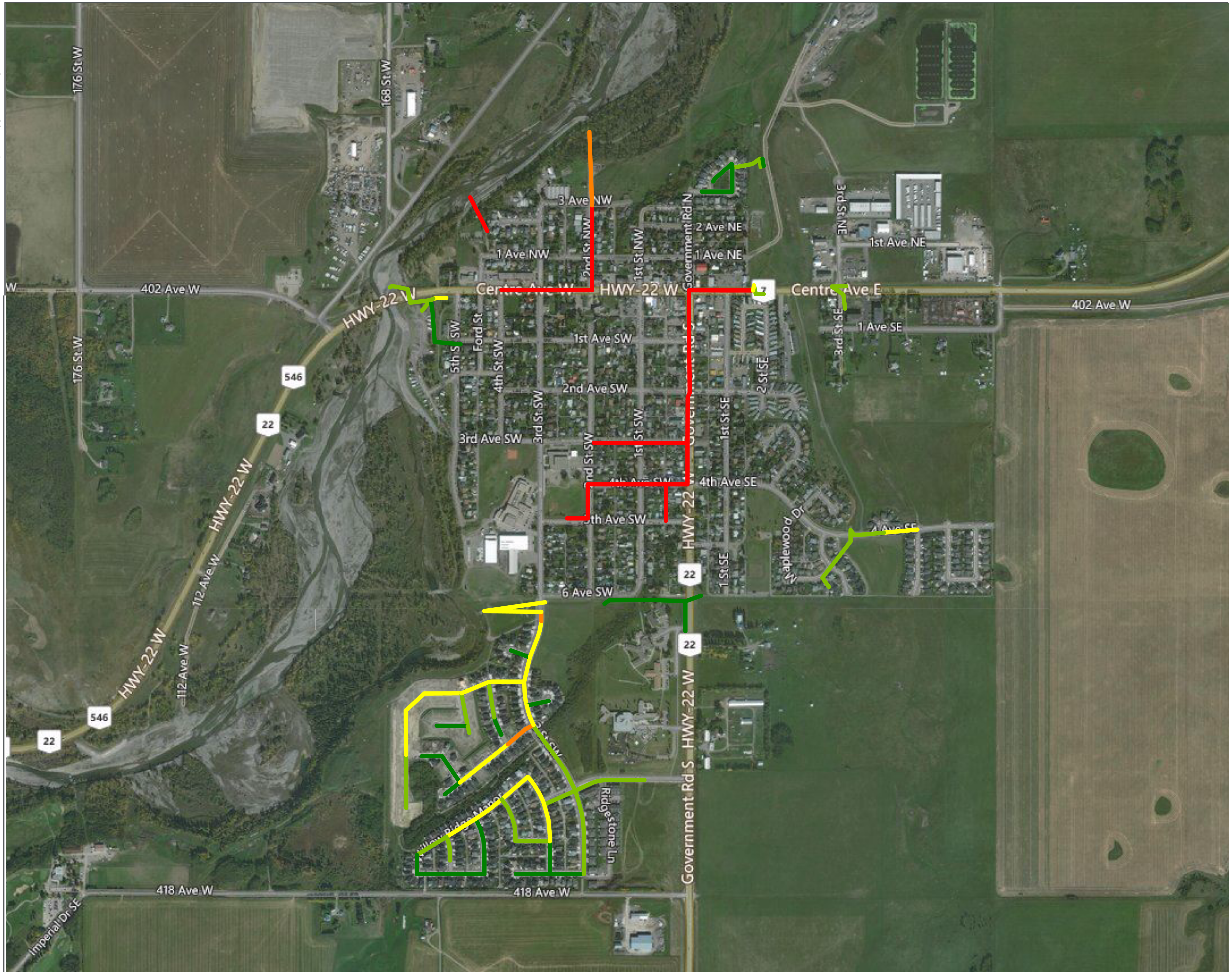
Stormwater Management and Design Manual, City of Calgary Water Resources, 2011

Bow, Elbow, Highwood and Sheep River Hydrology Assessment, Golder Associates, 2017

Willow Ridge Master Drainage Plan, Jubilee Engineering Consultants Ltd., 199

HYDAT Database – Canada, Water Survey of Canada, 2021

APPENDIX A: Existing System Level of Service



TOWN OF BLACK DIAMOND

Town of Black Diamond

Stormwater Master Drainage Plan

1:2 Year Return Period

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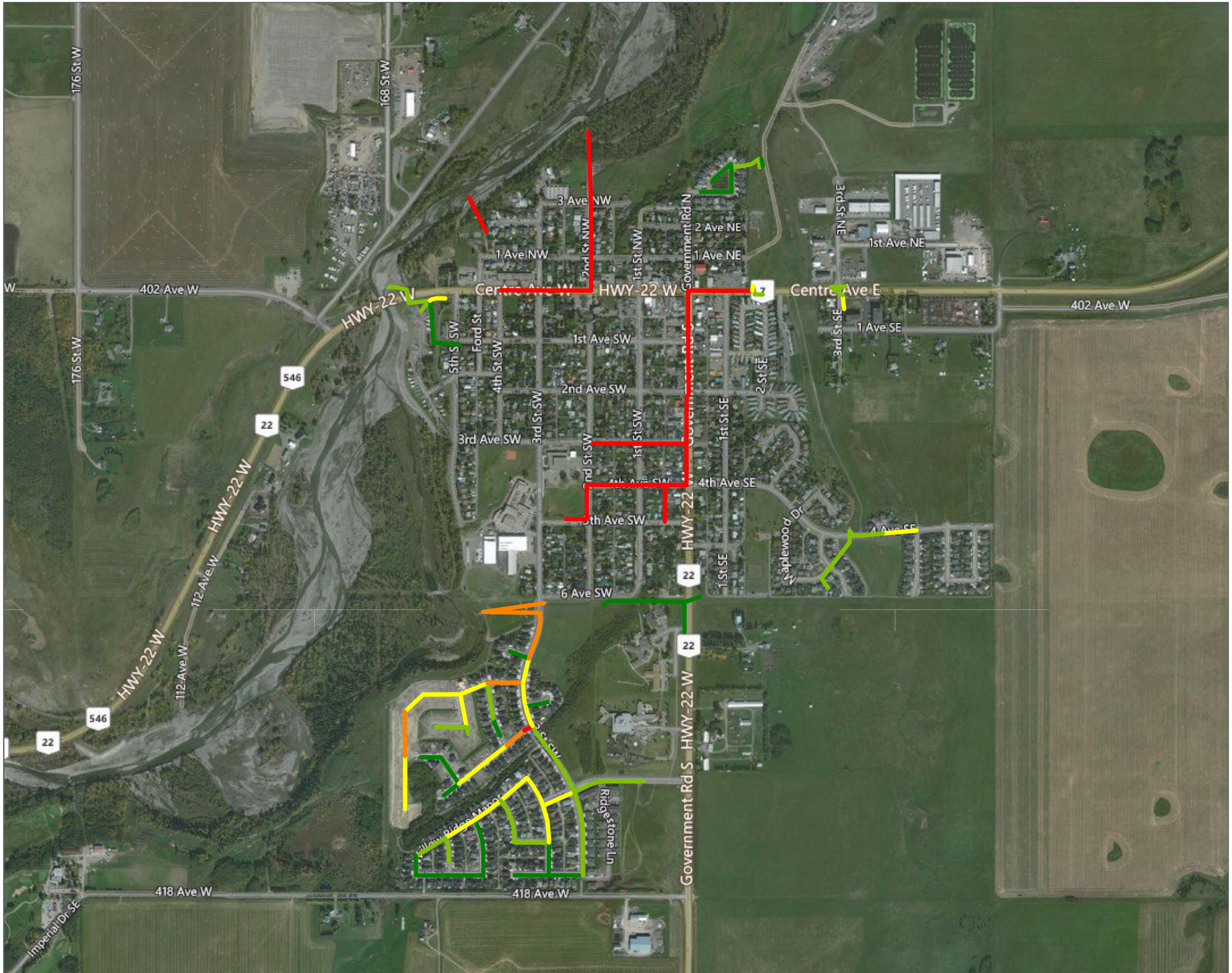
FIGURE A-1



Town of Black Diamond

Stormwater Master Drainage Plan

1:5 Year Return Period

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Revision:	A
Date:	2020 / 7 / 29

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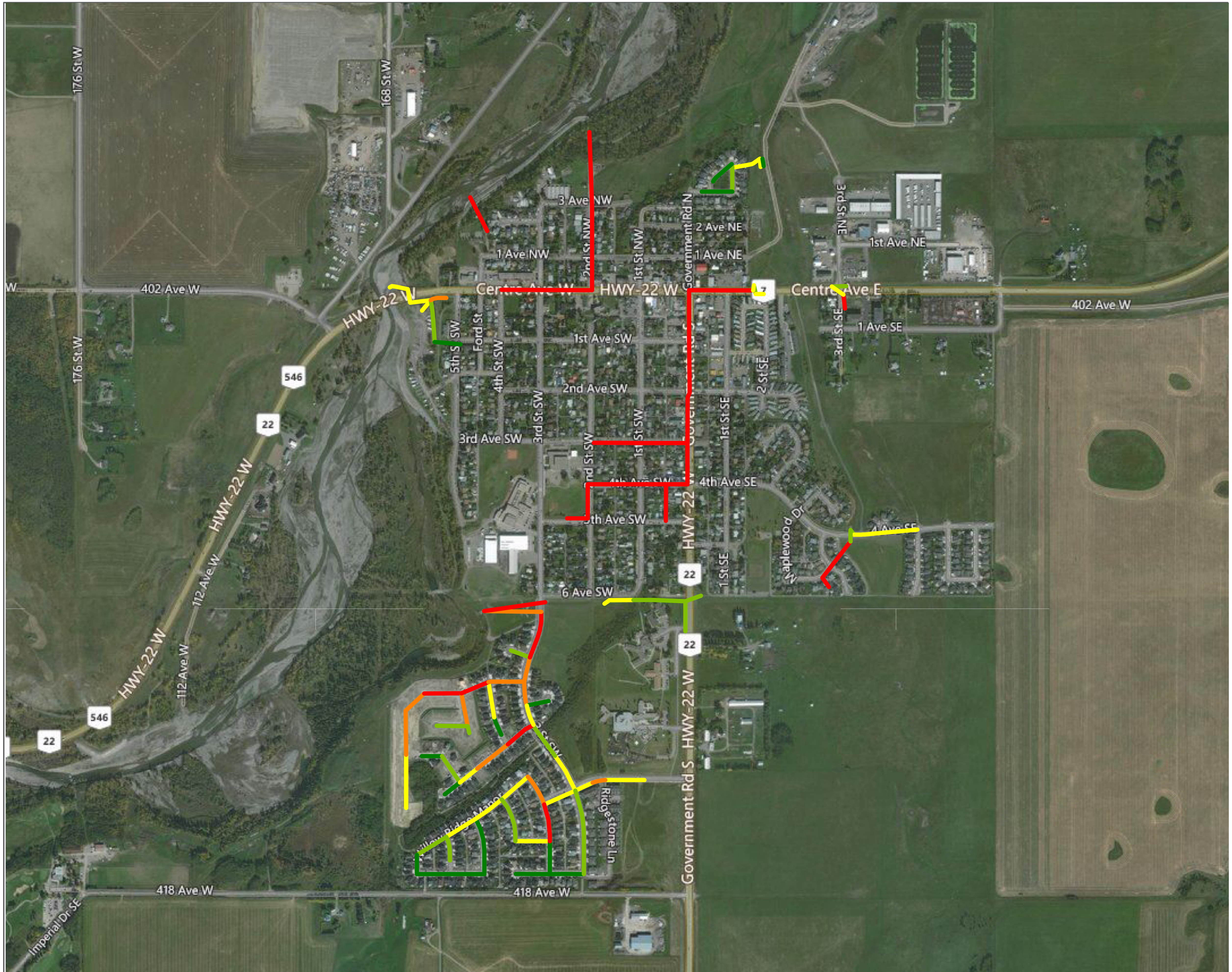
FIGURE A-2



Town of Black Diamond

Stormwater Master Drainage Plan

1:100 Year Return Period

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FIGURE A-3

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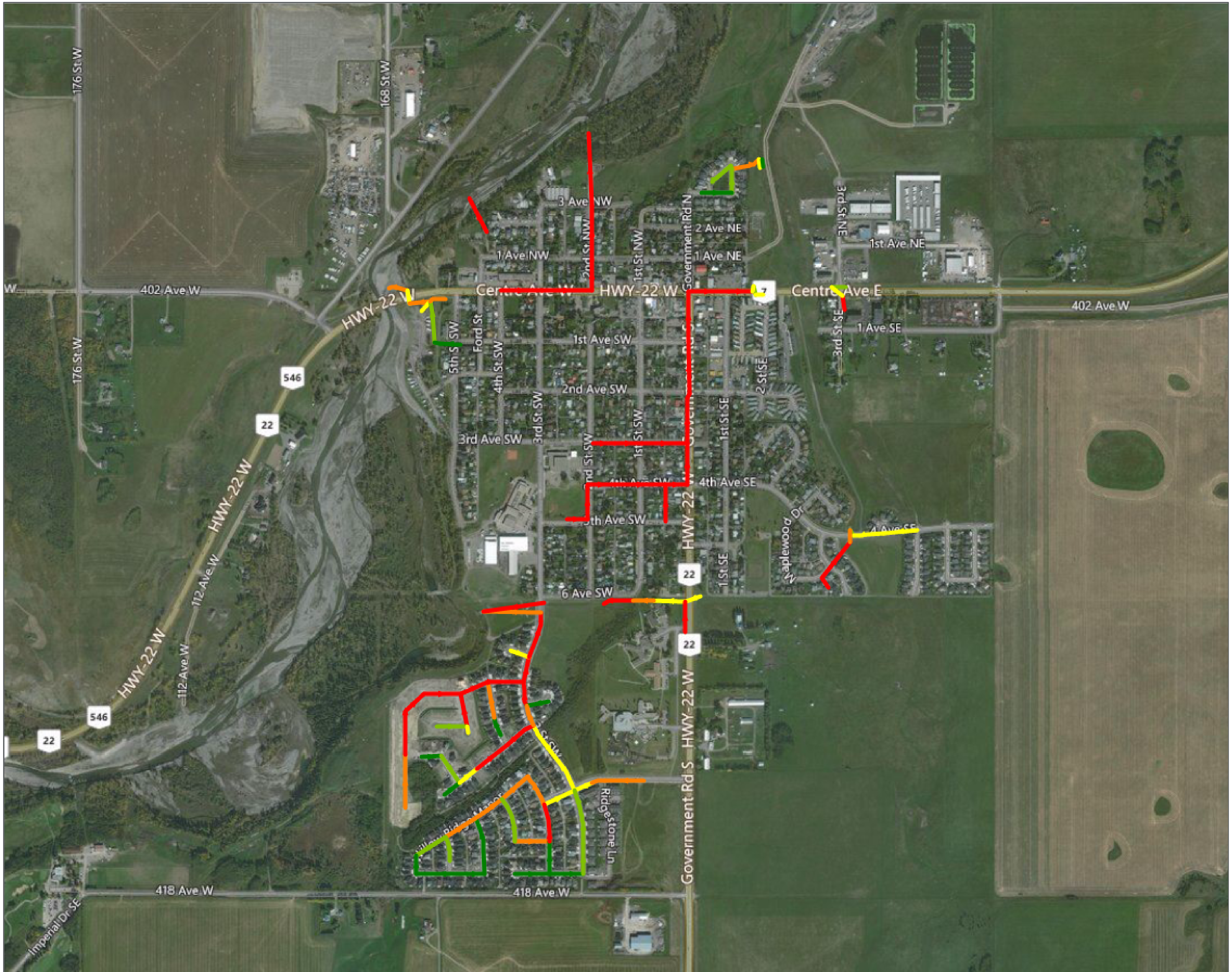

Town of Black Diamond

Stormwater Master Drainage Plan

1:200 Year Return Period

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FIGURE A-4

APPENDIX B: EXISTING PROBLEM AREAS AND RECOMMENDATIONS

Location	Observed Issue	Problem Diagnosis	Level of Service, Risk and Considerations	Recommendation
Government Road and 1st Ave SW	Catchbasin is overwhelmed and surface ponding escapes via private property to the east. Traffic must be frequently diverted during high intensity rain and hail storms.	The pipe network along Government road is surcharged during a 1:2 year event. (for further discussion of the whole pipe reach, see Section 3.0) This location represents a low sag in the road, allowing surcharge to surface and the overland escape for this location is via private property. Stormwater is also flowing overland from the south along Government Road and contributing to the flooding of the intersection. This stormwater is currently not intercepted by existing catchbasins prior to flowing to the government road pipe network. .	1:2 year return period. Low fills up to a maximum depth of +/- 0.2 meters and then spills across private property. If there is no overland drainage easement, the Town may be responsible for damage due to flooding.	An overland flowpath should be created, and options to increase pipe sizes to reduce surcharge to surface at this catchbasin are discussed in Appendix C.
1st Street SE and Centre Ave	Large area of ponding escapes overland via private property north of Centre Ave.	Undersized pipes prevent effective capture of overland drainage, and the spill direction of the ponding area occurs via private property (currently a gravel vacant lot.)	The curb elevation east of this location raises up, preventing spill along the gutter towards the drainage ditch.	Development of this gravel lot should be aware of this overland flow path. A drainage easement should be registered, if one does not already exist. Another option is to add a swale along Centre Ave east to the ditch in front of the Black Diamond Gallery (134 Centre Avenue E).
2nd Avenue NW Cul-de-sac	Deep ponding on the street with no overland escape. Depth reaches 0.9 meters until overland escape to 3rd Street NW and 3rd Avenue NW is activated. An overland flow path from 1st Ave NW and 4A Street NW also contributes flow to this ponding area during extreme events.	The original design drawings for 2nd Avenue NW assume the overland stormwater flows exit 2nd Ave NW via the pathway to the west. There is a catchbasin at the end of the pathway that captures flows and discharges to the river. If the catchbasin were to become plugged, the overland escape would be to the east towards 3rd Street NW and 3rd Avenue NW. There is also a stormwater pump station near the river that is designed to pump the stormwater out to the river during an extreme rainfall event, when the river is high. This was installed as part of the 2013 flood recovery and mitigation efforts and berm construction.	In the model of the 100 year event, the ponding area fills to its maximum depth of 0.9 meters. This represents a risk, as the maximum depth of surface ponding should be no more than 0.5 meters during the peak period of a 100-year event, as detailed in Section 3.4.8 of the Stormwater Management Guidelines for the Province of Alberta.	Recommend the catchbasin capture capacity be increased at this at this location (twinned).
Centre Ave and 2nd St NW in front of Municipal Building	Large ponding area on the road spills into the parking lot.	The municipal building parking lot is the culmination of a very long overland flow path from the south. Catchment area is roughly 22.3 hectares. The overland flow path continues north across Centre Ave and down 2nd Avenue.	This ponding area is a result of the surface elevation of the parking lot being lower than the spill elevation across the road.	Regrading or filling in the surface depression would reduce ponding in the parking lot and is not expected to negatively affect the downstream overland flow network. Approximate elevation of spill north across Centre Ave is 1173.805.
Riverwood Pond	The design catchment area for the pond includes Riverwood, the Hospital, and a predevelopment area.	A culvert under Government Street at the Hospital directs ditch drainage from the south and diverts it toward the Riverwood Pond. The actual catchment area is 148.8 hectares. The orifice and design discharge rate of the pond is not known.	The design catchment area for this pond appears to be 44.7 ha (Willow Ridge Master Drainage Plan, May 1999, Jubilee Engineering Consultants Ltd), and does not include flows from the Hospital.	Development in this catchment area should consider impacts to the pond due to changes in impervious area and assumed peak flow rates. If the design discharge rate for the pond can be determined, a recommendation to modify the orifice size in the pond can be made to account for the larger drainage area.
1st Avenue NE, Industrial Area	Ditches do not appear to have been constructed to the design depth per the original design.	The original drainage plan for the area did not anticipate that flows from the Rona would enter 3rd Street. Rather, they were designed to enter a ditch to the north of the study area. The drainage ditch was not constructed per the original design.	Continued development in this area without consideration of proper ditch sizing poses a risk of overland flooding.	Revise the Diamond Valley Industrial Stormwater Plan to match the current catchment boundaries. Provide recommendations for future developments within the area to deepen the shallow ditches.

Location	Observed Issue	Problem Diagnosis	Level of Service, Risk and Considerations	Recommendation
Culvert at Centre Avenue East	The 1:100 year 24 hour model indicates that the elevation of the channel at Centre Avenue south of the box culvert is **1078.84m** and it is spilling over the highway	The culvert is undersized to convey the peak flow during the 1:100 year 24 hour event.	A diagonal escape route (shown in Section 4.0) cuts across the intersection at 2nd Street SE, and the flowpath may impact properties on the southwest corner of the intersection. The peak flowrate of the overland spill in the 1:100 year 24 hour storm is 3 m^3/s. This overland flowrate, depth and velocity exceeds Provincial guidelines for safe velocities in gutters and swales.	It is recommended that the culvert capacity at this crossing should be increased, and that the overland flowpath across 2nd Street SE and then over the highway be evaluated to mitigate risk of flooding at the intersection of 2nd Street SE and Centre Avenue.
Government Road, North End	Pathway was installed this year with a riprap ditch that washed out.	This location has an overland catchment area that is 3.74 hectares. The area extends as far south as Centre Ave, and west as 1st Street NW. The slope down the trail is 16%. From the model, flow parameters are Q = 270 l/s during a 1:5 year, 24 hour design storm, and during a 1:100 year design storm Q= 650 l/s. Before the pathway was constructed, it appears that this flow was dispersed across the width of the roadway and passed down the slope as sheet flow without concentrating to create points of erosion.	The velocity and volume of water coming down the pathway at a concentrated location is causing erosion. Redesign of the pathway to accommodate the 1:100 year flowrate results in a very large ditch (up to 5 meters wide with Class 1 riprap. Class 1 riprap is a nominal diameter of 300mm nominal mass of 40kg.) The overland drainage analysis reveals a flow path that travels west to east at the base of the hill. If the Town decides to proceed with ditch reconstruction, a review of the flowpath in relation to the pathway should be completed to ensure culverts are installed where the flow path crosses the pathway	The pathway should be reconstructed with a riprap channel that is designed to withstand erosion either on both sides or one side. Given the steepness of the slope, the design should consider the details on how the ditch design merges with the bottom of the slope. Note: a riprap channel is one solution. Other alternatives could be considered to minimise the size of the ditch in relation to the pathway.
Groundwater	Reports of high groundwater table impacting basements in older areas of town with no weeping tile.	It is likely that local aquifers associated with the Sheep River may create instances of local high groundwater.	Impacts of groundwater are not within the scope of this study.	If high groundwater continues to impact basements and cause flooding, a hydrogeological assessment of the water table should be performed to understand the groundwater gradient.
Impacts of Freezing on Storm Infrastructure	There are a number of shallow catchbasins that routinely require maintenance to thaw in spring.	Stormwater infrastructure is sized to operate during peak storm events. The Alberta freeze-thaw winter climate can create flooding and impacts to system operation. Frozen infrastructure are a result of the fact that a stormwater system is open to freezing temperatures and airflow.	While this is a common problem faced by municipalities, maintenance in spring may not present a problem worth addressing unless the frequency and costs are larger than the capital costs to fix the problems., solutions should consider a balanced approach between capital investments and operations and maintenance budgets.	Frozen catchbasins can be addressed with heat tracing, but it is recommended that a review of the likelihood and consequence of the freezing be compared to the costs of capital investment and operations and maintenance costs for catch basin steaming and flushing.
	Energy dissipation structure west of Riverwood Pond experienced ice jams in the winter of 2019/2020, causing flooding across the adjacent pathway.	Frozen infrastructure is a result of the fact that a stormwater system is open to freezing temperatures and airflow.	Ice jamming in the channel has caused flooding of an adjacent pathway. Risks of injury due to slipping caused it to be closed.	Request record drawings from the developer to review if the structure was constructed as designed. Retrofit suggestions may be prepared once the drawings are available for review.
Curling Club	Parking lot next to curling club experiences ponding of water and freezing.	There is an area of ponding in this parking lot. Onsite catchbasins may not be operating well, or overland flowpaths within the parking lot may not be well defined.	Surface flooding can be resolved by ensuring that the parking lot drains to the existing catchbasins. An overland flowpath in 3rd Street SW exists, if an overland flowpath from the parking lot can be established. The catchbasins in the parking lot are not considered to be public infrastructure.	An inspection of the location and maintenance of existing catchbasins in the parking lot should be completed first. If there is not an overland flowpath, the parking lot could be regraded to direct water to 3rd Street SW.

APPENDIX C: RETROFIT OPTIONS FOR GOVERNMENT ROAD AND 1st AVE SW

This Appendix documents discussion with the Town about the problem are of flooding at Government Road and 1st Ave SW. As discussed, this problem area may be solved with a number of overland and underground retrofit solutions. See Figure A-6 for an illustration of these options. As discussed in the report, Section 3.4, the issues in this area relate to both the lack of overland emergency escape and undersized infrastructure causing surcharge of stormwater to surface at this location.

Estimates for each option have been provided to indicate a relative construction cost.

$: 500,000 – 1,000,000

$$: 1,000,000-2,000,000

$$$: 2,000,000 – 3,000,000

A high level cost estimate would need to be completed to verify and determine estimated costs for budgeting purposes.

Overland Emergency Escape

It is recommended that an overland emergency escape solution is implemented to prevent repeated action by the Town's emergency services to mitigate the risk of damage to private property. A swale through the Griffiths Senior Centre parking lot (122 Government Road S) would create a defined flowpath to the back alley and then east out to 1st Street SE. To enable this option, engagement with the landowners would be required, as well as businesses adjacent to the lane.

Cost Estimate: $

Options to Mitigate Surcharge to Surface:

Option 1 – Relief Pipe Connection

Relief pipe connection through the Griffiths Senior Centre (Griffiths Memorial Centre Association, 122 Government Road S) parking lot, to back alley. Total pipe length is 220 meters, 750mm, at 0.2% slope. The overland flowpath through private property remains and would be utilized in a rainfall event greater than a 1:5 year storm. This would require coordination with Alberta Transportation for the connection of the relief pipe at Government Road and at Centre Avenue.

Cost Estimate: $$$

Option 2 – Upsize the Pipes

Increase the size of pipes under Government Road and Centre Ave between 1st Avenue Southwest and the outfall. Pipe sizes would increase from 750 to 1050 for 320 meters. The overland flowpath through private property remains and would be utilized in a rainfall event greater than a 1:5 year storm. This would require coordination and approval from Alberta Transportation for pipe replacement in Government Road and in Centre Avenue. The requirement for traffic detours should also be a consideration for this option.

Cost Estimate: $$$

Option 3 – Extend Pipe North

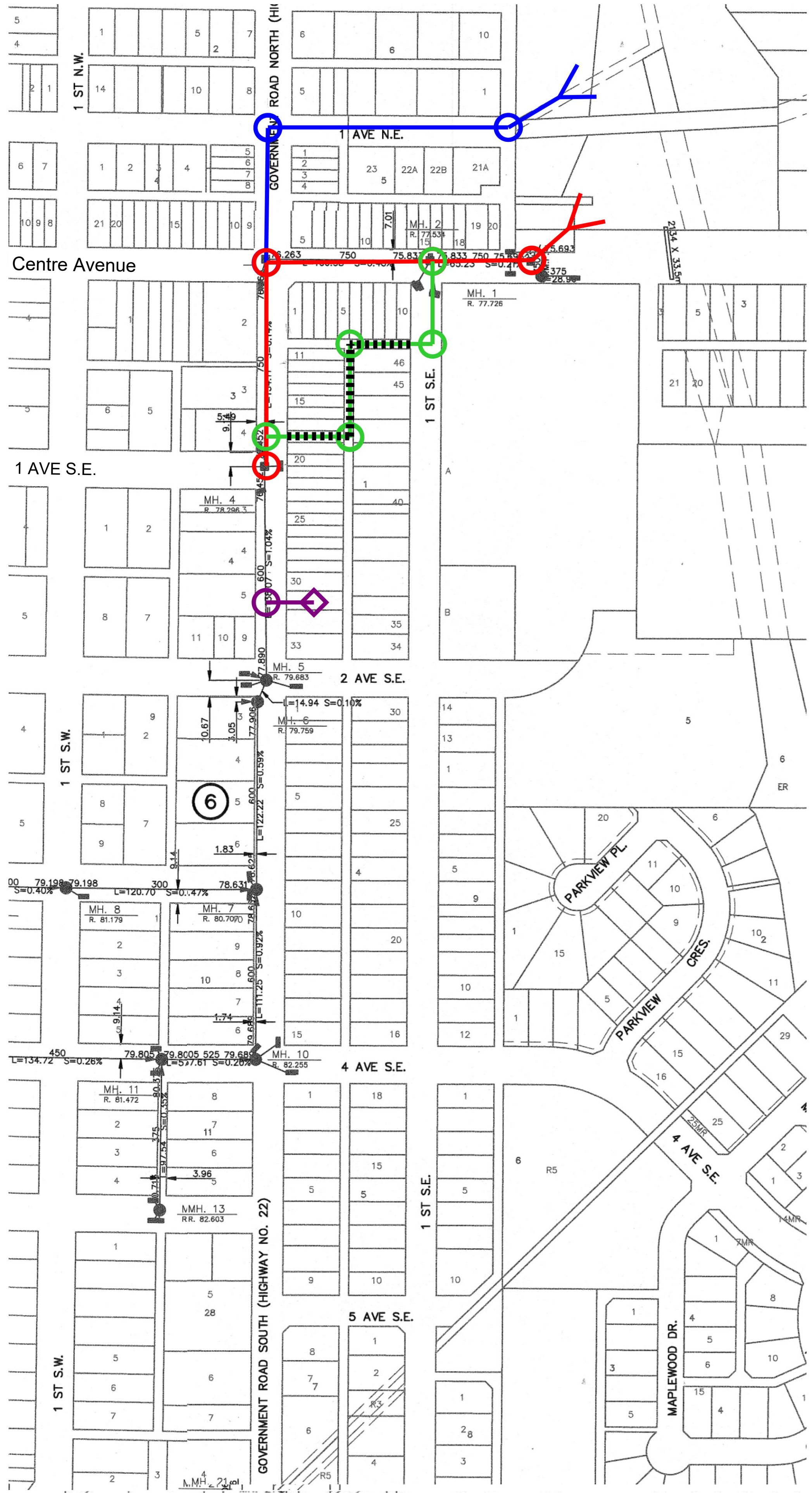
Relief pipe from Government, north to 1st Ave NW, and east to discharge at Kaiser Ditch. Pipe size is 750, length is 300m, slope is 0.55% with minimum cover of 1.2 meters. The overland flowpath through private property would still be required and would be utilized in a rainfall event greater than a 1:5 year storm. This would require coordination and approval from Alberta Transportation for the connection of the pipe at Government Road and Centre Avenue.

Cost Estimate: $

Option 4 – Surface Storage surge pond on private lot along Government Road near 2nd Ave SE

Purchase lot along Government Road for the purposes of constructing a surge pond for the infrastructure. Surge pond volume would be approximately 1200m3 for a 1:100 year, 24 hour event. The overland flowpath through private property remains and would be utilized in a rainfall event greater than a 1:5 year storm. This would require coordination with Alberta Transportation for the connection of the pipe at Government Road.

Cost Estimate: $$ (assuming purchase of lot at assessed property value)



Town of Black Diamond

Stormwater Master Drainage Plan

Retrofit Options

LEGEND

- Overland Swale
- Option 1
- Option 2
- Option 3
- Option 4

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FIGURE A-6

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APPENDIX D: AREAS 2 AND 6 STORM POND SERVICING OPTIONS

URBAN SYSTEMS MEMORANDUM

DATE: June 21, 2021
TO: Sharlene Brown, Tom Dougall, Rod Ross
CC: Meghan Aebig, Liliana Bozic, Erin Eyre
FROM: Taylor Swailes, Shane Dorchak
FILE: 0925.0036.01
SUBJECT: Town of Black Diamond – Areas 2 and 6 Storm Pond Servicing Options

1.0 INTRODUCTION

This memorandum discusses options for discharge locations from the future development areas 2 and 6, discussed in Section 4.2 of the Master Drainage Plan (MDP).

As per the MDP, it is assumed that a stormwater facility (storm pond) for Area 6 will drain north into the Area 2 stormwater system. Therefore, this analysis only includes discharge from an assumed Area 2 facility. The ultimate storm pond location is assumed to be on the east side of the development, where there is currently a natural low point as shown in **Figure 1** below. The existing ground elevation in this area is 1184.0 m. For this analysis, a wet pond was assumed as per City of Calgary Standards, with the HWL 1.5 m below the surrounding ground elevation and an active storage zone 2 m deep. Therefore, the Normal Water Level is set to an elevation of 1180.5m in these scenarios. This also allows for emergency escape to the east in all scenarios considered, as evident from the topography in Figure 1.

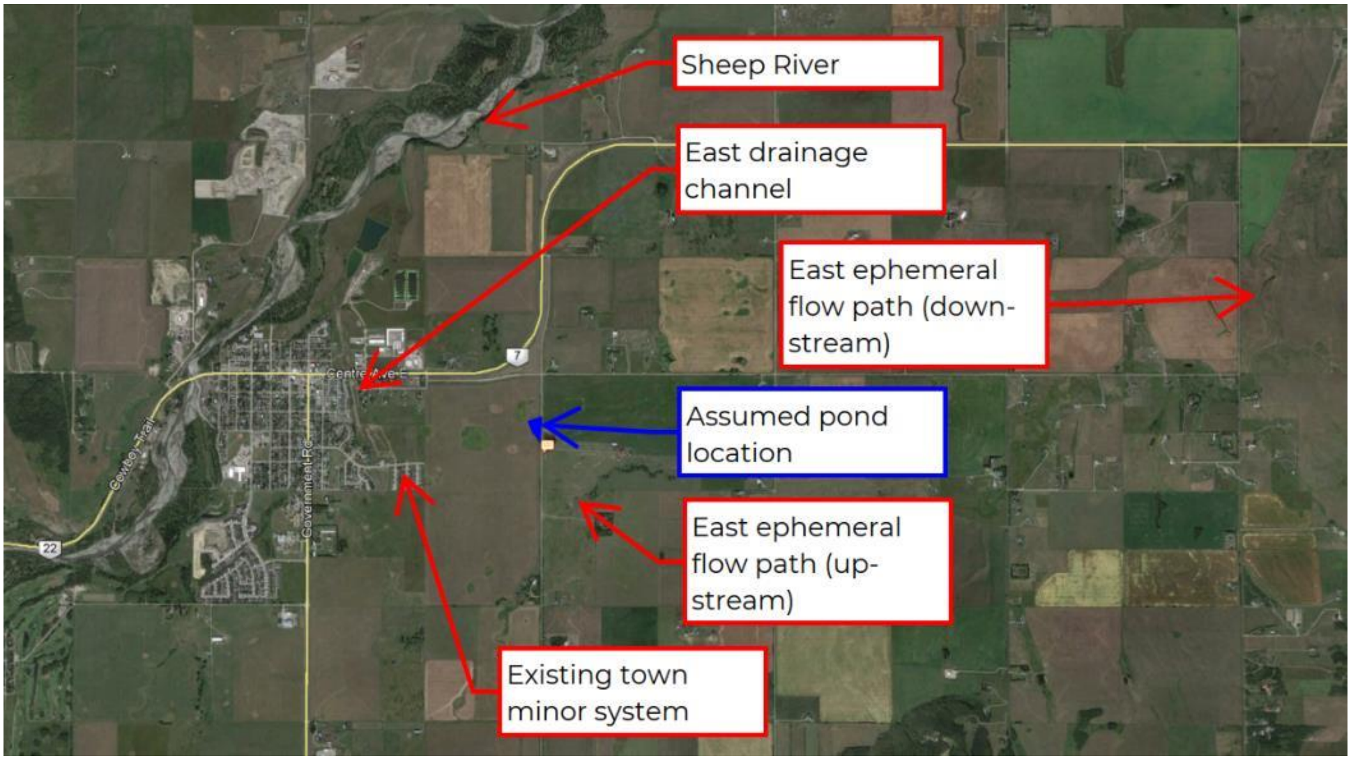
Figure 1: Assumed Pond Location with Topography

2.0 STORMWATER POND DISCHARGE OPTIONS

Several options for stormwater pond servicing are shown in the sections that follow. Five ultimate discharge locations are considered, as shown in Figure 2:

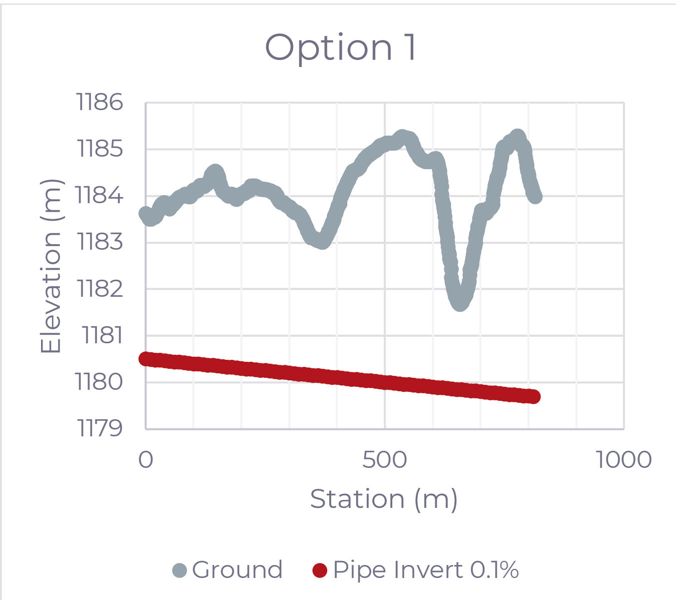
- North to Sheep River;
- West to the east drainage channel (ditch);
- West to the existing town minor system;
- South to the east ephemeral flow path, upstream; and
- East to the east ephemeral flow path, downstream.

Figure 2: Five discharge Locations Relative to Pond

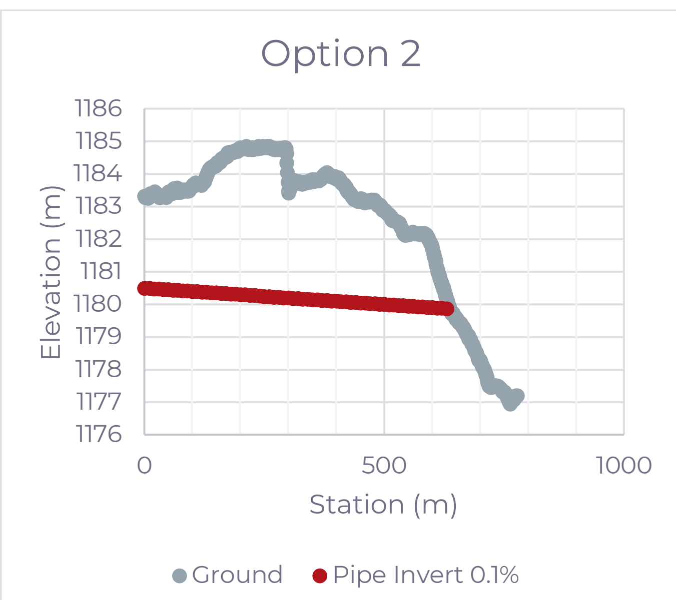


2.1 DISCHARGE SOUTH TO THE EAST EMPHEMERAL FLOW PATH (UPSTREAM)

Option 1 shows it is not possible to drain directly south through the Highway 23 ROW to the east ephemeral flow path; the elevation of the east ephemeral flow path as it crosses Highway 23 is too high for gravity drainage.

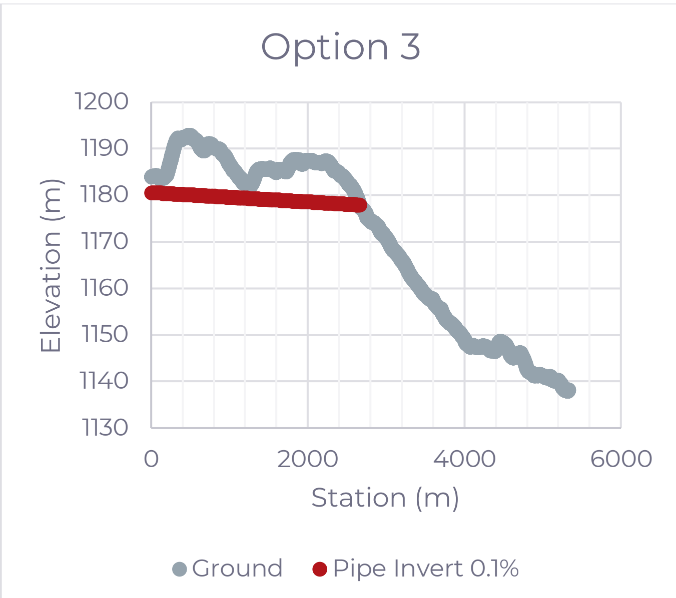


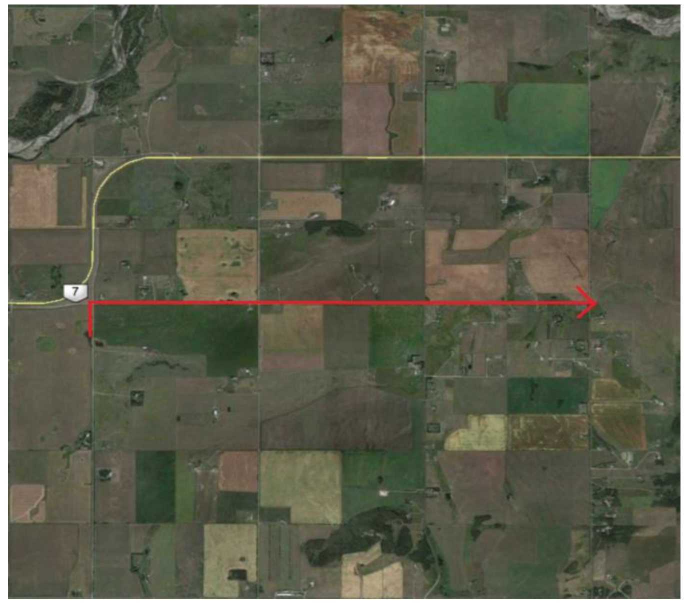
Option 2 uses approximately 650m of pipe with cuts of 5m or less to discharge into the east ephemeral drainage path. This is the most direct discharge route but requires drainage easements outside of the Town boundary and requires Water Act approval, with consent of the downstream landowners.



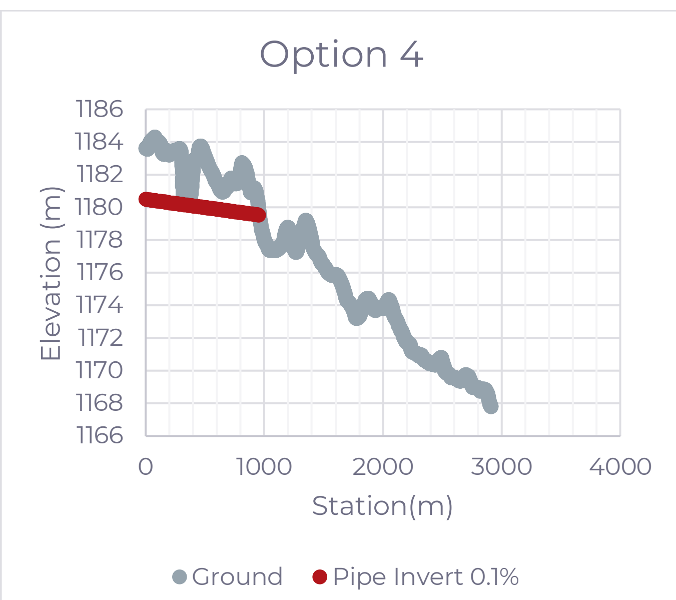
2.2 DISCHARGE EAST TO THE EAST EMPHEMERAL FLOW PATH (DOWNSTREAM)

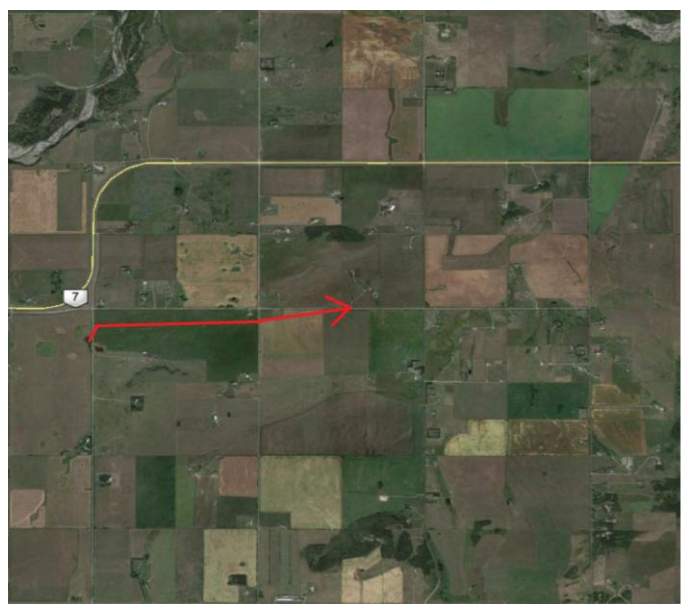
Option 3 requires approximately 2.5km of pipe with depths of up to 15m before the trunk daylights into the Highway 202 ditch; from there overland drainage is possible to the downstream east ephemeral drainage channel. This is a relatively long length of offsite infrastructure and at greater depths than typical storm installations.



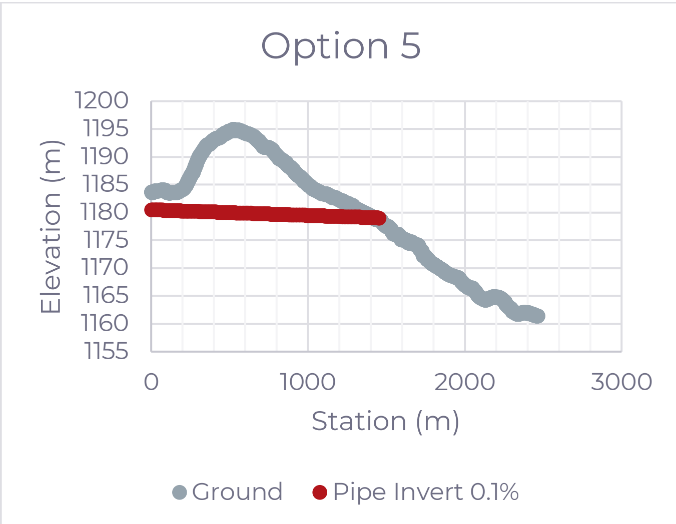


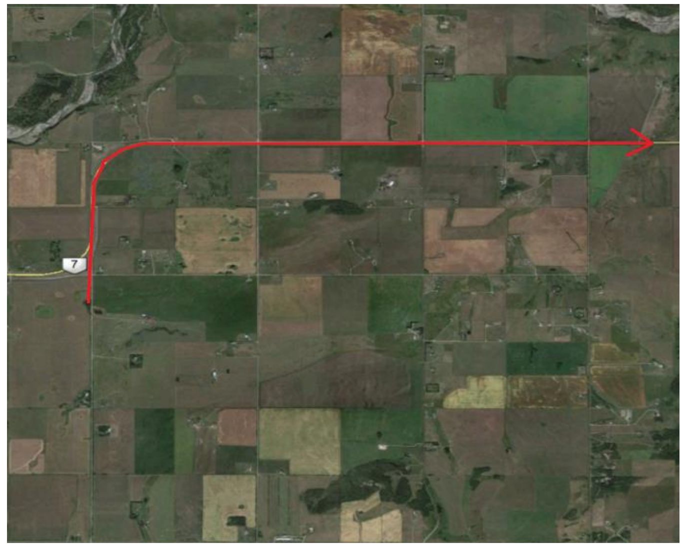
Option 4 requires approximately 1km of pipe with cuts of up to 5m through the adjacent land to avoid the hills to the north. This requires easements or purchase of land outside of the Town boundary, and coordination with landowners and therefore may be difficult to achieve; however, it addresses concerns with the capacity of the upstream ephemeral drainage path.





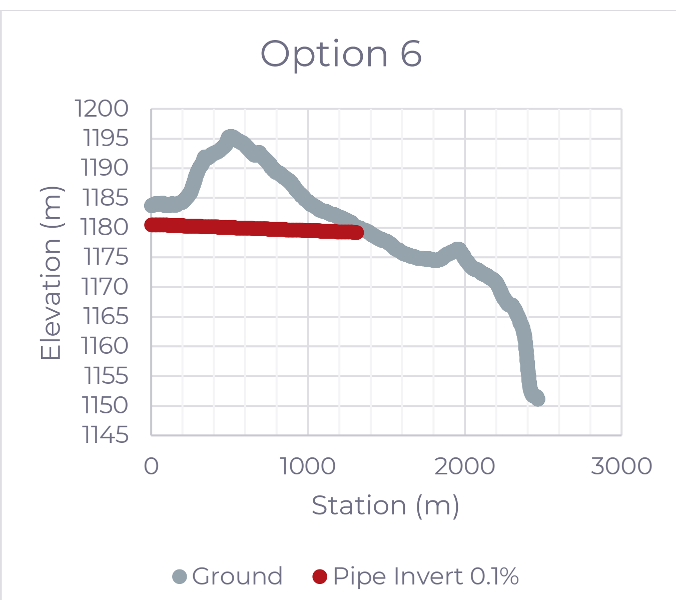
Option 5 requires approximately 1.2km of tunneling with cuts of up to 15m to follow highway 7 to the ephemeral drainage path. Similarly to Option 2, it is a relatively long length of offsite infrastructure and at greater depths than typical storm installs.

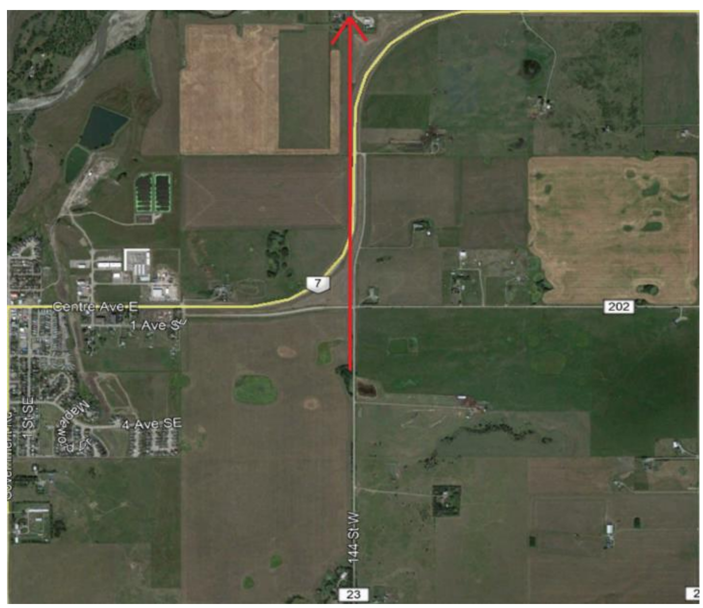




2.3 DISCHARGE NORTH TO THE SHEEP RIVER

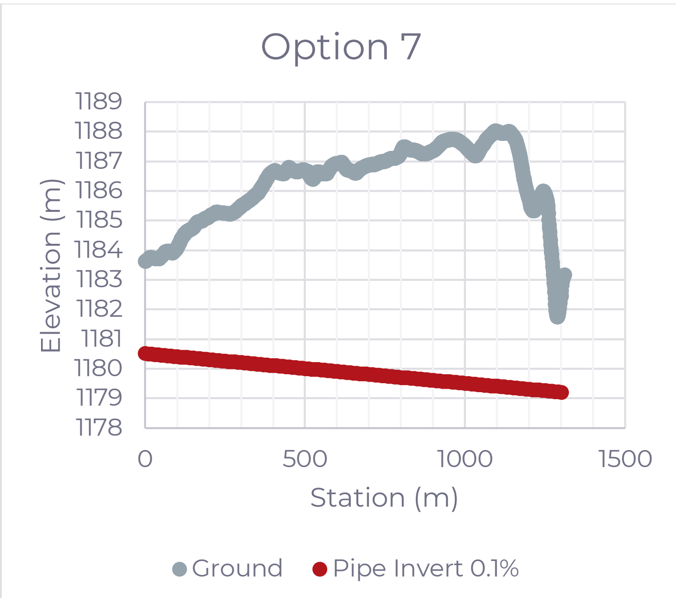
Option 6 requires approximately 1.2km of tunnelling with up to 15m cuts before the trunk daylights. This shows that the largest difficulty in draining north along highway 7 are the large depths immediately north of Area 2, and there is no additional benefit in draining further north to the Sheep River compared to following the Highway 7 ditch down to its drainage at the east ephemeral flow path.



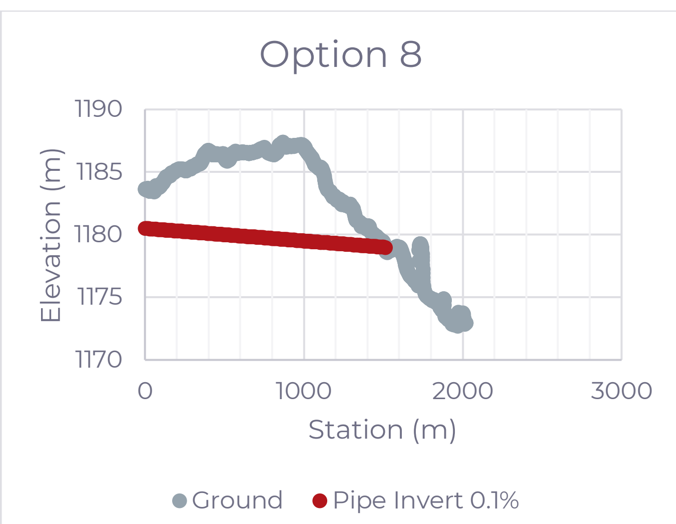


2.4 DISCHARGE WEST TO THE EXISTING DITCH

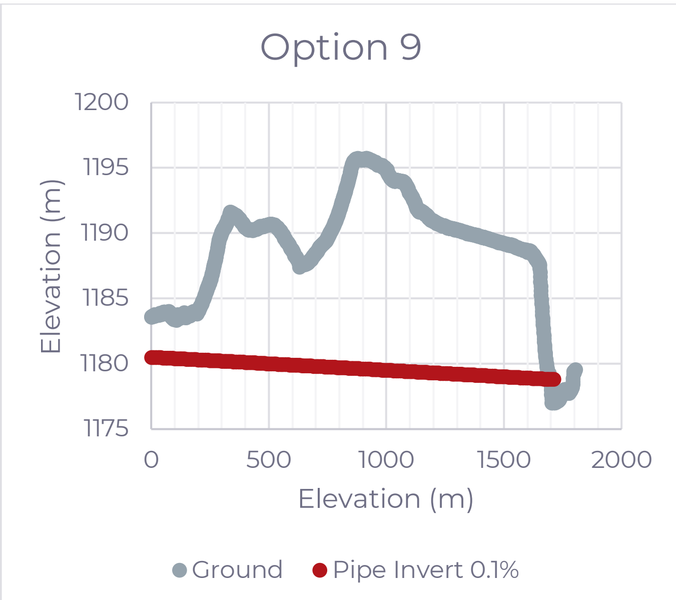
Option 7 shows it is not possible to go straight west and daylight into the existing ditch due to grading considerations with the height from a pond's NWL to surrounding grade, and active storage depth. Even though the east drainage channel is lower than the existing grade in the proposed pond location, it is not possible to provide gravity drainage down to NWL.



However, because of the slope of the east drainage channel, it may be possible to achieve gravity drainage through a storm trunk running parallel to the channel at a lower slope, until it daylights just south of the highway 7 crossing. This Option (8) would require approximately 1.5km of pipe with up to 8m cuts. This option would require working in the drainage channel and coordinating utility conflicts with existing infrastructure in the area. Additional coordination would be required with the Kaiser ASP to ensure the location of the trunk is aligned with the planned layout. This option appears to feasible.

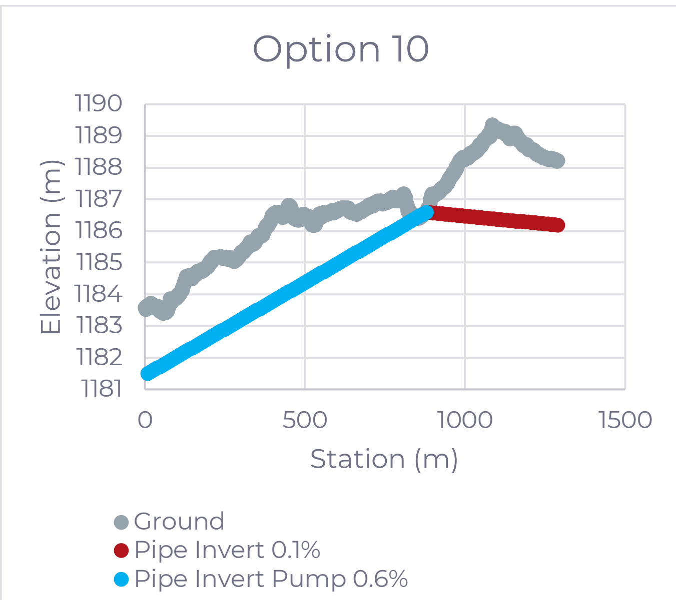


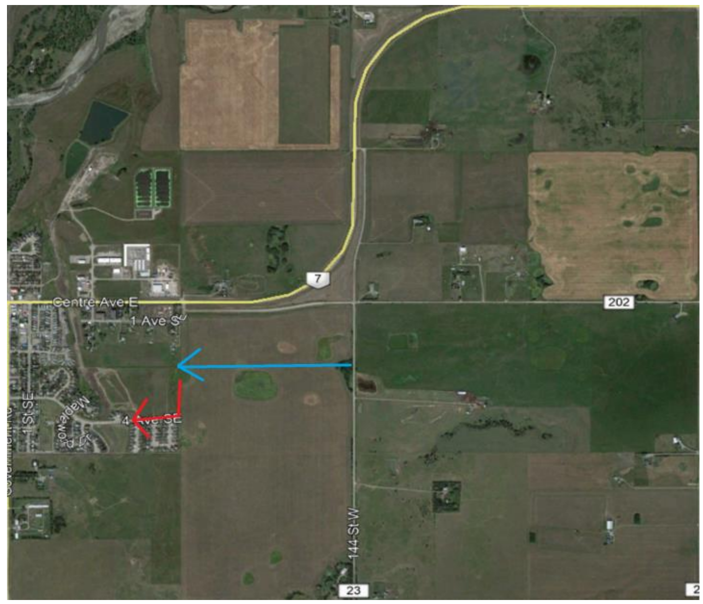
Option 9 uses approximately 1.7km of tunnelling with up to 15m cuts and follows the road ROWs to reach the existing ditch, routing underneath 1st Ave SE rather than through the Kaiser ASP area. The advantage of this option is that coordination with the Kaiser landowners would not be required. However, the trunk would be extremely deep under 1st Ave SE, which would result in expensive construction and maintenance.



2.5 DISCHARGE WEST TO THE UNDERGROUND STORM SYSTEM

Option 10 shows the feasibility of discharging the pond to the east drainage channel using a pumped system. With this system, approximately 800m of forcemain (blue line) would be required to pump up to the West edge of area 2; from there, flow can drain via gravity (red line) to reach the existing minor system on 4th Ave SE. The total required head on the pump would be approximately 6.5 m. This option would require either coordination with the Kaiser ASP to drain through the Kaiser Area, or reconstruction of a small portion of 4th Ave SE to tie to the existing manhole.





3.0 SUMMARY

Options 10 (pumping to the underground storm system) and 8 (discharge to the existing ditch) are the most feasible routes to service the storm pond. By discharging to the east drainage channel, the timelines and engagement efforts associated with a Water Act approval for an outfall to the east ephemeral drainage channel can be avoided. We look forward to discussing these options further with you.

Sincerely,

URBAN SYSTEMS LTD.

Shane Dorchak
Engineer in Training

Reviewed by:

PROFESSIONAL ENGINEER ALBERTA
TAYLOR A. SWAILES
ID #128551
2021-06-21

PERMIT TO PRACTICE
URBAN SYSTEMS LTD.
RM SIGNATURE: Jenna Majkut
RM APEGA ID #: 106133
DATE: Jun. 21 2021
PERMIT NUMBER: P003836
The Association of Professional Engineers and Geoscientists of Alberta (APEGA)

Taylor Swailes, P.Eng.
Hydrologic Engineer

cc: Erin Eyre, Meghan Aebig, Liliana Bozic

/SD
Enclosure

\\usl.urban-systems.com\projects\Projects_CAL\0925\0036\01\Z-Reference\Outbound\Town\2021-06-17-Storm Pond Servicing Options\2021-06-11-memo-stormwater_servicing_options.docx