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Burns Maendel Consulting Engineers Ltd.

Crystal Springs Colony - New Colony Development Hydrologic and Hydraulic Assessment

REPORT

Prepared for:

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RE: Crystal Springs Colony New Colony Development
Hydrologic and Hydraulic Assessment

TREK Geotechnical Inc. is pleased to submit our report for the hydrologic and hydraulic assessment for the above noted project. This report analyzes the existing channel and culvert capacities and makes maintenance and conveyance upgrade recommendations for Willow Creek, South Malonton Drain and Unnamed Drain study reaches which are located adjacent to the new colony development.

Please contact the undersigned if you have any questions. Thank you for the opportunity to serve you on this assignment.

Sincerely,

TREK Geotechnical Inc.
Per:

[redacted]

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Water Resources Engineer
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Encl.

Revision History

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Authorization Signatures

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1.0 Introduction

This report summarizes the results of the hydrotechnical analysis completed by TREK Geotechnical Inc. (TREK) to provide a drainage assessment of a portion of Willow Creek located north of the development and the South Malonton Drain which borders the development in the south and east and joins the Willow Creek reach northeast of the development and west of the Road 15E crossing as shown on Figures 1 and 2. An unnamed drain, which transects the proposed development, is also included in the assessment as this drain appears to be backwatered from the South Malonton Drain.

The proposed Crystal Springs Colony community development is located approximately 12 km southwest of Gimli, MB and within lands currently undeveloped measuring approximately 259 hectares (640 acres) in area and is bounded by Road 106 N to the south, Road 15 E to the east, Road 107 N to the north and vacant, undeveloped land to the west. The property is comprised of a mixture of dense forest and open boggy areas with scattered bushes and grass. The community development will include residential, industrial, and agricultural structures, as well as a school and gymnasium, kitchen, dining room, church, orchard, cemetery, sports field, ice rink, wastewater lagoon, parking areas, and access roads.

In the spring of 2022, a series of weather systems brought significant precipitation and snow to much of southern Manitoba, with some areas experiencing record high rainfall during the months of April and May, on top of runoff from a significant winter snowpack. The Interlake Region was especially impacted, with extensive overland flooding and record high flows resulting in communities declaring local states of emergency. Additionally, a large rainfall event was also reported for the Interlake Region more recently on July 19, 2022. TREK understands that the proposed development was impacted during this more recent event by overland flooding from Willow Creek in the north and from the South Malonton Drain in the south and east, warranting the assessment of the existing drainage.

Pertinent features of project area are as follows:

- Municipality - RM of Gimli
- Stream - Willow Creek
- Drain Order - Fourth
- Flow Direction - East
- Designation of Drain Map - No. 31E
- Total Drainage Area - 178 km^2
- UTM Coordinates - West of Rd 15E Zone: 14 U – 633515 m E, 5604580 m N

TREK's hydrotechnical study includes the assessment of existing drain capacities and flood stages, the development of flood protection levels and sizing of new access crossings to the proposed development. The drainage assessment was conducted at the request of Burns Maendel Consulting Engineers Ltd. (BMCL) and on the basis of a site visit by TREK staff. Drain sections and profile surveys were conducted by BMCL in September 2022.

2.0 Hydrology

2.1 Willow Creek

As shown on Figure 1, the runoff within the Willow Creek watershed trends southeast, with flows being intercepted by lateral ditches and directed to Willow Creek through several tributaries including Bass Drain and Peiluck Drain which join Willow Creek just upstream of the study area. Willow Creek continues east from Rd 15E, before discharging into Lake Winnipeg just east of PTH 9 south of Gimli.

The total contributing area of the Willow Creek watershed just west of Rd 15E was estimated by TREK as approximately 178 km^2 (Figure 1). The incremental areas contributing to Willow Creek have been identified and delineated at key locations over the length of the drain (DA1 to DA6). Table 1 summarizes the drainage areas for the 6 key areas identified in the Willow Creek watershed and shown on Figure 1.

Table 1: Willow Creek – Sub-catchments

Location	Name	Area (km^2)
Willow Creek at the Rd 107 N Crossing	DA1	131.34
South Malonton Drain at the Existing Rd 106 N Access Crossing	DA2	24.45
Unnamed Drain at the Confluence with South Malonton Drain	DA3	1.65
South Malonton Drain Drainage Area South of Road 106 N	DA4	15.7
Crystal Springs Colony Drainage Area East of Unnamed Drain	DA5	2.19
Willow Creek Drainage Area Northeast of the Rd 107E Crossing	DA6	2.44

Willow Creek is ungauged near the study site; however, the Willow Creek Near Gimli WSC gauge (05SB002) has streamflow records available from 1960 to 1991. Hydrologic estimates and regional discharge coefficients can be generated for the WSC gauge site using the available gauge streamflow data combined with correlated streamflow data.. The flood hydrology for the study site on Willow Creek can then be derived using regional techniques utilizing the regional discharge coefficients, the contributing drainage area, and the applicable regional exponent. The frequency-discharge estimates calculated are summarized in Table 2.

Table 2: Willow Creek - Flood Hydrology

Discharge Event	Regional Discharge Coefficients*	Mean Daily Discharge Willow Creek at Rd 107N Drainage Area = 131.3 km^2 (m^3/s)	Mean Daily Discharge Willow Creek at Rd 15E Drainage Area = 175.3 km^2 (m^3/s)
1%	0.607	25.3	31.6
2%	0.482	20.1	25.1
3%	0.416	17.4	21.7
5%	0.341	14.2	17.8
10%	0.250	10.4	13.0
20%	0.173	7.2	9.0
50%	0.084	3.5	4.4
3DQ10	0.199	8.3	10.4

* Updated discharge coefficients provided by MTI on November 09, 2022 (regional exponent n = 0.765).

2.2 South Malonton Drain

South Malonton Drain is a 3rd order drain that joins Willow Creek at Rd 15E, with the drainage area approximately 24% of the Willow Creek watershed drainage area at Rd 15E. The lower portion of the drain along the west side of Rd 15E consists of steep banks and an incised main channel, while the drain along north side of Rd 106N is in places shallow and infrequently maintained.

The total drainage area of the South Malonton Drain to the confluence with Willow Creek has been delineated as 41.8 km^2 as shown on Figure 1. The drainage area size falls within the "regional" range, allowing for estimation of the hydrology using regional methods. Since the South Malonton Drain is ungauged; the Willow Creek Near Gimli WSC gauge (05SB002) will be used as the index gauge for the project site with hydrologic estimates derived based on proration of drainage area with the applicable regional exponent for Zone 3 (0.765). The frequency-discharge estimates calculated are summarized in Table 3.

Table 3: South Malonton Drain at the Confluence with Willow Creek - Flood Hydrology

Discharge Event	Regional Discharge Coefficient "C" * Willow Creek near Gimli Gauge 05SB002 Drainage Area = 236 km²	Mean Daily Discharge Estimate for South Malonton Drain at the Confluence with Willow Creek (Rd 15E) Drainage Area = 41.8 km² Regional Method (m^3/s)
1%	0.607	10.6
2%	0.482	8.4
3%	0.416	7.2
5%	0.341	5.9
10%	0.250	4.3
20%	0.173	3.0
50%	0.084	1.5
3DQ10	0.199	3.5

* Updated discharge coefficients provided by MTI on November 09, 2022 (regional exponent n = 0.765).

The drainage area of the South Malonton Drain to the proposed colony access road crossing on Rd 106N has been delineated as 24.5 km² (DA2). The drainage area size falls within the "transitional" range for estimating hydrology (Rational Method $\leq$ 13 km² and Regional Method > 39 km²), therefore the hydrology for the drain was derived using the "transitional" approach. The transitional approach utilizes direct interpolation on the basis of drainage area between the rational method estimate for a 13 km² drainage area and the regional method estimate for a 39 km² drainage area.

Runoff events, and not snowmelt typically govern flood hydrology for watersheds with small drainage areas. The Province of Manitoba has developed standards[1], based on the application of rational analysis techniques, for estimating discharge for small rural watersheds. Unit area runoff values applicable to a specific frequency of occurrence are given, with correction factors to account for land use, soil type, slope and rainfall intensity which enables estimation of rational coefficients. The drainage area is predominantly flat terrain with silty soils and a combination of cropped, wooded and grassed lands.

The discharge estimates for the South Malonton Drain, upstream of the Rd 106 N access crossing at Sta 22+10, are summarized in Table 4. These discharge estimates would be used for the design and sizing of the proposed colony access road off of Rd 106N located at Sta 23+79. s

1 "Runoff from Small Rural Watersheds" (Harden, 1986), Province of Manitoba, Department of Natural Resources Water Resource Branch

Table 4: South Malonton Drain Just Downstream of Sta 22+10 - Flood Hydrology

Discharge Event	Regional Discharge Coefficient "C" * Willow Creek near Gimli Gauge 05SB002 Drainage Area = 236 km^2	Rational Discharge Coefficient "C" ** Rational Method*** Drainage Area = 13 km^2	Mean Daily Discharge Estimate for South Malonton Drain at Sta 22+10 Drainage Area = 24.5 km^2 Transitional Method (m^3/s)
1%	0.607	0.469	7.8
2%	0.482	0.437	6.7
3%	0.416	0.412	6.0
5%	0.341	0.362	5.1
10%	0.250	0.319	4.1
20%	0.173	0.213	2.8
50%	0.084	0.084	1.2
3DQ10	0.199	0.254	3.3

* Updated discharge coefficients provided by MTI on November 09, 2022 (regional exponent n = 0.765).

** Flat, silty soil and a combination of woodland, pasture, and crop.

*** Source – Province of Manitoba Department of Natural Resources Water Resource Branch "Runoff from Small Watersheds.

2.3 Unnamed Drain

A small unnamed drain transects the proposed development which has been affected by backwater from the South Malonton Drain as reported by the client. The hydrology for the Unnamed Drain catchment was derived using methodology and standards consistent with those used by the Province of Manitoba, Water Stewardship. The contributing drainage area of the Unnamed Drain to the confluence with the South Malonton Drain has been delineated as approximately 1.7 km^2 as shown on Figure 1 (DA3).

The rational method for estimation of hydrology is selected for drainage areas that are less than 13 km^2. Manitoba Stewardship, Water Branch has developed standard methodology, runoff coefficients and correction factors which are found within the "Runoff from Small Rural Watersheds" design manual. Appropriate runoff coefficients and correction factors for the site are selected to account for land use, soil type, slope and rainfall intensity. Aerial photography and topographic mapping are used to support the assessment. The drainage area is predominantly flat terrain with silty soils and pasture and wooded lands. The flood estimates are summarized in Table 5.

Table 5: Unnamed Drain at the Confluence with South Malonton Drain - Flood Hydrology

Discharge Event	Rational Discharge Coefficient "C" *	Mean Daily Discharge Estimate for Unnamed Drain at the Confluence with South Malonton Drain Drainage Area = 1.7 km^2 Rational Method (m^3/s)
1%	0.438	0.72
2%	0.409	0.67
3%	0.386	0.64
5%	0.339	0.56
10%	0.298	0.49
20%	0.197	0.32
50%	0.075	0.12
3DQ10	0.237	0.39

* Flat, silty soil and a combination of mostly woodland and pasture.

2.4 Fish Passage Hydrology

The sites have been evaluated for habitat classification, with reference to the habitat classification map developed by Fisheries and Oceans Canada (Maps 062H07). Only the Willow Creek reach is classified as Type A complex habitat, while the South Malonton Drain tributary and Unnamed Drain have no classification. As such, it has been assumed that the new crossings on South Malonton Drain and the Unnamed Drain do not have specific requirements for limiting velocities to enable fish passage.

3.0 Hydraulic Assessment – Existing Conditions

Steady-state hydraulic backwater models of the Willow Creek study reach, South Malonton Drain and Unnamed Drain were developed to assess the existing hydraulic conditions of the creek, drains and culvert crossings.

The South Malonton Drain study reach is a linear excavation located within the road right-of-way. The channel slope is for the most part continuous within the upper reach at approximately 0.014% and steepens to a 1-2% slope within the lower reach along Rd 15E near the confluence with Willow Creek. A length of approximately 3.1 km of the South Malonton Drain was included in the assessment, extending from the confluence with the Willow Creek at STA 0+00 in the northeast to the high point in the ditch approximately 1,800 m west of Rd 15E at STA 31+00 on Road 106N.

A separate model was developed for the Unnamed Drain, extending 1.1 km northwest from the confluence with the South Malton Drain (Sta 20+00). Flood hydraulics of the South Malonton Drain and ultimately the Unnamed Drain are heavily influenced by the undersized access crossings located along Rd 106 N and Rd 15 E. There are several sections within the upper reach where depth available for flow is limited, with resultant breakouts from the drain onto adjacent lands during higher runoff events. Additionally, the elevated water surface profile hinders field drainage and runoff from lateral drains including the Unnamed Drain which require that water levels drop in the larger drain before the laterals can convey runoff.

In addition, the 2.2 km study reach of Willow Creek was also included in the assessment to develop a tailwater condition and assess the flooding along the development's north boundary. The Willow Creek model extends approximately 1.4 km upstream and 0.8 km downstream from the Rd 15E crossing (STA 8+07). Willow Creek is for the most part a natural channel from Rd 107N downstream to Lake Winnipeg, however upstream of Rd 107N, the creek has been channelized.

The steady-state hydraulic backwater models for the drains were developed using the US Army Corps of Engineers, Hydrologic Engineering Centre River Analysis System (HEC-RAS) software. The HEC-RAS model is a one-dimensional backwater model, which is considered to be the universal standard for computing steady-state water surface profiles. The backwater models for the drains were developed using cross sections, channel profiles and details of the culvert crossings surveyed by BMCL in September 2022 as well as MLI Lidar topographic data to represent the overbank areas. It is important to note that TREK's developed one-dimensional (1D) steady-state HEC-RAS model does not account for attenuation of flows through floodplain storage, as it assumes a peak flow with unlimited supply of water. Therefore, the estimated water levels for the drains are assumed to be conservative and therefore slightly higher than expected. Additional dynamic modelling of the modelled drain reach would be required to account for attenuation of storage and more accurate water levels which was not part of this scope.

The model has not been calibrated to observed water levels during periods of high flow, and hydraulic parameters such as channel roughness have been selected based on observations, judgement and experience gained from similar projects. Note, however, that estimated results have been compared to available aerial images showing the 2022 spring flooding extents. The Manning's n (hydraulic

roughness) value for the South Malonton Drain main channel was selected as 0.035 to represent a mostly clean and straight channel with no riffles or deep pools while the flood plain was represented assuming dense brush with a Manning's n value of 0.08. The Manning's n value for the main channel of Willow Creek was selected as 0.035 to represent a straight channel with some stones and weeds while the flood plain was represented assuming dense brush and trees with a Manning's n value of 0.1. The Manning's n value for the main channel of Unnamed Drain was selected as 0.045 to represent a straight channel with considerable weed growth, with stones while the flood plain was represented assuming dense brush and grasses with a Manning's n value of 0.06 on the east side and 0.1 on the west side to represent the treed areas.

The existing drains were assessed for several flow scenarios. Additionally, the capacities of the existing culvert crossings within the South Malonton Drain and Willow Creek study reaches were assessed to ensure that the culverts are not resulting in higher than standard hydraulic headloss and resultant localized and unnecessary flooding. Refer to Figure 2 for the culvert locations.

Figure 3 presents the existing conditions computed water surface profiles for the South Malonton Drain, while Figure 4 presents the computed water surface profiles for Willow Creek in its existing condition. Tables 6 and 7 summarize the existing hydraulic conditions for the culvert crossings on South Malonton Drain and Willow Creek.

Table 6: Existing Field Crossings over South Malonton Drain - Hydraulic Summary

Probability	Discharge	Water Level Upstream of Crossing	Water Level Downstream of Crossing	Headloss	Clearance to Soffit	Clearance to Top of Road	Opening Velocities
	(m^3/s)	(m)	(m)	(m)	(m)	(m)	(m/s)
STA 28+81 Double 1.2 m Diameter CSP Culverts - Soffit Elv. = 249.58 - Existing Top of Road = 250.11							
Q1%	7.8	250.20	250.20	<0.05	-0.62 (submerged)	-0.09 (OT)	0.27/0.27
Q5%	5.1	250.03	249.88	0.14	-0.45 (submerged)	0.08	1.13/1.13
Q10%	4.1	250.05	249.72	0.31	-0.47 (submerged)	0.06	1.54/1.54
Q50%	1.2	249.23	249.12	0.1	0.35	0.88	0.87/0.84
STA 22+10 Double 1.2 m Diameter CSP Culverts - Soffit Elv. = 248.90 - Existing Top of Road = 250.09							
Q1%	7.8	249.82	248.89	0.76	-0.91 (submerged)	0.27	2.51/2.51
Q5%	5.1	249.45	248.69	0.68	-0.54 (submerged)	0.64	2.28/2.37
Q10%	4.1	249.11	248.59	0.46	-0.20 (submerged)	0.98	1.90/2.05

Q50%	1.2	248.37	248.18	0.17	0.54	1.72	1.13/1.10
STA 6+86 Single 1.8 m Diameter CSP Culvert - Soffit Elv. = 246.95 - Existing Top of Road = 247.38							
Q1%	10.6	247.40	246.55	0.19	-0.46 (submerged)	-0.02 (OT)	1.56/1.56
Q5%	5.9	247.17	246.11	0.65	-0.22 (submerged)	0.21	2.41/3.19
Q10%	4.3	246.83	245.97	0.57	0.11	0.55	2.10/2.87
Q50%	1.5	246.07	245.78	0.24	0.88	1.31	1.33/1.63

* Clearance calculated from upstream water level and assumed existing culvert soffit elevation. Negative values indicate soffit submergence. OT indicates roadway overtopped.

CSP = Corrugated Steel Pipe

Dia. = Diameter

The crossings along the South Malonton Reach at Rd 106 N and Rd 15 E, which are comprised of double and single CSP culverts, are inadequately sized for passing the assumed 5% design discharge, and have headlosses greater than the typically accepted 0.3 m. There are several sections along the south and east ditch where depth available for flow is limited, with resultant breakouts from the drain onto adjacent lands during larger events above the 50% (2-year) flood event. These breakouts are partly attributed to the undersized culverts, which if properly sized would effectively lower the water surface profile, reducing the frequency of these breakouts. Additionally, the elevated water surface profile hinders property drainage and runoff from lateral drains including the Unnamed Drain which require that water levels drop in the larger drain before the laterals can convey runoff. As noted, the Unnamed Drain is heavily affected by backwater from the South Malonton Drain. The areas affected by the flooding are located near the Unnamed Drain confluence where the north prairie is significantly lower (approx. Elev. 248.2± m) from STA 20+60 to 19+00, near STA 12+60 at the properties southeast corner (Elev. 247.0± m) and upstream of the Rd 15 E access crossing between approximately STA 13+20 and 6+80 for flows above the Q50% event.

It was noted that the Willow Creek tailwater condition does not have a large backwater impact on the lower South Malonton Drain reach as the downstream reach of the drain near the confluence with Willow Creek is relatively steep, with an approximate 2% slope.

Table 7: Willow Creek Crossing Hydraulic Summary – Existing Conditions

Probability	Discharge	Water Level Upstream of Crossing	Water Level Downstream of Crossing	Headloss	Clearance to Soffit	Clearance to Top of Road	Opening Velocities
	(m^3/s)	(m)	(m)	(m)	(m)	(m)	(m/s)
STA 19+24 - Three 1.8 m Diameter CSP Culverts through Rd 107N - Soffit Elv. = 246.40							
Q1%	25.3	246.49	245.72	0.57	-0.79 (Submerged & OT)	-0.09	0.74/0.76
Q5%	14.2	246.41	245.33	0.97	-0.71 (Submerged & OT)	-0.01	0.88/1.31
Q10%	10.4	246.34	245.15	1.11	-0.64 (Submerged & OT)	0.06	0.86/1.66
Q50%	3.5	245.57	244.63	0.91	0.13	0.83	0.45/1.86
3DQ10	8.3	246.28	245.02	1.19	-0.58 (submerged)	0.12	0.84/1.93
STA 8+07 - Four 2.2 m Diameter CSP Culverts through Rd 15E - Soffit Elv. = 243.84							
Q1%	31.6	243.17	242.70	0.43	-0.35 (submerged)	0.67	2.12/2.21
Q5%	17.8	242.46	242.23	0.22	0.36	1.38	1.52/1.61
Q10%	13.0	242.20	242.02	0.17	0.62	1.64	1.32/1.41
Q50%	4.4	241.60	241.51	0.08	1.22	2.24	0.84/0.91
3DQ10	10.4	242.04	241.89	0.14	0.78	1.80	1.20/1.28

* Clearance calculated from upstream water level and assumed existing culvert soffit elevation. Negative values indicate soffit submergence. OT indicates roadway overtopped.

CSP = Corrugated Steel Pipe

Dia. = Diameter

The crossing along the Willow Creek Reach at Rd 107 N (Sta 19+24), which is comprised of three 1.8 m diameter CSP culverts, is inadequately sized for passing the 5% design discharge, and has headlosses and velocities greater than MTI's hydraulic standard values which are presented in the following section. The results show that the existing road frequently overtops during flood events larger than the 50% event (2-year). Although judged as undersized, there is no requirement for upgrading the crossing as the crossing does not adversely affect the proposed development. However, upgrades to the structure should be considered if future buildings or developments are constructed near the crossing location. The downstream crossing at Rd 15 E (Sta 8+07) is comprised of four 2.2 m diameter CSP

culverts which provide additional capacity to pass larger flows. However, the velocities are slightly exceeded at the 5% design discharge. The crossing does not appear to have a significant effect on flooding on the adjacent property, and such, upgrades to this crossing would not be judged as necessary for the colony development

It appears that the Willow Creek adjacent to the Crystal Springs property, between the Rd 15E and Rd 107N crossings, has an incised channel with a wide floodplain that is capable of conveying larger flows without spilling its banks and inundating the adjacent Colony development significantly. The terrain to the south of Willow Creek in the northeast corner of the property is generally high above the floodplain as noted on Figure 4. Note however, there are two field drains that discharge into the creek at STA 17+17 and 14+85 which would be affected by backwater on Willow Creek during the 1% event (100-year). With the exception of the Rd 107N crossing, the waterway and Rd 15E crossing are functioning adequately, not warranting any upgrades within the modelled Willow Creek reach.

3.1 Potential Overflow from Willow Creek into the Unnamed Drain

A desktop review of the available MLI Lidar data showed that a section of the existing Road 107 N could be potentially overtopped by high water levels from the Bass Drain (Willow Creek South tributary) resulting in Bass Drain flows spilling into the Unnamed Drain watershed. The identified overflow location is approximately 2.4 km west of the Rd 107 N culvert crossing at the Crystal Springs property boundary as shown on Figure 1. The roadway profile of the Road 107 N overflow location is shown on Figure 7 with the lowest top of road elevation at approximately 294.4± while the adjacent Bass Drain north dike elevation is mostly higher than the road elevation. The south prairie level along the north property boundary is typically lower than the road adjacent and Bass Drain north prairie level. Therefore, raising of the road locally between approximately Sta 0+80 and 9+80 to elevation 250.6 m is recommended to reduce the likelihood of overflow from the Willow Creek into the Unnamed Drain watershed at the identified location. Alternatively, a dike could be constructed along the perimeter of the property from approximately Sta 0+80 to 9+80 with the same crest elevation to provide the required flood protection. However, this might require land acquisitions if the property is not currently owned by the Client.

Note this tributary reach of Willow Creek was not included in TREK's initial modelling and is outside the study area. As such it is unknown how high the water surface profiles can rise within the north ditch during larger flood events. Additional survey and hydraulic modelling would be required to estimate possible water surface profile elevations within the Bass Drain reach at the overflow location and determine at what flow the road would overtop.

4.0 Drainage Improvement Options

The following sections present the recommended upgrades for the South Malonton Drain and Unnamed Drain. The proposed upgrades consist of drain regrading/cleanout in addition to crossing upgrades. No changes to Willow Creek within the study area are proposed. The design criteria for the proposed upgrades are also presented.

4.1 Design Standards and Drainage Objectives

Hydraulic Requirements – Culvert Crossings

The following hydraulic design criteria were applied for the municipal road crossings:

- Design discharge – 5% (1:20 year) design flow.
- Replacement crossings to be replaced with corrugated steel pipe (CSP) culverts.
- Maximum headloss of 0.3 m during the passage of the design discharge.
- Culvert soffit to remain free by 0.1 m of water surface during passage of design discharge. Note that if culvert headloss and velocity is acceptable, but soffit is not clear at the design discharge, then the soffit can be submerged by a maximum of 0.3 m.

4.2 Flood Protection Level Recommendation

Based on TREK's review, no floodplain maps, designated FPL or engineering reports exist for the proposed development within the study area. TREK is aware of the reported extensive flooding in 2022 that included a large portion of the study area as shown on the provided drone photos (attached for reference).

The flood magnitude and water levels associated with the developed design discharges have been determined for the South Malonton Drain, Unnamed Drain and Willow Creek within the study reach using steady state HEC-RAS backwater models. The models do not account for storage in the system and assume an infinite volume water. The model simulations showed that the South Malonton Drain has the potential to overflow the north bank of the drain on Road 106 N and west bank of the drain on Road 15 E in the vicinity of the proposed development during events greater than the 50-year event and as a result inundate these adjacent areas. The drain capacity is restricted by the undersized culvert crossings on Rd 106 N and Rd 15 E. Upgrading of the culvert structures would help to locally lower the flood levels within the study reach, however, the lower bank sections near the Unnamed Drain and south east corner of property would still flood during larger flood events due to the lower bank elevations.

The RM of Gimli Zoning By-Law 11-0013 states that no permanent building shall be constructed or placed in the vicinity of a lake, river, watercourse or body of water on land that has been identified by the province as a flood hazard or would be inundated by the hundred year flood or by a recorded flood exceeding the hundred year flood, unless it is demonstrated to the satisfaction of Council, in consultation with the authorities, that:

a) The land is not subject to flooding;

b) Proper measures will be taken to protect the building from flooding.

c) That access to the property is on a developed public road to a standard and elevation that meets with provincial flood protection measures.

Note that the RM of Gimli's Zoning Maps in Appendix A of the Zoning By-law document do not appear to include the proposed Crystal Springs Colony development area and it is unclear if the zoning law applies at this location. However, it was judged that these zoning bylaws would apply at this location, even though not identified. On that basis, it is proposed that all permanent structures are located behind dikes or on land which has been raised by fill to an elevation of at least 0.6 metres above the 100-year flood level following standard flood protection requirements. The minimum 0.6 m freeboard indicated provides additional elevation above predicted water levels to take into consideration uncertainty in predicted floods and related water levels, and unforeseen conditions including beaver dams, debris blockage, etc.. The elevation to set the development structures above flood level would be dictated by the type of structure (residence, granary, barn, etc.) and the level of risk the property owner is willing to accept. In general, residential properties are set higher to avoid risk of flooding.

4.3 Hydraulic Design – Proposed Drainage Upgrades

Design options for drainage upgrades are presented below that include culvert replacements in combination with channel cleanout. The design options satisfy the specific hydraulic requirements, ensures the long-term integrity and sustainability of the drain, while providing benefits for improved land drainage by effectively lowering the water surface profile. The proposed design option for the drain reconstruction is summarized in the following sections.

Although drainage effectiveness will be improved relative to existing conditions, the reconstruction will not prevent flooding under extreme conditions. Extreme rainfall events may still result in localized flooding; however, channel and crossing improvements will reduce the impacts of such an event relative to what would have been observed under existing drainage conditions. Furthermore, adequate land drainage for the proposed development will be crucial to reduce localized flooding.

Routine maintenance in the South Malonton Drain is recommended to remove thick vegetation and to improve drainage efficiency. Thick vegetation can reduce a channels conveyance by up to 50%, elevating water levels and preventing drainage from meeting the intended design levels. Mowing channel vegetation or shallow excavation cleanout of vegetation is recommended to restore channel conveyance to the intended design level.

4.3.1 South Malonton Drain Crossing Upgrades

The inadequately sized culvert crossing at STA 22+10 is to be removed and a new crossing to access the proposed colony will be constructed at STA 23+79, as shown on the attached layout plan (Appendix A), with larger corrugated steel culverts. Additionally, the access road crossing on Rd 15 E (STA 6+86) is to be replaced with larger corrugated steel culverts as described below. Table 7 provides a summary

of the hydraulic conditions with the proposed culvert upgrades. No upgrades are proposed for the crossing located at STA 28+82 as this structure is located further upstream and outside the Crystal Springs property boundary.

New Rd 106 N Access Crossing – Two 1.8 m Diameter by 25.0 m Long CSP Culverts

- The length of the structure is dictated by the proposed road profile as shown on the Layout Drawings (Appendix A) assuming an 8 m road width with 3:1 slopes. The top of roadway elevation was assumed to be 250.7 m.
- The proposed structure would be located at Sta 23+79, approximately 1130 m west of Rd 15E
- Upstream (west) and downstream (east) culvert inverts set at elevations 247.85 and 247.80 m respectively.
- All culverts will be embedded a minimum of 0.1 m below channel grade.

The upstream and downstream aprons should be rock riprap armoured to minimize erosion and to maximize long term function. The upstream and downstream crossing aprons would have the following geometry:

- Armoured apron length = 3 m upstream and 4 m downstream of culvert ends.
- Apron inverts to be located 0.1 m above the proposed culvert invert elevations and extend away from the pipe ends with bottom elevation of 247.95 m at the upstream limit and elevation 247.9 m at the downstream limits of the apron.
- Rock armouring to be Class 350 rock – 0.525 m thick over non-woven geotextile. Rock armouring to extend up channel side slopes.
- All Class 350 rock to be well-graded, rounded, sound field stone or quarried rock with the following gradation: 100% < 350 mm, 50% > 200 mm, and 80% > 100 mm. 30% granular material by volume will be blended with the Class 350 rock prior to placement in order to fill the interstitial space/voids within the rock. The granular will be clean gravel or crushed rock with the following gradation: 100% <100 mm, 50% > 20mm and 80% > 3mm.

The channel should be excavated and reshaped to provide a smooth transition from the 4.6 m wide base at the culverts ends and riprap aprons to the proposed 1.5 m channel base width. Transitions should be over a distance of 5 m.

Rd 15 E Replacement Access Crossing – Two 2.0 m Diameter by 23.0 m Long CSP Culverts

- The length of the structure is dictated by the proposed road profile as shown on the Layout Drawings (Appendix A) assuming a 5 m road width with 3:1 slopes. The top of roadway elevation was assumed to be 248.11 m.

- The proposed structure would be located at Sta 6+86, approximately 580 m north of Rd 106N.
- Upstream (south) and downstream (north) culvert inverts set at elevations 245.12 and 245.05 m respectively.
- All culverts will be embedded a minimum of 0.1 m below channel grade.
- The channel should be excavated and reshaped to provide a smooth transition from the 5.0 m wide base at the culverts ends and riprap aprons to the proposed 1.6 m channel base width. Transitions should be over a distance of 5 m.
- Regrade the drain with the proposed geometric template over 200 m from the Sta 7+66 to Sta 5+62 at 0.29% with a 1.6 m base width and 2.5:1 side slopes.

The upstream and downstream aprons should be rock riprap armoured to minimize erosion and to maximize long term function. The upstream and downstream crossing aprons would have the following geometry:

- Armoured apron length = 3 m upstream and 4 m downstream of culvert ends.
- Apron inverts to be located 0.1 m above the proposed culvert invert elevations and extend away from the pipe ends with bottom elevation of 245.22 m at the upstream limit and elevation 245.15 m at the downstream limits of the apron.
- Rock armouring to be Class 350 rock – 0.525 m thick over non-woven geotextile. Rock armouring to extend up channel side slopes.
- All Class 350 rock to be well-graded, rounded, sound field stone or quarried rock with the following gradation: 100% < 350 mm, 50% > 200 mm, and 80% > 100 mm. 30% granular material by volume will be blended with the Class 350 rock prior to placement in order to fill the interstitial space/voids within the rock. The granular will be clean gravel or crushed rock with the following gradation: 100% <100 mm, 50% > 20mm and 80% > 3mm.

Sketches of typical culvert structure installation are appended for reference.

Table 8: Proposed Field Crossings over South Malonton Drain - Hydraulic Summary

Probability	Discharge	Water Level US of Crossing	Water Level DS of Crossing	Headloss	Clearance to Soffit	Clearance to Top of Road	Opening Velocities	Min. Required Road Raising
	(m^3/s)	(m)	(m)	(m)	(m)	(m)	(m/s)	(m)
STA 23+79 Two 1.8 m Diameter CSP Culverts - Soffit Elv. = 249.65								
Q1%	7.8	249.76	249.41	0.30	-0.11 (submerged)	0.92	1.62/1.66	0
Q5%	6.0	249.37	249.18	0.17	0.28	1.31	1.24/1.25	0
Q10%	4.1	249.22	249.07	0.14	0.43	1.46	1.11/1.11	0
Q50%	1.2	248.62	248.56	0.06	1.03	2.06	0.66/0.62	0
STA 6+86 – Proposed Two 2.0 m Diameter CSP Culverts - Soffit Elv. = 247.12*								
Q1%	10.6	247.31	246.93	0.33	-0.26 (submerged)	0.80	1.74/1.76	0.73
Q5%	5.9	246.69	246.50	0.17	0.36	1.42	1.26/1.24	0.73
Q10%	4.3	246.45	246.31	0.13	0.60	1.66	1.10/1.06	0.73
Q50%	1.5	245.90	245.82	0.08	1.15	2.21	0.77/0.71	0.73

* Assumed Design Top of Road Elev. 250.68 m.
US = Upstream
DS = Downstream

It is recommended that the FPL for the proposed lagoon in the southeast corner of the property will be set to elevation 248.40 m, which is the 1% flood level with added minimum freeboard of 0.6 m (2 ft). Alternatively, a dike could be constructed along the perimeter of the property from approximately STA 13+80 to 6+80 with the same crest elevation to provide the required flood protection. Through-grade culverts equipped with flap gates would be required to convey runoff from the property through the dike into South Malonton Drain, preferably as far downstream into the drain as practical.

4.3.2 ***Unnamed Drain Crossing Design***

A new road access crossing will be constructed at STA 5+05 over the Unnamed Drain as shown on the attached layout plan (Appendix A). Table 9 provides a summary of the hydraulic conditions for the proposed culvert upgrade.

New Access Crossing - Two 1.4 m Diameter by 24.0 m Long CSP Culvert

- The length of the structure is dictated by the proposed road profile as shown on the Layout Drawings (Appendix A) assuming a 8 m road width with 3:1 slopes and 34 degree skew. The top of roadway elevation was assumed to be 249.55 m which is approximately 0.86 m above the 1% design water level.
- The proposed structure would be located at Sta 5+05.
- Upstream (north) and downstream (south) culvert inverts set level at elevation 247.55 m.
- The culvert will be embedded a minimum of 0.3 m below channel grade.
- The channel should be excavated and reshaped to provide a smooth transition from the 3.8 m wide base at the culverts ends and riprap aprons to the existing channel base width.

The upstream and downstream aprons should be rock riprap armoured to minimize erosion and to maximize long term function. The upstream and downstream crossing aprons would have the following geometry:

- Armoured apron length = 3 m upstream and 4 m downstream of culvert ends.
- Apron inverts to be located 0.3 m above the proposed culvert invert elevations and extend away from the pipe ends with bottom elevation 247.85 m at the upstream limit and downstream limits of the apron.
- Rock armouring to be Class 350 rock – 0.525 m thick over non-woven geotextile. Rock armouring to extend up channel side slopes.
- All Class 350 rock to be well-graded, rounded, sound field stone or quarried rock with the following gradation: 100% < 350 mm, 50% > 200 mm, and 80% > 100 mm. 30% granular material by volume will be blended with the Class 350 rock prior to placement in order to fill the interstitial space/voids within the rock. The granular will be clean gravel or crushed rock with the following gradation: 100% <100 mm, 50% > 20mm and 80% > 3mm.

Sketches of typical culvert structure installation are appended for reference.

Table 9: Proposed Road Crossing over Unnamed Drain - Hydraulic Summary

Probability	Discharge	Water Level US of Crossing	Water Level DS of Crossing	Headloss	Clearance to Soffit*	Clearance to Top of Road*	Opening Velocities
	(m^3/s)	(m)	(m)	(m)	(m)	(m)	(m/s)
Tailwater Elevation 248.67 (1% South Malonton Drain Water Level)							
Q1%	0.72	248.69	248.67	<0.05	0.26	0.86	0.33/0.33
Q5%	0.56	248.68	248.67	<0.05	0.27	0.87	0.26/0.26
Q10%	0.49	248.68	248.67	<0.05	0.27	0.87	0.23/0.23
Q50%	0.12	248.67	248.67	<0.05	0.28	0.88	0.06/0.06
Tailwater Elevation 247.88 (50% South Malonton Drain Water Level)							
Q1%	0.72	248.28	248.11	0.15	0.67	1.27	0.71/1.10
Q5%	0.56	248.23	248.08	0.13	0.72	1.32	0.63/0.96
Q10%	0.49	248.20	248.07	0.12	0.75	1.35	0.59/0.86
Q50%	0.12	248.02	247.97	0.05	0.93	1.53	0.30/0.41

*Proposed Soffit Elev. 248.95m and Assumed Design Top of Road Elev. 249.55 m.

It is recommended that the FPL for the properties adjacent to the Unnamed Drain which is backwatered by the South Malonton Drain be set to elevation 249.29 m, which is the 1% flood level with added minimum freeboard of 0.6 m (2 ft). This assumes that a new crossing is constructed along the proposed access road. Alternatively, a dike could be constructed along the perimeter of the property from approximately STA 20+50 to 19+00 (South Malonton Drain profile) with approximately the same crest elevation to provide the required flood protection. Through-grade culverts equipped with flood/flap gates would be required to convey runoff from the Unnamed Drain through the dike into South Malonton Drain downstream.

5.0 Other Considerations

The proposed design upgrades include culvert replacements and some limited drain reconstruction in the lower reach of the South Malonton Drain. That combined with vegetation control, will improve drainage locally. However, there may be an advantage to do a drain reconstruction on the South Malonton Drain from Sta 6+86 upstream to Sta 23+79, to further lower the water surface profile thereby lowering the requirements for raising/diking the developed area above flood levels. Drain reconstruction would require regrading the drain invert combined with widening the channel base and flattening the side slopes. The drain currently is the responsibility of the province, therefore approvals from the regulators would be required before the work is completed. Any reconstruction would require additional land to widen the channel away from the road towards the development, however the owner would be the colony, so that may not be of concern as typically occurs.

Another possible future consideration would be the development of a flood retention area in the Unnamed Drain to the west of the proposed colony access road. The flood retention area, developed as a dry pond (i.e. typically dry and only flooded following a rain), could benefit the colony by storing flood runoff and releasing slowly into the South Malonton Drain, easing flood levels. It may be possible to use this feature to mitigate any considerations related to changes to runoff from the proposed development, as this area could store the excess rainfall typically required when changing land use.

6.0 Conclusion and Recommendations

The drainage improvements proposed, which include both drain cleanout and road crossing upgrades, will result in locally lowered water profiles within the identified length of the drainage course, thereby improving overall drainage relative to existing conditions. Although drainage effectiveness will be improved relative to existing conditions, the drainage upgrades will not prevent flooding under extreme conditions. Extreme rainfall events may still result in localized flooding; however, channel improvements and larger culverts in combination with the proposed flood protection levels for the buildings and roads will greatly reduce the impacts of such an event relative to what would have been observed under existing drainage conditions.

To improve the drainage, it is recommended to immediately remove thick riparian vegetation from the South Malton Drain. Proper maintenance is vital to drains achieving desired objectives and to mitigate flooding issues in the vicinity.

7.0 Closure

The technical information provided in this report is in accordance with current engineering principles and practices (Standard of Practice). The findings of this report were based on information (field investigation & survey) provided by BMCL. Hydrotechnical analysis is based on environmental characteristics assumed to extend uniformly throughout the contributing area and watershed-scale, temporally-discrete hydrologic events.

All information provided in this report is subject to our standard terms and conditions for engineering services, a copy of which is provided to each of our clients with the original scope of work, or a mutually executed standard engineering services agreement. If these conditions are not attached, and you are not already in possession of such terms and conditions, contact our office and you will be promptly provided with a copy.

This report has been prepared by TREK Geotechnical Inc. (the Consultant) for the exclusive use of the NMCL (the Client) and their agents for the work product presented in the report. Any findings or recommendations provided in this report are not to be relied upon by any third parties, except as agreed to in writing by the Client and Consultant prior to use.

Site Photos

Photo No. 1: Unnamed Drain at Existing Access Road (looking south toward Rd 106N) – Spring 2022 (Photo provided by BMCL)

Photo No. 2: Unnamed Drain at Existing Access Road (looking south toward Rd 106N) – Spring 2022 (Photo provided by BMCL)

Photo No. 3: Unnamed Drain at Existing Access Road (looking south toward Rd 106N) – Spring 2022 (Photo provided by BMCL)

Photo No. 4: Unnamed Drain at Existing Access Road (looking north toward Rd 107N) – Spring 2022 (Photo provided by BMCL)

Photo No. 5: Southeast Corner - Proposed Lagoon Location (looking southeast towards Rd 106N and 15E) – Spring 2022 (Photo provided by BMCL)

Photo No. 6: Willow Creek East of Rd 15E (looking upstream) – September 13, 2022

Photo No. 7: South Malonton Drain at the Confluence with Willow Creek (looking upstream) – September 13, 2022

Photo No. 8: Willow Creek South of Rd 107 N (looking upstream) – September 13, 2022

Photo No. 8: Willow Creek South of Rd 107 N (looking downstream) – September 13, 2022

Photo No. 8: Lower South Malonton Drain near STA 0+90 (looking upstream) – September 13, 2022

Photo No. 9: South Malonton Drain upstream of Rd 15N Access Crossing at STA 6+98 (looking downstream) – September 13, 2022

Photo No. 10: South Malonton Drain upstream of Rd 15N Access Crossing at STA 6+98 (looking upstream) – September 13, 2022

Photo No. 11: South Malonton Drain Looking East near STA 19+15 (looking downstream) – September 13, 2022

Photo No. 12: South Malonton Drain at Confluence with Unnamed Drain at STA 20+00 (looking downstream) – September 13, 2022

Photo No. 13: South Malonton Drain downstream of Rd 106N Access Crossing at STA 22+03 (looking downstream) – September 13, 2022

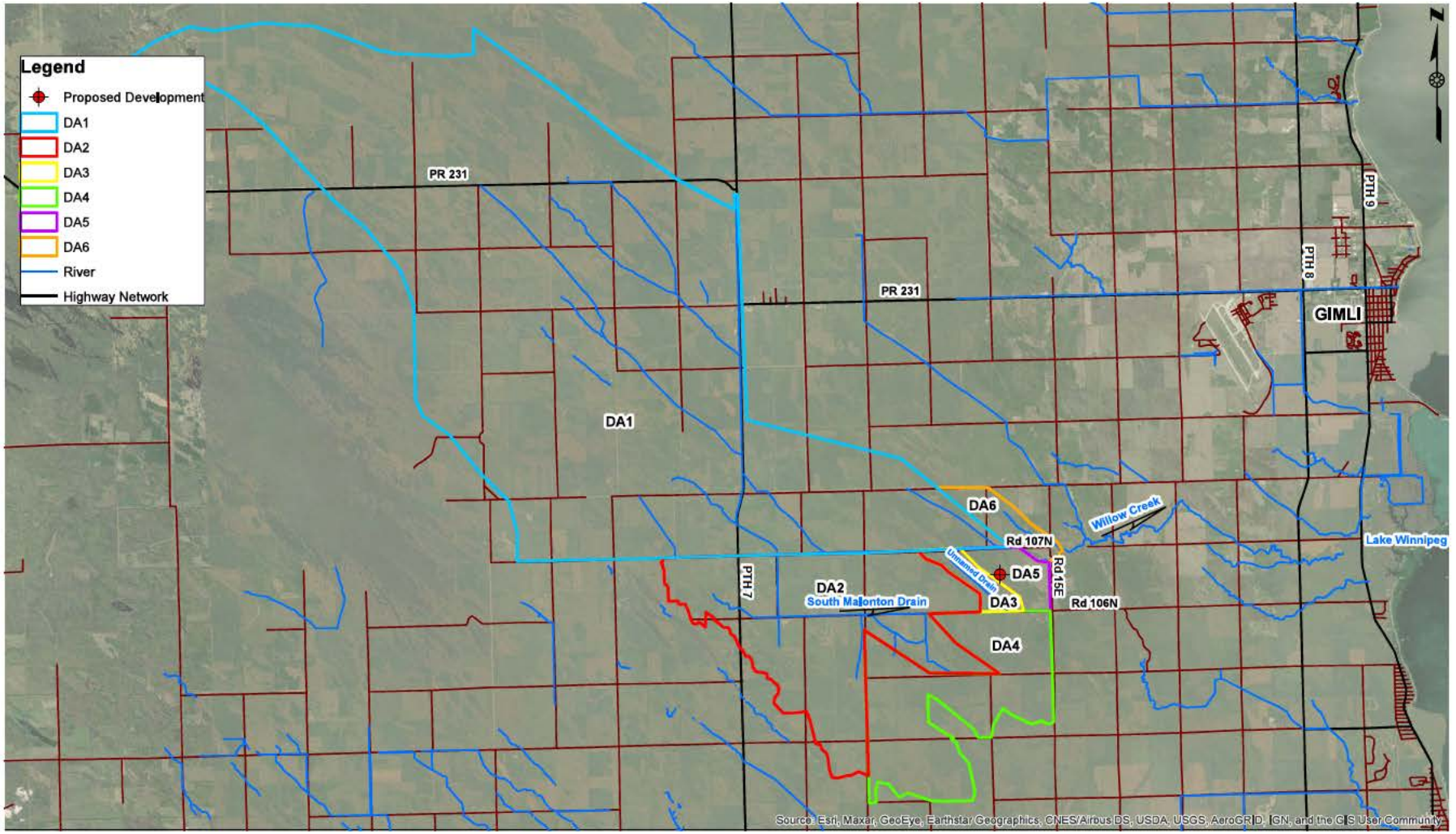
Photo No. 14: South Malonton Drain upstream of Rd 106N Access Crossing at STA 22+17 (looking upstream) – September 13, 2022

Photo No. 15: Unnamed Drain at STA 2+00 (looking north) – September 13, 2022

Figures

TREK GEOTECHNICAL

0105 068 00
Burns Maendel Consulting Engineers Ltd.
Crystal Springs Colony Community Development



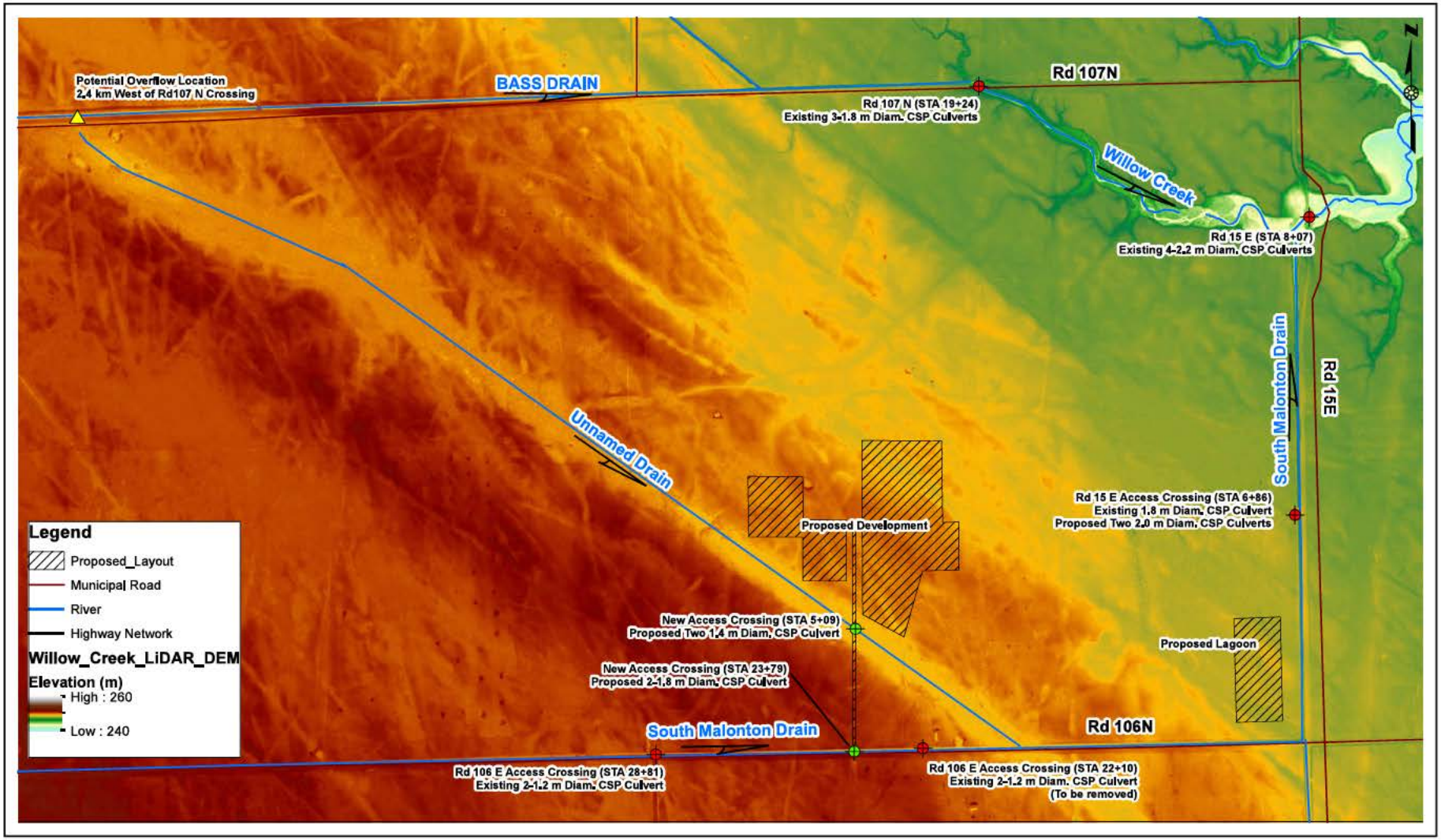
Document Path: Z:\Projects\0105 Burns Maendel Consulting Ltd\0105 068 00 Crystal Springs Drainage\3 Survey and Dwg\3.3 GIS\Location_Plan_TREK_TEMPLATE_Figure 2.mxd

NOTES:

1. REFERENCE: CANVEC © NATURAL RESOURCES CANADA, 2012
2. REFERENCE: LIDAR PROVIDED BY MTI FOR THE RM OF BROKENHEAD

0 1.25 2.5 5 7.5 10 Kilometers

Figure 01
WILLOW CREEK
LOCATION PLAN



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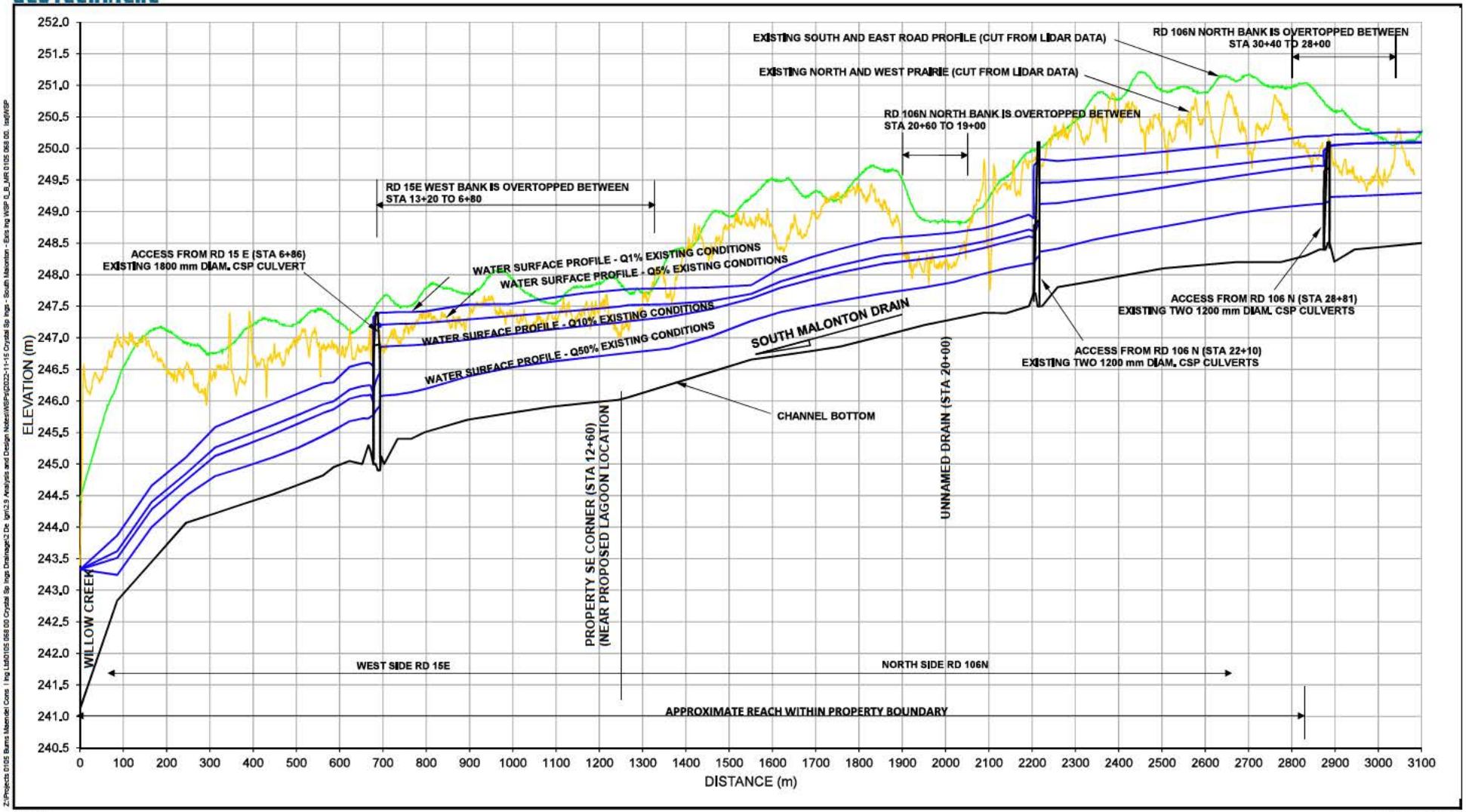
NOTES:

1. REFERENCE: CANVEC © NATURAL RESOURCES CANADA, 2012
2. REFERENCE: LIDAR PROVIDED BY MTI FOR THE RM OF BROKENHEAD

0 0.125 0.25 0.5 0.75 1 Kilometers

Figure 02
STUDY AREA
LAYOUT PLAN

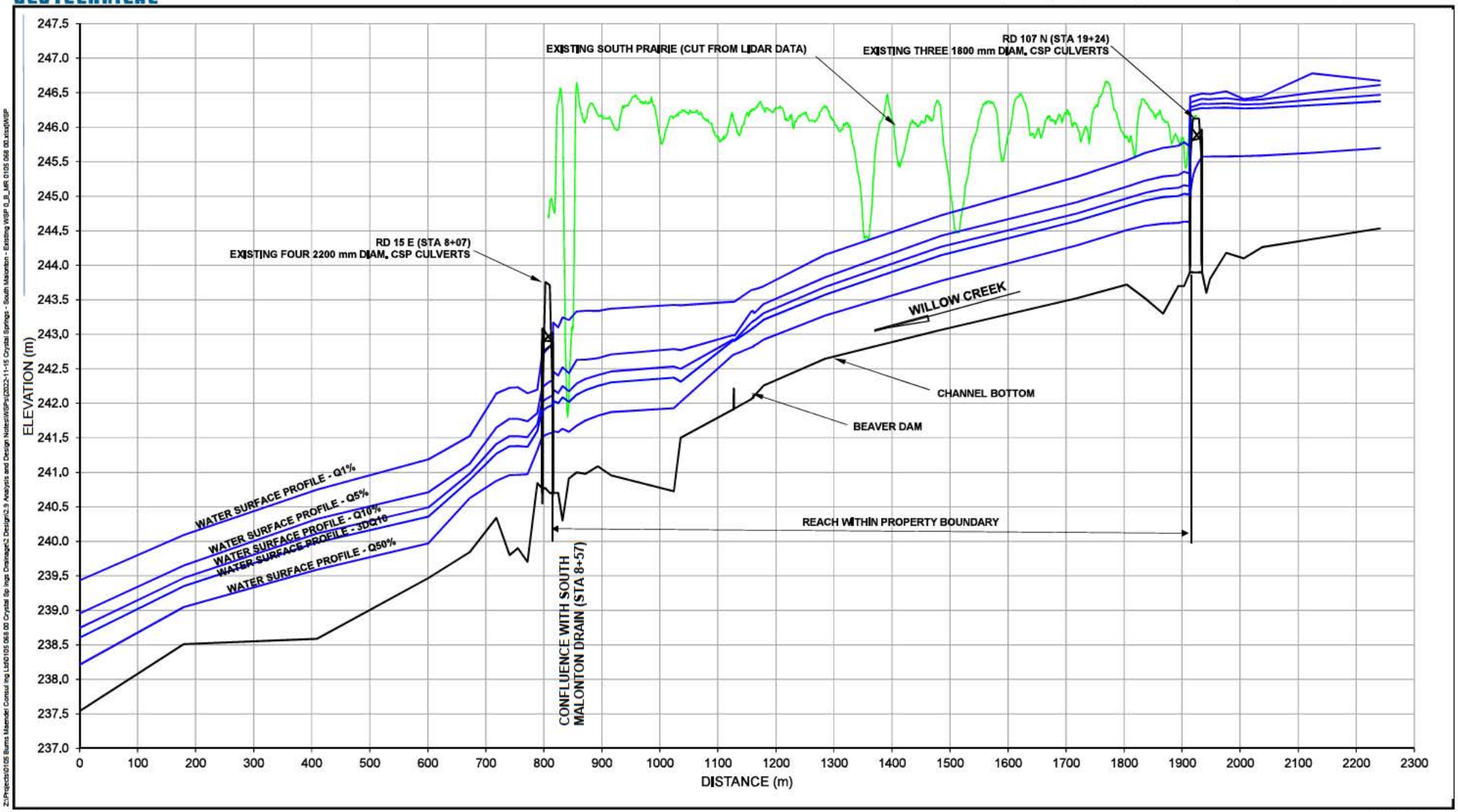


NOTES:

1. HEC-RAS MODEL DEVELOPED FROM 2022 SURVEY DATA PROVIDED BY BURNS MAENDEL CONSULTING LTD.
2. WATER SURFACE PROFILES REFLECT HYDRAULIC CONDITIONS WITH THE 1% TAILWATER LEVEL ON WILLOW CREEK - EL 243.41.
3. WATER SURFACE PROFILES REFLECT HYDRAULIC CONDITIONS WITH THE EXISTING CROSSING STRUCTURES IN PLACE.

Figure 03

SOUTH MALONTON DRAIN ALONG RD 106 N AND RD 15E
EXISTING CONDITIONS - WATER SURFACE PROFILES



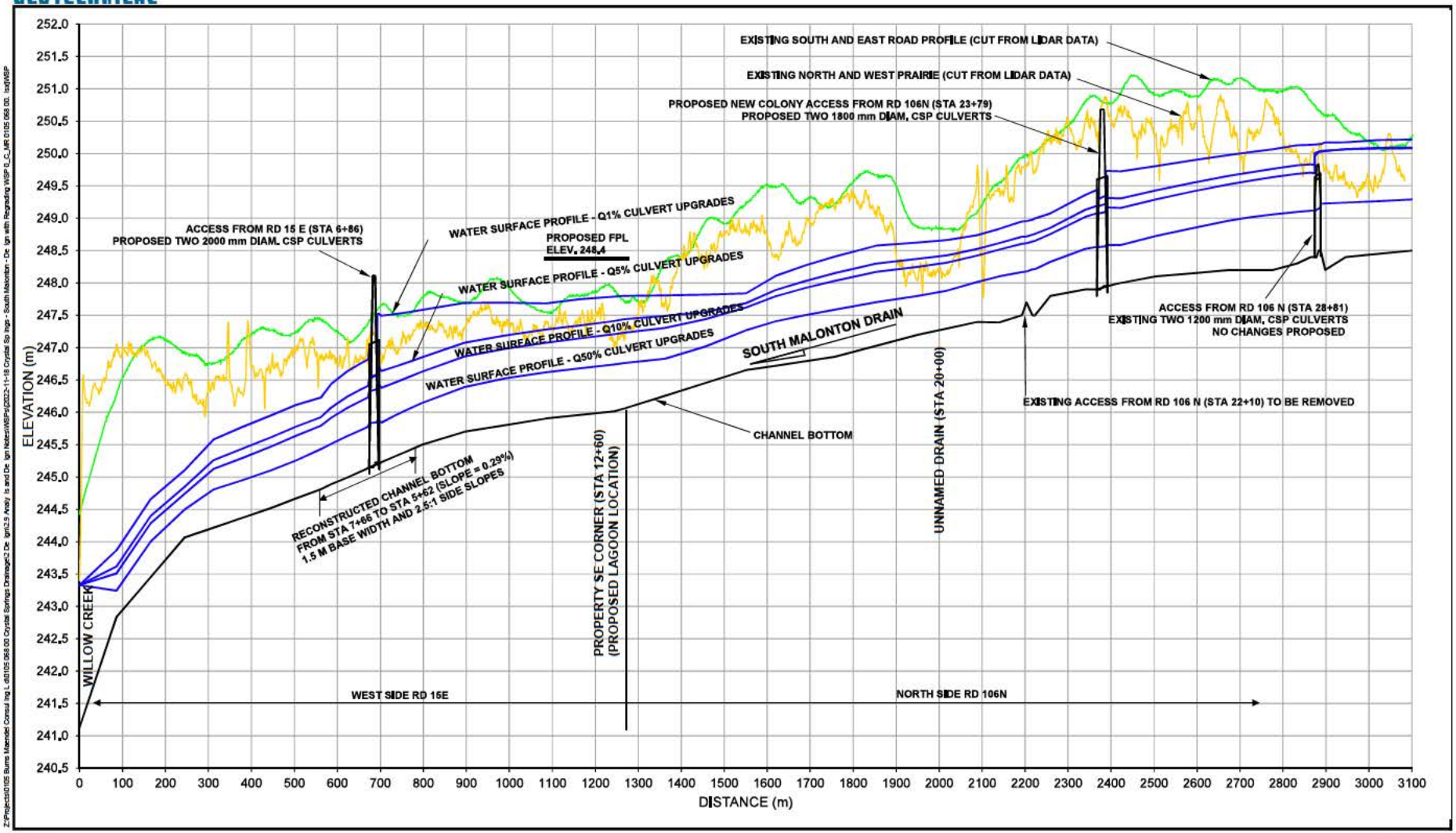
NOTES:

1. HEC-RAS MODEL DEVELOPED FROM 2022 SURVEY DATA PROVIDED BY BURNS MAENDEL CONSULTING LTD.
2. WATER SURFACE PROFILES REFLECT HYDRAULIC CONDITIONS WITH THE EXISTING CROSSING STRUCTURES IN PLACE.

Figure 04

WILLOW CREEK

EXISTING CONDITIONS - WATER SURFACE PROFILES



NOTES:

1. HEC-RAS MODEL DEVELOPED FROM 2022 SURVEY DATA PROVIDED BY BURNS MAENDEL CONSULTING LTD.
2. WATER SURFACE PROFILES REFLECT HYDRAULIC CONDITIONS WITH 1% TAILWATER LEVEL ON WILLOW CREEK - EL 243.41
3. WATER SURFACE PROFILES REFLECT HYDRAULIC CONDITIONS WITH THE PROPOSED DOUBLE 1800 mm DIAM. CSP CULVERTS AT THE PROPOSED ACCESS ROAD FROM RD 106 N AND DOUBLE 2000 mm DIAM. CSP CULVERTS AT THE EXISTING FARMYARD CROSSING AT RD 15 E, WITH THE EXISTING FIELD CROSSING AT STA 22+10 REMOVED, AND WITH PROPOSED REGRADED CHANNEL FROM STA 7+97 TO STA 5+62.

Figure 05

SOUTH MALONTON DRAIN ALONG RD 106 N AND RD 15E

CULVERT UPGRADES - WATER SURFACE PROFILES

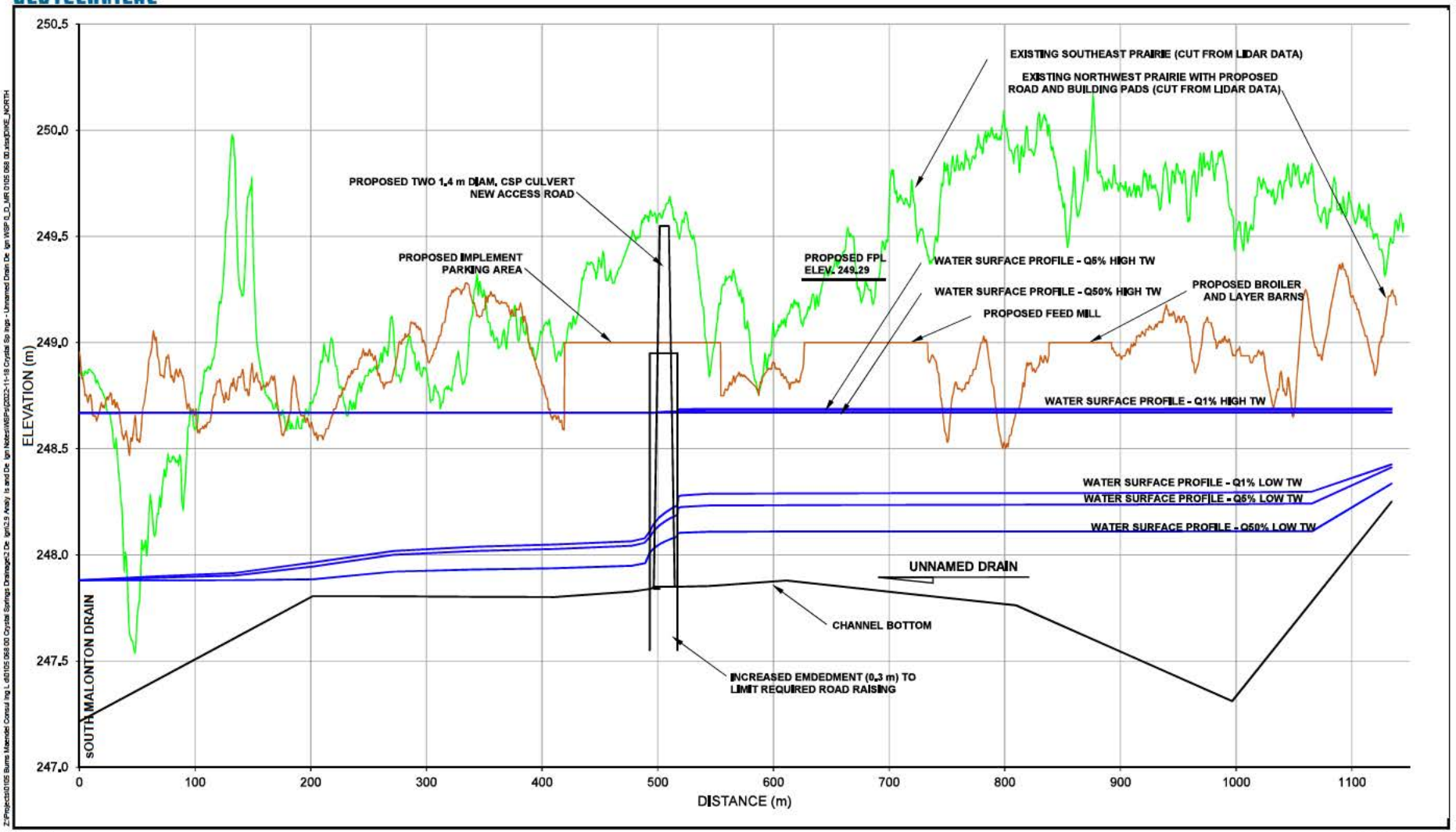


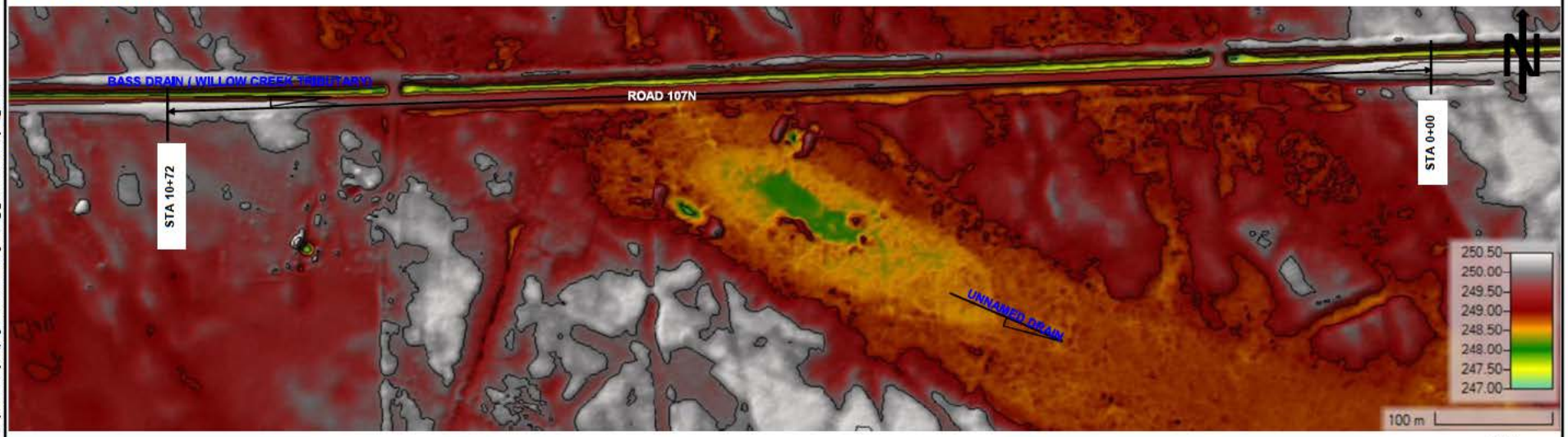
Figure 06

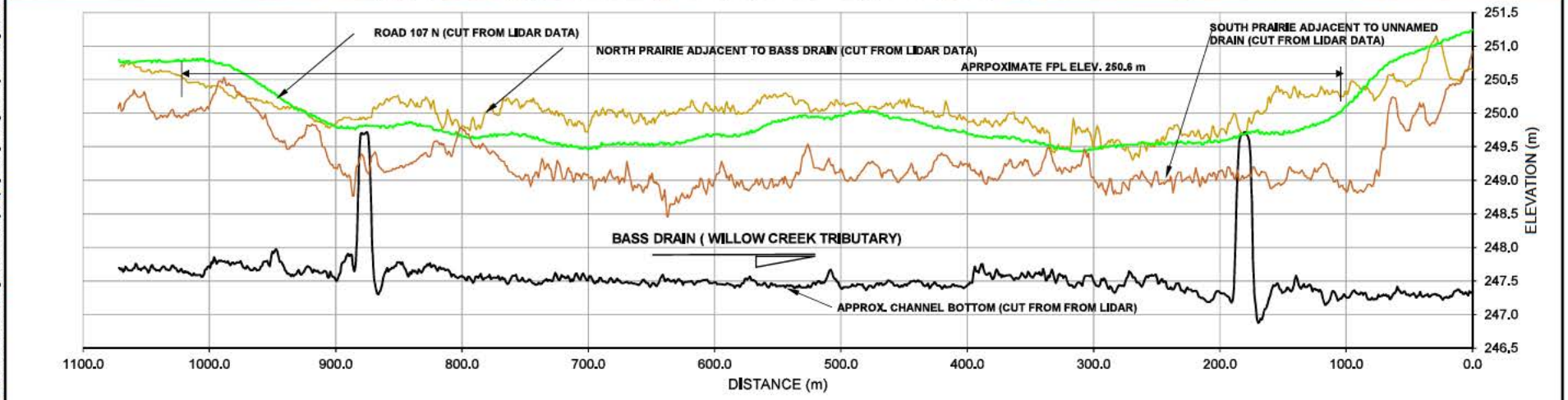
NOTES:

1. HEC-RAS MODEL DEVELOPED FROM 2022 SURVEY DATA PROVIDED BY BURNS MAENDEL CONSULTING LTD.
2. WATER SURFACE PROFILES REFLECT HYDRAULIC CONDITIONS WITH LOW (EL. 247.88) AND HIGH (EL.248.67) TAILWATER LEVEL ON SOUTH MALONTON DRAIN
3. WATER SURFACE PROFILES REFLECT HYDRAULIC CONDITIONS WITH THE PROPOSED SINGLE 1200 mm DIAM. CSP CULVERT FOR THE CROSSING OVER UNNAMED DRAIN.

UNNAMED DRAIN

CULVERT UPGRADES - WATER SURFACE PROFILES





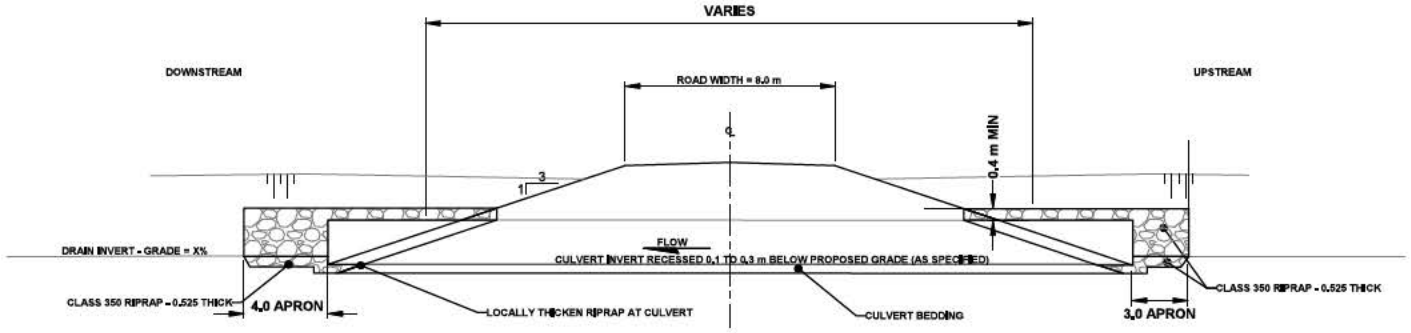
NOTES:

1. PROFILES CUT FROM MANITOBA LAND INITIATIVE LIDAR DATA FOR WILLOW CREEK WHICH WAS CONVERTED TO CGVD 2013 DATUM.
2. STATION 0+00 IS APPROXIMATLEY 2395 m WEST OF THE INTERSECTION OF RD 15E AND RD 107 N at STA 0+00 OF THE WILLOW CREEK MODEL.

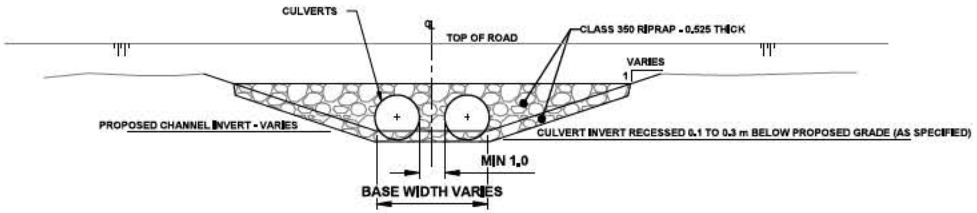
Figure 07

NORTH OF UNNAMED DRAIN

POTENTIAL ROAD 107 N OVERFLOW LOCATION



PROFILE THROUGH CULVERT CROSSING
SCALE: NTS



SECTION UPSTREAM OF CULVERT CROSSING
SCALE: NTS

NOTES

CULVERT FOUNDATION
1) THE CULVERT FOUNDATION MEANS THE NATURAL SOIL, UNDERLYING THE EXCAVATION, UPON WHICH THE CULVERT BEDDING OR THE CULVERT IS TO BE PLACED.
2) THE CULVERT FOUNDATION SHALL BE PREPARED AND COMPACTED TO THE STAKED GRADELINE AND FOR A WIDTH SUFFICIENT TO PERMIT COMPACTION OF THE BEDDING UNDER THE CULVERT HAUNCHES. BED EXCAVATION TO HAVE A MINIMUM WIDTH OF 0.5 m FROM OUTSIDE EDGE OF CULVERT.
3) UNSUITABLE MATERIAL FROM BELOW THE STAKED GRADELINE SHALL BE REMOVED TO AN APPROVED DEPTH AND REPLACED WITH SUITABLE BEDDING AND SUITABLE GEOTEXTILE IF REQUIRED, TO PROVIDE UNIFORM CONTINUOUS SUPPORT.

CULVERT PLACEMENT
1) CULVERTS SHALL BE PLACED AT THE LOCATION, GRADE AND ALIGNMENT AS INDICATED ON THE PLAN OR AS DIRECTED BY ENGINEERING REPRESENTATIVE.
2) CULVERT SECTIONS SHALL BE PLACED SO THAT THE COUPLER CORRUGATIONS SHALL PROPERLY ENGAGE PIPE CORRUGATIONS WITH THE MINIMUM GAP BETWEEN SECTION ENDS. COUPLER BOLTS SHALL BE FULLY TIGHTENED.

CULVERT BEDDING
1) THE CULVERT BEDDING MEANS A LAYER OF SELECTED MATERIAL, GENERALLY CULVERT GRAVEL, CONSTRUCTED ON THE CULVERT FOUNDATION SO AS TO UNIFORMLY SUPPORT THE CULVERT.
2) CULVERT GRAVEL SHALL BE WELL GRADED AND SHALL CONSIST OF SOUND, DURABLE PARTICLES OF GRAVEL, STONE, SAND AND FINES, FREE FROM SOD, ROOTS AND ORGANIC MATERIAL. THE SHALE CONTENT SHALL NOT EXCEED 25% BY WEIGHT OF THE PARTICLES RETAINED ON A 4.75 mm SIEVE. THE CULVERT GRAVEL SHALL MEET THE FOLLOWING GRADATION REQUIREMENTS:
PASSING 37.5 mm = 100%
PASSING 4.75 m 25 - 80%
PASSING 425 um 15 - 40%
PASSING 75 um 5 - 15%
3) CULVERT GRAVEL FOR BEDDING SHALL BE SPREAD UNIFORMLY ALONG THE FULL LENGTH OF THE CULVERT FOUNDATION. THE BEDDING SHALL BE PLACED SO THAT AFTER COMPACTING, A DEPTH OF AT LEAST 300 mm OF GRAVEL REMAINS UNDER THE FULL LENGTH OF THE CULVERT.
4) AFTER THE CULVERT HAS BEEN INSTALLED AND ASSEMBLED ON THE LOOSE BEDDING, THE BEDDING ON BOTH SIDES OF THE CULVERT SHALL BE COMPACTED. CULVERT BEDDING SHALL BE COMPACTED AT OPTIMUM MOISTURE CONTENT TO A MINIMUM OF 95% AASHTO STANDARD DRY DENSITY.

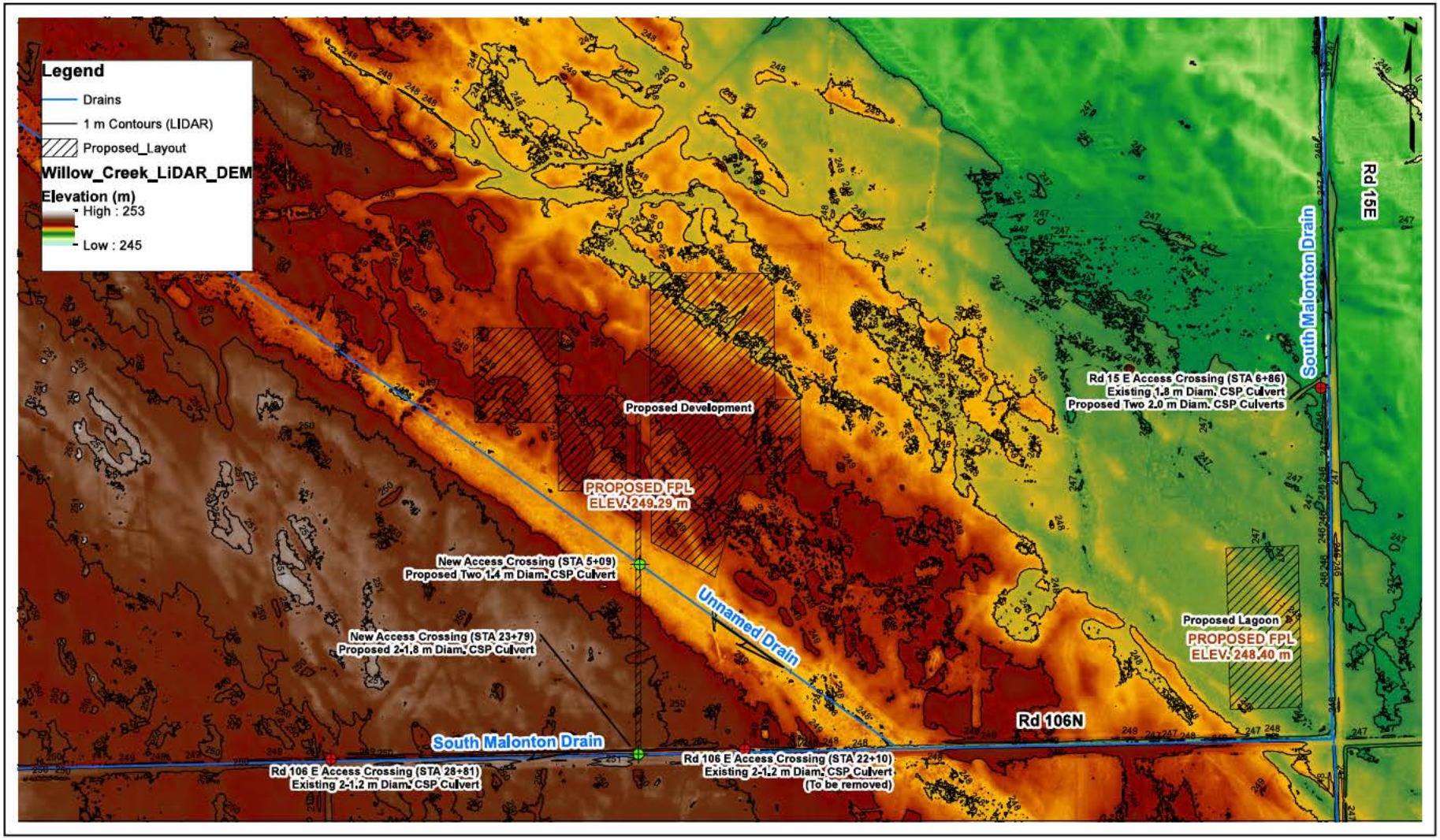
CULVERT BACKFILLING - BELOW SPRINGLINE
1) FILL MATERIAL UNDER HAUNCHES SHALL BE PLACED ALTERNATELY IN 150 mm LAYERS ON BOTH SIDES OF THE PIPE AND COMPACTED. THE MATERIAL UNDER THE HAUNCHES MUST BE IN FIRM CONTACT WITH THE ENTIRE BOTTOM SURFACE OF THE STRUCTURE. BACKFILL AND COMPACTION UNDER HAUNCHES IS A MANUAL JOB, CONSISTING OF SHOVEL PLACEMENT, TIMBER RAMMER OR HAND HELD PACKERS.
2) COMPACTION TO SPRINGLINE - AFTER THE HAUNCH AREA HAS BEEN BACKFILLED AND COMPACTED, ADDITIONAL BEDDING MATERIAL SHALL BE PLACED ADJACENT TO THE PIPE HAUNCHES IN LIFTS NOT EXCEEDING 150 mm. EACH LIFT SHALL BE COMPACTED WITH A PLATE TYPE MECHANICAL COMPACTOR. BEDDING MATERIAL SHALL BE PLACED IN THIS MANNER UP TO THE LEVEL OF THE SPRINGLINE. MATERIAL PLACED ABOVE THE SPRINGLINE SHALL BE PLACED AS DESCRIBED IN BACKFILL.

CULVERT BACKFILLING - ABOVE SPRINGLINE
1) BACKFILL WILL MEAN CULVERT GRAVEL OR SELECTED MATERIAL USED FOR FILL ADJACENT TO AND OVER AN ASSEMBLED CULVERT. THE LEVEL OF BACKFILL ON BOTH SIDES OF THE CULVERT SHALL BE MAINTAINED APPROXIMATELY EQUAL AT ALL TIMES TO PREVENT DISTURBING THE CULVERT.
2) EXCAVATED MATERIAL OR MATERIAL SIMILAR TO THE ROADWAY EMBANKMENT SHOULD BE ENCOURAGED AS BACKFILL. IN FROST SUSCEPTIBLE SOILS, HEAVY CLAY MATERIAL SHALL NOT BE USED AS BACKFILL.
3) WHEN CULVERT GRAVEL IS NOT USED, MATERIAL PLACED UNDER THE HAUNCHES SHALL BE CAREFULLY SELECTED TO ENSURE THAT IT IS FREE OF ROCKS AND LUMPS.
4) CULVERTS SHALL BE BACKFILLED IN UNIFORM LAYERS NOT EXCEEDING 150 mm AND SHALL BE COMPACTED TO A MINIMUM OF 95% AASHTO STANDARD DRY DENSITY.
5) BACKFILL SHALL BE PLACED AND COMPACTED IN UNIFORM LAYERS UNTIL THE EMBANKMENT HAS BEEN CONSTRUCTED TO A SUFFICIENT HEIGHT ABOVE THE TOP OF THE CULVERT SO THAT NORMAL GRADING EQUIPMENT CAN OPERATE WITHOUT DISTORTING THE CULVERT.

CHANNEL EXCAVATION
1) THE DRAIN MAY REQUIRE EXCAVATION UPSTREAM AND DOWNSTREAM TO PROVIDE A SMOOTH TRANSITION TO THE EXISTING CHANNEL.
2) THE LIMITS OF THE CHANNEL TRANSITION SHALL BE AS INDICATED ON THE PLAN OR AS DIRECTED BY ENGINEERING REPRESENTATIVE

RIPRAP
1) THE CLASS 350 RIPRAP WILL BE WELL-GRADED, ROUNDED, CLEAN FIELD STONE OR QUARRIED CRUSHED ROCK WITH THE FOLLOWING GRADATION: 100% < 350 mm, 50% > 200 mm AND 80% > 100 mm.
2) RIPRAP TO BE PLACED OVER ARMTEC 230 NON-WOVEN GEOTEXTILE OR EQUIVALENT

Figure 08
CRYSTAL SPRINGS COLONY DEVELOPMENT
CULVERT INSTALLATION DETAILS



Document Path: Z:\Projects\0105 Burns Maendel Consulting Ltd\0105 068 00 Crystal Springs Drainage\3 Survey and Dwg\3.3 GIS\Proposed_Development_TEMPLATE_Figure 9.mxd

NOTES:

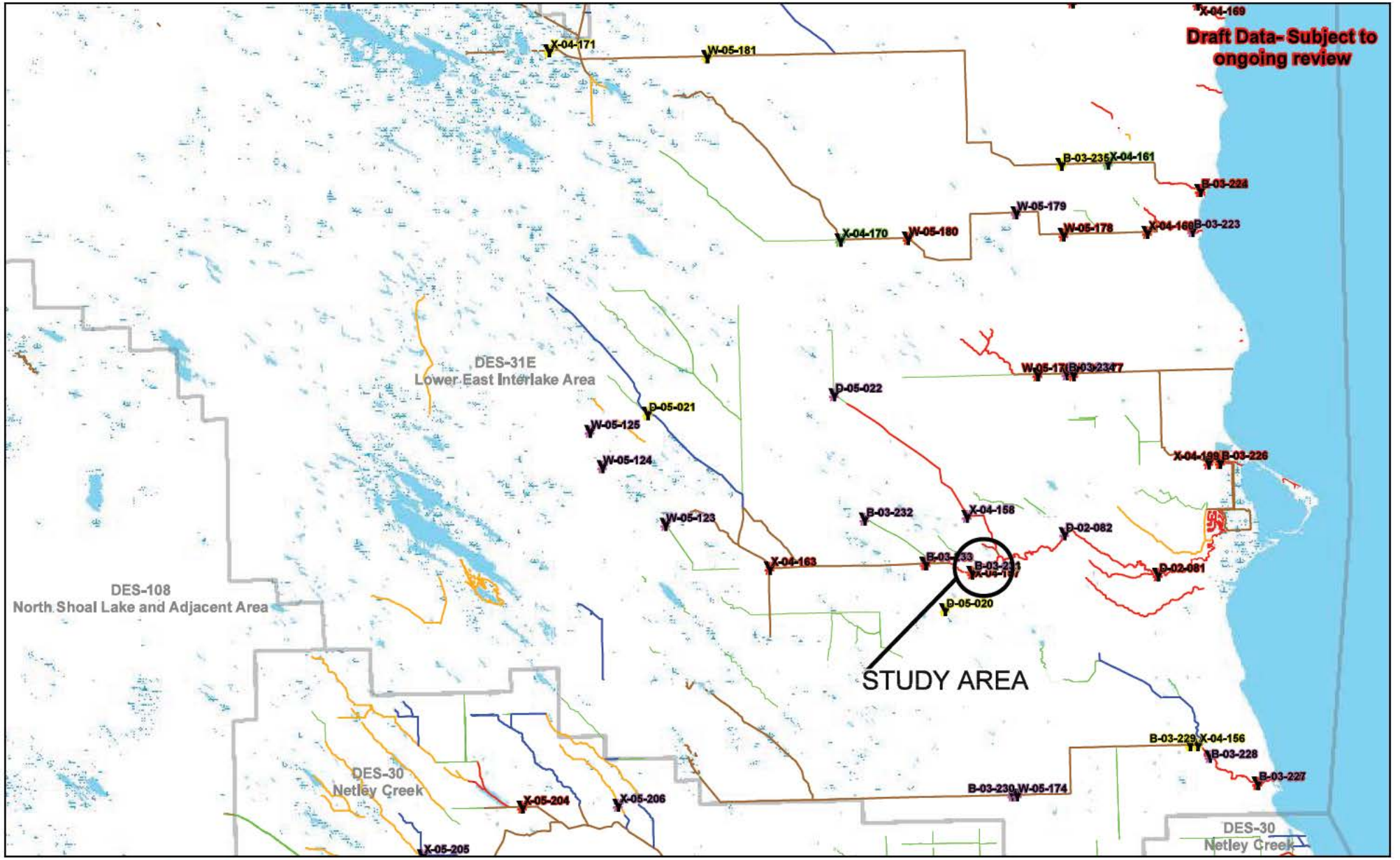
1. REFERENCE: CANVEC © NATURAL RESOURCES CANADA, 2012
2. REFERENCE: LIDAR PROVIDED BY MTI FOR THE RM OF BROKENHEAD

Kilometers
0 0.075 0.15 0.3 0.45 0.6

Figure 09
STUDY AREA
PROPOSED UPGRADES

Appendix A

Fish Habitat Classification



062I13	062I14	062I15
062I12	062I11	062I10
062I05	062I06	062I07

Habitat Classification

A
B
C
D
E

Fishing Results

Indicator Species
Non-Indicator Species
No Catch
No Fishing Effort

Appendix 9

Sampling sites, fish captures and habitat classification of streams and constructed drains throughout agricultural areas of Manitoba (2002 – 2006)

062I11

Produced April 2012

Appendix B

Development Drawings (provided by BMCL)

BURNS MAENDEL
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CRYSTAL SPRINGS COLONY
NEW COLONY
DEVELOPMENT

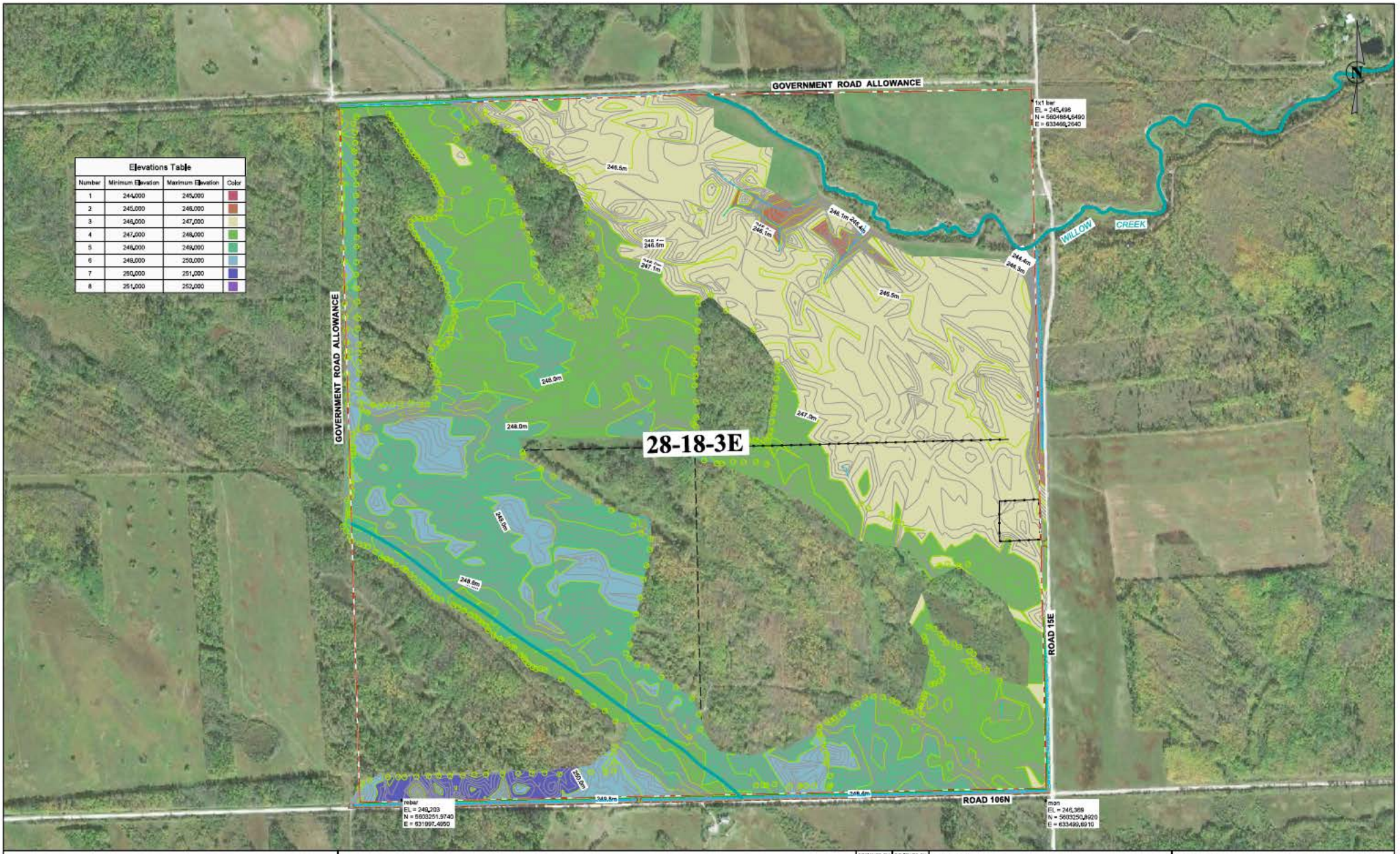
28-13-3 EPM
RM OF ARMSTRONG, MB

CIVIL DRAWINGS

DWG NO.	DRAWING NAME	REV
C1.1	TOPOGRAPHICAL SURVEY	A
C1.2	NORTH SURVEY	A
C1.3	SOUTH SURVEY	A
C1.4	PROPOSED SITE CONCEPT PLAN	J
C1.5	MAJOR DRAINAGE PLAN	A
C1.6	SITE GRADING PLAN - MAIN ACCESS ROAD	A
C1.7	SITE GRADING PLAN - FEED LOT AND INDUSTRIAL AREAS	A
C1.8	SITE GRADING PLAN - MAIN SHOP AND RESIDENTIAL AREAS	A

DATE
JULY 21, 2022

PROJECT NO:
BMCE21-011



NO	DATE	APPL	BY	DESCRIPTION
A	JULY 21, 2022	DJL	AK	ISSUED FOR CLIENT REVIEW

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DESIGNED BY:
REVIEWED BY:
DRAWN BY: CR
PROJECT START DATE: MARCH 26, 2021
PLOT SIZE: A1 (594x841)
SCALE: 1:4000

PROJECT NAME:
CRYSTAL SPRING COLONY
NEW COLONY SITE DEVELOPMENT
28-18-3 EPM, RM OF ARMSTRONG, MB

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Fax: (204) 728-4418

DRAWING TITLE:
TOPOGRAPHICAL SURVEY

PROJECT NUMBER: BMCE-21-011
DRAWING NO: C1.1

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SCALE: 1:2000

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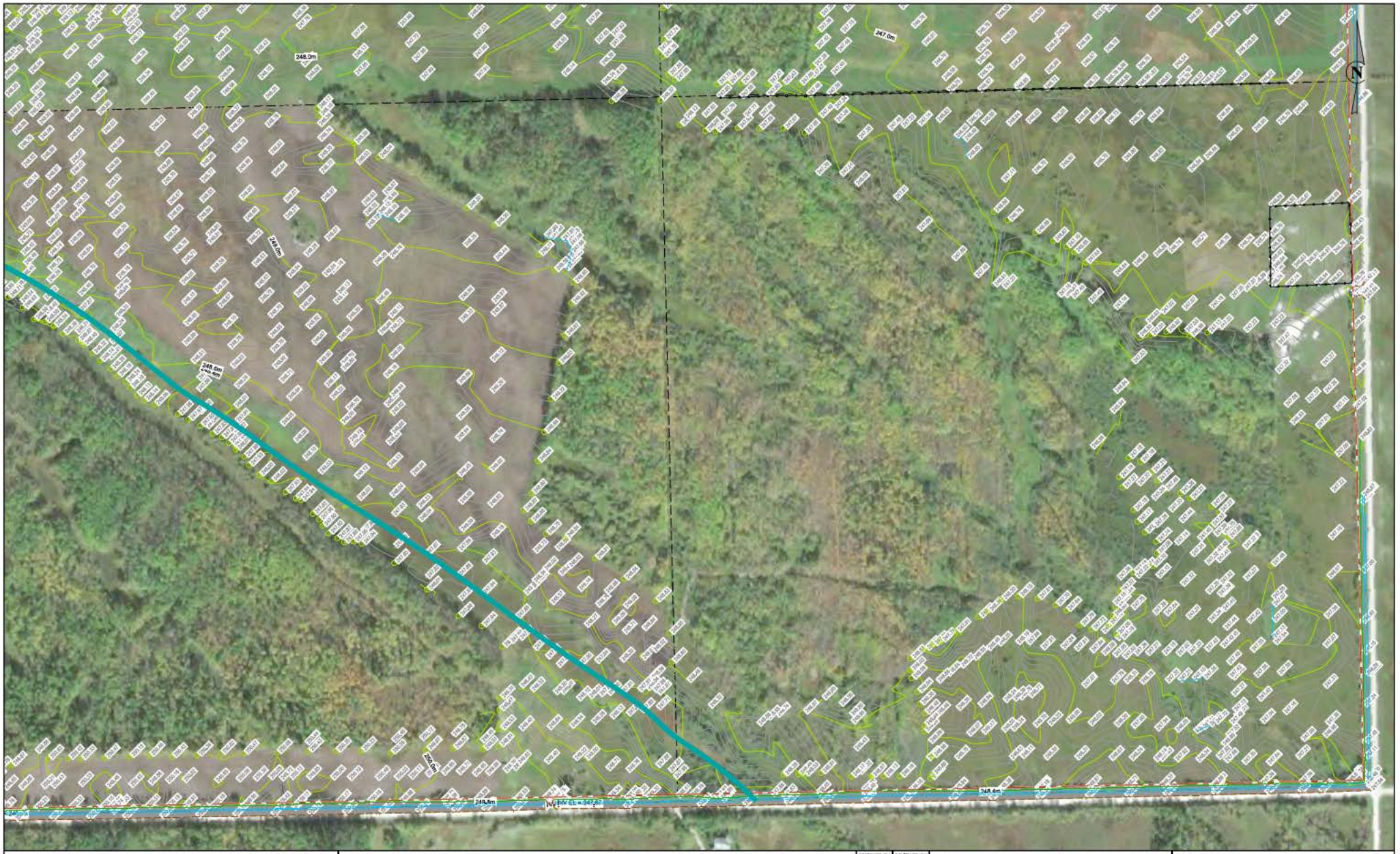
Fax: (204) 728-4418

DRAWING TITLE:
NORTH SURVEY

PROJECT NUMBER: BMCE-21-011
DRAWING NO: C1.2



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DRAWN BY: CR
PROJECT START DATE: MARCH 26, 2021
PLOT SIZE: A1 (594x841)
SCALE: 1:2000

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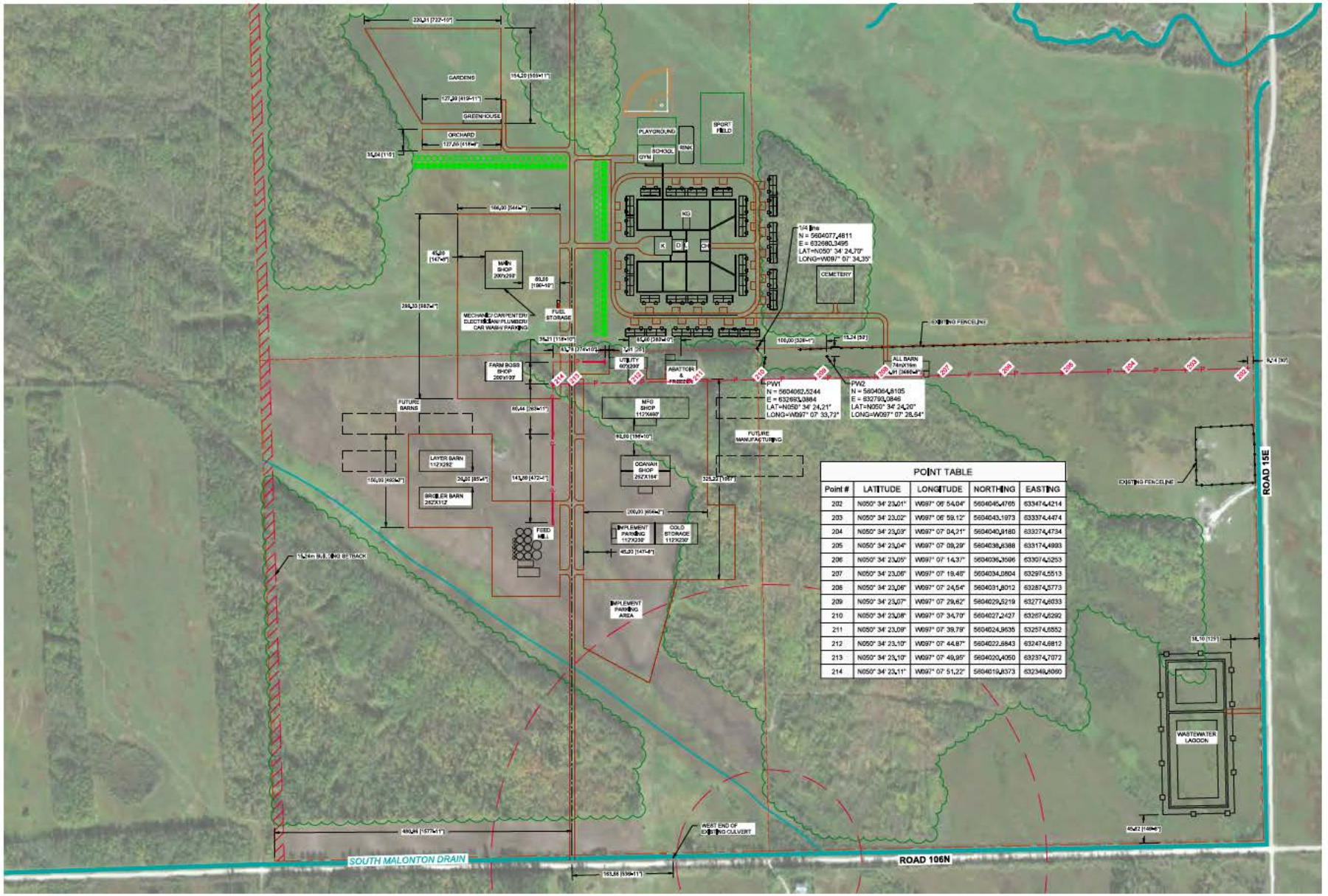
DRAWING TITLE:
SOUTH SURVEY

PROJECT NUMBER: BMCE-21-011
DRAWING NO: C1.3



POINT TABLE				
Point #	LATITUDE	LONGITUDE	NORTHING	EASTING
202	N050° 34' 23.01"	W097° 08' 54.04"	5604045.4765	633474.4214
203	N050° 34' 23.02"	W097° 08' 59.12"	5604043.1973	633374.4474
204	N050° 34' 23.03"	W097° 07' 04.21"	5604040.9180	633274.4734
205	N050° 34' 23.04"	W097° 07' 09.29"	5604038.6388	633174.4993
206	N050° 34' 23.05"	W097° 07' 14.37"	5604036.3596	633074.5253
207	N050° 34' 23.06"	W097° 07' 19.46"	5604034.0804	632974.5513
208	N050° 34' 23.06"	W097° 07' 24.54"	5604031.8012	632874.5773
209	N050° 34' 23.07"	W097° 07' 29.62"	5604029.5219	632774.6033
210	N050° 34' 23.08"	W097° 07' 34.70"	5604027.2427	632674.6292
211	N050° 34' 23.09"	W097° 07' 39.79"	5604024.9635	632574.6552
212	N050° 34' 23.10"	W097° 07' 44.87"	5604022.6843	632474.6812
213	N050° 34' 23.10"	W097° 07' 49.95"	5604020.4050	632374.7072
214	N050° 34' 23.11"	W097° 07' 51.22"	5604019.8373	632349.8060

NO:	DATE	APP'L	BY	DESCRIPTION
J	MAR 28, 2022	D.B.	J.K.	REVISED LAYOUT BACK TO PREVIOUS / RELOCATED POWER AT IND PAD
I	MAR 25, 2022	D.B.	J.K.	REVISED LAYOUT
H	MAR 24, 2022	D.B.	J.K.	REVISED LAYOUT
G	FEB 22, 2022	D.B.	J.K.	ADDED PROPOSED ELECTRICAL SERVICE
F	FEB 22, 2022	D.B.	J.K.	REVISED PROPOSED WELL (PW1) LOCATION
E	FEB 14, 2022	D.B.	J.K.	REVISED UTILITY BLDG AND ABATTOIR LOCATIONS / REVISED WELL LOCATIONS
D	FEB 9, 2022	D.B.	J.K.	ADDED PROPOSED WELL LOCATIONS

REVISIONS

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DESIGNED BY: JK	REVIEWED BY: DB
DRAWN BY: JK	
PROJECT START DATE: JUNE 2021	
PLOT SIZE: A1 (594x841)	
SCALE: 1:3000	

PROJECT NAME:
NEW COLONY DEVELOPMENT
28-18-3 EPM, RM OF ARMSTRONG, MB

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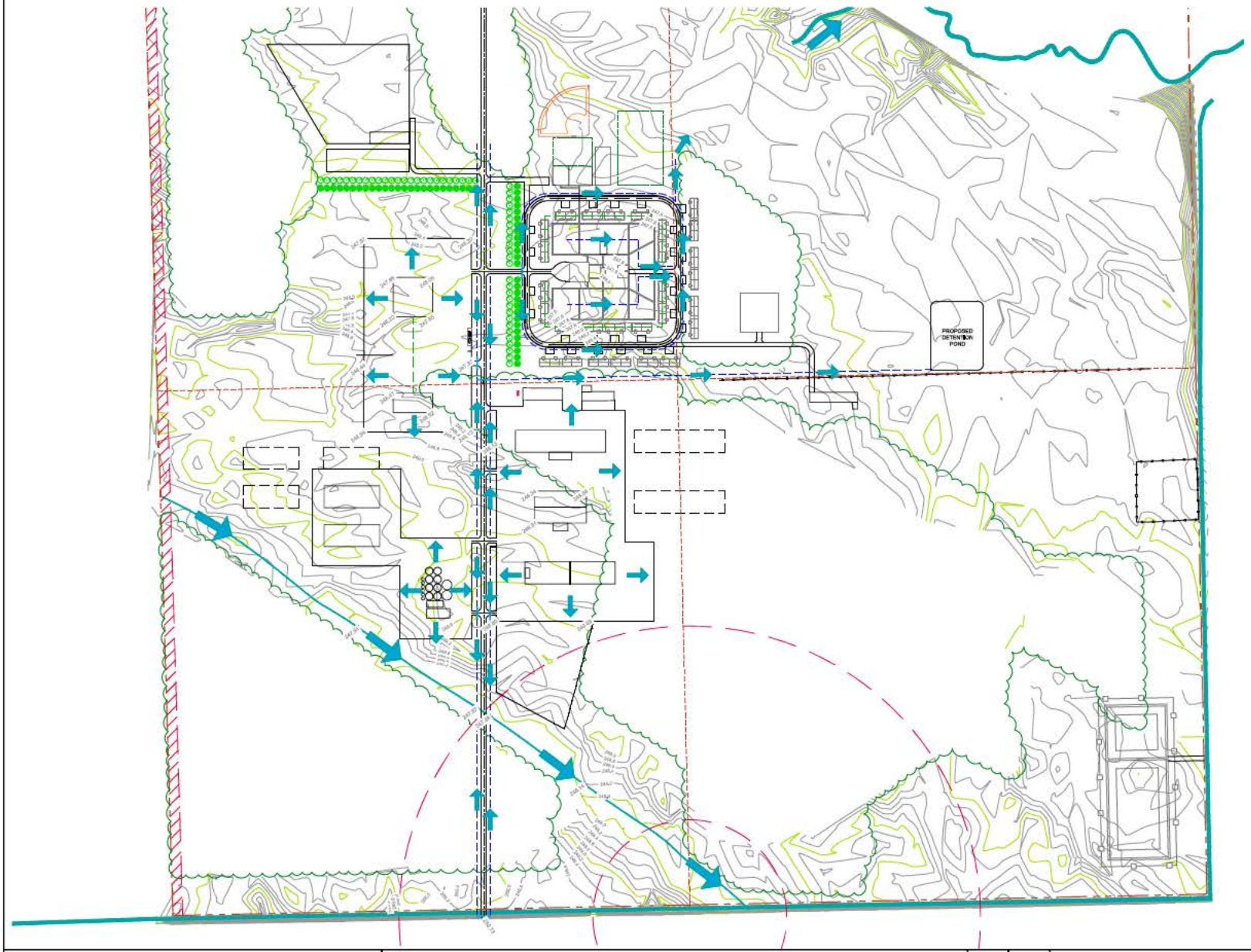
DRAWING TITLE:
PROPOSED SITE CONCEPT
OPTION #4

PROJECT NUMBER: BMCE21-011

DRAWING NO: C1.4



N

GENERAL NOTES:

1. ALL UNITS ARE IN METRES AND DECIMALS THEREOF.
2. EXISTING FEATURE LOCATIONS AND PROPERTY LINE INFORMATION IS DERIVED FROM SURVEY INFORMATION COLLECTED BY BMCE ON MAR 10 - 12, 2021.
3. LOCAL ELEVATION BENCHMARKS PROVIDED FOR ...
4. PRIOR TO CONSTRUCTION THE CONTRACTOR IS RESPONSIBLE FOR CONTACTING THE INDIVIDUAL UTILITY COMPANIES FOR LOCATES.
5. LOCATIONS OF UNDERGROUND STRUCTURES AND SERVICES AS SHOWN ARE BASED ON THE BEST AVAILABLE INFORMATION. NO GUARANTEE IS GIVEN THAT ALL UTILITIES ARE SHOWN OR THAT THE GIVEN LOCATIONS ARE EXACT.
6. HORIZONTAL AND VERTICAL CONTROL TO BE PROVIDED ON SITE BY THE ENGINEER FOR CONTRACTOR AT TIME OF CONSTRUCTION.

NO	DATE	APP.	BY	DESCRIPTION
A	JULY 21, 2022	D.B.	J.K.	ISSUED FOR CLIENT REVIEW

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DESIGNED BY: D.B. | REVIEWED BY:
DRAWN BY: J.K.
PROJECT START DATE: MAR 2021
PLOT SIZE: A1 (594x841)
SCALE: AS NOTED

PROJECT NAME:
CRYSTAL SPRINGS COLONY
NEW COLONY DEVELOPMENT
28-18-03 EPM, RM OF ARMSTRONG, MB

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DRAWING TITLE:
MAJOR DRAINAGE PLAN

PROJECT NUMBER: BMCE-21-011
DRAWING NO: C1.5

GENERAL NOTES:

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2. EXISTING FEATURE LOCATIONS AND PROPERTY LINE INFORMATION IS DERIVED FROM SURVEY INFORMATION COLLECTED BY BMCE ON MAR 10 - 12, 2021.
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NO	DATE	APP.	BY	DESCRIPTION
A	JULY 21, 2022	D.B.	AK.	ISSUED FOR CLIENT REVIEW

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DRAWN BY:	J.K.
PROJECT START DATE:	MAR 2021
PLOT SIZE:	A1 (594x841)
SCALE:	AS NOTED

PROJECT NAME:
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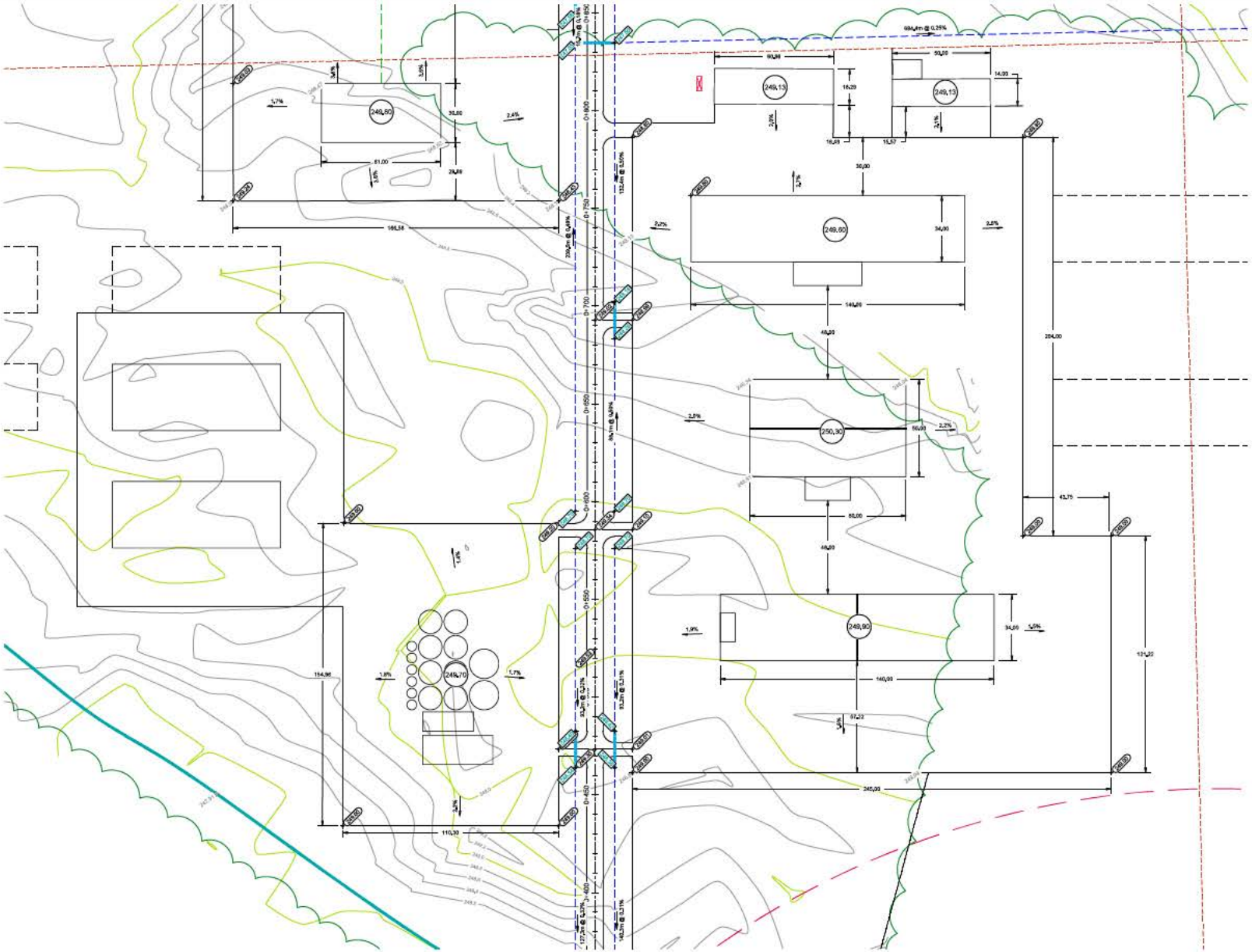
DRAWING TITLE:
SITE GRADING PLAN
MAIN ACCESS ROAD

PROJECT NUMBER: BMCE-21-011

DRAWING NO: C1.6



NO	DATE	APP.	BY	DESCRIPTION
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DRAWN BY:	J.K.
PROJECT START DATE:	MAR 2021
PLOT SIZE:	A1 (594x841)
SCALE:	AS NOTED

PROJECT NAME:
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NEW COLONY DEVELOPMENT
28-18-03 EPM, RM OF ARMSTRONG, MB

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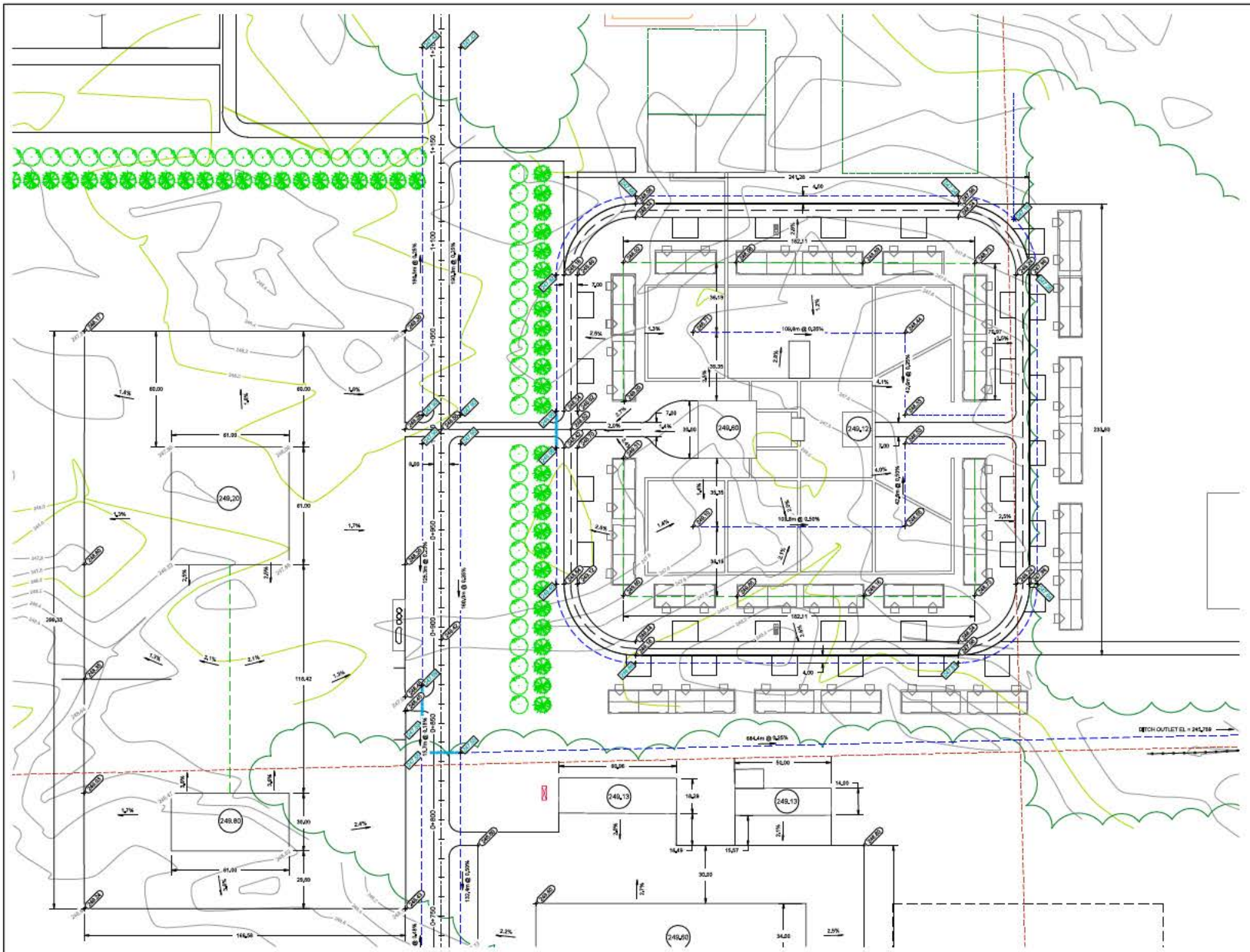
DRAWING TITLE:
SITE GRADING PLAN
FEED LOT AND INDUSTRIAL AREAS

PROJECT NUMBER: BMCE-21-011

DRAWING NO: C1.7



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NO	DATE	APP'D	BY	DESCRIPTION
A	JULY 21, 2022	D.B.	AK.	ISSUED FOR CLIENT REVIEW

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DESIGNED BY:	REVIEWED BY: D.B.
DRAWN BY:	J.K.
PROJECT START DATE:	MAR 2021
PLOT SIZE:	A1 (594x841)
SCALE:	AS NOTED

PROJECT NAME:
CRYSTAL SPRINGS COLONY
NEW COLONY DEVELOPMENT
28-18-03 EPM, RM OF ARMSTRONG, MB

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DRAWING TITLE:
SITE GRADING PLAN
MAIN SHOP AND RESIDENTIAL AREAS

PROJECT NUMBER: BMCE-21-011

DRAWING NO: C1.8