STORMWATER DRAINAGE ANALYSIS

Val Quentin, Lac. Ste. Anne County, AB

Prepared by Bolson Engineering and Environmental Services Ltd.

Stormwater Drainage Analysis of Val Quentin

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Executive Summary

Bolson Engineering was retained by Lac Ste. Anne County (Client) to conduct a Stormwater Drainage Analysis for the Summer Village of Val Quentin. Val Quentin is located on the southern shore of Lac Ste. Anne in Lac Ste. Anne County (Municipal District No. 13) approximately 60 km northwest of Edmonton. All stormwater within Val Quentin is designed to flow north to the lake through several discharge points. This report by Bolson Engineering analyses the existing drainage patterns in Val Quentin and the surrounding areas using data from existing reports, topographical surveys, LiDar Data, and stormwater modeling software. No major problem areas were identified, and some proposed remediation options to address possible future issues are discussed within the report.

Drainage plans were developed using 1 m LiDAR data obtained from the County of Lac. Ste. Anne along with topographical survey and cadastral base map information. With this data, a corresponding digital elevation model of the plan study area was created and catchment and flow paths delineated using Global Mapper Watershed and Catchment Generation tools. After processing the data, two primary regional drainage catchments were identified with a total of 19 sub-catchment areas that feed into 8 outlet locations. To calculate outlet capacities and catchment flow rates, a release rate of 2.5 L/s/ha was considered based on the Big Lake Stormwater Management Plan results and good engineering practices.

Hydrological modeling was completed using Autodesk's Storm and Sanitary Analysis 2020 (using USEPA's SWMM v5.0 engine). The rainfall runoff rate for the 1:100yr 4-hr Chicago Distribution event in the largest sub-catchment (sub-catchment 13 = 527.2 ha), was found to be 9.12 m^3/s (17.3 L/s/ha) which is higher than regional flood discharge rate estimates, as expected.

No major drainage improvement projects were proposed for construction within the village.

Bolson Engineering identified the drainage patterns, rainfall-runoff event flows, outlet capacities for the sub-catchment areas, and completed an infrastructure review for the Summer Village of Val Quentin and the plan study area. Suggested improvements and information on how to deal with future development have also been provided. If there are any major changes in the land use or newly flooded areas occur within the study area, the results of this report and conceptual design should be reviewed and adjusted accordingly.

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1. Introduction

Bolson Engineering was retained by Lac Ste. Anne County (Client) to conduct a Stormwater Drainage Analysis for the Summer Village of Val Quentin. Val Quentin is located on the southern shore of Lac Ste. Anne in Lac Ste. Anne County (Municipal District No. 13) approximately 60 km northwest of Edmonton. The project location is shown in **Figure 1 –Val Quentin Plan Area Site Plan**. The region surrounding Val Quentin, its neighbouring villages and summer villages, and additional areas included in the analysis are shown in **Figure 2 –Val Quentin Plan Area Overall Plan**.

The Summer Village of Val Quentin was officially established on June 1st, 1960. Val Quentin covers approximately 30 hectares of land and as of the 2021 Census of Population had a population of 158 people living permanently in 74 of its 160 total private dwellings. The population of the summer village fluctuates significantly during the summer months due to the seasonal cabins and homes present within Val Quentin.

As is typical with most summer villages and in particular those present around the shores of Lac. Ste. Anne, the original development of the area started out as a small lake front community that grew and expanded over time with minimal long range planning considered, particularly for stormwater management requirements. Stormwater management is often very basic and lacking in regional scope in areas such as this. Frequently, drainage courses traverse municipal boundaries and stormwater management is an intermunicipal issue between other villages and the adjacent larger county's. Therefore, summer villages such as Val Quentin may have unique drainage issues and stormwater management challenges.

FIGURE 1: VAL QUENTIN PLAN AREA SITE PLAN

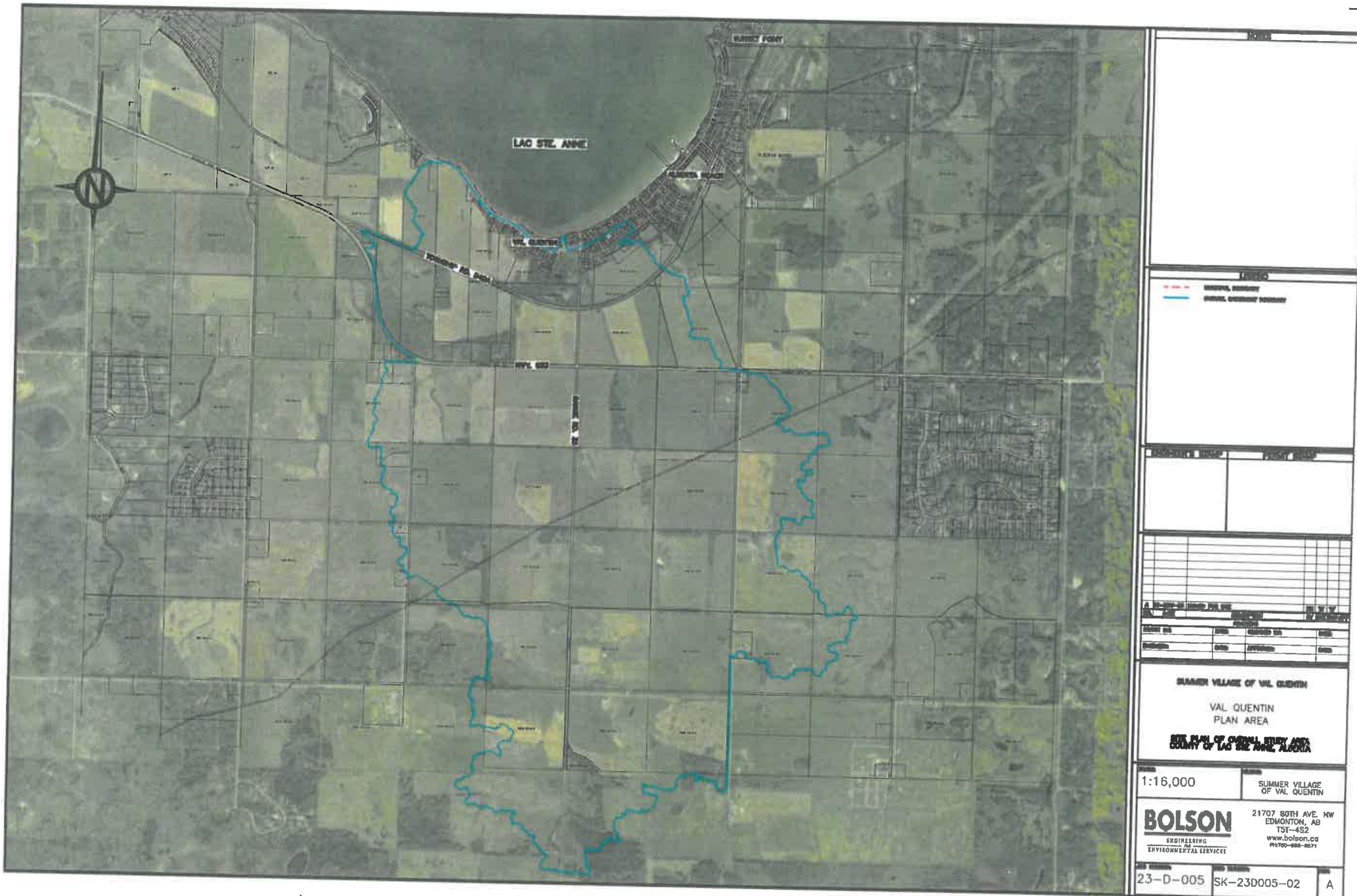


FIGURE 2: VAL QUENTIN PLAN AREA OVERALL PLAN

1.1 Project Scope

As there has not been a previous stormwater analysis completed for Val Quentin, it was requested that one be completed. This report summarizes the findings of a preliminary drainage analysis and evaluation, which is focused on identifying the existing drainage conditions and the short-term actions necessary to rectify the major drainage issues if identified. The goal of this project is to identify the major drainage paths and discharge points of the village and to provide recommendations to have a functionable stormwater management system in the future. This report presents preliminary design concepts for discussion and approval purposes. Detailed design is required prior to implementation or construction of any modifications within the village.

The main objectives of this stormwater drainage analysis are to:

- Review existing reports, standards, land use maps, natural features, and drainage issues within the plan boundary;
- Inventory the existing drainage infrastructure;
- Identify both regional and local drainage patterns and delineate existing flow routes;
- Quantify peak flow rates for design runoff events;
- Evaluate the existing infrastructure and identify issues if present;
- Propose corrective measures to resolve drainage issues;
- Provide drainage recommendations for future developments;

1.2 Geographic Characteristics

The Summer Village of Val Quentin occupies an area of approximately 30 ha and consists of existing residential, proposed future residential, and open space areas.

The existing and proposed land use concept is detailed in the Municipal Development Plan 64401 MDP Fig 2-0.dgn and can be seen in **Figure 3 – 2007 MDP Land Use Concept – Summer Village of Val Quentin**. There are currently no commercial or industrial developments within the summer village. Figure 3 also identifies a large landfill and 450m setback area south of Val Quentin.

The main street in Val Quentin is 50th Avenue which has an east-west orientation slightly setback from the southern shore of Lac Ste. Anne. West of the village, 50th Avenue becomes Township Road 543B and as you travel east outside of Val Quentin 50th Avenue continues into the Summer Village of Alberta Beach.

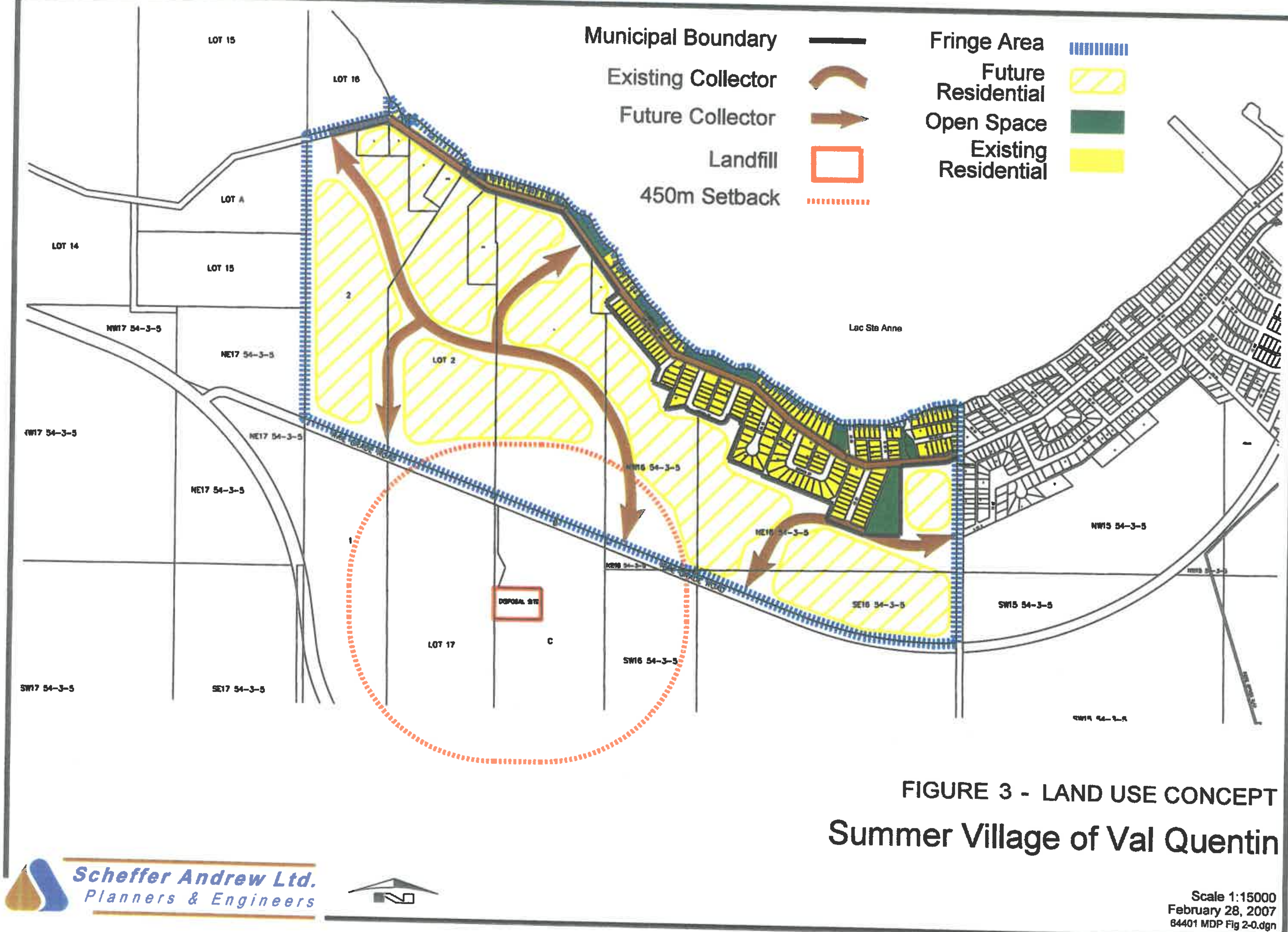


FIGURE 3 - LAND USE CONCEPT

Summer Village of Val Quentin

Scale 1:15000
February 28, 2007
84401 MDP Fig 2-0.dgn

Val Quentin is accessed by travelling from Highway 43 to Highway 633 and taking Range Road 33 into the east end of the village, or entering via Ste. Anne Trail/Township Road 543B at the west end of the village. Val Quentin is bound to the north by the shore of Lac Ste. Anne, to the east by the Summer Village of Alberta Beach, and by agricultural land to the south and west.

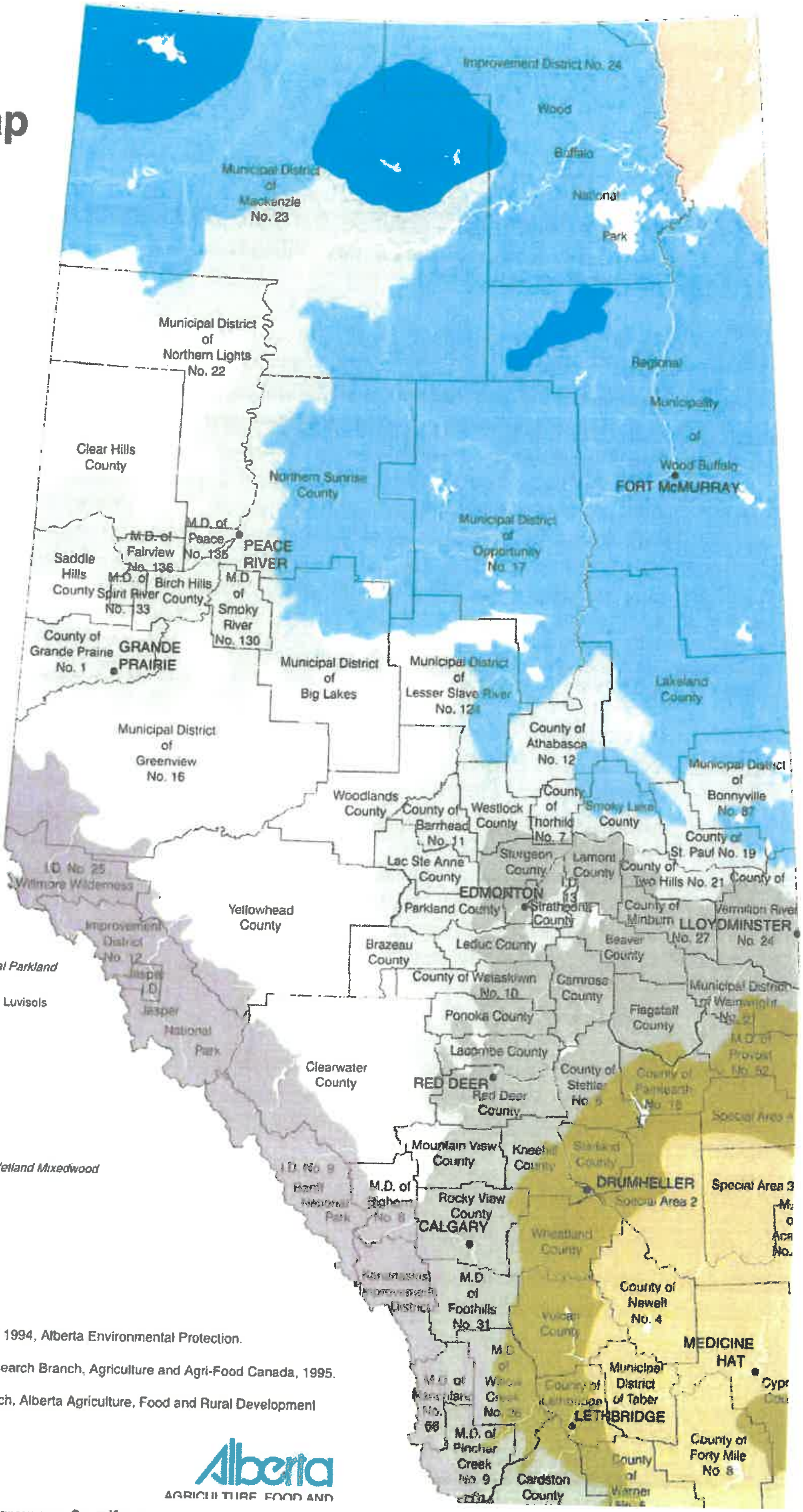
The Summer Village of Val Quentin lies within the Boreal Plain Ecozone and Boreal Transition Ecoregion. The ecoregion has characteristics of both the Western Alberta Uplands to the west, Aspen Parkland to the east and south, and Mid-Boreal Uplands to the north. The boreal transition ecoregion marks the northern limit of arable agriculture and the southern limit of closed boreal forest. The predominant vegetation includes a closed cover of tall quaking aspen intermixed with balsam poplar, white spruce and balsam fir and a thick understory of mixed herbs and tall shrubs. Poorly drained sites are usually covered with sedges, willow, some black spruce, and tamarack. The region features topography of hummocky to kettled plains and is characterized by a mix of farmland, forests and many small ponds and sloughs occupying shallow depressions.

The geology of the Val Quentin area consists primarily of sand and clay till deposits overlying the bedrock of the Wapiti Formation (Alberta Geological Society). The soil itself falls into the Dark Gray Chemozemics and Dark Gray-Gray Luvisols formation as noted in the Soil Group Map of Alberta (included below for reference), which is a black-colored soil containing a high percentage of humus, phosphorus and ammonia. This soil is typical of the Prairie Regions. The near surface geology of the Val Quentin area is characterized by glacial deposits which include, but are not limited to, tills and lacustrine deposits that vary in thickness across the area. Intermixed with these glacial deposits are sands, silts, and gravels that may be of fluvial origin. Below the surficial deposits within the Val Quentin area is the Horseshoe Canyon Formation. The Horseshoe Canyon Formation is the lower part of the Alberta Group. The Horseshoe Canyon consists of sandstone, siltstone and shale with interbedded coal seams.

Figure 4 –Existing Natural Features shows the wetland and water body data of the study area as per recent aerial photograph overlaid by the basemap and wetland and water body boundaries obtained from Altalis as of October 31st, 2023. Lac Ste. Anne is located directly adjacent to Val Quentin and there are no other wetlands or water bodies identified within the village limits themselves. Within the Val Quentin plan area, 5 smaller wetlands were noted.

Soil Group Map of Alberta

0 200 km
0 100 mi



Soil Groups*
Natural Subregions**

Soil Group	Natural Subregions
Brown Chernozemics	*Dry Mixedgrass*
Dark Brown Chernozemics	*Mixedgrass, Northern Fescue*
Black Chernozemics	*Foothills Fescue, Foothills Parkland, Central Parkland*
Dark Gray Chernozemics, Dark Gray - Gray Luvisols	*Dry Mixedwood, Peace River Parkland*
Brunisols, Gray Luvisols	*Montane, Sub-alpine, Alpine*
Gray Luvisols	*Upper and Lower Foothills*
Gray Luvisols, Organics	*Peace River Lowlands, Boreal Highlands, Wetland Mixedwood*
Organic Cryosols, Gray Luvisols	*Sub-arctic*
Brunisols	*Athabasca Plain, Kazan Upland*

*Alberta Soil Survey information.

**Natural Regions and Subregions of Alberta Map, 1994, Alberta Environmental Protection.

Map compiled by Alberta Land Resource Unit, Research Branch, Agriculture and Agri-Food Canada, 1995.

Produced by Conservation and Development Branch, Alberta Agriculture, Food and Rural Development

Agriculture and Agri-Food Canada

Alberta AGRICULTURE, FOOD AND

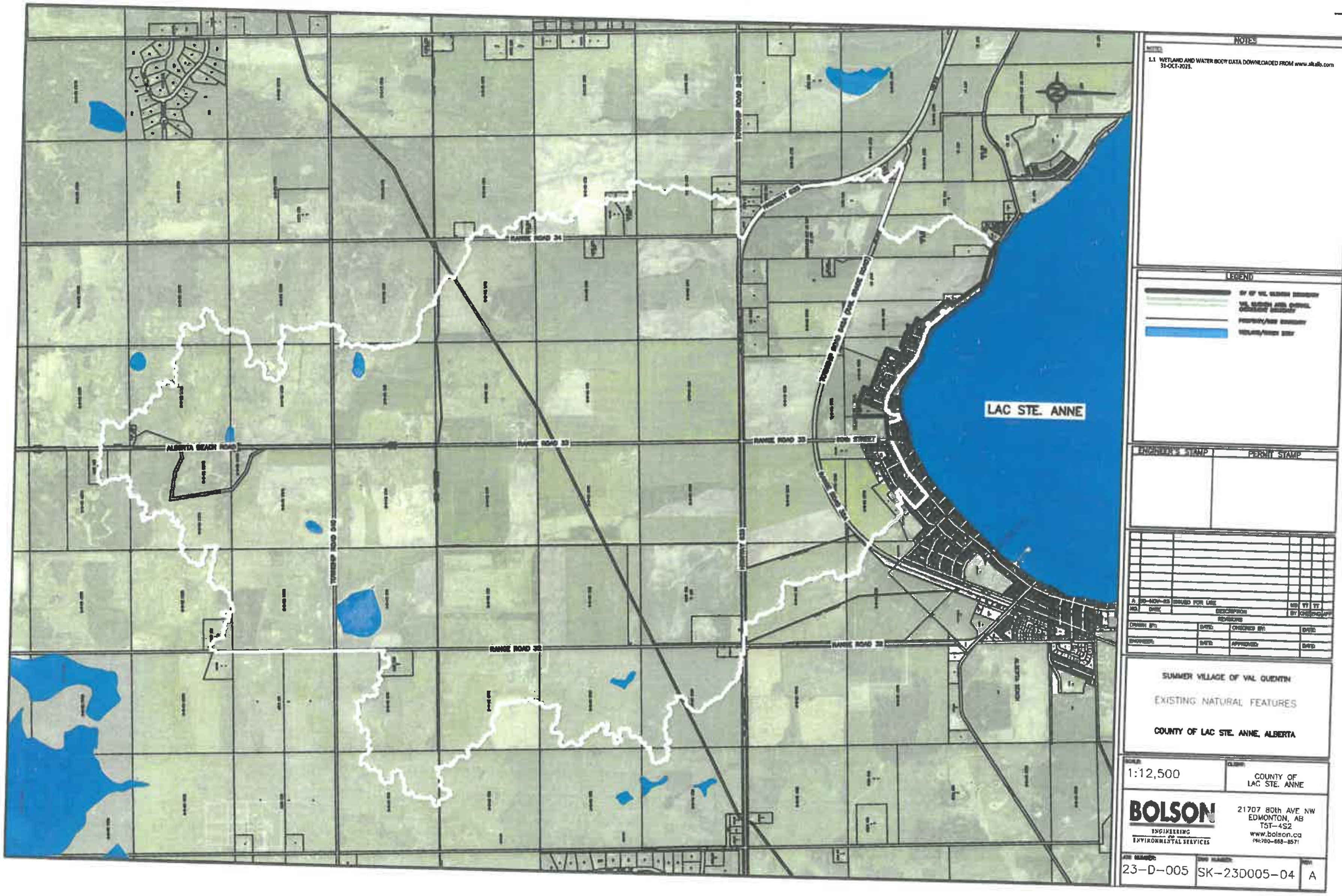


FIGURE 4: NATURAL FEATURES

2. Drainage Evaluation

Outlined below is the methodology and findings of the stormwater drainage evaluation for Val Quentin, including the existing catchments, flow routes and outlets.

2.1 Drainage Evaluation Methodology

The following is a summary of the activities that were performed for the preliminary drainage evaluation:

- Cadastral basemap data was obtained and spatial files were created for reference using the basemap data;
- 1m LiDAR data was obtained from the County of Lac Ste. Anne and a corresponding digital elevation model (DEM) of the area within proximity to Val Quentin was created;
- Review of aerial photography obtained from publically available sources (ESRI Maps, Bing Maps and Google Maps);
- Topographic survey of existing drainage infrastructure upstream and within Val Quentin was conducted, processed, and reviewed;
- Catchment and flow paths were delineated utilizing Global Mapper Watershed and Catchment Generation Tools;
- Site visits were conducted to confirm drainage patterns, photograph problem areas, and confirm flow paths determined from previously mentioned analysis;
- The delineated catchment areas and associated flow paths were modified as required based on field observations, analysis of the topographic survey data, and review of aerial photography.

2.2 Drainage Characteristics of the Val Quentin Watershed

The preliminary drainage evaluation identified and delineated the drainage characteristics of the Val Quentin watershed. **Figure 5 –Existing Topography** shows the elevation change across the study area as you move closer to Lac Ste. Anne. The entire area currently drains north towards the lake with a fairly significant overall slope. **Figure 6 – Regional Drainage Patterns** identified two primary regional drainage catchments that both intersect/drain through Val Quentin. The two catchments have contours showing relatively flat terrain gently sloping from south to north towards Lac Ste. Anne. The regional drainage catchments have been further divided into 19 sub-catchments based on the flow paths, major culvert crossings, and outlets to Lac Ste. Anne of which there are 8 total.

The eight identified outlets and corresponding flow paths and catchment areas are labeled 1 to 8. The areas contributing to each outlet are summarized in the table below and further detailed in **Figure 7 –Village Topography and Drainage Patterns Key Plan** and **Figures 8-13 Village Topography and Drainage Patterns 1-6.**

OUTLET	1	2	3	4	5	6	7	8	AVG
AREA (HA)	75.26	0.68	0.75	10.07	770.45	5.09	1111.53	39.35	251.7
AREA (AC)	185.97	1.68	1.85	24.88	1903.82	12.58	2746.65	97.24	622.0
TYPE	925mm	450mm	600mm	1200mm	1400mm	700mm	Channel	450mm	-

TABLE 2.2.1 – *VAL QUENTIN OUTLETS*

Ultimately, all flows within the study area are released to Lac Ste. Anne through one of the above noted outlets. Water upstream travels through culverts, channels, and ditches to make its way to these outlets and a large portion of the stormwater outside the village limits is unmanaged within undeveloped agricultural properties. All flows within the summer village limits appear to be managed and accommodated through right of ways, drainage easements, and site grading.

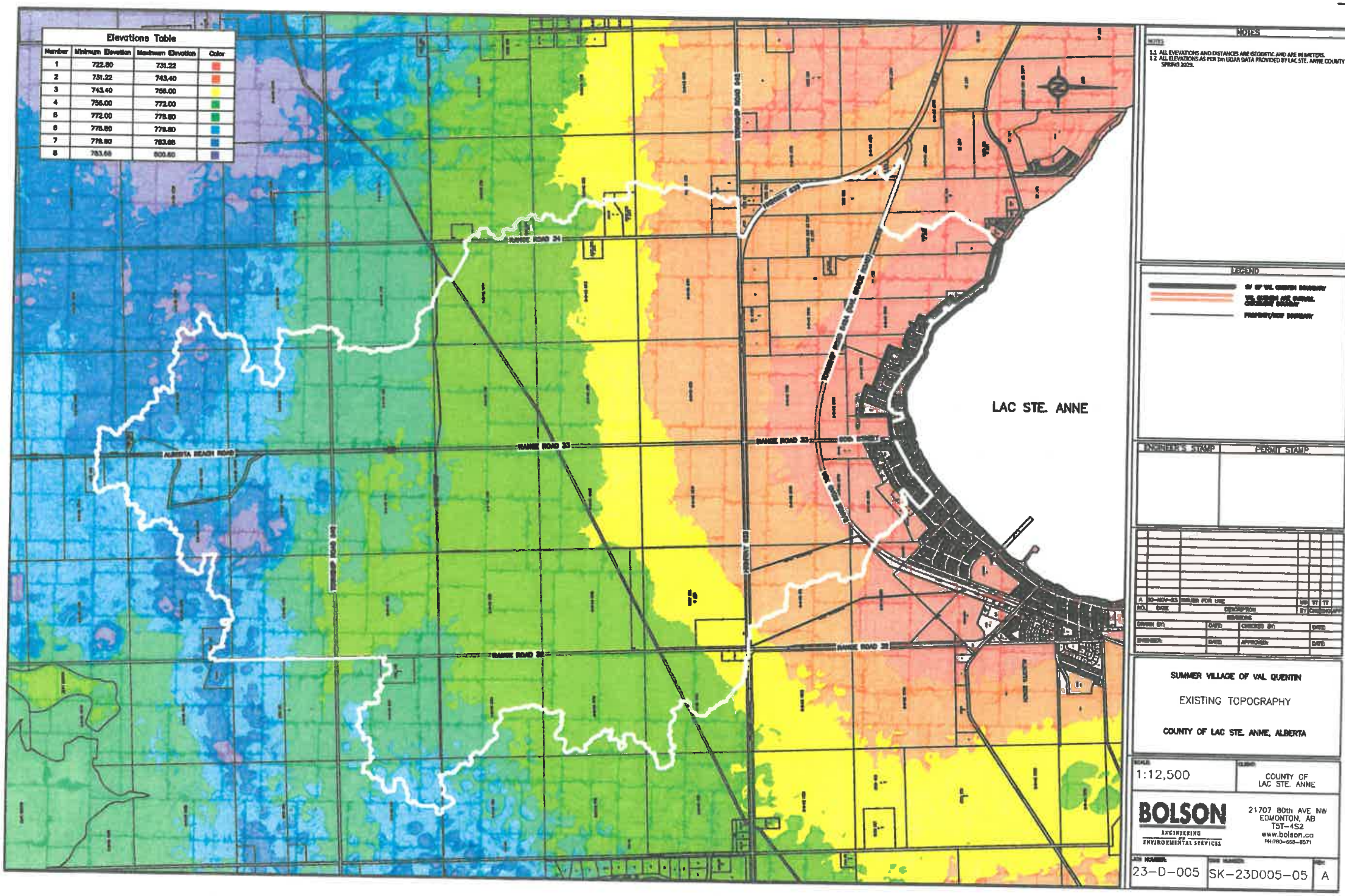


FIGURE 5: EXISTING TOPOGRAPHY

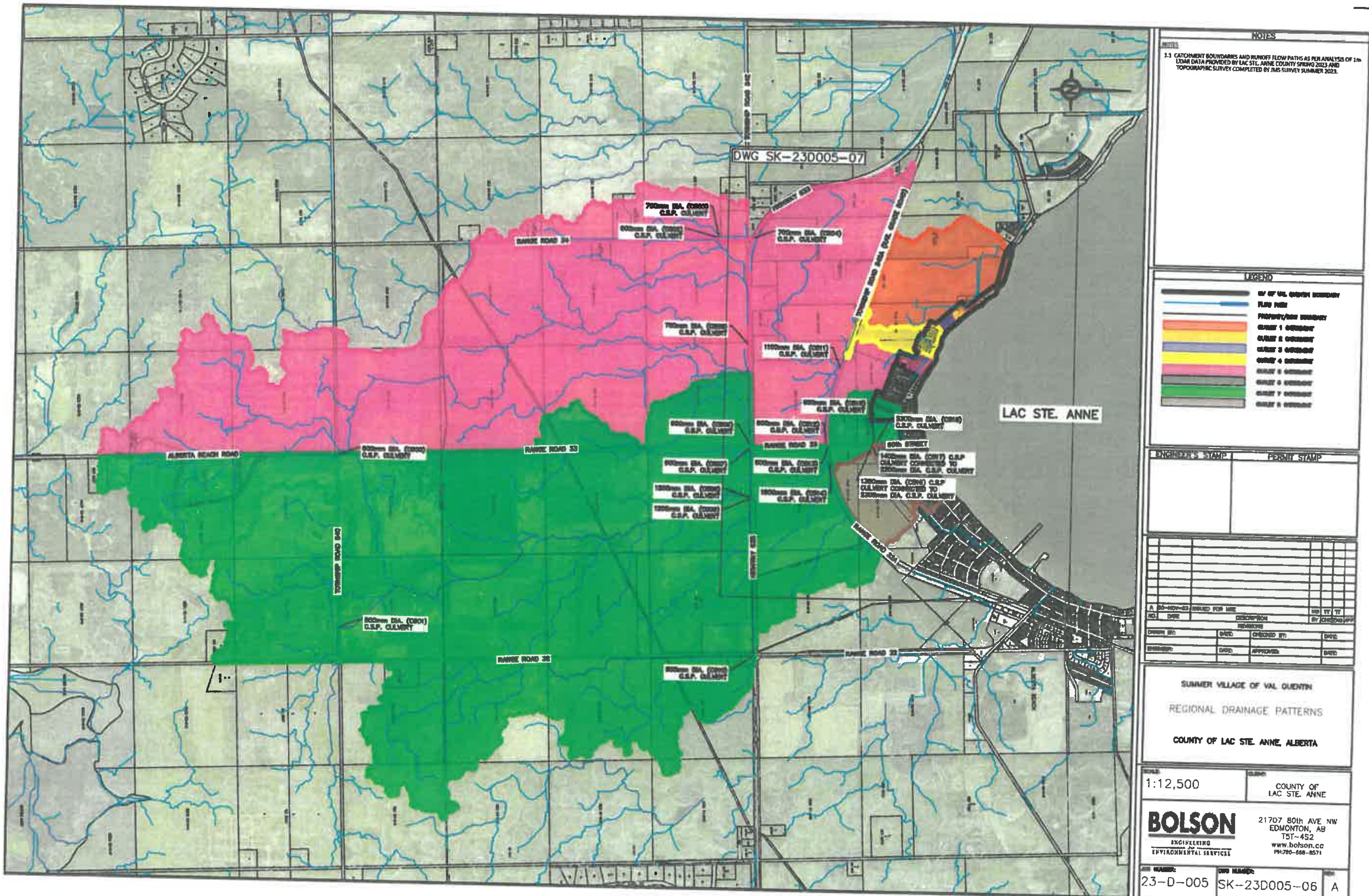


FIGURE 6: REGIONAL DRAINAGE PATTERNS

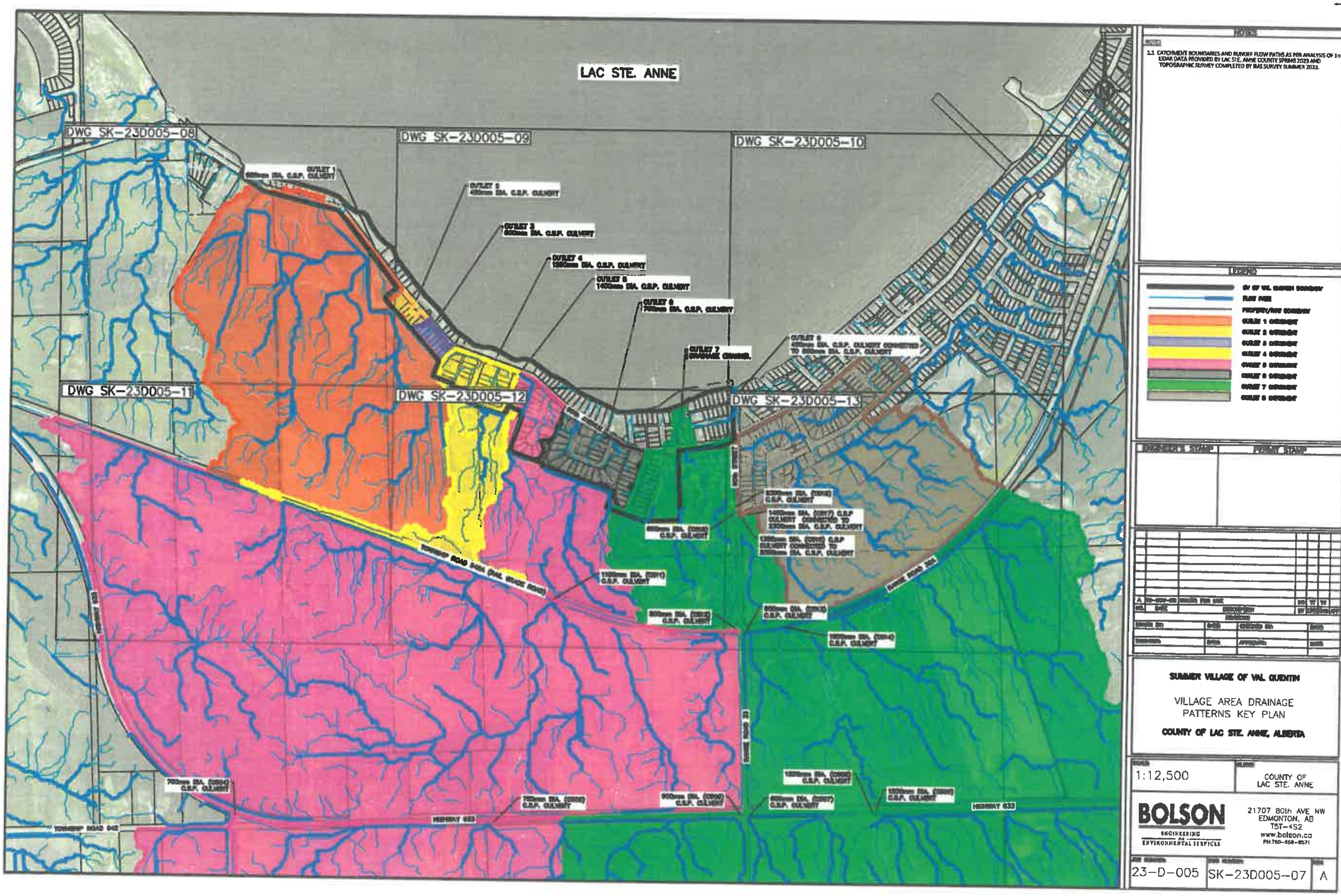


FIGURE 7: VILLAGE TOPOGRAPHY AND DRAINAGE PATTERNS KEY PLAN

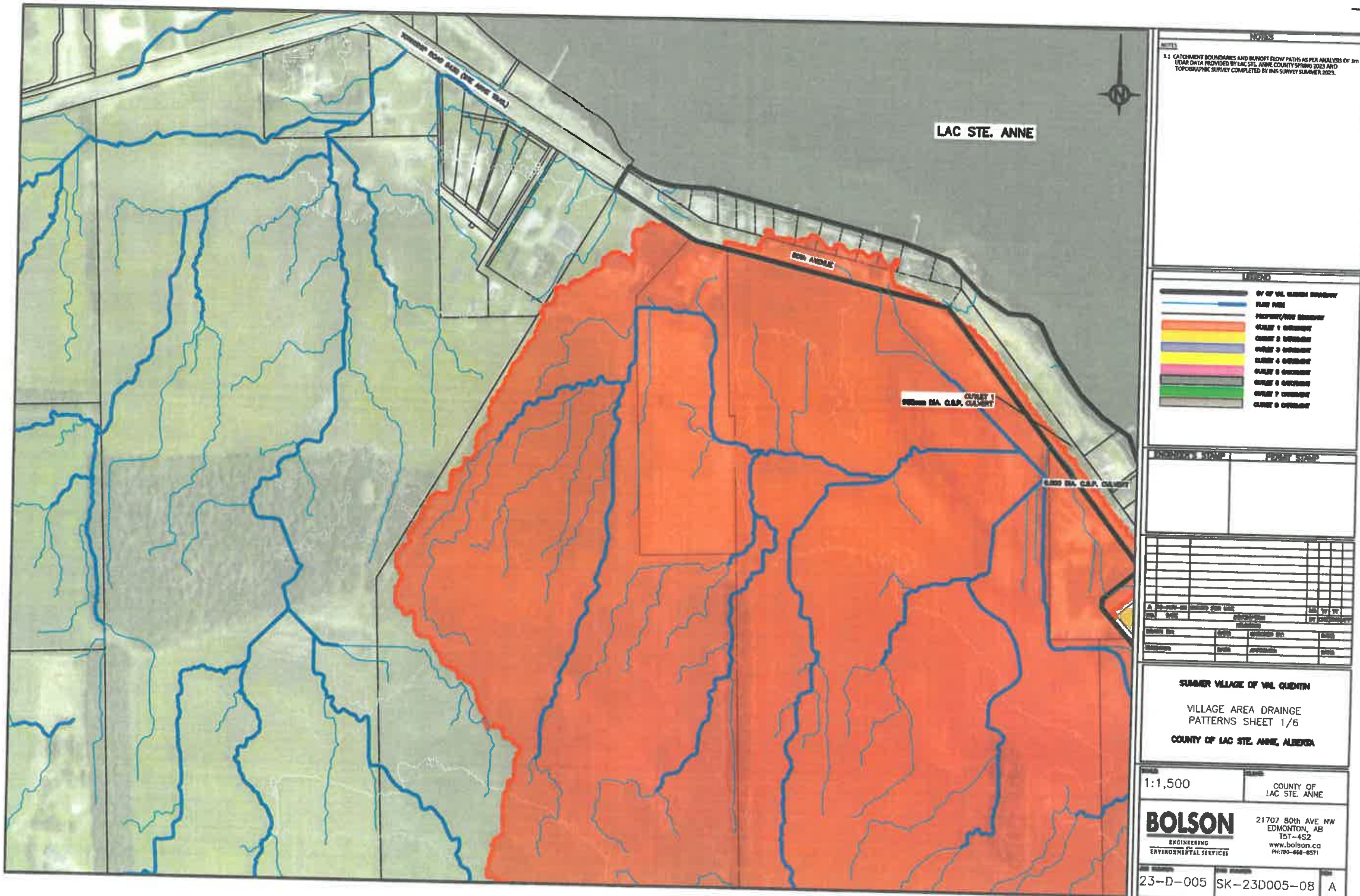


FIGURE 8: VILLAGE TOPOGRAPHY AND DRAINAGE PATTERNS 1 OF 6

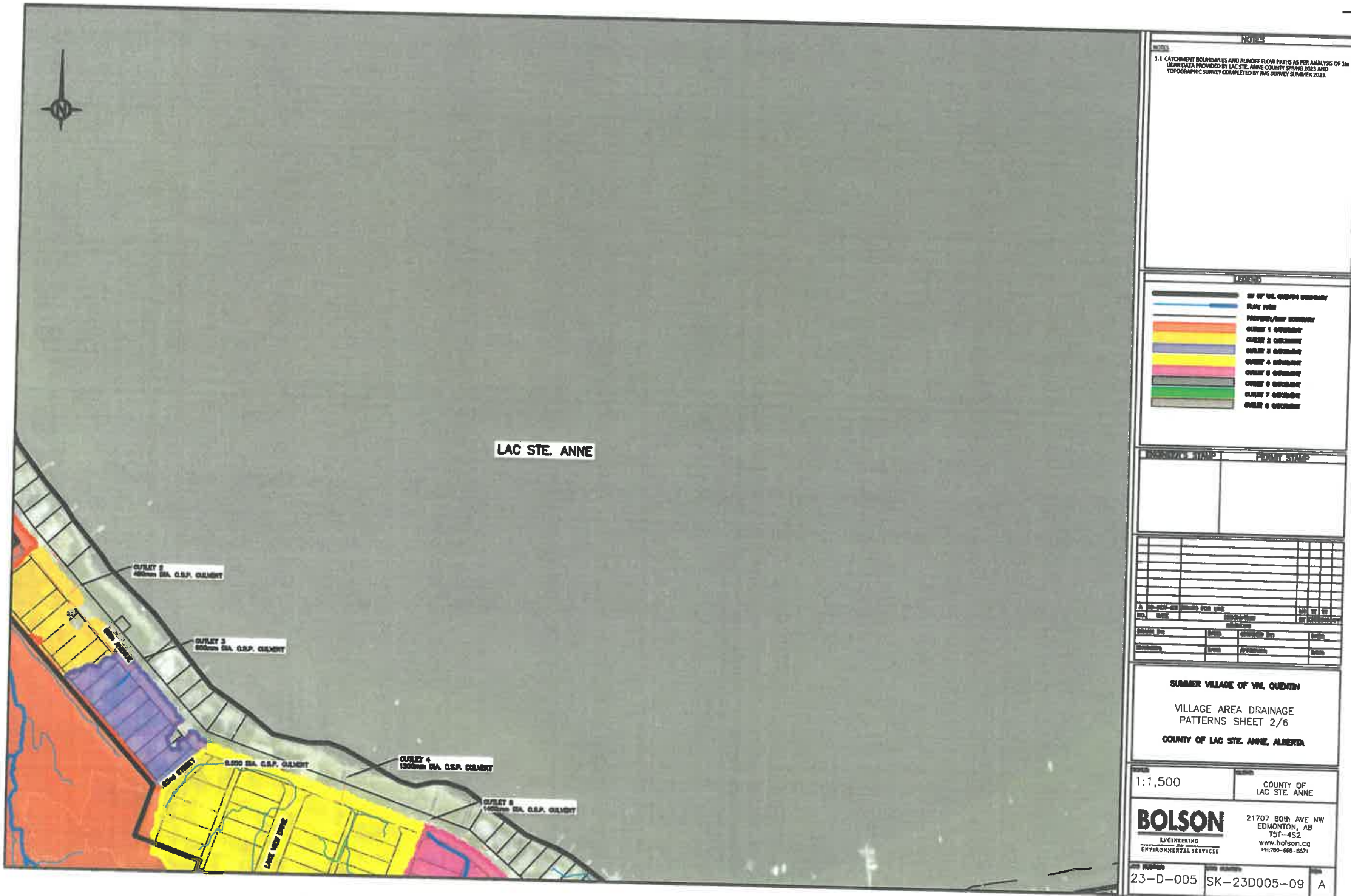


FIGURE 9: VILLAGE TOPOGRAPHY AND DRAINAGE PATTERNS 2 OF 6

FIGURE 10: VILLAGE TOPOGRAPHY AND DRAINAGE PATTERNS 3 OF 6

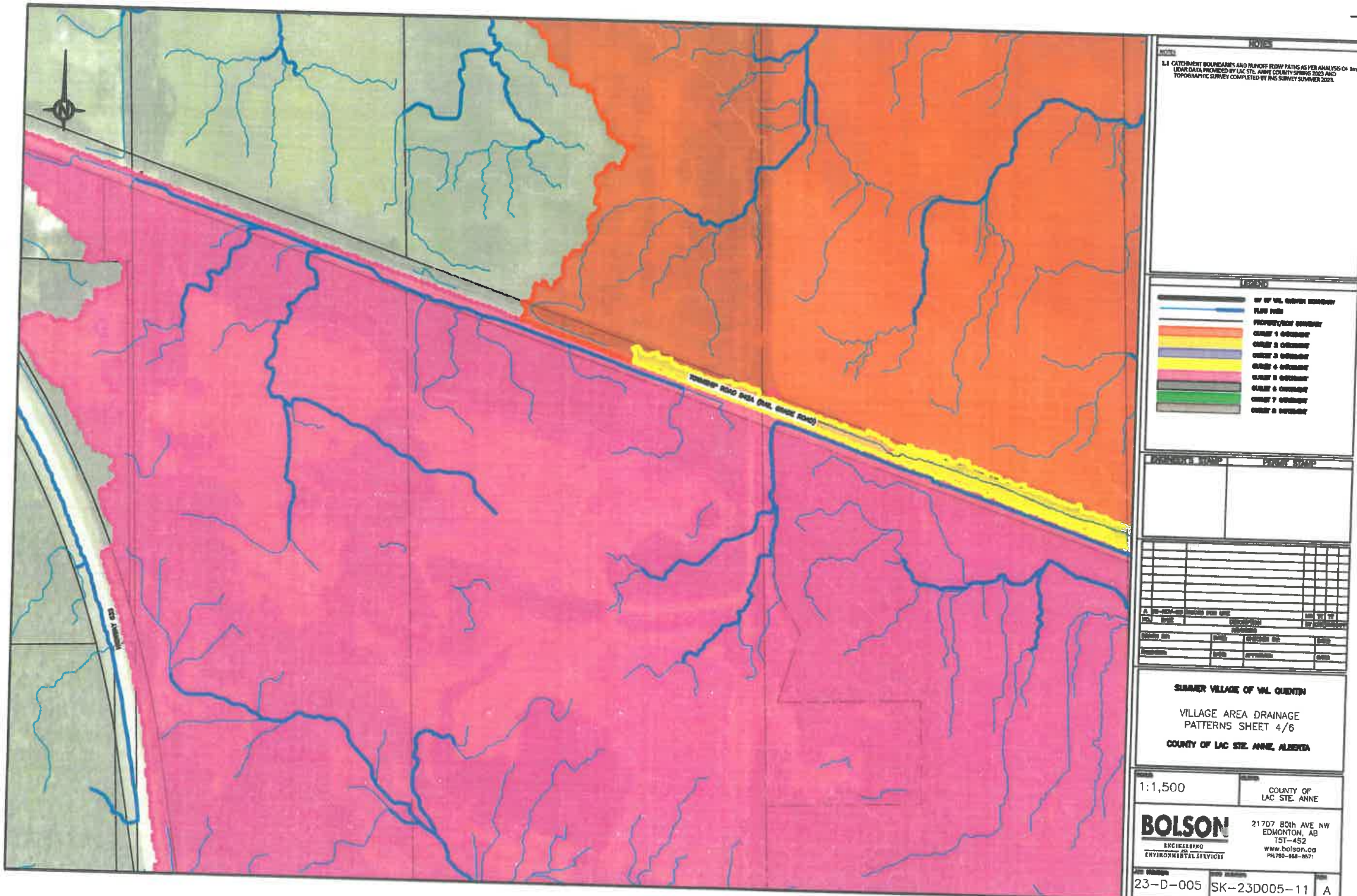


FIGURE 11: VILLAGE TOPOGRAPHY AND DRAINAGE PATTERNS 4 OF 6

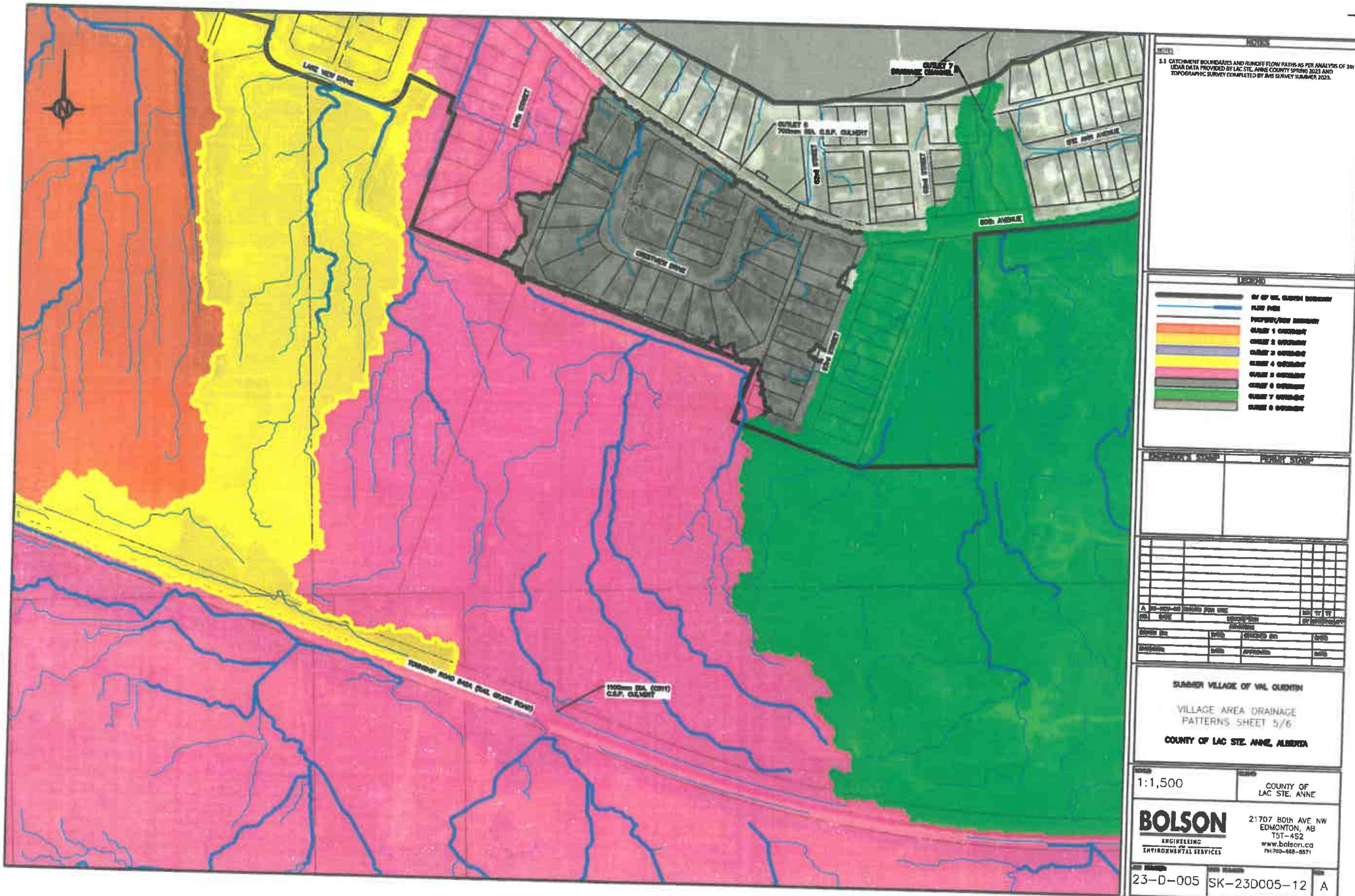


FIGURE 12: VILLAGE TOPOGRAPHY AND DRAINAGE PATTERNS 5 OF 6

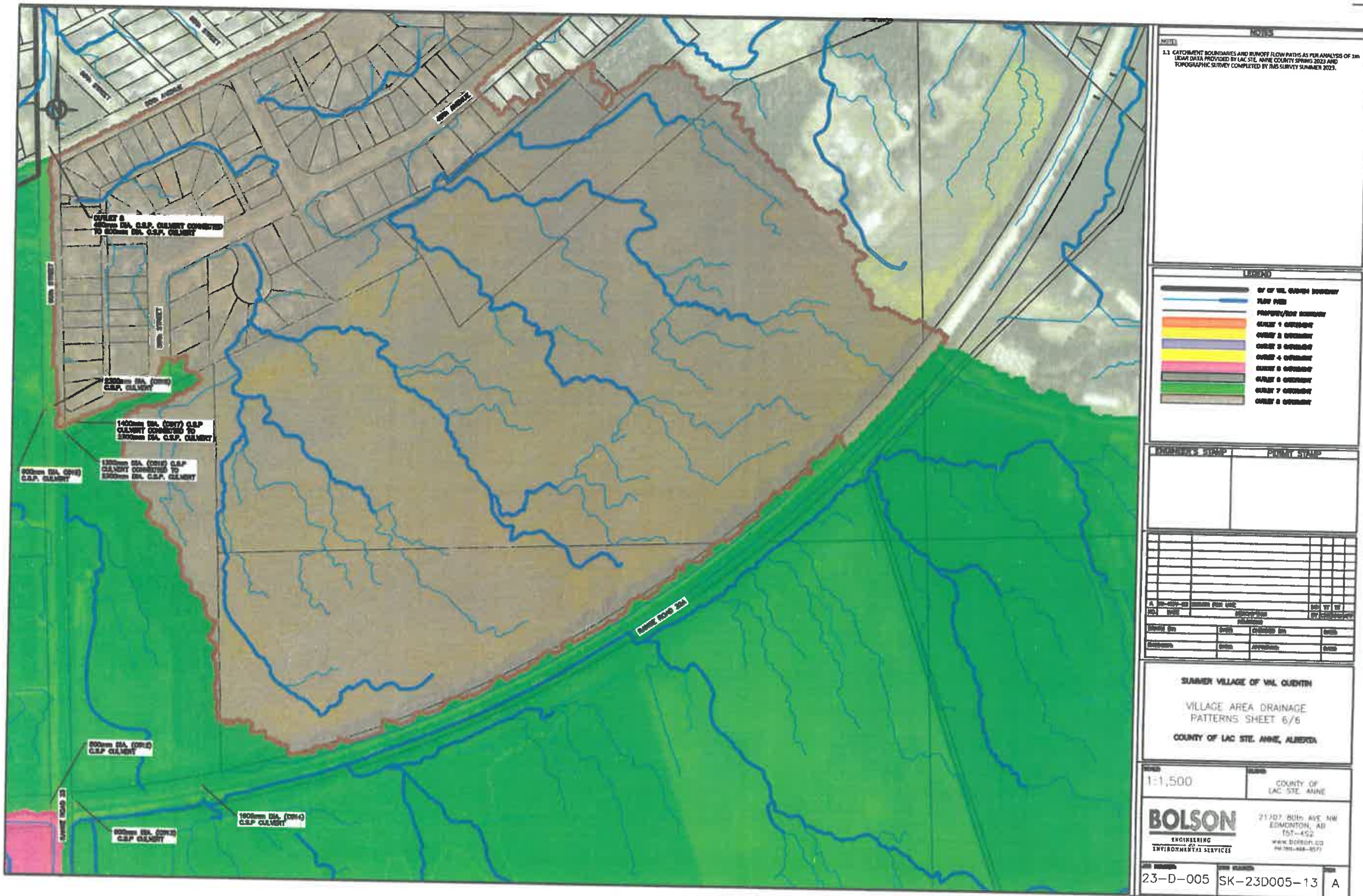


FIGURE 13: VILLAGE TOPOGRAPHY AND DRAINAGE PATTERNS 6 OF 6

Culverts within the Summer Village of Val Quentin and the study area were documented to confirm size, slope, inverts and condition for the major overland flow routes as well as confirming size and condition of the culverts along the adjacent roadways and residential approaches. This information is presented in **Appendix A** – *Existing Drainage Features and Infrastructure*.

A total of 117 culverts were identified and documented within Val Quentin itself, with 19 being identified as road crossing/drainage channel culverts and the remaining 98 as residential approaches. There are no industrial approaches in the summer village and no industrial activities in the future land use plan.

According to the General Municipal Servicing Standards (GMSS) criteria, the minimum pipe sizing (diameter) for culverts is as follows:

- Residential Approach = 500mm
- Industrial Approach = 500mm
- Roadway Centreline 600mm

The GMSS also specifies that ditch grades are to be a minimum of 0.5% and that the culvert grade should not be less than the ditch grades at the inlet and outlet. Within the study area, 56 culverts along the major overland flow routes were surveyed and the remaining 61 documented as to size and condition. According to the GMSS standard, 91 of these culverts are undersized and of the 56 surveyed along the major overland flow routes 17 have slopes < 0.5%.

2.3 Review of Relevant Documents

As part of the stormwater drainage analysis for Val Quentin, various existing planning, environmental, and drainage reports for the area were reviewed along with relevant policies, standards, legislation and bylaws. The main documents that were reviewed consist of:

1. Lac Ste. Anne County General Municipal Servicing Standards (GMSS)
2. Big Lake Stormwater Management Plan
3. North Saskatchewan Watershed Alliance – Isle Lake and Lac Ste. Anne State of the Watershed Report
4. Lac Ste. Anne and Lake Isle Water Quality Management Society – Briefing on Water Quality
5. SE Design and Consulting Stormwater Management Plan – Summer Village of Sunset Point
6. SE Design and Consulting Drainage Analysis and Improvement Plan – Alberta Beach Central Drainage Course
7. Summer Village of Val Quentin – Land Use Bylaw 218-08
8. Alberta Beach Regional Inter-Municipal Development Plan
9. Summer Village of Val Quentin Municipal Development Plan

A review of the above noted reports did not identify any current drainage issues within the Summer Village of Val Quentin, but they did note recommended design parameters to be considered for existing and future development within the plan area.

Lac Ste. Anne County issued their General Municipal Servicing Standards (GMSS) in January 2008 and most recently amended the standards in 2017. Section F of the document describes the standards for Stormwater Management Systems within the county. For major drainage systems, including roads, gutters, lot drainage and detention facilities, the design standard is a 1:100-year rainfall event. Section G describes the requirements for roadside ditching and culverts to be designed to the 1:25-year rainfall event, as well as other drainage design standards.

For future developments within Val Quentin, the post-development runoff rate must be limited such that it does not exceed the pre-development runoff rate. A review of various stormwater management reports for the region has noted that the majority reference the Big Lake Stormwater Management Plan for the pre-development flow rate and the release rate for future developments. The Big Lake Stormwater Management Plan is a study that includes the entire Sturgeon River Basin (approximately 3,500 km^2).

Based on the findings of the Big Lake Stormwater Management Plan, pre-development rates for the main basins within the plan area were determined. The authors of the technical data within the report (Sameng Inc. and Associated Engineering) conducted a regional flood-frequency analysis of streamflow data within the basins and compared that to adjacent basins. Table 2.3.1 below (Table 7.1 from the Associated Engineering Summary report in the Big Lake Stormwater Management Plan) shows the predicted flow rates that were found based on the effective drainage area and 1:100 unit flow rate.

EFFECTIVE DRAINAGE AREA (km^2)	1:100 YEAR UNIT FLOW (L/s/ha)
1	10.3
10	4.6
100	2.1
1000	0.9

TABLE 2.3.1 *REGIONAL FLOOD DISCHARGE RATES FOR THE 1:100 YEAR FLOOD*

The study area for this report falls within the Big Lake Basin Study Area. Consequently, we believe it would be appropriate to adopt some of the key report findings for the analysis of Val Quentin. Since the project area has 8 outlets, it essentially has many small basins, each with a unique time of concentration. The average effective drainage area to each outlet is 251.7 ha (2.52 km^2), less than ten square kilometers. Therefore, on average it is expected that these basins could generate more than the 10.3 L/s/ha determined for smaller drainage areas during a 1:100-year event. However, in terms of a regional study it would be more appropriate to consider the entire catchment area south of Val Quentin (~20km^2) in terms of an overall unit flow. This would result in a unit flow in the approximate range of 4.6L/s/ha overall, however to be conservative each of outlets from the upstream areas were analyzed using the 10.3L/s/ha criteria for smaller catchment areas. The preliminary 1:100-year flow rate estimates for the outlets in Val Quentin utilizing Table 2.3.1 are as follows:

OUTLET	1	2	3	4	5	6	7	8	AVG
AREA (HA)	75.26	0.68	0.75	10.07	770.45	5.09	1111.53	39.35	251.7
FLOW RATE (m^3/S)	0.78	0.01	0.01	0.10	7.94	0.05	11.45	0.41	2.59

TABLE 2.3.2 – *VAL QUENTIN OUTLET FLOW RATES*

The Big Lake Basin Study found the acceptable post-development release rate to be 2.5 L/s/ha for future developments within the plan area. This proposed release rate was determined on the basis that:

- it is consistent with pre-development flows in the basin;
- it represents the lower limit of pre-development flows for areas the size of Stony Plain and Spruce Grove;
- it minimizes the operation and maintenance problems with stormwater management facilities while providing for improvements to water quality;
- it is consistent with historic drainage facilities in the basin.

The Val Quentin study area was modeled with several different release rates between 0.1 and 10 L/s/ha and with different storm events as well as considering different factors such as the long-term impacts on peak streamflow and lake water-level rise, size and cost of required stormwater management ponds, drawdown period (days) of stormwater management ponds and various regulatory requirements.

The recommended release rate of 2.5 L/s/ha is a compromise between all these factors to balance the downstream impacts of development with the long-term development costs for future expansion. Since 2.5 L/s/ha is less than the estimated pre-development discharge rate for the outlets in the Val Quentin Study Area (minimum 10.3 L/s/ha), it is recommended to be adopted as the release rate for future development and expansion in the Summer Village of Val Quentin.

3. Existing Drainage Issues

A review of LiDar data, site topographical survey, site reconnaissance, and modeling of stormwater events did not identify any specific drainage issues within the Summer Village of Val Quentin at this time.

In general, all flows within the summer village are managed through overland conveyance systems (ditches, culverts, channels) and these conveyance systems are within existing right of ways and drainage easements. Un-accommodated flows were not noted within the summer village (major flows that were not managed on private or public property) and all catchment and sub-catchment flow paths could be identified and a corresponding outlet location mapped and reviewed to confirm capacity requirements were satisfactory based on various different storm parameters.

The main outlets to Lac Ste. Anne are all sized appropriately for the catchment areas they currently service. If future development is planned for the summer village, or expansion of the summer village limits occurs, additional design considerations will be required and these are discussed in greater detail in Section 5 – Accommodating Future Development.

There were also some concerns noted with regards to existing infrastructure (culverts and channel systems) within the summer village and surrounding plan area. These items are identified and discussed in greater detail within Section 6 – Existing Infrastructure Review.

4. Hydrological Modeling

The software Autodesk's Storm and Sanitary Analysis 2020 (using USEPA's SWMM v5.0 engine) was used to develop a hydrological model to represent the drainage in the Val Quentin Study area to help validate the results presented within the Big Lake Stormwater Management Plan. This software was used to determine the approximate quantity of generated runoff from the areas within proximity to Val Quentin during an estimated rainfall event. Table 4.1 lists the primary parameters used in the model analysis. Individual basin parameters, including slope/equivalent and width/length/area were estimated from analysis of the LiDAR topography data. Recent aerial photography was also reviewed to determine other infiltration related parameters based on existing conditions and current land uses observed.

PARAMETERS	VALUE
Sub-catchments	
Impervious (%)	Varies
Ground Slope (%)	Varies
N Impervious	0.015
N Pervious	0.25
Depression Storage, Impervious (mm)	2.5
Depression Storage, Pervious (mm)	6.4
Zero Impervious (%)	25
Horton Infiltration Parameters	
Initial Rate (mm/hr)	75
Final Rate (mm/hr)	3.5
Decay Rate (l/hrs)	4
Overland Flow Paths (Irregular Cross-Sections)	
Roughness	0.032
Pipes (Culverts - Circular Cross Sections)	
Roughness	0.012

TABLE 4.1 – SUMMARY OF ADOPTED HYDROLOGIC PARAMETERS

The percent imperviousness for the various catchments ranged from 10% (typical for undeveloped farm land) to 40% (typical for rural residential properties) and varied depending on the above mentioned review of aerial photography land use. The Manning's roughness coefficient (N) and depression storage values for impervious surfaces (0.015 and 2.5 mm respectively) were selected to represent a range of overland flow surfaces from the modeled area based on previous experience of the project area. Similarly, the permeable surface values (0.25 and 6.4 mm respectively) were selected based on previous design experience and represent a range of expected values for the general area. The zero impervious value of 25% was also kept as a default.

The Horton infiltration soil parameters (75 mm/hr initial rate, 3.5 mm/hr final rate and a decay rate of 4 1/hrs) used were consistent with organic/loam soils with little or no vegetation to reflect early spring conditions before vegetation has had sufficient time to establish. For the predicted open channel flow paths an average Manning's roughness coefficient for the channels observed was estimated to be 0.032 based on applicable literature and previous experience. Also, the culverts observed on site were all noted to be corrugated metal pipes so a typical Manning's roughness coefficient of 0.012 was assumed for all pipe/culvert crossings.

4.1 Summary of Basin Characteristics:

19 sub-catchment areas were identified as part of the analysis for Val Quentin. Analysis of the basin parameters for the hydraulic model and field observations identified the following basin characteristics for these sub-catchment areas:

a) All of the outlets have small contributing areas (≤ 1 km^2) except for outlet 5 (7.7 km^2) and outlet 7 (11.12 km^2);
b) Channel banks are actually quite defined along the major flow paths;
c) The basin has significant storage capacity in offsite/external contributing areas as well as in existing ditch and overland conveyance systems;
d) Some of the internal ditch and culvert systems within the Summer Village of Val Quentin were of a minimal (< 0.5%) slope.

These basin characteristics are all indicative of a smaller catchment with a shorter time of concentration; thus, we expected to model peak flow rates that are larger than anticipated from the regional analysis and this was the case as per flow rates that were determined for each of the sub-catchment areas as shown in Table 4.2.1 in the section below.

4.2 Design Storm Selection:

The design storm event used for this event-based model was a 1:100yr 4-hr Chicago Distribution event based on Table 2.7 of the City of Edmonton/EPCOR's Design and Construction Standards Volume 3-02. This design storm uses a Chicago Distribution to represent estimated 4-hr storm events based on 11 Edmonton rain gauges with data from 1984 through 2020. This design storm was chosen as this is considered representative for the greater Edmonton region but is also conservative as the City of Edmonton has recently updated their storm water design requirements to account for future impacts of climate change.

SUBCATCHMENT	CONTRIBUTING AREA (Ha)	1:100 YEAR MODEL PEAK RUNOFF RATE (m^3/s)	BIG LAKE REGIONAL ANALYSIS RUNOFF RATE (m^3/s)
1	75.258	2.47	0.78
2	0.683	0.14	0.01
3	0.753	0.16	0.01
4	10.073	0.52	0.10
5	19.929	0.96	0.21
6	5.094	0.56	0.05
7A	20.82	1.32	0.21
7B	5.558	0.20	0.06
8	39.346	1.85	0.41
9	169.913	3.66	1.75
10	9.15	0.36	0.09
11	84.456	2.43	0.87
12	53.449	1.86	0.55
13	527.156	9.12	5.43
14	56.304	1.61	0.58
15	81.625	2.27	0.84
16	445.683	9.26	4.59
17	207.556	4.54	2.14
18	86.577	2.03	0.89
19	113.796	3.42	1.17

TABLE 4.2.1 – SUB-CATCHMENT ESTIMATED PEAK RAINFALL RUNOFF RATES

As mentioned, the rainfall runoff rates predicted by the SWMM model were higher than the rates anticipated based on the Big Lake regional flood discharge rate estimates as shown in Table 4.2.1 above. This is somewhat expected due to the relatively small size of the effective drainage areas as the rates developed as part of the regional flood analysis would typically be based on larger catchments. From the model results, the downstream flow rates at several of the outlets appear to be under represented due to extremely shallow, flat, or reverse graded culverts which are indicating runoff is cutoff upstream of the outlets. Because of this and to be consistent with previous reports developed for the area it was decided to proceed with the runoff rates determined based on the Big Lake regional analysis rates rather than those from the hydrological model.

These runoff rates based on the upstream catchment areas for the regional analysis were compared against the expected outlet capacities based on the survey data (culvert inverts/slopes/lengths) and model parameters (Manning's Roughness and entrance/exit parameters) and are shown below in Table 4.2.2:

OUTLET	1	2	3	4	5	6	7	8
EX. CAPACITY (m^3/s)	0.2	0.7	0.6	4.4	9.2	1.0	42.7	0.6
FLOW RATE (m^3/s)	0.78	0.01	0.01	0.10	7.94	0.05	11.45	0.41

TABLE 4.2.2 – *OUTLET CAPACITIES AND EXPECTED FLOW RATES*

From the data in the table it can be observed that there is currently adequate capacity for each of the outlet culvert/channels with the exception of Outlet 1. This is due to the fact the Outlet 1 culvert is slightly reverse graded based on current topographic survey data. It is not anticipated that this would cause an overall flow restriction for this catchment area as the culvert is relatively large (925mm diameter), however it could possibly result in nuisance flooding of the area upstream of the inlet during major storm events. It is recommended that the culvert be reinstated to achieve at least 0.5% grade to meet current design standards, however it is understood that this could be difficult based on existing upstream and downstream elevations. At minimum, if it is possible to achieve at least 0.2% grade along this culvert then it is expected that there will be sufficient capacity at this outlet (0.85m^3/s capacity compared to a 0.78m^3/s expected flow rate).

5. Accommodating Future Development

From the information outlined in the latest Land Use Concept for the Summer Village of Val Quentin from the 2007 MDP, any proposed future development for the summer village is indicated to be residential in nature with future collector roadways to connect the areas to the existing summer village. The future plans are to expand the summer village to the south while avoiding the former landfill disposal site and its required setbacks.

Accommodating any future potential residential development should consider the following drainage design criteria:

1. Runoff quantity is to be managed by providing storage in a stormwater management facility to allow for the pre-development 2.5 L/s/ha release rate. Depending on the size of the area being developed this can be provided through wet or dry ponds, onsite ponding and storage areas, or low impact development measures.

2. Runoff quality is to be managed by providing a low-velocity stormwater management facility that achieves sediment removal to the current Alberta Environment regulatory requirements (for larger parcel developments that will require a stormwater management facility).

3. Major drainage courses are to be accommodated in roadside ditches or drainage right of ways that lead to the stormwater management facility or connect to existing drainage conveyance systems that have the capacity to handle additional flows.

4. All new structures shall be set at elevations that are a minimum of 0.300m above any designed ponding or stormwater storage facilities.

5. All new development shall be designed in such a way as to prevent cross lot drainage onto adjacent privately titled properties.

6. Downstream outlets and sub-catchment areas must not have additional flows provided to them that would exceed their available capacities. If water is managed as noted above this will not be an issue.

7. All new culverts and ditches within future development areas should follow the GMSS criteria for culvert sizing and slopes:

- Residential Approach = 500mm
- Industrial Approach = 500mm
- Roadway Centreline 600mm
- Minimum 0.5% culvert and ditch grades

At this time there is no noted planned future development for the Summer Village of Val Quentin that we are aware of. Depending on the size and type of future development will dictate the need for any future stormwater management facilities and detailed design requirements at that time. If proper stormwater design parameters are followed with future design (especially limiting developed release rates to 2.5 L/s/Ha) then the current outlet release systems within the summer village will adequately handle any new development for the foreseeable future.

6. Existing Infrastructure Review

As part of the stormwater drainage analysis for this project, an inventory of existing culverts and drainage infrastructure was completed within the village limits and off-site in the plan study area. **Appendix A** – *Existing Drainage Features and Infrastructure* has drawings providing a summary of the 117 total culverts that were observed within the village while **Figure 6 –Regional Drainage Patterns** includes the locations of the 19 off-site culverts that were surveyed and evaluated within the plan area.

The culverts were all analyzed to confirm the size, slope, condition, and installation type to confirm if they were adequate for the current use and installed to current design standards. There are no underground storm systems within the summer village or plan area and therefore all water is conveyed to the 8 major outlets through overland ditches, culverts, and swales. As a point of reference, the GMSS was used to review the culverts and ditch slopes as per the following criteria:

- Residential Approach = 500mm
- Roadway Crossing = 600mm
- Culvert Slope = 0.5%

The results of the review of the 117 culverts within Val Quentin are summarized in Table 6.1 below, with culvert parameters below the minimum GMSS standards highlighted in yellow. The culvert numbering system showing the location of each culvert can be viewed in the plans included in **Appendix A** – *Existing Drainage Features and Infrastructure*. In general, 19 of the culverts are identified as road crossings with the remaining 98 as residential/park approach culverts. Of the culverts reviewed, 91 were sized below the GMSS standards and 17 of the surveyed culverts along the major overland flow routes had slopes < 0.5%. This does not meant the culverts require replacement or are creating drainage issues at this time, but they should be monitored and if issues occur replaced with appropriate sized and sloped culverts.

CULVERT ID	DIAMETER (mm)	SLOPE (%)	COMMENTS
100	450	1.71	Road Crossing; Village of Alberta Beach/End Flattened
101	600	0.34	
102	300	0.01	Park Access/Damaged End
103	300	0.15	Park Access/Ditch poorly graded
104	600	2.14	
105	600	0.16	Road Crossing
106	500	1.6	
107	400	0.76	
108	400	0.74	
109	400	0.31	Road Crossing
110	300	4.54	
111	400	1.2	Road Crossing
112	700	0.65	Major Outlet #6
113	500	0.15	
114	500	0.6	
115	500	0.24	
116	500	0.94	
117	500	0.65	
118	400	0.77	Road Crossing
119	400	0.56	
120	300	0.41	
121	400	0.03	Road Crossing
122	300	2.37	
123	400	0.89	
124	500	0.58	Road Crossing
125	500	0.98	
126	300	0.38	
127	300	0.4	
128	1400	7.31	
129	1400	2.06	Major Outlet #5/Culvert damaged and possibly failing
130	1200	1.09	Major Outlet #4

CULVERT ID	DIAMETER (mm)	SLOPE (%)	COMMENTS
131	500	1.18	
132	500	0.57	Road Crossing
133	300	0.66	
134	500	0.64	Road Crossing
135	500	0.5	
136	500	0.59	
137	500	0.19	
138	500	0.12	
139	600	0.92	Major Outlet #3
140	500	1.17	
141	500	0.71	
142	500	1.75	
143	300	0.79	
144	450	1.68	
145	500	0.76	
146	450	1.33	Major Outlet #2
147	300	0.45	Very Long (>35m)
148	300	0.63	
149	500	0.4	Road Crossing
150	400	0.85	
151	925	-0.23	Major Outlet #1 (Reverse Graded)
152	300	1.16	Culvert end doesn't match ditch
153	300	1.84	Culvert end doesn't match ditch
154	400	0.32	
155	400	1.55	
156	400		
157	400		
158	400		
159	400		
160	400		

CULVERT ID	DIAMETER (mm)	SLOPE (%)	COMMENTS
161	400		
162	400		
163	400		
164	400		
165	400		
166	400		
167	400		
168	400		
169	400		
170	400		
171	400		
172	400		
173	400		
174	400		
175	400		
176	300		
177	300		
178	300		
179	300		
180	400		
181	400		
182	350		Road Crossing/Culvert end damaged
183	400		
184	400		
185	400		
186	400		
187	400		
188	400		
189	400		
190	400		

CULVERT ID	DIAMETER (mm)	SLOPE (%)	COMMENTS
191	300		Settlement Issues/Crushed culvert
192	300		Flattened
193	300		Flattened
194	300		
195	400		
196	400		
197	400		
198	400		
199	400		
200	400		
201	400		
202	400		
203	400		
204	400		
205	300		
206	350		Road Crossing/Minimal Cover
207	400		Road Crossing/Minimal Cover
208	350		
209	400		Culvert end slightly buried
210	400		
211	400		
212	400		
213	400		
214	400		
215	400		
216	400		

TABLE 6.1 – SUMMARY OF VAL QUENTIN CULVERT INVENTORY

Additionally, 19 culverts in the plan study area to the south of Val Quentin were surveyed and reviewed for condition and size. The results of the review are summarized below in Table 6.2.

CULVERT ID	DIAMETER (mm)	COMMENTS
500	600	Debris in culvert; Shallow Slope
501	500	Shallow Slope
502	600	
503	700	Damaged culvert end
504	700	
505	750	
506	900	Damaged culvert end; Shallow Slope
507	900	
508	1200	
509	1200	
510	800	
511	1100	
512	500	Damaged and buried culvert end/Reverse graded
513	900	Damaged culvert ends
514	1900	Shallow Slope
515	600	
516	1350/2300	Different sizes connected together
517	1400/2300	Different sizes connected together
518	2300	

TABLE 6.2 – SUMMARY OF OFF-SITE STUDY AREA CULVERT INVENTORY

The culvert inventory review identified that there does not seem to be any consistent design criteria for the culverts within the Summer Village of Val Quentin. Moving forward, it is recommended to adopt similar design standards that were prepared for the Summer Village of Sunset Point by SE Engineering and are included for reference in **Appendix D** – *Typical Standard Details*. Rip-rap in particular was missing from most of the culvert ends installed within the village and sizing did not follow the GMSS. This may create minor issues for public works to maintain the culvert systems, however the expected flows through the summer village conveyance system should not overwhelm any of the existing culverts provided they are properly maintained and monitored.

Another item of note was that some of the residential approach culverts had shallow cover (<0.300m) which can create freezing and maintenance issues and shorten the expected lifespan of the culverts. Future installation of culverts and maintenance/repair of existing culverts should follow the Armtec Tables 6 and 7 or equivalent as included in **Appendix D** – *Typical Standard Details* for the proposed depth of cover that is recommended based on the culvert type used.

Preliminary Cost Estimates

No major drainage programs are recommended to be implemented within the plan area at this time however it is recommended to remediate some of the existing damaged culverts within Val Quentin. Any culverts that are noted in the culvert inventory as having damaged ends or crushed/flattened conditions are recommended to be repaired. An estimated cost of **$1,500 - $2,000/culvert** is a reasonable value to replace the damaged culvert ends.

It is also recommended to place rip rap on the culverts throughout the summer village as required. A large majority of the culverts have little or no rip-rap on the culvert ends and this can cause erosion or damage to the culvert ends. A conservative value of **$50,000 - $60,000** can be considered to supply and place rip rap on all culverts that require it.

Many of the residential culverts within the village were also observed to have shallow cover (< 0.300m). A typical table for recommended shallow cover requirements is included in **Appendix D** – *Typical Standard Details* and in the future it is advised to follow these guidelines for installation of new culverts or during the repair/replacement of any existing culverts that is completed.

Culvert C129 (Major Outlet #5) that crosses 50th Avenue appeared to be damaged and compromised at the time of the review. Temporary shoring supports have been installed within the culvert system to prevent further failure and the culvert appears to be displaced and flattening likely due to roadway loads from above and lack of adequate backfill and compaction. It is recommended at this location to remove the 12.40m of 1400mm CSP culvert and replace it with a thicker wall culvert or box style culvert/concrete culvert to ensure that it can handle the expected loading and prevent future failure of the culvert system. Proper detailed design would be required to ensure structural integrity of the new installation and based on existing flows the culvert sizing of 1400mm is adequate for this road crossing. The length of the culvert should be extended to allow for proper side slopes of the road top.

Culvert C151 (Major Outlet #1) is reverse graded and preventing adequate flow through the culvert system during major storm events. It is recommended to remove and reinstall the 925mm culvert to achieve a minimum of 0.5% slope to prevent possible upstream flooding during large storms and to ensure the upstream catchments can adequately drain out to Lac Ste. Anne.

A summary of the proposed repairs for both Culvert C151 and C126 are outlined below.

Culvert C129:

Specifications: 1400mm CSP Culvert
Upstream Invert = 722.95
Downstream Invert = 722.70
Length = 12.4m; Slope = 2.06%

CULVERT C129

Existing culvert is damaged and possibly failing due to structural integrity. Debris and temporary supports were observed within the culvert and little to no rip-rap at the outlets.

Recommendations: Remove and replace culvert with 1400mm CSP culvert that has been designed to ensure structural integrity can be maintained at this location. Install rip rap at ends.

Estimated Cost of Repair:

C-129 (1400mm CSP CULVERT)				
ITEM	***UNIT***	***QUANTITY***	***$/UNIT***	***TOTAL***
Remove and Replace 1400mm CSP Culvert	m	15.0	$2,000.00	$30,000.00
Road Crossing	L. Sum	1.0	$55,000.00	$55,000.00
Rip-Rap	m2	10.0	$150.00	$1,500.00
Engineering (15%)	L. Sum	1.0	-	$12,975.00
Contingency (10%)	L. Sum	1.0	-	$8,650.00
			TOTAL:	**$108,125.00**

Culvert C151:

Specifications: 925mm CSP Culvert
Upstream Invert = 723.169
Downstream Invert = 723.204
Length = 15.5m; Slope = -0.23%

CULVERT C151

Existing culvert is reverse graded.

Recommendations: Remove and reinstall existing culvert with minimum 0.5% slope. Install rip rap at ends.

Estimated Cost of Repair:

C-151 (925mm CSP CULVERT)				
ITEM	***UNIT***	***QUANTITY***	***$/UNIT***	***TOTAL***
Remove and Reinstall 925mm CSP Culvert with 0.5% Slope	m	15.5	$850.00	$13,175.00
Road Crossing	L. Sum	1.0	$55,000.00	$55,000.00
Rip-Rap	m2	4.0	$150.00	$600.00
Engineering (15%)	L. Sum	1.0	-	$10,316.25
Contingency (10%)	L. Sum	1.0	-	$6,877.50
			TOTAL:	$85,968.75

7. Closure

We trust that this report meets your present requirements. We have identified the drainage patterns, rainfall-runoff event flows, outlet capacities for the sub-catchment areas, and completed an infrastructure review for the Summer Village of Val Quentin and the plan study area. Suggested improvements and information on how to deal with future development have also been provided. If there are any major changes in the land use or newly flooded areas occur within the study area, the results of this report and conceptual design should be reviewed and adjusted accordingly.

This document was prepared by Bolson Engineering in accordance with generally accepted engineering practices and is intended for the exclusive use and benefit of the Summer Village of Val Quentin and Lac Ste. Anne County.

APPENDIX A:

EXISTING DRAINAGE FEATURES AND INFRASTRUCTURE

CULVERT DATA TABLE

NAME	DIAMETER (mm)	LENGTH (m)	SLOPE (%)	UPSTREAM INVERT	DOWNSTREAM INVERT
C155	400	9.6	1.55	724.387	724.238
C154	400	10.06	0.32	724.994	724.962
C153	300	7.95	1.84	724.352	724.206
C152	300	10.46	1.16	724.346	724.225
C151	925	15.05	-0.23	723.169	723.204

VAL QUENTIN
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CULVERT DATA TABLE

NAME	DIAMETER (mm)	LENGTH (m)	SLOPE (%)	UPSTREAM INVERT	DOWNSTREAM INVERT
C150	400	13.1	0.85	723.431	723.319
C149	500	11.87	0.40	723.53	723.482
C148	300	25.63	0.63	723.732	723.57
C147	300-450	37.39	0.45	723.476	723.308
C146	500	25.63	1.33	723.209	722.869
C145	500	21.62	0.76	723.454	723.289
C144	450	9.7	1.68	723.631	723.468
C143	300	8.12	0.79	723.686	723.622
C142	500	7.73	1.75	723.611	723.476
C141	500	18.85	0.71	723.507	723.374
C140	500	10.89	1.17	723.33	723.203
C139	600	15.73	0.92	723.194	723.05
C138	500	7.51	0.12	723.328	723.319
C137	500	7.51	0.19	723.432	723.418
C136	500	11.51	0.59	723.509	723.441
C135	500	11.51	0.50	723.507	723.45

CULVERT DATA TABLE

NAME	DIAMETER (mm)	LENGTH (m)	SLOPE (%)	UPSTREAM INVERT	DOWNSTREAM INVERT
C134	500	13.75	0.64	723.646	723.558
C133	300	5.19	0.66	723.779	723.745
C132	500	11.57	0.57	723.453	723.387
C131	500	8.88	1.18	723.184	723.079
C130	1200	24.22	1.09	722.681	722.416
C129	1400	12.37	2.06	722.953	722.698
C128	1400	9.06	7.31	723.953	723.291
C127	300	6.01	0.40	723.338	723.314
C126	300	13.95	0.38	723.195	723.142
C125	500	8.04	0.98	723.373	723.294
C124	500	12.84	0.58	723.377	723.303
C123	400	7.84	0.89	723.56	723.49

LAC STE. ANNE COUNTY, ALBERTA

VAL QUENTIN
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DITCH AND CULVERTS PLAN
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CULVERT DATA TABLE NAME	DIAMETER (mm)	LENGTH (m)	SLOPE (%)	UPSTREAM INVERT	DOWNSTREAM INVERT
C122	300	8.97	2.37	723.806	723.593
C121	400	8.61	0.03	723.63	723.627
C120	300	10.05	0.41	723.767	723.726
C119	400	7.79	0.56	723.655	723.611
C118	400	10.91	0.77	723.429	723.345
C117	500	7.98	0.65	723.686	723.634
C116	500	7.94	0.94	723.593	723.518
C115	500	7.93	0.24	723.503	723.484
C114	500	8.11	0.60	723.571	723.522
C113	500	9.93	0.15	723.324	723.309
C112	700	13.43	0.65	723.292	723.205
C111	400	11.84	1.20	723.766	723.624
C110	300	6.57	4.54	723.965	723.667
C109	400	13.67	0.31	723.742	723.7
C108	400	8.54	0.74	723.768	723.705
C107	400	8.95	0.76	723.768	723.7

CULVERT DATA TABLE NAME	DIAMETER (mm)	LENGTH (m)	SLOPE (%)	UPSTREAM INVERT	DOWNSTREAM INVERT
C106	500	8.85	1.60	723.591	723.449
C105	600	11.55	0.16	723.297	723.278
C104	600	6.88	2.14	723.257	723.11
C103	300	6.03	0.15	722.9	722.891
C102	300	7.3	0.01	723.103	723.102
C101	600	5.89	0.34	723.474	723.454
C100	450	19.8	1.71	723.517	723.179

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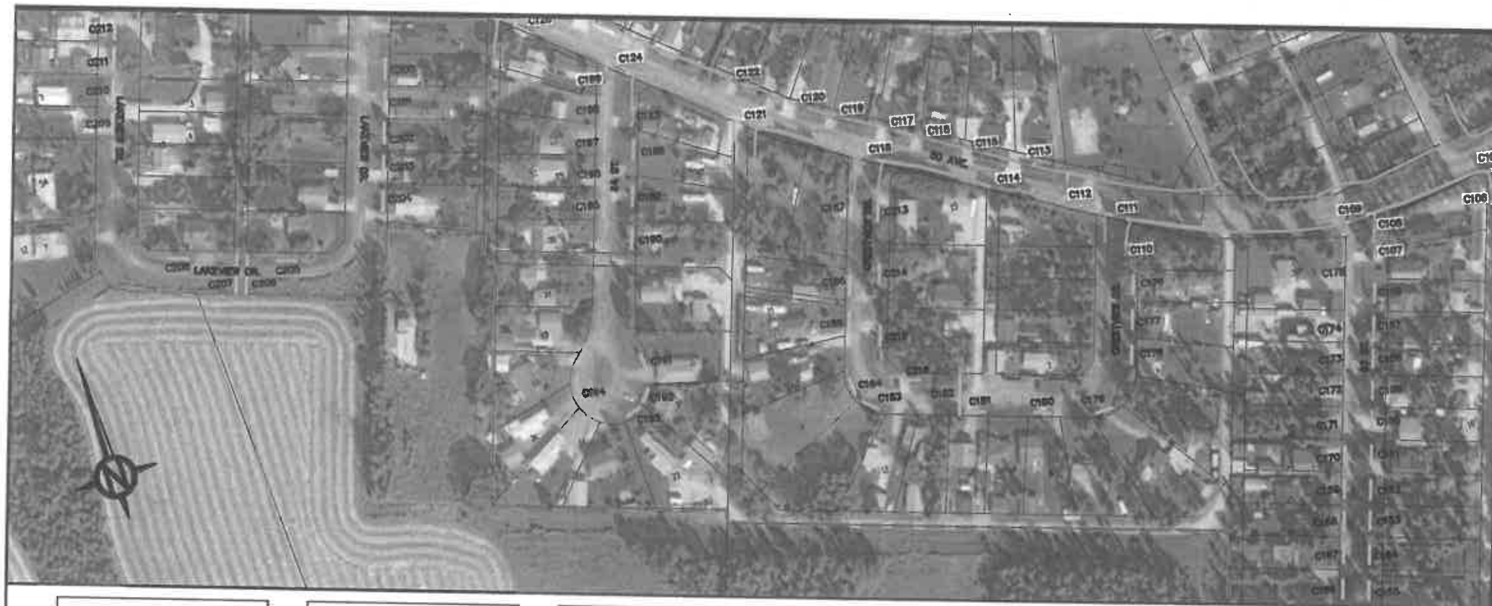

CULVERT DATA TABLE	
NAME	DIAMETER (mm)
156	400
157	400
158	400
159	400
160	400
161	400
162	400
163	400
164	400
165	400
166	400
167	400
168	400
169	400

CULVERT DATA TABLE	
NAME	DIAMETER (mm)
170	400
171	400
172	400
173	400
174	400
175	400
176	300
177	300
178	300
179	300
180	400
181	400
182	350
183	400

CULVERT DATA TABLE	
NAME	DIAMETER (mm)
184	400
185	400
186	400
187	400
188	400
189	400
190	400
191	300
192	300
193	300
194	300
195	400
196	400
197	400

CULVERT DATA TABLE	
NAME	DIAMETER (mm)
198	400
199	400
200	400
201	400
202	400
203	400
204	400
205	300
206	350
207	400
208	350
209	400
210	400
211	400

CULVERT DATA TABLE	
NAME	DIAMETER (mm)
212	400
213	400
214	400
215	400
216	400

LAC STE. ANNE COUNTY, ALBERTA

VAL QUENTIN
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APPENDIX B:

SITE PHOTOGRAPHS

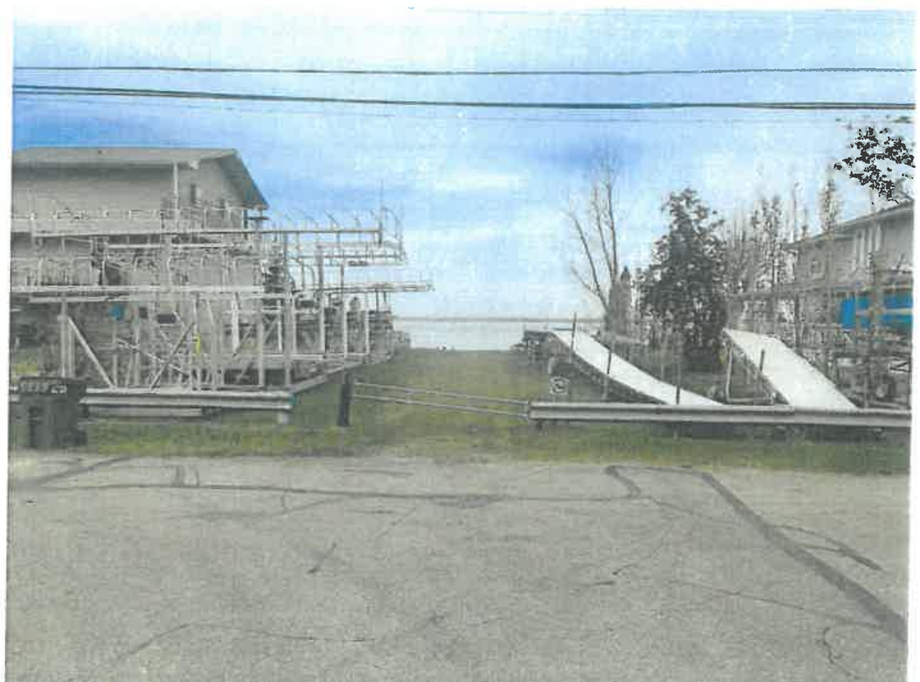
BRIDGE OVER CHANNEL FOR LOT LP

C102 – DAMAGED END

C100 – SLIGHTLY FLATTENED

CHANNEL CROSSING 50TH AVENUE TO LOT LP

C103 – MISSING RIP RAP AND REQUIRES DITCH GRADING



12TH STREET LAKE ACCESS

LOT P

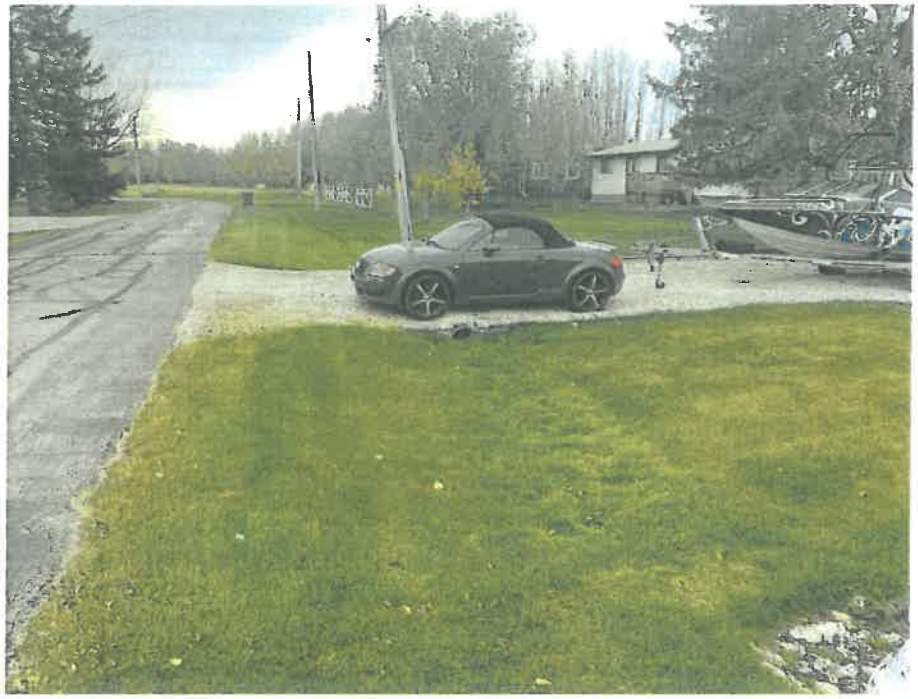
C152 – MISSING RIP RAP AND HIGHER THAN DITCH

C153 – MISSING RIP RAP AND HIGHER THAN DITCH

C149 – MISSING RIP RAP AND UNDERSIZED FOR ROAD CROSSING

C132 – CROSSING LAKEVIEW DRIVE

C210 – TYPICAL RESIDENTIAL APPROACH ALONG LAKEVIEW DRIVE



C209 – MISSING RIP RAP AND BURIED

DRAINAGE CHANNEL RUNNING NORTH BETWEEN LAKEVIEW DRIVE LOOP

C206 & 207 – UNDERSIZED FOR ROAD CROSSING AND MINIMAL COVER

C205 – MISSING RIP RAP

C203

C202

C201

C200

C129 – MAY REQUIRE ADDITIONAL SUPPORT (CROSSING 50TH AVENUE)

TYPICAL DITCH ALONG 50TH AVENUE

C193 – FLATTENED AND UNDERSIZED

C192 – FLATTENED AND UNDERSIZED

C191 – HEAVING AND UNDERSIZED

DITCH SYSTEM ALONG 64TH STREET

C187

C213

C186

C214

C185

C215

C184

C183

C182 – CROSSING CRESTVIEW DRIVE

C180

DITCHES AND APPROACHES ALONG 63RD STREET

C107

APPENDIX C:

OUTLET 7 CHANNEL CROSS SECTIONS

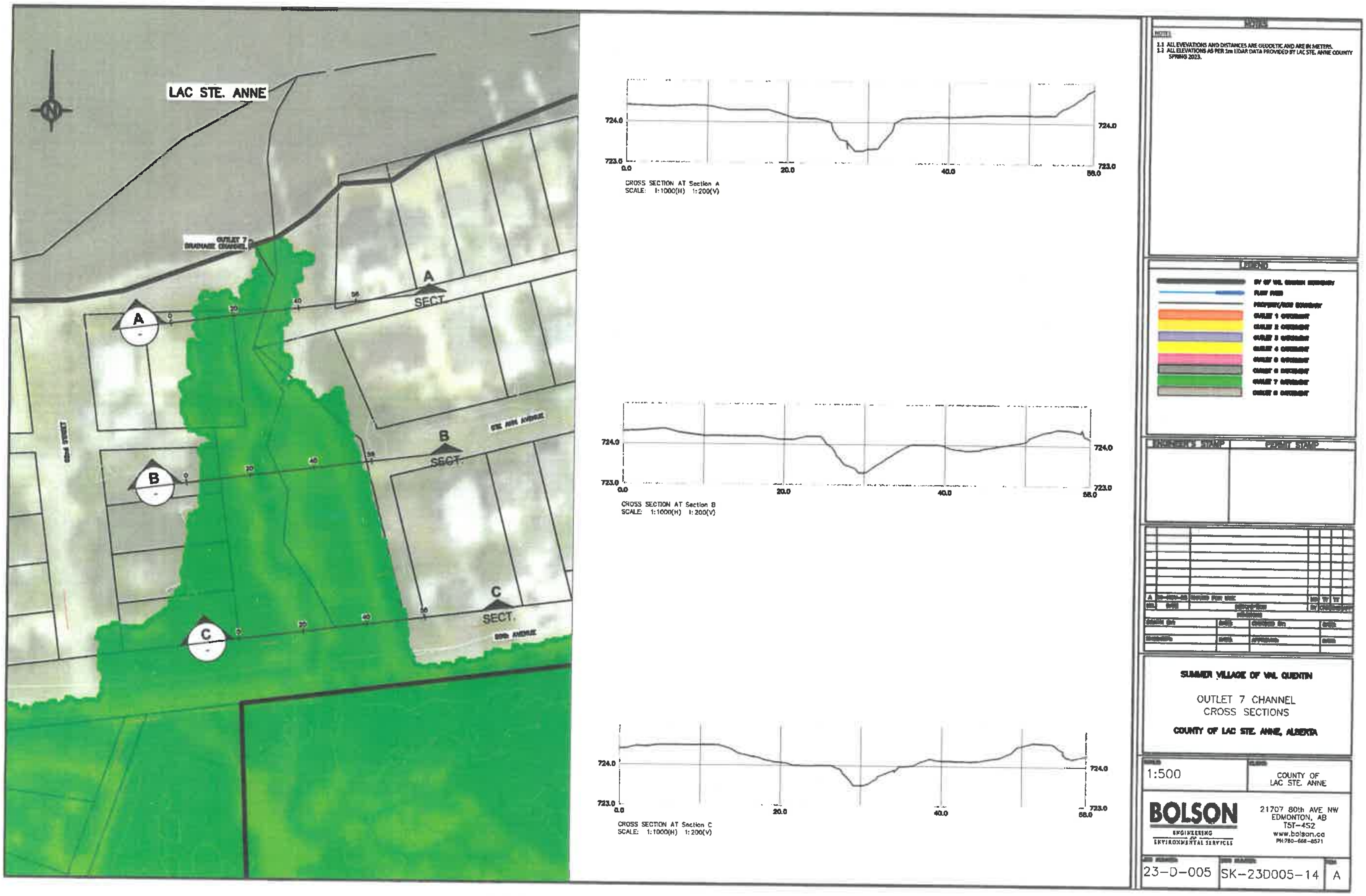


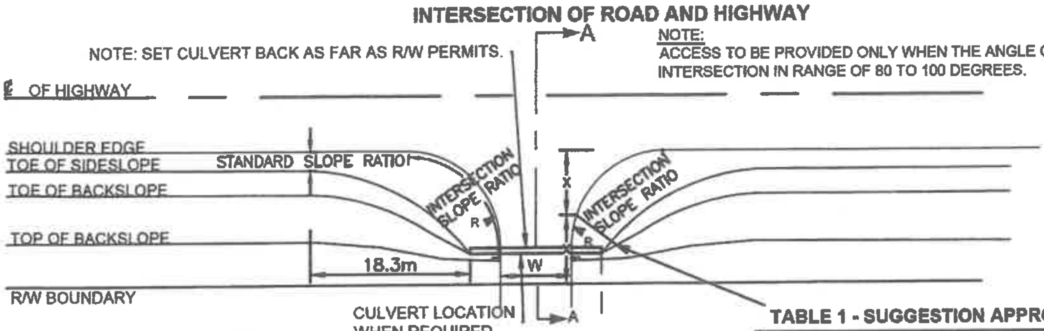
FIGURE 14: OUTLET 7 CHANNEL CROSS SECTIONS

APPENDIX D:

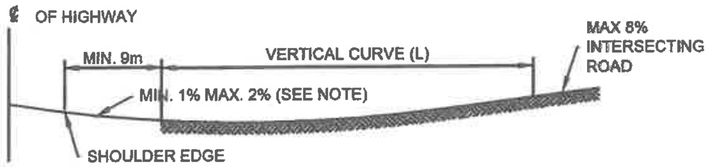
TYPICAL STANDARD DETAILS

APPROACH TREATMENT FOR MINOR INTERSECTING ROADWAY

INTERSECTION OF ROAD AND HIGHWAY



SECTION A-A
INTERSECTING ROAD IN CUT



SECTION A-A
INTERSECTING ROAD IN FILL

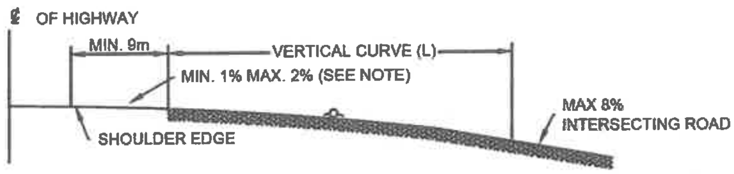
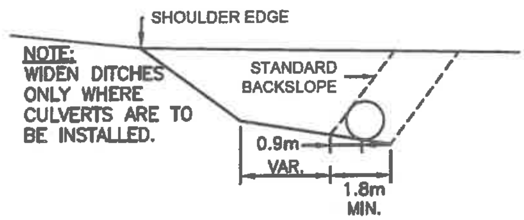


TABLE 1 - SUGGESTION APPROACH SIDESLOPES *

Primary Highway Posted>= 100km/h	Fill Height	Desirable Slope on New Approach
Undivided Highway AADT <1,000	<4m fill >4m fill	7:1 4:1
Undivided Highway 1,000<AADT<3,000	<4m fill >4m fill	7:1 5:1
Undivided Highway AADT >3,000	<4m fill >4m fill	7:1 6:1
Divided Highway AADT <6,000	<4m fill >4m fill	7:1 7:1
Divided Highway 6,000<AADT<15,000	<4m fill >4m fill	8:1 7:1
Divided Highway AADT>15,000	<4m fill >4m fill	10:1 7:1

* APPROACH TO SLOPE TO BE MEASURED AT A POINT MIDWAY BETWEEN THE HIGHWAY SHOULDER AND BASIC RIGHT-OF-WAY BOUNDARY AS ILLUSTRATED ON FIGURES D-33a AND D-33b



DETAIL OF DITCH AND CULVERT LOCATION

MINIMUM LENGTH OF VERTICAL CURVE

ALGEBRAIC DIFF IN GRADIENT (%)	LENGTH (m)	
	CREST	SAG
1	6	8
2	12	15
3	18	23
4	24	30
5	30	38
6	37	46
7	/	46
8	/	46
9	/	46

NOTE:
WHERE THE MINOR INTERSECTING ROADWAY HAS A LARGE NUMBER OF WB-15 VEHICLES TURNING, THE APPROACH TREATMENT SHOWN IN FIGURE D-3.3a SHOULD BE USED.

NOTE:
DESIRABLE MINIMUM 1% IS TO PREVENT PONDING AND SUBSEQUENT ICING AT THE INTERSECTION.

DESIRABLE MAXIMUM 2% IS FOR EASE OF OPERATION IN ALL WEATHER CONDITIONS.

APPROACH GRADES BETWEEN 0.5 % AND 3%, ABSOLUTE MAXIMUM 6% ARE CONSIDERED ACCEPTABLE. APPROACH ROAD GRADES UP TO 1% SLOPING DOWN TOWARD THE HIGHWAY MAY BE USED TO MATCH SUPERELEVATION ON THE HIGHWAY, IF DESIRABLE FOR ENGINEERING REASONS.

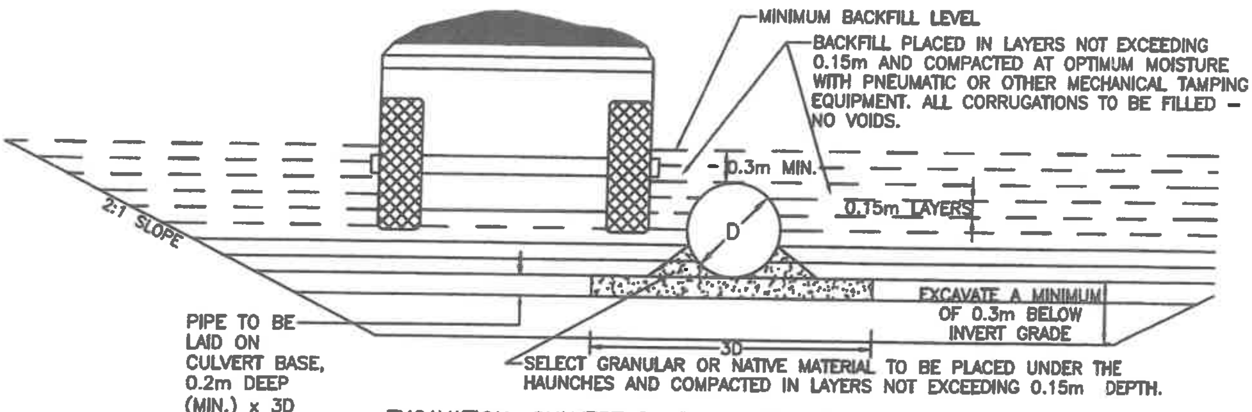
TABLE FOR DETERMINATION OF ROADWAY WIDTH			RADIUS OF INTERSECTION EDGE OF SHOULDER (R)
USE	ROADWAY WIDTH, W * (m)		
	SINGLE	JOINT	SINGLE OR JOINT ACCESS
RESIDENTIAL	8	10	10
AGRICULTURAL	10	10.5	15
UTILITY MAINTENANCE	8		15
PUBLIC ROAD ALLOWANCE	8		15

* ENGINEERING DISCRETION SHOULD BE USED IN SELECTING A ROADWAY WIDTH TO SUIT THE NEEDS OF THE ACCESS.

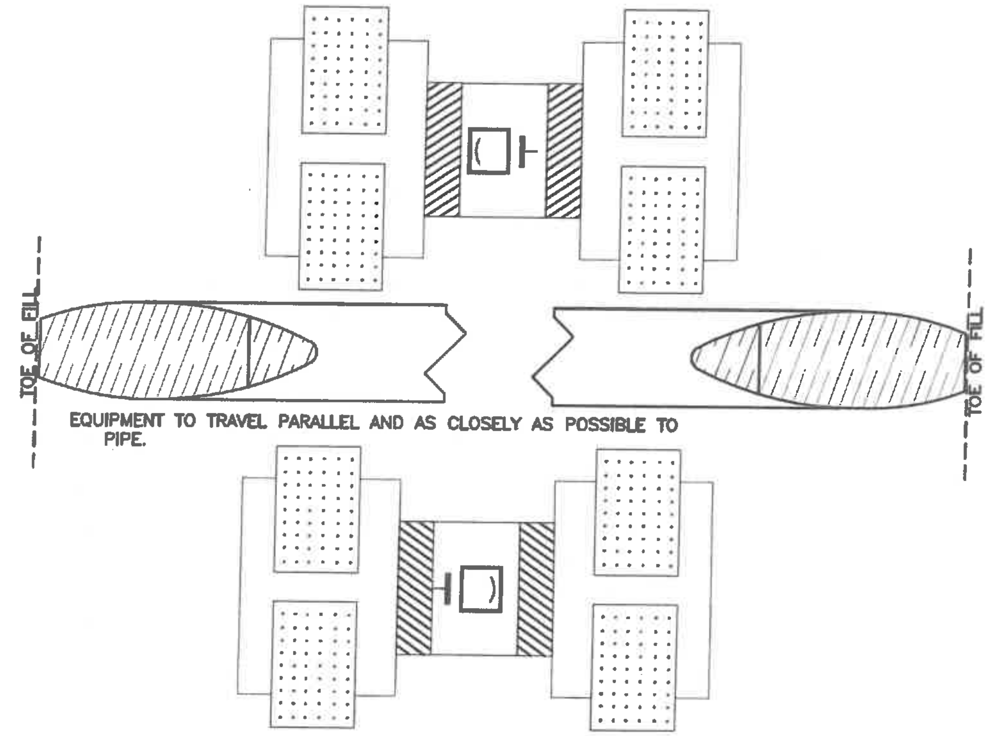
	MINIMUM CULVERT REQUIRED	Scale: N.T.S.
	APPROACH: 500mm	Date: JUNE 24, 2020
	CENTERLINE: 600mm	Drawn By: SE Design

DESIGN SPECIFICATIONS FOR CULVERTS

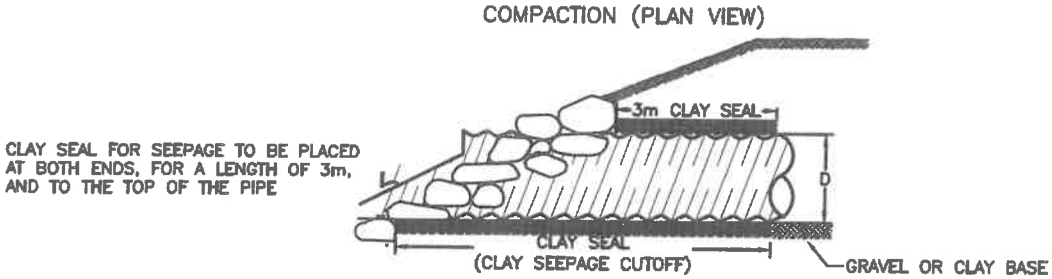
CORRUGATED METAL PIPE CULVERT INSTALLATION



EXCAVATION, CULVERT BASE AND BACKFILLING



COMPACTION (PLAN VIEW)



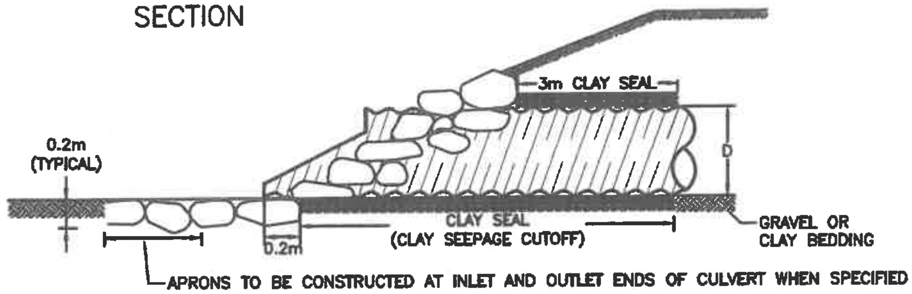
CLAY SEAL DETAIL

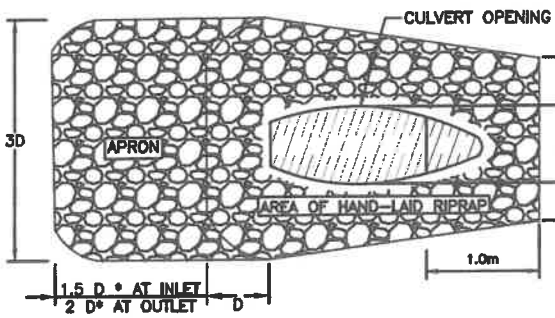
	MINIMUM CULVERT REQUIRED	Scale: N.T.S.
	APPROACH: 500mm	Date: JUNE 25, 2020
	CENTERLINE: 600mm	Drawn By: SE Design

DESIGN SPECIFICATIONS FOR CULVERTS

HAND LAID ROCK RIPRAP

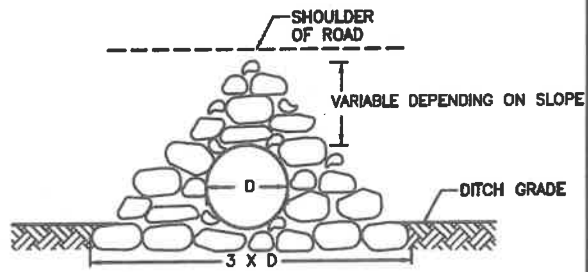
SECTION





* THESE ARE THE TYPICAL MINIMUM DIMENSIONS.

PLAN VIEW



ELEVATION

NOTES:

1. ROCKS AND BOULDERS SHALL BE SELECTED AS NEARLY CUBICAL IN FORM AS PRACTICAL AND SHALL HAVE AT LEAST A MINIMUM DIMENSION OF 200mm. THE STONES SHALL BE PLACED WITH THEIR BEDS AT RIGHT ANGLES TO THE SLOPE, THE LARGER STONES BEING USED IN THE BOTTOM COURSES AND THE SMALLER STONES AT TOP. THEY SHALL BE LAID IN CLOSE CONTACT SO AS TO BREAK JOINTS AND IN SUCH MANNER THAT THE WEIGHT OF THE STONE IS CARRIED BY THE EARTH AND NOT BY THE ADJACENT STONES. THE FINISHED WORK SHALL PRESENT AN EVEN TIGHT, AND REASONABLY PLANE SURFACE, VARYING NOT MORE THAN 75mm FROM THE REQUIRED CONTOUR.

2. WHERE NO SPECIAL TREATMENT IS REQUIRED CULVERT INVERT ELEVATIONS ARE TYPICALLY SET ABOUT 0.15 X DIAMETER BELOW THE DRAINAGE COURSE ELEVATION.

3. A CLAY SEAL IS TO BE PLACED AT BOTH ENDS OF THE CULVERT FOR A LENGTH OF 3m TO CUT OFF SEEPAGE. THE CLAY SEAL SHALL EXTEND FROM THE BOTTOM OF THE EXCAVATION TO 300mm ABOVE THE CROWN OF THE PIPE AND FOR THE FULL WIDTH OF THE EXCAVATION.

4. WHERE APRONS ARE REQUIRED DUE TO HIGH VELOCITY FLOW OR EROSION PRONE SOIL, TYPICALLY THE MINIMUM INLET APRON IS 1.5x DIAMETER LONG WHILE THE MINIMUM OUTLET APRON (WHERE WATER VELOCITY IS HIGHER IS HIGHER) IS TWO DIAMETERS LONG.

ESTIMATED RIPRAP SURFACE AREAS*

PIPE DIAMETER (mm)	AREA OF ONE END EXCLUDING APRON (m^2)	AREA OF ONE END INCLUDING INLET APRON (m^2)	AREA OF ONE END INCLUDING OUTLET APRON (m^2)
500	2	3	4
600	3	5	6
700	4	6	7
800	5	8	9
900	6	10	11
1000	7	12	13
1100	9	14	16
1200	10	16	19
1400	13	22	25

* THE ESTIMATED RIPRAP SURFACE AREAS SHOWN IN THIS TABLE ARE BASED ON A 4:1 SIDESLOPE

MINIMUM CULVERT REQUIRED

APPROACH: 500mm

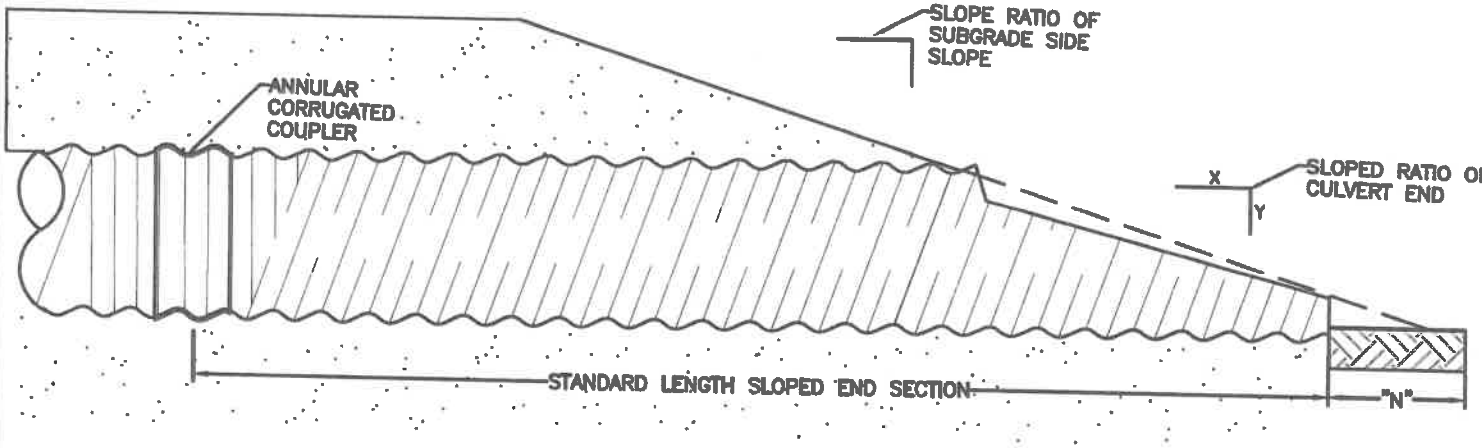
CENTERLINE: 600mm

Scale: N.T.S.

Date: JUNE 25, 2020

Drawn By: SE Design

DESIGN SPECIFICATIONS FOR CULVERTS



SLOPED END INSTALLATIONS FOR ROUND SECTION CORRUGATED METAL PIPE

SELECTION OF SLOPE RATIO FOR SLOPED END SECTION:

A 4 : 1 SLOPED END SECTION SHALL BE USED IN CONJUNCTION WITH ALL SUBGRADE SIDE SLOPES WITH THE EXCEPTION OF 1200mm DIA. AND LARGER WHERE APPLICABLE.

C.S.P. DIAMETER – D mm	SLOPE RATIO OF CULVERT END X:Y	"N" – m				INVERT LENGTH OF SLOPE END SEC. METRE
		WITH 3:1 SUBGRADE SLOPE RATIO	WITH 4:1 SUBGRADE SLOPE RATIO	WITH 5:1 SUBGRADE SLOPE RATIO	WITH 6:1 SUBGRADE SLOPE RATIO	
400	4 : 1	0.3	0.5	0.8	1.2	6.0
500	4 : 1	0.3	0.6	0.9	1.5	6.0
600	4 : 1	0.3	0.6	1.0	1.6	6.0
700	4 : 1	0.3	0.8	1.2	2.0	6.0
800	4 : 1	0.4	0.9	1.4	2.3	6.0
900	4 : 1	0.5	1.0	1.6	2.5	6.0
1000	4 : 1	0.5	1.2	1.8	2.8	6.0
1200	3 : 1 4 : 1	0.5 0.5	1.7 1.4	2.4 2.2	3.7 3.5	6.0
1400	3 : 1 4 : 1	0.5 0.5	1.9 1.6	2.8 2.5	4.3 3.9	6.0

DETERMINING INSTALLATION LENGTH

THE LENGTH OF PIPE CULVERT TO BE INSTALLED SHALL BE DETERMINED AS FOLLOWS:

1) ESTABLISH THE THEORETICAL LENGTH BASED ON SLOPE STAKE REQUIREMENTS. WHERE NO SPECIAL TREATMENT IS REQUIRED, CULVERT INVERT ELEVATIONS ARE TYPICALLY SET ABOUT 0.15 X DIAMETER BELOW THE DRAINAGE COURSE ELEVATION.
2) ADJUST THE THEORETICAL LENGTH BY APPLYING THE END CORRECTION N AS DETERMINED FROM THE TABLE TO EACH END OF THE CULVERT.
3) INSTALLATION LENGTH SHALL BE THE LENGTH DETERMINED IN "2" ABOVE, ROUNDED OFF TO THE NEAREST METRE.

MINIMUM CULVERT REQUIRED

APPROACH: 500mm

CENTERLINE: 600mm

Scale: N.T.S.

Date: JUNE 25, 2020

Drawn By: SE Design

DESIGN SPECIFICATIONS FOR CULVERTS

STEELCOR PIPE HEIGHT OF COVER LIMITS

CL-625 and AREMA Cooper E-80 Live Loading

Table 6: 68mm x 13mm Corrugations

Minimum Cover (mm)			Maximum Height of Cover (m) for the Following Specified Wall Thickness (mm)				
Diameter	Highway	Railway	1.6mm	2.0mm	2.8mm	3.5mm	4.2mm
mm	CL-625	E-80					
300	300	300	70	91	-	-	-
400	300	300	53	68	-	-	-
500	300	300	42	54	-	-	-
600	300	300	35	45	66	-	-
700	300	300	30	39	57	-	-
800	300	300	26	34	50	-	-
900	300	300	23	30	44	56	70
1,000	300	300	21	27	40	50	63
1,200	300	300	-	23	33	42	52
1,400	300	500	-	-	27	35	43
1,600	300	500	-	-	22	28	35
1,800	500	500	-	-	-	22	27
2,000	500	500	-	-	-	-	22

Table 7: 125mm x 25mm Corrugations

Minimum Cover (mm)			Maximum Height of Cover (m) for the Following Specified Wall Thickness (mm)			
Diameter	Highway	Railway	1.6mm	2.0mm	2.8mm	3.5mm
mm	CL-625	E-80				
1,200	300	500	18	23	34	-
1,400	300	500	15	20	29	35
1,600	300	500	13	18	25	31
1,800	300	500	12	16	22	28
2,000	300	500	11	14	20	25
2,200	300	700	10	12	18	23
2,400	500	700	-	11	17	21
2,700	500	700	-	-	15	18
3,000	500	1,000	-	-	13	16
3,300	500	1,000	-	-	-	14
3,600*	700	1,000	-	-	-	12*

NOTES:

* FLEXIBILITY LIMIT EXCEEDED - FOR SPECIFIED USE ONLY

1. DEAD LOAD IS BASED ON A UNIT WEIGHT OF BACKFILL OF 19 KN/M^3
2. WHERE HEIGHT OF COVER EXCEEDS THE DIAMETER, A REDUCTION LOAD FACTOR OF 0.86 HAS BEEN USED
3. LIVE LOAD INCLUDES IMPACT
4. MINIMUM COVER IS TAKEN FROM TOP OF PIPE TO PROFILE GRADE OR TO THE TOP OF THE FINISHED GRANULAR BASE
5. SPECIAL CARE MUST BE TAKEN WITH TRUCK LOADS DURING CONSTRUCTION
6. FOUNDATION INVESTIGATION IS RECOMMENDED PRACTICE
7. THE ABOVE HEIGHT OF COVER TABLES ARE INDUSTRY STANDARDS. LOCAL, PROVINCIAL OR FEDERAL STANDARDS MAY DIFFER