ROLLING MEADOWS ESTATES DRAINAGE STUDY

Parkland County

Final Report

May 2025

Corporate Authorization

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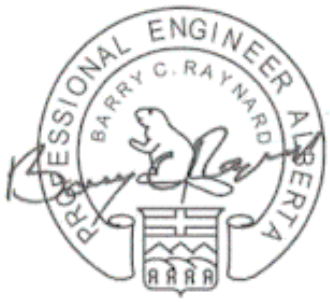

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1.0 Introduction

Rolling Meadows Estates is a country residential subdivision that was developed in the 1970's. It is located north of Highway 16 near Spruce Grove and immediately south of the Atim Creek floodplain.

Rolling Meadows has a history of flooding issues since it was developed. The flooding complaints are reported by residents to both County administration and elected officials.

In response to the on-going flooding issues at Rolling Meadows, Parkland County engaged ISL Engineering and Land Services to undertake a drainage study. The study was authorized on October 9, 2024.

1.1 Scope of Study

The scope of work for this study included stakeholder engagement, hydrologic and hydraulic analyses, review of historical flooding, field survey, and development of potential solutions to address flooding. It is noted that the study focuses on surface water and specifically excludes groundwater. The need for a detailed hydrogeological (groundwater) study is addressed later in this report.

1.2 Existing Topography and Drainage

There are multiple rural watercourses that drain through Rolling Meadows to Atim Creek, including two significant catchment areas from the City of Spruce Grove. The total drainage area currently draining to Rolling Meadows is shown in **Figure 1.1.** It includes approximately 830 hectares (ha) of undeveloped lands within and south of Spruce Grove, about 400 ha of urban development within Spruce Grove, about 375 ha of rural lands (primarily undeveloped) downstream of Spruce Grove, and the 60 ha of country residential development within Rolling Meadows.

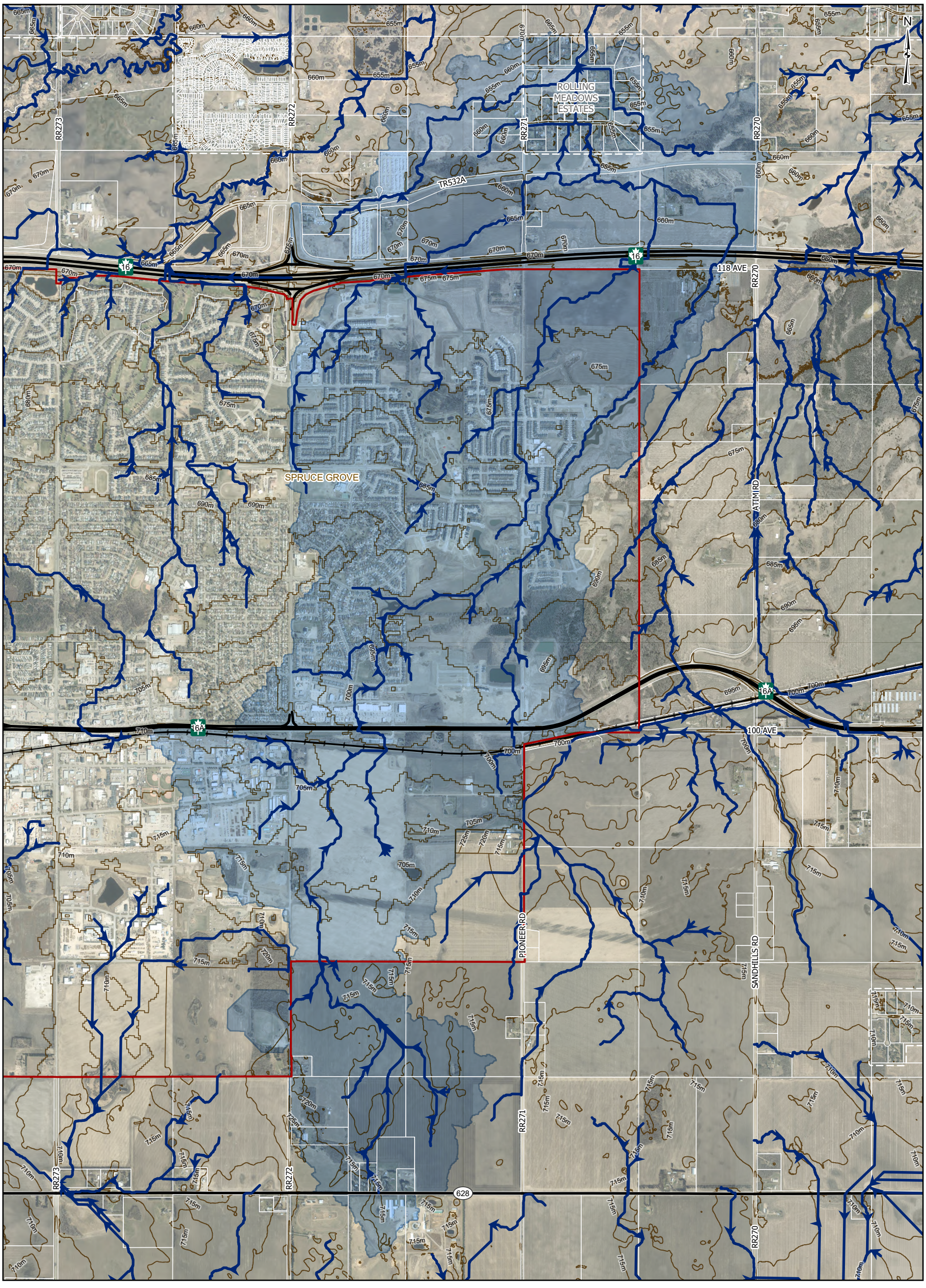
There are five watercourses draining to Rolling Meadows:

1. Watercourses draining Kenton Outfall from Spruce Grove across agricultural lands before crossing Range Road 271, entering Rolling Meadows from the west
2. A local rural watercourse that crosses Range Road 271 north of Township Road 532A, entering Rolling Meadows from the west
3. A local rural catchment that crosses Township Road 532A east of Range Road 271 before entering Rolling Meadows from the south

4. A large watercourse that drains the eastern part of Spruce Grove (Prescott Outfall, also includes County lands south of Spruce Grove), as well as local agricultural lands downstream of Spruce Grove, that crosses Township Road 532A before entering Rolling Meadows from the south
5. A local watercourse draining agricultural lands east of Rolling Meadows and entering Rolling Meadows from the east

These five watercourses merge within Rolling Meadows and discharge to Atim Creek wetland complex at the north end of the subdivision. It is noted that the Atim Creek wetland complex extends south to include the north edge of Rolling Meadows. The local Rolling Meadows drainage system is shown in **Figure 1.2**. The culvert locations shown in Figure 1.2 are approximate. The watercourse outlet to Atim Creek is about 3 km upstream of Highway 44 and approximately 6 km upstream of Big Lake.

The drainage basin extends from an elevation of about 720 m south of Spruce Grove to approximately 653 m at the north end of Rolling Meadows. Most of Rolling Meadows have elevations of between 658 m and 653 m. There is a central Municipal Reserve within Rolling Meadows. Most of this Municipal Reserve is below 653.5 m and has never been developed for recreational use, presumably due to the frequency of flooding.



LEGEND

- Modelled Drainage Path
- Contour (5m)
- Provincial Highway
- Rolling Meadows Drainage Area (1647.7 ha)
- Municipal Boundary
- Subdivisions
- Parcels

TITLE

ROLLING MEADOWS ESTATES DRAINAGE AREA

PROJECT

ROLLING MEADOWS DRAINAGE STUDY

PROJECTION

NAD 1983 CSRS 10TM AEP Resource

DATA SOURCES

Topographic Map:Parkland County, Maxar

0 0.25 0.5
1:26,000 KM

parkland county

FIGURE	1.1
DATE	5/2/2025
PROJECT NO.	16177
AUTHOR	jlalonde-bester

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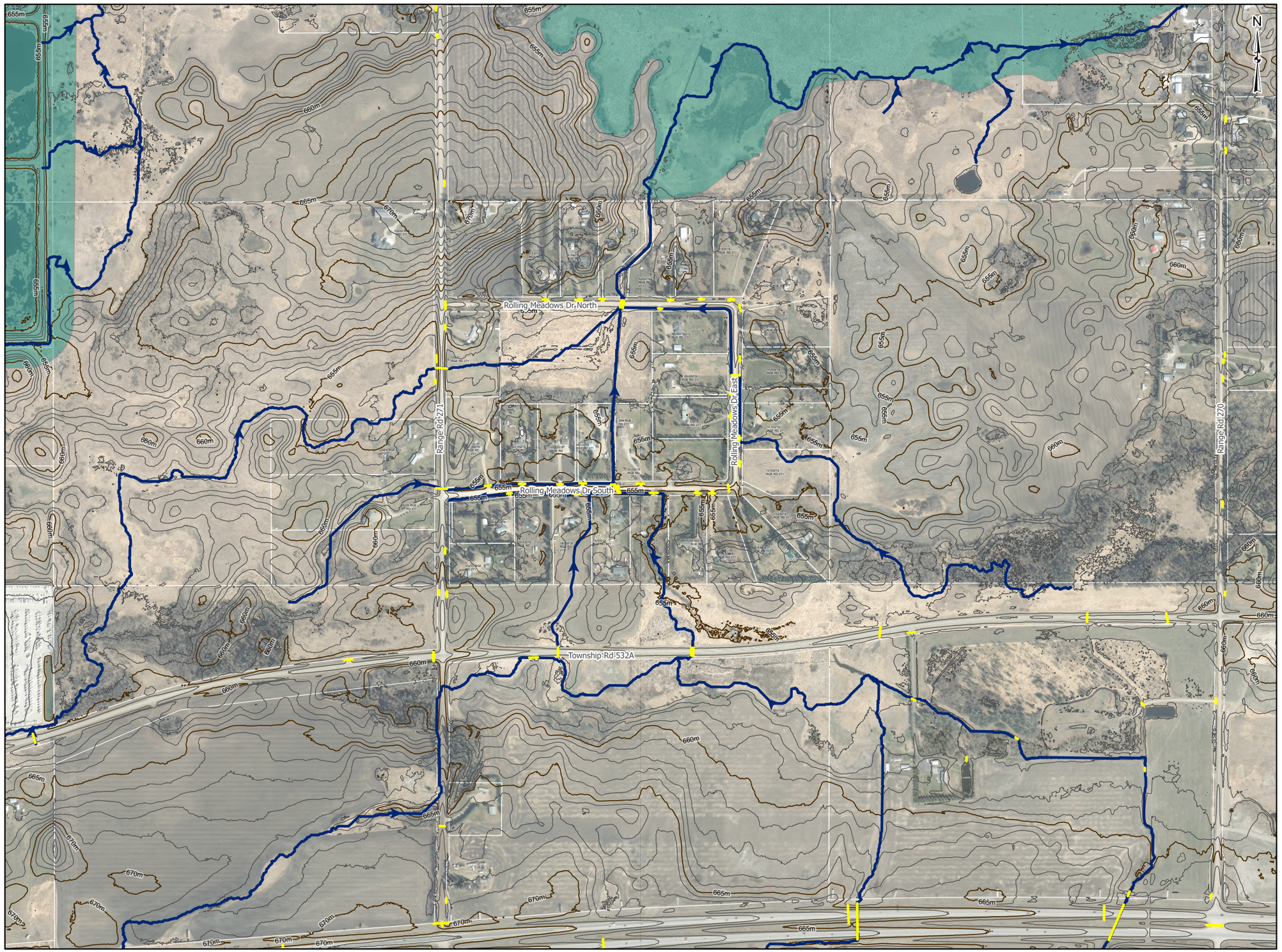


LEGEND

- Contour (1m)
- Contour (5m)
- Culvert
- Modelled Drainage Paths
- Parcels
- Atim Creek ESA

TITLE

ROLLING MEADOWS ESTATES EXISTING DRAINAGE AND TOPOGRAPHY

PROJECT

ROLLING MEADOWS DRAINAGE STUDY

NOTES

- Existing stormwater management facility GIS data is known to contain some future planned stormwater management facility data.

DATA SOURCES

- Topographic Map: Parkland County, Maxar Parkland County, IHS, Government of Canada

PROJECTION

NAD 1983 CSRS 3TM 114

0 80 160

1:8,000 Meters

parkland county

FIGURE	1.2
DATE	5/2/2025
PROJECT NO.	16177
AUTHOR	jlalonde-bester

Document: C:\Users\jlalonde-bester\OneDrive - ISL Engineering and Land Services\Documents\ArcGIS\Projects\MyProject10\MyProject10.aprx - Figure 1.2_Topography

1.3 Rolling Meadows Estates Development

Prior to the development of Rolling Meadows in the 1970's, the quarter-section was used for agriculture. Air photography of the quarter section from 1965 to 1992 was obtained to observe the changes in land use prior to, during and following development. These photographs are attached in **Appendix A** with the current property lines overlain for reference purposes. The 1965 air photo is shown below.

Rolling Meadows 1965 with future lots shown for reference purposes

The 1965 and 1970 photos illustrate the impact of the existing watercourses had on agricultural operations prior to development. It is also noted that a large wetland area exists at the location of the central Municipal Reserve parcel.

To facilitate development, the watercourses (and wetlands) were realigned. It also appears that some of the original wetlands were drained as part of development. The subdivision itself was developed between 1970 and 1978, although some lots were not built on until after 1992. It is also noted that Lot 12 is still not developed.

1.4 Background Documents

The background documents and materials used for this study are listed in **Table 1.1** below, along with the relevant information obtained from each.

Table 1.1 Summary of Background Documents

Background Document	Relevant Information
St. Albert Flood Hazard Study – Sturgeon River, Matrix Solutions Inc, 2022	• Hydraulic modeling included Big Lake and Sturgeon River through St. Albert to Highway 37 • Floodplain mapping extended upstream to Atim Creek at Highway 44 • Study included a Big Lake water level frequency analysis • It appears that the floodplain mapping for Atim Creek east of Highway 44 was based on the Big Lake water level, with no water level differential between Highway 44 and Big Lake. As the 100-Year floodplain is approximately 1 km wide in this area, the assumption is considered reasonable
Parkland County Environmental Conservation Master Plan – Phase 1 Background Technical Report, O2 Planning + Design, 2014	• Description of Atim Creek ESA • Map of Atim Creek ESA north of Rolling Meadows
Atim Creek North Area Structure Plan (2002)	• Land use planning context
Parkland County Stormwater Master Plan (2023)	• GIS photo, LIDAR, legal and culvert data • Modeled drainage paths
Spruce Grove Stormwater Master Plan (2024)	• Existing drainage basins contributing to Rolling Meadows • Future drainage basins contributing to Rolling Meadows • PCSWMM model
Rolling Meadows Estates Water Management Project (Samide Engineering, 1997).	• Design report and drawings for watercourses draining to Lots 17 and 19, including culvert and ditch designs.
Range Road 271 Upgrading, Parkland County, 1986	• Culvert size for RR 271 crossing at Rolling Meadows Drive South

2.0 Reported Flooding Issues

2.1 Recorded Drainage Flooding Complaints

The County's Roadway Maintenance and Drainage is responsible for responding to drainage complaints. They keep a database of complaints based on location and type of complaint. The drainage complaints from Rolling Meadows from 2017 to 2022 were collected, reviewed and sorted to include only flood related issues. The timing of the complaints was noted to help assess whether it was related to spring runoff (snowmelt) or summer rainfall.

The timing, description and reported causes of flooding as reported to the County from 2017 to 2022 is summarized in **Table 2.1** below.

Table 2.1 Summary of Historic Flooding Complaints 2017-2022

Date	Flooding Description	Reported Cause
June 2017	• Excessive water draining into Rolling Meadows from the south	• Upstream runoff
April 2018	• Water flooding ditches	• Frozen culvert
March 2019	• Flooding private lots along Range Road 271	• Blockage of RR 271 culvert
July – August 2019	• Several approach culverts are partially plugged • Excessive water in east roadway ditches	• Possible ditch diversion by residents • Large flow from farmland to the east • Saturated soil conditions • Lack of flow in downstream ditch
April 2020	• flooding of low-lying areas on private property • water close to flowing over roadway	• Spring runoff event • Frozen culverts • Downstream constraints
May 2021	• Flooding private lots	• Culvert blocked
February - March 2022	• Flooding of private lots including driveway	• Large culverts almost full of ice

2.2 November 2024 Open House

An open house was hosted by Parkland County on November 20, 2024, at Kiwi Nurseries, which is approximately 1 km southeast of Rolling Meadows. A brief What We Heard report is attached in **Appendix B**. Attendees were given a questionnaire to fill out to help the project team better understand the flooding issues and how they have impacted residents. **Table 2.2** below summarizes the questionnaire responses.

Table 2.2 Summary of Open House Questionnaire Responses

Item	Resident's Responses
Flooding Description	• Spring runoff and heavy rainfall • Water ponding on lot for extended time • Ditches not draining
Impacts on Residents	• Tree and grass loss • Septic field damage • Land settlement • Damage to home • Damage to driveway
Factors	• Lack of ditch maintenance • Ditches not adequate • Increased runoff from Spruce Grove • Frozen culverts not thawed in time • Farmer installed crossing to north • Saturated ground

2.3 Other Reported Flooding Concerns

A representative of Rolling Meadows made a presentation to County management and County Council prior to this study. The key concerns that were highlighted are summarized below.

- Direct relationship between precipitation, snowmelt, stagnant water and recharge of alluvial aquifer in the subdivision
- Failure of private sewer systems due to groundwater infiltration
- Severe flooding in 1996 impacted roads, basements and private sewer systems.

Photographs of recent flood events were provided to the County. These photographs are attached in **Appendix C** and include locations and dates. High water level (HWL) elevations were estimated for each photo based on detailed topographic mapping at each location.

It is also noted that the County has heard from several residents over the years who have added fill to low areas on their lot to mitigate flooding on their private property.

3.0 Hydrologic and Hydraulic Analyses

3.1 Atim Creek Tailwater Conditions

3.1.1 Sturgeon River Flood Hazard Study

The tailwater conditions in Atim Creek immediately north of Rolling Meadows were estimated based on the information available at the time of this study. The most relevant information is from the 2020 St. Albert Flood Hazard Study (Matrix Solutions) conducted for Alberta Environment and Protected Areas. That study included hydraulic analysis of the Sturgeon River from Big Lake to Highway 37. The floodplain mapping was extended upstream to Highway 44, presumably based on the modeling high water level at the mouth of Big Lake to the Sturgeon River.

Atim Creek ESA Immediately north of Rolling Meadows
Source: Parkland County Environmental Conservation Master Plan, O2 Planning + Design, 2014

The computed high water level in Big Lake (and presumably Atim Creek at Highway 44) from the 2020 St. Albert Flood Hazard Study is shown in **Table 3.1** below. It is noted that this study used a flow frequency analysis approach and not a rainfall frequency analysis.

Table 3.1 Computed High Water Level Frequency at Highway 44 / Big Lake

Flood Return Period	Water Surface Elevation (m)
2-Year	651.37
5-Year	651.92
10-Year	652.28
20-Year	652.58
100-Year	653.29
1,000-Year	654.45

Source: Table 4, St. Albert Flood Hazard Study, Matrix Solutions Inc,, 2020
Note: Cross-section 2 is shown in this table. It is described as upstream model boundary and may be at the mouth of Big Lake entering Sturgeon River in St. Albert. It is assumed that the difference in water level between Highway 44 and St. Albert would be very small.

3.1.2 Atim Creek Tailwater Analysis

Two hydrologic conditions for backwater from Atim Creek / Big Lake were considered:

1. Large Big Lake / Sturgeon River flood event, typically due to spring runoff or extended period of rainfall from greater Sturgeon River basin. It is noted that the upper Sturgeon River includes Isle Lake and Lac St. Anne, which impacts its hydrology.
2. Design rainfall event over Spruce Grove and Rolling Meadows, with Big Lake assumed to have a high water level equal to or less than the 2-Year event.

During extreme hydrologic events such as the 100-Year and 1,000-Year events, the water surface elevation at Highway 44 is well above the Atim Creek floodplain wetland surface of about 651.8 m (estimated from County LiDAR), and the floodplain surface is between 500 m and 1 km wide. The Atim Creek wetland surface is approximately 652.7 m, and the floodplain remains at least 500 m as far upstream as RR 271. Thus, it can be expected that there would be minimal drop in the HWL between Rolling Meadows and Highway 44 during these events. Thus, the above 100-Year and 1,000-Year HWL can be assumed to apply to the north end of Rolling Meadows. These HWL will have the following impacts:

- the 1:100 year Big Lake HWL results in flooding of multiple private lots
- the 1:1,000 year Big Lake HWL results in multiple homes being flooded

To assess the impact of extreme rainfall events over the Rolling Meadows watershed, it was assumed that the water level in Atim Creek was at or below the 2-Year HWL of 651.37 m. In this case, the water level in Atim Creek at Highway 44 is below the surrounding wetland elevation of about 651.8 m (estimated based on County LiDAR). The wetland elevation immediately north of Rolling Meadows is about 652.7 m, about 0.9 m higher than at Highway 44. Extrapolating the 2-Year HWL at Highway 44 upstream based on the 0.9 m elevation difference results in a water surface elevation of 652.27 m. This was compared to the following:

- water surface elevation in the channel north of Rolling Meadows in the County photo base of 652.6 m,
- surveyed top of ice elevation in December 2024 of 652.3 m, and
- Atim Creek wetland elevation of 652.7 m immediately north of Rolling Meadows.

Based on the above, an Atim Creek tailwater elevation of 652.7 m was selected for the hydraulic analysis.

3.2 Hydrologic / Hydraulic Model Set Up

A PCSWMM™ model was developed for the Rolling Meadows drainage system. To incorporate the existing upstream drainage area, the PCSWMM model developed for the City of Spruce Grove Stormwater Master Plan was utilized. The PCSWMM model was expanded to include larger catchment areas between Spruce Grove and Rolling Meadows, as well as smaller catchments within Rolling Meadows.

Figure 3.1 shows the catchment areas downstream of Spruce Grove. The key catchment areas downstream of Spruce Grove and upstream of Rolling Meadows are described below.

Key Catchment Areas Downstream of Spruce Grove:

- Kenton Outfall drains about 214 ha of Spruce Grove immediately south of Highway 16 and east of Century Road / RR 272. It discharges to TWP 532A ditches, then to a wetland north of 532A and eventually to RR 271 through local catchment "S6". The RR 271 culvert was upgraded to 900 mm as part of the Kenton Outfall construction.
- "S2" is a rural catchment north and south of 532A that crosses RR 271 immediately north of Rolling Meadows Drive South. The upstream part of this catchment shares the wetland complex with "S6" above and may be hydraulically connected. However, the County LiDAR shows this as a separate catchment. The RR 271 culvert is partially embedded on the east side of RR 271.
- "S5" drains land immediately north of Highway 16 west of RR271 and extends northeast crossing RR 271 and TWP 532A before entering Rolling Meadows at Lot 19.

- "S3-1" is a large rural catchment between Highway 16 and Rolling Meadows, generally between RR 270 and 271. It's drainage system accepts flows from the Prescott Outfall in Spruce Grove and "S3-2" in the County south of Highway 16 and west of RR 270. It drains into Rolling Meadows through Lot 17.
- "S3-2" is about 38 ha in the County and drains 910 ha of upstream area in Spruce Grove and Parkland County south of Highway 16A (refer to Figure 1.2 drainage basin)
- "S4" is a large rural catchment area east and southeast of Rolling Meadows that is north of Highway 16 and west of RR 270. It drains to a wetland on the east edge of Lot 12 in Rolling Meadows
- "S7" is a small rural catchment east of Rolling Meadows that drains towards Lots 8 and 9.

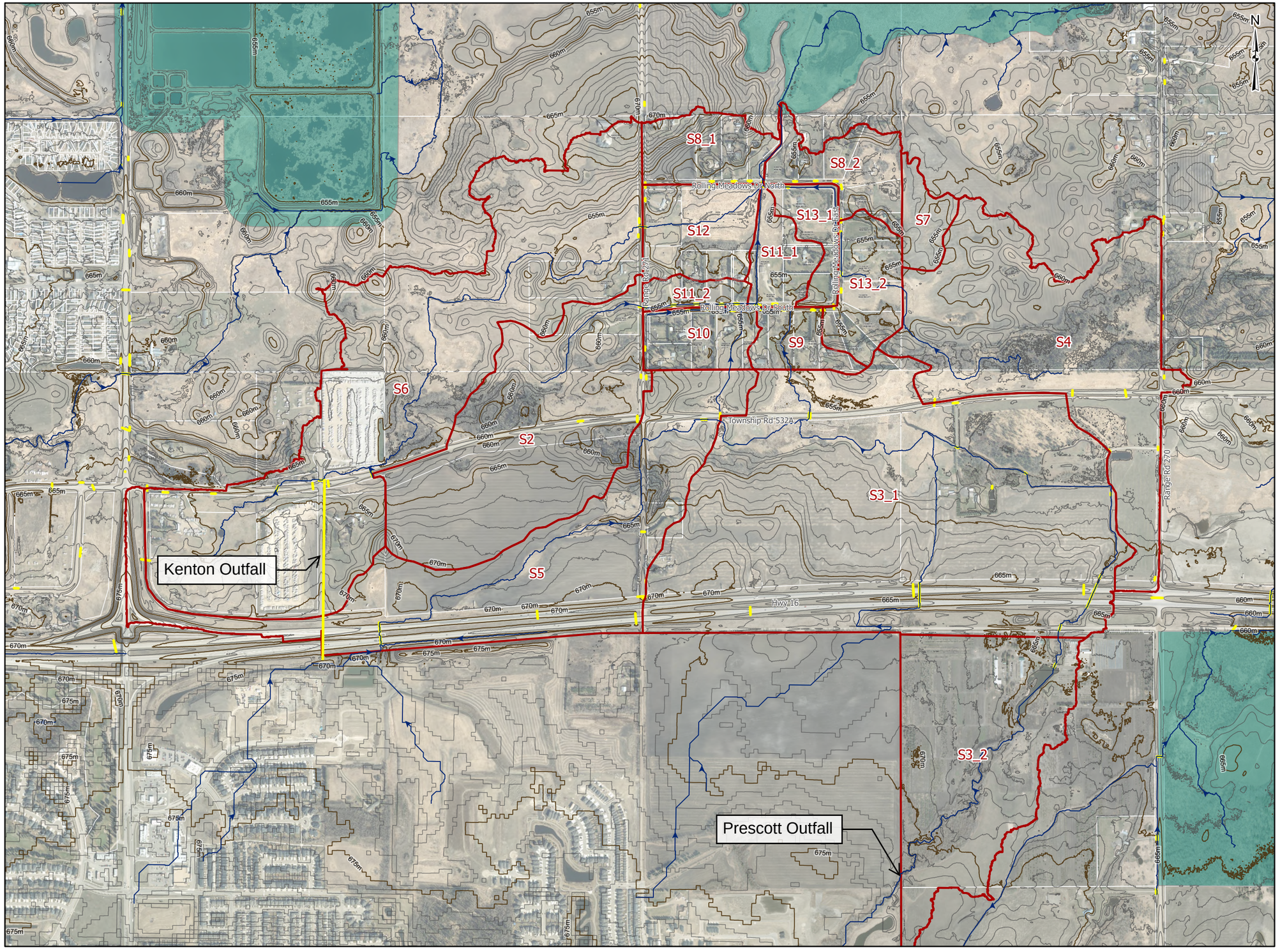
Drainage Ditch from Kenton Outfall west of RR 271

The local catchments within Rolling Meadows are also shown in **Figure 3.1**. This figure includes topographic contours to help define catchment boundaries.

The hydraulic model downstream of Spruce Grove is shown in **Figure 3.2**. This includes the natural drainage paths and constructed ditches, as well as detailed culvert information (culvert sizes are visible when zoomed in). The elements within Spruce Grove were obtained from the Spruce Grove Storm Master Plan PCSWMM model and refined as needed. Runoff from the City of Spruce Grove was routed through the City's existing stormwater management facilities with discharges controlled based on each SWMF's control structures. The maximum allowable discharge rate for most of Spruce Grove's SWMF is 2.5 L/s/ha. The resulting hydrographs were used as input to the current model. It is noted that the existing system model included an additional 5 quarter sections (more or less) of land south of Highway 16A that has the potential to drain through the City of Spruce Grove drainage system, refer to Figure 1.1. This area was included in the City of Spruce Grove ultimate stormwater service area as noted below.

The future system model was based on the ultimate development in Spruce Grove and assumed future development of the upstream lands within Parkland County to Highway 628. These future City of Spruce Grove flows were then used as inputs to the future system model.

The watercourse / ditch profiles and cross-sections downstream of the City of Spruce Grove were developed from the County's LiDAR surface. This includes watercourses upstream of Rolling Meadows and ditches within the subdivision. Key ditch cross-sections were surveyed and compared to the LiDAR surface. The LiDAR generated cross-sections were determined to be adequate for hydraulic modeling.



LEGEND

- Contour (1m)
- Contour (5m)
- Culvert
- Modelled Drainage Paths
- Catchment Areas
- Parcels
- Atim Creek ESA

TITLE

ROLLING MEADOWS ESTATES CATCHMENT AREAS DOWNSTREAM OF SPRUCE GROVE

PROJECT

ROLLING MEADOWS DRAINAGE STUDY

NOTES

- Existing stormwater management facility GIS data is known to contain some future planned stormwater management facility data.

DATA SOURCES

- Topographic Map: Parkland County, Maxar Parkland County, IHS, Government of Canada

PROJECTION

NAD 1983 CSRS 3TM 114

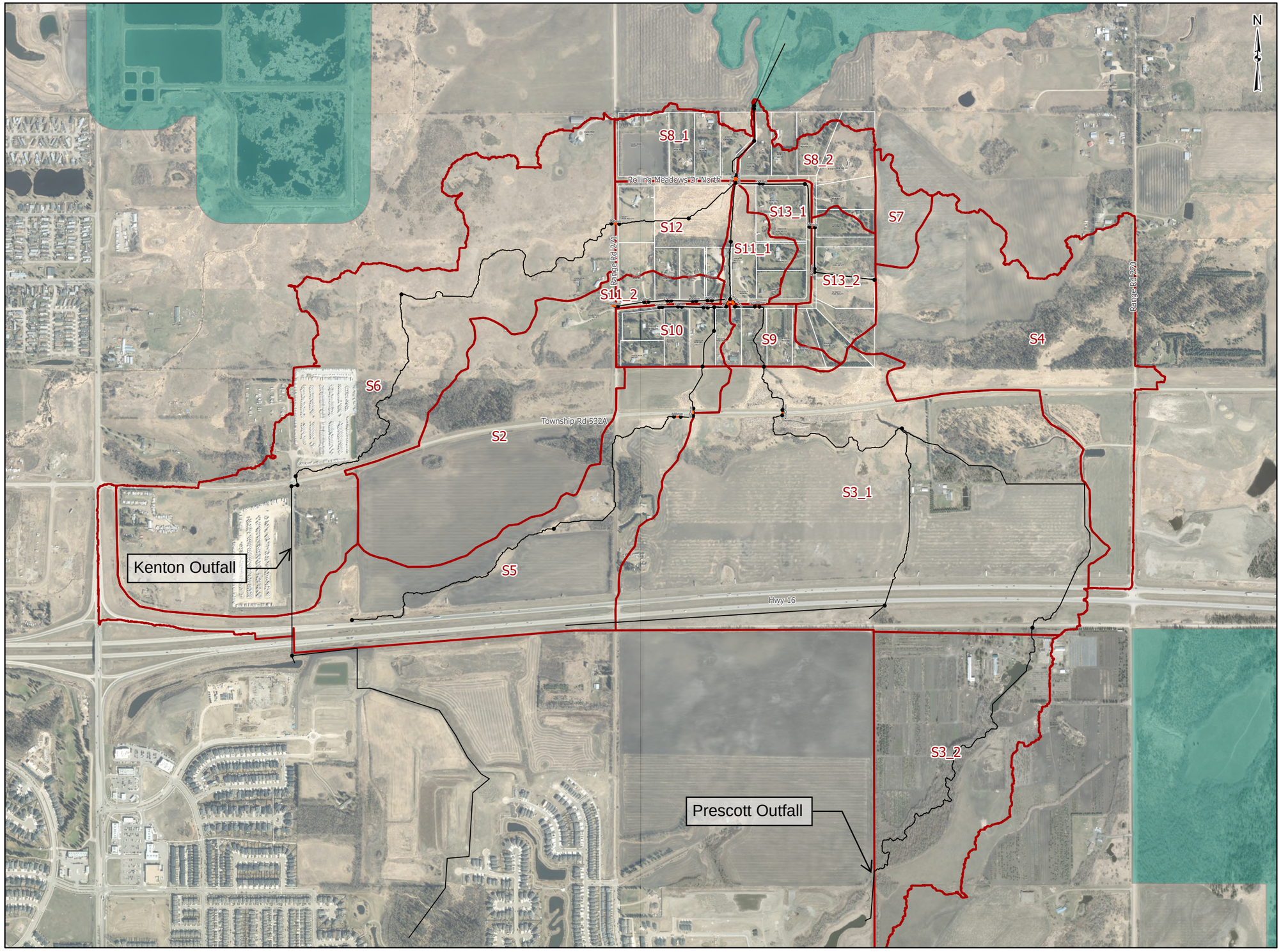
0 120 240

1:12,000 Meters

parkland county

FIGURE	3.1
DATE	5/2/2025
PROJECT NO.	16177
AUTHOR	jlalonde-bester

Document: C:\Users\jlalonde-bester\OneDrive - ISL Engineering and Land Services\Documents\ArcGIS\Projects\MyProject10\MyProject10.aprx - Figure 3.1_RM_Catchment_Areas



N

LEGEND

- Nodes
- Conduits
- Culverts
- Catchment Areas
- Parcels
- Atim Creek ESA

TITLE

ROLLING MEADOWS ESTATES HYDRAULIC MODEL

PROJECT

ROLLING MEADOWS DRAINAGE STUDY

NOTES

- Existing stormwater management facility GIS data is known to contain some future planned stormwater management facility data.

DATA SOURCES

- Topographic Map: Parkland County, Maxar Parkland County, IHS, Government of Canada

PROJECTION

NAD 1983 CSRS 3TM 114

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parkland county

FIGURE	3.2
DATE	5/2/2025
PROJECT NO.	16177
AUTHOR	jlalonde-bester

Document: C:\Users\jlalonde-bester\OneDrive - ISL Engineering and Land Services\Documents\ArcGIS\Projects\MyProject10\MyProject10.aprx - Figure 3.2_Hydraulic Model

The culvert data was interpreted from the Parkland County Stormwater Master Plan GIS database. The default culvert information is based on the adjacent ground elevations in the LiDAR model. The relevant Highway 16, RR 271, and TWP 532A culverts were surveyed in December 2024 and verified in March 2025. The RR 271 culvert was compared to the design drawings for the Kenton Outfall (IBI Group, 2015) and confirmed. The diameters of the remaining major culverts were compared to and the Rolling Meadows Estates Water Management Project report (Samide Engineering, 1997). It is understood that this water management project was completed in 1997-98, which included major upgrades to the culverts draining S5 and S3-1 at Rolling Meadows Drive South and Rolling Meadows Drive North. Minor discrepancies were noted between the proposed culvert sizes in the Samide report and that measured in the field.

The key culvert conveying offsite drainage are listed in **Table 3.2** below:

Table 3.2 Key Culverts Conveying Off-site Drainage

Location	Culvert Size(s)
RR 271	900 mm
Rolling Meadows Drive South – West Centerline (from Lot 19)	900 mm
Rolling Meadows Drive South – East Centerline (from Lot 17)	2- 1600 mm
Rolling Meadows Drive South – East – Lot 17 Driveway	2-1600 mm
Rolling Meadows Drive South	2-1600 mm & 1-1000 mm

Lot 17 Driveway Culverts

3.3 Existing System Modeling Results

The existing stormwater drainage system was simulated with a 1:100 year, 24 hour rainfall event over the entire drainage basin. The existing system modeling results are shown in **Figure 3.3**, and include the following:

- Maximum simulated high water level (HWL) upstream and downstream of key culverts
- Peak flows through key culverts and ditches

The following observations are made:

- The flows from the Prescott Outfall through Lot 17 are the largest off-site flows through Rolling Meadows at 4.7 m^3/s
- The flows from the Kenton Outfall through the RR 271 culvert are relatively large at 1.4 m^3/s
- The flows from southwest of Rolling Meadows through Lot 19 (Catchment S5) are significant at 0.9 m^3/s
- The flows from southwest of Rolling Meadows (Catchment S2) are significant at 0.5 m^3/s, but the flows crossing RR 271 at Rolling Meadows Drive South are not significant, due to the embedded culvert.
- The flows from east of Rolling Meadows approaching the wetland along the east edge of Lot 12 are 0.8 m^3/s, however these flows are reduced as they pass through Lot 12. These flows are significant, especially given that this lot does not have a drainage channel. The downstream peak flows decrease, indicating storage on private lots and roadway ditches.
- As expected, the total flows crossing Rolling Meadows Drive North are very large at 7.3 m^3/s.

Two scenarios were modeled, one with the existing farm crossing in place, and one with the farm crossing removed. (Note: as the number and size of culverts was unknown during modeling, a sensitivity analysis was carried out, refer to Section 3.5). The modeling results were similar for both scenarios except for the maximum simulated HWL at Rolling Meadows Drive North. With the downstream farm crossing in place, the maximum HWL downstream of the three culverts is 653.01 m, while the upstream HWL is 653.08 m. It is interesting to note that these culverts are not surcharged, with the HWL just below the culvert obverts. It is noted that most of the peak flows is diverted around the farm crossing overland, which results in a HWL being about 0.3 m higher due to this crossing.

For the scenario with the farm crossing removed, the downstream HWL is noticeably lower at 652.74 m (compared to 653.01 m), while the upstream HWL is only slightly lower at 653.03 m(with the farm crossing removed (compared to 653.08 m). The reason for this appears to be that the upstream ends of these culverts are higher than the downstream ends, and they are only partially full during peak flow conditions. Thus, the inlet geometry of these culverts restricts the flows, requiring higher backwater conditions to convey the peak flows of 7.3 m^3/s irrespective of the tailwater conditions.

652.7m

Number and size of culverts unknown at the time of modeling. Sensitivity analysis conducted for a range of culvert sizes.

N

53232 RGE RD 271

53231 RGE RD 271

2-53219 RGE RD 271

3-53219 RGE RD 271

4-53219 RGE RD 271

5-53219 RGE RD 271

6-53219 RGE RD 271

7-53219 RGE RD 271

8-53219 RGE RD 271

9-53219 RGE RD 271

10-53219 RGE RD 271

11-53219 RGE RD 271

12-53219 RGE RD 271

13-53219 RGE RD 271

14-53219 RGE RD 271

15-53219 RGE RD 271

16-53219 RGE RD 271

17-53219 RGE RD 271

18-53219 RGE RD 271

19-53219 RGE RD 271

20-53219 RGE RD 271

20A-53219 RGE RD 271

21-53219 RGE RD 271

22-53219 RGE RD 271

23-53219 RGE RD 271

24-53219 RGE RD 271

25-53219 RGE RD 271

25A RGE RD 271

26-53219 RGE RD 271

27-53219 RGE RD 271

28-53219 RGE RD 271

29-53219 RGE RD 271

53224 RGE RD 271

53227 RGE RD 271

53217 RGE RD 271

653.0m
652.7m

653.2m

653.2m

653.5m

653.3m

654.6m

653.6m

654.8m

654.4m

654.3m

653.9m

655m

656.5m

654.5m

655.1m

Rolling Meadows Dr North

Rolling Meadows Dr South

Range Rd 271

Rolling Meadows Dr East

7.2 m3/s

0.2 m3/s

1.4 m3/s

0.2 m3/s

2.7 m3/s

5.7 m3/s

0.2 m3/s

0.4 m3/s

0.8 m3/s

0.06 m3/s

0.1 m3/s

0.1 m3/s

0.1 m3/s

0.1 m3/s

1.1 m3/s

1.3 m3/s

1.7 m3/s

4.7 m3/s

4.7 m3/s

0.9 m3/s

Culvert is embedded 80% in model

LEGEND

- Nodes
- Culverts
- Conduits
- Parcels
- Contour (0.2m)
- Contour (1m)
- ## m / ## m — HWL with d/s farm crossing / HWL without d/s farm crossing
- ## m3/s — Peak Flow in Culvert

TITLE

ROLLING MEADOWS ESTATES EXISTING SYSTEM RESULTS

PROJECT

ROLLING MEADOWS DRAINAGE STUDY

NOTES

- Existing stormwater management facility GIS data is known to contain some future planned stormwater management facility data.

DATA SOURCES

- Topographic Map: Parkland County Parkland County, IHS, Government of Canada

PROJECTION

NAD 1983 CSRS 3TM 114

0 30 60

1:3,500 Meters

parkland county

FIGURE	3.3
DATE	4/8/2025
PROJECT NO.	16177
AUTHOR	jlalonde-bester

Document: C:\Users\jlalonde-bester\OneDrive - ISL Engineering and Land Services\Documents\ArcGIS\Projects\MyProject10\MyProject10.aprx - Figure 3.3_Existing_System_Results

3.4 Comparison to Observed Flooding

The 1:100 year, 24 hour rainfall event modeling results were compared to the reported flooding information, historical flooding photographs, and detailed topographic mapping. The photographs of historical flooding are attached in Appendix C. Detailed topographic mapping was used to estimate the associated high water levels.

Comparing the 1:100 year, 24 hour rainfall modeling results with the observed historical high water levels, the following observations are made:

- Lot 4 – the observed HWL is approximately 653.2 m, while the modeled 1:100 year rainfall HWL is about 653.0 m; this is heavily influenced by the assumed tailwater level and the impact of the farm crossing
- Lot 10 – the reported HWL (no photo, mapping provided by homeowner) is about 653.5 m, while the modeling 1:100 year rainfall HWL is 653.6 m
- Lot 23 – the observed HWL is about 654.5, while the modeled 1:100 year rainfall HWL is 654.4; the modeled HWL is very dependent on the RR 271 culvert parameters (much higher HWL if culvert only partially embedded)

Based on these and similar reported findings, the 1:100 year rainfall simulation provides a reasonable proxy for the historic flooding events, including spring runoff. The model is capable of showing critical "bottlenecks" in the drainage system. However, there is uncertainty in the impact of the downstream Atim Creek tailwater and the farm crossing immediately north of Rolling Meadows.

Figure 3.4 shows the estimated flooding locations based on a combination of reported flooding by residents during the November 2024 open house and the hydraulic modeling analysis.

LEGEND

- Contour (0.2m)
- Contour (1m)
- Estimated Flooding Areas
- Parcels
- Atim Creek ESA

Based on hydraulic modeling and review of flooding photographs provided by residents

TITLE

ROLLING MEADOWS ESTATES ESTIMATED FLOODING LOCATIONS

PROJECT

ROLLING MEADOWS DRAINAGE STUDY

NOTES

- Existing stormwater management facility GIS data is known to contain some future planned stormwater management facility data.

DATA SOURCES

- Topographic Map: Parkland County Parkland County, IHS, Government of Canada

PROJECTION

NAD 1983 CSRS 3TM 114

0 30 60

1:3,500 Meters

parkland county

FIGURE	3.4
DATE	5/2/2025
PROJECT NO.	16177
AUTHOR	jlalonde-bester

Document: C:\Users\jlalonde-bester\OneDrive - ISL Engineering and Land Services\Documents\ArcGIS\Projects\MyProject10\MyProject10.aprx - Figure X_Flooding Locations

3.5 Existing System Modeling Observations

As previously mentioned, the existing system model was simulated with the farm crossing in place and with it removed. A sensitivity analysis was also completed for a range of possible culvert sizes at the crossing. The following observations are noted:

- Farm crossing likely impacts HWL at north end of Rolling Meadows. Based on the sensitivity analysis, the HWL north of Rolling Meadows Drive North is approximately 0.3 m higher with the farm crossing in place. If the culvert is small, then stormwater will flow around the crossing at an elevation of about 652.7 m. Thus the upstream HWL does not change substantially if the farm crossing culvert(s) are smaller than assumed. Following completion of the modeling, drone footage was found that shows three culverts. However, the culvert sizes have not been verified.
- Range Road 271 and Township Road 532A both block peak flows from upstream, which is beneficial for Rolling Meadows. It is noted that there is visible wetland vegetation upstream of these culvert crossings and significant upstream areas for stormwater storage.
- The two main watercourses draining Spruce Grove through Rolling Meadows appear to have reasonably adequate capacity – backwater conditions don't encroach onto private property significantly
- The local drainage systems that drain off-site flow from adjacent agricultural lands through Rolling Meadows appear to be undersized at two locations:
    - RR 271 north of Rolling Meadows Drive – Lot 21 to 24 driveway culverts not sized for off-site flows
    - Lot 12 flows from east – no constructed ditch on Lot 12, downstream culverts not sized for off-site flows

4.0 Assessment

Based on a review of the background materials, reported flooding locations, and hydraulic modeling results, the historic flooding in Rolling Meadows is complex. The underlying causes of the historic flooding at Rolling Meadows Estates are multi-faceted and are believed to include the following:

- Elevation of Rolling Meadows relative to Atim Creek ESA and floodplain
- Location of Rolling Meadows within historic watercourses and wetlands
- Farm crossing immediately north of Rolling Meadows
- High groundwater levels
- Local drainage system not designed to accept, manage and discharge off-site flows
- Development of Spruce Grove

These underlying causes, generally sorted in order of priority, are described below.

Elevation of Rolling Meadows relative to Atim Creek ESA and floodplain

The north, northeast and central parts of Rolling Meadows are only marginally above the Atim Creek ESA and floodplain. Unfortunately, the 2020 Sturgeon River Flood Hazard Assessment did not extend upstream (west) of Highway 44, and there has not been a detailed Atim Creek floodplain study immediately north of Rolling Meadows. However, based on the 2020 study, the 100-Year HWL at Rolling Meadows is at least 653.29 m (which is the 100-Year HWL in Big Lake). This HWL will flood multiple private lots at the north end of Rolling Meadows without additional backwater effects. Based on recorded flooding complaints and detailed site topography, it appears that this HWL has been reached (or close to it) multiple times in the past 10 years.

The tailwater conditions in Atim Creek and the upstream channel into Rolling Meadows during spring runoff is not known. The tailwater analyses and hydraulic modeling analysis in Section 3 is based on open water conditions. It is likely that the Atim Creek channel and/or parts of its floodplain will be frozen during early spring runoff while Spruce Grove runoff that has melted first tries to make its way through Rolling Meadows to Atim Creek

It is also expected that runoff from developed areas, including Spruce Grove and Rolling Meadows, could flow downstream and freeze in shaded areas (including culverts). This downstream freezing can result in higher downstream tailwater conditions, thereby exacerbating the upstream flood risk.

The only way to mitigate the downstream tailwater conditions is to ensure that development occurs well above the Atim Creek floodplain elevation. Unfortunately, this was not provided when the Rolling Meadows subdivision was developed and is impractical to correct post development.

Location of Rolling Meadows within historic watercourses and wetlands

As previously noted, almost every lot within Rolling Meadows has either a watercourse, a wetland or both prior to development. The reader is referred to the 1965 and 1970 air photos in Appendix A with the current property lines superimposed on the photos.

In some cases, there is evidence of farming operations through low-lying wet areas, indicating that the watercourses and minor wetlands were likely limited to spring runoff.

Based on current development approval processes, development of the Rolling Meadows quarter section would not be allowed today, at least not in its current form.

Farm Crossing Immediately North of Rolling Meadows

There is a farm crossing located approximately 30m north of Rolling Meadows on the main channel that drains Rolling Meadows plus a large area of upstream Parkland County and Spruce Grove. The farm crossing appears to have been installed between 1978 and 1992 based on the available air photography.

The farm crossing may have been installed in response to changes in the flow patterns in this watercourse due to upstream development. Larger and more frequent flows occurring later in the spring, and during the summer and early fall, may have impacted farming operations. Based on a review of Alberta Environment and Protected Area's website, this farm crossing does not appear to have an approval in place.

Based on a review of the County's aerial imagery, it is presumed that a culvert was installed with the crossing. As it is private property, it could not be inspected during this study and the elevation and diameter of the culvert (and number of culverts) is unknown. It is noted that the County provided drone footage of the farm crossing late in this study that shows three culverts that appear to be between 600 mm and 900 mm diameter. As previously mentioned, a sensitivity analysis was conducted that concluded that the backwater effects from a range in culvert sizes were similar, thus the modeling results are still applicable.

As previously noted, this farm crossing appears to adversely impact the backwater levels in Rolling Meadows north of Rolling Meadows Drive North.

High Groundwater Levels

As previously noted, a formal hydrogeological investigation was not included in the scope of this study. This assessment is based on a review of historical air photos, hydrologic / hydraulic modeling, hydrogeological reports for the nearby Wagnar Natural Area, and anecdotal information provided by residents.

The hydrogeology of the Wagnar Natural Area indicates a recharge area south of Highway 16 and a discharge area within the Wagnar Natural Area. The County has also noted that there are multiple springs immediately north of Highway 16 where the groundwater table intercepts the ground surface. These springs are known to be about 3 km east of Rolling Meadows. Based on similar topography, it is likely that the hydrogeology near Rolling Meadows is similar, and thus several of the wetlands around and within Rolling Meadows are likely influenced by regional groundwater flows.

It is difficult to determine the degree to which increased surface runoff from Spruce Grove is impacting groundwater levels within Rolling Meadows. Urban runoff from Spruce Grove will flow at moderate levels for extended periods of time, thus raising the local groundwater levels along the main ditches running through Rolling Meadows. However, without a detailed hydrogeological study, it is not possible to assess the impacts of these flows on the remainder of Rolling Meadows.

Local drainage system not designed for off-site flows

There are two locations where relatively large offsite areas drain to Rolling Meadows where the local drainage system does not appear to be designed to accommodate them. This includes:

- land east and southeast of Rolling Meadows draining to Lot 12, and
- land southwest of Rolling Medows draining to Range Road 271 at Rolling Meadows Drive South.

These offsite flows result in excessive flows through either private lots (e.g., Lot 12) or local roadway ditches (Rolling Meadows Drive South ditch along Lots 21 to 24). These excessive flows appear to directly correlate with reported flooding at these locations.

Development of Spruce Grove

The development process of converting either agricultural land or natural areas into urban development dramatically changes the hydrology of the area. While the stormwater management facilities control runoff to no more than the 1:100 year pre-development rates, the total volume of runoff is higher. The frequency of lower discharge rates increases, from either more frequent rainfall events or during spring runoff. Also, the timing of runoff changes, with spring runoff from urban areas being discharged earlier than that in rural areas.

As previously noted, hydraulic modeling indicates that the 1:100 year runoff from Spruce Grove can be accommodated by the Rolling Meadows drainage system with the 1998 upgrades to the main culverts. Thus, the current development of Spruce Grove does not appear to cause flooding due to the hydraulic capacity of the existing conveyance system through Rolling Meadows.

However, the development of Spruce Grove may be contributing to flooding in two ways:

- The changes in hydrology may be adversely impacting Rolling Meadows during spring runoff with runoff flowing over frozen ditches and partially frozen culverts. This could then raise the tailwater elevation during periods of freeze / thaw. Unfortunately, it is not possible to confirm this impact without monitoring the flows and ice elevations during spring runoff (possibly multiple spring runoff periods).
- The extended periods of moderate flow through Rolling Meadows may be contributing to higher groundwater levels in Rolling Meadows. Higher groundwater levels decrease the ability of the land to absorb surface water and can further impact the total runoff volumes.

Discussion

The causes of flooding within Rolling Meadows appears to be due to a combination of factors, as described above. Several of these factors which are likely significant contributors to flooding (elevation of Rolling Meadows relative to Atim Creek, historic watercourses / wetlands, high groundwater levels) cannot be changed. However, it may be feasible to minimize the impacts of these factors through drainage system improvements. The other factors can potentially be addressed through surface water improvements.

Flood mitigation options to address the above factors can generally be described as:

- diverting Spruce Grove flows around Rolling Meadows
- removing or upgrading the capacity of the downstream farm crossing, and
- upgrading the local drainage system within Rolling Meadows.

These options are described in detail in the following section.

5.0 Development of Flood Mitigation Options

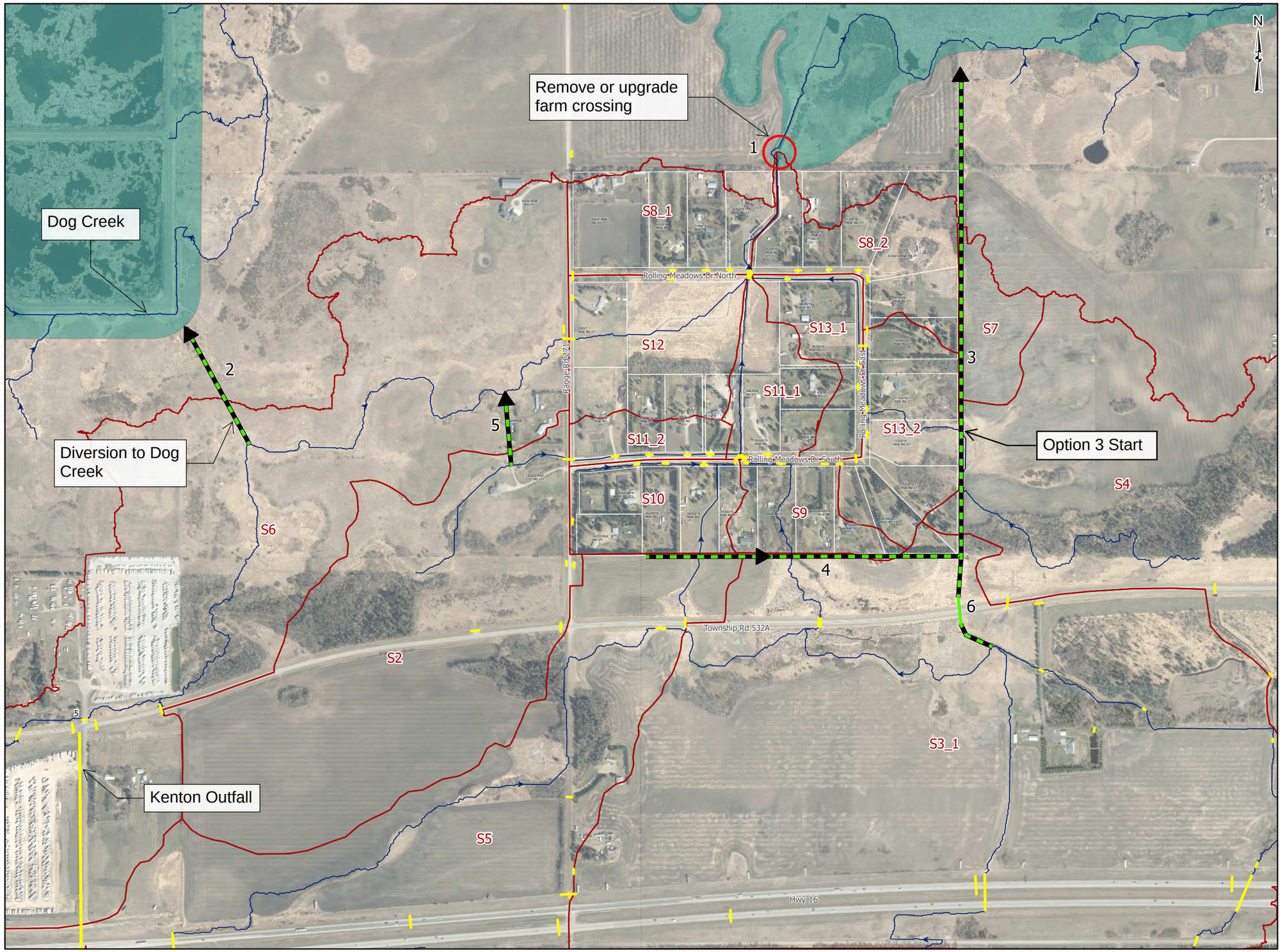
5.1 Introduction

Several flood mitigation options were developed during this study to address the ongoing flooding issues within Rolling Meadows. The offsite flood mitigation options are described in Section 5.2, while the on-site options are described in Section 5.3.

Most options work in tandem with other options. The hydraulic benefits of various combinations of flood mitigation options are discussed in Section 6.0.

5.2 Off-site Flood Mitigation Options

The offsite flood mitigation options are described below and shown in **Figure 5.1**.



LEGEND

- Modelled Drainage Paths
- Culvert
- New Culvert
- New Drainage Ditch
- Parcels
- Catchment Areas
- Atim Creek ESA

TITLE

ROLLING MEADOWS ESTATES OFF-SITE FLOOD MITIGATION OPTIONS

PROJECT

ROLLING MEADOWS DRAINAGE STUDY

NOTES

- Existing stormwater management facility GIS data is known to contain some future planned stormwater management facility data.

DATA SOURCES

- Topographic Map: Parkland County, Maxar Parkland County, IHS, Government of Canada

PROJECTION

NAD 1983 CSRS 3TM 114

0 80 160

1:8,000 Meters

parkland county

FIGURE	5.1
DATE	5/2/2025
PROJECT NO.	16177
AUTHOR	jlalonde-bester

Document: C:\Users\jlalonde-bester\OneDrive - ISL Engineering and Land Services\Documents\ArcGIS\Projects\MyProject10\MyProject10.aprx - Figure 5.1_Off-Site_Flood_Mitigation_Options

Option 1 – Remove Farm Crossing Immediately North of Rolling Meadows

The hydraulic modeling shows that the HWL is approximately 0.3 m higher on the north side of Rolling Meadows Drive North with the farm crossing in place, assuming a culvert between 600 mm and 1500 mm, as compared to no crossing in place. The difference is reduced for areas upstream of the Rolling Meadows Drive North. The approximate 0.3 m impact is based on the estimated tailwater elevation of 652.7 m., and the impact would be greater for lower tailwater elevations and lesser for higher tailwater conditions. It is understood that the County assisted the landowner with the installation of the farm crossing culverts.

As this crossing is adversely affecting the natural drainage system, the County should work with the landowner to either remove this crossing or upgrade the hydraulic capacity of the culverts. As the Atim Creek tailwater elevations adversely impact Rolling Meadows, upgrading of these culverts requires there to be minimal HWL differential across the culverts under high flow conditions. This would likely require multiple large box culverts. Other design options could be investigated at the design phase, such as a large overflow weir set marginally above the creek elevation.

As this option provides benefits to the flood prone lands at the north end of Rolling Meadows with no negative impacts on the County, all other options are based on this hydraulic restriction being removed.

Option 2 – Divert Kenton Outfall Drainage to Dog Creek

This option involves excavating a drainage ditch approximately 50 m long to divert the Kenton Outfall drainage system to Dog Creek. This potential diversion is located about 700 m west of RR 271 and 500 m north of TWP 532A. While the main channels for both watercourses are about 200 m apart, the length of the diversion can be much shorter due to the adjacent wetland connecting to each.

The objective of this diversion is to reduce the peak flow and volume of runoff from Spruce Grove reaching Rolling Meadows. Approximately half of rural catchment S6 and all of the Kenton Outfall flows can be diverted. The remainder of catchment S6 would continue to cross RR 271 and flow through the open space to the culvert crossing at Rolling Meadows Drive North. Hydraulic modeling results indicate that this diversion reduces the peak flows during the 1:100 year rainfall event at RR 271 culvert from 1.4 m^3/s to 0.5 m^3/s. However, due to the large wetland storage area downstream of RR 271, this diversion results in only a 0.2 m drop in the upstream HWL at Rolling Meadows Drive North (from 653.21 m to 653.04 m).

This option has numerous challenges:

- There would be a dramatic reduction in runoff to the wetland complex immediately west of RR271. To minimize this impact, it may be necessary to maintain low flows towards Rolling Meadows with a small diameter culvert as part of the diversion design. Maintaining this diversion is expected to be challenging, especially during spring runoff.
- The diversion would block access for agricultural operations and would presumably require culverts for access.
- The diversion is on private land and would require the landowner to agree to access for both construction and ongoing maintenance.
- The diversion would require approval from Alberta Environment and Protected Areas.
- Construction activities would be in and around existing wetlands and would presumably require monitoring and restoration of the wetlands.

Based on the limited benefit to Rolling Meadows and the numerous implementation challenges, Option 2 is not recommended at this time.

Option 3 – East Diversion Ditch

The East Diversion Ditch is proposed to divert runoff from east of Rolling Meadows from entering the subdivision, specifically Catchments S4 and S7. As previously noted, the peak runoff from the 50 ha Catchment S4 is estimated to be 0.8 m^3/s. This runoff enters Rolling Meadows through Lot 12 and has contributed to flooding of Lot 11 and likely Lots 10, 28 and 29.

This diversion ditch is shown in Figure 5.1 and 5.2 immediately east of Rolling Meadows with in NE13-53-27-4 and extending into SE24-53-27-4. This alignment is proposed to minimize the number of land agreements required. However, it is also feasible to shift the ditch west into Rolling Meadows along the back edge of Lots 8 through 12 if necessary. It is noted that during the open house, several residents mentioned that they were reluctant to give up land as part of a flood mitigation solution.

The East Diversion Ditch will be approximately 600 to 800 m long, starting near the northeast corner of Lot 12 and extending north to the Atim Creek ESA and floodplain. Figure 5.1 shows it being diverted to the east within SE24-53-27-4 to minimize the overall length. The ditch invert would be located at or slightly above the wetland immediately east of Lot 12 to protect the function of the wetland. The design would include a small dyke to block flows from entering Rolling Meadows and force runoff north into the diversion. The width of the ditch depends on whether it is combined with upstream diversions as noted below. However, the bed width is not expected to significantly impact the total excavation requirements, or the land acquisition requirements.

Hydraulic modeling indicates that this diversion successfully reduces the peak flows and flood risk through the east part of Rolling Meadows and should be considered by the County. A design concept for Option 3 and Option 4 is presented in Appendix D.

It is also noted that this diversion will also intercept off-site flows entering Lots 8 and 9 from the east.

Option 4 – South & East Diversion Ditches

Option 4 expands on Option 3 and extends the diversion ditch upstream to intercept the off-site flows entering Rolling Meadows at Lots 17 and 19. As previously noted, the drainage ditch through Lot 17 includes a large part of east Spruce Grove and upstream Parkland County. The watercourse through Lot 19 drains lands north of Spruce Grove. The downstream ditches and culverts were upgraded as part of the Rolling Meadows Water Management Project in 1997-98.

The design concept for this option is similar to Option 3 and the downstream part of the diversion system includes Option 3. The upstream end of Option 4 could be extended west to intercept a small area of off-site drainage to Lot 20 which presumably contributes to flooding on the east side of that lot.

The design concept for Option 4 is also shown in Appendix D.

Option 5 – West Diversion Ditch

Option 5 is similar to Option 2 as it is an off-site diversion on private land west of Rolling Meadows. It would divert water from the S2 catchment to the S6 catchment (Kenton Outfall) to minimize the flows crossing RR 271 at Rolling Meadows Drive South. This would protect the properties on both sides of RR 271, including 53220 RR 271 and Lots 21 to 24 within Rolling Meadows. It could therefore minimize downstream upgrading within Rolling Meadows.

The diversion ditch would be approximately 150 m long and require a maximum excavation depth of about 2 m. It would require acquisition of a drainage easement within two country residential lots, 53220 RR 271 and 53224 RR 271.

It is proposed that this option be compared to the on-site flood mitigation options needed to protect Lots 21 to 24.

Option 6 – South Upstream Diversion Ditch

Option 6 is proposed as an upstream diversion southeast of Rolling Meadows that will, in conjunction with Option 4, minimize flooding of the property south of TWP 532A. The landowner attended the open house and indicated that their property has seen increased flooding with the development of Spruce Grove. This diversion would include either upgrading the TWP 532A crossing (possibly using an existing bridge sized culvert) to convey upstream flows from Spruce Grove through the Option 4 diversion to Atim Creek.

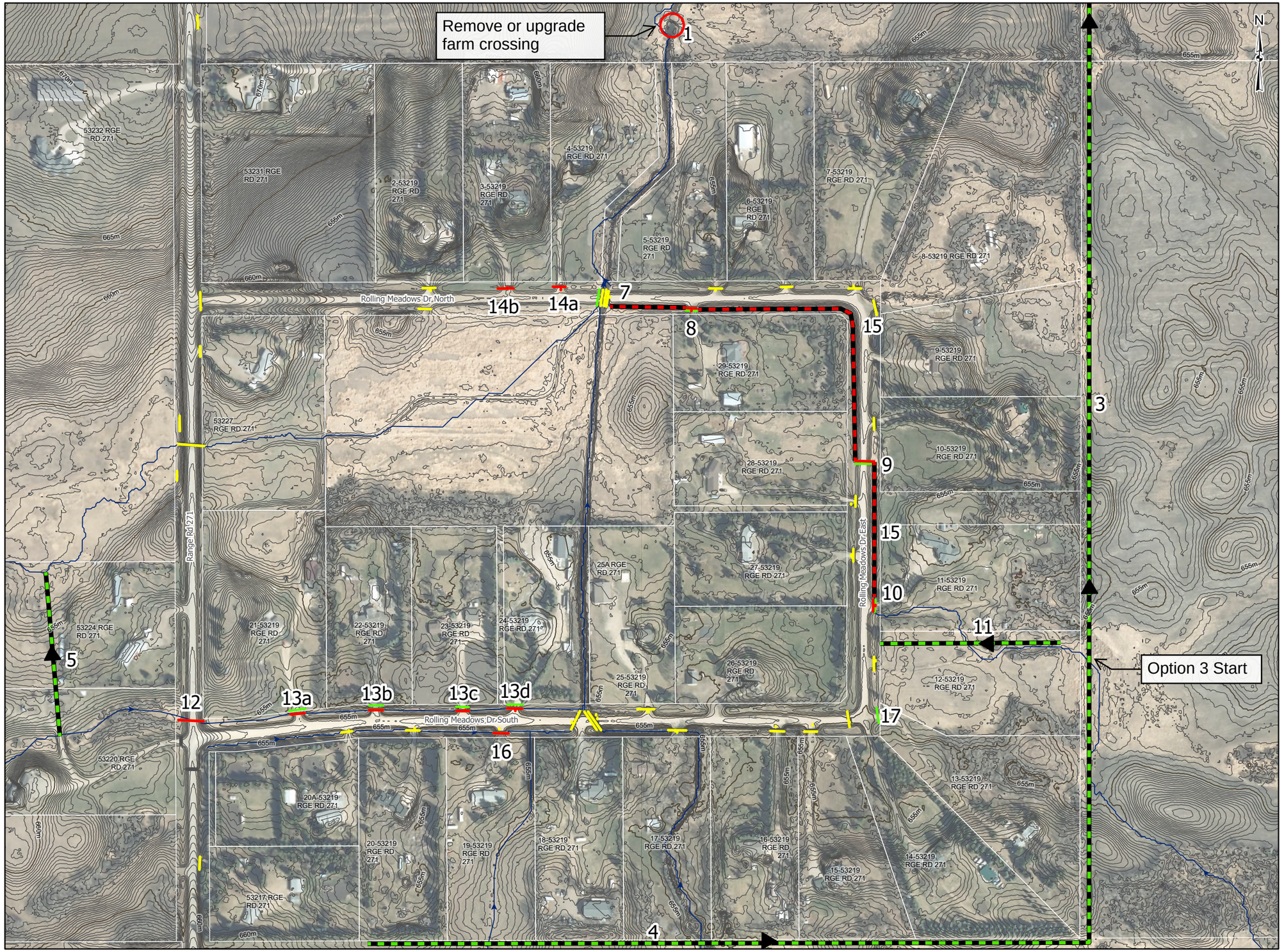
It is suggested that the County consider this option if construction of the South & East Diversion Ditch (Option 4) proceeds. It is noted that there is still significant planned growth in the east and southeast parts of Spruce Grove, and the County could discuss ways to efficiently convey these large flows through the County to Atim Creek with the City of Spruce Grove, including this option. While development will control post-development to pre-development rates, the timing and volume of runoff will change.

Wetland Considerations

Most of the above options have the potential to drain existing wetlands. The design options will need to be refined to maintain existing wetlands to the greatest degree possible. This will require the ditch grade to be at or slightly higher than the wetland. It will also require small dykes to be installed adjacent to the ditches to prevent stormwater from entering Rolling Meadows (Options 3 and 4). Any reduction in functional wetlands area would require the County to pay compensation.

5.3 On-site Flood Mitigation Options

The on-site options are described below and shown in **Figure 5.2**.



TITLE

ROLLING MEADOWS ESTATES ON-SITE FLOOD MITIGATION OPTIONS

PROJECT

ROLLING MEADOWS DRAINAGE STUDY

NOTES

- Existing stormwater management facility GIS data is known to contain some future planned stormwater management facility data.

DATA SOURCES

- Topographic Map: Parkland County Parkland County, IHS, Government of Canada

PROJECTION

NAD 1983 CSRS 3TM 114

0 30 60

1:3,500 Meters

parkland county

FIGURE	5.2
DATE	4/8/2025
PROJECT NO.	16177
AUTHOR	jlalonde-bester

Document: C:\Users\jlalonde-bester\OneDrive - ISL Engineering and Land Services\Documents\ArcGIS\Projects\MyProject10\MyProject10.aprx - Figure 5.2_On-Site_Flood_Mitigation_Options

Option 7 – Upgrade Rolling Meadows Drive North Culverts

Option 7 proposes the installation of an additional culvert at Rolling Meadows Drive North. While there is already one 1000 mm and two 1600 mm culverts, there is still a nominal 0.2 m headloss through these culverts during the 1:100 year event. The rationale for providing additional capacity at this location is the concern with the downstream tailwater conditions, combined with the historic upstream flooding, and the need to minimize any increases in upstream water levels. Also, additional culverts at this location would offset the impact of the existing culverts being partially frozen during spring runoff.

An additional 1500 mm culvert is proposed at this crossing, subject to refinement considering other upstream ditch and culvert upgrading options. A bridge could also be considered as a future design option.

Option 8 – Upgrade Lot 29 Driveway Culvert

Hydraulic modeling indicates that the existing culvert is not adequate, especially if off-site flows continue to enter at Lot 12. Even without these off-site flows, upgrading this culvert and the Rolling Meadows Drive North culvert (Option 7) helps protect Lots 28 and 29.

Option 9 – Upgrade Rolling Meadows Drive East Culvert

Upgrading the Rolling Meadows Drive east culvert is required if off-site flows continue to enter at Lot 12. The existing culvert appears to be adequate to convey the on-site flows.

Option 10 – Upgrade Lot 11 Driveway Culvert

The existing culvert beneath the Lot 11 driveway is not adequate to accommodate off-site flows and will need to be upgraded if these flows continue to enter Rolling Meadows at Lot 12.

Option 11 – Construct Drainage Swale Through Lot 12

The off-site flows enter Lot 12 from the east and have been observed to drain through multiple drainage paths to the Rolling Meadows Drive East roadway ditch. This option incorporates a drainage swale through Lot 12, presumably along the north edge of this lot. This option would need to be combined with Options 7 to 10 above in order to adequately convey these off-site flows. Should Option 3 or 4 be developed, then this swale will not be required.

Option 12 – Restore Range Road 271 Culvert

As previously noted, the existing RR 271 culvert at Rolling Meadows Drive South is not fully functional as the downstream end is approximately 80% embedded. It is not known if this culvert has been modified to minimize off-site flows entering Rolling Meadows and protect Lots 21 to 24.

Downstream end of RR 271 culvert immediately north of Rolling Meadows Drive South

Option 12 is proposed to restore the function of this culvert to protect the lands upstream of RR 271 from flooding. This must be done in conjunction with upgrading the Lot 21 to 24 driveway culverts (Option 13 below).

Option 13 – Upgrade Lot 21 to 24 Driveway Culverts and Ditches

Option 13 includes upgrading the four driveway culverts on the north side of Rolling Meadows Drive to Lots 21 to 24. These upgrades are required to safely convey the off-site flows west of RR 271 to the main ditch on the east side of Lot 24. The need for, and design of, these upgrades is heavily dependent on the condition of the RR 271 culvert (Option 12 above). Hydraulic modeling of the existing (embedded) RR 271 culvert suggests that these driveway culverts may be adequate. However, residents from all four properties have reported flooding in the roadway ditch. Modeling conducted with the RR 271 culvert restored showed large scale flooding of this ditch with HWL that would extend well onto private lots.

It is noted that the Lot 24 driveway culvert is the most important based on the extent of reported flooding immediately upstream of this culvert. Also, the field survey indicated that this culvert is back-graded and may be partially embedded. Thus, it would be beneficial to upgrade this culvert (Option 13d) even if the upstream driveway culverts are not upgraded.

This option also includes minor upgrading of the existing roadway ditch if needed. This should be reviewed at the design stage.

Option 14 – Upgrade Lot 3 and 4 Driveway Culverts

The reported flooding at Lots 3 and 4 suggest that these driveway culverts may have contributed to the upstream flooding. Based on photographs taken during spring runoff, the estimated HWL in Lot 3 and the west part of Lot 4 is slightly higher than the HWL on the east side of the Lot 4 culvert. Residents have also provided photographic evidence of water flowing over the Lot 4 driveway during spring runoff flooding. It is noted that the hydraulic modeling did not include the Lot 3 and 4 driveway culverts.

Upgrading of these culverts is proposed primarily to reduce the risk of upstream flooding during spring runoff conditions when the culverts may be frozen. The invert of these culverts is below the assumed summer tailwater level of 652.7 m. This may require the driveway to be raised to minimize the risk of freezing up during spring runoff.

Option 15 – Upgrade Rolling Meadows Drive North / East Ditches

The design of the roadway ditches downstream of Lot 12 should be reviewed if the off-site flows are allowed to flow into Rolling Meadows at Lot 12. If needed these ditches should be upgraded along with the culvert upgrades (Options 7 to 10). Hydraulic modeling indicates that a local high point in the ditch profile has an adverse impact on the upstream HWL at Lot 28.

Rolling Meadows Drive East looking north towards Lot 29

Option 16 – Review Lot 19 Driveway Culvert

The design of the south ditch on Rolling Meadows Drive South should be reviewed. It appears that the Lot 19 driveway culvert is back-graded, resulting in water ponding in the upstream ditch after each rainfall / snowmelt runoff event.

Option 17 – Install Driveway Culvert at Lot 13

There is a small low area adjacent to the Lot 13 driveway that has resulted in the driveway settling. A new culvert is proposed at this driveway, allowing the low area immediately southwest of the driveway to connect to the main Rolling Meadows Drive East ditch to the north.

5.4 Cost Estimates

Concept level cost estimates for each of the potential flood mitigation options are listed in **Table 5.1** below.

Table 5.1 Concept Level Flood Mitigation Cost Estimates

Option	Description	Notes	Concept Level Cost Estimate
1	Remove or Upgrade Farm Crossing Immediately North of Rolling Meadows	Remove downstream farm crossing / upgrade culvert to convey high flows at nominal HWL differential.	$20,000 (removal) $100,000 (upgrade)
2	Divert Kenton Outfall Drainage to Dog Creek	Not recommended	n/a
3	East Diversion Ditch	800m length, design flow 1 m^3/s	$400,000
4	South & East Diversion Ditches	1750 m length, design flow 4 m^3/s	$900,000
5	West Diversion Ditch	150 m length, design flow 1 m^3/s	$200,000
6	South Upstream Diversion Ditch	Addresses flooding south of TWP 532A; requires Option 4 to be implemented, assumes new TWP 532A bridge sized culvert	$500,000 to $1 million
7	Upgrade Rolling Meadows Drive North Culverts	Additional 1500 mm culvert	$60,000
8	Upgrade Lot 29 Driveway Culvert	Install two 750 mm culverts	$30,000
9	Upgrade Rolling Meadows Drive East Culvert	Install two 750 mm culverts	$40,000
10	Upgrade Lot 11 Driveway Culvert	Install two 750 mm culverts	$30,000
11	Construct Drainage Swale Through Lot 12	Requires a drainage easement across privately owned Lot 12	$30,000
12	Restore Range Road 271 Culvert	Requires upgrading Lot 21 to 24 driveway culverts (Option 13).	$10,000
13a to 13d	Upgrade Lot 21 to 24 Driveway Culverts	Install two 600 mm culverts at each driveway	$80,000 ($20,000 each)
14	Upgrade Lot 3 and 4 Driveway Culverts	Install two 750 mm culverts	$40,000 ($20,000 each)
15	Upgrade Rolling Meadows Drive North / East Ditches	Allowance only; design needed to determine grading requirements	$20,000
16	Review Lot 19 Driveway Culvert	Restore grade on culvert if needed	$10,000
17	Install Driveway Culvert at Lot 13	Install 350 mm culvert	$10,000

Notes:

1. Option 1 costs are order of magnitude estimate only. If the farm crossing is needed for farming operations, then the existing culverts could be upgraded to convey high flows with minimal HWL differential (e.g., multiple box culverts).
2. Options 3 and 4 are shown in Appendix D. Option 3 is from Station 0+950 to 1+750, while Option 4 is from Station 0+000 to 1+750. Cost estimates include land acquisition purchases.
3. Options 5 and 6 are order of magnitude estimate only. Option 6 will require a bridge sized culvert across TWP 532A.
4. The cost for Options 8 and 13d will vary slightly depending on whether it is sized to include off-site flows or not.
5. The cost to upgrade several culverts at the same time is expected to be lower due to efficiencies and reduced mobilization effort.
6. All cost estimates include 15% for engineering and 40% contingency and are rounded to the nearest $10,000.
7. Wetland compensation costs, if required, are not included in these estimates. It is anticipated that the design of the diversion ditches would be able to minimize wetland loss.

6.0 Assessment of Flood Mitigation Options

6.1 Introduction

The overall goal for Rolling Meadows, given the physical constraints, is to minimize surface flooding to the greatest extent possible, with no or minimal surface runoff on private property during spring runoff and summer rainfall events. Several potential combinations of individual flood mitigation options were assessed using the hydraulic model using the 1:100 year rainfall event. As previously mentioned, hydraulic modeling of the 1:100 year rainfall event acts as a proxy for spring snowmelt events. In the case of spring snowmelt, engineering judgement was applied based on an understanding of the impact of freeze thaw cycles on the County's ditches and culverts.

6.2 Hydraulic Analysis of Flood Mitigation Options

Hydraulic analyses were conducted for the following combination of flood mitigation options.

North Side

- Options 1 and 14

This combination of options minimizes the tailwater elevation at the north end of Rolling Meadows and the potential impacts of the Lot 3 and 4 driveway culverts freezing up.

East Side

- Options 1, 3, 7, and 8
- Options 1, 7 to 10, 11, and 15
- Options 1, 4, and 8

The hydraulic modeling indicated that each of the above combinations provides a similar level of flood mitigation for Rolling Meadows. It is also noted that Option 4 (South and East Diversion) may also help lower the water table in the central part of Rolling Meadows.

West Side

- Options 1, 5, and 13d
- Options 1, 12 and 13

Each of the above options addresses the flooding in the north ditch of Rolling Meadows Drive South.

6.3 Ultimate System Hydraulic Analysis

Hydraulic modeling of the recommended options was also conducted for ultimate development conditions of Spruce Grove to confirm that the proposed upgrading will be adequate for future development conditions. With future development controlling urban runoff to predevelopment rates, the ultimate system model has similar peak flows as the existing system model. Thus, the proposed upgrading for existing conditions will also apply for future development conditions. It is noted that the only upgrading options being affected by changes to future flows from Spruce Grove are Options 1 and 7.

As noted in Section 3.2 to be conservative the existing system model included an additional 5 quarter sections (more or less) of land south of Highway 16A that has the potential to drain through the City of Spruce Grove drainage system. This area was included in the City of Spruce Grove ultimate stormwater service area. This additional area is currently within Parkland County and the City has planned it's downstream infrastructure to accommodate post-development flows from this area, whether it is part of the City or County. If this area is developed and connected to the City's stormwater system, it may result in slightly larger flows than are currently experienced. As these lands are outside of the City of Spruce Grove, its development is likely 20 years or more away (whether it is in the City or County).

6.4 Combination of Flood Mitigation Options – Cost Comparison

The concept level cost estimate for the various combinations of flood mitigation options is provided in **Table 6.1** below.

Table 6.1 Concept Level Cost Estimates – Combinations of Flood Mitigation Options

Location	Combination of Flood Mitigation Options	Concept Level Cost Estimate	Cost of Recommended Option
North Side	Options 1 and 14	$60,000	$60,000
East Side	Options 3, 7, and 8	$490,000	Not recommended
	Options 7 to 10, 11, and 15	$210,000	$210,000
	Options 4, and 8	$930,000	Not recommended
West Side	Options 5, and 13d	$220,000	Not recommended
	Options 12 and 13	$90,000	$90,000
Various	Options 16 and 17	$20,000	$20,000
Total Cost of Recommended Options			$380,000

Notes:

1. Cost estimates are based on removal of farm crossing (Option 1).
2. All cost estimates include 15% for engineering and 40% contingency and are rounded to the nearest $10,000.

6.5 Discussion

To address the east side drainage issues, the least cost alternative is to upgrade the internal Rolling Meadows drainage system by completing Options 7 to 10, 11 and 15 at an estimated cost of $210,000. The same is true for the west side drainage issues, where the lowest cost alternative is to upgrade the existing culverts (and ditches if necessary) at a cost of $90,000.

While it would be preferable to divert the large upstream areas draining into Rolling Meadows at Lots 12, 17 and 19, the capital costs would be much higher (Option 3 or 4). Based on the hydraulic modeling results and the above cost estimates, the diversion ditches are not be justified at this time.

As previously mentioned, there are a number of uncertainties that need to be considered before the diversion ditch concept can be permanently ruled out. The key issues include:

- The tailwater conditions in Atim Creek
- The unknown interaction between surface water flows and groundwater levels
- The role of ice buildup within the Atim Creek floodplain, and upstream ditches and culverts during spring runoff conditions, and its impact on flooding
- The future changes due to ongoing development in Spruce Grove
- The future land acquisition cost for the diversion ditch.

The recommended upgrading is shown in **Figure 6.1**.

Remove or upgrade farm crossing

1

Rolling Meadows Dr North

750mm 14b

750mm 14a

1500mm 7

2x750mm 8

15

2x750mm 9

2x750mm

10

11

12 500mm

13a 2x600mm

13b 2x600mm

13c 2x600mm

13d 2x600mm

Rolling Meadows Dr South

Rolling Meadows Dr East

Range Rd 271

53232 RGE RD 271

53231 RGE RD 271

53227 RGE RD 271

53224 RGE RD 271

53220 RGE RD 271

53217 RGE RD 271

2-53219 RGE RD 271

3-53219 RGE RD 271

4-53219 RGE RD 271

5-53219 RGE RD 271

6-53219 RGE RD 271

7-53219 RGE RD 271

8-53219 RGE RD 271

9-53219 RGE RD 271

10-53219 RGE RD 271

11-53219 RGE RD 271

12-53219 RGE RD 271

13-53219 RGE RD 271

14-53219 RGE RD 271

15-53219 RGE RD 271

16-53219 RGE RD 271

17-53219 RGE RD 271

18-53219 RGE RD 271

19-53219 RGE RD 271

20-53219 RGE RD 271

20A-53219 RGE RD 271

21-53219 RGE RD 271

22-53219 RGE RD 271

23-53219 RGE RD 271

24-53219 RGE RD 271

25-53219 RGE RD 271

25A RGE RD 271

26-53219 RGE RD 271

27-53219 RGE RD 271

28-53219 RGE RD 271

29-53219 RGE RD 271

N

LEGEND

- Modelled Drainage Paths
- Culvert
- Culvert Upgrade
- New Culvert
- Ditch Upgrade
- New Drainage Ditch
- Parcels
- Contour (0.2m)
- Contour (1m)

TITLE

ROLLING MEADOWS ESTATES RECOMMENDED FLOOD MITIGATION OPTIONS

PROJECT

ROLLING MEADOWS DRAINAGE STUDY

NOTES

- Existing stormwater management facility GIS data is known to contain some future planned stormwater management facility data.

DATA SOURCES

- Topographic Map: Parkland County Parkland County, IHS, Government of Canada

PROJECTION

NAD 1983 CSRS 3TM 114

0 30 60

1:3,500 Meters

parkland county

FIGURE	6.1
DATE	4/9/2025
PROJECT NO.	16177
AUTHOR	jlalonde-bester

Document: C:\Users\jlalonde-bester\OneDrive - ISL Engineering and Land Services\Documents\ArcGIS\Projects\MyProject10\MyProject10.aprx - Figure 6.1 Recommended Upgrades

7.0 Implementation Considerations

Based on the above findings, the following implementation plan is proposed:

Short term

- The County should arrange for the hydraulic restriction in the downstream farm crossing to be removed or upgraded (Option 1)
- The County should implement the onsite drainage system upgrades (Options 7 to 17) as soon as possible.
- The County should conduct a "desktop" hydrogeological study to develop a high-level understanding of the groundwater levels and flow to better understand the role of groundwater in surface flooding in Rolling Meadows.

Medium Term

- The County should work with residents to monitor the surface and groundwater levels in Rolling Meadows following the completion of the recommended upgrades.
- Subject to the results of the monitoring program, the County should consider working with residents to find ways to minimize the impacts of large runoff events (spring snowmelt and rainfall). This could include facilitating site grading or purchasing portions of lots that are subject to frequent flooding.
- If warranted, the County should conduct a detailed hydrogeological study of Rolling Meadows.
- The County should work with Spruce Grove to better understand the planned stormwater discharges from the City to and through Rolling Meadows and determine if it would be more appropriate to divert part of their flows around the subdivision.

Long Term

- If necessary, the County should revisit the need for the diversion ditch along the south and east sides of Rolling Meadows.

8.0 Conclusions and Recommendations

8.1 Conclusions

1. All lands within Rolling Meadows beneath 653.29 m is susceptible to flooding based on the Big Lake 1:100 year high water level. This effects parts of Lots 3 to 9 in Rolling Meadows. These lots are susceptible to surface flooding whenever tailwater from Atim Creek prevents the exit of stormwater from the subdivision.
2. It is not well understood how the Atim Creek floodplain responds to snowmelt from upstream while the creek is still frozen.
3. Historical air photos taken prior to development show almost every lot in Rolling Meadows being impacted by watercourses or wetlands. The flooding complaint locations are typically at the same locations as the historic watercourses / wetlands.
4. The farm crossing on the main channel immediately north of Rolling Meadows appears to be contributing to the flooding experienced at the north end of Rolling Meadows. The crossing is on private property and the consultant has not had access to it to determine the size of culverts installed.
5. Hydraulic modeling indicates that the main drainage channels through Lots 17 and 19, between Lots 24 and 25, and between Lots 4 and 5 is adequate to convey existing flows (although Lots 4 and 5 depend on tailwater conditions). This system was upgraded in 1997-98 with sufficient capacity to convey the 1:100 year flows without adversely affecting the adjacent areas.
6. The drainage area east and southeast of Rolling Meadows (Catchment S4) currently drains into Rolling Meadows at Lot 12. This lot and the downstream drainage system were not designed to accommodate these off-site flows.
7. Hydraulic modeling indicates that Lots 11, 12, 28 and 29 appear to be at risk of surface flooding due to the upstream off-site flows and the capacity constraints in downstream culverts.
8. It is expected that the groundwater table is close to the ground surface over most of Rolling Meadows. The interaction between the surface water and groundwater is not well understood, nor is the magnitude of groundwater flows.
9. The drainage area southeast of Rolling Meadows (Catchment S2) currently drains to Rolling Meadows via a culvert across RR 271, connecting to the north ditch along Rolling Meadows Drive South (Lot 21). The driveway culverts were not designed to accommodate these off-site flows. Also, the RR 271 culvert is partially embedded on the downstream side, which currently minimizes the flows entering Rolling Meadows.

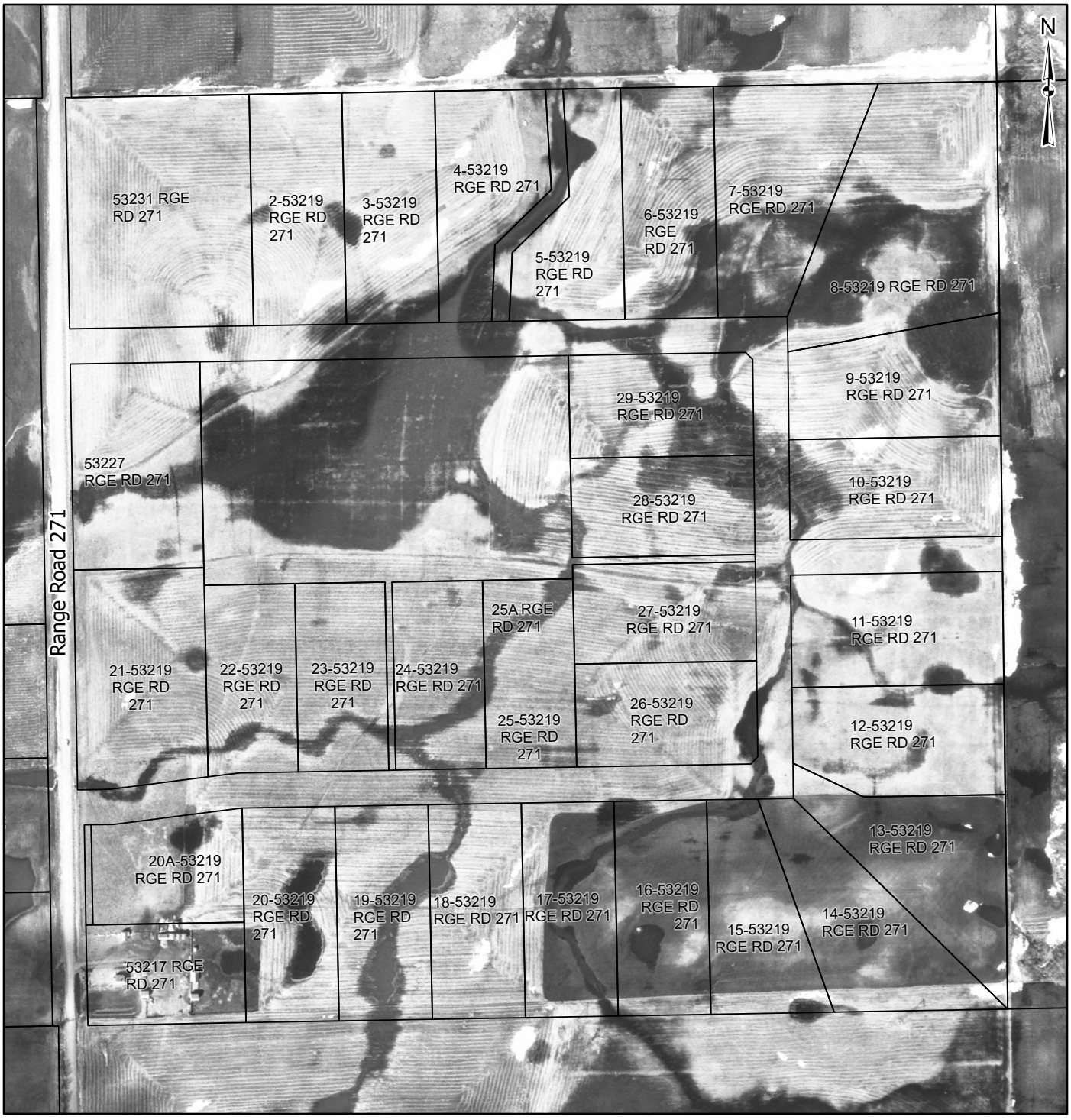
10. The centerline culverts on Range Road 271 and Township Road 532A upstream of Rolling Meadows restrict the flows to Rolling Meadows during the 1:100 year runoff event and thus contribute to local flooding immediately upstream of the culverts. While this has a detrimental effect on the upstream lands, it is not recommended that these culverts be upgraded unless the downstream flows can be safely diverted around Rolling Meadows.
11. The cumulative flows from Spruce Grove to Parkland County crossing Highway 16 immediately west of Range Road 270 are likely larger than what would have occurred during pre-development conditions, especially for smaller rainfall events. This is due, in part, to the increase in runoff volume associated with urban development.
12. There is further impact of flow between the constructed stormwater drainage system in Spruce Grove to an overland natural drainage flows in Rolling Meadows, with more susceptibility to freeze/thaw cycles in spring melt.

8.2 Recommendations

1. Parkland County should work with the landowner immediately north of Rolling Meadows to either remove or upgrade the farm crossing upgraded as soon as possible. To accommodate farming operations, it would be acceptable to upgrade the existing culvert and crossing, as long as the culvert is capable of conveying high flows without significant backwater effects.
2. The County should consider undertaking a hydrogeological study of Rolling Meadows to better understand the role that groundwater has in historic flooding.
3. The County should implement the onsite drainage system upgrades (Options 7 to 17) as soon as possible. The culvert and ditch designs should be refined as part of the detailed design phase. It is noted that round culverts may not be the optimal shape where it is necessary to maximize hydraulic capacity while minimizing the headloss across the culvert.
4. The County should work with residents to minimize the impacts of flooding on their property. This may include accommodating grading and filling requests.
5. The County should work with residents to monitor the surface and groundwater levels in Rolling Meadows.
6. If warranted, the County should conduct a detailed hydrogeological study of Rolling Meadows.
7. The County should work with Spruce Grove to better understand the planned stormwater discharges from the City to and through Rolling Meadows and determine if it would be more appropriate to divert part of their flows around the subdivision.
8. If necessary, the County should revisit the need for the diversion ditch along the south and east sides of Rolling Meadows.
9. The County should restrict development activity on areas below the Big Lake 1:100 year high water level of 653.29 m.

APPENDIX A

Historic Air Photos



LEGEND

Parcels

TITLE

APRIL 1965
HISTORICAL IMAGERY

PROJECT

ROLLING MEADOWS DRAINAGE STUDY

CLIENT

PARKLAND COUNTY

PROJECTION

NAD 1983 10TM AEP Forest

DATA SOURCES

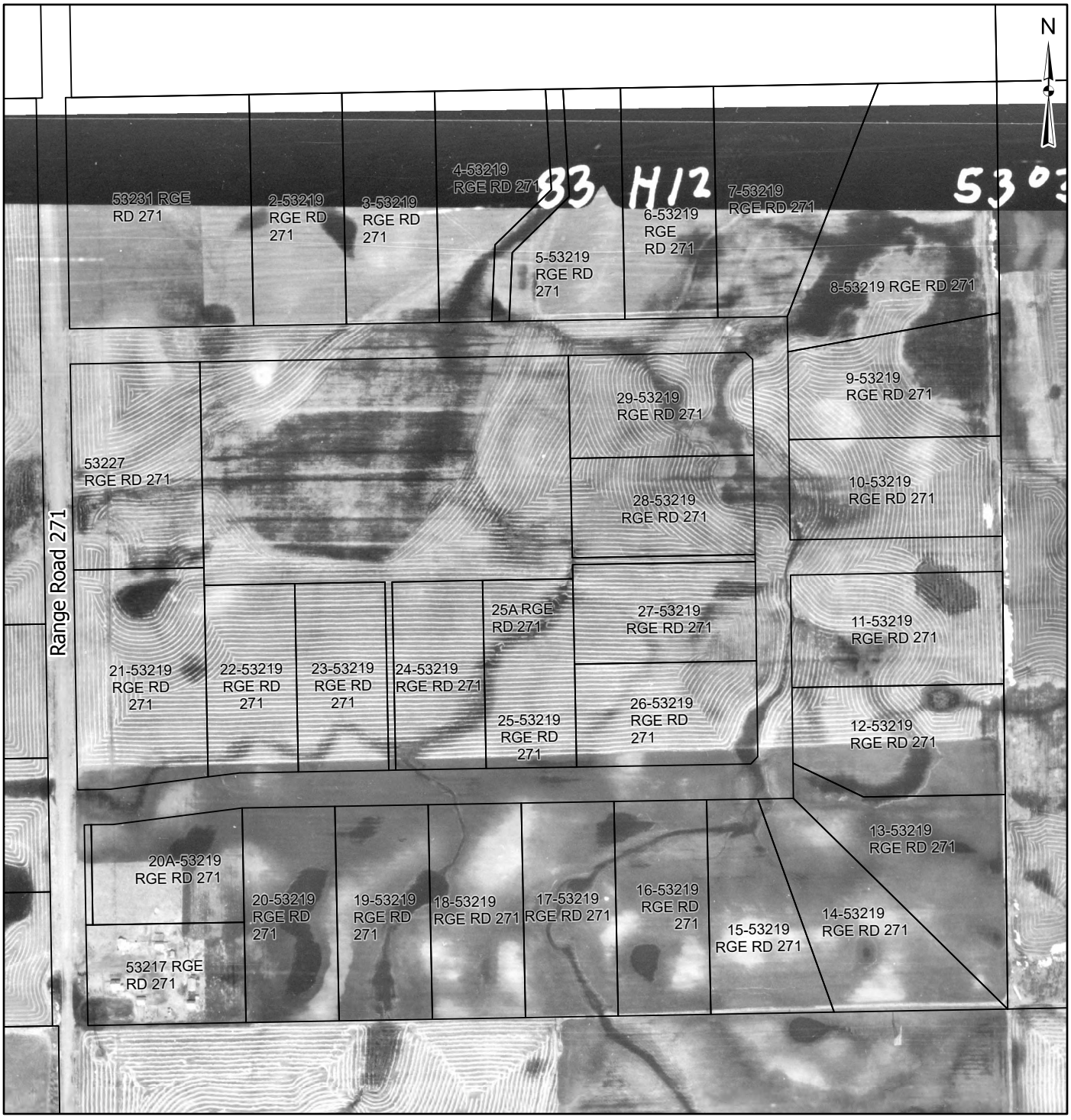
- Topographic Map:Parkland County, Sturgeon County, Maxar

0 10 20
1:5,000 KM

parkland county

FIGURE	A1
DATE	12/6/2024
PROJECT NO.	16177
AUTHOR	jlalonde-bester

Document: C:\Users\jlalonde-bester\OneDrive - ISL Engineering and Land Services\Documents\ArcGIS\Projects\MyProject6\MyProject6.aprx - xxxxx_figure_85x11_portrait



LEGEND

Parcels

TITLE

APRIL 1970
HISTORICAL IMAGERY

PROJECT

ROLLING MEADOWS DRAINAGE STUDY

CLIENT

PARKLAND COUNTY

PROJECTION

NAD 1983 10TM AEP Forest

DATA SOURCES

- Topographic Map:

0 10 20
1:5,000 KM

parkland county

FIGURE	A2
DATE	12/6/2024
PROJECT NO.	16177
AUTHOR	jlalonde-bester

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LEGEND

Parcels

TITLE

APRIL 1978
HISTORICAL IMAGERY

PROJECT

ROLLING MEADOWS DRAINAGE STUDY

CLIENT

PARKLAND COUNTY

PROJECTION

NAD 1983 10TM AEP Forest

DATA SOURCES

- Topographic Map:

0 10 20
1:5,000 KM

parkland county

FIGURE	A3
DATE	12/6/2024
PROJECT NO.	16177
AUTHOR	jlalonde-bester

Document: C:\Users\jlalonde-bester\OneDrive - ISL Engineering and Land Services\Documents\ArcGIS\Projects\MyProject6\MyProject6.aprx - xxxxx_figure_85x11_portrait

LEGEND

Parcels

TITLE

JULY 1992
HISTORICAL IMAGERY

PROJECT

ROLLING MEADOWS DRAINAGE STUDY

CLIENT

PARKLAND COUNTY

PROJECTION

NAD 1983 10TM AEP Forest

DATA SOURCES

- Topographic Map:

0 10 20
1:5,000 KM

parkland county

FIGURE	A4
DATE	12/6/2024
PROJECT NO.	16177
AUTHOR	jlalonde-bester

Document: C:\Users\jlalonde-bester\OneDrive - ISL Engineering and Land Services\Documents\ArcGIS\Projects\MyProject6\MyProject6.aprx - xxxxx_figure_85x11_portrait

APPENDIX B

Open House Report

Rolling Meadows Estates Drainage Study
November 20, 2024 Open House - What We Heard report

Target Stakeholders

The target stakeholders were residents of Rolling Meadows and adjacent areas. Invitations were sent to stakeholders in Rolling Meadows and surrounding areas, refer to the attached map for the mailout area on October 31, 2024.The invitations included a summary of the scope of the drainage study and a map of the study area.

Open House Attendance

The open house ran from 5pm to 8pm on November 20, 2024. Based on the sign-in sheet, a total of 29 people attended the open house, representing approximately 19 individual lots within Rolling Meadows and two adjacent properties. The turn-out was considered excellent given that the total number of lots within Rolling Meadows is only 33.

Councilor Kristina Kowalski and Mayor Allan Gamble also attended the open house.

Open House Materials

The project team prepared maps of the Rolling Meadows study area plus a map of the upstream drainage area that drains through the subdivision. These maps were useful for in-depth discussion with residents.

Detailed maps (11x17 sheets) showing individual lots were available for residents to mark up to indicate their historic flooding. Questionnaires were also handed on to allow residents to summarize their flooding experiences and to comment on potential solutions to flooding.

Responses Received

A total of 10 questionnaires were returned to the project team during the open house. The following table summarizes the responses received.

Table 1: Summary of Questionnaire Responses

Item	Resident's Responses
Flooding Description	• Spring runoff and heavy rainfall • Water ponding on lot for extended time • Ditches not draining
Impacts on Residents	• Tree and grass loss • Septic field damage • Land settlement • Damage to home • Damage to driveway
Factors	• Lack of ditch maintenance • Ditches not adequate • Increased runoff from Spruce Grove • Frozen culverts not thawed in time • Farmer installed crossing to north • Saturated ground
Comments	• What is long-term solution? • Maintenance concerns • Follow up meeting?

Attendees also marked up the detailed maps to show the location of historic flooding on their property or adjacent property. The locations and elevations will be used by the project team to analyze the flooding patterns.

Online Survey

Stakeholders were provided the opportunity to provide input via a dedicated project page on the County's website. As of December 31, 2024, no stakeholders had provided comments to the project webpage.

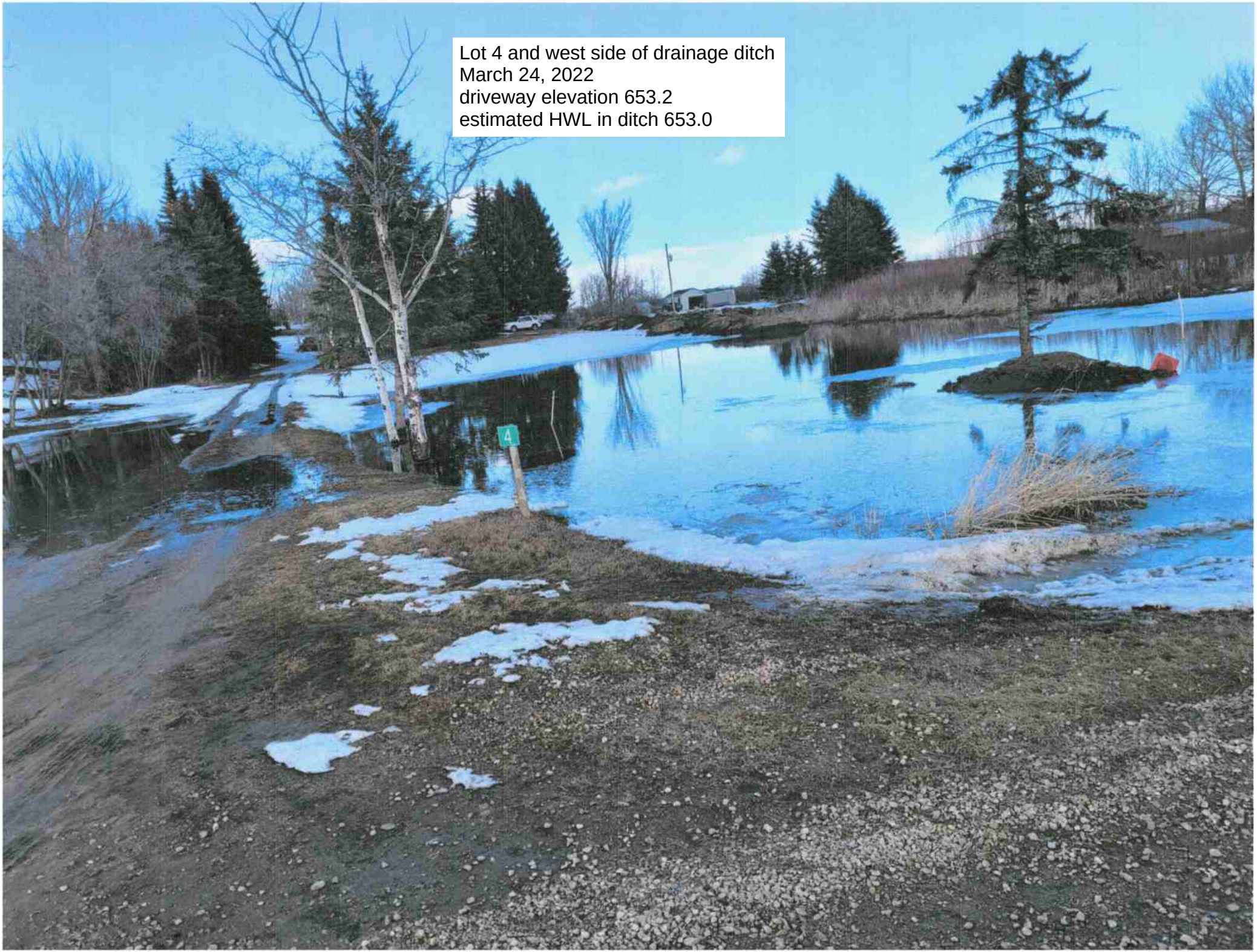
Summary

The open house was considered to be a success, with the following objectives obtained:

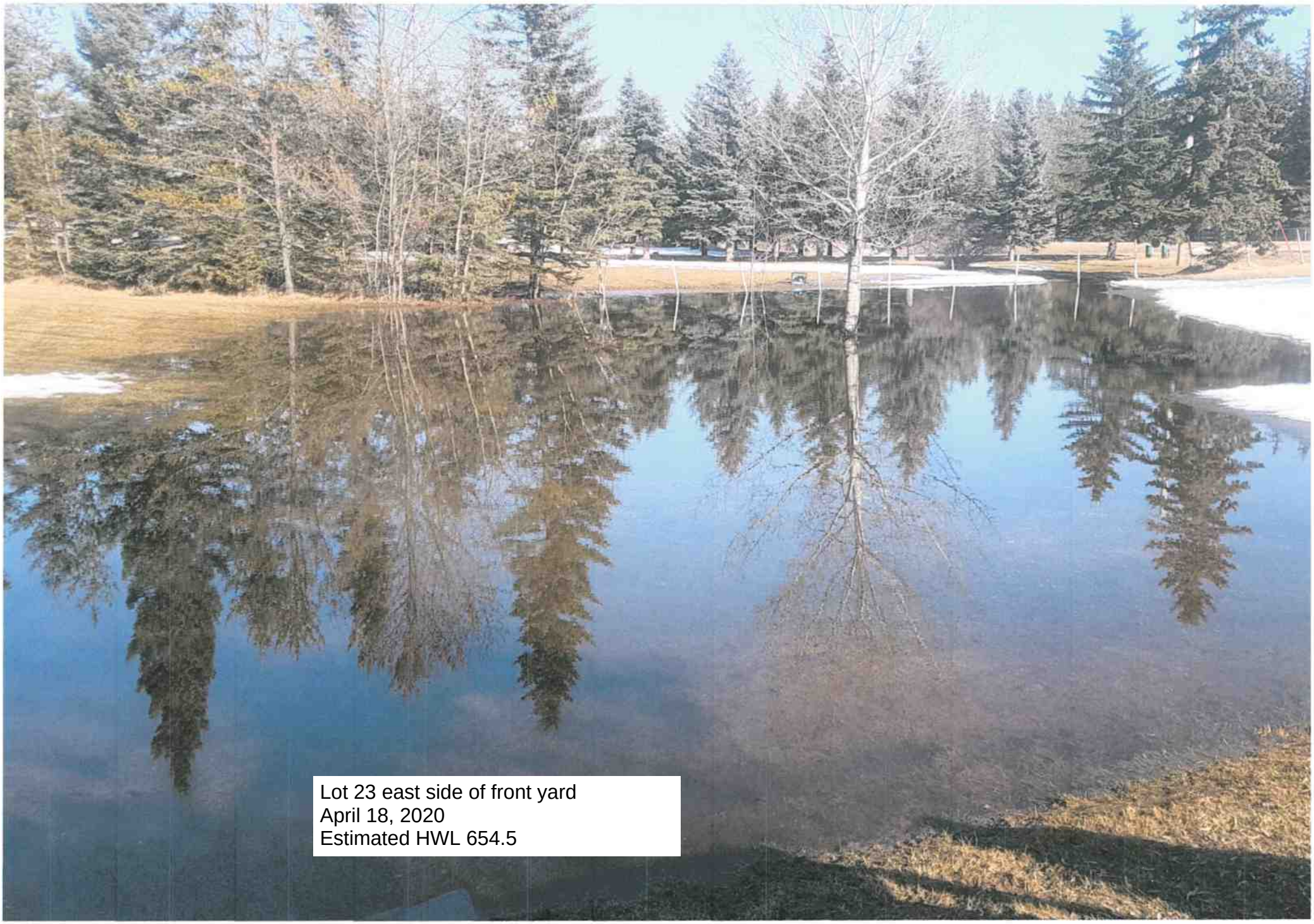
- Advising the residents / stakeholders of the study
- Project team hearing stories from residents of their historic flooding issues, flooding locations, potential causes, and the impacts on their lives
- Questionnaires received provides key information that the project team needs to analyze flooding, document impacts to residents, and the residents general willingness to provide access to their land for potential engineering solutions
- Marked up maps provides historic flooding locations and approximate elevations that will be used by the project team to compare to the hydraulic modeling results

APPENDIX C

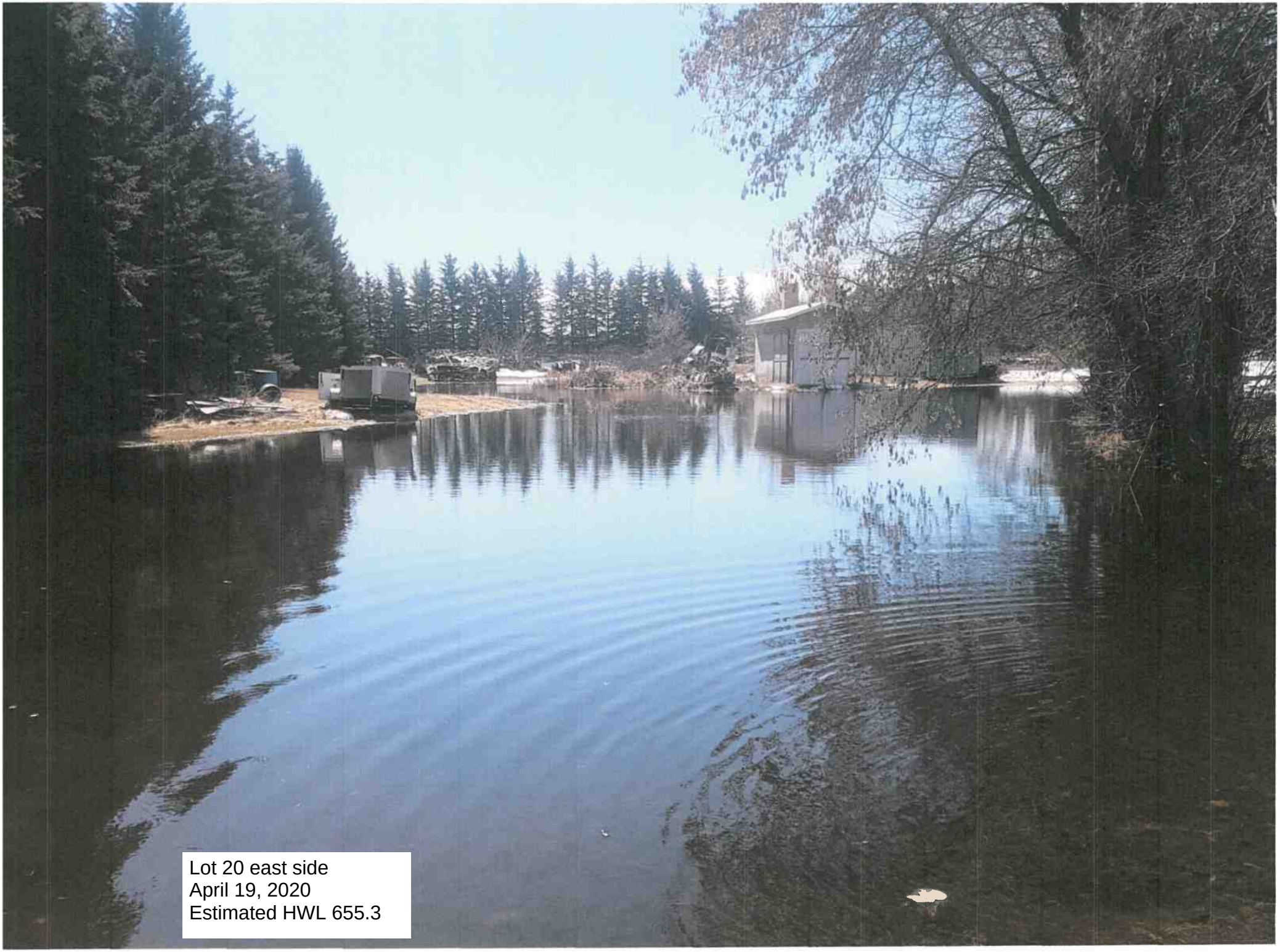
Historic Flooding Images


Lot 4 and west side of drainage ditch
March 24, 2022
driveway elevation 653.2
estimated HWL in ditch 653.0
4

Road allowance between Lots 23 & 24
April 17, 2020
Estimated HWL 654.6

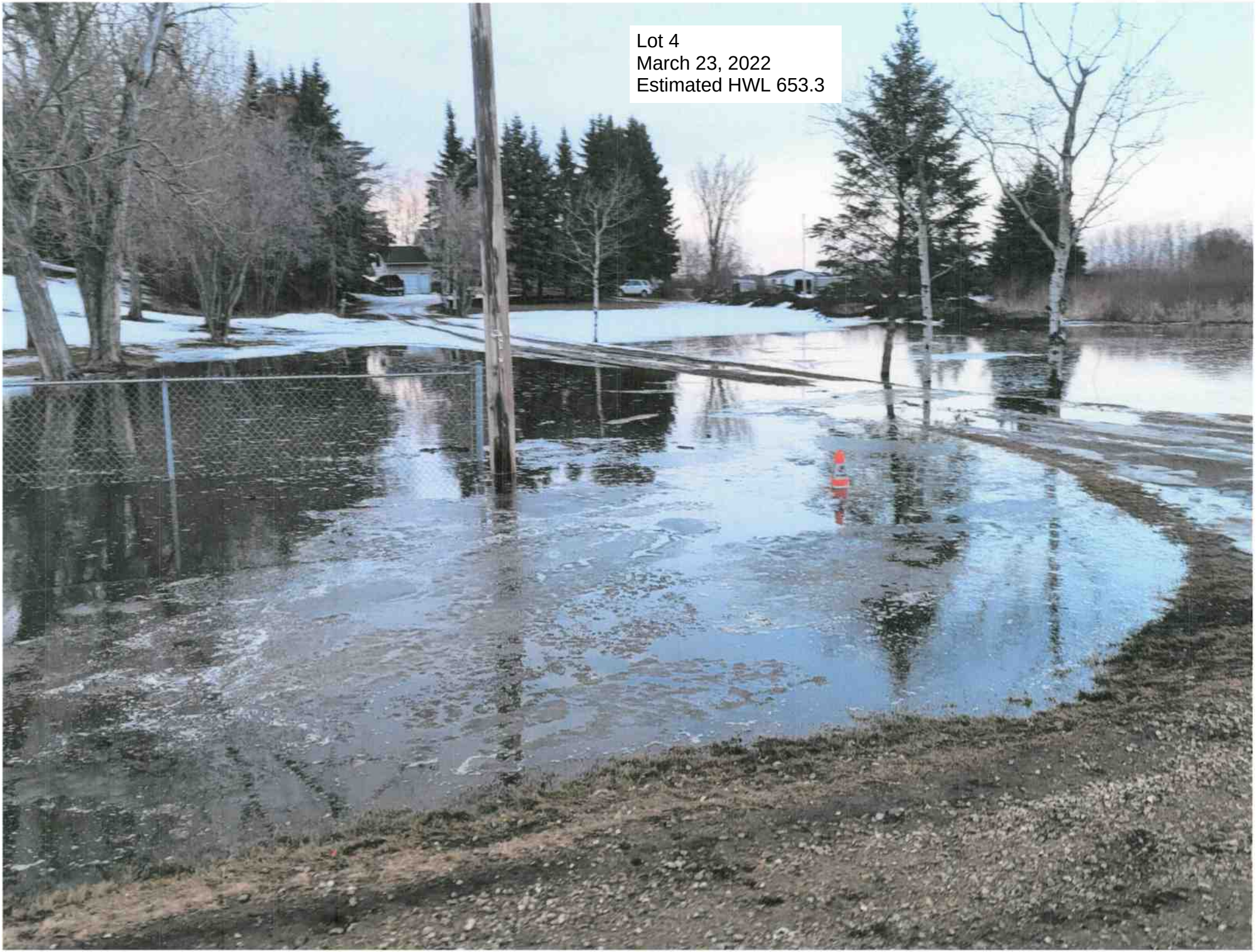

Lot 23 east side of front yard
April 18, 2020
Estimated HWL 654.5


Lot 23 west side of front yard
April 18, 2020
estimated HWL 654.6


Lot 20 east side
April 19, 2020
Estimated HWL 655.3


Lot 23 east side of front yard
May 22, 2020
Estimated HWL 654.4


Main drainage ditch between Lots 4 and 5
March 21, 2022
Estimated HWL 653.2

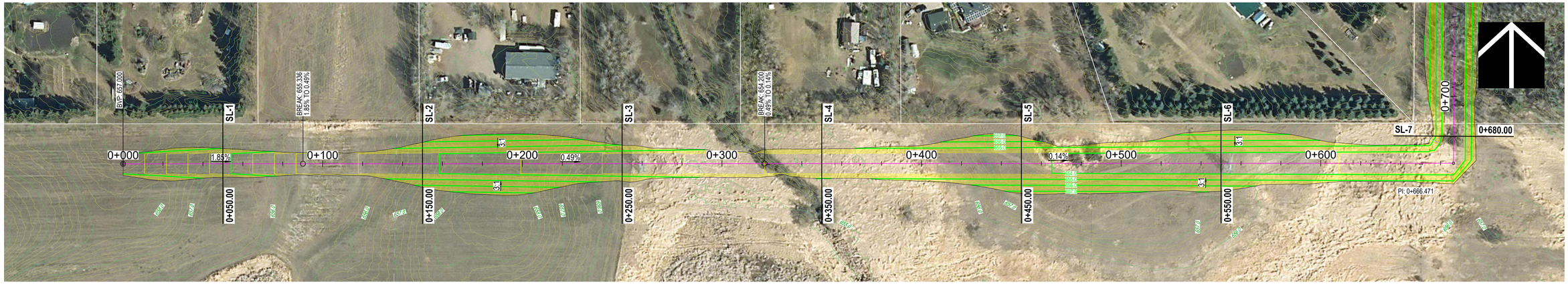

Lot 4
March 23, 2022
Estimated HWL 653.3

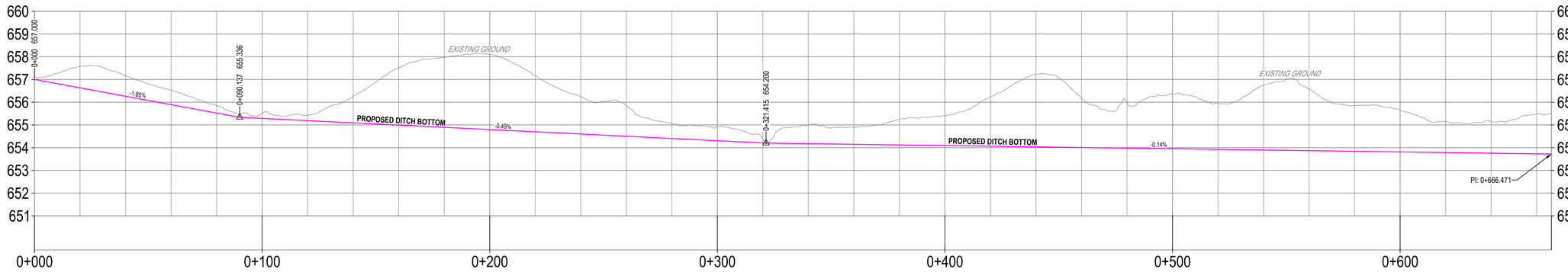

Main drainage ditch looking southwest
March 12, 2022
Estimated HWL 653.2

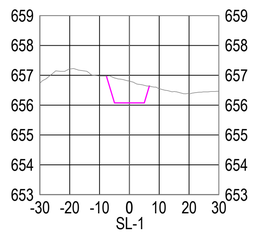

Lots 3 and 4 looking northwest
March 24, 2022
Estimated HWL 653.3

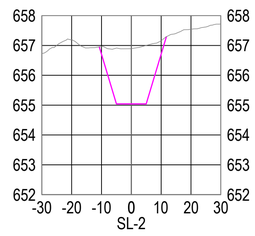
APPENDIX D

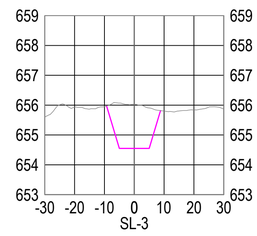
South East Diversion Design

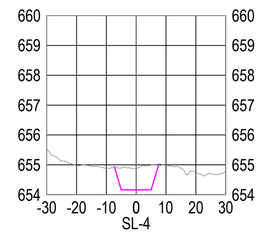


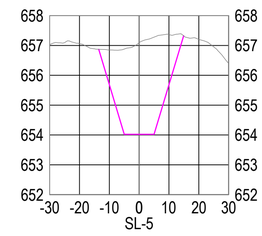


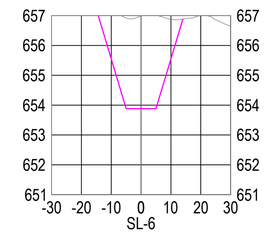












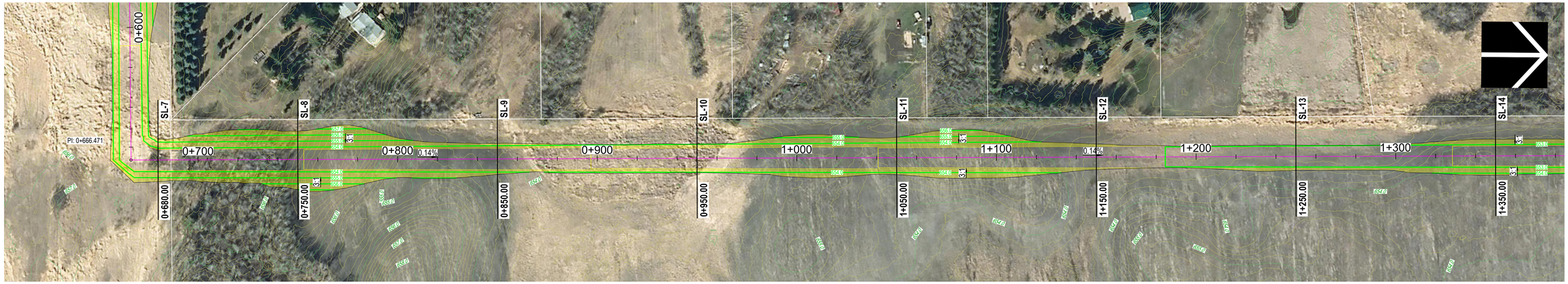
Matt Jullion | Mar. 10, 25 | Z:\Shared\Projects\160001\160016177_Parkland_Stormwater_Master_Plan\02_CADD\20_Drafting\203_Sketches\MJ Working\16177_PPS_Ditches.dwg

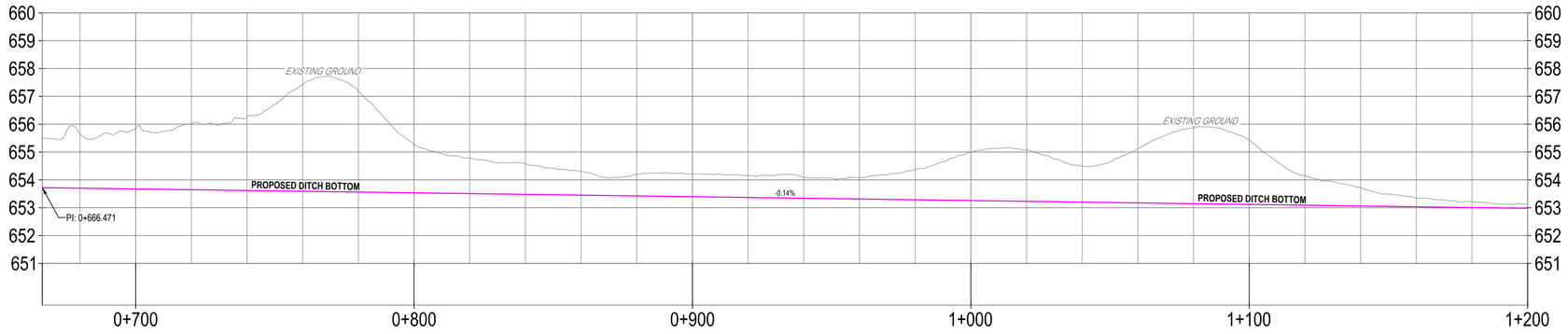
ROLLING MEADOWS DRAINAGE STUDY

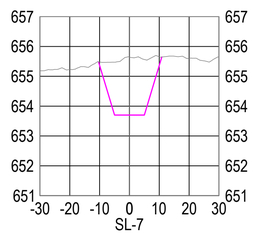
FIGURE 1

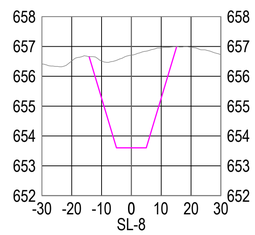
HORZ 1:1000 0 10 20 30 40m

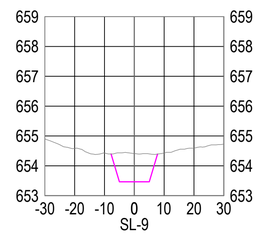
MAR 2025

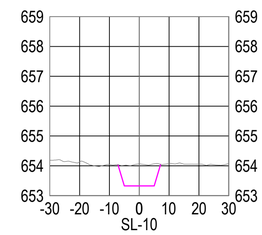


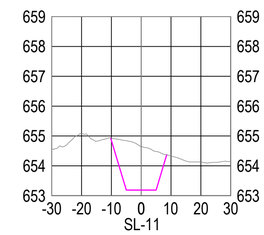


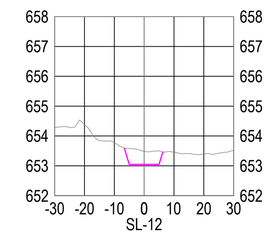












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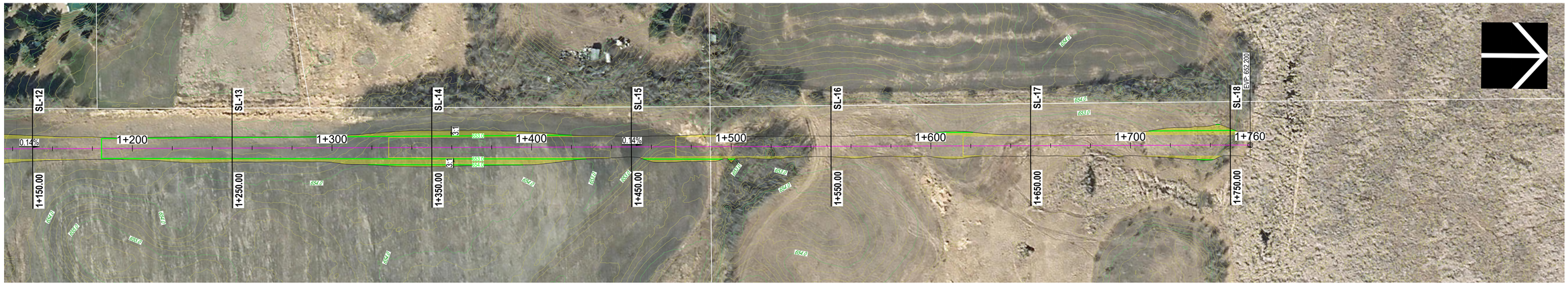
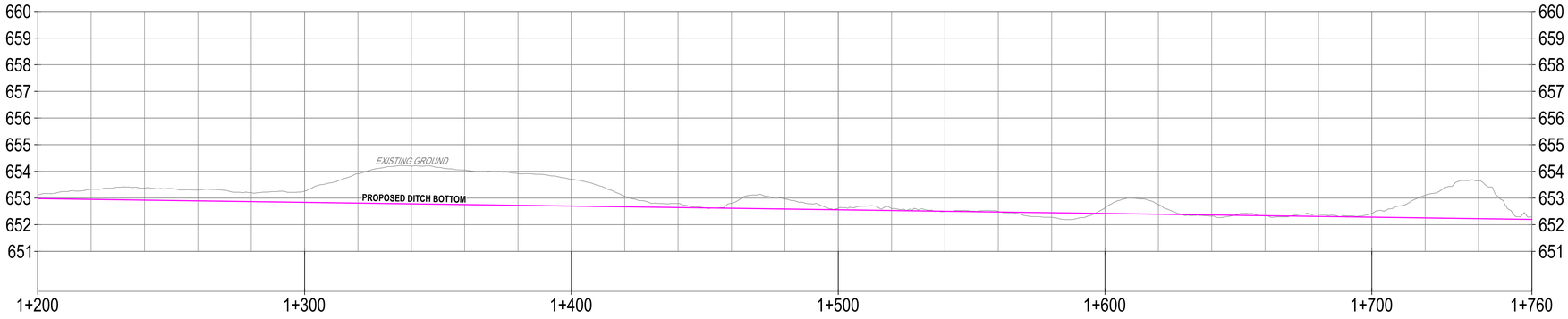
ROLLING MEADOWS DRAINAGE STUDY

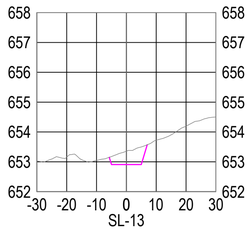
FIGURE 2

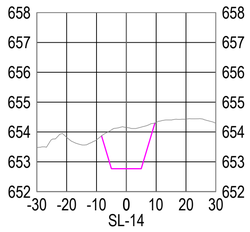
HORZ 1:1000 0 10 20 30 40m

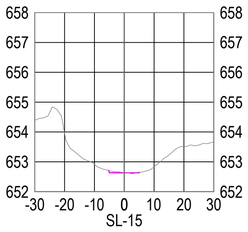
MAR 2025

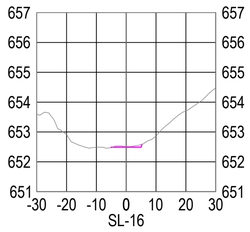


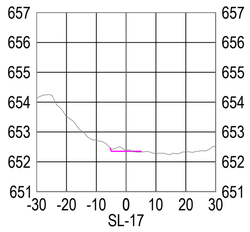


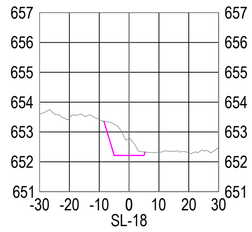












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ROLLING MEADOWS DRAINAGE STUDY

FIGURE 3

HORZ 1:1000 0 10 20 30 40m

MAR 2025