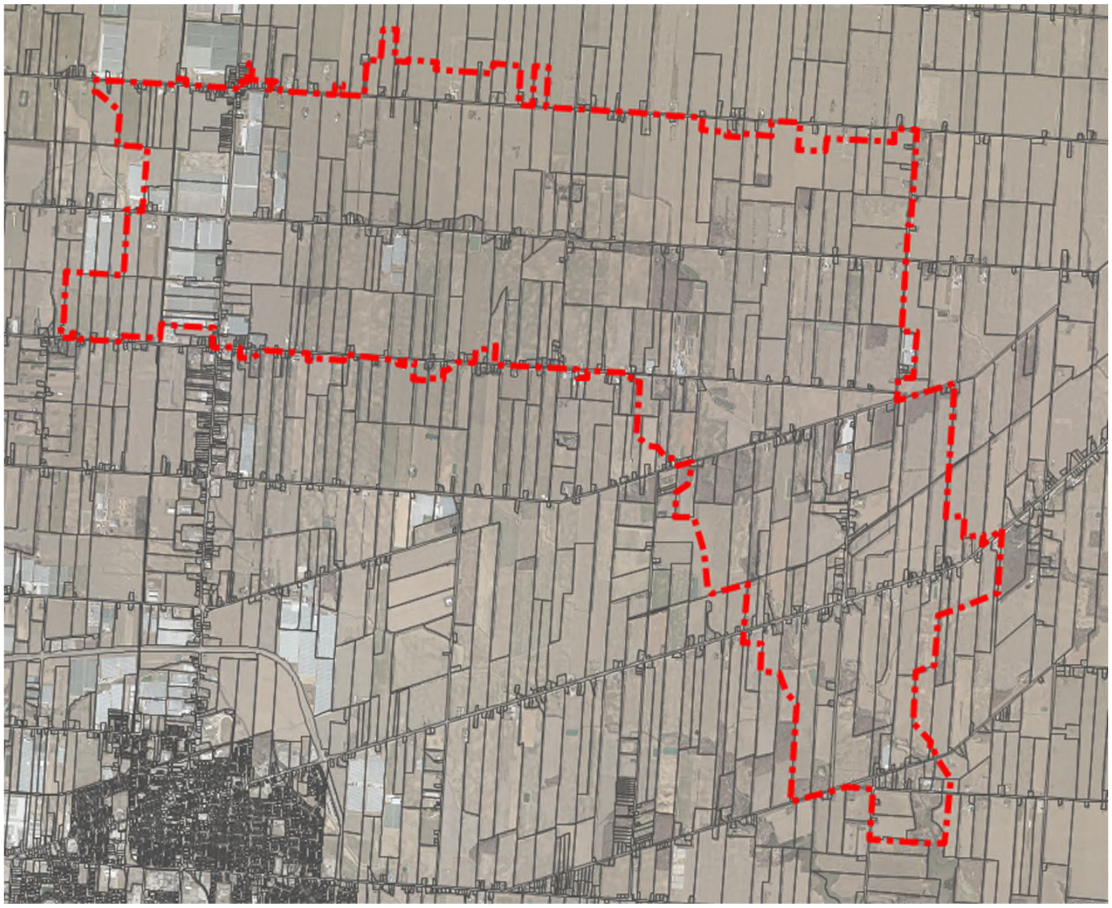
LEBO CREEK MASTER DRAINAGE STUDY
FINAL REPORT



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Peralta Engineering

Landmark Engineers Inc.

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AMENDMENT NO.1

The final report dated August 15, 2022 has been amended with the following changes:

1. *Figure A-3 and associated maps in Appendix E:* Identify "temporary floodplain areas" in lieu of the "existing floodplain storage" and "concept floodplain storage". Affected flood elevation maps (E-9, E-12, E-25 to E-27) have also been revised to reflect these changes.

2. *Section 2.1.3:* Additional discussion included to clarify the specified 25% buildout limit and future development conditions.

3. *Section 3.2:* Revise "Other Areas" to "Outside of Service Area".

4. *Section 4.1:* Revise discussion regarding floodplain areas and potential ERCA setback requirements.

5. *Section 4.1.1:* Revise discussion regarding measures related to long-term function of the SWM ponds.

6. *Section 5.2:* Revise recommendation item 7 to suit revised section 4.1 and clarify conditions of temporary floodplain areas.

1.0 INTRODUCTION

The study on the Lebo Creek watershed was performed through a collaboration between Landmark Engineers Inc. and N.J. Peralta Engineering Ltd, using the strengths of each consultant for the different aspects of the project. Landmark has vast experience with performing hydrologic and hydraulic modeling of rural and urban watersheds. Furthermore, a member of the Landmark team authored the 2019 Leamington Stormwater Master Drainage Study for Reid Drain, Silver Creek and Big Creek Watersheds when they were working for Stantec Consulting Ltd. They have taken that knowledge and experience and applied it to this watershed. Peralta has extensive familiarity with the Lebo Creek Drain watershed and drainage system through their Drainage Act experience in the Municipality, as well as first-hand knowledge of the Stormwater Management details for the majority of greenhouse developments in the watershed. Peralta provided drain survey information as well as information with regards to ongoing projects in the watershed and on the Lebo Creek Drain itself.

1.1 BACKGROUND

Significant greenhouse development is proposed within the Municipality of Leamington. To accommodate the proposed large-scale development and mitigate any adverse impacts to the receiving watercourses/municipal drains, a holistic stormwater management approach is required – one that evaluates the impacts of **increased stormwater runoff volume** at the watershed scale. This stormwater master drainage study serves to provide a stormwater management plan (SWMP) for the Lebo Creek watershed. See **Figure A1** of **Appendix A** for a map outlining the study area.

While individual greenhouse development properties are currently required to provide stormwater management (SWM) controls to mitigate adverse impacts, three main concerns arise from the current lot level SWM approach:

1. Individual property SWM assessments can lead to inconsistent SWM measures being undertaken;
2. Surrounding roadways are typically elevated above existing topography – roadways acting as dykes and eliminating opportunities for floodproofing via overland flow routing; and
3. Erosion potential from large-scale development is not assessed or well understood.

1.2 OBJECTIVES

The main objectives of the study are to evaluate the overall watershed drainage systems and derive specific stormwater design criteria such as the allowable release rate(s) and flood control measures for development to proceed without adversely impacting the overall drainage systems from an erosion and flood control perspective.

The study recommends a two-tiered allowable release rate approach. A lower tier release rate is to mitigate long-term erosion potential from increased runoff volume resulting from development. An upper tier release rate is to provide secondary outflow during infrequent storm events, thus reducing storage volume requirements and drawdown times during these infrequent storm events.

Flood control measures are recommended to a **minimum standard** equal to a 1:100-year return period. The following section further explains return periods in relation to level of service and risk.

1.3 UNDERSTANDING LEVEL OF SERVICE AND RISK

Level of service refers to the efficiency of the drainage system to capture and convey runoff away from the surface and buildings. In the context of drainage, level of service is described in terms of a return period – the likelihood that a storm event of specified magnitude will occur in any given year. For example, a 1:100-year storm event has a 1/100 or 1% chance of occurring in any given year. The return period can give a false sense of safety as a 1% chance is interpreted as an absolute rather than a statistical average.

To illustrate this point, the following table correlates return periods and probability of exceedance (or risk) over the design life.

Table 1.3 – Probability of Exceedance (Risk)

Return Period	Design Life					
	2	**5**	**10**	**25**	**50**	**100**
2	75%	97%	100%	100%	100%	100%
5	36%	67%	89%	100%	100%	100%
10	19%	41%	65%	93%	99%	100%
25	8%	18%	34%	64%	87%	98%
50	4%	10%	18%	40%	64%	87%
100	2%	5%	10%	22%	39%	63%

Risk (r) = $1 – (1-1/T)^L$, where T = return period and L = Design Life (MNRF, 2002)

For example, there is a 63% chance of exceeding a 1:100-year storm in the next 100 years. It should be acknowledged historical records used to derive return periods are often based on less than 100 years of data.

In summary, the minimum standard of 1:100-year design **does not guarantee** that a given site will never flood but rather, it provides mitigating measures to achieve a low risk of flooding. Where an individual site's potential damages due to flooding are high, it is the practitioner's responsibility to design to a more conservative standard or to provide a sufficient emergency flow route in accordance with the proponent's site-specific needs.

Assessing risk and level of service for a project must ultimately consider the consequence of failure (damages) resulting from exceedance of the design level of service.

2.0 MODEL ANALYSIS

This section provides a general summary of the hydrologic and hydraulic model analysis method and parameters used to evaluate the existing drainage system and impacts of future development.

2.1 HYDROLOGY

2.1.1 Software

The analysis was performed using the PCSWMM 2021 Professional 2D software version 7.4.3220. PCSWMM utilizes the U.S. EPA SWMM5 engine (currently version 5.1.015). PCSWMM provides a modern, easy-to-use graphical user interface for the U.S. EPA SWMM5 program. The EPA Storm Water Management Model (SWMM) is a dynamic rainfall-runoff simulation model used for single event or long-term (continuous) simulation of runoff quantity and quality for rural and urban areas.

2.1.2 Rainfall

A wide range of rainfall events were considered to achieve various objectives, ranging from Regulatory Storms for flood control and more frequent design storms for erosion threshold analysis to actual measured storm events for model calibration.

i) Flood Control – Regulatory Storm

The Regulatory Storm used for floodline mapping is defined as a 1:100-year 6-hour event with a rainfall of 3.9 inches (99 millimetres) and Probable Maximum Storm (also referred to as the Probable Maximum Precipitation) distribution.

The Probable Maximum Storm distribution is the largest precipitation event that can be reasonably expected to occur over a selected basin. The storm is typically used to calculate flow rates for the design of spillway structures and other hydraulic structures, where failure could result in the loss of life. Albeit the risk of loss of life is relatively low for the drainage systems in the region, the consequence of flooding is likely to result in significant damages to greenhouse crops. Combined with a general lack of overland flow routing, the foregoing distribution is appropriate.

With regards to assessing potential impacts of climate change, the Windsor / Essex Region Stormwater Management Standards Manual (Dec 2018) recommends that a 39% increase from 108.1mm to 150mm be evaluated as a “stress test” event to ensure sufficient freeboard is provided to account for potential increase in rainfall due to the climate change. The “stress test” event is to be distributed using an SCS Type II 24-Hour distribution.

ii) Erosion Control

The 1:5 year 4-hour Chicago storm and 32mm AES 12-hour storm were used for erosion threshold analysis purposes. The 32mm rainfall amount is based upon the 90th percentile storm for our region, as defined by the Ministry of Environment, Conservation and Parks (MECP, previously MOECC and MOE). This regional rainfall amount replaces the provincial standard 25mm that has commonly been used for erosion control. The Chicago and AES distributions allow evaluation of the drainage system under two various types of storm distributions – the Chicago storm evaluates the system under a high intensity thunderstorm whereas the AES storm is a regional low intensity storm.

iii) Model Calibration

The following storm events were analyzed for model calibration:

- May 14-19, 2020
- June 26-27, 2020
- August 26-29, 2020

Spatial variation of the storms was determined using radar rainfall obtained from NEXRAD Level III Digital Precipitation Rate (DPR) product for Detroit, Michigan station (Station ID: KDTX). The radar was uniformly adjusted by a factor of 1.3 to 1.5 to match the rainfall measured by available rain gauges. See **Appendix B** for model calibration and rainfall details.

While there are inherent limitations with the accuracy of the radar rainfall, and sometimes with rain gauges, the radar rainfall is believed to provide a better rainfall representation than the alternative of distributing the limited rain gauge rainfall over the entire 3,572-hectare (ha) Lebo Creek catchment area.

2.1.3 Proposed Buildout Conditions

The model assumes 90% impervious for proposed buildout conditions. Important note: The municipality has projected the following proposed ultimate buildout limits for the purposes of completing this study:

- **25% buildout, equivalent to 900 of 3,572 hectares**

The foregoing represents an upper limit of anticipated development. A reassessment of the watershed would be required if additional development is contemplated in the future.

Current buildout conditions have been accounted for in the model as per the details summarized in **Figure A1** of **Appendix A**. The current buildout has a total property area of approximately 300 ha.

For proposed buildout conditions, we have assessed the impact of the 600-ha potential future development based on the following hypothetical distributions (i.e., actual buildout locations may vary):

i) Approximately 300 ha would be developed within the designated service area, which represents full development of the portion of the designated service area which lies within the Lebo Creek watershed. The designated service area is bounded by:
   - North Limit – Mersea Road 8
   - South Limit – Mersea Road 6
   - East Limit – One farm lot east of Highway 77
   - West Limit – County Road 31

ii) Approximately 300 ha would be developed outside of the service area, where the following two scenarios were considered:
   a. Proposed Condition 1 (Pr1) – Development concentrated along Mersea Road 6, between Mersea Road 12 and County Road 37;
   b. Proposed Condition 2 (Pr2) – Development concentrated immediately east of service area, between Mersea Road 6 & 8.

2.1.4 Flow Generation

Model flows were generated using PCSWMM's RUNOFF and GROUNDWATER routines. The RUNOFF routine has commonly been used as part of the SWMM engine to produce runoff hydrographs based on kinematic wave theory of surface flow over a subcatchment. The latter GROUNDWATER routine is much less common, however it was found to be imperative to create a model that reasonably mimics actual runoff response of the study area.

The GROUNDWATER routine was incorporated not for the purposes of evaluating groundwater levels but rather to account for interflow. Interflow is the lateral movement of water in the unsaturated zone (the upper layer of soil) that transmits subsurface water to a watercourse prior to becoming groundwater. In simpler terms, this routine was used to mimic tile drainage of the agricultural fields. This model approach resonates with real-world conditions as the study area generally consists of very flat agricultural lands with impervious underlying clay soils.

Many input parameters are required for the model to estimate the runoff response of a particular subcatchment. Refer to **Appendix B** for a detailed discussion of the model setup and summary of parameters used.

2.1.5 Hydrologic Soil Group

The study area consists of the following soil types:

- 64% Brookston Clay Sand Spot Phase (B-s), classified as Hydrologic Soil Group D
- 15% Brookston Clay (Bc), classified as Hydrologic Soil Group D
- 21% Berrien Sandy Loam (Bel), classified as Hydrologic Soil Group C

See **Figure A2** of **Appendix A** for Essex Soils Map.

2.2 HYDRAULICS

2.2.1 Open Channel Sections

Open channel cross-sections were derived electronically using OMAFRA Lidar Digital Terrain Model (DTM) – Lake Erie Basin 2017(1). Cross-sections were taken at 100 metre intervals to capture variations in drain size and inverts throughout the study area. The Lidar derived sections were compared to a number of surveyed drain sections for ground-truthing and found to correlate very well with a typical variance of about 0.1 metres along the drain banks. A limitation of the Lidar product for this particular use is that it does not measure ground surface elevations below water – resulting in shallower drains that provide some level of conservatism with respect to hydraulic capacity assessments. However, survey information was gathered for a significant portion of the Lebo Creek and this information was integrated

(1) The elevation values used in the modelling analysis and included in this report are referenced to the Canadian Geodetic Vertical Datum of 1928 - 1978 Adjustment (CGVD-1928:1978). The OMAFRA Lidar DTM was provided in a different coordinate system, the Canadian Geodetic Vertical Datum of 2013 (CGVD-2013). This product was converted to CGVD-1928:1978 before inclusion in the model by applying a constant adjustment factor of 0.47 metres, which was determined by comparing known benchmarks within the study area.

into the Lidar surface in order to capture the actual drain bottom. This was particularly important in the downstream reach of Lebo Creek where the normal water level is notably higher than the drain bottom.

2.2.2 Open Channel Roughness

Field observations confirmed that the open drains within the study area can generally be classified as having light to moderate brush on banks. A roughness coefficient of 0.040 was applied to these sections. For dense wooded sections, a main channel roughness of 0.025 with overbank roughness of 0.12 was applied.

2.2.3 Culverts

Culvert types, diameters or box dimensions and inverts were determined by field survey. Entrance loss coefficients of 0.5 for culverts with headwalls and 0.9 for projecting culverts were applied. An exit loss of 0.5 was applied to all culverts.

2.3 CALIBRATION/VALIDATION

The Lebo Creek watershed characteristics such as soil type and slope are similar to that of the Ruscom watershed. Thus, our model setup consisted of the same hydrologic approach and parameters that were used in the Leamington Stormwater Master Drainage Study for the Reid Drain, Silver Creek and Big Creek Watersheds. This hydrologic approach was validated by calibration to the Ruscom River station flow and level gauge, which has been recording data for 50 years.

While the Lebo Creek watershed does include some Hydrologic C type soils (e.g., Berrien Sandy Loam), the underlying soils remain predominantly Hydrologic D type soils (e.g, clay), like the soils of the Ruscom watershed.

As validation to the foregoing transposition of hydrologic analysis from the Ruscom watershed to the Lebo watershed, we undertook eight (8) months of flow monitoring on the Lebo Creek from April through November 2020. The transposed data provided a good fit to observed data and only minor adjustments were deemed necessary to capture the variable hydrologic response of the sandy loam soils within the Lebo Creek watershed.

Similar to the afore-mentioned calibration to the Ruscom gauge, the Lebo Creek model results demonstrate that runoff flow rates and volumes from agricultural lands are significantly impacted by the antecedent moisture conditions (i.e., moisture conditions preceding the storm event). Flow rates and volumes tend to be higher in the early spring and late fall when the moisture conditions in the upper layer of the soil are generally wet to saturated. Meanwhile, flow rates and volumes tend to be lower in the summer months when soils are dry. This is due to greater subsurface storage to attenuate flows and shrinking clay soils that yield higher infiltration of water, which seeps below the drainage tiles as groundwater.

As an added measure of validation, we also performed the hydrologic analysis using the empirically-derived SCS methodology. Detailed information regarding the calibration/validation results is included in **Appendix B**.

3.0 ALLOWABLE RELEASE RATES

With a calibrated hydrologic/hydraulic model, a two-tiered allowable release rate approach considered the lower tier allowable release rate for frequent storms based on an erosion threshold analysis as well as an upper tier allowable release rate for larger, infrequent storm based on conveyance capacity analysis of the drainage system.

3.1 EROSION CONTROL

3.1.1 Erosion Potential

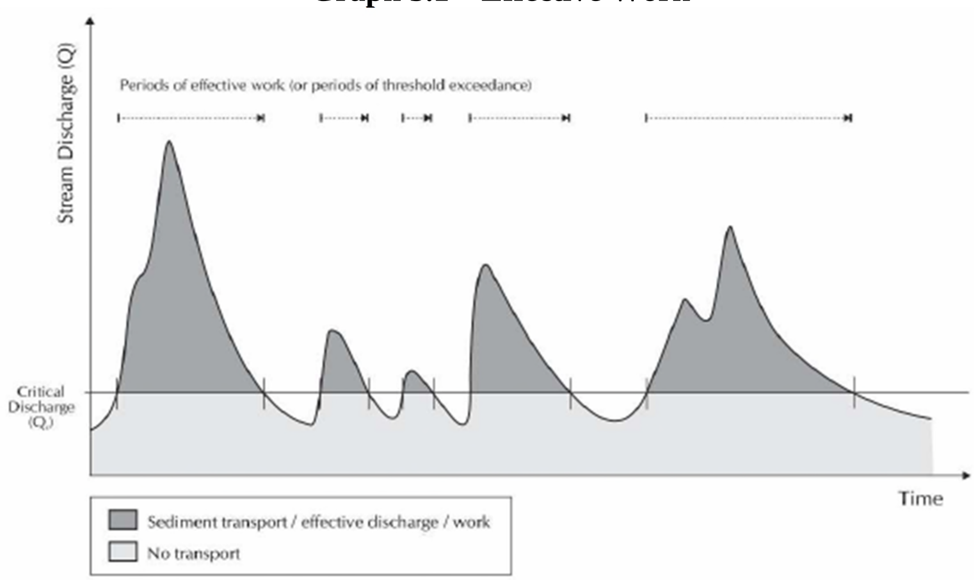
Increased flows and alterations to sediment supply associated with land use change can exacerbate erosion within receiving watercourses. In turn, this can lead to channel instability, degradation of aquatic habitat, and can create downstream hazards by increasing rates of bank erosion and channel migration (CVC, 2010).

While development with proper SWM controls will effectively reduce peak flows, the runoff volume will be significantly increased by development with a corresponding increase in outflow duration from the storage facility (i.e., SWM pond). Thus, while peak flows are being reduced, the prolonged flow duration from many stormwater ponds to the receiving drain can increase erosion potential. Given the scale and magnitude of impervious level proposed by greenhouse development, an erosion threshold assessment was undertaken to identify site specific erosion threshold discharge targets. **Appendix C** includes a technical memo outlining the erosion assessment and development of erosion threshold discharge rates.

3.1.2 Erosion Mitigation

The prescribed lower tier release rate serves to mitigate erosion from development by limiting effective work periods to pre-development conditions. As depicted in Graph 3.1 below, effective work occurs when flows exceed the critical discharge rate.

Graph 3.1 – Effective Work



Appendix D depicts discharge graphs at three selected locations within the watershed study under both the 5-year and 32mm storms discussed in section 2.1 of the report. The critical discharge is depicted by the "exceedance line" and volume of exceedance values represent the effective work – same principle as depicted in Graph 3.1 above. The lower tier allowable release rate has been adjusted to satisfy the design criteria, namely that: effective work under "Proposed" buildout conditions (per buildout limits of section 2.1.3) does not exceed the effective work of the "Existing" condition.

For erosion control, the lower tier release rate is to be applied for all storms up to 1:5-year 4-hour with Chicago distribution. Based upon the results of the analysis, a lower tier allowable release rate of **1.5 L/s/ha** is recommended to maintain post-development effective discharge (work) at or below pre-development rates.

The erosion assessment identified some existing localized erosion issues along the Lebo Creek and Hooker Drain, particularly within the naturalized sections. This is likely caused by one or more of the following factors:

- horizontal alignment of drain (i.e., erosion along the far bank of a bend or at culvert transitions);
- obstructions in drain (e.g., fallen trees);
- soil structure within the drain cross-section and potential bank seepage (e.g., non-cohesive sandy loam along drain banks and seepage at the sandy loam/clay interface);
- overly steep drain gradient.

A determination of whether or not these issues warrant remedial measures and/or drain improvements to mitigate potential future erosion is beyond the scope of this study. Notwithstanding, **Appendix D** includes discussion regarding potential erosion mitigation measures that could be considered where future drain maintenance and/or improvements are deemed warranted.

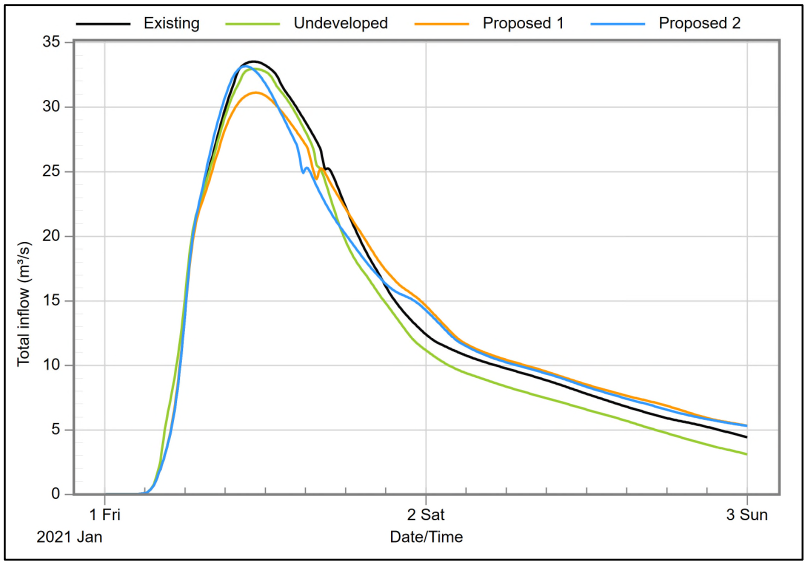
3.2 CONVEYANCE CAPACITY ANALYSIS

For infrequent storms that exceed the 1:5-year minor (lower tier) storm, an upper tier allowable release rate is provided to reduce pond drawdown times. A hydraulic analysis was performed to evaluate the overall conveyance capacity of the drainage networks within the Lebo Creek watershed. Based upon the results of the analysis, the following upper tier allowable release rates are recommended:

- ***Service Area: 12.0 L/s/ha;***
- ***Outside of Service Area: 6.0 L/s/ha.***

These controlled rates are such that the Lebo Creek watershed outflow will not exceed existing condition peak flow under proposed buildout conditions. Graph 3.2 below shows a comparison of 100-year peak rates at the Lebo Creek outfall to Hillman Marsh, located approximately 600 metres downstream (south) of Fox Run Road.

Graph 3.2 – Lebo Creek 100-Year Peak Flow @ Hillman Marsh



3.2.1 Minor Storm Capacity Assessment

Under minor storm conditions, the existing lands drain at relatively low rates, which are driven by agricultural tile drainage with limited surface runoff from the generally flat topography. The existing drainage system is able to fully convey flows under a 1:5-year minor storm event.

3.2.2 Major Storm Capacity Assessment

Under the 1:100-year design storm, the existing drainage spills its banks in a few locations. These locations can be identified on the floodline maps in **Appendix E** where a widened floodway is depicted.

When temporary surface ponding is widely spread across undeveloped agricultural lands, the risk of damage is usually minimal. However, as development is planned to progress and its density becomes more concentrated, the previous surface area available for short-duration surface ponding will be gradually reduced - resulting in more concentrated surface ponding with increasing depth and potential for damage. The root of this issue is that the study area does not benefit from an overland flow route whereby the increasing surface ponding can be safely routed away from buildings. Rather, the elevated roadways act as overland flow barriers which confine the surface ponding to its surrounding low-lying lands; a phenomenon which progressively increases the potential for flood damage.

Thus, the controlled discharge rates for proposed development combined with the widened floodways at existing spill locations will serve to mitigate potential adverse impacts from development.

3.3 FLOW CONTROLS AND POND DRAWDOWN

The recommended lower tier allowable release rate is relatively small, which results in a prolonged pond drawdown time. While this small rate is necessary to accommodate the proposed development and mitigate impacts to the receiving drainage system, it creates a potential for overly-extended pond drawdown times. At its extreme, a sluggish pond drawdown could be too slow to restore storage volume required to handle successive rainfall events. **Appendix F** presents an assessment of pond drawdown times based on historical rainfall.

Based on the foregoing, the flow control design should be mindful of reduced pond outflow from gravity outlets as a result of reduced head differential between fluctuating tailwater (i.e., drain water level) and fluctuating headwater (i.e., pond water level). It is recommended that the flow control element be sized based on an assumed average operating head rather than the more conservative maximum head approach that commonly considers the difference between the flow control invert and the maximum headwater elevation (e.g., pond high water level). While individual site conditions may vary, the following is suggested guidance for flow control sizing within this study area:

- *For Lower Tier Rate:*
  - Headwater Elev. = Pond High Water Level (HWL) based on 5-Year Storm
  - Tailwater Elev. = Drain HWL based on AES 32mm Storm
- *For Upper Tier Rate:*
  - Headwater Elev. = Midpoint between Pond HWLs for 5-Year & 100-Year Storms
  - Tailwater Elev. = Midpoint between Drain HWLs for AES 32mm & 100-Year Storms

Refer to **Appendix E** for tabular summary of HWLs for AES 32mm and 100-Year Storms.

Ultimately, flow controls should be sized to ensure that the pond can release 90% of the total 100-year storage volume within 5 days, starting from the time the pond reaches the 100-year HWL.

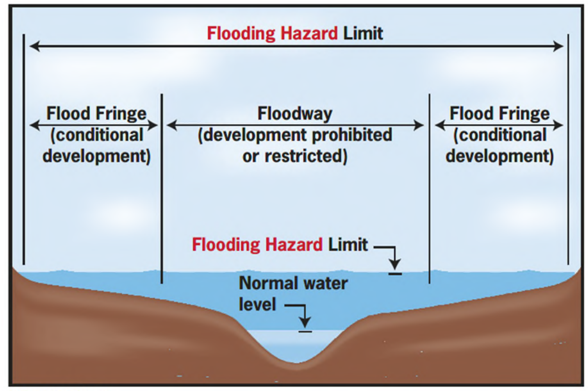
4.0 FLOOD CONTROL

This section discusses floodline mapping, floodproofing elevations, storage requirements to control peak flows from development and flood risks during winter conditions.

4.1 FLOODLINE MAPPING

Appendix E includes floodline mapping of all drains with an upstream limit of a minimum contributing areas that are less than the standard practice of 125 hectares as a minimum upstream drainage area for flood hazard mapping. The floodline elevations are derived from the Probable Maximum Storm as defined in section 2.1.2 with hydrologic parameters as listed in **Appendix B**. For purposes of determining floodline elevations, a sensitivity analysis was performed to assess the hydraulics with and without culverts. The maps display the maximum floodline elevation. **Appendix E** also includes a detailed tabular breakdown of elevation for various scenarios.

A two-zone floodway concept has been adopted for this study area. This concept allows for conditional development of low-lying areas outside of the designated floodway. Thus, the flood levels were calculated on this assumed future condition where the flood fringe flow area would be eliminated. Figure B-3 (right), taken from the MNRF 2002 Technical Guide – River & Stream Systems: Flooding Hazard Limit, illustrates this concept.



(NOT TO SCALE)
Figure B-3 - Two Zone Floodway - Floodfringe concept

The floodline elevations are based on a modelled floodway corridor as illustrated on the maps. This corridor typically consists of a minimum 8-metre setback from all drain banks, however the floodway is expanded (i.e., wider) through naturalized drain sections and floodplain areas are specified where added conveyance/storage is necessary to mitigate unacceptable rises in floodline elevations resulting from loss of existing floodplain storage. Refer to **Figure A3** for an overall plan depicting these corridors/areas. Note that ERCA may require additional setbacks beyond the limits of the designated floodway corridor (e.g., erosion hazard setbacks, preservation of valley lands, etc..). No development can occur in the designated floodways and floodplain areas, which represent a minimum corridor/area that must remain unobstructed and without the placement of fill until such time that it can be determined through a technical study and/or modelling assessment that these areas can be developed without impact to flood elevations or downstream erosion.

4.1.1 Stormwater Pond Attenuation

The foregoing MNRF 2002 Technical Guide provides guidance on floodline mapping. Most notably, it recommends that stormwater ponds should not be considered in floodline mapping (i.e., floodline mapping should assume uncontrolled flow from development). The intent of this guidance is to ensure that potential pond failures and subsequent uncontrolled flows are accounted for in downstream flow and corresponding floodline mapping. Given the unique characteristics of the region, we believe that this guidance is not applicable to the study area.

The study area conditions such as relatively flat topography, pond excavations below grade or with minor berming and ponds designed for Regulatory Storm conditions (i.e., 1:100-year storm in Essex County) would result in pond facilities that can be relied upon to attenuate runoff. The foregoing is prefaced on the condition that pond facilities are appropriately designed to store the 1:100-year Regulatory Storm and that the facilities are constructed and maintained to function as designed.

The findings and recommendations of this study have accounted for pond facilities in the floodline mapping, even those on private property, with the understanding that the Municipality acknowledges the responsibility to ensure that the ponds are properly designed and function as designed. Since 2018, the Municipality has included Special Provisions in new Site Plan Agreements related to greenhouse development to ensure proper long-term function of SWM ponds. These Provisions include the Municipality's legal right to inspect the pond during and post-construction, enforce maintenance or remedial works if required, and/or mobilize on private property to perform any necessary remedial works at the cost of the owner. Consistent with this approach, it is recommended that the Municipality continue to include such Special Provisions in all new Site Plan Agreements going forward.

Those ponds not subject to these Special Provisions within the Municipality's Site Plan Agreements (i.e., generally ponds that predate 2018), are subject to their terms and conditions to operate and maintain as mandated by the Ministry of the Environment, Conservation and Parks through their Stormwater Management Environmental Compliance Approval.

4.2 FLOODPROOFING

The floodline elevations provided in **Appendix E** provide a minimum standard for floodproofing elevations. Building elevations must satisfy minimum Essex Region Conservation Authority (ERCA) floodproofing requirements with regards to minimum freeboard – which typically requires that the minimum lowest opening into all buildings should be at least 0.3 metres above the floodline elevation or the on-site calculated 1:100-year water storage elevation, whichever is greater.

For general reference purposes, the floodline maps in **Appendix E** depict existing building footprints and denote an approximate existing grade elevation. It should be understood that these elevations represent an approximate estimate of existing ground elevation as measured by the Lidar DTM at the centroid of each building envelope. As such, the actual existing ground elevation may vary along the perimeter of a building, particularly larger buildings. Moreover, lowest opening elevations may vary from existing ground elevations.

4.3 STORAGE AND FREEBOARD REQUIREMENTS

Consistent with the floodline mapping, the 1:100-year 6-hour storm is recommended for evaluating 1:100-year design storage requirements of the proposed sites.

With regards to potential impacts of climate change, it is recommended that a 39% increase from 108.1mm to 150mm be evaluated as a "stress test" event to ensure sufficient freeboard is provided to mitigate impacts of increased rainfall.

- A minimum freeboard depth – as measured from the 1:100-year design high water level to the lowest building opening – should be the greater of 0.3 metres or the storage depth required to store excess runoff exceeding the 1:100-year level. Excess runoff volumes should be determined from the "stress test" event, which is herein proposed to be 150mm of rainfall with SCS Type II distribution.

4.4 WINTER CONDITIONS

With proposed large-scale greenhouse development changing the landscape of the pre-existing agricultural lands, the potential for ice buildup in the open channel drainage systems creates a significant flood risk that would otherwise result in relatively little to no damage from surface ponding across agricultural lands. There are several open drains alongside roadways which are subject to road salting and snow plow operations. These operations significantly increase the potential for ice buildup in the drains, which could result in a partial to full blockage of the conveyance channel and consequently, flooding of greenhouse development.

The prescribed floodline elevations of this study do not account for the potential risk associated with ice blockage, nor can it reasonably quantify the level of risk associated with such an event. However, the following is a list of potential risk mitigation measures:

- Deepening of floodplain areas within floodway corridor for added conveyance/storage.
- Drawdown of ponds during winter season to provide buffer storage and corresponding reduction in flows from snowmelt and/or winter rainfall events.

5.0 CONCLUSION

5.1 SUMMARY

- Significant greenhouse development is proposed within the Municipality of Leamington. To accommodate the proposed large-scale development and mitigate any adverse impacts to the receiving watercourses/municipal drains, a holistic stormwater management approach is required – one that evaluates the impacts of **increased stormwater runoff volume** at the watershed scale.
- The study recommends a two-tiered allowable release rate approach. A lower tier release rate is to mitigate long-term erosion potential from increased runoff volume resulting from development. An upper tier release rate is to provide secondary outflow during infrequent storm events, thus reducing storage volume requirements and drawdown times during these infrequent storm events.
- Flood control measures are recommended to a **minimum standard** equal to a 1:100-year return period. Section 1.3 explains return periods in relation to level of service and risk.
- The municipality has projected the following proposed ultimate buildout limits for the purposes of completing this study:
    - **25% buildout, equivalent to 900 hectares**
- Current buildout conditions have been accounted for in the floodline mapping as per the details summarized in **Figure A1** of **Appendix A.**
- The Lebo Creek model results demonstrate that flow rates and volumes are significantly impacted by the antecedent moisture conditions (i.e., moisture conditions preceding the storm event). Flow rates and volumes tend to be higher in the early spring and late fall when the moisture conditions in the upper layer of the soil are generally wet to saturated. Meanwhile, flow rates and volumes tend to be lower in the summer months when soils are dry. This is due to greater subsurface storage to attenuate flows and shrinking clay soils that yield higher infiltration of water, which seeps below the drainage tiles as groundwater.

5.2 RECOMMENDATIONS

1. For erosion control, a lower tier release rate of **1.5 L/s/ha** is to be applied for all storms up to 1:5-year 4-hour with Chicago distribution;

2. For infrequent storms that exceed the 1:5-year minor (lower tier) storm, the following upper tier allowable release rates are recommended:
   - ***Service Area: 12.0 L/s/ha;***
   - ***Outside of Service Area: 6.0 L/s/ha.***

3. Storage requirements should generally be based on the 1:100-year 6-hour storm (99 millimetres) with Probable Maximum Storm distribution as follows:

1st hour – 8%	*3rd hour – 11%*	*5th hour – 15%*
2nd hour – 9%	*4th hour – 49%*	*6th hour – 8%*

- The site should also be designed to contain the "stress test" event volume within the property and below the lowest building opening.

- A minimum freeboard depth – as measured from the 1:100-year design high water level to the lowest building opening – should be the greater of 0.3 metres or the storage depth required to store excess runoff exceeding the 1:100-year level. Excess runoff volumes should be determined from the "stress test" event, which is herein proposed to be 150mm of rainfall with SCS Type II distribution.

4. **Important Note to Proponents and Practitioners:** Minimum freeboard depth is a floodproofing measure based on a minimum standard level of service, which has been defined herein as a 1:100-year design storm. (Refer to section 1.3 for further discussion on level of service and risk). The design criteria herein do not guarantee that a given site will never flood but rather, they provide mitigating measures to achieve a low risk of flooding. Where an individual site's potential damages due to flooding are high, it is the practitioner's responsibility to design to a more conservative standard or to provide a sufficient emergency flow route in accordance with the proponent's site-specific needs.

5. The findings and recommendations of this study have accounted for pond facilities and controlled flow rates based upon the current buildout condition depicted in **Figure A1** of **Appendix A**. These flow restrictions, even those on private property, are accounted for with the understanding that the Municipality acknowledges the responsibility to ensure that these existing ponds as well as future ponds are properly designed and function as designed. As such, the Municipality must secure their legal right to inspect the pond construction, enforce maintenance or remedial works if required, and/or mobilize on private property to perform any necessary remedial works at the cost of the owner.

6. Stormwater ponds are to be built as landforms (i.e., pond shall not be raised above ground via dykes which could potentially fail).

7. A two-zone floodway concept has been adopted for this study area. The floodline elevations are based on a modelled floodway corridor as illustrated on the maps. This corridor typically consists of a minimum 8-metre setback from all drain banks, however the floodway is expanded (i.e., wider) through naturalized drain sections and floodplain areas are specified where added conveyance/storage is necessary to mitigate unacceptable rises in floodline elevations resulting

from loss of existing floodplain storage. Refer to **Figure A3** for an overall plan depicting these corridors/areas. Note that ERCA may require additional setbacks beyond the limits of the designated floodway corridors (e.g., erosion hazard setbacks, preservation of valley lands, etc..).

No development can occur in the designated floodway corridors and temporary floodplain areas, which represent a minimum corridor/area that must remain unobstructed and without the placement of fill until such time that it can be determined through a technical study and/or modelling assessment that these areas can be developed without impact to flood elevations or downstream erosion.

Beyond the designated limits of the floodway corridors and floodplain areas, the remaining areas within the study limits are to be considered as flood fringe – which is conditional development subject to meeting specified design criteria to the satisfaction of the Municipality and Conservation Authority.

8. Flow controls sizing should be sized based on the recommendations of section 3.3 herein.

9. The model should be kept up-to-date as a living model that incorporates new development as it occurs. This would allow for evaluation of impacts from potential drainage channel / floodplain improvements on a site-by-site basis.

We trust that you will find the above satisfactory at this time; however, should you have any questions relating to same, please contact us immediately. Thank you for your co-operation and assistance with this project.

All of which is respectfully submitted,

Landmark Engineers

Alain Michaud, P.Eng.

LICENSED PROFESSIONAL ENGINEER
A. D. MICHAUD
100098942
2022-09-20
PROVINCE OF ONTARIO

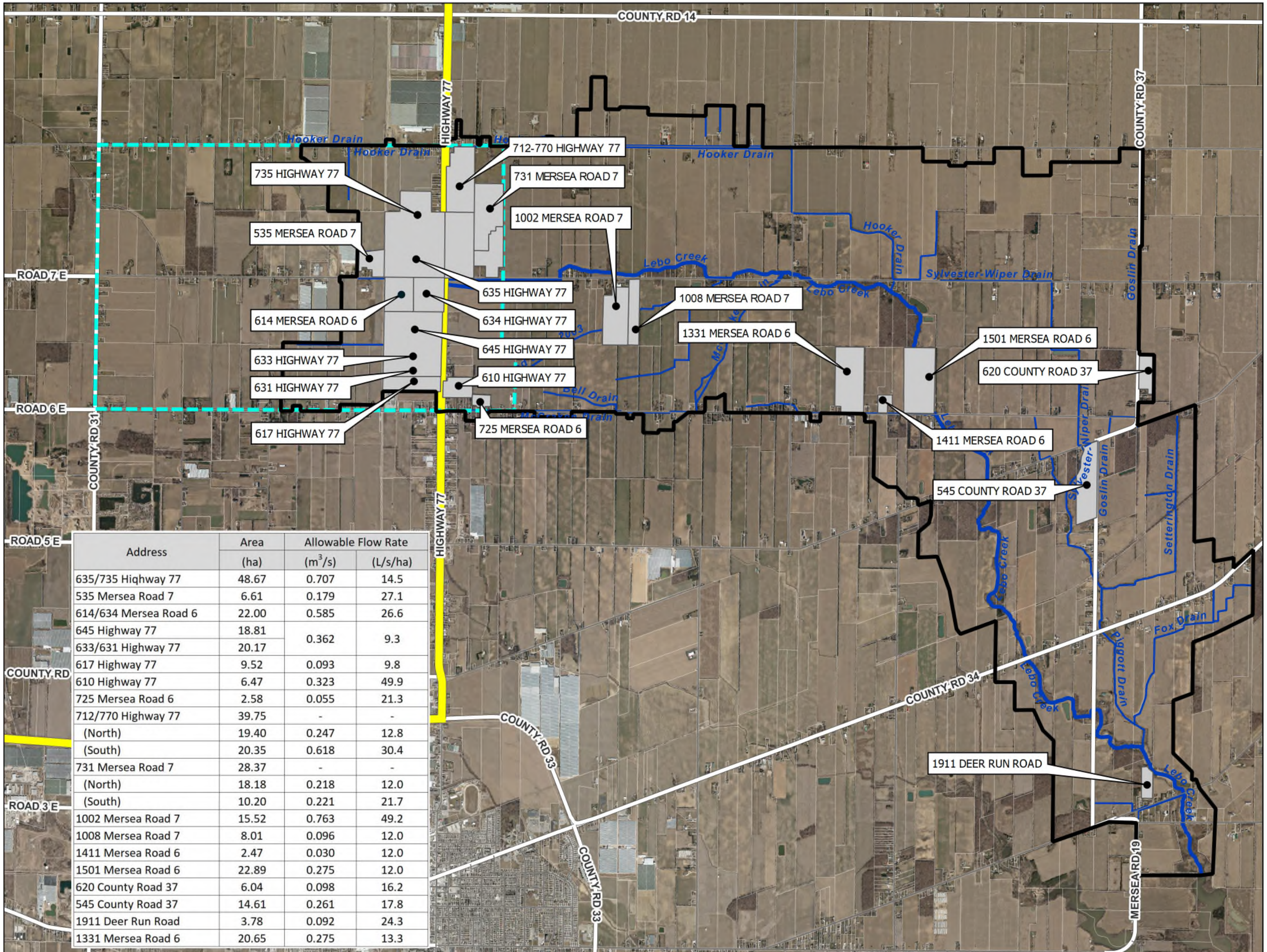
Peralta Engineering

Heide Mikkelsen, P.Eng.

LICENSED PROFESSIONAL ENGINEER
H. C. MIKKELSEN
2022-09-20
PROVINCE OF ONTARIO

APPENDIX A

FIGURES



Address	Area (ha)	Allowable Flow Rate (m^3/s)	Allowable Flow Rate (L/s/ha)
635/735 Highway 77	48.67	0.707	14.5
535 Mersea Road 7	6.61	0.179	27.1
614/634 Mersea Road 6	22.00	0.585	26.6
645 Highway 77	18.81	0.362	9.3
633/631 Highway 77	20.17		
617 Highway 77	9.52	0.093	9.8
610 Highway 77	6.47	0.323	49.9
725 Mersea Road 6	2.58	0.055	21.3
712/770 Highway 77	39.75	-	-
(North)	19.40	0.247	12.8
(South)	20.35	0.618	30.4
731 Mersea Road 7	28.37	-	-
(North)	18.18	0.218	12.0
(South)	10.20	0.221	21.7
1002 Mersea Road 7	15.52	0.763	49.2
1008 Mersea Road 7	8.01	0.096	12.0
1411 Mersea Road 6	2.47	0.030	12.0
1501 Mersea Road 6	22.89	0.275	12.0
620 County Road 37	6.04	0.098	16.2
545 County Road 37	14.61	0.261	17.8
1911 Deer Run Road	3.78	0.092	24.3
1331 Mersea Road 6	20.65	0.275	13.3

LEGEND:

- WATERSHED BOUNDARY
- SITES WITH PRE-EXISTING RATES AS PROVIDED BY N.J. PERALTA
- SERVICED AREA

Peralta Engineering

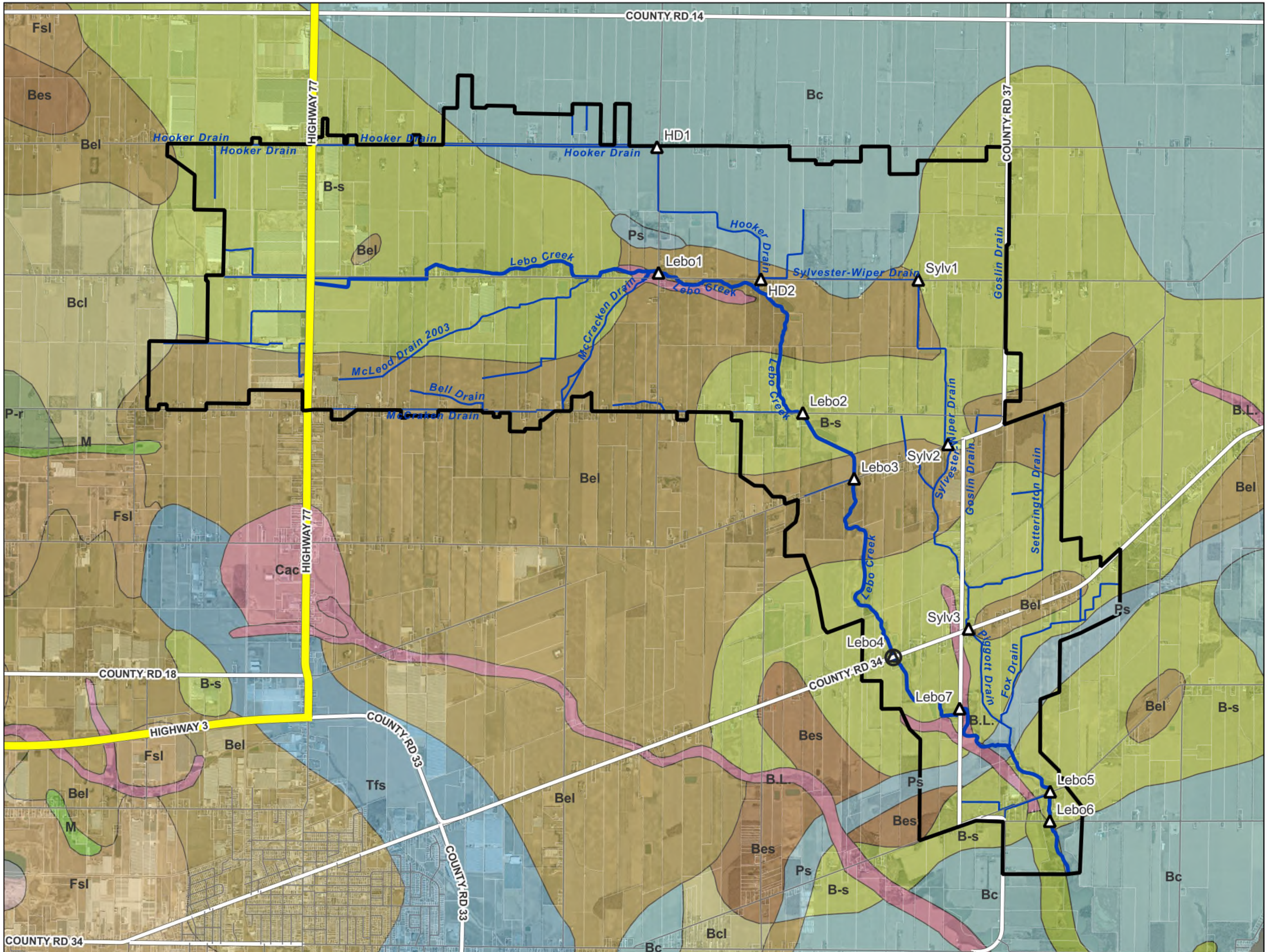
Landmark Engineers Inc.

client: THE MUNICIPALITY OF LEAMINGTON

project: LEBO CREEK MASTER DRAINAGE STUDY

title: CURRENT BUILDOUT

drawn by / date	EMK AUG 2022	project no.	19-023
designed by / date		figure no.	A-1
checked by / date	ADM AUG 2022	scale	1:40,000



LEGEND:

WATERSHED BOUNDARY

SOIL TYPE

- BERRIEN SAND (Bes)
- BERRIEN SANDY LOAM (Bel)
- BOTTOM LAND (B.L.)
- BROOKSTON CLAY SAND SPOT PHASE (B-s)
- BROOKSTON CLAY (Bc)
- BROOKSTON CLAY LOAM (Bcl)
- BURFORD LOAM (Bg)
- CAISTOR CLAY (Cac)
- COLWOOD FINE SANDY LOAM (Cdl)
- FOX SANDY LOAM (Fsl)
- MARSH (Ma)
- MUCK (M)
- PARKHILL LOAM RED SAND SPOT PHASE (P-r)
- PARKHILL LOAM (Pl)
- PLAINFIELD SAND (Ps)
- TOLEDO CLAY (Toc)
- TUSCOLA FINE SANDY LOAM (Tfs)

SURVEY STATIONS

- FLOW MONITORING STATION
- SURVEY SITE

Peralta Engineering

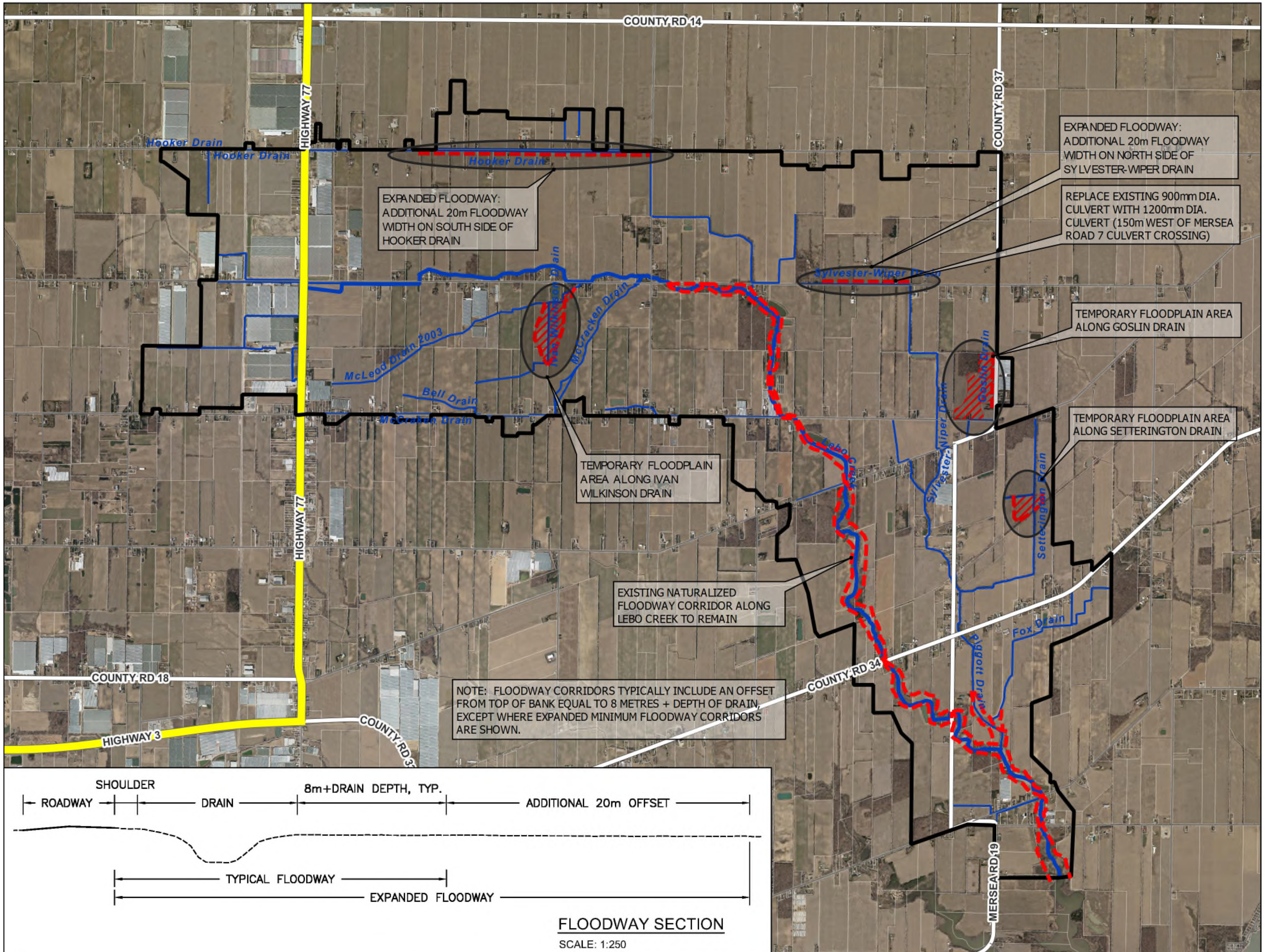
Landmark Engineers Inc.

client: THE MUNICIPALITY OF LEAMINGTON

project: LEBO CREEK MASTER DRAINAGE STUDY

title: SOIL MAP

drawn by / date	EMK / AUG 2022	project no.	19-023
designed by / date		figure no.	A-2
checked by / date	ADM / AUG 2022	scale	1:40,000



Peralta Engineering

Landmark Engineers Inc.

client	THE MUNICIPALITY OF LEAMINGTON
project	LEBO CREEK MASTER DRAINAGE STUDY
title	EXPANDED FLOODWAY CORRIDORS & FLOODPLAIN STORAGE COMPENSATION AREAS
drawn by / date	EMK / SEP 2022
project no.	19-023
designed by / date	
figure no.	A-3
checked by / date	ADM / SEP 2022
scale	1:40,000

APPENDIX B

MODEL SETUP AND CALIBRATION

1.0 MODEL SETUP

1.1 RUNOFF ROUTINE

The parameters listed in Table 1.1 below were applied to the model subcatchments based on their respective soil type.

Table 1.1 – Design Parameters for RUNOFF Routine

Soil Type	Infiltration Green-Ampt			Dp
	Su	k	IMD	
Bc	180	0.5	0.10	10
B-s	180	1.3	0.10	10
Bel	250	3.0	0.26	10

where:

Su = suction head, mm
k = saturated hydraulic conductivity, mm/hr
IMD = initial moisture deficit
Dp = pervious depression storage, mm

1.2 GROUNDWATER ROUTINE

The parameters listed in Table 1.2 below were applied to the model subcatchments based on their respective soil type.

Table 1.2 – Design Parameters for GROUNDWATER Routine

Soil Type	Aquifer		
	k	IM	DS
Bc	0.5	0.38	5MD
B-s	1.3	0.38	5MD
Bel	3.0	0.19	10MD

where:

k = saturated hydraulic conductivity, mm/hr
IM = initial moisture
DS = deep seepage, mm/hr
MD = moisture deficit

Lateral Flow

The lateral flow equation includes coefficients and exponents which were calibrated to match observed flows, thus mimicking the runoff response of the tile drainage systems. The following parameters were derived from model calibration:

- A1 = 0.022 (Bc); 0.01 (B-s, Bel)
- B1 = 1 (all soil types)
- A2, B2, A3 = 0

Initial/Threshold Water Table Elevation

Initial water table elevation corresponds to the starting water table elevation whereas the threshold water table elevation represents the minimum elevation for tile drainage (interflow) to occur. A 0.3m thick upper layer of soil was assumed to mimic subsurface water that is temporarily stored and slowly drained by tile drainage (interflow) prior to becoming groundwater. The surface elevation of each subcatchment groundwater layer was set at 0.4m above the drain invert elevation and the initial/threshold water table elevation was set at 0.3m below surface elevation.

Soil Parameters

The following soil parameters were used:

- Porosity = 0.48 (Bc, B-s)); 0.45 (Bel)
- Wilting Point = 0.27 (Bc, B-s); 0.09 (Bel)
- Field Capacity = 0.38 (Bc, B-s); 0.19 (Bel)
- Conductivity Slope = 30
- Tension Slope = 10

2.0 MODEL CALIBRATION

2.1 OBSERVED DATA

Flow monitoring data was collected by AMG Environmental between April 2020 and December 2020. One (1) flow monitoring location was selected to measure both water levels and velocity. Flow is typically derived from velocity readings based on the hydraulic cross-section. However, the velocity readings obtained did not provide reliable data and thus the model calibration relied solely upon the level data. **Figure B1** herein shows the observed levels throughout the monitoring period as well as the selected events used for model calibration.

2.2 RAINFALL

The original model calibration strategy considered the availability of rain gauges in the vicinity of the study area and determined that there were a sufficient number of private/public gauges to support the model calibration efforts. During the flow monitoring period, we discovered that the ERCA gauge at Hillman Marsh was not recording rainfall. This issue was eventually resolved, however, this gauge did not provide any readings during the flow monitoring period. More importantly, during our model calibration efforts, we discovered that the private gauges were not reliably capturing the amount/intensity of rainfall that would intuitively be expected given the observed peak flows in the flow monitoring data. We suspected that the gauges were not capturing the spatial variation of the selected calibration rainfall events.

As a result of the above, we undertook a radar rainfall analysis to better understand the spatial variation of rainfall over the study area. We found that the radar rainfall captured significant spatial variation for the selected calibration rainfall events. We then calibrated the radar rainfall amounts to match rainfall amounts measured on the ground by private gauges. Using this calibrated radar information as rainfall inputs into the model resulted in simulated flows and levels that compared very well with observed data.

The model calibration efforts benefitted from a number of useful rainfall events captured during the eight-month monitoring period. A total of three (3) rainfall events were selected for calibration, which varied by season, magnitude and intensity. Table 2.2 below provides a summary of the calibration events, where the rainfall amounts are based on the calibrated (i.e., adjusted to match ground rain gauge recordings) radar rainfall averaged over the entire watershed.

Table 2.2 – Rainfall Events Used for Calibration

EVENT	FROM		TO		DUR. (hrs)	RAINFALL mm
1	14-May-2020	10:00	19-May-2020	14:00	124	63
2	26-Jun-2020	10:00	27-Jun-2020	20:00	34	51
3	26-Aug-2020	7:00	29-Aug-2020	5:00	70	91

Events 1 to 3 were compared to Windsor Airport IDF data to assess their relative magnitude, refer to **Figure B2** herein for IDF curve comparisons. Event 1 consisted of several days of low intensity rainfall, which was less than a 2-year storm return period. Event 2 was a relatively high-intensity rainfall event that exceeded a 2-year storm for a 6-hour duration. Event 3 was a multi-cell summer storm with several short-duration high-intensity rainfalls that were individually less intense than a 2-year return period but combined for a total rainfall equal to a 10-year storm over a 24-hour duration.

2.3 CALIBRATION PARAMETERS

The calibration process was largely driven by adjustments to rainfall loss parameters such as infiltration and depression storage. The soil parameters were tailored to suit antecedent moisture conditions for each specific calibration event. The following tables provide a summary of the parameters used for each event. As additional model validation, the tables below also summarize the parameters used for the SCS hydrology simulations.

Table 2.3.1 – Event 1 Calibration Parameters

Soil Type	SWMM5 HYDROLOGY							SCS HYDROLOGY		
	Infiltration Green-Ampt			Aquifer			Dp			
	Su	k	IMD	k	IM	DS		CN	IA	PF
Bc	180	0.01	0.10	0.5	0.42	0	0	94	1	100
B-s	180	0.1	0.10	1.3	0.42	0	0	89	1	100
Bel	250	3.0	0.26	3.0	0.19	12MD	10	80	20	100

Table 2.3.2 – Event 2 Calibration Parameters

Soil Type	SWMM5 HYDROLOGY							SCS HYDROLOGY		
	Infiltration Green-Ampt			Aquifer			Dp			
	Su	k	IMD	k	IM	DS		CN	IA	PF
Bc	180	0.01	0.10	0.5	0.42	MD	10	94	10	100
B-s	180	0.1	0.10	1.3	0.42	MD	10	89	10	100
Bel	250	3.0	0.26	3.0	0.19	12MD	10	80	20	100

Table 2.3.3 – Event 3 Calibration Parameters

Soil Type	SWMM5 HYDROLOGY							SCS HYDROLOGY		
	Infiltration - Green Ampt			Aquifer			Dp			
	Su	k	IMD	k	IM	DS		CN	IA	PF
Bc	180	3.0	0.21	3.0	0.38	10MD	20	70	0.3S	100
B-s	180	5.0	0.21	5.0	0.38	35MD	20	60	0.3S	100
Bel	250	10.0	0.36	10.0	0.19	38MD	20	50	0.3S	100

where:

Su = suction head, mm
k = hydraulic conductivity, mm/hr
IMD = initial moisture deficit
IM = initial moisture
DS = deep seepage, mm/hr
MD = moisture deficit (i.e., porosity – moisture content)
Dp = pervious depression storage, mm
CN = curve number
IA = initial abstractions, mm
PF = peaking factor

2.4 CALIBRATION RESULTS

Figure B3 herein illustrates the good fit of observed versus simulated levels using both the SWMM5 hydrology and SCS hydrology methods. **Figure B4** herein illustrates the simulated flows for each of the calibration events. It is apparent in this figure that the dry antecedent moisture conditions in late August have a profound impact on runoff as compared to the wet conditions in mid-May.

Figure B5 herein illustrates an excellent fit of 100-year simulated flows using both the SWMM5 and SCS hydrology, based on the design parameters listed in **Table 2.4** below.

Table 2.4 – Design Parameters for SCS Hydrology

Soil Type	SCS HYDROLOGY		
	CN	IA	PF
Bc	85	10	100
B-s	82	10	100
Bel	75	20	100

where:

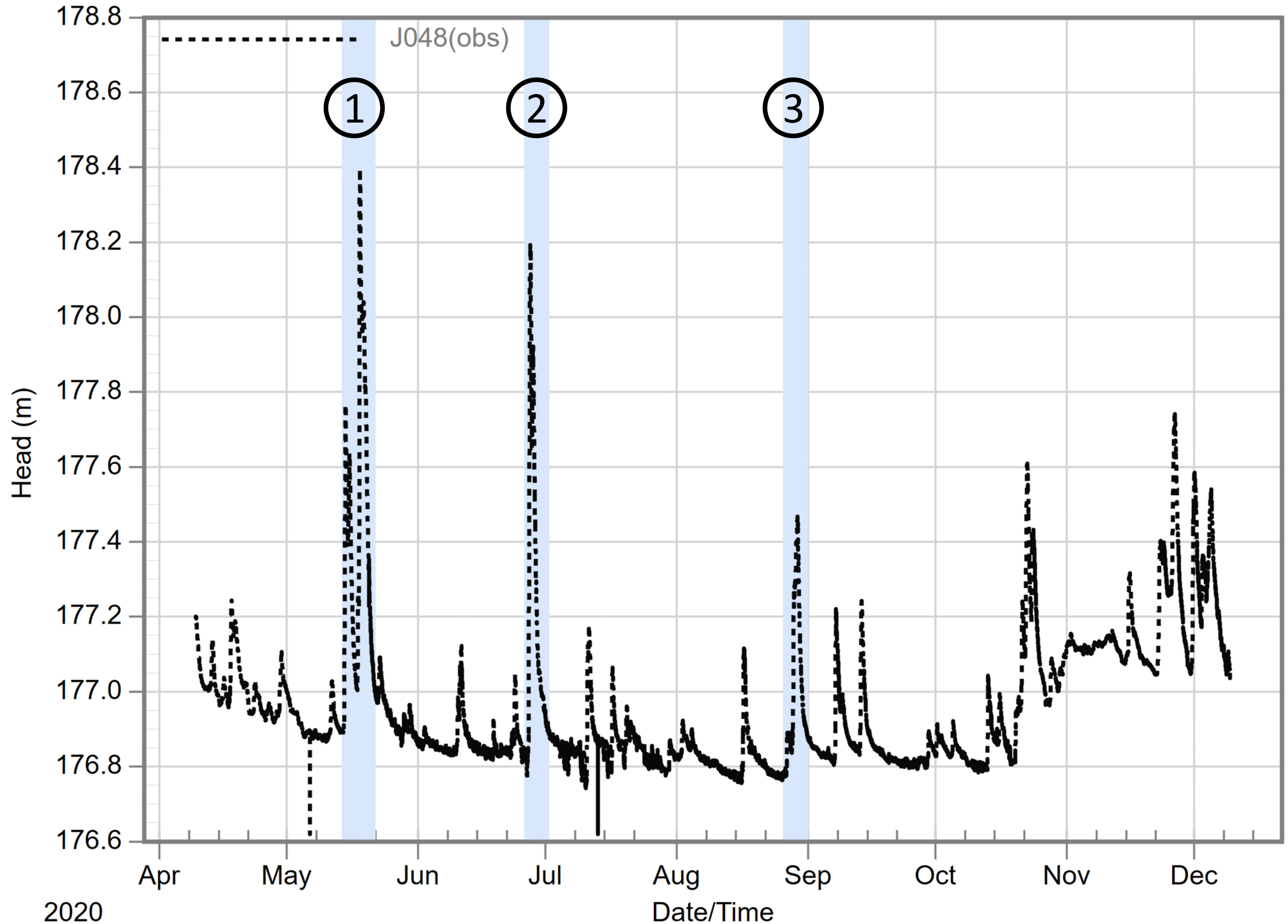
CN = curve number
IA = initial abstractions, mm
PF = peaking factor

CALIBRATION EVENTS

① Event 1:
May 14-19, 2020

② Event 2:
June 26-27, 2020

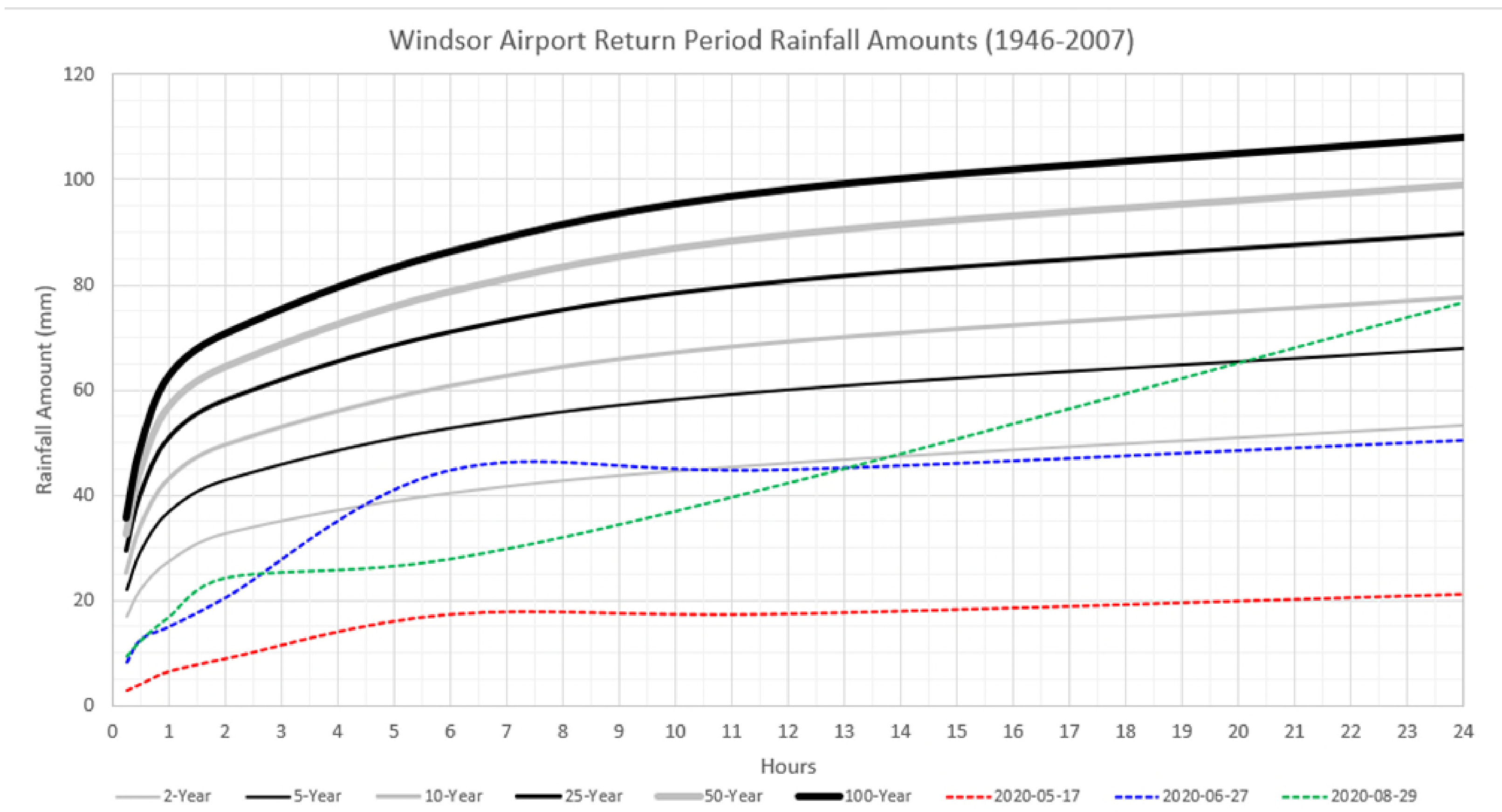
③ Event 3:
Aug 26-29, 2020



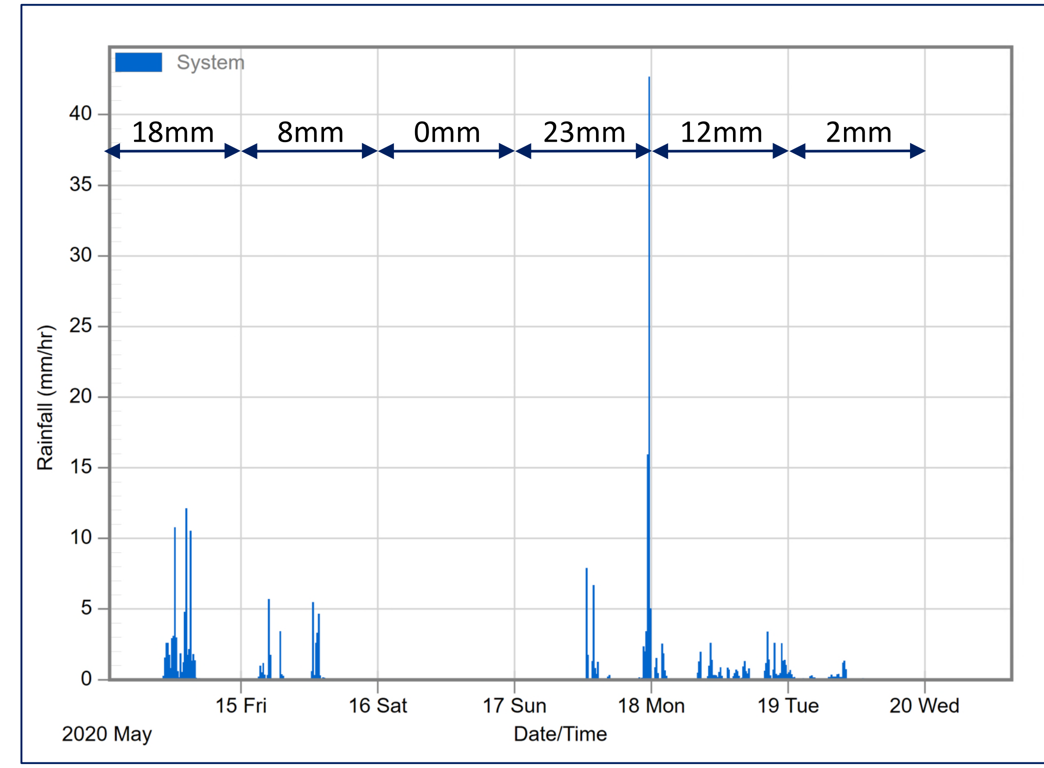
Landmark Engineers Inc.

NOTE: FLOW MONITORING DATA MEASURED ON LEBO CREEK AT UPSTREAM SIDE OF COUNTY ROAD 34

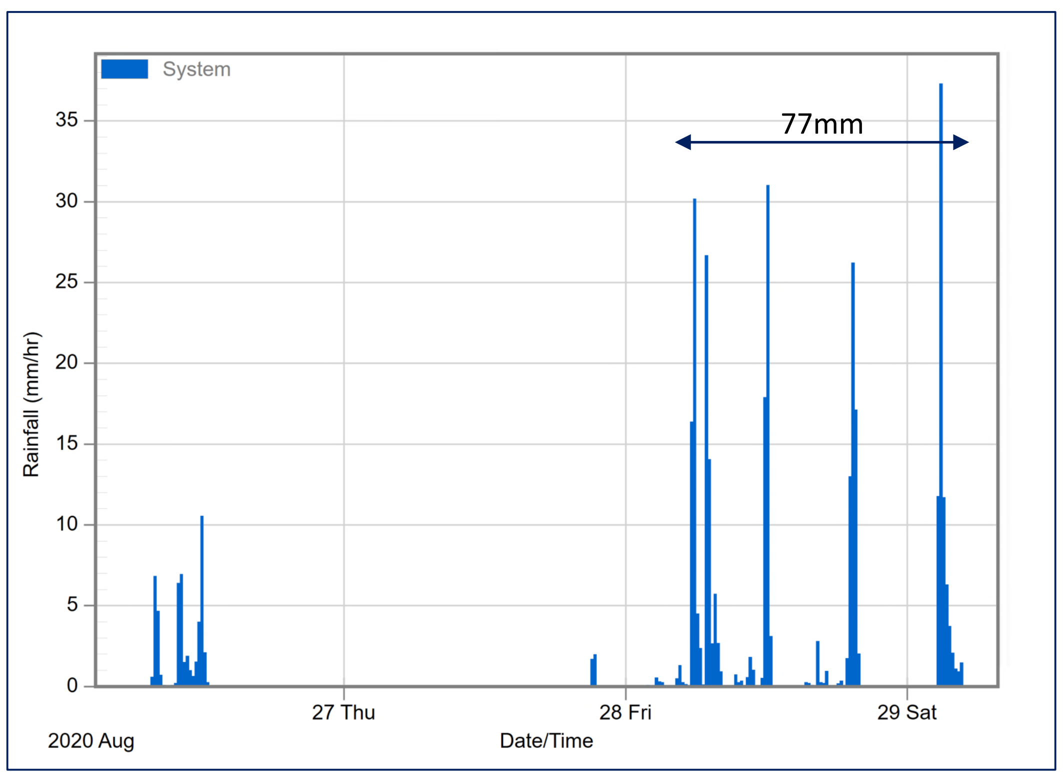
Title: FLOW MONITORING DATA	Date: JUNE 2022	FIGURE	
	Scale: NTS	B1	
Project: LEBO CREEK MASTER DRAINAGE STUDY	Project No. 19-023		



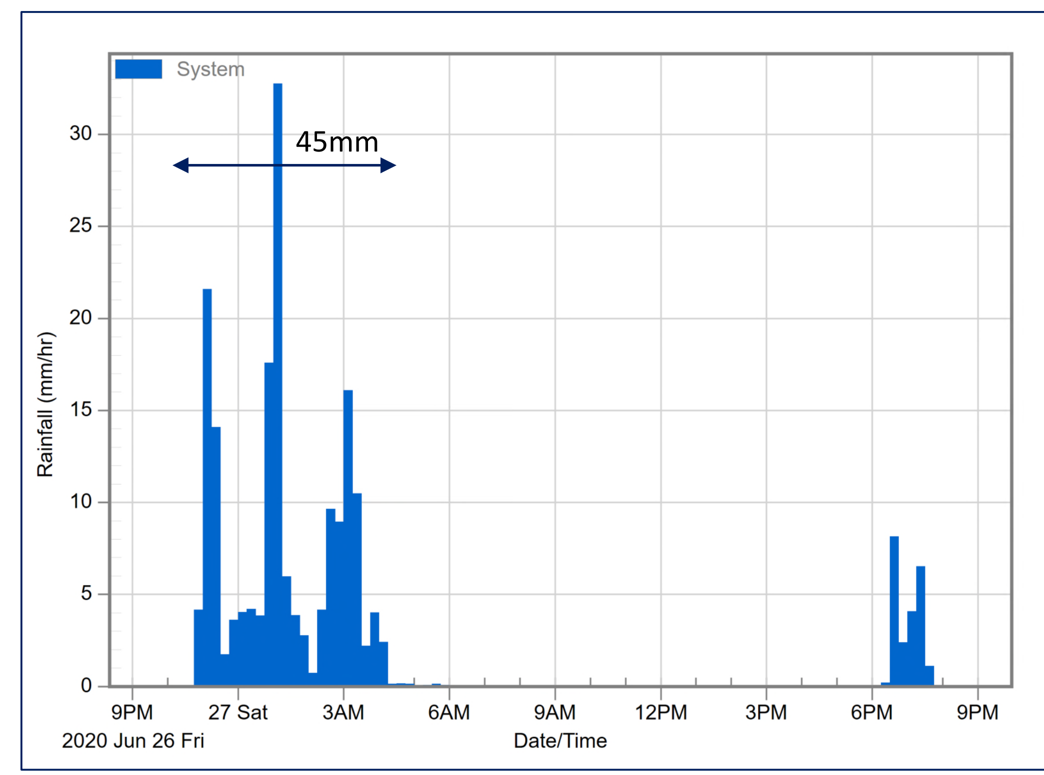
EVENT 1: MAY 14-19, 2020 – 63 mm



EVENT 3: AUGUST 26-29, 2020 – 91 mm



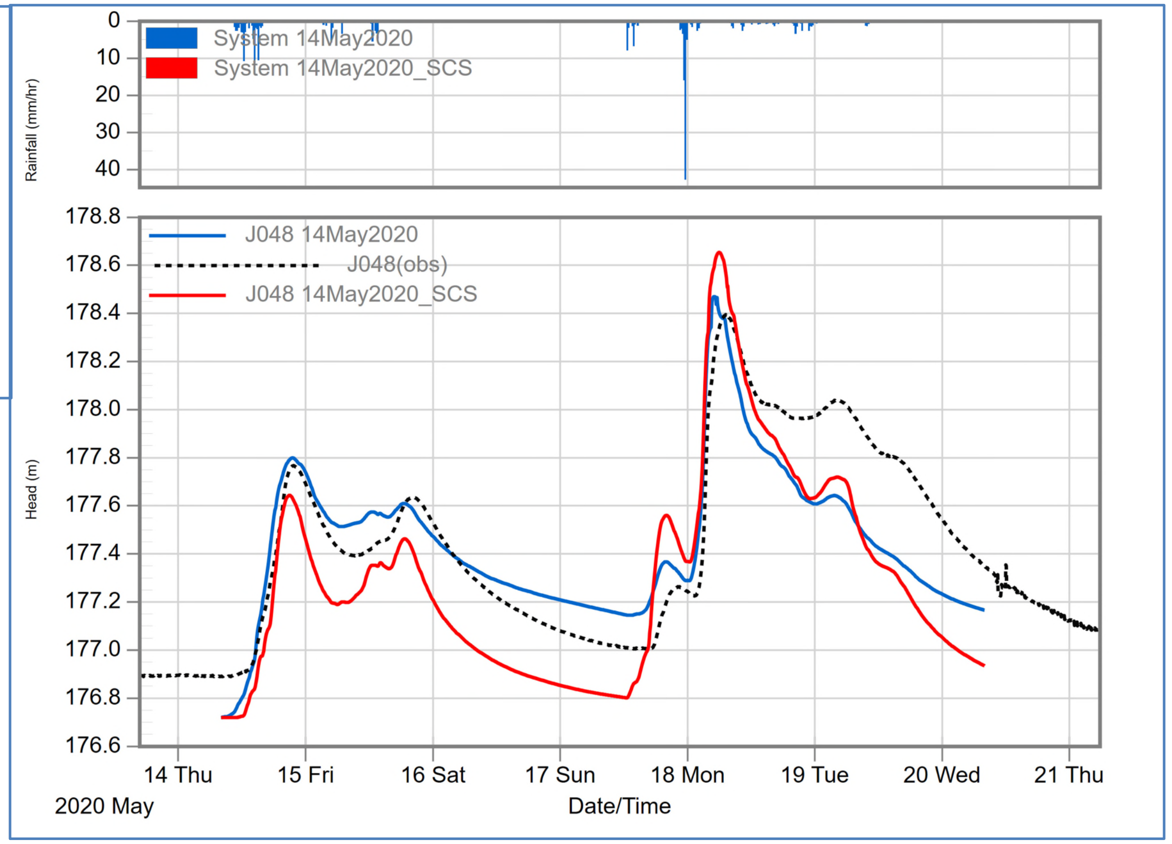
EVENT 2: JUNE 26-27, 2020 – 51 mm



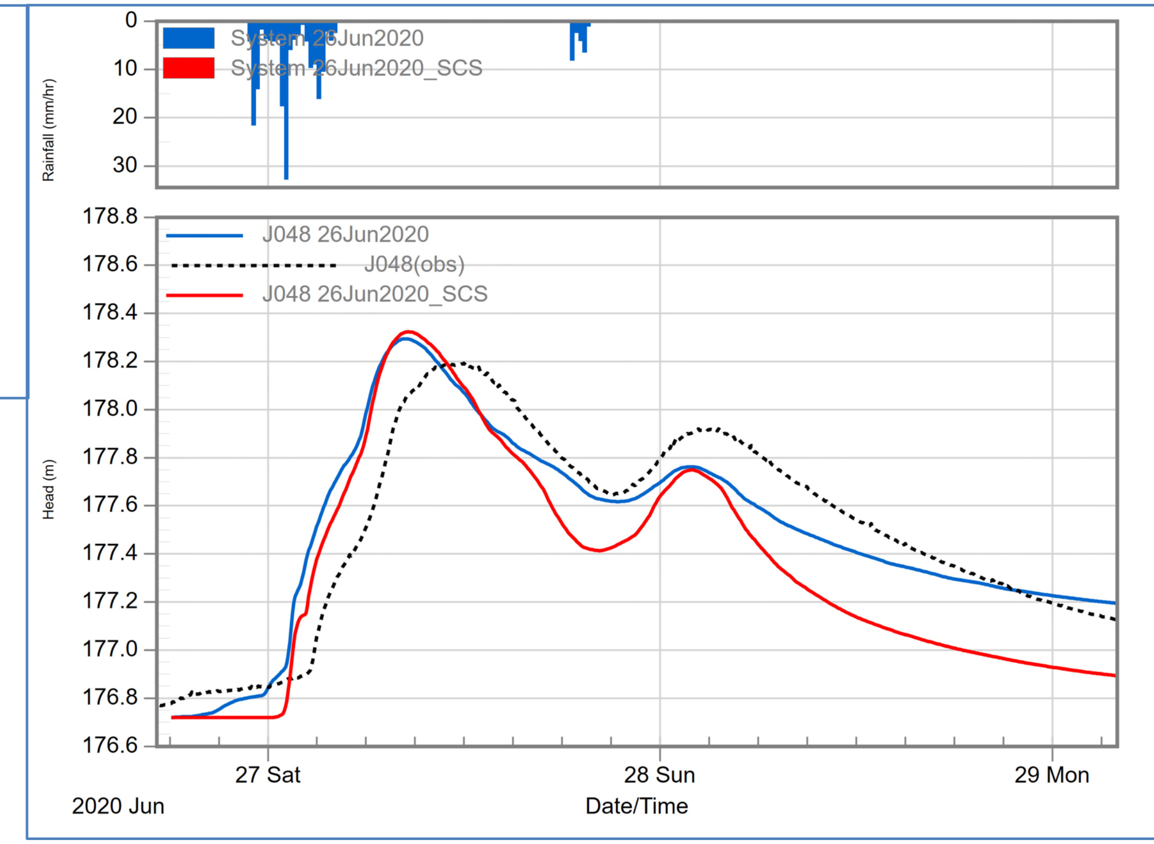
Landmark Engineers Inc.

Title	Date	FIGURE
RAINFALL HYETOGRAPHS	JUNE 2022	B2
	Scale: NTS	
Project: LEBO CREEK MASTER DRAINAGE STUDY	Project No.: 19-023	

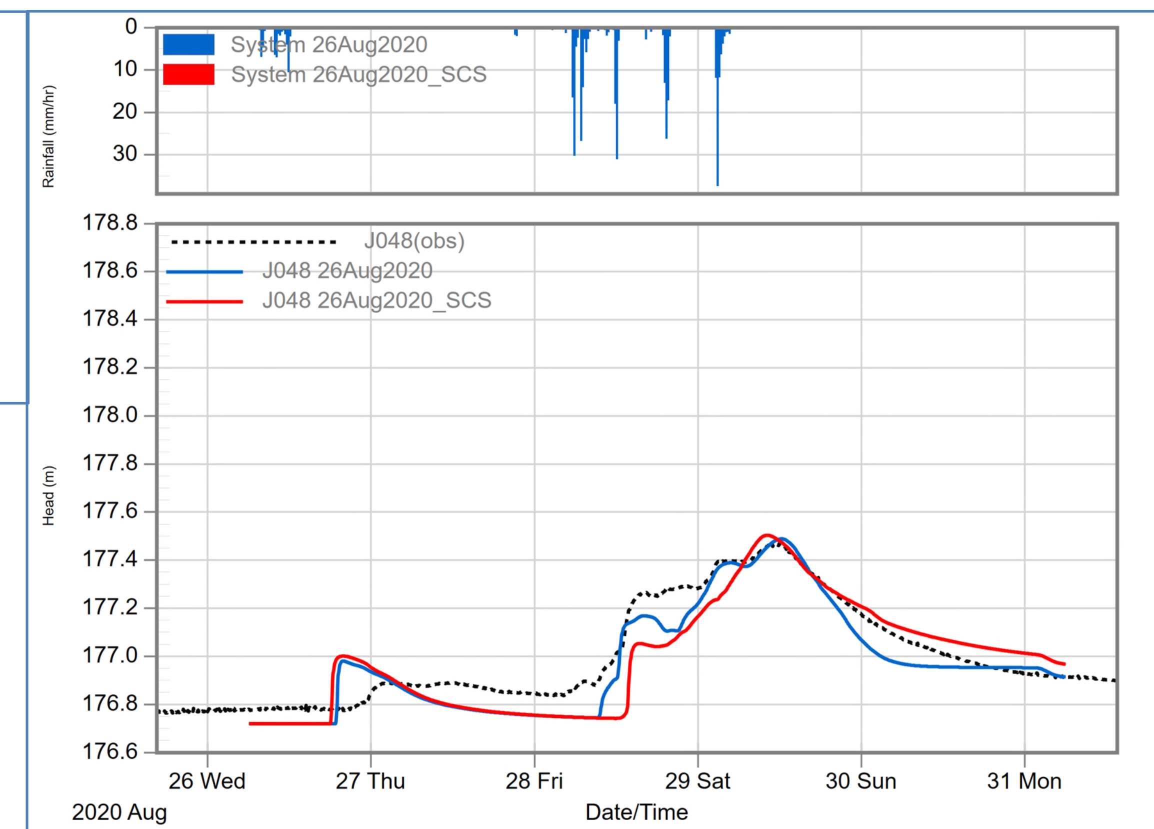
Event 1: May 14-19, 2020



Event 2: June 26-27, 2020



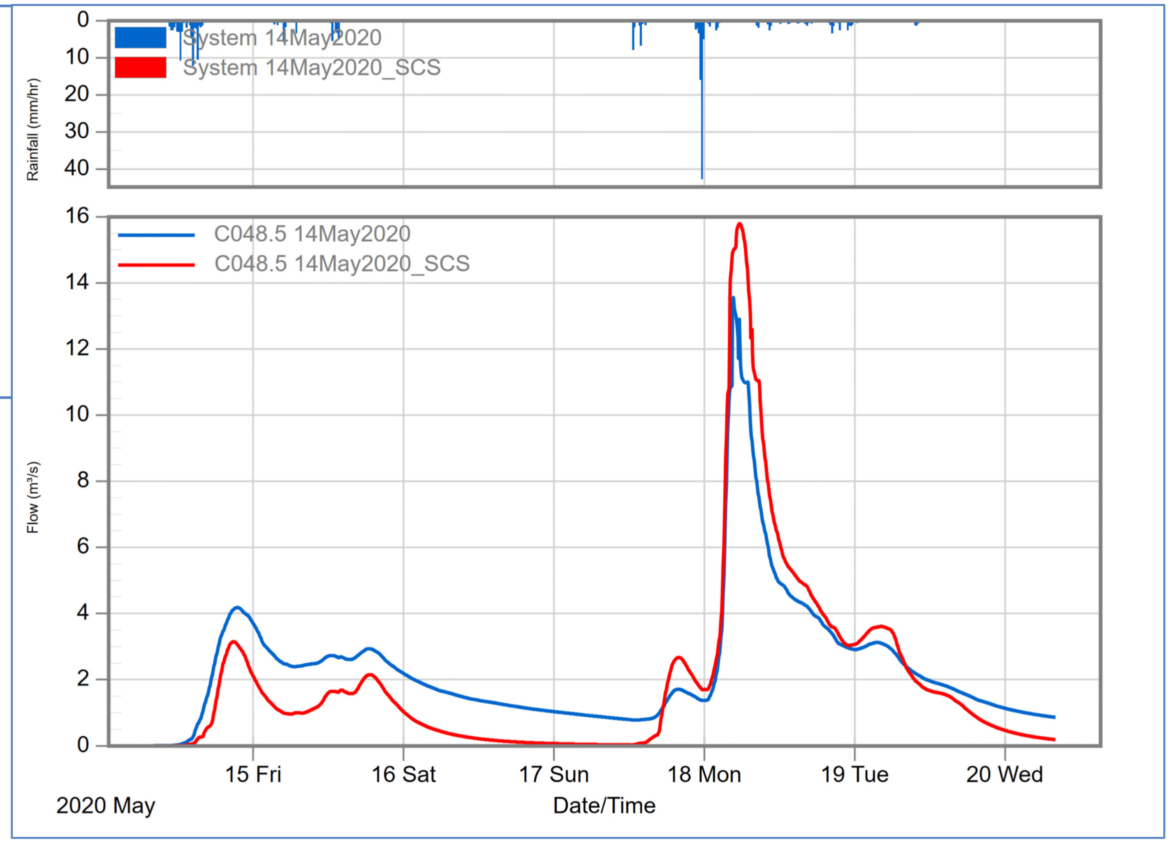
Event 3: August 26-29, 2020



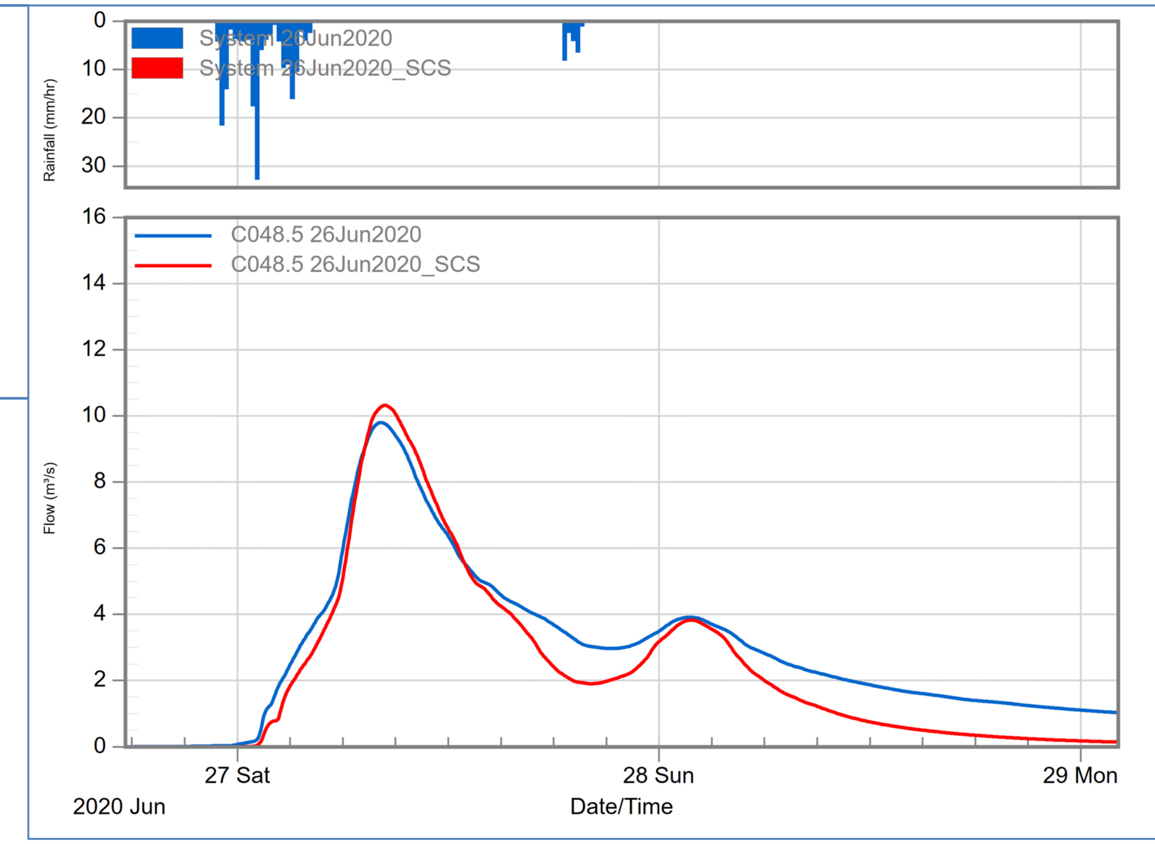
Landmark Engineers Inc.

Title: OBSERVED VERSUS SIMULATED LEVELS	Date: JUNE 2022		FIGURE B3
	Scale: NTS		
Project: LEBO CREEK MASTER DRAINAGE STUDY	Project No. 19-023		

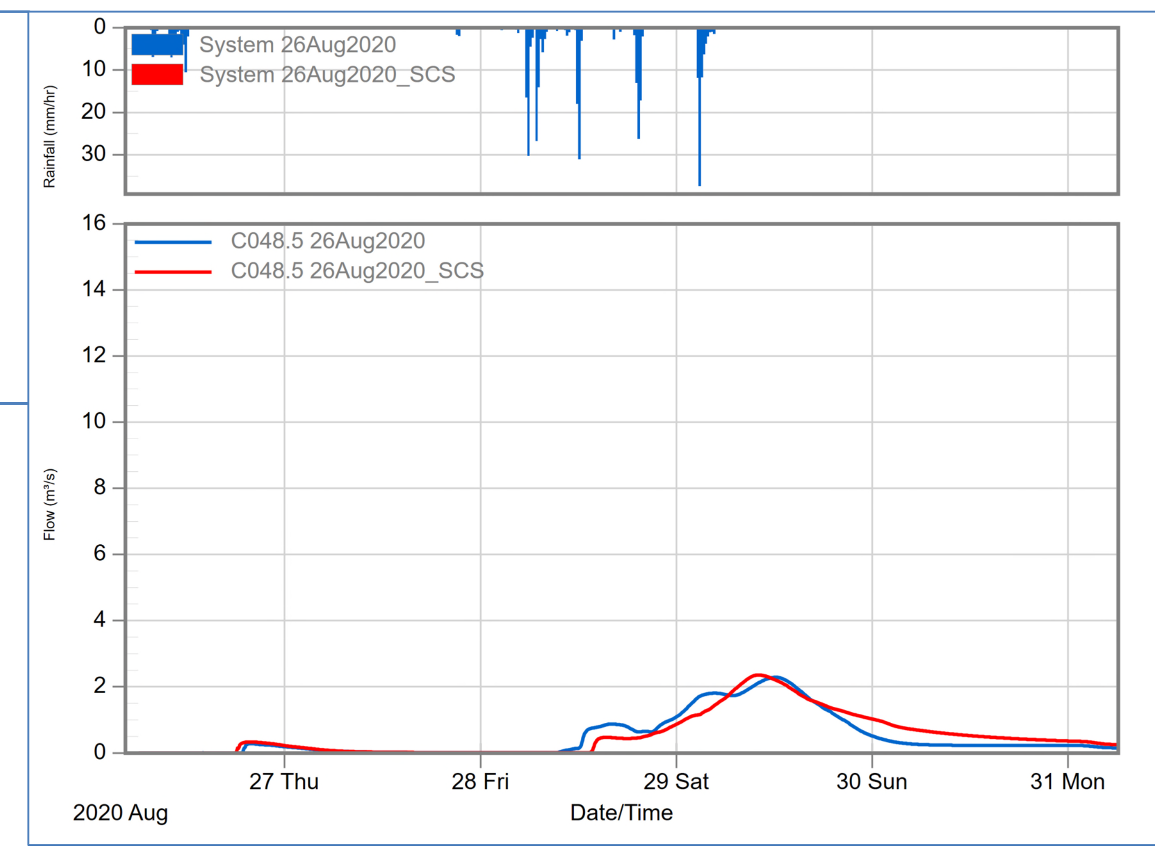
Event 1: May 14-19, 2020



Event 2: June 26-27, 2020



Event 3: August 26-29, 2020

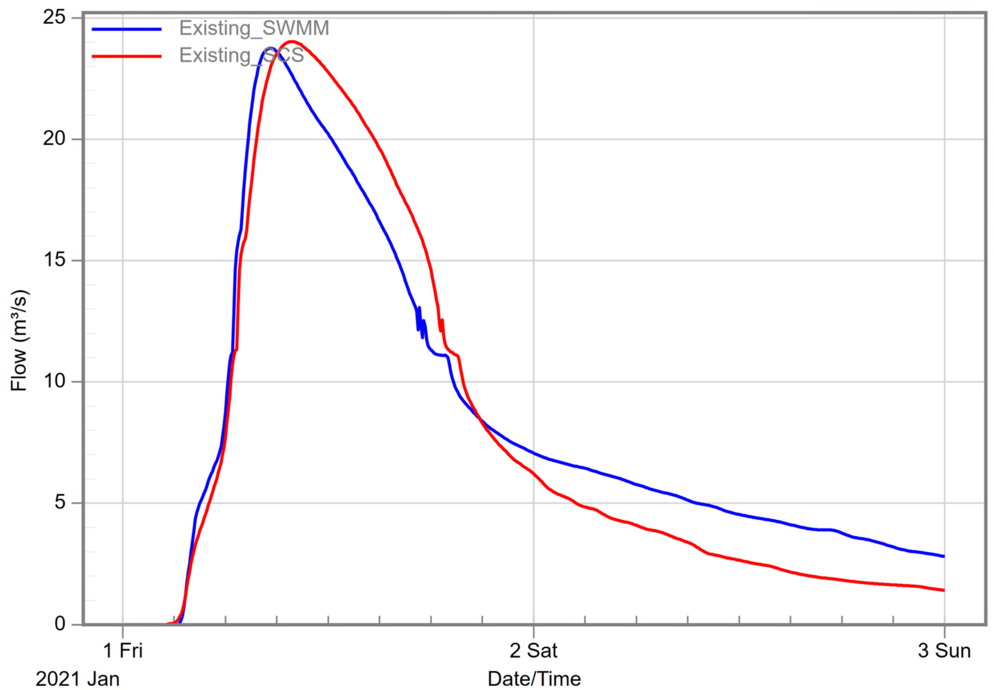


Landmark Engineers Inc.

Title: SIMULATED FLOWS		Date: JUNE 2022	FIGURE B4
		Scale: NTS	
Project: LEBO CREEK MASTER DRAINAGE STUDY		Project No. 19-023	

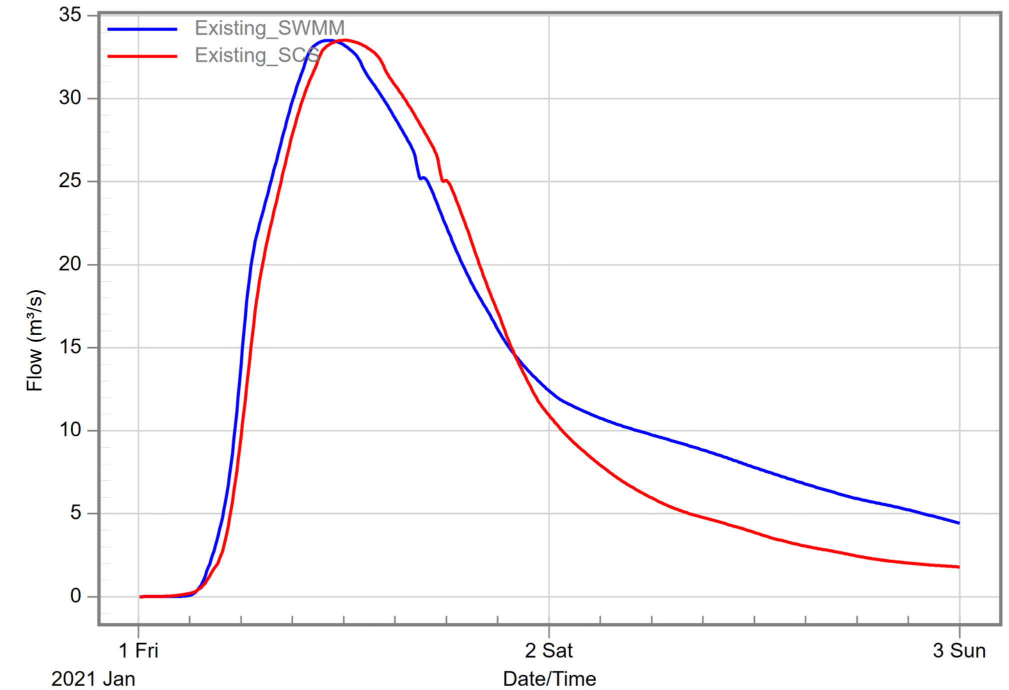
Lebo Creek @ County Road 34

Link C048.5



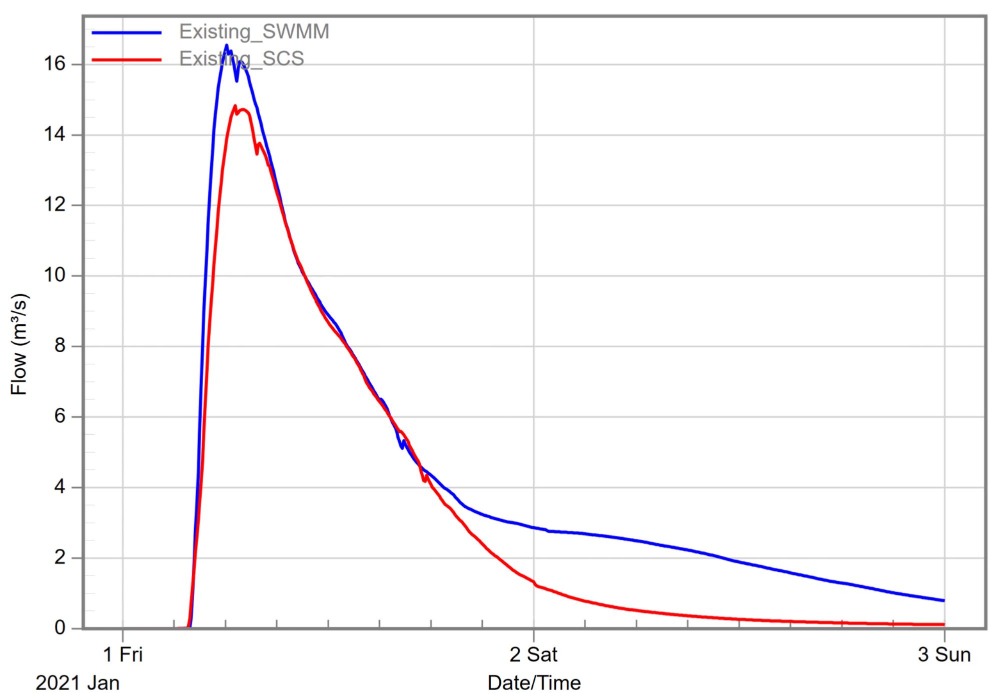
Lebo Creek @ Hillman Marsh

Link C002



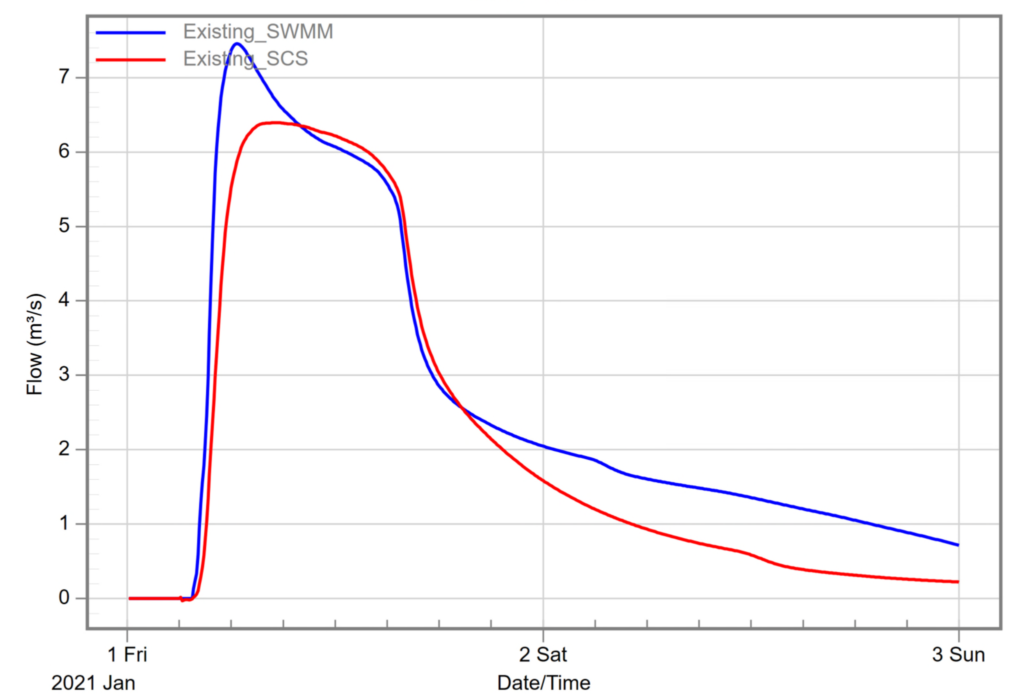
Piggot Drain @ Lebo Creek

Link C207



Hooker Drain @ Lebo Creek

Link C327



Landmark Engineers Inc.

Title: 100-YEAR FLOWS – SWMM5 VERSUS SCS	Date: JUNE 2022	Scale: NTS	FIGURE B5
Project: LEBO CREEK MASTER DRAINAGE STUDY	Project No. 19-023		

APPENDIX
C

EROSION THRESHOLD ASSESSMENT

July 30 2022
MTE File No.: 47117-100

Alain Michaud
Landmark Engineers Inc.
2280 Ambassador Drive
Windsor, ON, N9C 4E4
Email: amichaud@landmarkengineering.ca

Dear Alain:

RE: Lebo Creek Erosion Threshold Analysis –Lebo Creek Watershed, Leamington, ON

MTE has been retained by Landmark Engineering Inc. (on behalf of the proponent) to complete an erosion threshold assessment of Lebo Creek [Figure 1] to support development of a stormwater master plan for the Lebo Creek watershed in Leamington, ON.

General Background

The increase in flow volume within a watercourse, as a result of surrounding land use change, can have dramatic impacts on the form and function of a watercourse. When there is not proper consideration and planning for new developments whereby stormwater is directed towards drainage channels, there is an increased risk to channel erosion and aquatic habitat degradation (CVC, 2010).

Significant numbers of new greenhouses and industrial development have been proposed within the Municipality of Leamington and the greater Essex County areas. With these additional greenhouse developments, substantial increases of hydrological inputs to drainage channels are anticipated. In order to properly identify areas most sensitive to change, it is recommended that an erosion threshold assessment be completed to support the Municipal stormwater master plan. The purpose of this assessment was to determine the erosion threshold capability for Lebo Creek within the Municipality of Leamington. The scope of work for the erosion threshold assessment included:

- Review background information for the Lebo Creek watershed including topographic mapping, physiography, and orthographic imagery
- Site investigations including a detailed aquatic habitat assessment and geomorphic data collection
- Completion of an erosion threshold analysis

Physiographic Background

The Lebo Creek watershed is within the St. Clair Clay Plains topographic region. Site specifically, the drainage area consists of Brookston Clay and Berrien Sandy Loam (Figure a2, Landmark 2022).The Brookston sand spot phase noted in areas of the watershed, recognizes the presence of shallow sandy knolls. As a result of these soil associations, it is expected some sand to be evident in eroded material within the bedload of the drains. However, underlying the A horizon of these soils, is a very coarse and tough clay, leading to poorly drained soils.

In other areas of the watershed, there are segments of Berrien Sandy Loam. The riparian corridor tends to be wooded when the drainage system passes through this Sandy Loam.

Geomorphic Investigations

Geomorphic site assessments were completed at 12 representative reaches [Figure 1], representing three (3) watercourses, within the Lebo Creek watershed. Two (2) of the representative reaches were at the bottom of the watershed close to Hillman Marsh. Site investigations were completed by MTE staff on June 1st and July 14th 2020 for the Lebo Creek watershed [Appendix A]. These site investigations included a qualitative evaluation of stability within the channels, aquatic habitat assessments including vegetation characteristics, site photographs [Appendix A], and collection of sediment samples for grain size analysis.

Table 1: Results of the aquatic habitat and geomorphic site assessments sorted by most upstream to the most downstream for each drainage feature.

Station Name	Bank Vegetation	Substrate	Stability
Lebo Creek Watershed			
HD1	Abundantly vegetated with grasses and sparse numbers of trees	Slightly loose silty clay and muck.	Slight slumping of left bank but overall, both banks stable. Trapezoidal channel morphology
HD2	Tree and shrub species abundant (Sugar Maple, White Ash, etc.)	Fairly firm sandy silt with gravels and clays also present	Erosion on both banks. Downed trees and exposed roots abundant on upstream side. Slumping of banks and scouring also noted.
Lebo1	Tree and shrub species dominant (Ironwood, White Ash, Black Walnut) with forbs and grasses to a lesser extent downstream	Fairly loose sandy silt with coarse gravels present. Some evidence of sedimentation in the feature.	Stability issues on left bank (scouring, exposed roots). Same issues on the right bank but to a lesser degree.
Lebo2	Grasses dominant with trees and shrubs also present (Black Walnut, Willow species)	Firm sandy gravels with lesser amounts of silty material.	Small localized area of erosion downstream but overall stable on both banks. No major erosion issues.
Lebo3	Narrow grass bank on upstream section bordered by farm field, with abundant trees and shrubs downstream on banks.	Clayey silt with evidence of gravels near shore.	Defined channel form with no notable erosion issues. Floodplain appears wide enough to handle bankfull flows.
Lebo4	Grasses the dominant form with trees and shrubs to a lesser extent.	Loose sandy silt with sparse gravels. Notable evidence of sedimentation in the channel	Erosion noted on both banks. Bank scouring, localized downed vegetation, undercut banks, etc.
Lebo5	Trees and shrubs abundant upstream with floodplain wetland grasses and forbs downstream	Silty clay and muck	No erosion issues noted. Stable channel with abundant floodplain.
Lebo6	Trees and shrubs abundant with wetland plants contained in the ground layer	Silty clay and muck	No erosion issues noted. Stable channel with abundant floodplain.
Lebo7	Grasses abundant downstream with trees and shrubs in higher abundance upstream	Fairly firm silty clay with areas of gravel and sand noted	Channel appears stable with no notable erosion issues.
Sylv1	Abundance of non-native *Phragmites* downstream with sparse trees and shrubs. Grasses dominant on upstream banks.	Slightly loose silty clay with muck present.	Trapezoidal channel with no geomorphic issues. Both banks stable.
Sylv2	Grasses dominant in ground layer with trees and shrubs abundant (Willow and Black Walnut)	Slightly loose silty clay with trace gravels and sands.	Trapezoidal channel that appears intermittent in nature. Both banks appear stable.
Sylv3	Trees and shrubs abundant on both banks with grasses covering the ground layer	Firm sandy silt with gravels present throughout.	Minimal localized erosion downstream but overall both bank stable. Watercourse appears more permanent in nature.

As seen in Table 1, the surveyed sites are primarily characterized by cohesive materials (clays and silts) with non-cohesive materials (sand and gravels) representing fewer number of sites. Based on the results of the site assessments, it was determined that reach HD2, Lebo 1, and Lebo 4 show the highest degree of instability (i.e. evidence of bank erosion, basal scouring, downed vegetation) within the Lebo Creek watershed [Appendix A].

Erosion Threshold Analysis

An erosion threshold analysis was completed for the three (3) most sensitive reaches identified within the Lebo Creek watershed [Table 2]. This analysis was undertaken to guide the stormwater management criteria for future development in the study subwatersheds.

Table 2: Erosion Threshold Summary Data

Lebo Creek Watershed			
Reach	***HD2***	**Lebo1**	**Lebo4**
Existing Channel Data			
Drainage Area (ha)	627	975	2317
Water surface slope (%)	0.0007	0.0004	0.0006
Modelled Existing 2yr (4hr) flow (m3/s))	1.18	3.22	4.3
2yr flow depth (m)	0.58	1.05	1.3
Manning's N (bankfull)	0.04	0.025	0.031
Current Tractive Forces (Pa)			
2 yr (4hr)	4.1	4.2	5.1
overtop	n/a	7.8	8.2
100 yr	12.8	8.8	12.1
Bed Characteristics			
Critical Particle Size – D_{50} (mm)	0.53	0.32	0.26
Erosion Threshold – Various Models			
Uniform Shear Stress (Pa) (Julien 2010)	0.45	0.35	0.25
Low Fines in Flow (Chow, 1959)			
Critical Shear Stress (Pa)	2.87	2.39	2.63
Critical Discharge (m3/s)	0.71	1.3	0.62
High Fines in Flow (Chow, 1959)			
Critical Shear Stress (Pa)	4.31	3.93	3.88
Critical Discharge	1.33	2.9	1.22

The first set of data in Table 2 (Existing Channel Data) was generated from the engineering modelling of the watersheds, topographic cross-sections (Landmark, 2021) with the Manning's n adjusted through field calibration.

Based on these numbers, current tractive forces (Pa) were calculated using the relationship of streambed slope (s in m/m) and flow depth (d in m) for the 2 yr (4hr) Chicago storm, when the flows overtop the first valley system and then, where applicable the depth to the 100 yr return storm event.

$$T = 9.8*1000 * d * s$$

Streambed sediment samples were collected and sent for particle size analysis [Appendix B]. The d50 (diameter of the median particle size) was interpreted from the linear regression of the soil samples. The underlying parent material was not sampled.

The critical discharges in Table 2 were calculated by lowering the water depth in each cross section of the flow model, such that tractive forces matched the permissible tractive forces suggested by Chow (1959).

Based on a uniform sediment consisting strictly of the median particle size, Julien (2010) suggests tractive forces required to move these sediments would be generally an order of magnitude lower than currently present [Table 2]. While these streambeds are not uniformly one particle size, some soil movement does occur even in small storm events.

However, with non-cohesive sediments consisting of a range of grain sizes such as found at each site [Attachment B], Chow (1959) suggests that with a sediment supply from upstream, permissible shear stress tolerance can be increased. Presumably this is because sediment loss through shear stress mobilization can be replaced by sediment settling from upstream sources (bed load, bank failure, overland erosion).

In the first example in Table 2 (Low Fines), the assumption for the purposes of this review, is the suspended fine sediment load has been reduced through upper watershed development and stormwater treatment (notwithstanding bank failure may still replace at least some of this sediment load). In this Low Fines scenario, sediment bed loss and resultant channel downcutting would be expected in most storm events as critical shear stress is exceeded in the 2 yr. events at each location. Therefore, a supply of sediment to the channel will be an important consideration for development and stormwater management.

Assuming 25% of the watershed is developed, a greenhouse design threshold contemplated by the Municipality, the sediment replacement concept would likely remain similar to pre-development conditions, recognizing excess sediment is added and lost to the stream in storm events. In these instances, permissible critical shear stress for the stream bed (Chow, 1959) are nearly similar to the modelled tractive forces at each station.

Regardless of the method or approach used to determine “permissible” erosion threshold rates, current flows are sufficient to mobilize the bedload under all flow regimes. These tractive forces can compromise lateral bank stability and/or encourage downcutting of the channel bed.

Based on the above analysis, it would be expected that even under current conditions, bank failure and channel bed down cutting can be expected, in storm events greater than the 2 yr design return flows. While this observed bank failure and possible down cutting has been noted, it is not as severe or as wide spread as would be expected given the bedload particle size. This lower observed erosion rate would suggest that the underlying parent material (clay) and road crossing bed reinforcement are providing a level of grade control in the drainage system.

Summary

With the introduction of greenhouses within the Lebo Creek watershed, stormwater management will be needed to control overland runoff. Over-control of flow to compensate for current watershed flow will not be practical to throttle flows down to limit channel bank and bed load movement. Additional measures will need to be considered in the short and long term to ensure a stable drainage system. Bank failure which was observed in the field and the potential for channel downcutting, can ultimately place pressure on the road crossings and their structural stability. These crossings will need to be inspected regularly (this should happen even without watershed development), particularly after large storm events. Some bank and bed re-enforcement may be needed to alleviate tractive force pressure.

Bank failures can be expected under high energy flows. Vegetated side slopes will help maintain some stability but even well rooted systems can be compromised. Should future channel reconstruction works be considered, an altered channel morphology to widen storm flow paths, particularly between the base flow and larger storm events, would help to reduce flow depths and tractive forces. Reducing the channel roughness in the regular storm flow floodplain (grassland) would also reduce the water depth and improve tractive forces. However, these more drastic measures do not appear to be needed in the short term.

Recommendations

- Maintain planned maximum target of 25% buildout, unless further watershed modelling is completed to assess sediment loss/replacement processes
- Stormwater management design and over-controls will need to assessed to balance cost to risk for flow design. While the bulk of runoff is generated in the up to 2 yr storm, it is the larger storms that will mobilize the most sediment and exert the pressure on bank failure and/or down cutting. Higher energy flows will be the main consideration for this cost to risk analysis.
- Regardless of the design decisions, the channels will need to be monitored, particularly at the culvert crossings to ensure bank stability and channel form are not worsening to a point of requiring correction.
- Some additional measures may be required from time to time, which could include some or all of bed re-enforcement, channel widening, side slope protection and floodplain vegetation management to ensure long term sustainability of the drains and road crossings.

Should you wish to clarify any questions or require additional information as part of the review of this report, do not hesitate to contact us.

Yours Truly,

MTE Consultants Inc.

Peter Ashmore

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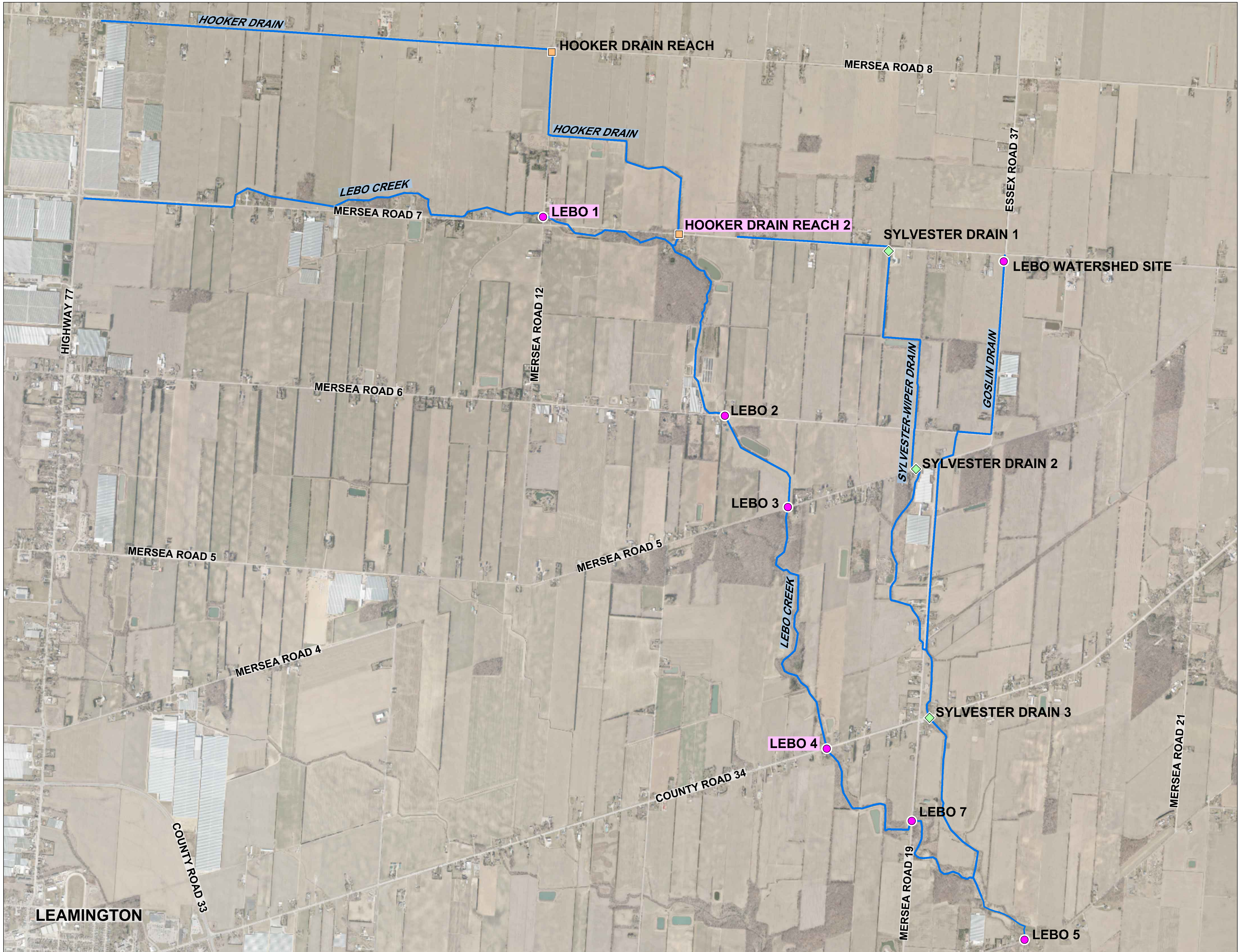
Reviewed by
Dr. Peter Ashmore, Associate

ZA/DH/pa:
Encl. – Figure 1 – Study Sites
Appendix A – Field notes and Select Photos
Appendix B – Soil Analysis



N

LEGEND

SITE BOUNDARY
WATERCOURSE

LEBO CREEK CROSSING
HOOKER DRAIN CROSSING
SYLVESTER DRAIN CROSSING

ADDITIONAL STUDY

REFERENCES

2021 AERIAL IMAGE, ESSEX COUNTY INTERACTIVE MAPPING SYSTEM.

NOTES

THIS FIGURE IS SCHEMATIC ONLY AND TO BE READ IN CONJUNCTION WITH ACCOMPANYING TEXT.

ALL LOCATIONS ARE APPROXIMATE.

SCALE IN KILOMETRES
0 0.5 1km
1:30

MTE
Engineers, Scientists, Surveyors

PROJECT
EROSION THRESHOLD STUDY
FINGAL CONVEYANCE SYSTEM & MEMBRANE BIOREACTOR TREATMENT SYSTEMS

TITLE
STATION LOCATIONS

Drawn DCH	Scale AS SHOWN	FIGURE 1
Checked	Project No. 47117-100	
Date May 30/22	Rev No. 0	

Client: Landmark Engineers Inc.
Plot Date: 13 June 2022 Time:09:37:49
CAD: P:\P\47117\100\2_PROD\47117-100-G01 SITE PLAN\47117-100-G01001.DWG Original Format in Tabloid (279mm x 432mm; 11" x 17")

Appendix A

Field Notes

MTE

MTE

(1)

HD 1

Project Name: Lebo Creek Erosion Threshold
MTE File No.: 47117-100
Station Name: Hooker Drain Reach (1)
Date: June 1, 2020.
Collectors: Zach Anderson.
Time Started: 12:35
Mersea Rd 8 and Mersea Rd 12. Intersection.
Time Finished: 12:55

Watercoure Name: Hooker Drain
Drainage System: Lebo Creek
GPS Coordinates: 42.1207, -82.551
Weather: sunny, windy, light humidity
Air Temp: 21°C Water Temp: 24°C
Land Use: Left Bank: Agricultural Right Bank: Agricultural.

Pollution Sources: Point: None. Non-Point: Road salt Farm Fertilizer Runoff.

Flow Regime: ☒ Flowing ☐ Dry ☐ Permanent ☒ Intermittent ☐ Ephemeral
Channel Form: ☒ Defined ☐ Undefined ☐ Natural ☒ Channelized ☐ Swale
Groundwater Evidence: ☐ None ☐ Springs/Seeps ☐ Vegetation ☐ Iron Staining ☐ Other

Pond/Lake Substrate silty clayey - loose.

Type	Bedrock	Sand	Silt	Clay	Muck	Marl	Detritus
%	/	10%	40%	30%	20%	/	/

Shoreline Substrate

Type	Bedrock	Boulder	Cobble	Gravel	Sand	Silt	Clay	Marl	Detritus
%	/	/	/	/	20%	50%	30%	/	/

General Comments

Agricultural roadside drain; likely intermittent. No riffles or pools. Both banks stable. Some slight slumping on left bank near intersection but not major. Trapezoidal channel. Evidence of some siltation. Abundant algae present.

MTE

In-Water Habitat

Underwater Cover		Vegetation			Algae
Type	%	Type	%	Examples	
None	20%	None	10	/	☐ None
Undercut Banks	/				☐ Slight
Boulders	/	Submergent	80	Curly-leaved Pondweed (Potamogeton crispus)	☒ Moderate
Cobbles	/				in between.
Woody Debris	/	Floating	/	/	☒ Heavy
Organic Debris	10%				
Macrophytes	70%	Emergent	10	Phragmites australis.	

Bank Habitat

Bank Cover		Shore Cover
Type	%	% Shaded
None	/	☐ 100-90 %
Undercut Banks	/	☐ 90-60%
Boulders	/	☐ 60-30%
Cobbles	/	☐ 30-10%
		☒ 0%
		no shading of drain.
Woody Debris	/	**Examples**
Organic Debris	/	P. australis, Poa spp.
Macrophytes	100%	Acer negundo.

Migratory Obstructions

☐ None	
☒ Seasonal	☐ Permanent
· Low flows may limit fish habitat movement u/s.	/

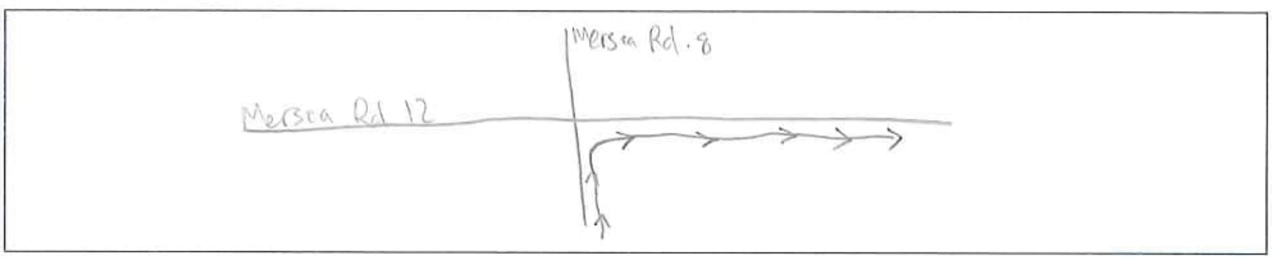
Potential Critical Habitat

☒ None ☐ Nursery Habitat ☐ Season Refugia ☐ Unknown

☐ Spawning Habitat ☐ Other: ______

Comments: No habitat features for fish identified

Sketch



Other Monitoring Conducted

☒ None ☐ Water Quality Sampling ☐ Flow Monitoring ☐ Fish Sampling ☐ Benthic Sampling ☐ Mussel Sampling

MTE

(2)

Aquatic Habitat Assessment

Lebo1

Project Name: Lebo Creek Erosion Threshold **MTE File No.:** 47117-100

Station Name: Lebo U/S (1) **Date:** June 1, 2020

Collectors: Zach Anderson **Time Started:** 13:01

Time Finished: 13:28

Watercoure Name: Lebo Creek **Drainage System:** Lebo Creek

GPS Coordinates: 42.1089, -82.5516.

Weather: Sunny, windy, low humidity. **Air Temp:** 21°C Water Temp = 20°C

Land Use: Left Bank: Residential/Agricultural stability issues-slight Right Bank: Residential/Agricultural relatively stable.

Pollution Sources: Point: none. Non-Point: Road runoff Farm fertilizers Gasoline from residences

Flow Regime: ☒ Flowing ☐ Dry ☒ Permanent ☐ Intermittent ☐ Ephemeral

Channel Form: ☒ Defined ☐ Undefined ☒ Natural ☐ Channelized ☐ Swale

Groundwater Evidence: ☐ None ☐ Springs/Seeps ☐ Vegetation ☐ Iron Staining ☐ Other

Pond/Lake Substrate

Gravels = 25%

Type	Bedrock	Sand	Silt	Clay	Muck	Marl	Detritus
%	/	35%	30%	10%	/	/	/

Shoreline Substrate

Type	Bedrock	Boulder	Cobble	Gravel	Sand	Silt	Clay	Marl	Detritus
%	/	/	/	/	10%	60%	30%	/	/

General Comments

Permanent natural watercourse. Cool water. Pools and riffles present in sections. Some stability issues on left bank (exposed roots, channel scouring). Right bank had less issues. Fish abundant (cyprinidae spp).

Cross section, substrate samples, depths.

MTE

Aquatic Habitat Assessment

In-Water Habitat

Underwater Cover		Vegetation			Algae
Type	%	Type	%	Examples	
None	60%	None	90%	/	☒ None
Undercut Banks	/				
Boulders	/	Submergent	10%	coontail (sparse)	☐ Slight
Cobbles	/				☐ Moderate
Woody Debris	30%	Floating	/	/	
Organic Debris	10%				☐ Heavy
Macrophytes	/	Emergent	/	/	

Bank Habitat

Migratory Obstructions

Bank Cover		Shore Cover	Migratory Obstructions	
Type	%	% Shaded	☒ None	
			☐ Seasonal	☐ Permanent
None	/	☐ 100-90 %	/	/
Undercut Banks	/	☒ 90-60%		
Boulders	/	☐ 60-30%		
Cobbles	/	☐ 30-10% ☐ 0%		
Woody Debris	20%	**Examples**		
Organic Debris	/	FRAXAME, OSTRVIR, ACERNEG		
Macrophytes	80%			

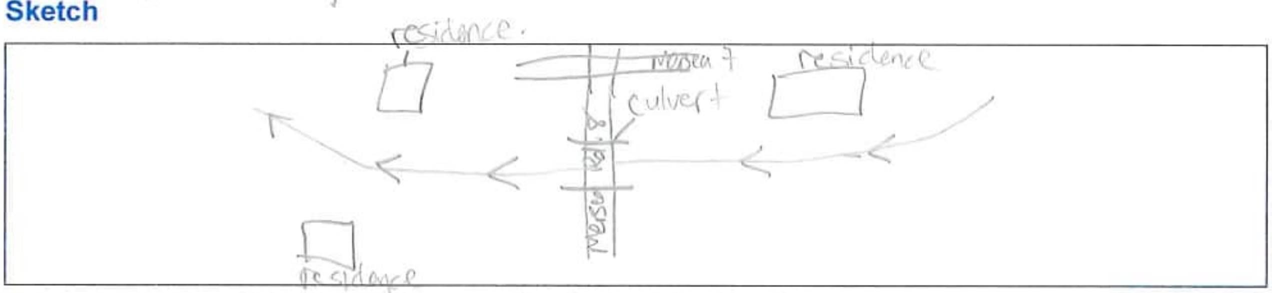
Potential Critical Habitat

☐ None ☒ Nursery Habitat ☒ Season Refugia ☐ Unknown

☒ Spawning Habitat ☐ Other: ____________

Comments: Several large schools of cyprinidae species observed at bridge crossing.

Sketch



Other Monitoring Conducted

☒ None ☐ Water Quality Sampling ☐ Flow Monitoring ☐ Fish Sampling ☐ Benthic Sampling ☐ Mussel Sampling

MTE

Aquatic Habitat Assessment

(8)

HD2

Project Name: Lebo Creek Erosion Threshold

MTE File No.: 47117-100.

Station Name: Hooker Drain Reach 2

Date: June 1, 2020.

Collectors: Zach Anderson

Time Started: 13:40

Time Finished: 14:00

Watercoure Name: Hooker Drain.

Drainage System: Lebo Creek.

GPS Coordinates: 42.1079, -82.5385

Weather: Sunny, windy,

Air Temp: 21°C Water Temp: 20°C

Land Use: Left Bank: residential

Right Bank: residential Agricultural

Pollution Sources: Point: none.

Non-Point: Road salt, farm runoff.

Flow Regime: ☒ Flowing ☐ Dry ☒ Permanent ☐ Intermittent ☐ Ephemeral

Channel Form: ☒ Defined ☐ Undefined ☐ Natural ☒ Channelized ☐ Swale

Groundwater Evidence: ☒ None ☐ Springs/Seeps ☐ Vegetation ☐ Iron Staining ☐ Other

Pond/Lake Substrate

Type	Bedrock	Sand	Silt	Clay	Muck	~~Marl~~ Gravels	Detritus
%	/	30%	40%	20%	/	10%	/

Shoreline Substrate

Type	Bedrock	Boulder	Cobble	Gravel	Sand	Silt	Clay	Marl	Detritus
%	/	/	/	/	20%	60%	20%	/	/

General Comments

Permanent drain (Hooker Drain) u/s of confluence of Lebo Creek. Some pools and minimal riffles. Issues with stability on both banks (downed trees, exposed roots, slumped material).

. Cross section, substrate samples, depths.

MTE

In-Water Habitat

Underwater Cover		Vegetation			Algae
Type	**%**	**Type**	**%**	**Examples**	
None	75%	None	90%	/	☒ None
Undercut Banks	/				☐ Slight
Boulders	5%	Submergent	/	/	☐ Moderate
Cobbles	/				☐ Heavy
Woody Debris	10%	Floating	/	/	
Organic Debris	/				
Macrophytes	10%	Emergent	10%	Impatiens capensis.	

Bank Habitat

Bank Cover		Shore Cover
Type	**%**	**% Shaded**
None	/	☐ 100-90 %
Undercut Banks	/	☒ 90-60%
Boulders	/	☐ 60-30%
Cobbles	/	☐ 30-10% ☐ 0%
Woody Debris	10%	**Examples**
Organic Debris	/	ACERSAC, FRAXAME
Macrophytes	90%	

Migratory Obstructions

☐ None	
☒ Seasonal	☐ Permanent
· Downed log debris could impede movement u/s	/

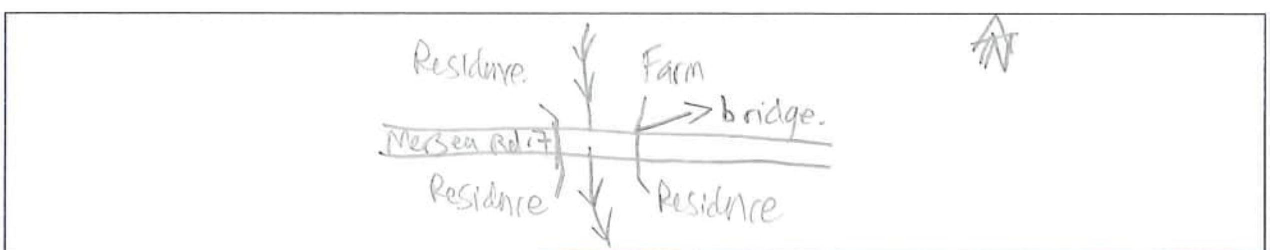
Potential Critical Habitat

☐ None ☐ Nursery Habitat ☒ Season Refugia ☐ Unknown

☐ Spawning Habitat ☐ Other: ____________________

Comments: No Fish observed but would likely be used seasonally.

Sketch



Other Monitoring Conducted

☒ None ☐ Water Quality Sampling ☐ Flow Monitoring ☐ Fish Sampling ☐ Benthic Sampling ☐ Mussel Sampling

(4)

MTE

Aquatic Habitat Assessment

SYLV1

Project Name: Lebo Creek Erosion Threshold

MTE File No.: 47117-100

Station Name: Sylvester Upper 1

Date: June 1, 2020

Collectors: Zach Anderson

Time Started: 14:07

Time Finished: 14:19.

Watercoure Name: Sylvester Drain.

Drainage System: Lebo Creek.

GPS Coordinates:

Weather: Sunny, windy.

Air Temp: 21°C. Water Temp=25°C

Land Use: Left Bank: Agricultural Right Bank: Agricultural.

Pollution Sources: Point: none. Non-Point: Agricultural/Road run off.

Flow Regime: ☒ Flowing ☐ Dry ☐ Permanent ☒ Intermittent ☐ Ephemeral

Channel Form: ☒ Defined ☐ Undefined ☐ Natural ☒ Channelized ☐ Swale

Groundwater Evidence: ☒ None ☐ Springs/Seeps ☐ Vegetation ☐ Iron Staining ☐ Other

Pond/Lake Substrate

Type	Bedrock	Sand	Silt	Clay	Muck	Marl	Detritus
%	/	/	50%	30%	20%	/	/

Shoreline Substrate

Type	Bedrock	Boulder	Cobble	Gravel	Sand	Silt	Clay	Marl	Detritus
%	/	/	/	/	10%	60%	30%	/	/

General Comments

Intermittent in nature for this reach. Warm water, Banks Stable, trapezoidal channel. No riffles or pools.

In-Water Habitat

Underwater Cover		Vegetation			Algae
Type	%	Type	%	Examples	
None	10%	None	30%	/	☐ None ☐ Slight ☒ Moderate ☐ Heavy
Undercut Banks	/				
Boulders	/	Submergent	40%	coontails.	
Cobbles	/				
Woody Debris	/	Floating	/	/	
Organic Debris	10%				
Macrophytes	80% 60%	Emergent	30%	P. australis.	

Bank Habitat

Bank Cover		Shore Cover
Type	%	% Shaded
None	15%	☐ 100-90 %
Undercut Banks	/	☐ 90-60%
Boulders	/	☐ 60-30%
Cobbles	/	☒ 30-10% ☐ 0%
Woody Debris	/	**Examples**
Organic Debris	10%	RHUSTYP, ACERNEG.
Macrophytes	75%	PHRAAUS.

Migratory Obstructions

☐ None	
☒ Seasonal	☐ Permanent
• Channel choked in sections by vegetation debris • Intermittency makes it a barrier	/

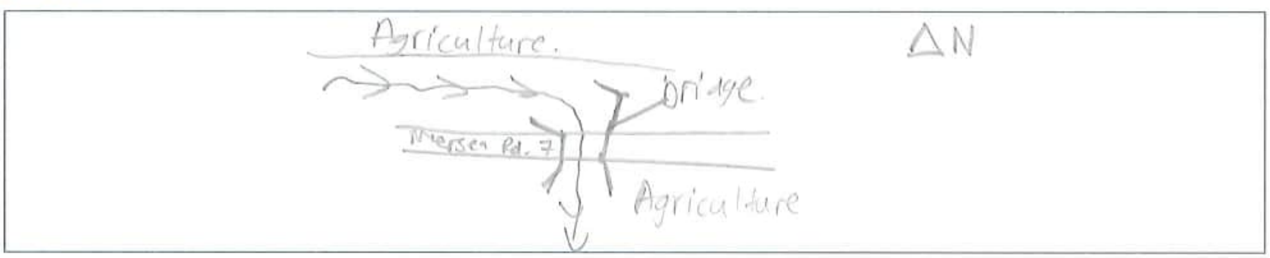
Potential Critical Habitat

☒ None ☐ Nursery Habitat ☐ Season Refugia ☐ Unknown

☐ Spawning Habitat ☐ Other: __________

Comments: warm water agricultural drain. No potential fish habitat

Sketch



Other Monitoring Conducted

☒ None ☐ Water Quality Sampling ☐ Flow Monitoring ☐ Fish Sampling ☐ Benthic Sampling ☐ Mussel Sampling

(6)

MTE

Aquatic Habitat Assessment

(Lebo2)

Project Name:	Lebo Creek Erosion Threshold	**MTE File No.:**	47117-100
Station Name:	Lebo (2)	**Date:**	June 1, 2020.
Collectors:	Zach Anderson.	**Time Started:**	14:27
		Time Finished:	14:43.

Watercoure Name: Lebo Creek **Drainage System:** Lebo Creek.

GPS Coordinates: 42.095163, -82.5343.

Weather: Sunny, windy. **Air Temp:** 22°C ; Water Temp: 22°C.

Land Use: Left Bank: residential, nursery/greenhouse Right Bank: Agricultural/Residential

Pollution Sources: Point: none. Non-Point: Road runoff, nursery, farm fields.

Flow Regime: ☒ Flowing ☐ Dry ☒ Permanent ☐ Intermittent ☐ Ephemeral

Channel Form: ☒ Defined ☐ Undefined ☒ Natural ☐ Channelized ☐ Swale

Groundwater Evidence: ☒ None ☐ Springs/Seeps ☐ Vegetation ☐ Iron Staining ☐ Other

Pond/Lake Substrate

Type	Bedrock	Sand	Silt	Clay	Muck	~~Marl~~ Gravels: 50%.	Detritus
%	/	30%.	20%.	/	/	/	/

Shoreline Substrate

silty clay / silty ~~clay~~ sands.

Type	Bedrock	Boulder	Cobble	Gravel	Sand	Silt	Clay	Marl	Detritus
%	/	/	/	/	30%.	40%	30%.	/	/

General Comments

Permanent cool water creek. Several schools of small to medium Fish observed (Cyprinidea sp.). Small localized area of erosion d/s of road crossing but otherwise stable.

MTE

In-Water Habitat

Underwater Cover		Vegetation			Algae
Type	**%**	**Type**	**%**	**Examples**	
None	70%	None	50%	—	☒ None ☐ Slight ☐ Moderate ☐ Heavy
Undercut Banks	—				
Boulders	—	Submergent	40%	Potamogeton crispus.	
Cobbles	—				
Woody Debris	10%	Floating	0%	—	
Organic Debris	—				
Macrophytes	20%	Emergent	10%	Impatiens capensis.	

Bank Habitat

Bank Cover		Shore Cover
Type	**%**	**% Shaded**
None	—	☐ 100-90 %
Undercut Banks	—	☐ 90-60%
Boulders	—	☐ 60-30%
Cobbles	—	☐ 30-10% ☒ 0%
Woody Debris	—	**Examples**
Organic Debris	20%	ACERNEG, SALIX spp.
Macrophytes	80%	

Migratory Obstructions

☒ None	
☐ Seasonal	☐ Permanent
—	—

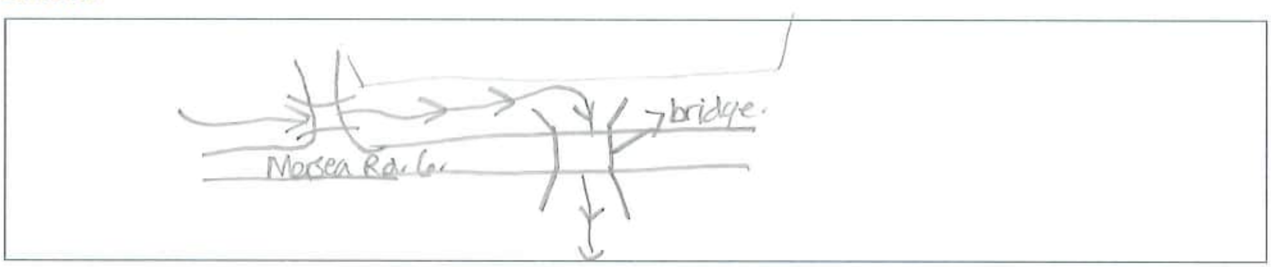
Potential Critical Habitat

☐ None ☒ Nursery Habitat ☒ Season Refugia ☐ Unknown

☒ Spawning Habitat ☐ Other: ______

Comments: Several schools of small to medium cyprinids observed. Likely shiner (behaviour based).

Sketch



Other Monitoring Conducted

☒ None ☐ Water Quality Sampling ☐ Flow Monitoring ☐ Fish Sampling ☐ Benthic Sampling ☐ Mussel Sampling

MTE

Aquatic Habitat Assessment

(6)

SYLV2

Project Name: Lebo Creek Erosion Threshold
MTE File No.: 47117-100.
Station Name: Sylvester Drain 2
Date: June 1, 2020.
Collectors: Zach Anderson.
Time Started: 14:50.
Time Finished: 15:06.

Watercoure Name: Sylvester Drain.
Drainage System: Lebo Creek.
GPS Coordinates: 42.0916, -82.5156
Weather: sunny windy
Air Temp: 22°C ; Water Temp= 20°C
Land Use: Left Bank: Agricultural/Residential Stable
Right Bank: Residential/Agricultural Stable.
Pollution Sources: Point: none.
Non-Point: road runoff, ag. fields.

Flow Regime: ☒ Flowing ☐ Dry ☒ Permanent ☒ Intermittent ☐ Ephemeral
Channel Form: ☒ Defined ☐ Undefined ☐ Natural ☒ Channelized ☐ Swale
Groundwater Evidence: ☒ None ☐ Springs/Seeps ☐ Vegetation ☐ Iron Staining ☐ Other

Pond/Lake Substrate

Type	Bedrock	Sand	Silt	Clay	Muck	~~Marl~~ Gravel	Detritus
%	/	10%.	60%.	20%.	/	10%.	/

Shoreline Substrate

Type	Bedrock	Boulder	Cobble	Gravel	Sand	Silt	Clay	Marl	Detritus
%	/	/	/	/	30%.	40%	30%	/	/

General Comments

Drain appears intermittent in sections but some refugia pools are around in summer. Banks appear stable on both sides; trapezoidal channel. Some fish observed.

MTE

In-Water Habitat

Underwater Cover		Vegetation			Algae
Type	%	Type	%	Examples	
None	75%	None	65%	/	☒ None
Undercut Banks	/				☐ Slight
Boulders	/	Submergent	/	/	☐ Moderate
Cobbles	/				☐ Heavy
Woody Debris	15%	Floating	0%	/	
Organic Debris	10%				
Macrophytes	/	Emergent	35%	P. australis. in section IMPACAP.	

Bank Habitat

Migratory Obstructions

Bank Cover		Shore Cover	Migratory Obstructions	
Type	%	% Shaded	☐ None	
			☒ Seasonal	☐ Permanent
None	5%	☐ 100-90 %	·Low flow may limit fish passage.	/
Undercut Banks	/	☐ 90-60%		
Boulders	/	☒ 60-30%		
Cobbles	/	☐ 30-10% ☐ 0%		
Woody Debris	10%	**Examples**		
Organic Debris	/	ACERNEG, SALIX, PHRAAUS.		
Macrophytes	85%			

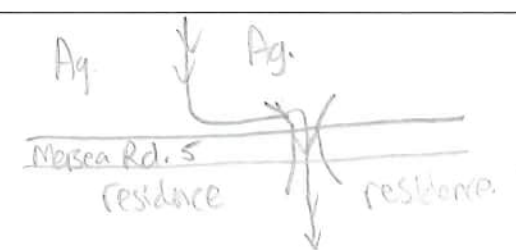
Potential Critical Habitat

☐ None ☐ Nursery Habitat ☒ Season Refugia ☐ Unknown

☐ Spawning Habitat ☐ Other: ________

Comments: Small school of fish observed at road crossing.

Sketch



Other Monitoring Conducted

☒ None ☐ Water Quality Sampling ☐ Flow Monitoring ☐ Fish Sampling ☐ Benthic Sampling ☐ Mussel Sampling

(7)

Lebo3

MTE

Aquatic Habitat Assessment

Project Name: Lebo Creek Erosion threshold
MTE File No.: 47117-100.
Station Name: Lebo (3)
Date: June 1, 2020.
Collectors: Zach Anderson.
Time Started: 15:10.
Time Finished: 15:30.

Watercoure Name: Lebo Creek.
Drainage System: Lebo Creek.
GPS Coordinates: 42.0887, -82.5276
Weather: Sunny, windy.
Air Temp: 22°C ; Water Temp:
Land Use: Left Bank: Agricultural, woodland d/s of crossing. Right Bank: Agricultural, woodland d/s of bridge.

Pollution Sources: Point: none Non-Point: Agricultural runoff.

Flow Regime: ☒ Flowing ☐ Dry ☒ Permanent ☐ Intermittent ☐ Ephemeral
Channel Form: ☒ Defined ☐ Undefined ☒ Natural ☐ Channelized ☐ Swale
Groundwater Evidence: ☒ None ☐ Springs/Seeps ☐ Vegetation ☐ Iron Staining ☐ Other

Pond/Lake Substrate

Type	Bedrock	Sand	Silt	Clay	Muck	Marl	Detritus
%	/	/	30%	40%	10%	20%	/

Shoreline Substrate

Agricultural.

Type	Bedrock	Boulder	Cobble	Gravel	Sand	Silt	Clay	Marl	Detritus
%	/	/	/	/	35%	45%	20%	/	/

General Comments

Defined channel form with flow. No erosion issues noted. Appears wide enough and with sufficient floodplain in vegetated areas to handle flows. >1.5m deep in middle.

MTE

In-Water Habitat

Underwater Cover	
Type	**%**
None	55
Undercut Banks	/
Boulders	/
Cobbles	10%
Woody Debris	/
Organic Debris	15%
Macrophytes	20

Vegetation		
Type	**%**	**Examples**
None	60%	/
Submergent	30%	Potamogeton crispus. Coontail
Floating	/	/
Emergent	10%	P. australis.

Algae
☒ None
☐ Slight
☐ Moderate
☐ Heavy

Bank Habitat

Bank Cover	
Type	**%**
None	10%
Undercut Banks	/
Boulders	/
Cobbles	/
Woody Debris	15%
Organic Debris	/
Macrophytes	75

Shore Cover
% Shaded
☐ 100-90 %
☐ 90-60%
☒ 60-30% d/s of bridge
☐ 30-10%
☐ 0%
Examples
JUGLNIG, ACERNEG.

Migratory Obstructions

☒ None	
☐ Seasonal	☐ Permanent
/	/

Potential Critical Habitat

☐ None ☒ Nursery Habitat ☐ Season Refugia ☐ Unknown

☒ Spawning Habitat ☐ Other: ________

Comments: No fish observed but habitat is suitable.

Sketch

Other Monitoring Conducted

☒ None ☐ Water Quality Sampling ☐ Flow Monitoring ☐ Fish Sampling ☐ Benthic Sampling ☐ Mussel Sampling

SYLV3

8

MTE

Aquatic Habitat Assessment

Project Name: Lebo Creek Erosion Threshold **MTE File No.:** 47117-100.

Station Name: Sylvester 3 **Date:** June 1, 2020.

Collectors: Zach Anderson. **Time Started:** 15:33.

Time Finished: 15:50.

Watercoure Name: Sylvester Drain. **Drainage System:** Lebo Creek.

GPS Coordinates: 42.0740, -82.5139

Weather: sunny, windy. **Air Temp:** 22°C ; Water Temp: 21°C

Land Use: Left Bank: Residential Right Bank: Residential/Agricultural.

Pollution Sources: Point: none. Non-Point: road runoff,

Flow Regime: ☒ Flowing ☐ Dry ☒ Permanent ☐ Intermittent ☐ Ephemeral

Channel Form: ☒ Defined ☐ Undefined ☐ Natural ☒ Channelized ☐ Swale

Groundwater Evidence: ☒ None ☐ Springs/Seeps ☐ Vegetation ☐ Iron Staining ☐ Other

Pond/Lake Substrate

Type	Bedrock	Sand	Silt	Clay	Muck	Gravel Marl	Detritus
%	/	50%	30%	/	/	20%	/

Shoreline Substrate

Type	Bedrock	Boulder	Cobble	Gravel	Sand	Silt	Clay	Marl	Detritus
%	/	/	/		30%	40%	30%	/	/

General Comments

Watercourse appears more permanent than intermittent. Minimal localized erosion. Fish observed.

MTE

Aquatic Habitat Assessment

In-Water Habitat

Underwater Cover		Vegetation			Algae
Type	%	Type	%	Examples	
None	55%	None	60%	/	☒ None ☐ Slight ☐ Moderate ☐ Heavy
Undercut Banks	/				
Boulders	/	Submergent	10%	Potamogeton crispus, Canada waterweed.	
Cobbles	15%				
Woody Debris	10%	Floating	/	/	
Organic Debris	/				
Macrophytes	20%	Emergent	30%	P. australis	

Bank Habitat

Bank Cover		Shore Cover
Type	%	% Shaded
None	/	☐ 100-90 %
Undercut Banks	/	☐ 90-60%
Boulders	/	☒ 60-30% US of crossing @ road.
Cobbles	/	☐ 30-10% ☐ 0%
Woody Debris	/	**Examples**
Organic Debris	/	SALIX spp., PINUS spp.
Macrophytes	100%	ACERSAC, VITIRAP

Migratory Obstructions

☒ None	
☐ Seasonal	☐ Permanent
/	/

Potential Critical Habitat

☐ None ☐ Nursery Habitat ☒ Season Refugia ☐ Unknown

☒ Spawning Habitat ☐ Other: ____________________

Comments: ____________________

Sketch

Other Monitoring Conducted

☒ None ☐ Water Quality Sampling ☐ Flow Monitoring ☐ Fish Sampling ☐ Benthic Sampling ☐ Mussel Sampling

(9)

MTE

Aquatic Habitat Assessment

(Lebo4)

Project Name: Lebo Creek Erosion Threshold
MTE File No.: 47117-100.
Station Name: Lebo (4)
Date: June 1, 2020.
Collectors: Zach Anderson.
Time Started: 15:53
Time Finished: 17:00

Watercoure Name: Lebo Creek.
Drainage System: Lebo Creek
GPS Coordinates: 42.07177, -82.5236
Weather: Sunny, windy.
Air Temp: 22°C ; Water Temp: 18°C
Land Use: Left Bank: residences/woodlot Right Bank: residences/woodlots.

Pollution Sources: Point: none. Non-Point: runoff from road.

Flow Regime: ☒ Flowing ☐ Dry ☒ Permanent ☐ Intermittent ☐ Ephemeral

Channel Form: ☒ Defined ☐ Undefined ☒ Natural ☐ Channelized ☐ Swale

Groundwater Evidence: ☒ None ☐ Springs/Seeps ☐ Vegetation ☐ Iron Staining ☐ Other

Pond/Lake Substrate

Type	Bedrock	Sand	Silt	Clay	Muck	Gravels ~~Marl~~	Detritus
%	/	70%.	20%.	/	/	10%.	/

Shoreline Substrate

Type	Bedrock	Boulder	Cobble	Gravel	Sand	Silt	Clay	Marl	Detritus
%	/	/	/	/	~~20%~~ 20	40%.	40%.	/	/

General Comments

Erosion noted on banks. Scours and some downed vegetation d/s. Evidence of sand deposition from u/s. Cross sections, depths, substrate sample taken.

MTE

In-Water Habitat

Underwater Cover		Vegetation			Algae
Type	%	Type	%	Examples	
None	30%	None	60%	/	☒ None
Undercut Banks	/				☐ Slight
Boulders	10%	Submergent	40%	Sago pondweed	☐ Moderate
Cobbles	/				☐ Heavy
Woody Debris	/	Floating	/	/	
Organic Debris	20%				
Macrophytes	40%	Emergent	/	/	

Bank Habitat

Bank Cover		Shore Cover
Type	%	% Shaded
None	/	☐ 100-90 %
Undercut Banks	/	☐ 90-60%
Boulders	/	☒ 60-30%
Cobbles	/	☐ 30-10%
		☐ 0%
Woody Debris	/	**Examples**
Organic Debris	/	grasses, ACERNEG.
Macrophytes	100%	

Migratory Obstructions

☒ None	
☐ Seasonal	☐ Permanent
/	/

Potential Critical Habitat

☐ None ☒ Nursery Habitat ☒ Season Refugia ☐ Unknown

☒ Spawning Habitat ☐ Other: ____________________

Comments: ____________________

Sketch

Other Monitoring Conducted

☒ None ☐ Water Quality Sampling ☐ Flow Monitoring ☐ Fish Sampling ☐ Benthic Sampling ☐ Mussel Sampling

(10)

MTE

Aquatic Habitat Assessment

Lebo5

Project Name: Lebo Creek Erosion Threshold
MTE File No.: 47117-100
Station Name: Lebo (5)
Date: June 1, 2020.
Collectors: Zach Anderson
Time Started: 17:08
Time Finished: 17:20.

Watercoure Name: Lebo Creek
Drainage System: Lebo Creek.
GPS Coordinates: 42.0581, -82.5043
Weather: sunny, windy.
Air Temp: 22°C;
Land Use: Left Bank: residence, natural
Right Bank: residences, ag, natural.

Pollution Sources: Point: none
Non-Point: road runoff.

Flow Regime: ☒ Flowing ☐ Dry ☒ Permanent ☐ Intermittent ☐ Ephemeral

Channel Form: ☒ Defined ☐ Undefined ☒ Natural ☐ Channelized ☐ Swale

Groundwater Evidence: ☒ None ☐ Springs/Seeps ☐ Vegetation ☐ Iron Staining ☐ Other

Pond/Lake Substrate

too deep to sample. >2m.

inferred.

Type	Bedrock	Sand	Silt	Clay	Muck	Marl	Detritus
%	/	/	40%.	20%.	30%.	/	10%.

Shoreline Substrate

Type	Bedrock	Boulder	Cobble	Gravel	Sand	Silt	Clay	Marl	Detritus
%	/	/	/	/	10%.	30%.	60%.	/	/

General Comments

Almost resembling a wetland. Too deep to complete a detailed survey but substrate + habitat features are inferred. Warmer water. Floodplain abundant. U/S of Hillman Marsh.

MTE

In-Water Habitat

Underwater Cover		Vegetation			Algae
Type	%	Type	%	Examples	
None	70%	None	50%	/	☐ None
Undercut Banks	/	Submergent	50%	pondweeds, algae.	☒ Slight
Boulders	/	Floating	/	/	☐ Moderate
Cobbles	/	Emergent	/	/	☐ Heavy
Woody Debris	15%				
Organic Debris	/				
Macrophytes	15%				

Bank Habitat

Bank Cover		Shore Cover
Type	%	% Shaded
None	/	☐ 100-90 %
Undercut Banks	/	☒ 90-60%
Boulders	/	☐ 60-30%
Cobbles	/	☐ 30-10%
		☐ 0%
Woody Debris	/	**Examples**
Organic Debris	/	SALIX spp.
Macrophytes	100%	ACERSAC

Migratory Obstructions

☐ None	
☒ Seasonal	☐ Permanent
• Downed vegetation backing up water.	

Potential Critical Habitat

☐ None ☒ Nursery Habitat ☒ Season Refugia ☐ Unknown

☐ Spawning Habitat ☐ Other: ____________

Comments: Low to no flow observed. Stagnant almost.

Sketch

Other Monitoring Conducted

☒ None ☐ Water Quality Sampling ☐ Flow Monitoring ☐ Fish Sampling ☐ Benthic Sampling ☐ Mussel Sampling

(17)

(Lebo 6)

MTE

Aquatic Habitat Assessment

Project Name: Lebo Creek Erosion Threshold

MTE File No.: 47117-100.

Station Name: Lebo (6)

Date: June 1, 2020.

Collectors: Zach Anderson.

Time Started: 17:28

Time Finished: 17:40.

Watercoure Name: Lebo Creek U/S Hillman

Drainage System: Lebo Creek.

GPS Coordinates: 42.055, -82.5046.

Weather: Sunny, windy.

Air Temp: 24°C

Land Use: Left Bank: natural, residence Right Bank: natural, wetland

Pollution Sources: Point: none. Non-Point: road runoff.

Flow Regime: ☐ Flowing ☐ Dry ☒ Permanent ☐ Intermittent ☐ Ephemeral

Channel Form: ☒ Defined ☐ Undefined ☐ Natural ☐ Channelized ☐ Swale

Groundwater Evidence: ☒ None ☐ Springs/Seeps ☐ Vegetation ☐ Iron Staining ☐ Other

Pond/Lake Substrate too deep to sample. Inferring substrate.

Type	Bedrock	Sand	Silt	Clay	Muck	Marl	Detritus
%	/	/	40%	20%	30%	/	10%

Shoreline Substrate

Type	Bedrock	Boulder	Cobble	Gravel	Sand	Silt	Clay	Marl	Detritus
%	/	/	/	/	10%	30%	60%	/	/

General Comments

Upstream of Hillman Marsh. Water is slowed down, creating a wetland area (marsh). No erosional concerns due to large floodplain.

MTE

In-Water Habitat

Underwater Cover		Vegetation			Algae
Type	%	Type	%	Examples	
None	/	None	/	/	☒ None ☐ Slight ☐ Moderate ☐ Heavy
Undercut Banks	/				
Boulders	/	Submergent	40%	potamogedon crispus	
Cobbles	/				
Woody Debris	10%	Floating	40%	Lemna minor, yellow pond lily	
Organic Debris	30%				
Macrophytes	60%	Emergent	20%	P. australis.	

Bank Habitat

Bank Cover		Shore Cover
Type	%	% Shaded
None	/	☐ 100-90 %
Undercut Banks	/	☐ 90-60%
Boulders	/	☐ 60-30%
Cobbles	/	☐ 30-10% ☒ 0%
Woody Debris	/	Examples
Organic Debris	/	RHUSTYP, SALIX,
Macrophytes	100%	PHRAAUS, CORNSER.

Migratory Obstructions

☒ None	
☐ Seasonal	☐ Permanent
/	/

Potential Critical Habitat

☐ None ☒ Nursery Habitat ☒ Season Refugia ☐ Unknown

☐ Spawning Habitat ☐ Other: ____________

Comments: Wide floodplain wetland area.

Sketch

Other Monitoring Conducted

☒ None ☐ Water Quality Sampling ☐ Flow Monitoring ☐ Fish Sampling ☐ Benthic Sampling ☐ Mussel Sampling

MTE

(12)

Aquatic Habitat Assessment

Project Name: Lebo Creek Erosion Threshold
MTE File No.: 47117-100.
Station Name: Lebo (7)
Date: June 1, 2020.
Collectors: Zach Anderson.
Time Started: 17:48
Time Finished:

Watercoure Name: Lebo Creek.
Drainage System: Lebo Creek
GPS Coordinates: 42.0665, -82.5152
Weather: Sunny, windy.
Air Temp: 23°C
Land Use: Left Bank: natural   Right Bank: residences, natural.

Pollution Sources: Point: none.   Non-Point: road runoff.

Flow Regime: ☐ Flowing ☐ Dry ☐ Permanent ☐ Intermittent ☐ Ephemeral

Channel Form: ☐ Defined ☐ Undefined ☐ Natural ☐ Channelized ☐ Swale

Groundwater Evidence: ☐ None ☐ Springs/Seeps ☐ Vegetation ☐ Iron Staining ☐ Other

Pond/Lake Substrate

Type	Bedrock	Sand	Silt	Clay	Muck	~~Marl~~ Gravel	Detritus
%	/	10%	40%	35%	/	15%	/

Shoreline Substrate

Type	Bedrock	Boulder	Cobble	Gravel	Sand	Silt	Clay	Marl	Detritus
%	/	/	/	/	30%	40%	30%	/	/

General Comments

MTE

In-Water Habitat

Underwater Cover		Vegetation			Algae
Type	%	Type	%	Examples	
None	55%	None	50%	/	☒ None ☐ Slight ☐ Moderate ☐ Heavy
Undercut Banks	/				
Boulders	/	Submergent	40%	Potamogeton crispus.	
Cobbles	/				
Woody Debris	/	Floating	10%	Lemna minor	
Organic Debris	35%				
Macrophytes	10%	Emergent	/	/	

Bank Habitat

Migratory Obstructions

Bank Cover		Shore Cover	Migratory Obstructions	
Type	%	% Shaded	☐ None	
			☒ Seasonal	☐ Permanent
None	/	☐ 100-90 % ☐ 90-60% ☐ 60-30% ☒ 30-10% d/s of culvert ☐ 0%	• Downed trees from woodland. Likely from windstorm.	/
Undercut Banks	/			
Boulders	/			
Cobbles	/			
Woody Debris	/	Examples		
Organic Debris	/	reed canary grass, ACERNE6		
Macrophytes	100%			

Potential Critical Habitat

☐ None ☐ Nursery Habitat ☒ Season Refugia ☐ Unknown

☐ Spawning Habitat ☐ Other: ______________________

Comments: ______________________

Sketch

Other Monitoring Conducted

☒ None ☐ Water Quality Sampling ☐ Flow Monitoring ☐ Fish Sampling ☐ Benthic Sampling ☐ Mussel Sampling

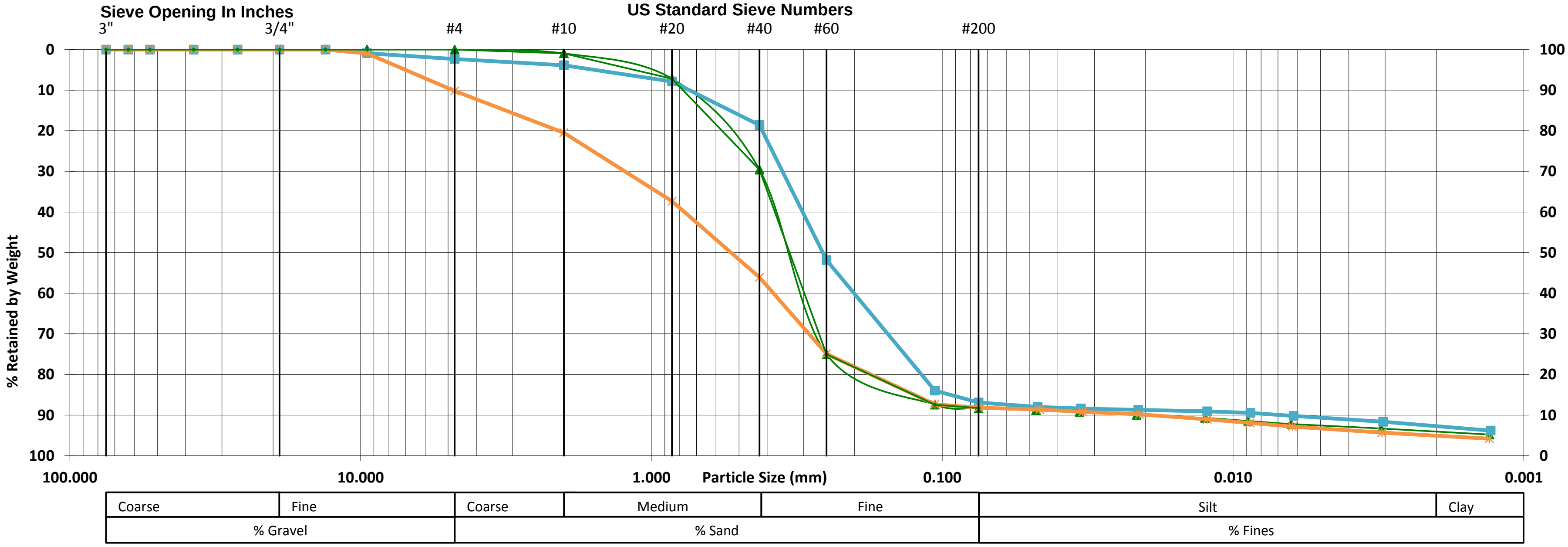
Appendix B

Soils Lab Analysis

Particle Size Distribution Analysis Test Results

Project Name:	**Lebo Creek Watershed Master Drainage Study & Erosion**	**Date Received:**	**June 9, 2020**	**MTE File No.:**	**47117-100**
Client:	**Landmark Engineers Inc.**	**Date Tested:**	**June 16-19, 2020**	**Table No.:**	**101**
Project Location:	**Lebo Creek, Leamington, ON**				

Unified Soil Classification



Symbol	*Sample #*	Description
▲	LEBO 1	SAND, trace Silt and Clay
■	LEBO 4	SAND, trace Silt, Clay, and Gravel
✱	HD 2	SAND, some Gravel, trace Silt and Clay

CERTIFIED BY CCIL
Canadian Council of Independent Laboratories
For specific tests as listed on www.ccil.com

NOTES:

APPENDIX D

EROSION CONTROL

1.0 EROSION MITIGATING MEASURES

Two types of rock vanes are suggested for consideration with regards to potential erosion mitigating measures: single vane (see Images 1 & 2) and cross vane (see Images 3 & 4). The main purpose of the vanes is to protect the drain banks from erosion by directing the flow toward the center of the channel. The motion of the water flowing over the vanes also serves to create scour pools, adding cover to the channel and oxygen to the water - which ultimately improves the quality of in-stream habitat.

1.1 SINGLE ROCK VANES

Single vanes typically extend about half way across the channel at a 20 to 30 degree angle to the bank. All rocks should be placed such that they are touching each other with footer rocks placed downstream from the top rocks (see Image 3).

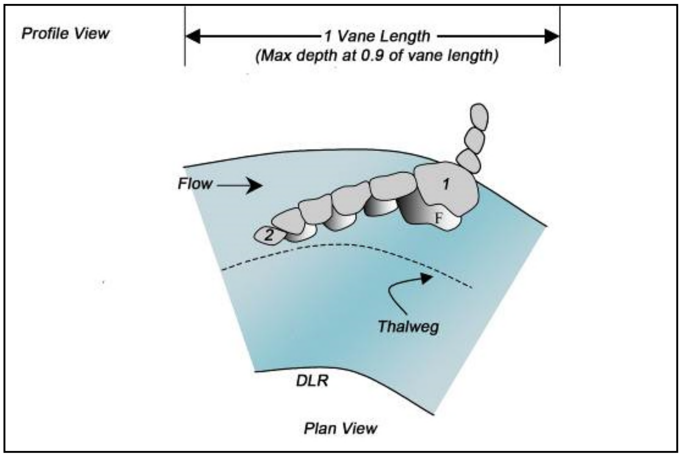


Image 1: Single Vane Details

Image 2: Armour Rock Vane

1.2 CROSS VANE

Cross vanes are comprised of three components: two single vanes and a centre structure, built perpendicular to the flow. The two vanes form a 'V' shape (see Image 3) and serve to slightly elevate the upstream water level, causing a downstream riffle. The rocks that form the vanes should be placed close together, leaving small voids to allow some of the flow to pass through. Geotextile fabric should also be placed upstream of the rocks, to prevent scouring under the structure.

At low water levels, the cross vane could be used as an informal drain crossing point. It is hoped that this would serve to discourage the construction of improvised crossings using less desirable materials.

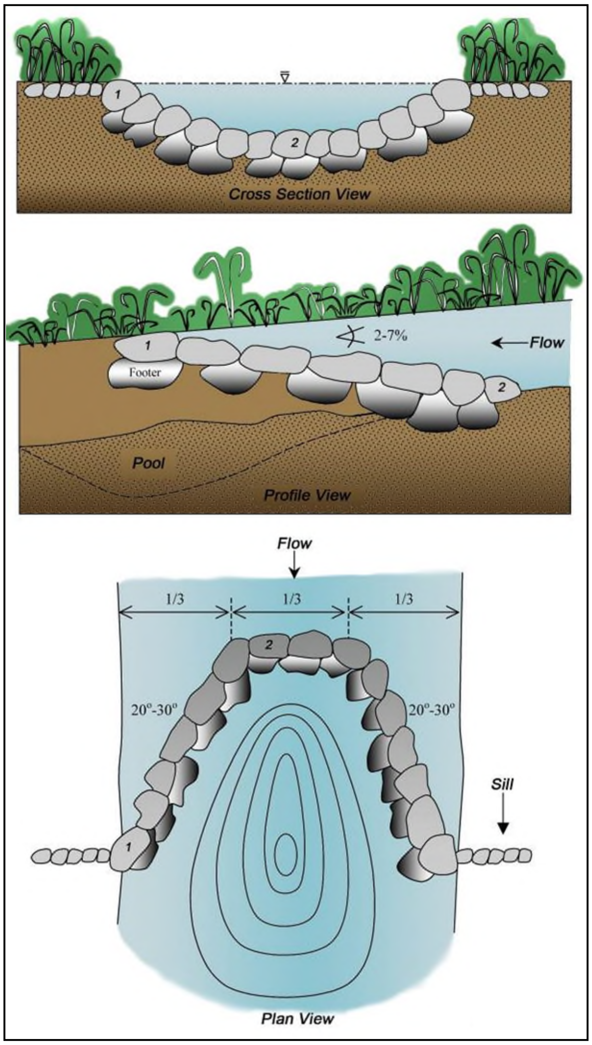
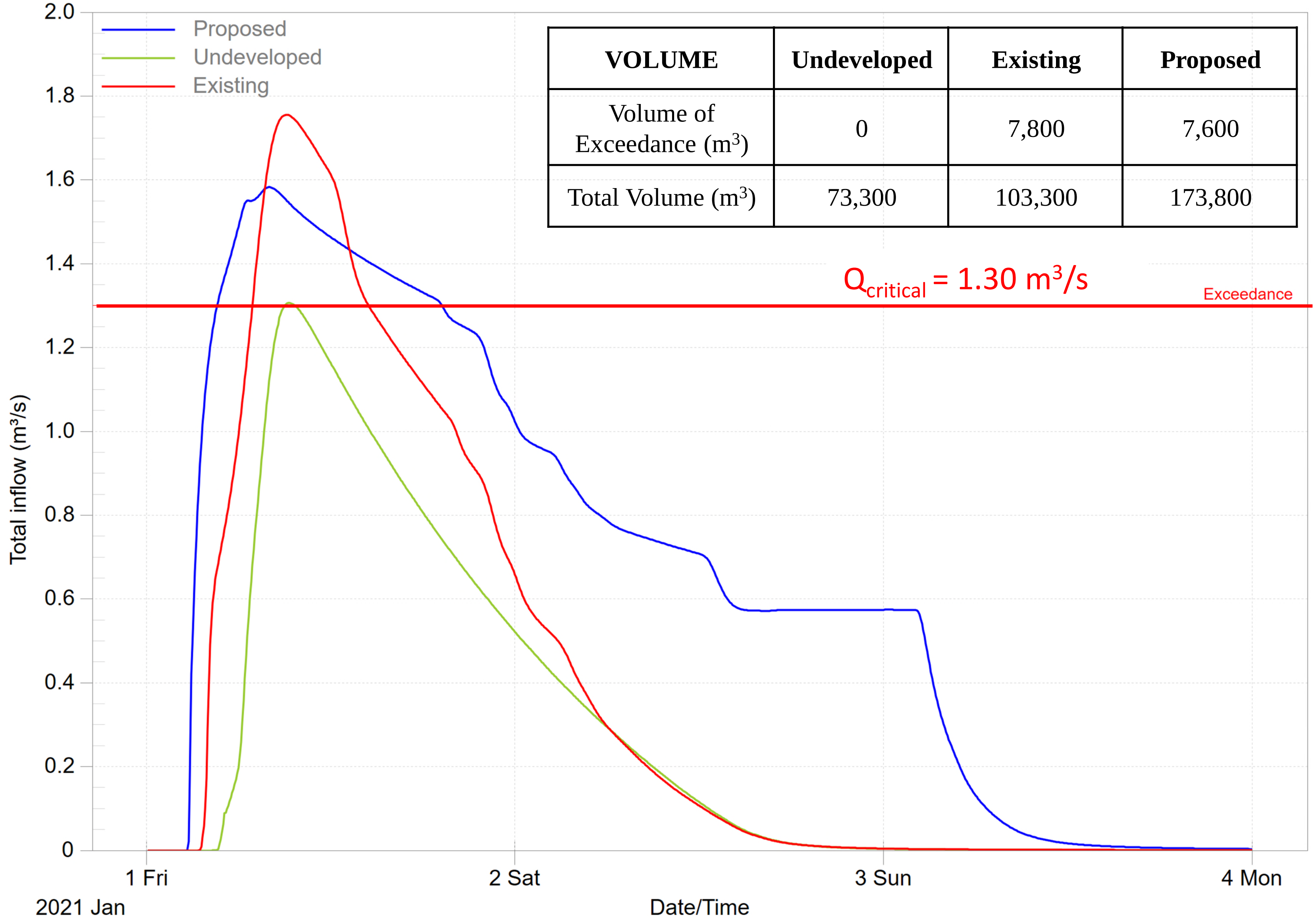


Image 3: Cross Vane Details

Image 4: Cross Vane

LEBO1 – LEBO CREEK @ MERSEA RD 12



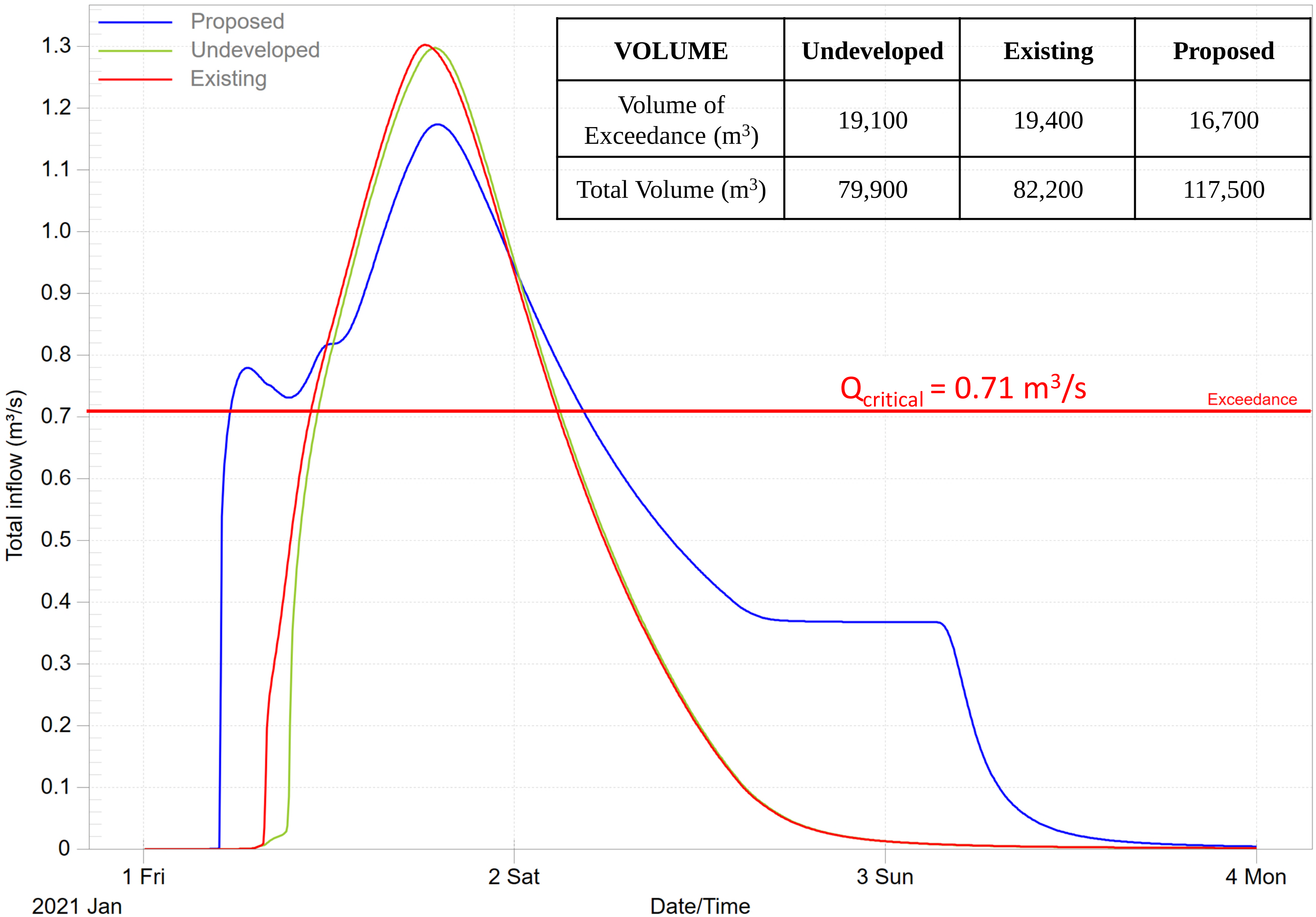
VOLUME	Undeveloped	Existing	Proposed
Volume of Exceedance (m^3)	0	7,800	7,600
Total Volume (m^3)	73,300	103,300	173,800

Landmark Engineers Inc.

Title	FLOW @ LEBO1 – AES 12-HOUR 32mm STORM
Project	LEBO CREEK MASTER DRAINAGE STUDY
Date	JUN 2022
Scale	NTS
Project No.	19-023

FIGURE D1

HD2 – HOOKER DRAIN @ MERSEA RD 7

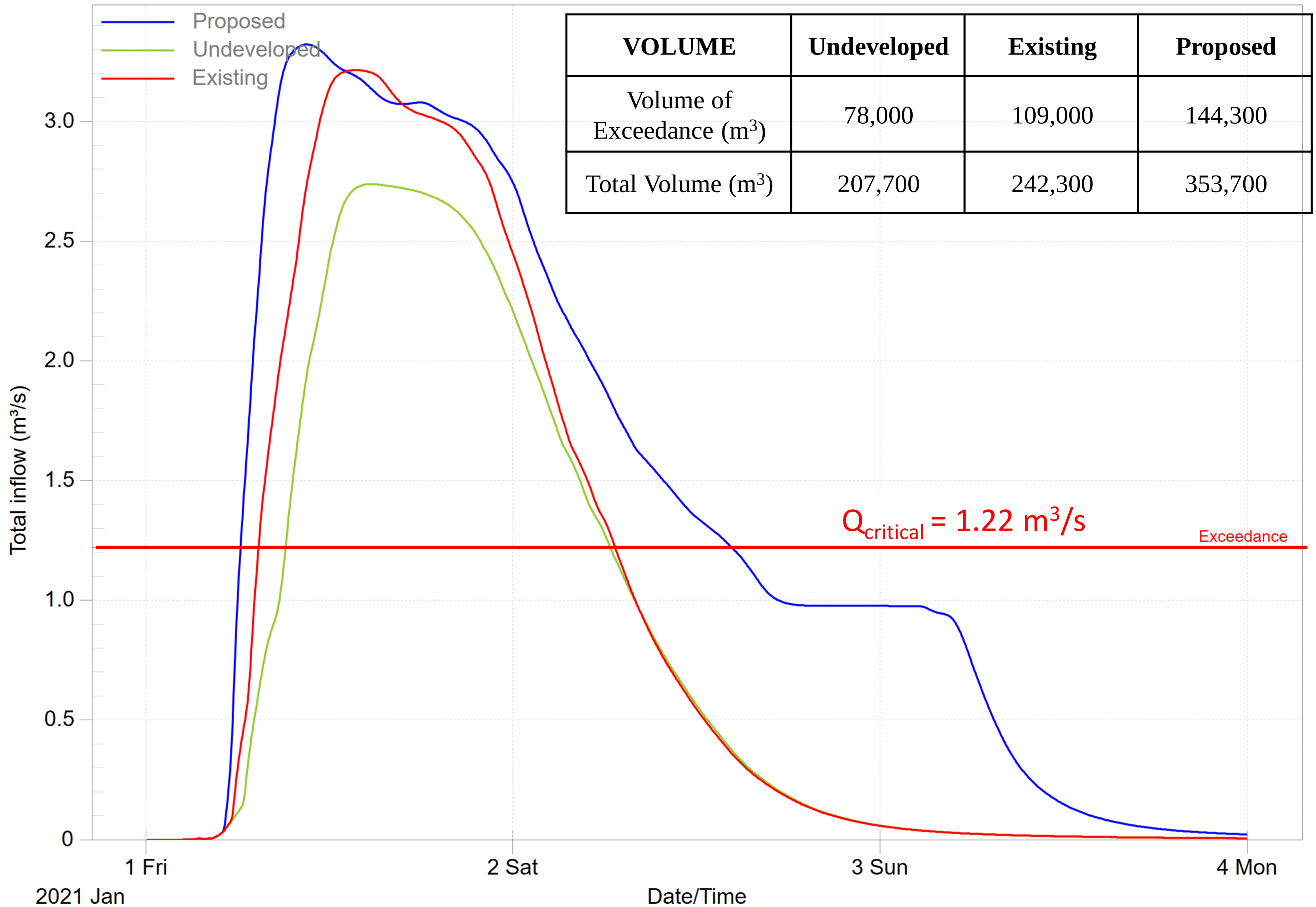


VOLUME	Undeveloped	Existing	Proposed
Volume of Exceedance (m^3)	19,100	19,400	16,700
Total Volume (m^3)	79,900	82,200	117,500

Landmark Engineers Inc.

Title: FLOW @ HD2 – AES 12-HOUR 32mm STORM	Date: JUN 2022	Scale: NTS	FIGURE D2
Project: LEBO CREEK MASTER DRAINAGE STUDY	Project No. 19-023		

LEBO4 – LEBO CREEK @ COUNTY RD 34



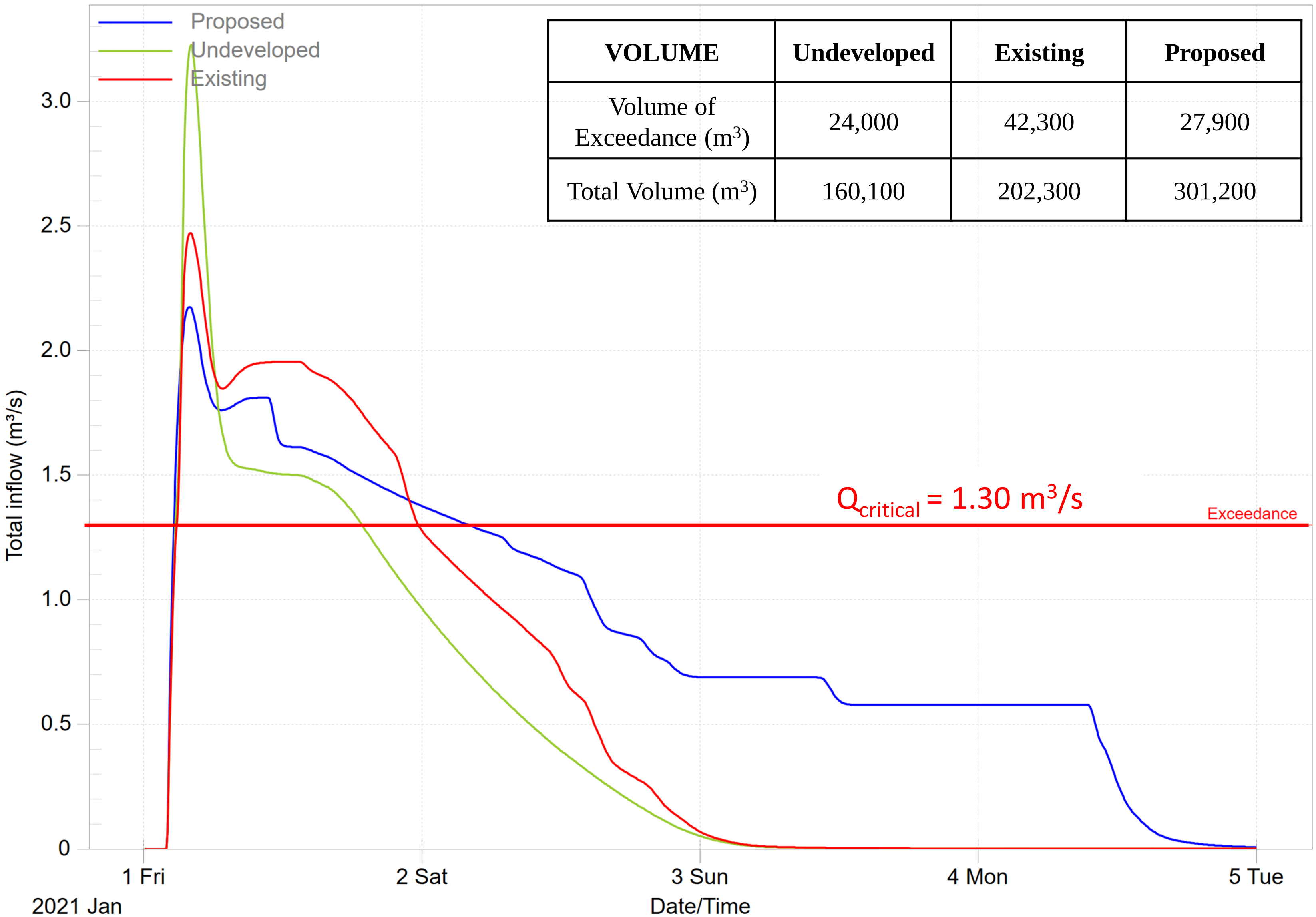
VOLUME	Undeveloped	Existing	Proposed
Volume of Exceedance (m^3)	78,000	109,000	144,300
Total Volume (m^3)	207,700	242,300	353,700

Landmark Engineers Inc.

Title	FLOW @ LEBO4 – AES 12-HOUR 32mm STORM	Date: JUN 2022	FIGURE D3
		Scale: NTS	
Project	LEBO CREEK MASTER DRAINAGE STUDY	Project No.: 19-023	

LEBO1 – LEBO CREEK @ MERSEA RD 12

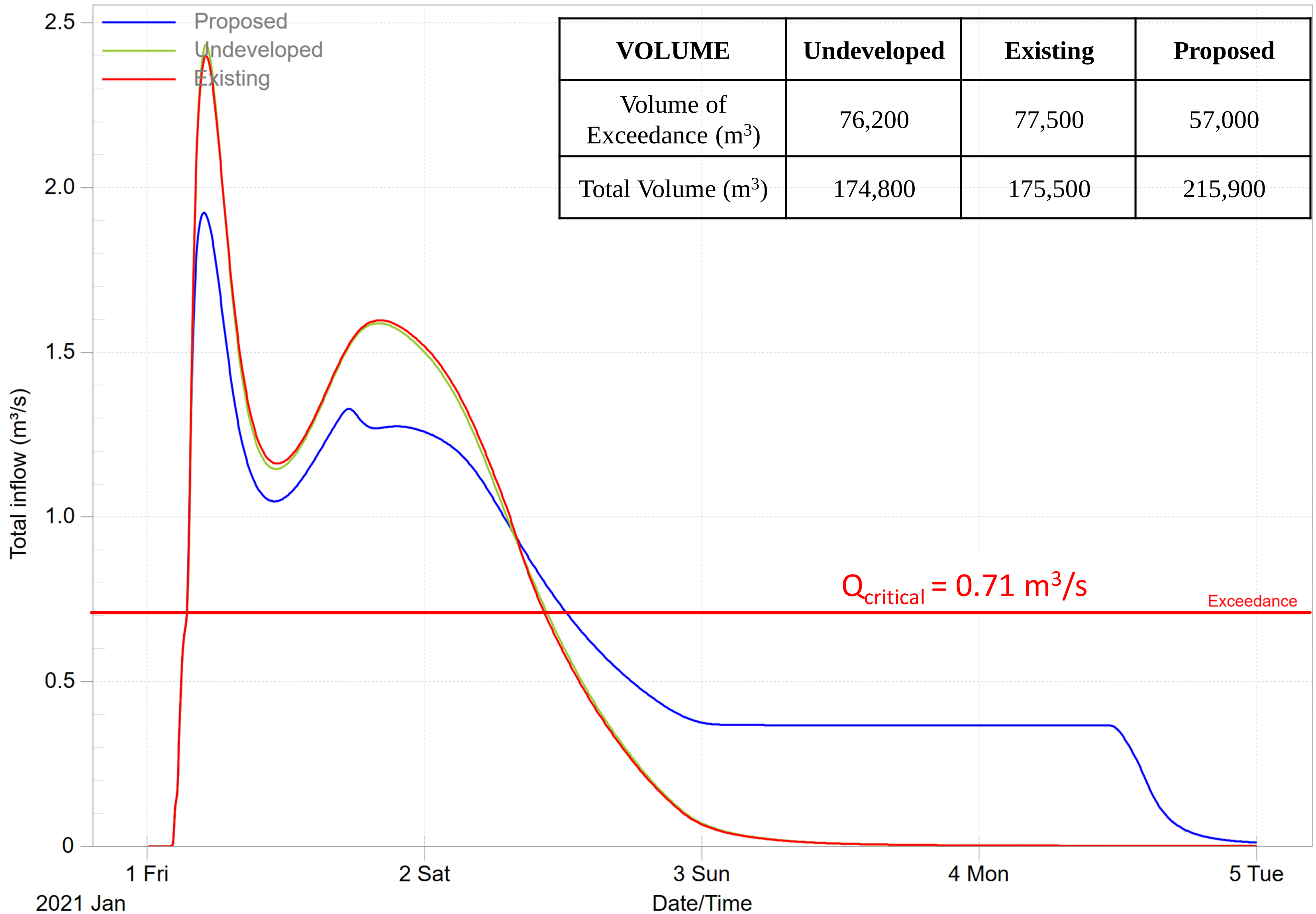
VOLUME	Undeveloped	Existing	Proposed
Volume of Exceedance (m^3)	24,000	42,300	27,900
Total Volume (m^3)	160,100	202,300	301,200



Landmark Engineers Inc.

Title: FLOW @ LEBO1 – 5-YEAR 4-HOUR STORM	Date: JUN 2022	FIGURE D4
	Scale: NTS	
Project: LEBO CREEK MASTER DRAINAGE STUDY	Project No. 19-023	

HD2 – HOOKER DRAIN @ MERSEA RD 7

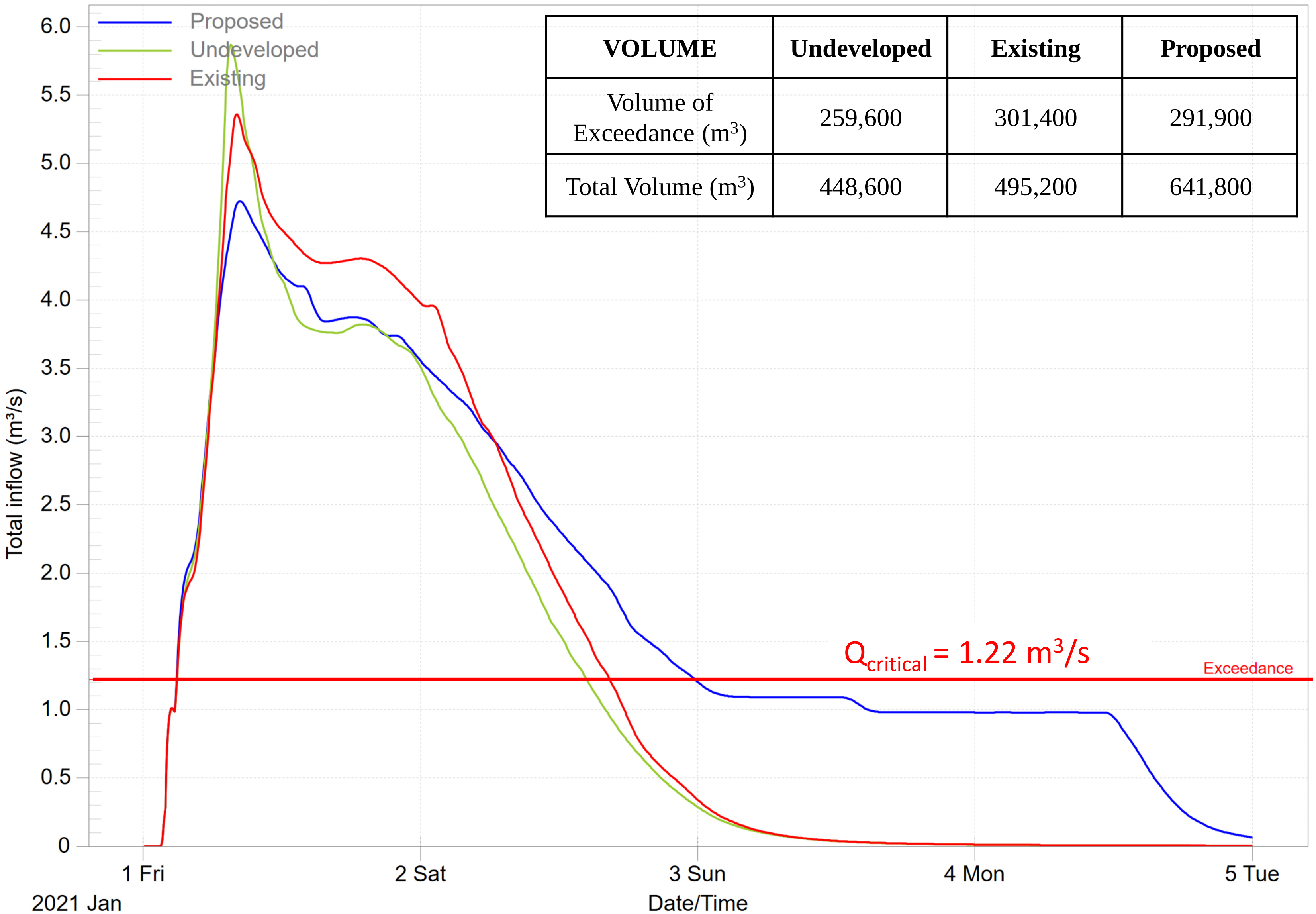


VOLUME	Undeveloped	Existing	Proposed
Volume of Exceedance (m^3)	76,200	77,500	57,000
Total Volume (m^3)	174,800	175,500	215,900

Landmark Engineers Inc.

Title: FLOW @ HD2 – 5-YEAR 4-HOUR STORM	Date: JUN 2022	Scale: NTS	FIGURE D5
Project: LEBO CREEK MASTER DRAINAGE STUDY	Project No. 19-023		

LEBO4 – LEBO CREEK @ COUNTY RD 34



VOLUME	Undeveloped	Existing	Proposed
Volume of Exceedance (m^3)	259,600	301,400	291,900
Total Volume (m^3)	448,600	495,200	641,800

Landmark Engineers Inc.

Title: FLOW @ LEBO4 – 5-YEAR 4-HOUR STORM

Project: LEBO CREEK MASTER DRAINAGE STUDY

Date: JUN 2022

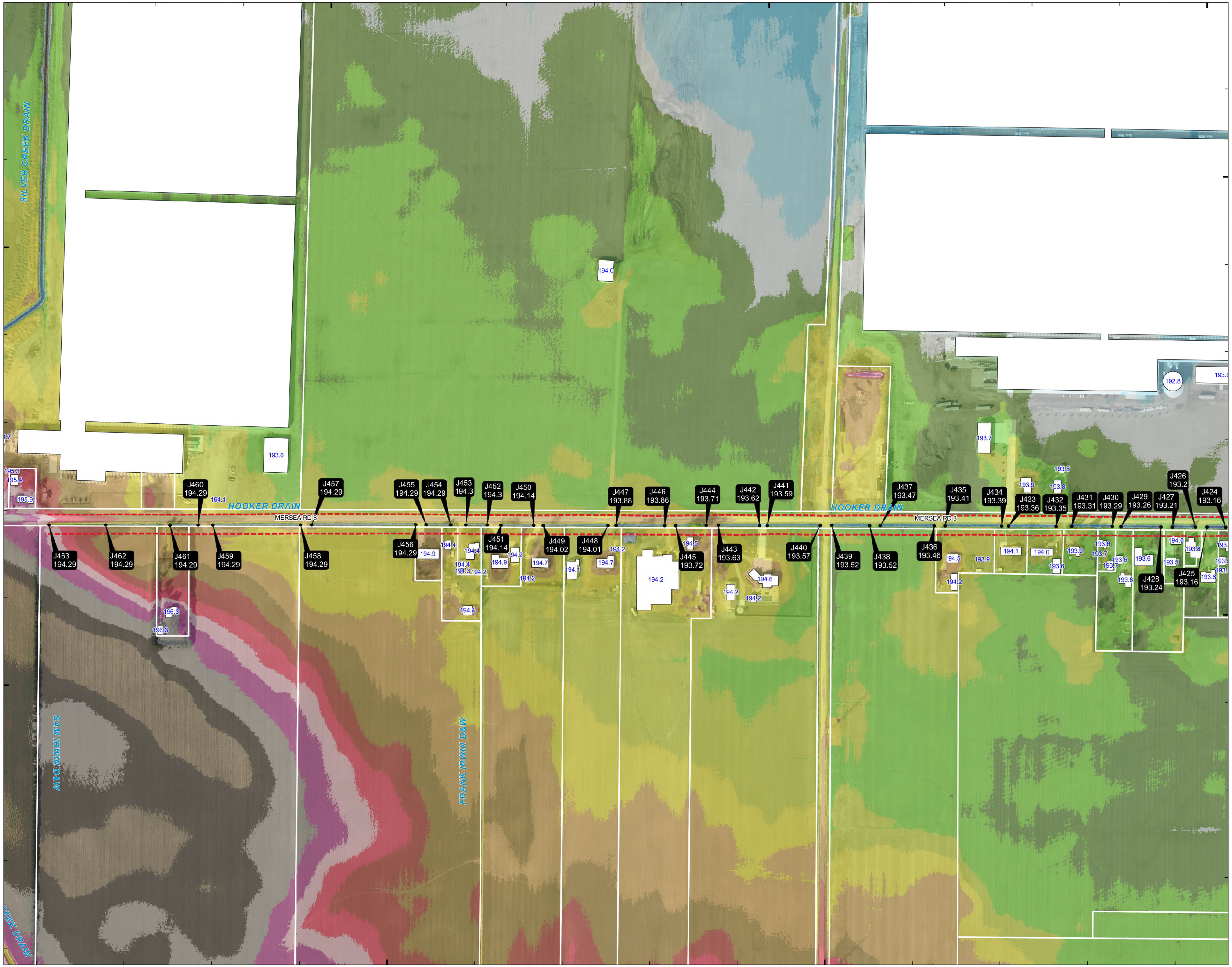
Scale: NTS

Project No. 19-023

FIGURE D6

APPENDIX
E

FLOODLINE MAPPING



LEGEND:

NODE ID
1:100 YEAR REGULATORY FLOOD ELEVATION (m)
NO-CULVERT SCENARIO INCREASE

MODELED NODE

EXISTING BUILDING & APPROXIMATE EXISTING GRADE ELEVATION (m)

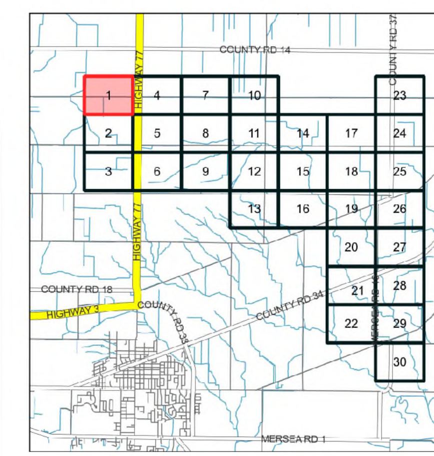
TYPICAL MINIMUM FLOODWAY CORRIDOR

EXISTING GROUND ELEVATION (m) (RANGES VARY ON EACH SHEET)

- 192.00 - 192.30
- 192.30 - 192.60
- 192.60 - 192.90
- 192.90 - 193.20
- 193.20 - 193.50
- 193.50 - 193.80
- 193.80 - 194.10
- 194.10 - 194.40
- 194.40 - 194.70
- 194.70 - 195.00
- 195.00 - 195.30
- 195.30 - 195.60
- 195.60 - 195.90
- 195.90 - 196.20
- 196.20 - 196.50
- 196.50 - 196.80

NOTES:

1. HORIZONTAL COORDINATE SYSTEM: NAD 1983 UTM ZONE 17N
2. VERTICAL COORDINATE SYSTEM: CGVD 1928 (1978 ADJUSTMENT)
3. CONTAINS INFORMATION LICENSED UNDER THE OPEN GOVERNMENT LICENSE - ONTARIO
4. SCALE APPLIES TO ORIGINAL DOCUMENT SIZE OF 24" BY 36"



Peralta Engineering

Landmark Engineers Inc.

client: THE MUNICIPALITY OF LEAMINGTON

project: LEBO CREEK MASTER DRAINAGE STUDY

title: PROJECTED FLOOD ELEVATIONS 1:100 YEAR EVENT

drawn by / date	FMK / AUG 2022	project no.	19-023
designed by / date		figure no.	E-1
checked by / date	ADM / AUG 2022	scale	1:2,000

LEGEND:

NODE ID
1:100 YEAR REGULATORY FLOOD ELEVATION (m)
NO-CULVERT SCENARIO INCREASE

MODELED NODE

EXISTING BUILDING & APPROXIMATE EXISTING GRADE ELEVATION (m)

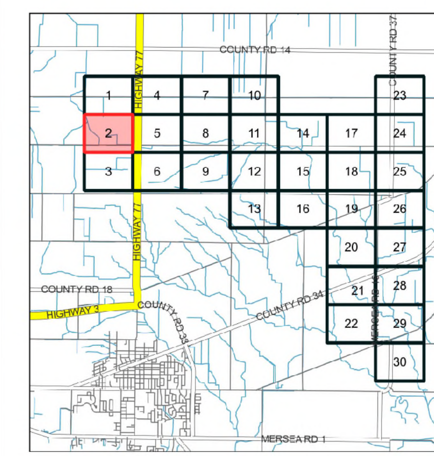
TYPICAL MINIMUM FLOODWAY CORRIDOR

EXISTING GROUND ELEVATION (m) (RANGES VARY ON EACH SHEET)

- 193.50 - 193.80
- 193.80 - 194.10
- 194.10 - 194.40
- 194.40 - 194.70
- 194.70 - 195.00
- 195.00 - 195.30
- 195.30 - 195.60
- 195.60 - 195.90
- 195.90 - 196.20
- 196.20 - 196.50
- 196.50 - 196.80
- 196.80 - 197.10
- 197.10 - 197.40
- 197.40 - 197.70
- 197.70 - 198.00
- 198.00 - 198.30

NOTES:

1. HORIZONTAL COORDINATE SYSTEM: NAD 1983 UTM ZONE 17N
2. VERTICAL COORDINATE SYSTEM: CGVD 1928 (1978 ADJUSTMENT)
3. CONTAINS INFORMATION LICENSED UNDER THE OPEN GOVERNMENT LICENSE - ONTARIO
4. SCALE APPLIES TO ORIGINAL DOCUMENT SIZE OF 24" BY 36"



Peralta Engineering

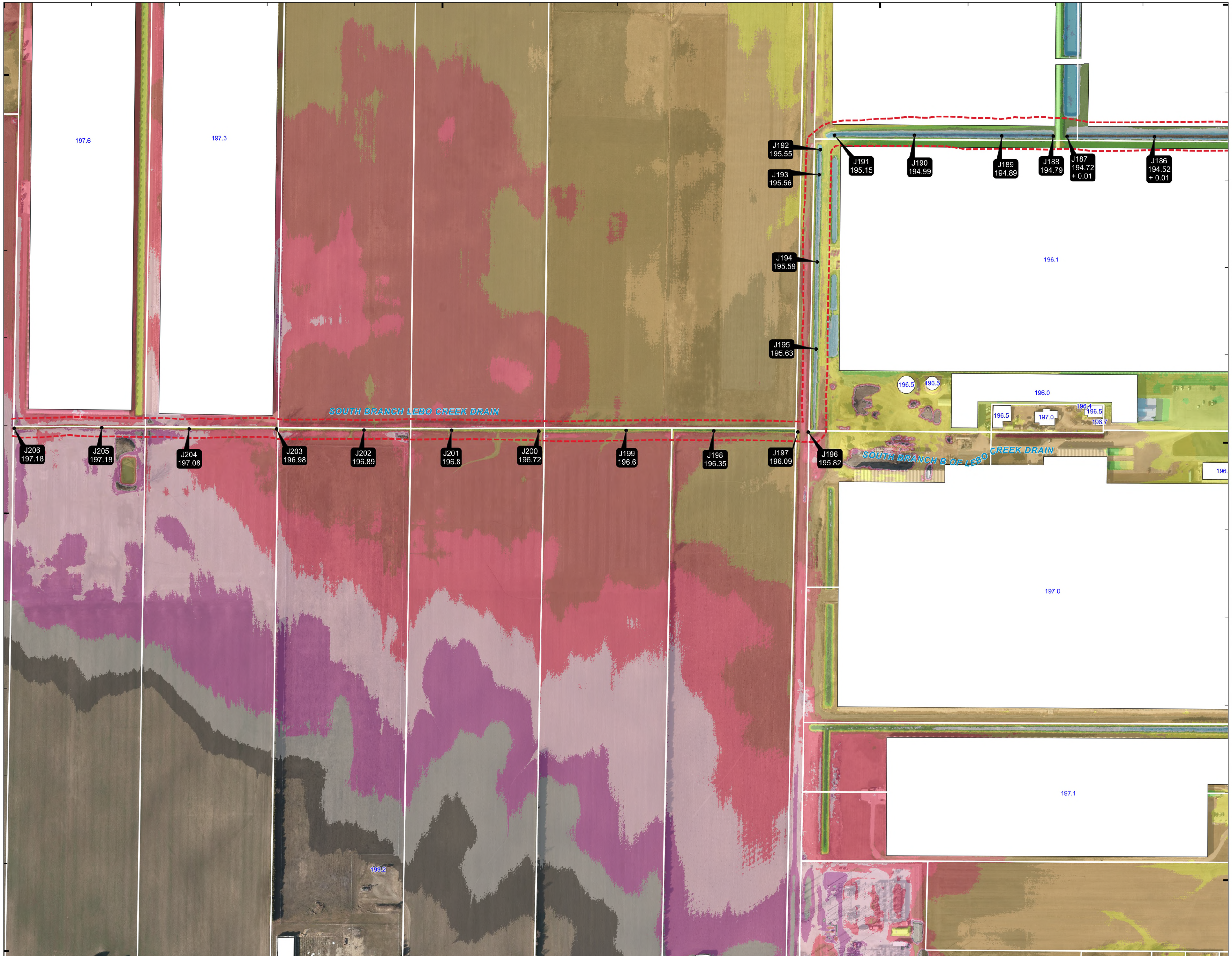
Landmark Engineers Inc.

client: THE MUNICIPALITY OF LEAMINGTON

project: LEBO CREEK MASTER DRAINAGE STUDY

title: PROJECTED FLOOD ELEVATIONS 1:100 YEAR EVENT

drawn by / date	FMK / AUG 2022	project no.	19-023
designed by / date		figure no.	E-2
checked by / date	ADM / AUG 2022	scale	1:2,000



LEGEND:

NODE ID
1:100 YEAR REGULATORY FLOOD ELEVATION (m)
NO-CULVERT SCENARIO INCREASE

MODELED NODE

190.0 — EXISTING BUILDING & APPROXIMATE EXISTING GRADE ELEVATION (m)

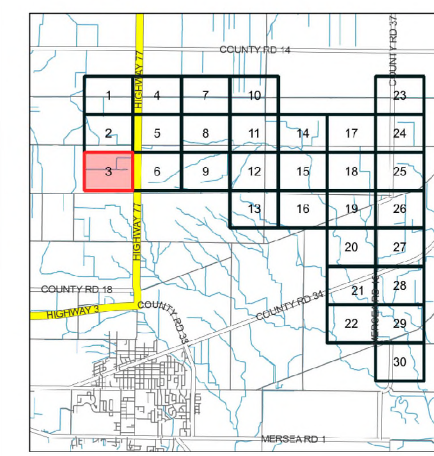
TYPICAL MINIMUM FLOODWAY CORRIDOR

EXISTING GROUND ELEVATION (m)
(RANGES VARY ON EACH SHEET)

- 194.10 - 194.40
- 194.40 - 194.70
- 194.70 - 195.00
- 195.00 - 195.30
- 195.30 - 195.60
- 195.60 - 195.90
- 195.90 - 196.20
- 196.20 - 196.50
- 196.50 - 196.80
- 196.80 - 197.10
- 197.10 - 197.40
- 197.40 - 197.70
- 197.70 - 198.00
- 198.00 - 198.30
- 198.30 - 198.60
- 198.60 - 198.90

NOTES:

1. HORIZONTAL COORDINATE SYSTEM: NAD 1983 UTM ZONE 17N
2. VERTICAL COORDINATE SYSTEM: CGVD 1928 (1978 ADJUSTMENT)
3. CONTAINS INFORMATION LICENSED UNDER THE OPEN GOVERNMENT LICENSE - ONTARIO
4. SCALE APPLIES TO ORIGINAL DOCUMENT SIZE OF 24" BY 36"



Peralta Engineering

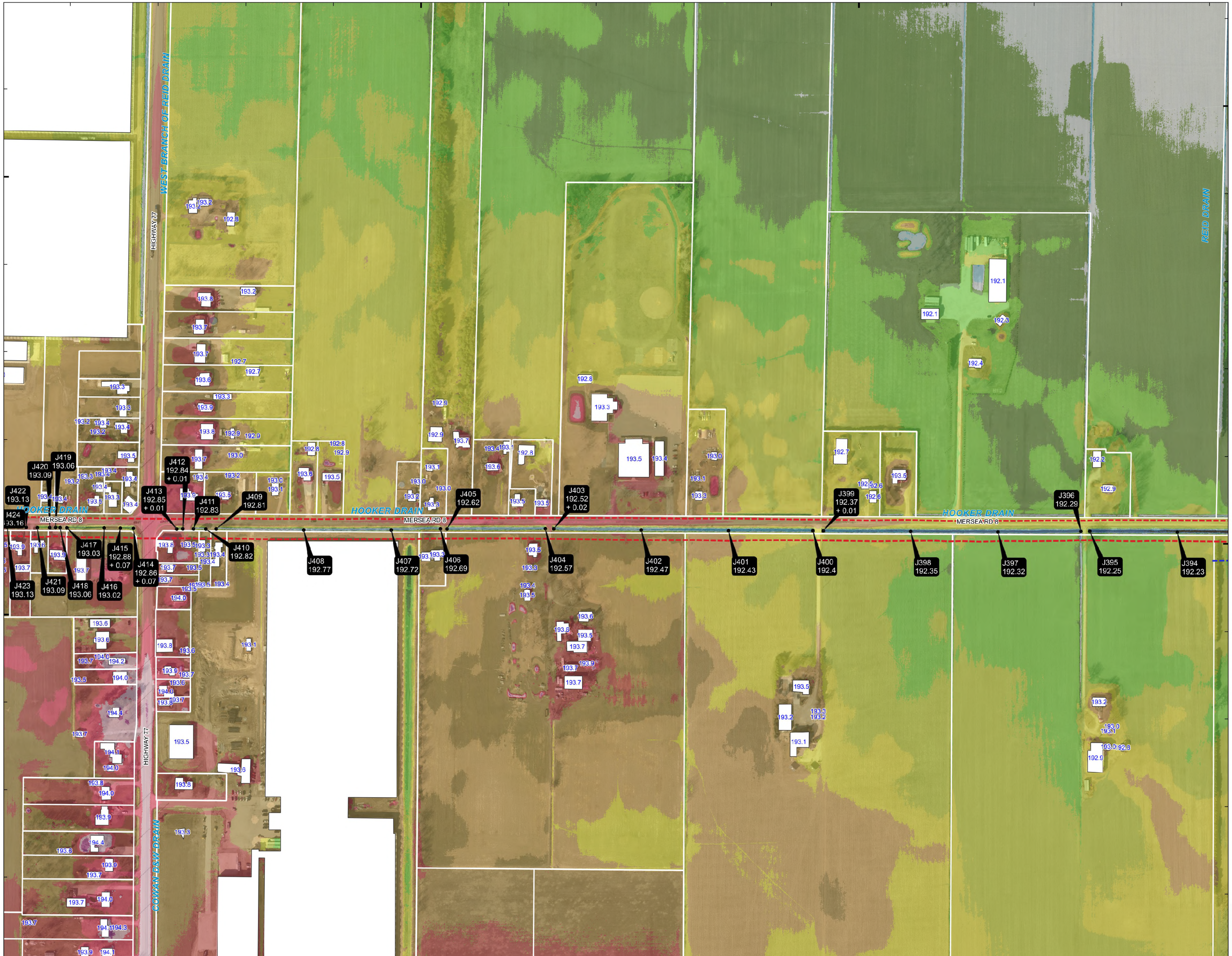
Landmark Engineers Inc.

client: THE MUNICIPALITY OF LEAMINGTON

project: LEBO CREEK MASTER DRAINAGE STUDY

title: PROJECTED FLOOD ELEVATIONS 1:100 YEAR EVENT

drawn by date	EMK AUG 2022	project no.	19-023
designed by date		figure no.	E-3
checked by date	ADM AUG 2022	scale	1:2,000



LEGEND:

NODE ID
1:100 YEAR REGULATORY FLOOD ELEVATION (m)
NO-CULVERT SCENARIO INCREASE

MODELED NODE

EXISTING BUILDING & APPROXIMATE EXISTING GRADE ELEVATION (m)

TYPICAL MINIMUM FLOODWAY CORRIDOR

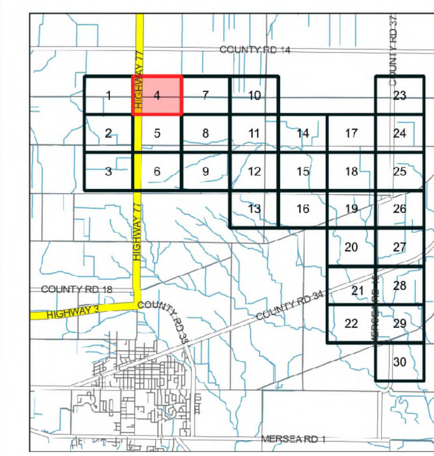
EXPANDED MINIMUM FLOODWAY CORRIDOR

EXISTING GROUND ELEVATION (m) (RANGES VARY ON EACH SHEET)

- 190.50 - 190.80
- 190.80 - 191.10
- 191.10 - 191.40
- 191.40 - 191.70
- 191.70 - 192.00
- 192.00 - 192.30
- 192.30 - 192.60
- 192.60 - 192.90
- 192.90 - 193.20
- 193.20 - 193.50
- 193.50 - 193.80
- 193.80 - 194.10
- 194.10 - 194.40
- 194.40 - 194.70
- 194.70 - 195.00
- 195.00 - 195.30

NOTES:

1. HORIZONTAL COORDINATE SYSTEM: NAD 1983 UTM ZONE 17N
2. VERTICAL COORDINATE SYSTEM: CGVD 1928 (1978 ADJUSTMENT)
3. CONTAINS INFORMATION LICENSED UNDER THE OPEN GOVERNMENT LICENSE - ONTARIO
4. SCALE APPLIES TO ORIGINAL DOCUMENT SIZE OF 24" BY 36"



Peralta Engineering

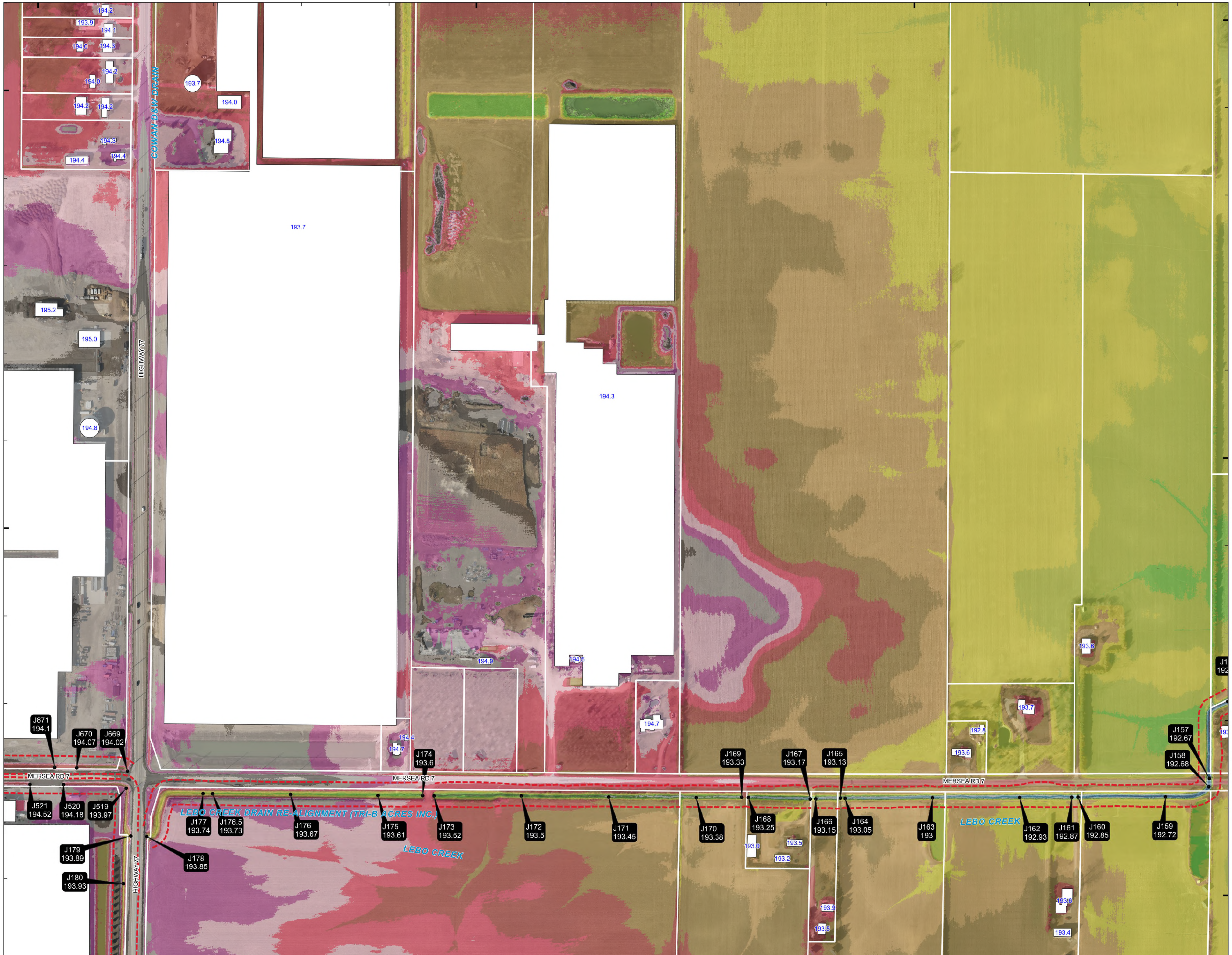
Landmark Engineers Inc.

client: THE MUNICIPALITY OF LEAMINGTON

project: LEBO CREEK MASTER DRAINAGE STUDY

title: PROJECTED FLOOD ELEVATIONS 1:100 YEAR EVENT

drawn by / date	EMK / AUG 2022	project no.	19-023
designed by / date		figure no.	E-4
checked by / date	ADM / AUG 2022	scale	1:2,000



LEGEND:

NODE ID
1:100 YEAR REGULATORY FLOOD ELEVATION (m)
NO-CULVERT SCENARIO INCREASE

MODELED NODE

EXISTING BUILDING & APPROXIMATE EXISTING GRADE ELEVATION (m)

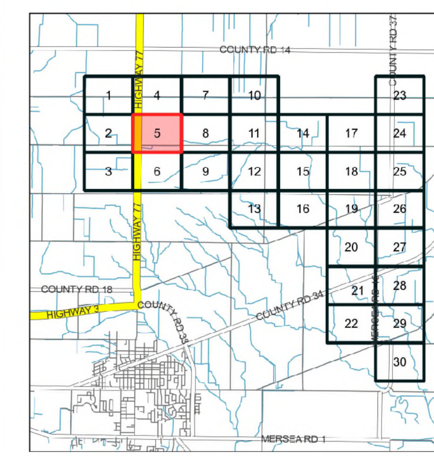
TYPICAL MINIMUM FLOODWAY CORRIDOR

EXISTING GROUND ELEVATION (m)
(RANGES VARY ON EACH SHEET)

- 190.50 - 190.80
- 190.80 - 191.10
- 191.10 - 191.40
- 191.40 - 191.70
- 191.70 - 192.00
- 192.00 - 192.30
- 192.30 - 192.60
- 192.60 - 192.90
- 192.90 - 193.20
- 193.20 - 193.50
- 193.50 - 193.80
- 193.80 - 194.10
- 194.10 - 194.40
- 194.40 - 194.70
- 194.70 - 195.00
- 195.00 - 195.30

NOTES:

1. HORIZONTAL COORDINATE SYSTEM: NAD 1983 UTM ZONE 17N
2. VERTICAL COORDINATE SYSTEM: CGVD 1928 (1978 ADJUSTMENT)
3. CONTAINS INFORMATION LICENSED UNDER THE OPEN GOVERNMENT LICENSE - ONTARIO
4. SCALE APPLIES TO ORIGINAL DOCUMENT SIZE OF 24" BY 36"



Peralta Engineering

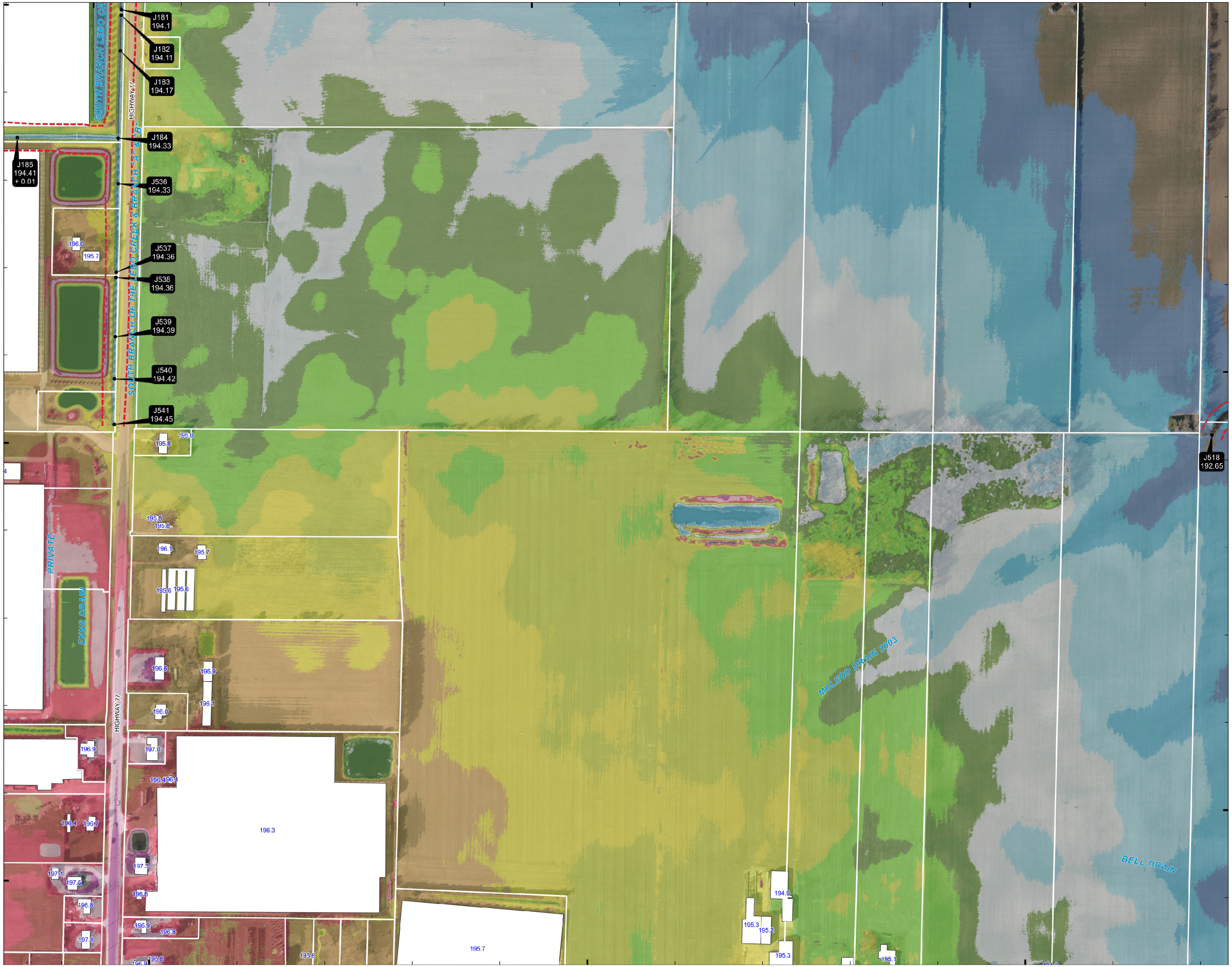
Landmark Engineers Inc.

client: THE MUNICIPALITY OF LEAMINGTON

project: LEBO CREEK MASTER DRAINAGE STUDY

title: PROJECTED FLOOD ELEVATIONS 1:100 YEAR EVENT

drawn by / date	FMK / AUG 2022	project no.	19-023
designed by / date		figure no.	E-5
checked by / date	ADM / AUG 2022	scale	1:2,000



LEGEND:

NODE ID
1:100 YEAR REGULATORY FLOOD ELEVATION (m)
NO-CULVERT SCENARIO INCREASE

MODELED NODE

190.0 EXISTING BUILDING & APPROXIMATE EXISTING GRADE ELEVATION (m)

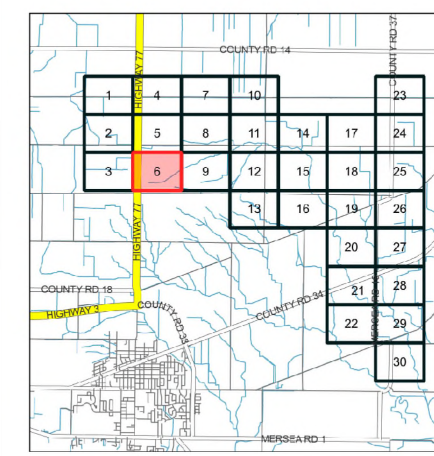
TYPICAL MINIMUM FLOODWAY CORRIDOR

EXISTING GROUND ELEVATION (m)
(RANGES VARY ON EACH SHEET)

- 193.20 - 193.50
- 193.50 - 193.80
- 193.80 - 194.10
- 194.10 - 194.40
- 194.40 - 194.70
- 194.70 - 195.00
- 195.00 - 195.30
- 195.30 - 195.60
- 195.60 - 195.90
- 195.90 - 196.20
- 196.20 - 196.50
- 196.50 - 196.80
- 196.80 - 197.10
- 197.10 - 197.40
- 197.40 - 197.70
- 197.70 - 198.00

NOTES:

1. HORIZONTAL COORDINATE SYSTEM: NAD 1983 UTM ZONE 17N
2. VERTICAL COORDINATE SYSTEM: CGVD 1928 (1978 ADJUSTMENT)
3. CONTAINS INFORMATION LICENSED UNDER THE OPEN GOVERNMENT LICENSE - ONTARIO
4. SCALE APPLIES TO ORIGINAL DOCUMENT SIZE OF 24" BY 36"



Peralta Engineering

Landmark Engineers Inc.

client
THE MUNICIPALITY OF LEAMINGTON

project
LEBO CREEK MASTER DRAINAGE STUDY

title
PROJECTED FLOOD ELEVATIONS
1:100 YEAR EVENT

drawn by date	EMK AUG 2022	project no.	19-023
designed by date		figure no.	E-6
checked by date	ADM AUG 2022	scale	1:2,000

LEGEND:

NODE ID
1:100 YEAR REGULATORY FLOOD ELEVATION (m)
NO-CULVERT SCENARIO INCREASE

MODELED NODE

190.0 EXISTING BUILDING & APPROXIMATE EXISTING GRADE ELEVATION (m)

TYPICAL MINIMUM FLOODWAY CORRIDOR

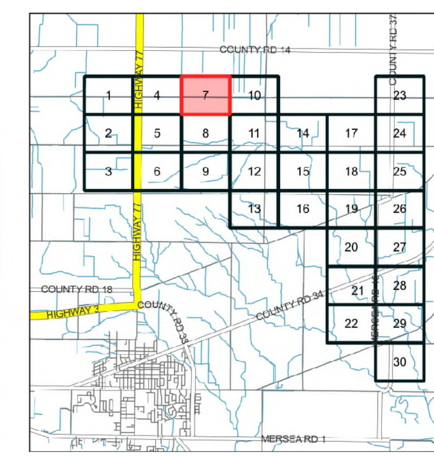
EXPANDED MINIMUM FLOODWAY CORRIDOR

EXISTING GROUND ELEVATION (m)
(RANGES VARY ON EACH SHEET)

189.30 - 189.60
189.60 - 189.90
189.90 - 190.20
190.20 - 190.50
190.50 - 190.80
190.80 - 191.10
191.10 - 191.40
191.40 - 191.70
191.70 - 192.00
192.00 - 192.30
192.30 - 192.60
192.60 - 192.90
192.90 - 193.20
193.20 - 193.50
193.50 - 193.80
193.80 - 194.10

NOTES:

1. HORIZONTAL COORDINATE SYSTEM: NAD 1983 UTM ZONE 17N
2. VERTICAL COORDINATE SYSTEM: CGVD 1928 (1978 ADJUSTMENT)
3. CONTAINS INFORMATION LICENSED UNDER THE OPEN GOVERNMENT LICENSE - ONTARIO
4. SCALE APPLIES TO ORIGINAL DOCUMENT SIZE OF 24" BY 36"



Peralta Engineering

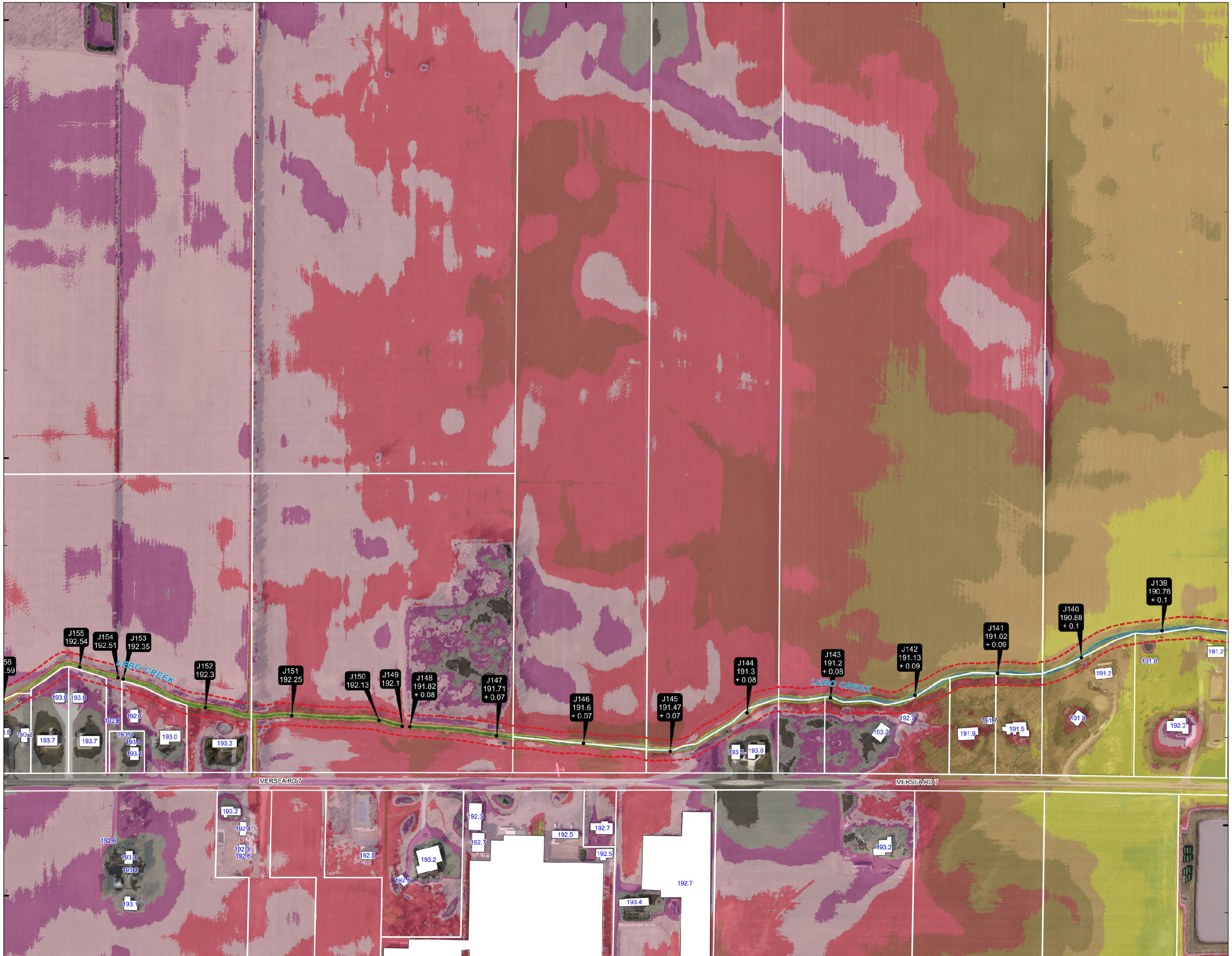
Landmark Engineers Inc.

client: **THE MUNICIPALITY OF LEAMINGTON**

project: **LEBO CREEK MASTER DRAINAGE STUDY**

title: **PROJECTED FLOOD ELEVATIONS 1:100 YEAR EVENT**

drawn by date	EMK AUG 2022	project no.	19-023
designed by date		figure no.	E-7
checked by date	ADM AUG 2022	scale	1:2,000



LEGEND:

NODE ID
1:100 YEAR REGULATORY FLOOD ELEVATION (m)
NO-CULVERT SCENARIO INCREASE

MODELED NODE

EXISTING BUILDING & APPROXIMATE EXISTING GRADE ELEVATION (m)

TYPICAL MINIMUM FLOODWAY CORRIDOR

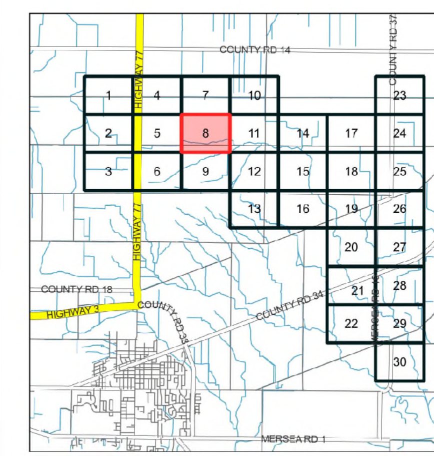
EXPANDED MINIMUM FLOODWAY CORRIDOR

EXISTING GROUND ELEVATION (m)
(RANGES VARY ON EACH SHEET)

- 188.70 - 189.00
- 189.00 - 189.30
- 189.30 - 189.60
- 189.60 - 189.90
- 189.90 - 190.20
- 190.20 - 190.50
- 190.50 - 190.80
- 190.80 - 191.10
- 191.10 - 191.40
- 191.40 - 191.70
- 191.70 - 192.00
- 192.00 - 192.30
- 192.30 - 192.60
- 192.60 - 192.90
- 192.90 - 193.20
- 193.20 - 193.50

NOTES:

1. HORIZONTAL COORDINATE SYSTEM: NAD 1983 UTM ZONE 17N
2. VERTICAL COORDINATE SYSTEM: CGVD 1928 (1978 ADJUSTMENT)
3. CONTAINS INFORMATION LICENSED UNDER THE OPEN GOVERNMENT LICENSE - ONTARIO
4. SCALE APPLIES TO ORIGINAL DOCUMENT SIZE OF 24" BY 36"



Peralta Engineering

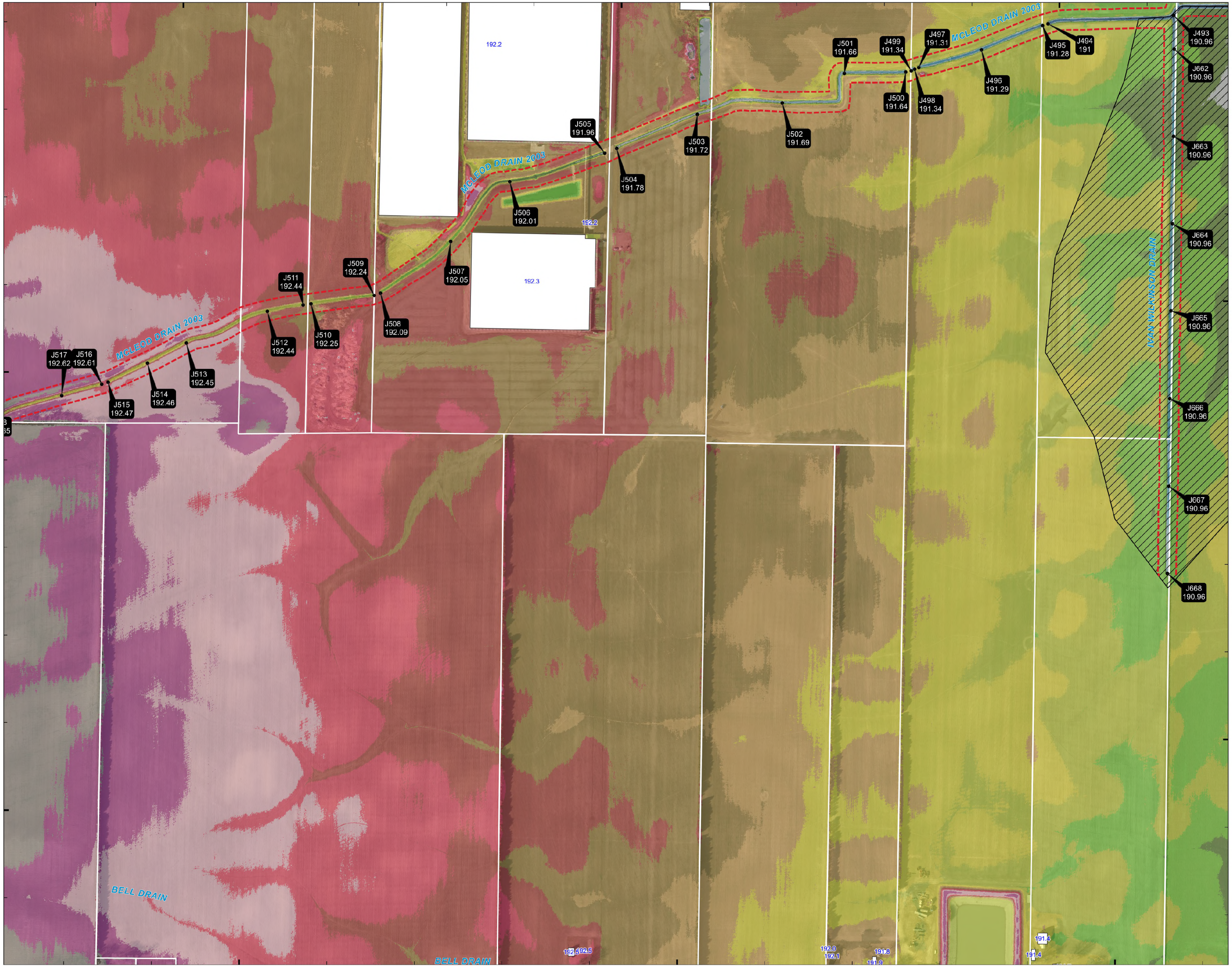
Landmark Engineers Inc.

client: THE MUNICIPALITY OF LEAMINGTON

project: LEBO CREEK MASTER DRAINAGE STUDY

title: PROJECTED FLOOD ELEVATIONS 1:100 YEAR EVENT

drawn by / date	FMK / AUG 2022	project no.	19-023
designed by / date		figure no.	E-8
checked by / date	ADM / AUG 2022	scale	1:2,000



LEGEND:

NODE ID
1:100 YEAR REGULATORY FLOOD ELEVATION (m)
NO-CULVERT SCENARIO INCREASE

MODELED NODE

190.0 EXISTING BUILDING & APPROXIMATE EXISTING GRADE ELEVATION (m)

TYPICAL MINIMUM FLOODWAY CORRIDOR

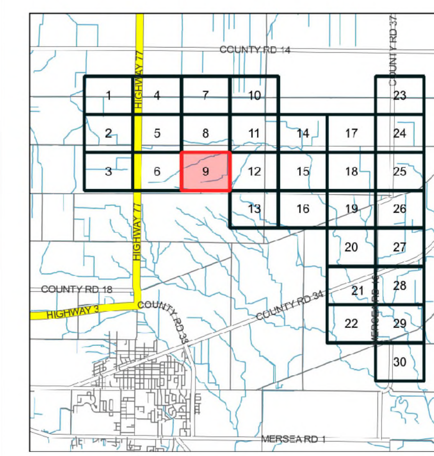
TEMPORARY FLOODPLAIN AREA

EXISTING GROUND ELEVATION (m)
(RANGES VARY ON EACH SHEET)

- 189.30 - 189.60
- 189.60 - 189.90
- 189.90 - 190.20
- 190.20 - 190.50
- 190.50 - 190.80
- 190.80 - 191.10
- 191.10 - 191.40
- 191.40 - 191.70
- 191.70 - 192.00
- 192.00 - 192.30
- 192.30 - 192.60
- 192.60 - 192.90
- 192.90 - 193.20
- 193.20 - 193.50
- 193.50 - 193.80
- 193.80 - 194.10

NOTES:

1. HORIZONTAL COORDINATE SYSTEM: NAD 1983 UTM ZONE 17N
2. VERTICAL COORDINATE SYSTEM: CGVD 1928 (1978 ADJUSTMENT)
3. CONTAINS INFORMATION LICENSED UNDER THE OPEN GOVERNMENT LICENSE - ONTARIO
4. SCALE APPLIES TO ORIGINAL DOCUMENT SIZE OF 24" BY 36"



Peralta Engineering

Landmark Engineers Inc.

client: THE MUNICIPALITY OF LEAMINGTON

project: LEBO CREEK MASTER DRAINAGE STUDY

title: PROJECTED FLOOD ELEVATIONS 1:100 YEAR EVENT

drawn by / date	FMK / SEP 2022	project no.	19-023
designed by / date		figure no.	E-9
checked by / date	ADM / SEP 2022	scale	1:2,000

LEGEND:

NODE ID
1:100 YEAR REGULATORY FLOOD ELEVATION (m)
NO-CULVERT SCENARIO INCREASE

MODELED NODE

EXISTING BUILDING & APPROXIMATE EXISTING GRADE ELEVATION (m)

TYPICAL MINIMUM FLOODWAY CORRIDOR

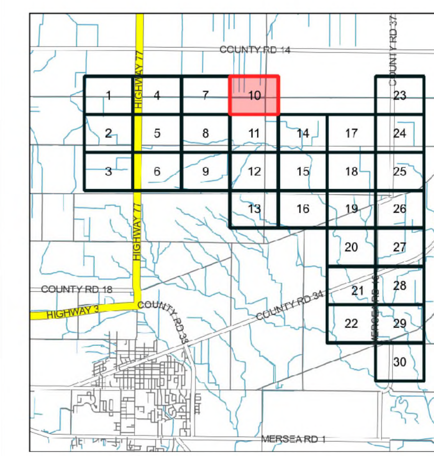
EXPANDED MINIMUM FLOODWAY CORRIDOR

EXISTING GROUND ELEVATION (m)
(RANGES VARY ON EACH SHEET)

- 188.40 - 188.70
- 188.70 - 189.00
- 189.00 - 189.30
- 189.30 - 189.60
- 189.60 - 189.90
- 189.90 - 190.20
- 190.20 - 190.50
- 190.50 - 190.80
- 190.80 - 191.10
- 191.10 - 191.40
- 191.40 - 191.70
- 191.70 - 192.00
- 192.00 - 192.30
- 192.30 - 192.60
- 192.60 - 192.90
- 192.90 - 193.20

NOTES:

1. HORIZONTAL COORDINATE SYSTEM: NAD 1983 UTM ZONE 17N
2. VERTICAL COORDINATE SYSTEM: CGVD 1928 (1978 ADJUSTMENT)
3. CONTAINS INFORMATION LICENSED UNDER THE OPEN GOVERNMENT LICENSE - ONTARIO
4. SCALE APPLIES TO ORIGINAL DOCUMENT SIZE OF 24" BY 36"



Peralta Engineering

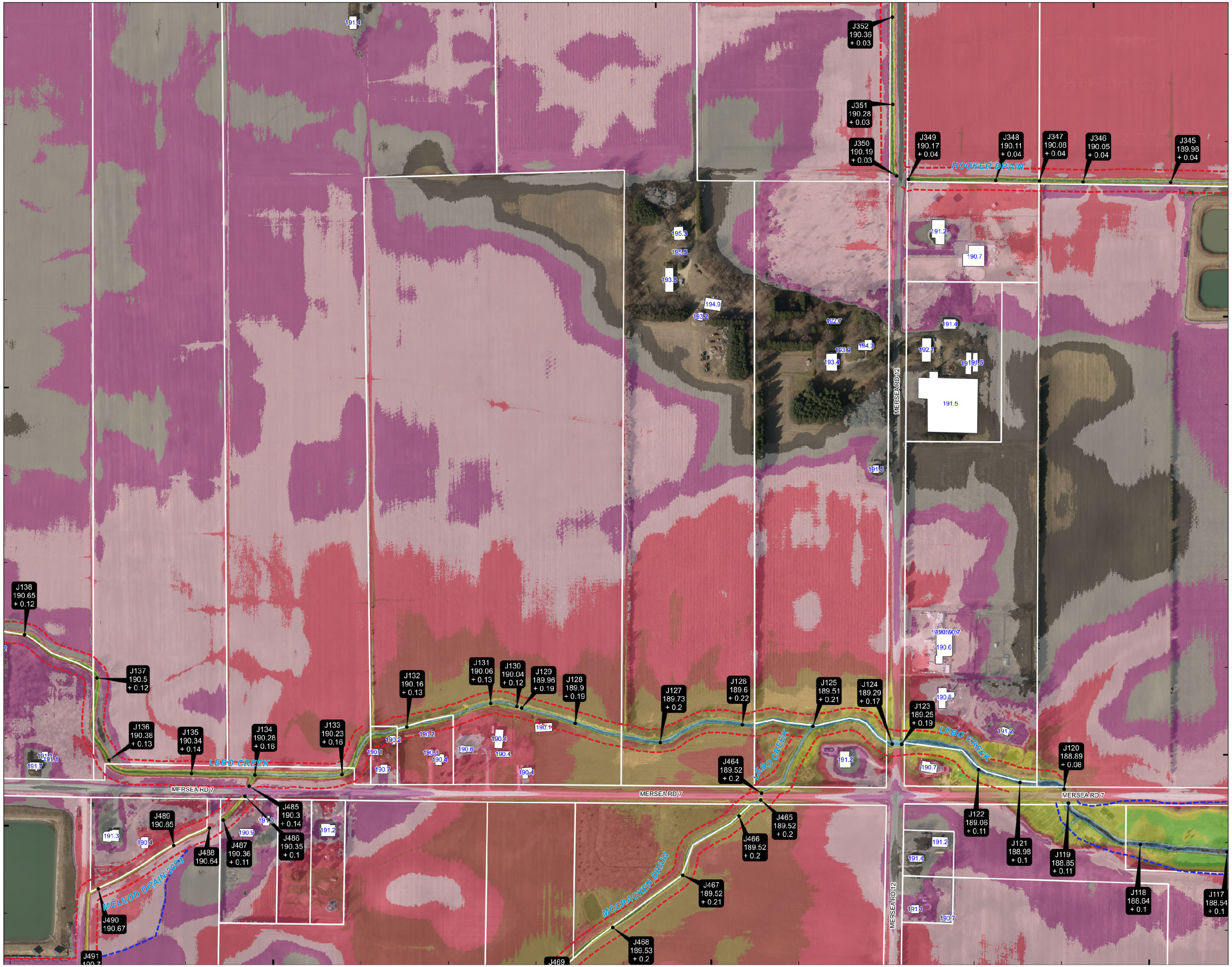
Landmark Engineers Inc.

client: THE MUNICIPALITY OF LEAMINGTON

project: LEBO CREEK MASTER DRAINAGE STUDY

title: PROJECTED FLOOD ELEVATIONS 1:100 YEAR EVENT

drawn by / date	FMK / AUG 2022	project no.	19-023
designed by / date		figure no.	E-10
checked by / date	ADM / AUG 2022	scale	1:2,000



LEGEND:

NODE ID
1:100 YEAR REGULATORY FLOOD ELEVATION (m)
NO-CULVERT SCENARIO INCREASE

MODELED NODE

EXISTING BUILDING & APPROXIMATE EXISTING GRADE ELEVATION (m)

TYPICAL MINIMUM FLOODWAY CORRIDOR

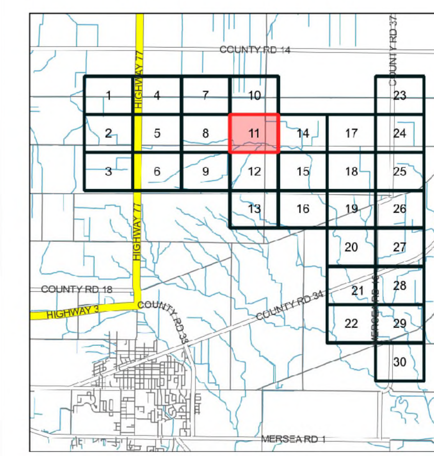
EXPANDED MINIMUM FLOODWAY CORRIDOR

EXISTING GROUND ELEVATION (m)
(RANGES VARY ON EACH SHEET)

- 186.90 - 187.20
- 187.20 - 187.50
- 187.50 - 187.80
- 187.80 - 188.10
- 188.10 - 188.40
- 188.40 - 188.70
- 188.70 - 189.00
- 189.00 - 189.30
- 189.30 - 189.60
- 189.60 - 189.90
- 189.90 - 190.20
- 190.20 - 190.50
- 190.50 - 190.80
- 190.80 - 191.10
- 191.10 - 191.40
- 191.40 - 191.70

NOTES:

1. HORIZONTAL COORDINATE SYSTEM: NAD 1983 UTM ZONE 17N
2. VERTICAL COORDINATE SYSTEM: CGVD 1928 (1978 ADJUSTMENT)
3. CONTAINS INFORMATION LICENSED UNDER THE OPEN GOVERNMENT LICENSE - ONTARIO
4. SCALE APPLIES TO ORIGINAL DOCUMENT SIZE OF 24" BY 36"



Peralta Engineering

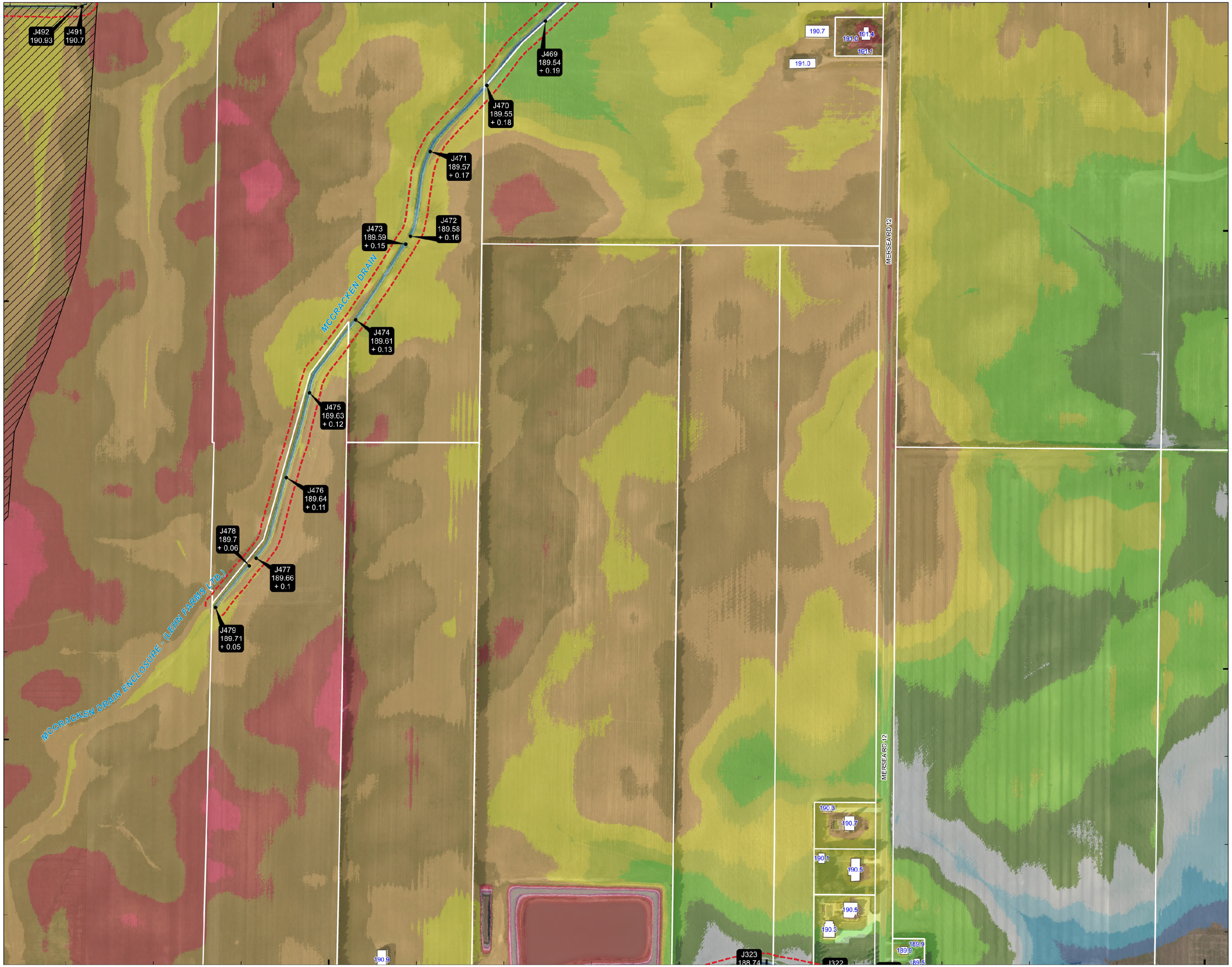
Landmark Engineers Inc.

client: THE MUNICIPALITY OF LEAMINGTON

project: LEBO CREEK MASTER DRAINAGE STUDY

title: PROJECTED FLOOD ELEVATIONS 1:100 YEAR EVENT

drawn by / date	FMK / AUG 2022	project no.	19-023
designed by / date		figure no.	E-11
checked by / date	ADM / AUG 2022	scale	1:2,000



LEGEND:

NODE ID
1:100 YEAR REGULATORY FLOOD ELEVATION (m)
NO-CULVERT SCENARIO INCREASE

MODELED NODE

190.0 EXISTING BUILDING & APPROXIMATE EXISTING GRADE ELEVATION (m)

TYPICAL MINIMUM FLOODWAY CORRIDOR

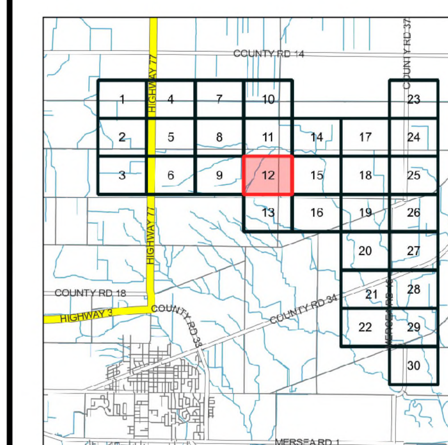
TEMPORARY FLOODPLAIN AREA

EXISTING GROUND ELEVATION (m)
(RANGES VARY ON EACH SHEET)

- 188.10 - 188.40
- 188.40 - 188.70
- 188.70 - 189.00
- 189.00 - 189.30
- 189.30 - 189.60
- 189.60 - 189.90
- 189.90 - 190.20
- 190.20 - 190.50
- 190.50 - 190.80
- 190.80 - 191.10
- 191.10 - 191.40
- 191.40 - 191.70
- 191.70 - 192.00
- 192.00 - 192.30
- 192.30 - 192.60
- 192.60 - 192.90

NOTES:

1. HORIZONTAL COORDINATE SYSTEM: NAD 1983 UTM ZONE 17N
2. VERTICAL COORDINATE SYSTEM: CGVD 1928 (1978 ADJUSTMENT)
3. CONTAINS INFORMATION LICENSED UNDER THE OPEN GOVERNMENT LICENSE - ONTARIO
4. SCALE APPLIES TO ORIGINAL DOCUMENT SIZE OF 24" BY 36"



Peralta Engineering

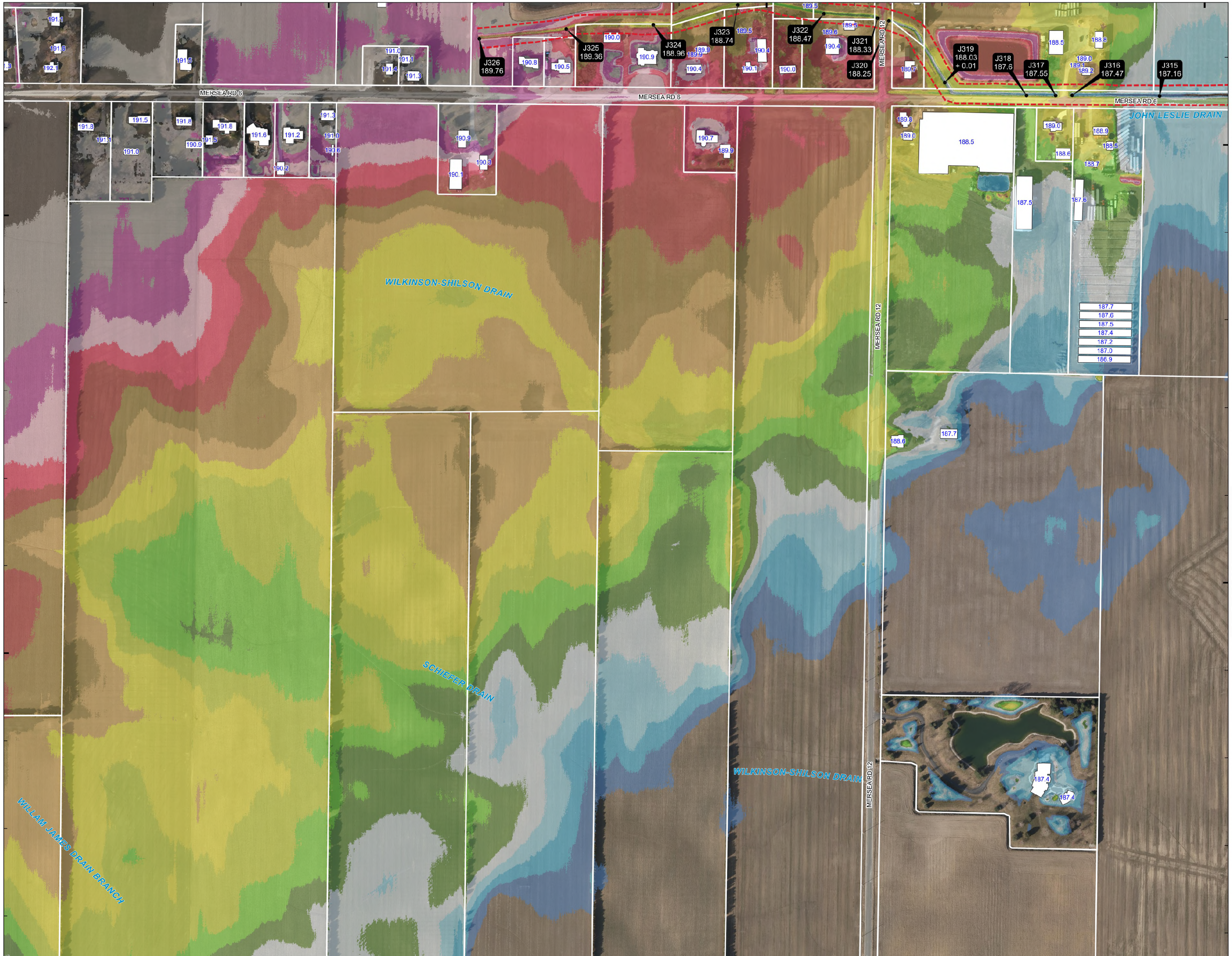
Landmark Engineers Inc.

client
THE MUNICIPALITY OF LEAMINGTON

project
LEBO CREEK MASTER DRAINAGE STUDY

title
PROJECTED FLOOD ELEVATIONS
1:100 YEAR EVENT

drawn by date	EMK SEP 2022	project no.	19-023
designed by date		figure no.	E-12
checked by date	ADM SEP 2022	scale	1:2,000



LEGEND:

NODE ID
1:100 YEAR REGULATORY FLOOD ELEVATION (m)
NO-CULVERT SCENARIO INCREASE

MODELED NODE

190.0 EXISTING BUILDING & APPROXIMATE EXISTING GRADE ELEVATION (m)

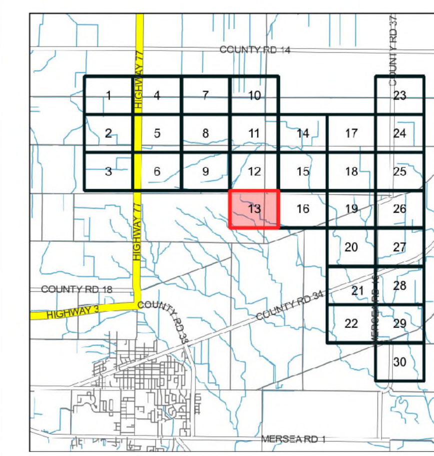
TYPICAL MINIMUM FLOODWAY CORRIDOR

EXISTING GROUND ELEVATION (m) (RANGES VARY ON EACH SHEET)

- 186.60 - 186.90
- 186.90 - 187.20
- 187.20 - 187.50
- 187.50 - 187.80
- 187.80 - 188.10
- 188.10 - 188.40
- 188.40 - 188.70
- 188.70 - 189.00
- 189.00 - 189.30
- 189.30 - 189.60
- 189.60 - 189.90
- 189.90 - 190.20
- 190.20 - 190.50
- 190.50 - 190.80
- 190.80 - 191.10
- 191.10 - 191.40

NOTES:

1. HORIZONTAL COORDINATE SYSTEM: NAD 1983 UTM ZONE 17N
2. VERTICAL COORDINATE SYSTEM: CGVD 1928 (1978 ADJUSTMENT)
3. CONTAINS INFORMATION LICENSED UNDER THE OPEN GOVERNMENT LICENSE - ONTARIO
4. SCALE APPLIES TO ORIGINAL DOCUMENT SIZE OF 24" BY 36"



Peralta Engineering

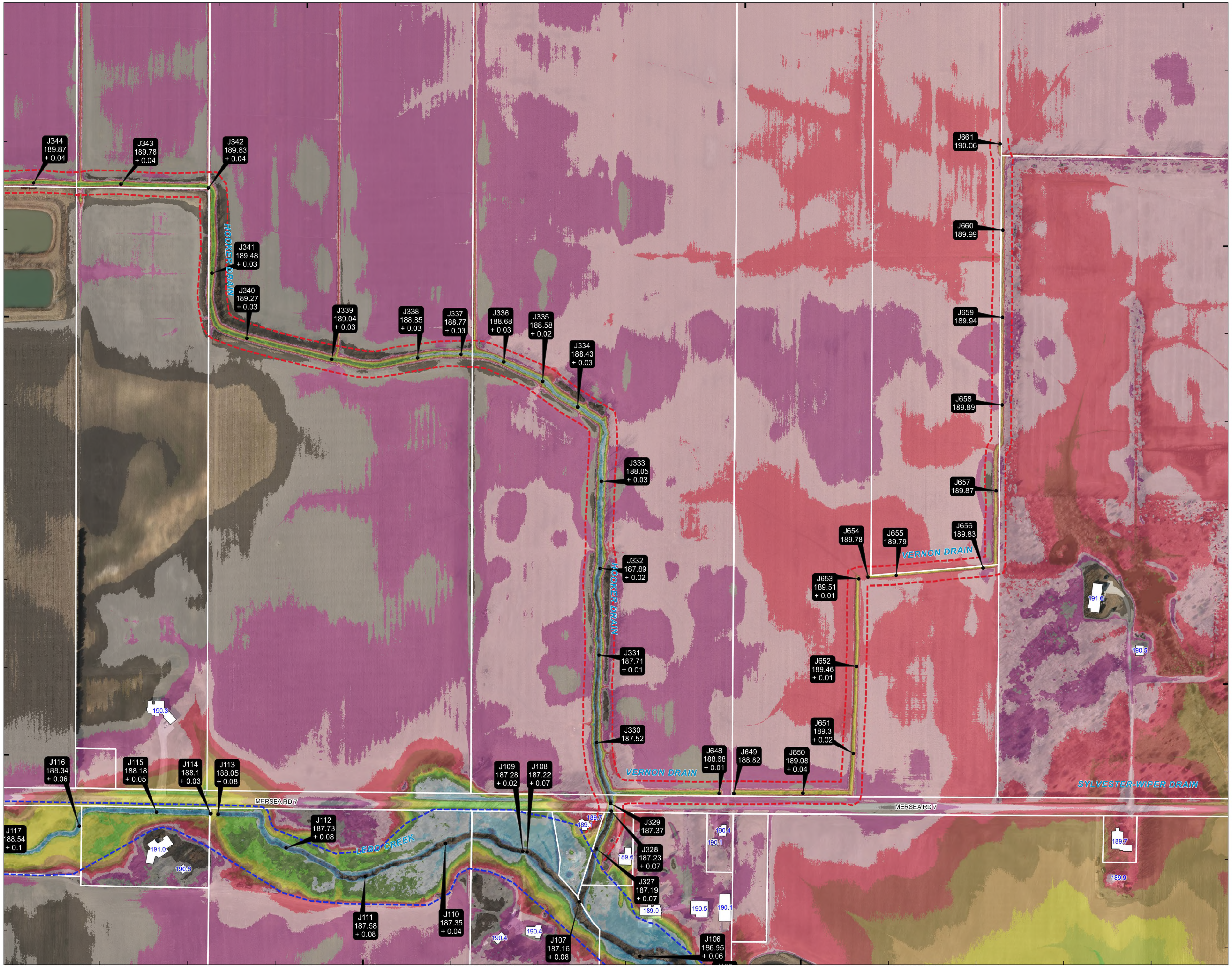
Landmark Engineers Inc.

client
THE MUNICIPALITY OF LEAMINGTON

project
LEBO CREEK MASTER DRAINAGE STUDY

title
PROJECTED FLOOD ELEVATIONS
1:100 YEAR EVENT

drawn by date	EMK AUG 2022	project no.	19-023
designed by date		figure no.	E-13
checked by date	ADM AUG 2022	scale	1:2,000



LEGEND:

NODE ID
1:100 YEAR REGULATORY FLOOD ELEVATION (m)
NO-CULVERT SCENARIO INCREASE

MODELED NODE

EXISTING BUILDING & APPROXIMATE EXISTING GRADE ELEVATION (m)

TYPICAL MINIMUM FLOODWAY CORRIDOR

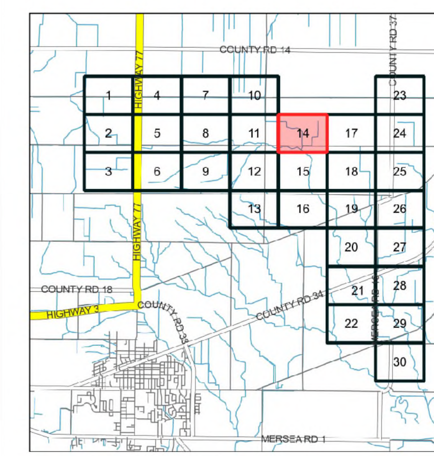
EXPANDED MINIMUM FLOODWAY CORRIDOR

EXISTING GROUND ELEVATION (m)
(RANGES VARY ON EACH SHEET)

- 186.30 - 186.60
- 186.60 - 186.90
- 186.90 - 187.20
- 187.20 - 187.50
- 187.50 - 187.80
- 187.80 - 188.10
- 188.10 - 188.40
- 188.40 - 188.70
- 188.70 - 189.00
- 189.00 - 189.30
- 189.30 - 189.60
- 189.60 - 189.90
- 189.90 - 190.20
- 190.20 - 190.50
- 190.50 - 190.80
- 190.80 - 191.10

NOTES:

1. HORIZONTAL COORDINATE SYSTEM: NAD 1983 UTM ZONE 17N
2. VERTICAL COORDINATE SYSTEM: CGVD 1928 (1978 ADJUSTMENT)
3. CONTAINS INFORMATION LICENSED UNDER THE OPEN GOVERNMENT LICENSE - ONTARIO
4. SCALE APPLIES TO ORIGINAL DOCUMENT SIZE OF 24" BY 36"



Peralta Engineering

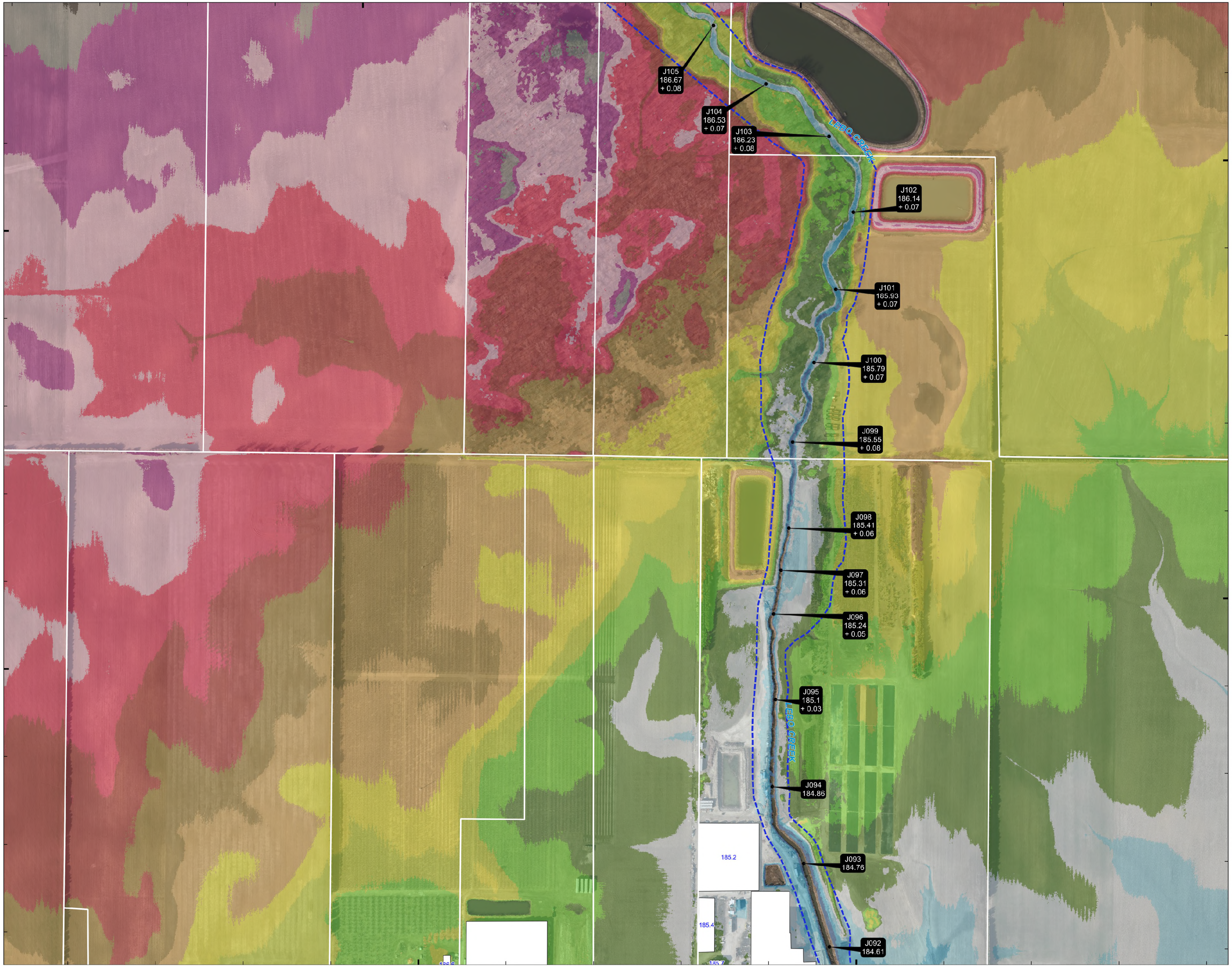
Landmark Engineers Inc.

client: THE MUNICIPALITY OF LEAMINGTON

project: LEBO CREEK MASTER DRAINAGE STUDY

title: PROJECTED FLOOD ELEVATIONS 1:100 YEAR EVENT

drawn by / date	FMK / AUG 2022	project no.	19-023
designed by / date		figure no.	E-14
checked by / date	ADM / AUG 2022	scale	1:2,000



LEGEND:

NODE ID
1:100 YEAR REGULATORY FLOOD ELEVATION (m)
NO-CULVERT SCENARIO INCREASE

MODELED NODE

190.0 EXISTING BUILDING & APPROXIMATE EXISTING GRADE ELEVATION (m)

TYPICAL MINIMUM FLOODWAY CORRIDOR

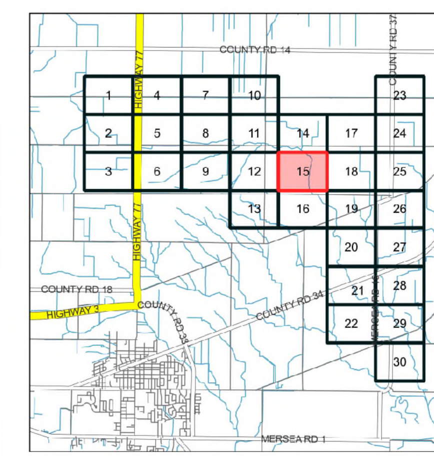
EXPANDED MINIMUM FLOODWAY CORRIDOR

EXISTING GROUND ELEVATION (m)
(RANGES VARY ON EACH SHEET)

- 183.50 - 184.00
- 184.00 - 184.50
- 184.50 - 185.00
- 185.00 - 185.50
- 185.50 - 186.00
- 186.00 - 186.50
- 186.50 - 187.00
- 187.00 - 187.50
- 187.50 - 188.00
- 188.00 - 188.50
- 188.50 - 189.00
- 189.00 - 189.50
- 189.50 - 190.00
- 190.00 - 190.50
- 190.50 - 191.00
- 191.00 - 191.50

NOTES:

1. HORIZONTAL COORDINATE SYSTEM: NAD 1983 UTM ZONE 17N
2. VERTICAL COORDINATE SYSTEM: CGVD 1928 (1978 ADJUSTMENT)
3. CONTAINS INFORMATION LICENSED UNDER THE OPEN GOVERNMENT LICENSE - ONTARIO
4. SCALE APPLIES TO ORIGINAL DOCUMENT SIZE OF 24" BY 36"



Peralta Engineering

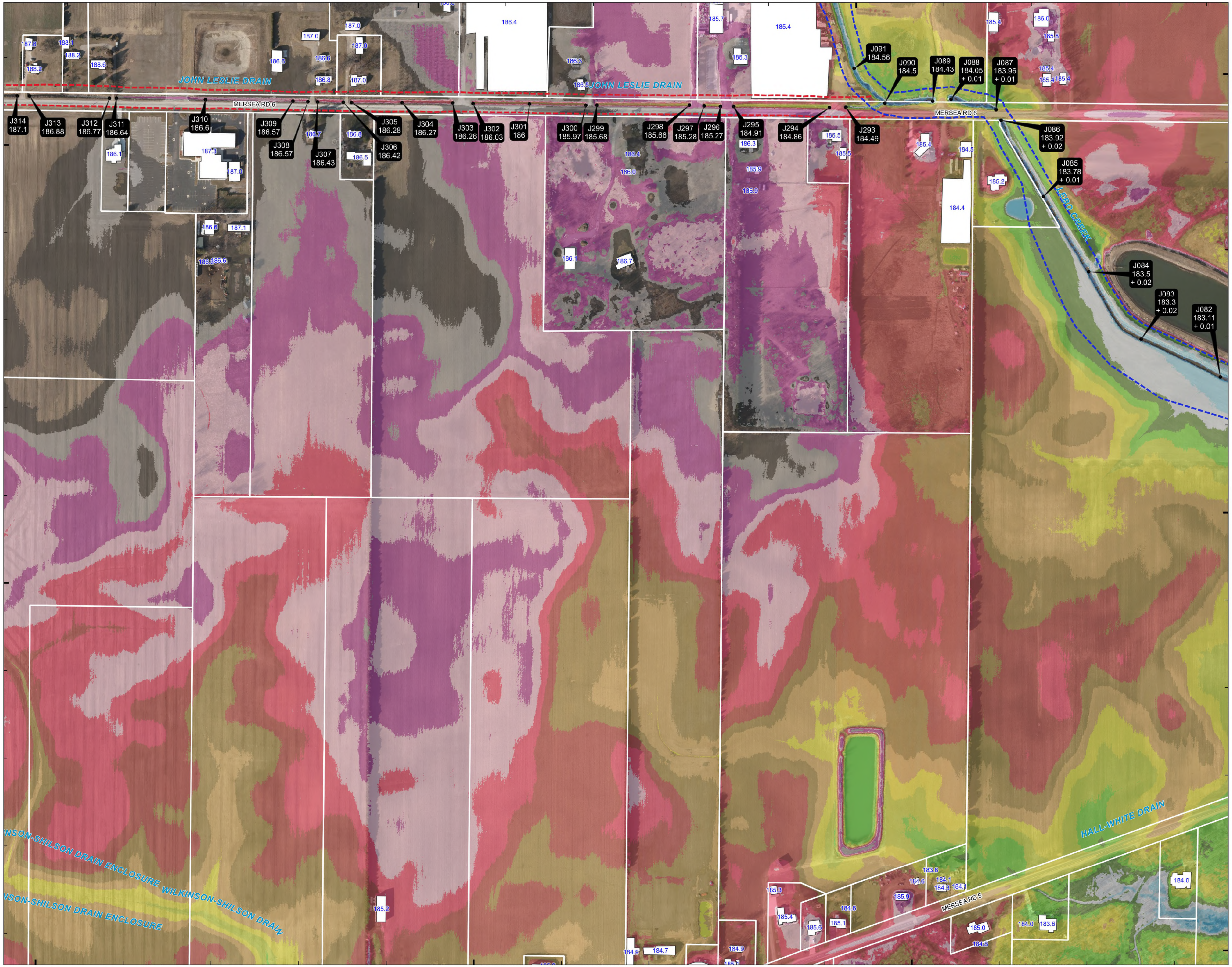
Landmark Engineers Inc.

client: **THE MUNICIPALITY OF LEAMINGTON**

project: **LEBO CREEK MASTER DRAINAGE STUDY**

title: **PROJECTED FLOOD ELEVATIONS 1:100 YEAR EVENT**

drawn by / date	EMK / AUG 2022	project no.	19-023
designed by / date		figure no.	E-15
checked by / date	ADM / AUG 2022	scale	1:2,000



LEGEND:

- NODE ID / 1:100 YEAR REGULATORY FLOOD ELEVATION (m) / NO-CULVERT SCENARIO INCREASE
- MODELED NODE
- 190.0 — EXISTING BUILDING & APPROXIMATE EXISTING GRADE ELEVATION (m)
- TYPICAL MINIMUM FLOODWAY CORRIDOR
- EXPANDED MINIMUM FLOODWAY CORRIDOR

EXISTING GROUND ELEVATION (m) (RANGES VARY ON EACH SHEET)

- 181.80 - 182.10
- 182.10 - 182.40
- 182.40 - 182.70
- 182.70 - 183.00
- 183.00 - 183.30
- 183.30 - 183.60
- 183.60 - 183.90
- 183.90 - 184.20
- 184.20 - 184.50
- 184.50 - 184.80
- 184.80 - 185.10
- 185.10 - 185.40
- 185.40 - 185.70
- 185.70 - 186.00
- 186.00 - 186.30
- 186.30 - 186.60

NOTES:

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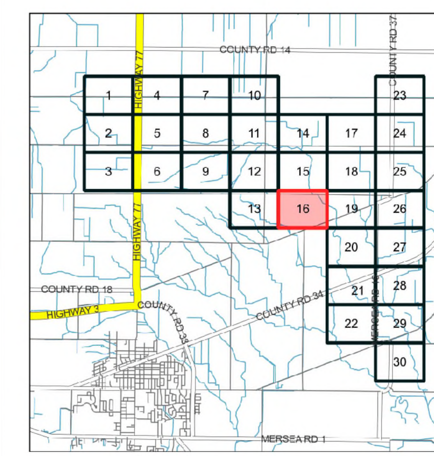
2. VERTICAL COORDINATE SYSTEM: CGVD 1928 (1978 ADJUSTMENT)
3. CONTAINS INFORMATION LICENSED UNDER THE OPEN GOVERNMENT LICENSE - ONTARIO
4. SCALE APPLIES TO ORIGINAL DOCUMENT SIZE OF 24" BY 36"



Peralta Engineering

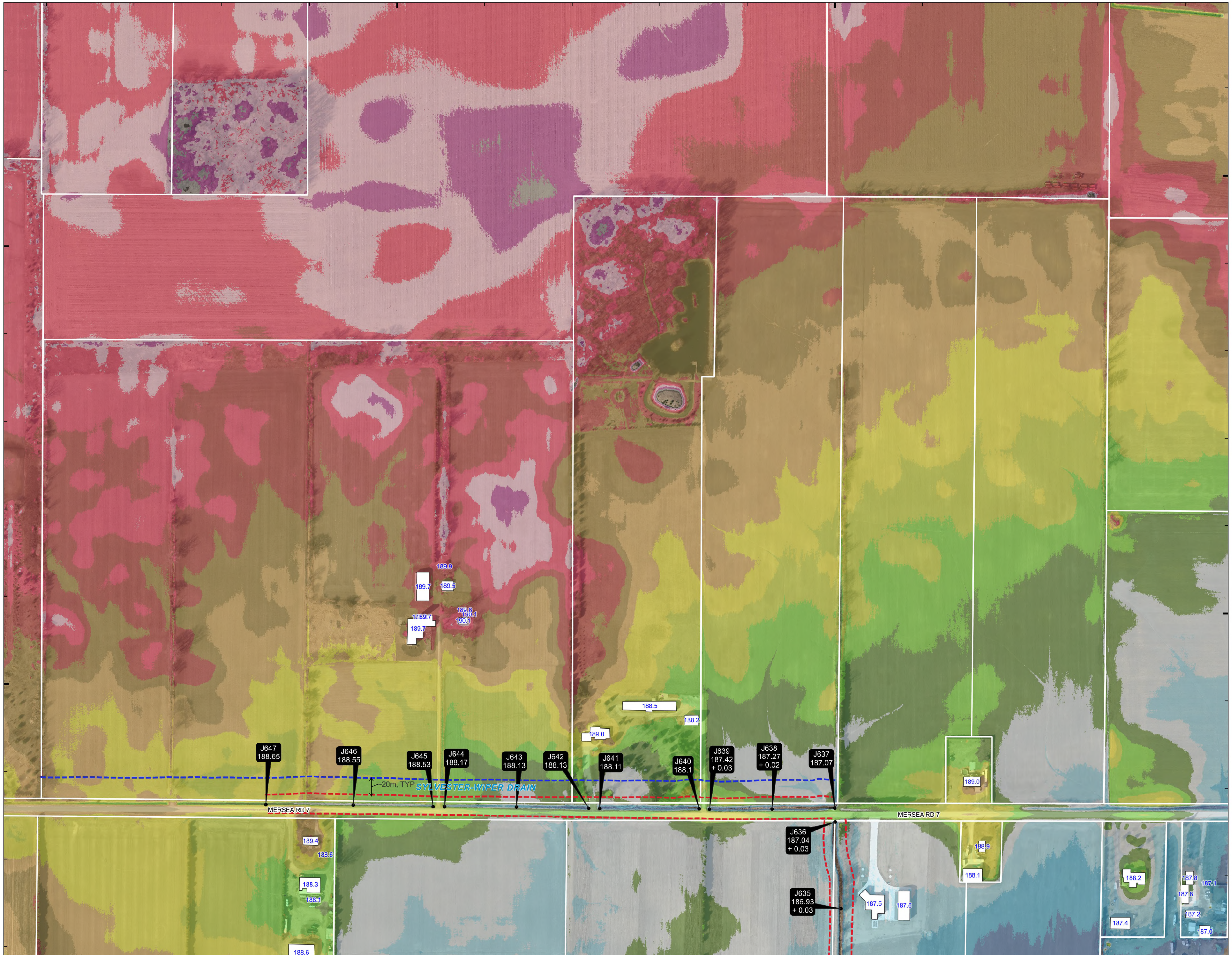
Landmark Engineers Inc.

client: **THE MUNICIPALITY OF LEAMINGTON**

project: **LEBO CREEK MASTER DRAINAGE STUDY**

title: **PROJECTED FLOOD ELEVATIONS 1:100 YEAR EVENT**

drawn by / date	EMK / AUG 2022	project no.	19-023
designed by / date		figure no.	E-16
checked by / date	ADM / AUG 2022	scale	1:2,000



LEGEND:

NODE ID
1:100 YEAR REGULATORY FLOOD ELEVATION (m)
NO-CULVERT SCENARIO INCREASE

MODELED NODE

190.0 EXISTING BUILDING & APPROXIMATE EXISTING GRADE ELEVATION (m)

TYPICAL MINIMUM FLOODWAY CORRIDOR

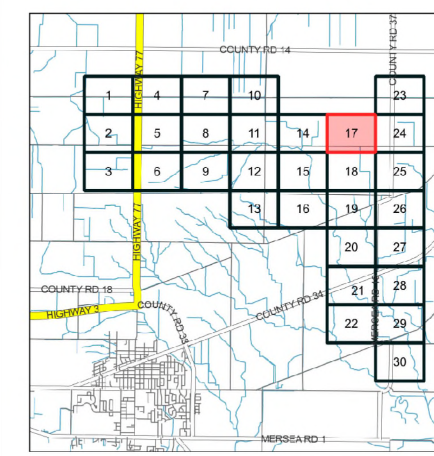
EXPANDED MINIMUM FLOODWAY CORRIDOR

EXISTING GROUND ELEVATION (m)
(RANGES VARY ON EACH SHEET)

186.60 - 186.90
186.90 - 187.20
187.20 - 187.50
187.50 - 187.80
187.80 - 188.10
188.10 - 188.40
188.40 - 188.70
188.70 - 189.00
189.00 - 189.30
189.30 - 189.60
189.60 - 189.90
189.90 - 190.20
190.20 - 190.50
190.50 - 190.80
190.80 - 191.10
191.10 - 191.40

NOTES:

1. HORIZONTAL COORDINATE SYSTEM: NAD 1983 UTM ZONE 17N
2. VERTICAL COORDINATE SYSTEM: CGVD 1928 (1978 ADJUSTMENT)
3. CONTAINS INFORMATION LICENSED UNDER THE OPEN GOVERNMENT LICENSE - ONTARIO
4. SCALE APPLIES TO ORIGINAL DOCUMENT SIZE OF 24" BY 36"



Peralta Engineering

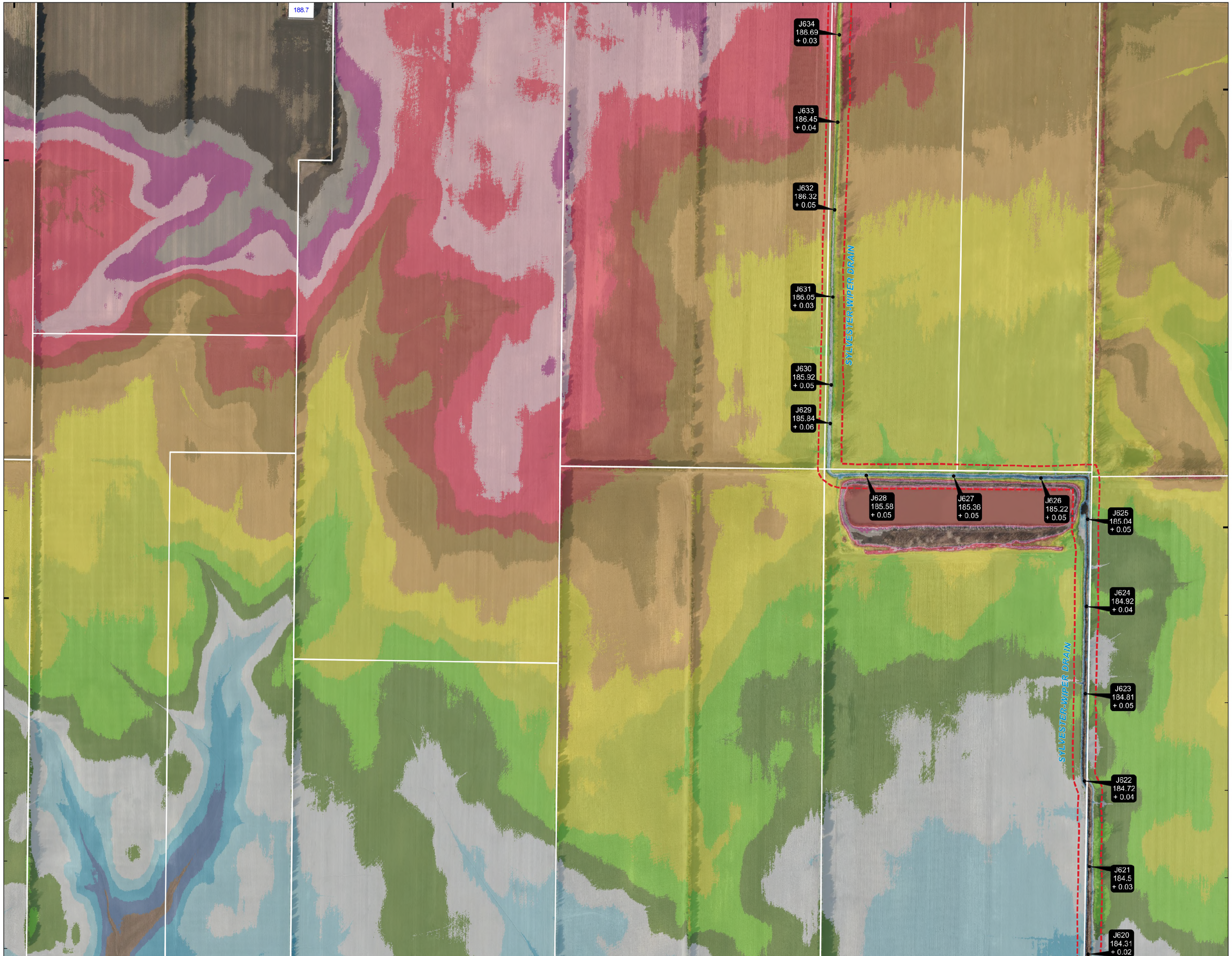
Landmark Engineers Inc.

client
THE MUNICIPALITY OF LEAMINGTON

project
LEBO CREEK MASTER DRAINAGE STUDY

title
PROJECTED FLOOD ELEVATIONS
1:100 YEAR EVENT

drawn by date	EMK AUG 2022	project no.	19-023
designed by date		figure no.	E-17
checked by date	ADM AUG 2022	scale	1:2,000



LEGEND:

NODE ID
1:100 YEAR REGULATORY FLOOD ELEVATION (m)
NO-CULVERT SCENARIO INCREASE

MODELED NODE

190.0 EXISTING BUILDING & APPROXIMATE EXISTING GRADE ELEVATION (m)

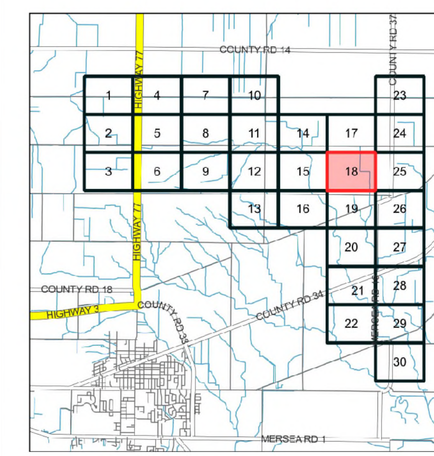
TYPICAL MINIMUM FLOODWAY CORRIDOR

EXISTING GROUND ELEVATION (m)
(RANGES VARY ON EACH SHEET)

- 183.90 - 184.20
- 184.20 - 184.50
- 184.50 - 184.80
- 184.80 - 185.10
- 185.10 - 185.40
- 185.40 - 185.70
- 185.70 - 186.00
- 186.00 - 186.30
- 186.30 - 186.60
- 186.60 - 186.90
- 186.90 - 187.20
- 187.20 - 187.50
- 187.50 - 187.80
- 187.80 - 188.10
- 188.10 - 188.40
- 188.40 - 188.70

NOTES:

1. HORIZONTAL COORDINATE SYSTEM: NAD 1983 UTM ZONE 17N
2. VERTICAL COORDINATE SYSTEM: CGVD 1928 (1978 ADJUSTMENT)
3. CONTAINS INFORMATION LICENSED UNDER THE OPEN GOVERNMENT LICENSE - ONTARIO
4. SCALE APPLIES TO ORIGINAL DOCUMENT SIZE OF 24" BY 36"



Peralta Engineering

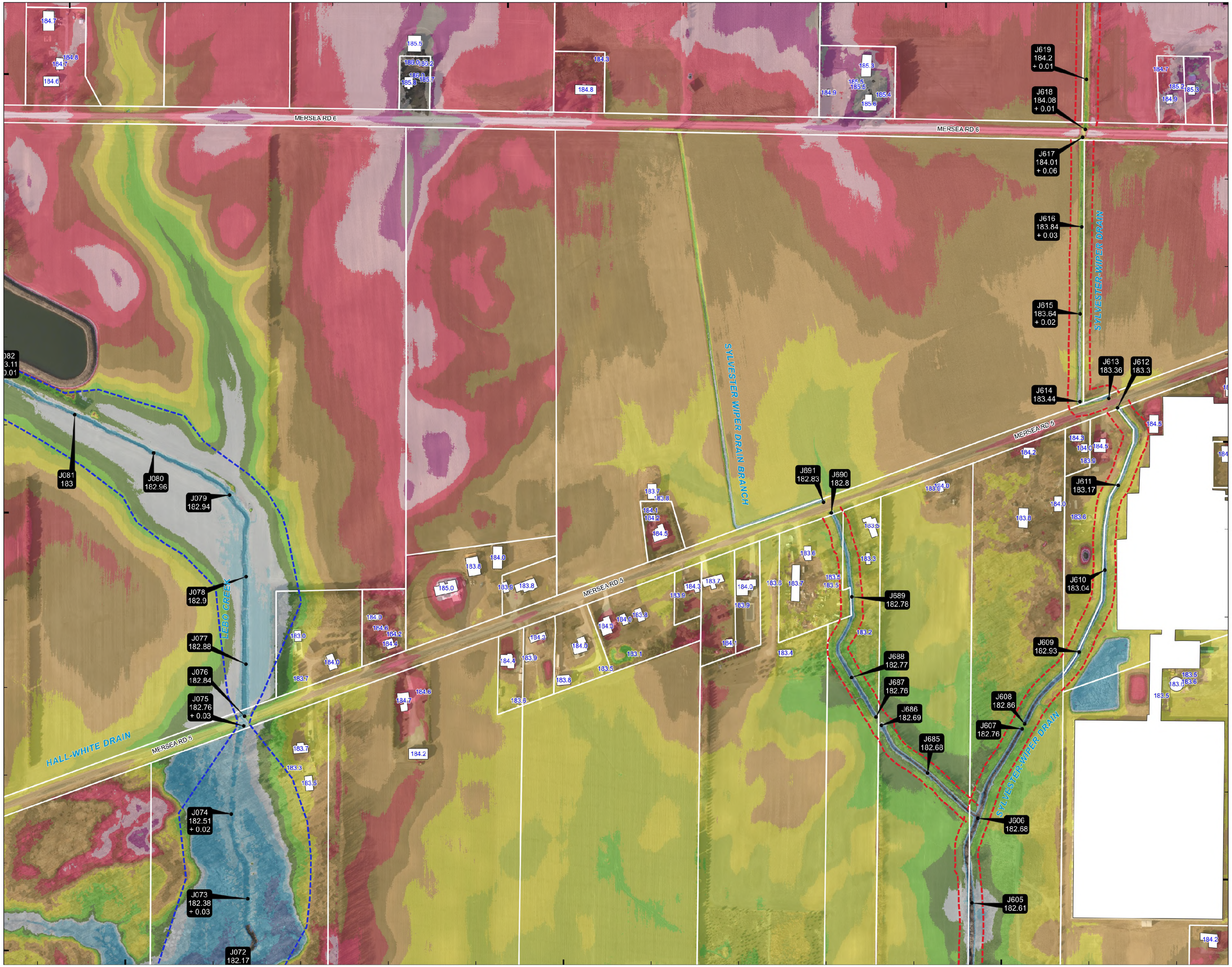
Landmark Engineers Inc.

client: **THE MUNICIPALITY OF LEAMINGTON**

project: **LEBO CREEK MASTER DRAINAGE STUDY**

title: **PROJECTED FLOOD ELEVATIONS 1:100 YEAR EVENT**

drawn by / date	EMK / AUG 2022	project no.	19-023
designed by / date		figure no.	E-18
checked by / date	ADM / AUG 2022	scale	1:2,000



LEGEND:

NODE ID
1:100 YEAR REGULATORY FLOOD ELEVATION (m)
NO-CULVERT SCENARIO INCREASE

MODELED NODE

190.0 EXISTING BUILDING & APPROXIMATE EXISTING GRADE ELEVATION (m)

TYPICAL MINIMUM FLOODWAY CORRIDOR

EXPANDED MINIMUM FLOODWAY CORRIDOR

EXISTING GROUND ELEVATION (m)
(RANGES VARY ON EACH SHEET)

- 181.20 - 181.50
- 181.50 - 181.80
- 181.80 - 182.10
- 182.10 - 182.40
- 182.40 - 182.70
- 182.70 - 183.00
- 183.00 - 183.30
- 183.30 - 183.60
- 183.60 - 183.90
- 183.90 - 184.20
- 184.20 - 184.50
- 184.50 - 184.80
- 184.80 - 185.10
- 185.10 - 185.40
- 185.40 - 185.70
- 185.70 - 186.00

NOTES:

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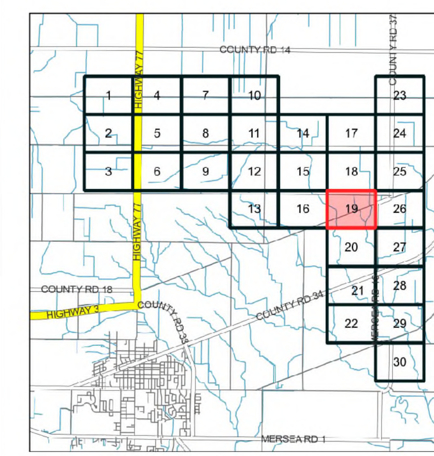
2. VERTICAL COORDINATE SYSTEM: CGVD 1928 (1978 ADJUSTMENT)
3. CONTAINS INFORMATION LICENSED UNDER THE OPEN GOVERNMENT LICENSE - ONTARIO
4. SCALE APPLIES TO ORIGINAL DOCUMENT SIZE OF 24" BY 36"



Peralta Engineering

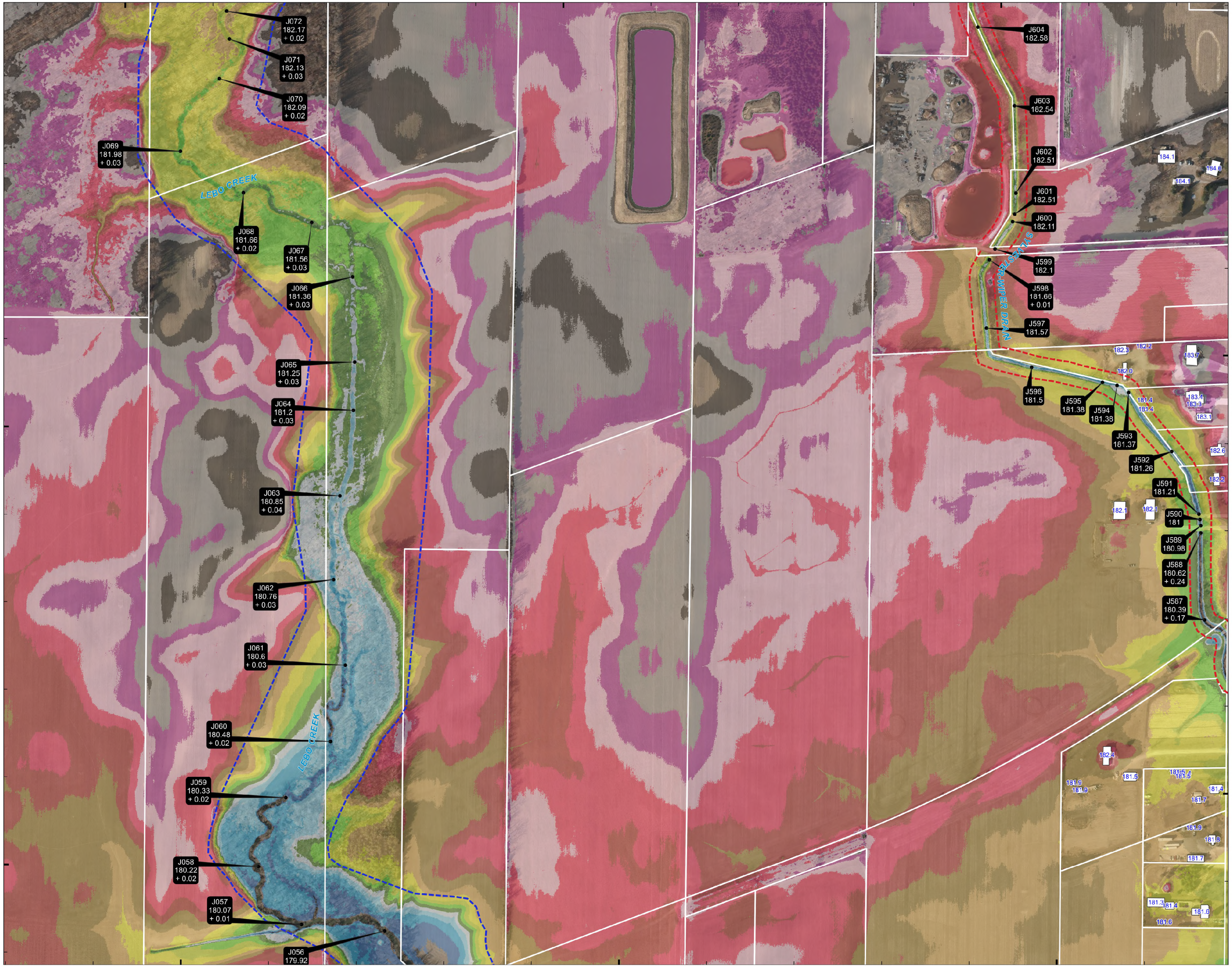
Landmark Engineers Inc.

client: **THE MUNICIPALITY OF LEAMINGTON**

project: **LEBO CREEK MASTER DRAINAGE STUDY**

title: **PROJECTED FLOOD ELEVATIONS 1:100 YEAR EVENT**

drawn by date	EMK AUG 2022	project no.	19-023
designed by date		figure no.	E-19
checked by date	ADM AUG 2022	scale	1:2,000



LEGEND:

NODE ID
1:100 YEAR REGULATORY FLOOD ELEVATION (m)
NO-CULVERT SCENARIO INCREASE

MODELED NODE

EXISTING BUILDING & APPROXIMATE EXISTING GRADE ELEVATION (m)

TYPICAL MINIMUM FLOODWAY CORRIDOR

EXPANDED MINIMUM FLOODWAY CORRIDOR

EXISTING GROUND ELEVATION (m)
(RANGES VARY ON EACH SHEET)

- 179.10 - 179.40
- 179.40 - 179.70
- 179.70 - 180.00
- 180.00 - 180.30
- 180.30 - 180.60
- 180.60 - 180.90
- 180.90 - 181.20
- 181.20 - 181.50
- 181.50 - 181.80
- 181.80 - 182.10
- 182.10 - 182.40
- 182.40 - 182.70
- 182.70 - 183.00
- 183.00 - 183.30
- 183.30 - 183.60
- 183.60 - 183.90

NOTES:

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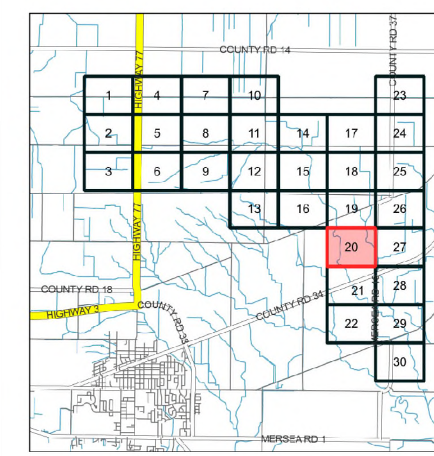
2. VERTICAL COORDINATE SYSTEM: CGVD 1928 (1978 ADJUSTMENT)
3. CONTAINS INFORMATION LICENSED UNDER THE OPEN GOVERNMENT LICENSE - ONTARIO
4. SCALE APPLIES TO ORIGINAL DOCUMENT SIZE OF 24" BY 36"



Peralta Engineering

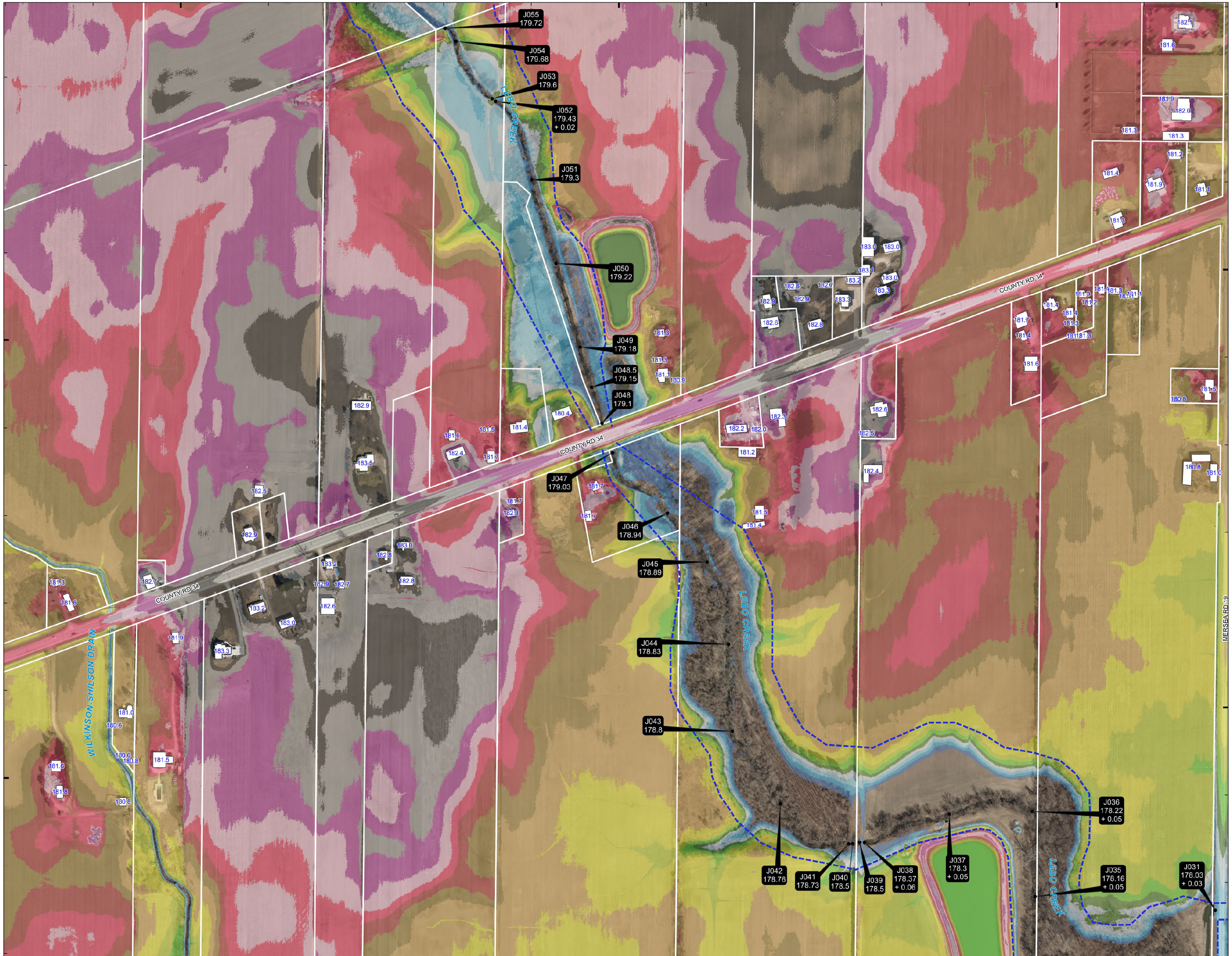
Landmark Engineers Inc.

client: THE MUNICIPALITY OF LEAMINGTON

project: LEBO CREEK MASTER DRAINAGE STUDY

title: PROJECTED FLOOD ELEVATIONS 1:100 YEAR EVENT

drawn by / date	FMK / AUG 2022	project no.	19-023
designed by / date		figure no.	E-20
checked by / date	ADM / AUG 2022	scale	1:2,000



LEGEND:

NODE ID
1:100 YEAR REGULATORY FLOOD ELEVATION (m)
NO-CULVERT SCENARIO INCREASE

MODELED NODE

190.0 EXISTING BUILDING & APPROXIMATE EXISTING GRADE ELEVATION (m)

TYPICAL MINIMUM FLOODWAY CORRIDOR

EXPANDED MINIMUM FLOODWAY CORRIDOR

EXISTING GROUND ELEVATION (m)
(RANGES VARY ON EACH SHEET)

- 178.20 - 178.50
- 178.50 - 178.80
- 178.80 - 179.10
- 179.10 - 179.40
- 179.40 - 179.70
- 179.70 - 180.00
- 180.00 - 180.30
- 180.30 - 180.60
- 180.60 - 180.90
- 180.90 - 181.20
- 181.20 - 181.50
- 181.50 - 181.80
- 181.80 - 182.10
- 182.10 - 182.40
- 182.40 - 182.70
- 182.70 - 183.00

NOTES:

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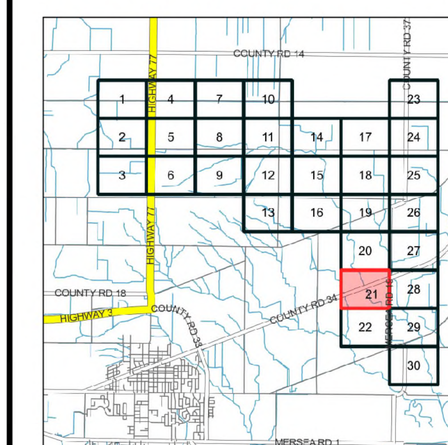
3. CONTAINS INFORMATION LICENSED UNDER THE OPEN GOVERNMENT LICENSE - ONTARIO
4. SCALE APPLIES TO ORIGINAL DOCUMENT SIZE OF 24" BY 36"



Peralta Engineering

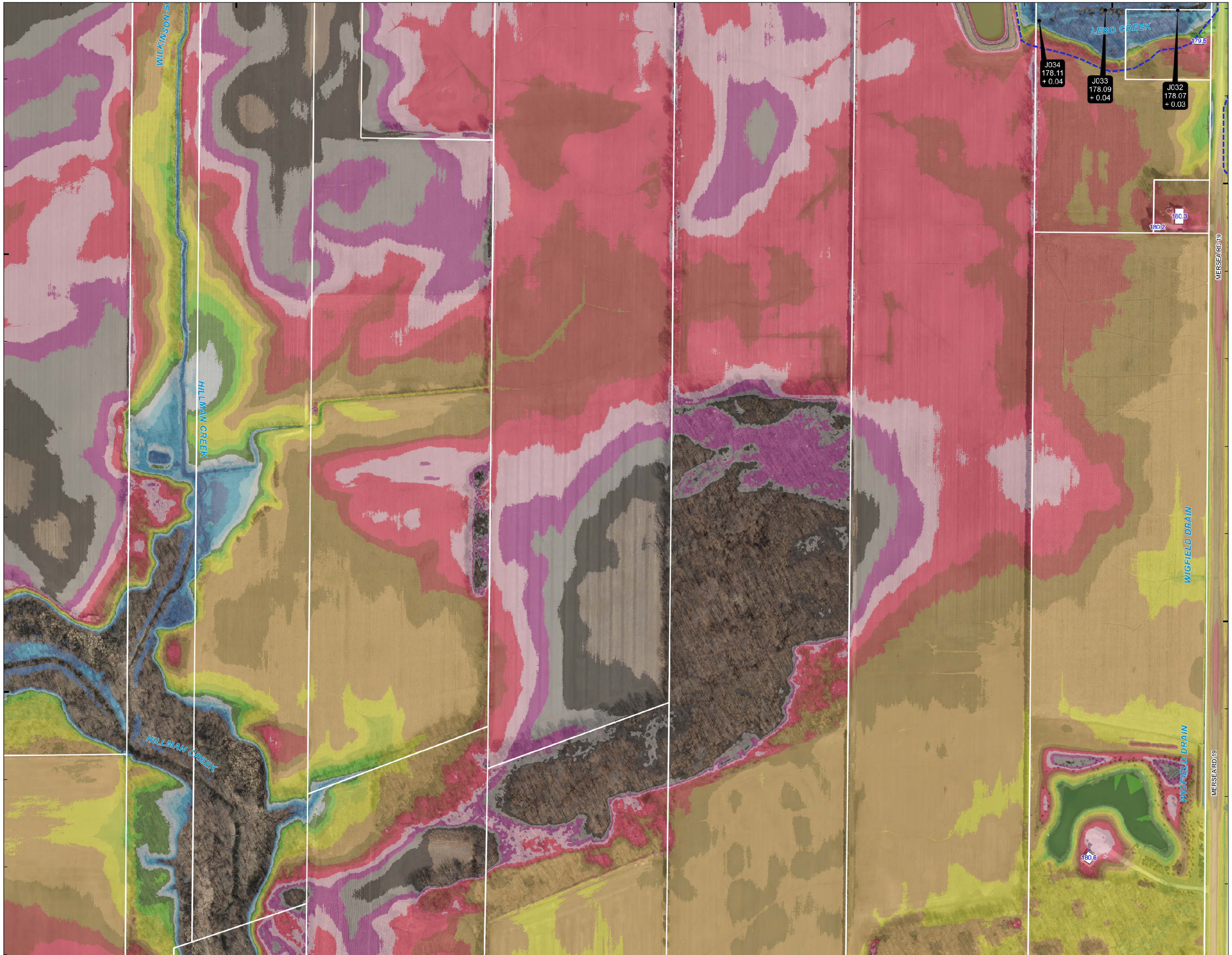
Landmark Engineers Inc.

client: **THE MUNICIPALITY OF LEAMINGTON**

project: **LEBO CREEK MASTER DRAINAGE STUDY**

title: **PROJECTED FLOOD ELEVATIONS 1:100 YEAR EVENT**

drawn by / date	EMK / AUG 2022	project no.	19-023
designed by / date		figure no.	E-21
checked by / date	ADM / AUG 2022	scale	1:2,000



LEGEND:

NODE ID
1:100 YEAR REGULATORY FLOOD ELEVATION (m)
NO-CULVERT SCENARIO INCREASE

MODELED NODE

190.0 EXISTING BUILDING & APPROXIMATE EXISTING GRADE ELEVATION (m)

EXPANDED MINIMUM FLOODWAY CORRIDOR

EXISTING GROUND ELEVATION (m) (RANGES VARY ON EACH SHEET)

- 177.00 - 177.30
- 177.30 - 177.60
- 177.60 - 177.90
- 177.90 - 178.20
- 178.20 - 178.50
- 178.50 - 178.80
- 178.80 - 179.10
- 179.10 - 179.40
- 179.40 - 179.70
- 179.70 - 180.00
- 180.00 - 180.30
- 180.30 - 180.60
- 180.60 - 180.90
- 180.90 - 181.20
- 181.20 - 181.50
- 181.50 - 181.80

NOTES:

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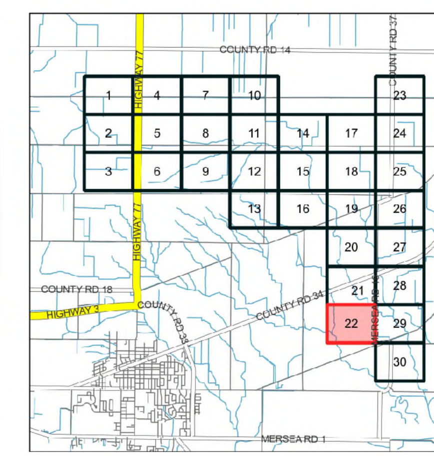


Peralta Engineering

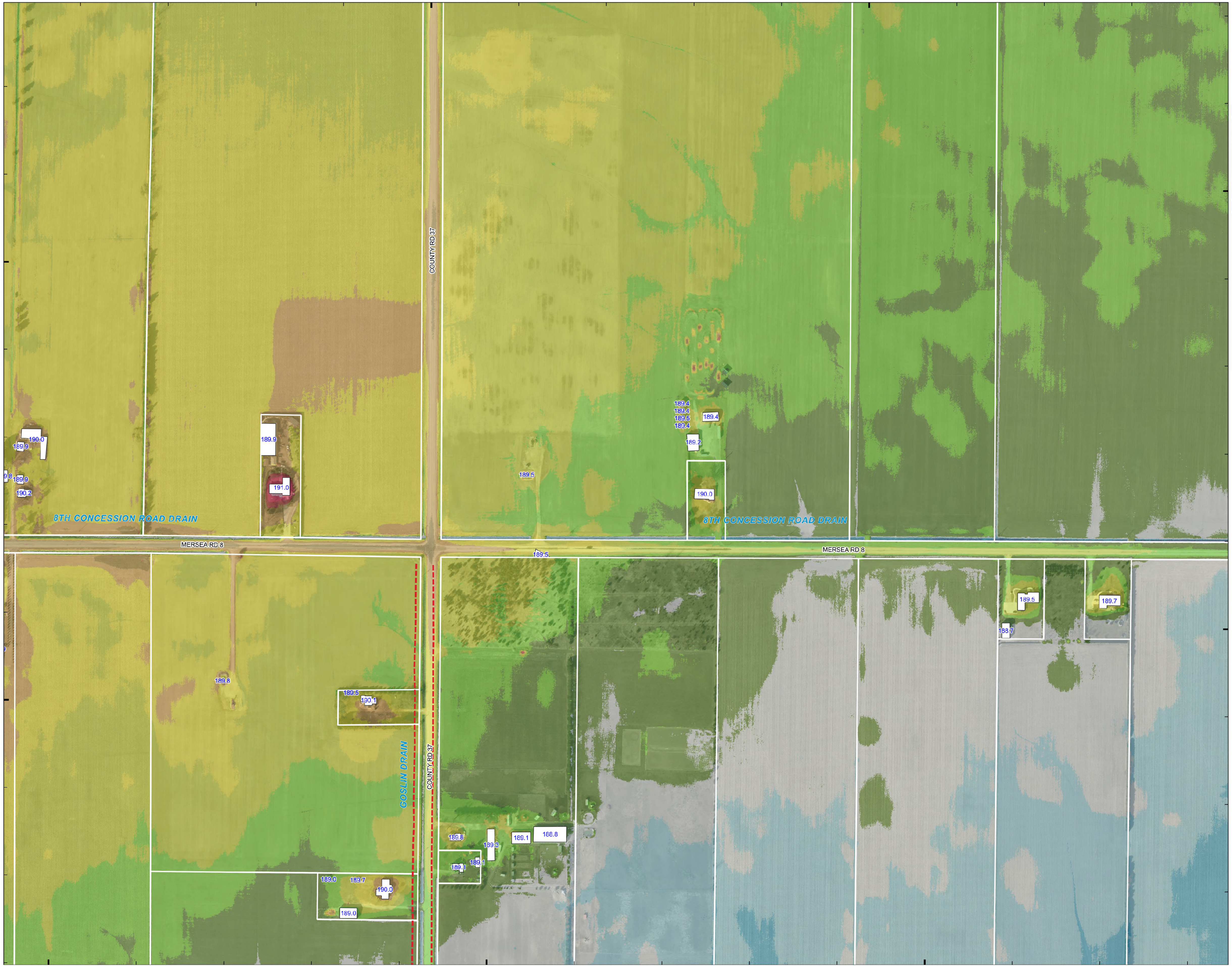
Landmark Engineers Inc.

client
THE MUNICIPALITY OF LEAMINGTON

project
LEBO CREEK MASTER DRAINAGE STUDY

title
PROJECTED FLOOD ELEVATIONS
1:100 YEAR EVENT

drawn by date	EMK AUG 2022	project no.	19-023
designed by date		figure no.	E-22
checked by date	ADM AUG 2022	scale	1:2,000



LEGEND:

NODE ID
1:100 YEAR REGULATORY FLOOD ELEVATION (m)
NO-CULVERT SCENARIO INCREASE

MODELED NODE

EXISTING BUILDING & APPROXIMATE EXISTING GRADE ELEVATION (m)

TYPICAL MINIMUM FLOODWAY CORRIDOR

EXISTING GROUND ELEVATION (m)
(RANGES VARY ON EACH SHEET)

- 187.50 - 187.80
- 187.80 - 188.10
- 188.10 - 188.40
- 188.40 - 188.70
- 188.70 - 189.00
- 189.00 - 189.30
- 189.30 - 189.60
- 189.60 - 189.90
- 189.90 - 190.20
- 190.20 - 190.50
- 190.50 - 190.80
- 190.80 - 191.10
- 191.10 - 191.40
- 191.40 - 191.70
- 191.70 - 192.00
- 192.00 - 192.30

NOTES:

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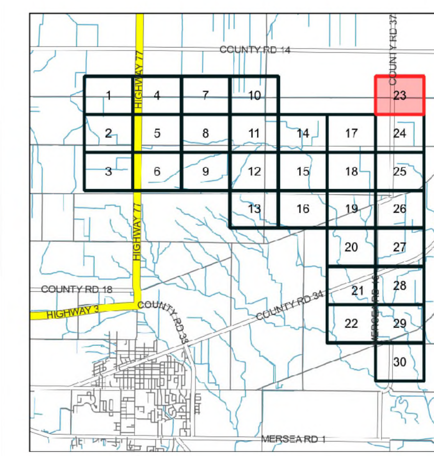
2. VERTICAL COORDINATE SYSTEM: CGVD 1928 (1978 ADJUSTMENT)
3. CONTAINS INFORMATION LICENSED UNDER THE OPEN GOVERNMENT LICENSE - ONTARIO
4. SCALE APPLIES TO ORIGINAL DOCUMENT SIZE OF 24" BY 36"



Peralta Engineering

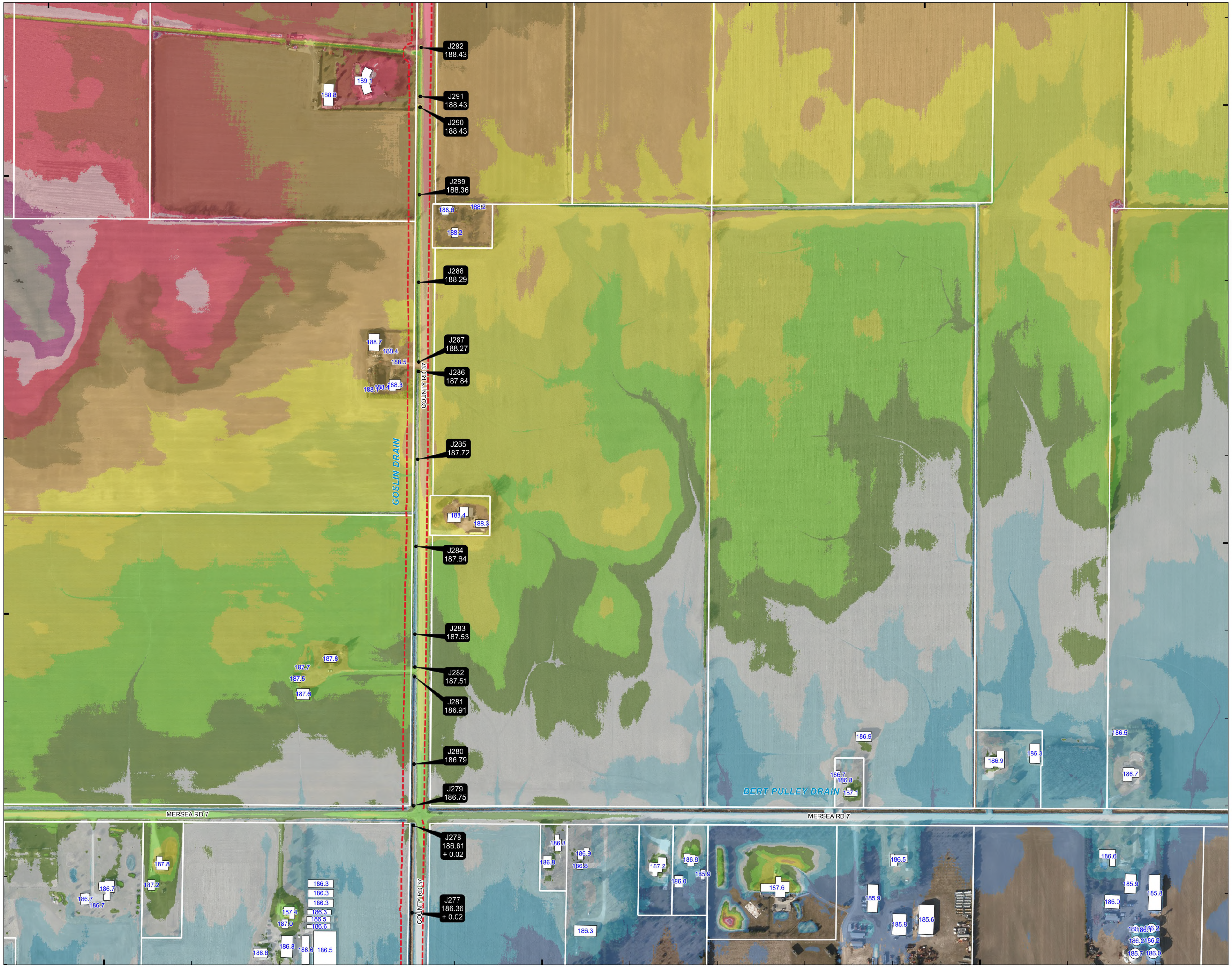
Landmark Engineers Inc.

client: THE MUNICIPALITY OF LEAMINGTON

project: LEBO CREEK MASTER DRAINAGE STUDY

title: PROJECTED FLOOD ELEVATIONS 1:100 YEAR EVENT

drawn by date	EMK AUG 2022	project no.	19-023
designed by date		figure no.	E-23
checked by date	ADM AUG 2022	scale	1:2,000



LEGEND:

NODE ID
1:100 YEAR REGULATORY FLOOD ELEVATION (m)
NO-CULVERT SCENARIO INCREASE

MODELED NODE

EXISTING BUILDING & APPROXIMATE EXISTING GRADE ELEVATION (m)

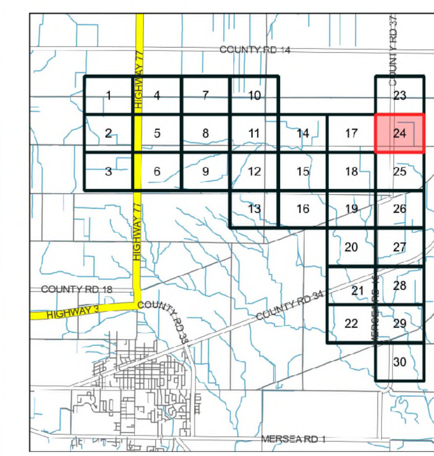
TYPICAL MINIMUM FLOODWAY CORRIDOR

EXISTING GROUND ELEVATION (m)
(RANGES VARY ON EACH SHEET)

- 185.70 - 186.00
- 186.00 - 186.30
- 186.30 - 186.60
- 186.60 - 186.90
- 186.90 - 187.20
- 187.20 - 187.50
- 187.50 - 187.80
- 187.80 - 188.10
- 188.10 - 188.40
- 188.40 - 188.70
- 188.70 - 189.00
- 189.00 - 189.30
- 189.30 - 189.60
- 189.60 - 189.90
- 189.90 - 190.20
- 190.20 - 190.50

NOTES:

1. HORIZONTAL COORDINATE SYSTEM: NAD 1983 UTM ZONE 17N
2. VERTICAL COORDINATE SYSTEM: CGVD 1928 (1978 ADJUSTMENT)
3. CONTAINS INFORMATION LICENSED UNDER THE OPEN GOVERNMENT LICENSE - ONTARIO
4. SCALE APPLIES TO ORIGINAL DOCUMENT SIZE OF 24" BY 36"



Peralta Engineering

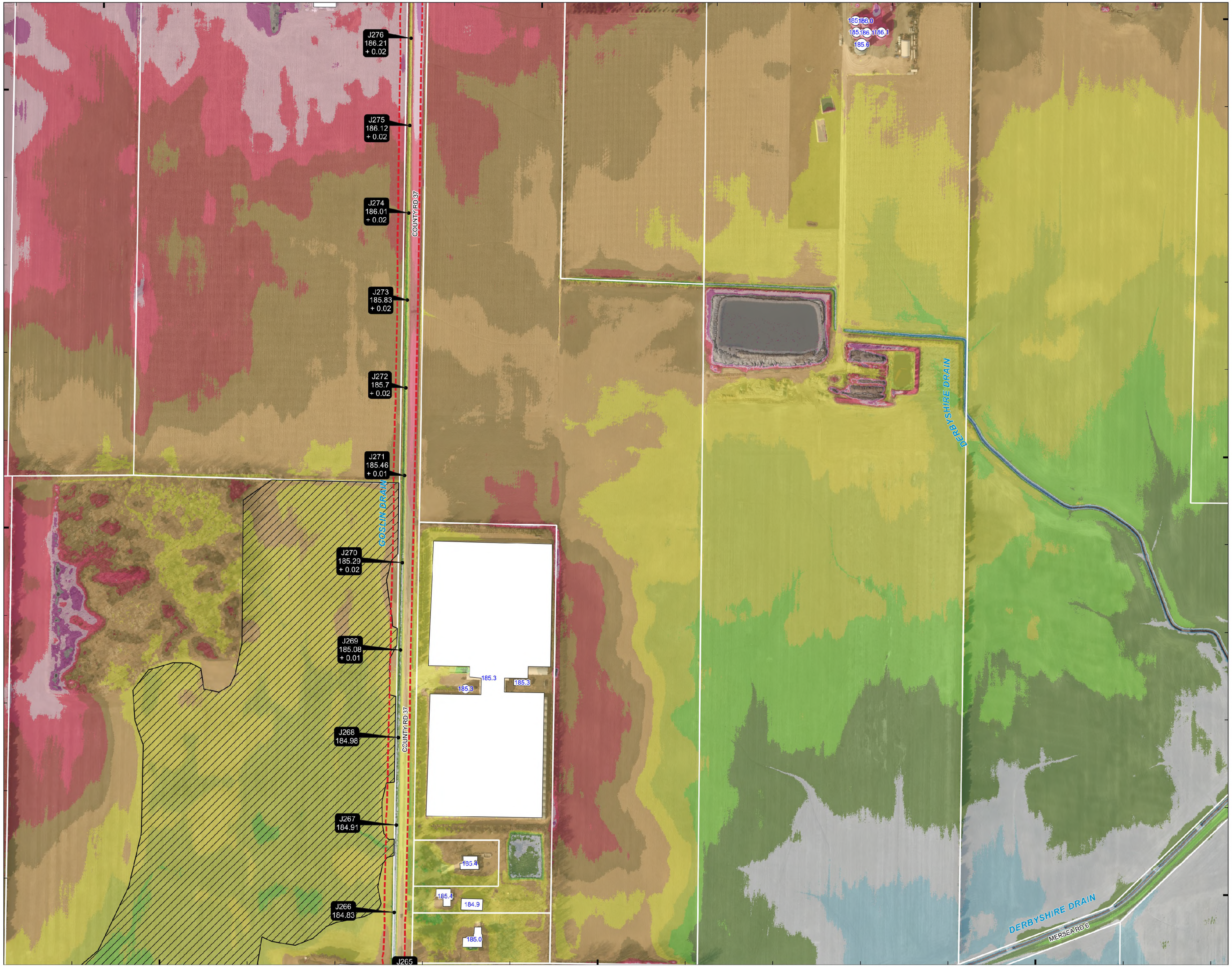
Landmark Engineers Inc.

client: THE MUNICIPALITY OF LEAMINGTON

project: LEBO CREEK MASTER DRAINAGE STUDY

title: PROJECTED FLOOD ELEVATIONS
1:100 YEAR EVENT

drawn by / date	EMK / AUG 2022	project no.	19-023
designed by / date		figure no.	E-24
checked by / date	ADM / AUG 2022	scale	1:2,000



LEGEND:

NODE ID
1:100 YEAR REGULATORY FLOOD ELEVATION (m)
NO-CULVERT SCENARIO INCREASE

MODELED NODE

190.0 EXISTING BUILDING & APPROXIMATE EXISTING GRADE ELEVATION (m)

TYPICAL MINIMUM FLOODWAY CORRIDOR

TEMPORARY FLOODPLAIN AREA

EXISTING GROUND ELEVATION (m)
(RANGES VARY ON EACH SHEET)

- 182.70 - 183.00
- 183.00 - 183.30
- 183.30 - 183.60
- 183.60 - 183.90
- 183.90 - 184.20
- 184.20 - 184.50
- 184.50 - 184.80
- 184.80 - 185.10
- 185.10 - 185.40
- 185.40 - 185.70
- 185.70 - 186.00
- 186.00 - 186.30
- 186.30 - 186.60
- 186.60 - 186.90
- 186.90 - 187.20
- 187.20 - 187.50

NOTES:

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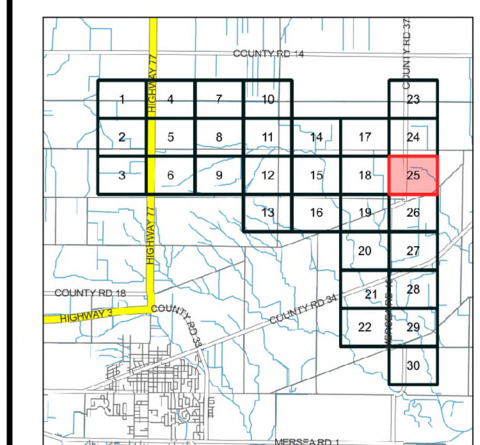


Peralta Engineering

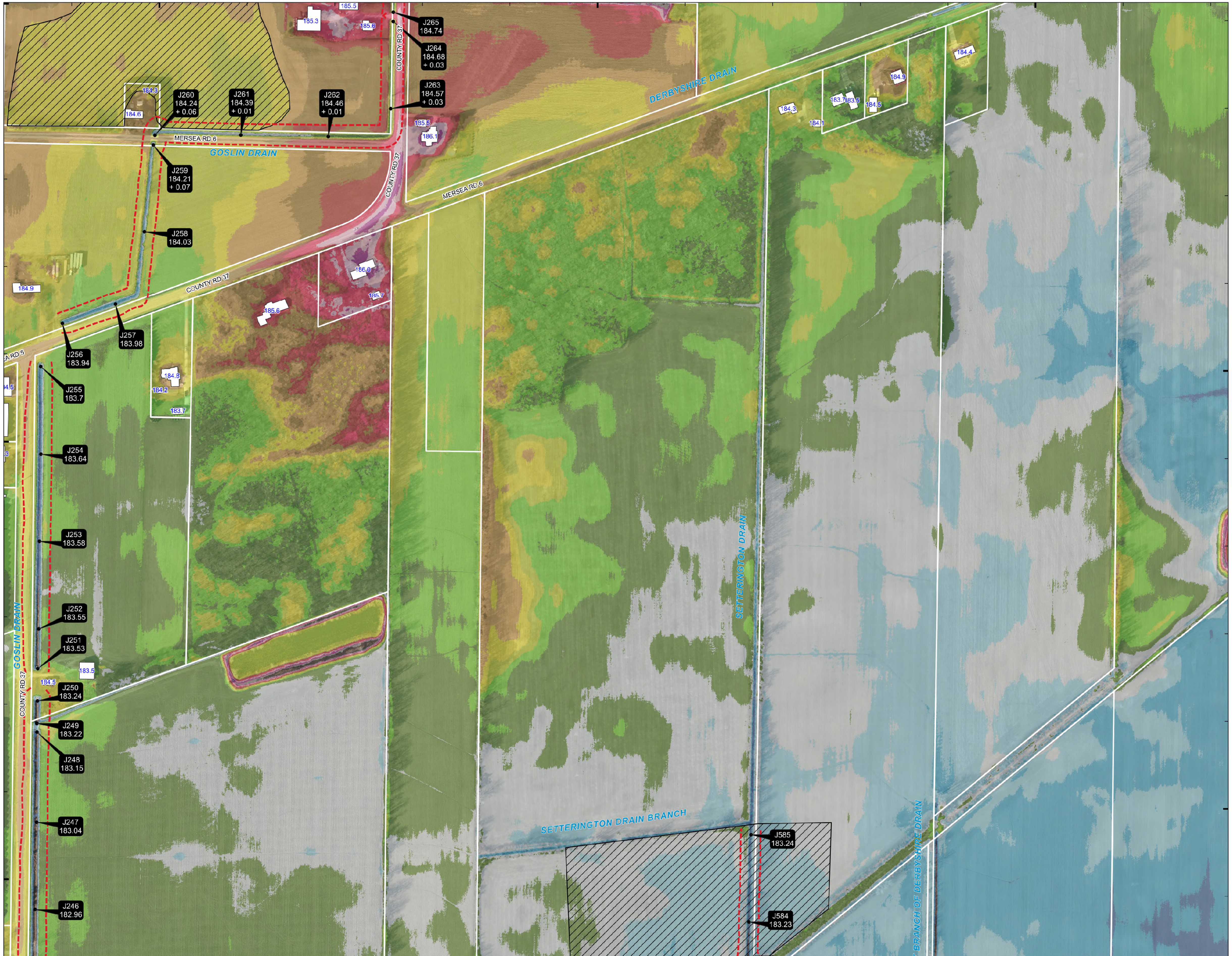
Landmark Engineers Inc.

client: THE MUNICIPALITY OF LEAMINGTON

project: LEBO CREEK MASTER DRAINAGE STUDY

title: PROJECTED FLOOD ELEVATIONS 1:100 YEAR EVENT

drawn by date	EMK SEP 2022	project no.	19-023
designed by date		figure no.	E-25
checked by date	ADM SEP 2022	scale	1:2,000



LEGEND:

NODE ID
1:100 YEAR REGULATORY FLOOD ELEVATION (m)
NO-CULVERT SCENARIO INCREASE

MODELED NODE

EXISTING BUILDING & APPROXIMATE EXISTING GRADE ELEVATION (m)

TYPICAL MINIMUM FLOODWAY CORRIDOR

TEMPORARY FLOODPLAIN AREA

EXISTING GROUND ELEVATION (m)
(RANGES VARY ON EACH SHEET)

- 182.10 - 182.40
- 182.40 - 182.70
- 182.70 - 183.00
- 183.00 - 183.30
- 183.30 - 183.60
- 183.60 - 183.90
- 183.90 - 184.20
- 184.20 - 184.50
- 184.50 - 184.80
- 184.80 - 185.10
- 185.10 - 185.40
- 185.40 - 185.70
- 185.70 - 186.00
- 186.00 - 186.30
- 186.30 - 186.60
- 186.60 - 186.90

NOTES:

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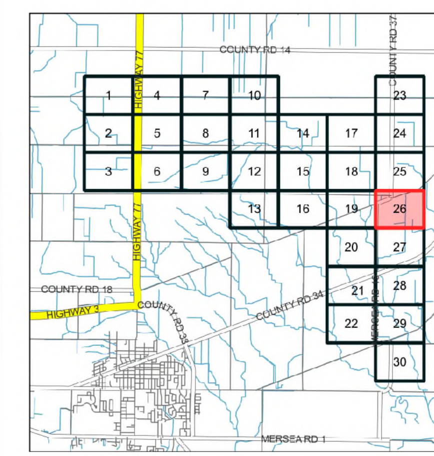


Peralta Engineering

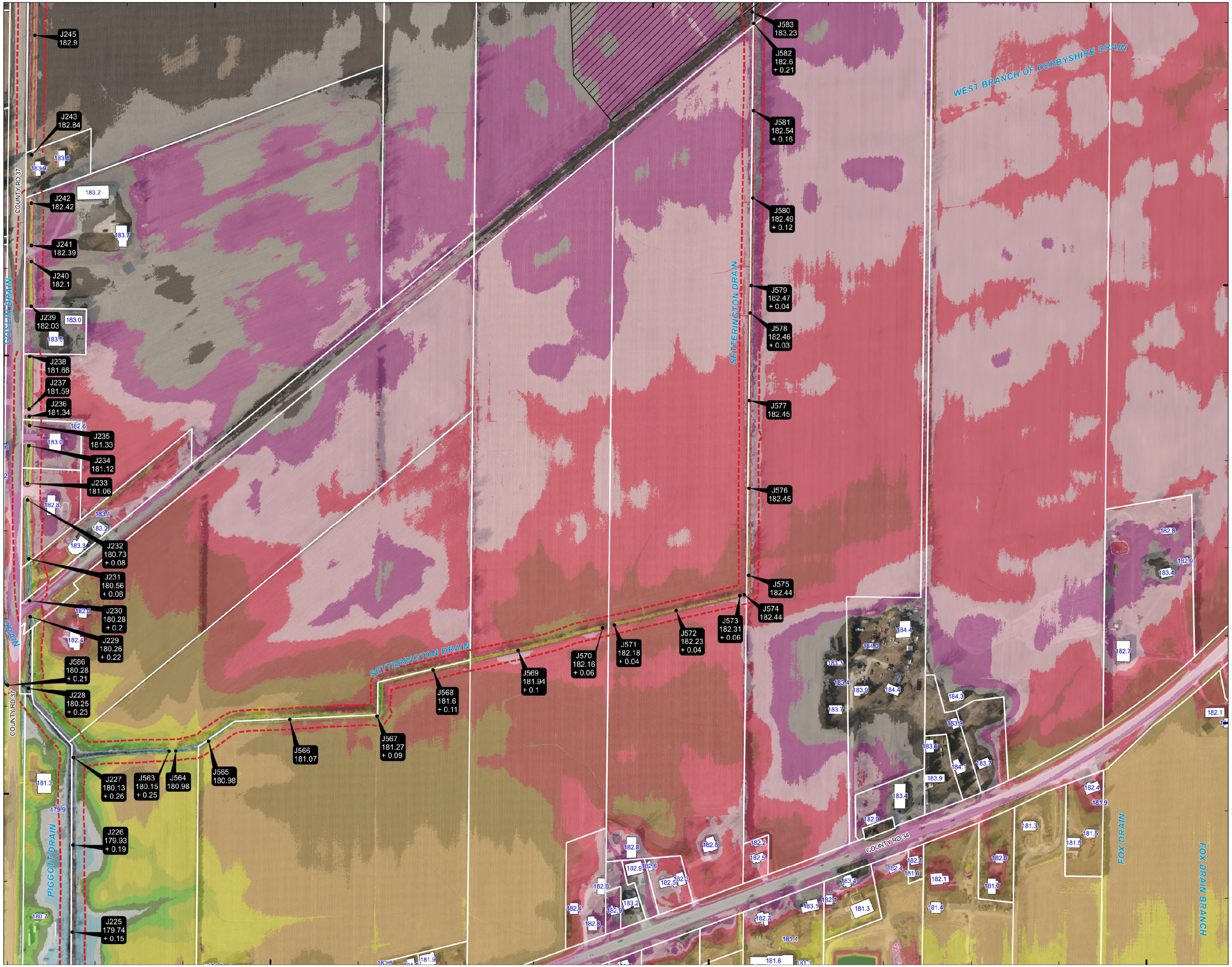
Landmark Engineers Inc.

client
THE MUNICIPALITY OF LEAMINGTON

project
LEBO CREEK MASTER DRAINAGE STUDY

title
PROJECTED FLOOD ELEVATIONS
1:100 YEAR EVENT

drawn by / date	FMK / SEP 2022	project no.	19-023
designed by / date		figure no.	E-26
checked by / date	ADM / SEP 2022	scale	1:2,000



LEGEND:

- NODE ID / 1:100 YEAR REGULATORY FLOOD ELEVATION (m) / NO-CULVERT SCENARIO INCREASE
- MODELED NODE
- EXISTING BUILDING & APPROXIMATE EXISTING GRADE ELEVATION (m)
- TYPICAL MINIMUM FLOODWAY CORRIDOR
- TEMPORARY FLOODPLAIN AREA

EXISTING GROUND ELEVATION (m)
(RANGES VARY ON EACH SHEET)

- 178.80 - 179.10
- 179.10 - 179.40
- 179.40 - 179.70
- 179.70 - 180.00
- 180.00 - 180.30
- 180.30 - 180.60
- 180.60 - 180.90
- 180.90 - 181.20
- 181.20 - 181.50
- 181.50 - 181.80
- 181.80 - 182.10
- 182.10 - 182.40
- 182.40 - 182.70
- 182.70 - 183.00
- 183.00 - 183.30
- 183.30 - 183.60

NOTES:

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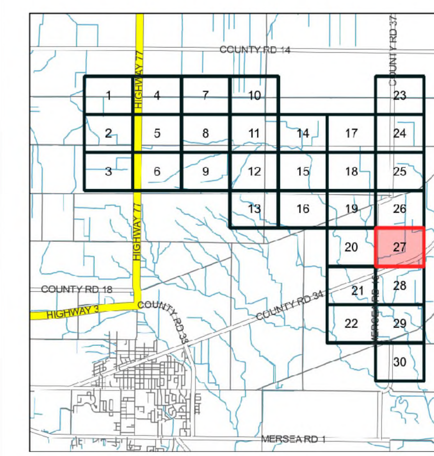

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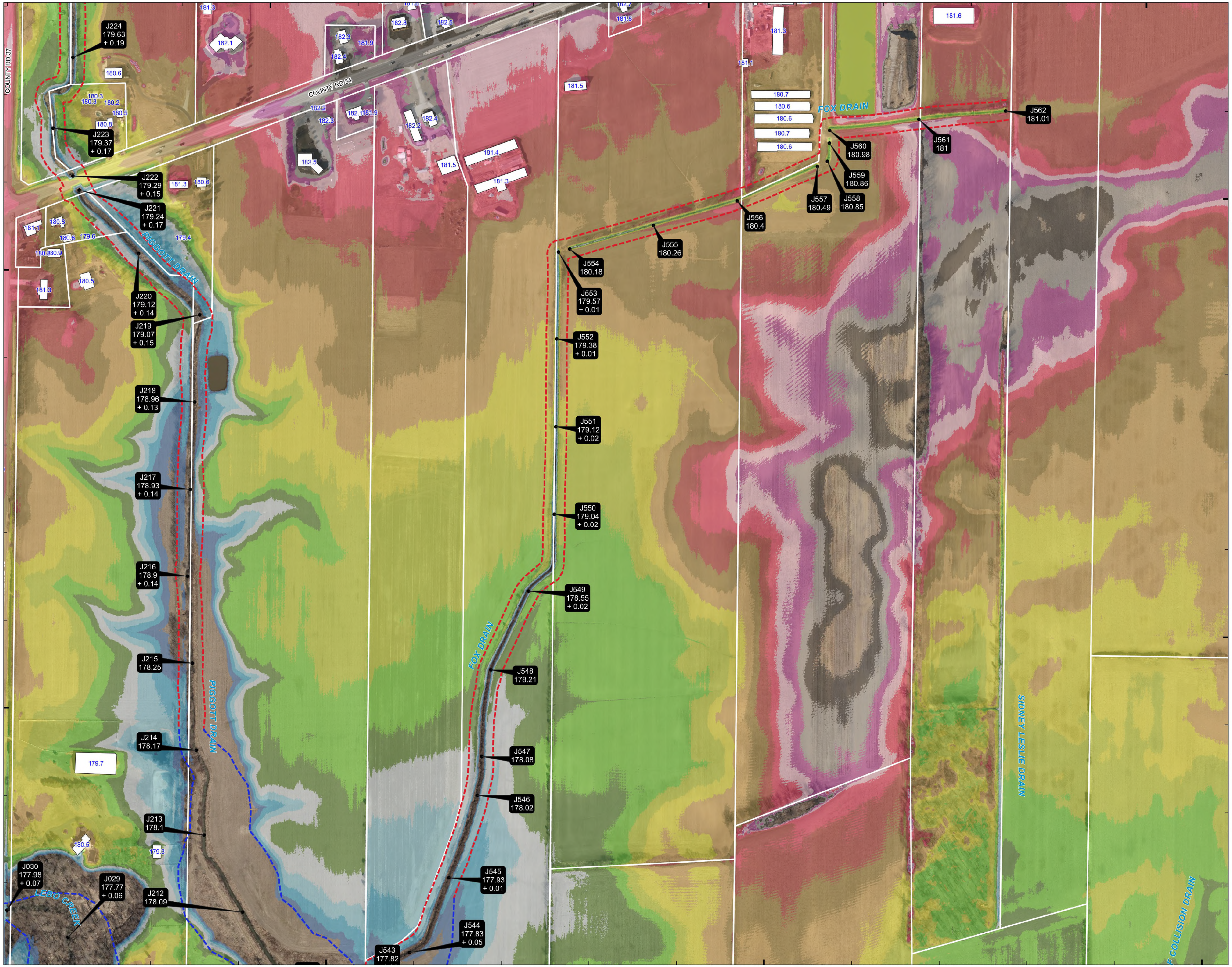
Landmark Engineers Inc.

client: THE MUNICIPALITY OF LEAMINGTON

project: LEBO CREEK MASTER DRAINAGE STUDY

title: PROJECTED FLOOD ELEVATIONS 1:100 YEAR EVENT

drawn by / date	FMK / SEP 2022	project no.	19-023
designed by / date		figure no.	E-27
checked by / date	ADM / SEP 2022	scale	1:2,000



LEGEND:

NODE ID
1:100 YEAR REGULATORY FLOOD ELEVATION (m)
NO-CULVERT SCENARIO INCREASE

MODELED NODE

190.0 EXISTING BUILDING & APPROXIMATE EXISTING GRADE ELEVATION (m)

TYPICAL MINIMUM FLOODWAY CORRIDOR

EXPANDED MINIMUM FLOODWAY CORRIDOR

EXISTING GROUND ELEVATION (m)
(RANGES VARY ON EACH SHEET)

- 177.90 - 178.20
- 178.20 - 178.50
- 178.50 - 178.80
- 178.80 - 179.10
- 179.10 - 179.40
- 179.40 - 179.70
- 179.70 - 180.00
- 180.00 - 180.30
- 180.30 - 180.60
- 180.60 - 180.90
- 180.90 - 181.20
- 181.20 - 181.50
- 181.50 - 181.80
- 181.80 - 182.10
- 182.10 - 182.40
- 182.40 - 182.70

NOTES:

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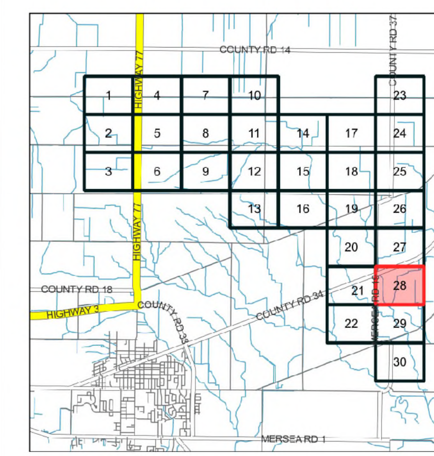


Peralta Engineering

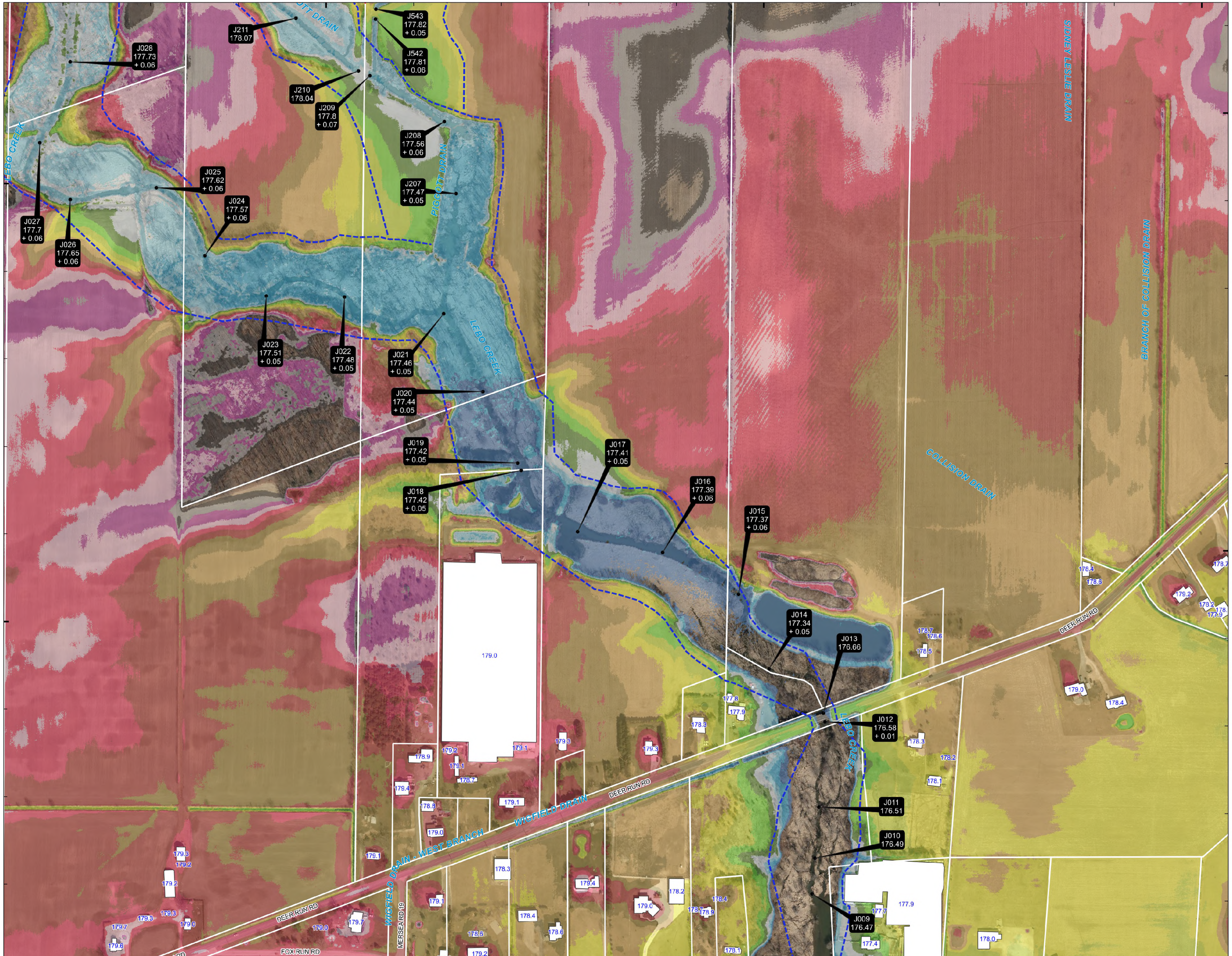
Landmark Engineers Inc.

client
THE MUNICIPALITY OF LEAMINGTON

project
LEBO CREEK MASTER DRAINAGE STUDY

title
PROJECTED FLOOD ELEVATIONS
1:100 YEAR EVENT

drawn by date	EMK AUG 2022	project no.	19-023
designed by date		figure no.	E-28
checked by date	ADM AUG 2022	scale	1:2,000



LEGEND:

NODE ID
1:100 YEAR REGULATORY FLOOD ELEVATION (m)
NO-CULVERT SCENARIO INCREASE

MODELED NODE

90.0 EXISTING BUILDING & APPROXIMATE EXISTING GRADE ELEVATION (m)

TYPICAL MINIMUM FLOODWAY CORRIDOR

EXPANDED MINIMUM FLOODWAY CORRIDOR

EXISTING GROUND ELEVATION (m) (RANGES VARY ON EACH SHEET)

- 175.80 - 176.10
- 176.10 - 176.40
- 176.40 - 176.70
- 176.70 - 177.00
- 177.00 - 177.30
- 177.30 - 177.60
- 177.60 - 177.90
- 177.90 - 178.20
- 178.20 - 178.50
- 178.50 - 178.80
- 178.80 - 179.10
- 179.10 - 179.40
- 179.40 - 179.70
- 179.70 - 180.00
- 180.00 - 180.30
- 180.30 - 180.60

NOTES:

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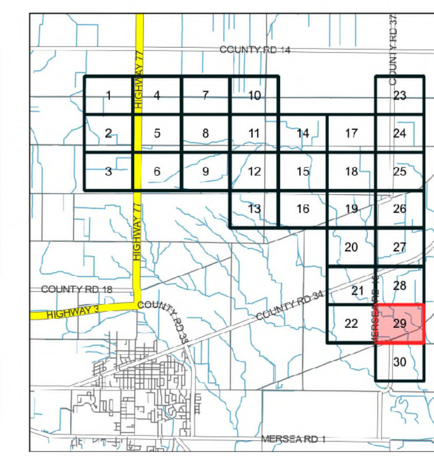


Peralta Engineering

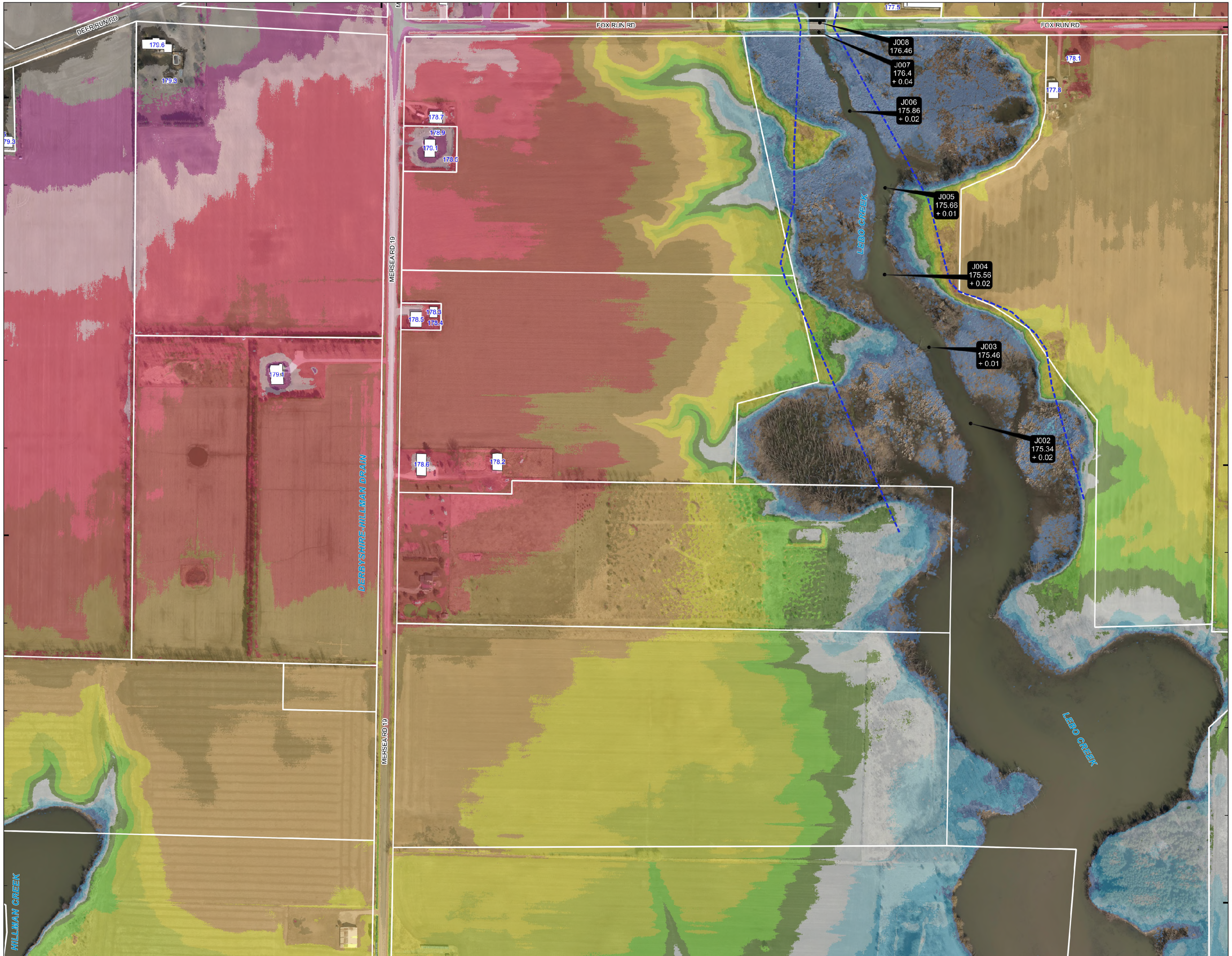
Landmark Engineers Inc.

client: THE MUNICIPALITY OF LEAMINGTON

project: LEBO CREEK MASTER DRAINAGE STUDY

title: PROJECTED FLOOD ELEVATIONS 1:100 YEAR EVENT

drawn by / date	FMK / AUG 2022	project no.	19-023
designed by / date		figure no.	E-29
checked by / date	ADM / AUG 2022	scale	1:2,000



LEGEND:

NODE ID
1:100 YEAR REGULATORY FLOOD ELEVATION (m)
NO-CULVERT SCENARIO INCREASE

MODELED NODE

190.0 EXISTING BUILDING & APPROXIMATE EXISTING GRADE ELEVATION (m)

EXPANDED MINIMUM FLOODWAY CORRIDOR

EXISTING GROUND ELEVATION (m)
(RANGES VARY ON EACH SHEET)

- 174.90 - 175.20
- 175.20 - 175.50
- 175.50 - 175.80
- 175.80 - 176.10
- 176.10 - 176.40
- 176.40 - 176.70
- 176.70 - 177.00
- 177.00 - 177.30
- 177.30 - 177.60
- 177.60 - 177.90
- 177.90 - 178.20
- 178.20 - 178.50
- 178.50 - 178.80
- 178.80 - 179.10
- 179.10 - 179.40
- 179.40 - 179.70

NOTES:

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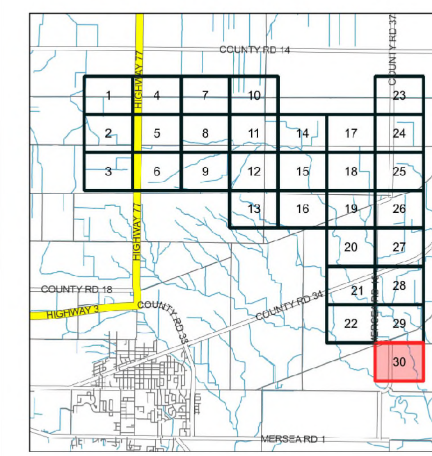

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title: PROJECTED FLOOD ELEVATIONS 1:100 YEAR EVENT

drawn by / date	EMK / AUG 2022	project no.	19-023
designed by / date		figure no.	E-30
checked by / date	ADM / AUG 2022	scale	1:2,000

PROJECTED FLOODLINE ELEVATIONS

Name	100-YEAR 6-HOUR STORM										AES 12-HOUR 32mm STORM
	Ex	Pr1	Pr2	Max.	Max. Scenario	Range	Max - Ex	No Culvert Scenario	Diff.	Increase	
J002	175.34	175.32	175.34	**175.34**	Ex	0.02	0.00	175.36	0.02	0.02	175.02
J003	175.46	175.43	175.45	**175.46**	Ex	0.03	0.00	175.47	0.01	0.01	175.11
J004	175.56	175.54	175.56	**175.56**	Ex	0.02	0.00	175.58	0.02	0.02	175.14
J005	175.66	175.63	175.65	**175.66**	Ex	0.03	0.00	175.67	0.01	0.01	175.19
J006	175.86	175.83	175.86	**175.86**	Ex	0.03	0.00	175.88	0.02	0.02	175.31
J007	176.4	176.26	176.3	**176.40**	Ex	0.14	0.00	176.44	0.04	0.04	175.52
J008	176.46	176.31	176.35	**176.46**	Ex	0.15	0.00	176.44	-0.02	-	175.52
J009	176.47	176.32	176.37	**176.47**	Ex	0.15	0.00	176.46	-0.01	-	175.52
J010	176.49	176.34	176.38	**176.49**	Ex	0.15	0.00	176.47	-0.02	-	175.53
J011	176.51	176.37	176.41	**176.51**	Ex	0.14	0.00	176.50	-0.01	-	175.54
J012	176.58	176.45	176.5	**176.58**	Ex	0.13	0.00	176.58	0.00	-	175.57
J013	176.66	176.53	176.58	**176.66**	Ex	0.13	0.00	176.61	-0.05	-	175.58
J014	177.34	177.22	177.31	**177.34**	Ex	0.12	0.00	177.39	0.05	0.05	176.05
J015	177.37	177.26	177.35	**177.37**	Ex	0.11	0.00	177.43	0.06	0.06	176.08
J016	177.39	177.28	177.37	**177.39**	Ex	0.11	0.00	177.45	0.06	0.06	176.09
J017	177.41	177.29	177.38	**177.41**	Ex	0.12	0.00	177.46	0.05	0.05	176.10
J018	177.42	177.31	177.4	**177.42**	Ex	0.11	0.00	177.47	0.05	0.05	176.11
J019	177.42	177.31	177.4	**177.42**	Ex	0.11	0.00	177.47	0.05	0.05	176.11
J020	177.44	177.33	177.41	**177.44**	Ex	0.11	0.00	177.49	0.05	0.05	176.12
J021	177.46	177.35	177.43	**177.46**	Ex	0.11	0.00	177.51	0.05	0.05	176.15
J022	177.48	177.37	177.45	**177.48**	Ex	0.11	0.00	177.53	0.05	0.05	176.20
J023	177.51	177.41	177.48	**177.51**	Ex	0.10	0.00	177.56	0.05	0.05	176.30
J024	177.57	177.48	177.55	**177.57**	Ex	0.09	0.00	177.63	0.06	0.06	176.54
J025	177.62	177.54	177.6	**177.62**	Ex	0.08	0.00	177.68	0.06	0.06	176.58
J026	177.65	177.58	177.63	**177.65**	Ex	0.07	0.00	177.71	0.06	0.06	176.61
J027	177.7	177.63	177.68	**177.70**	Ex	0.07	0.00	177.76	0.06	0.06	176.66
J028	177.73	177.66	177.71	**177.73**	Ex	0.07	0.00	177.79	0.06	0.06	176.68
J029	177.77	177.71	177.75	**177.77**	Ex	0.06	0.00	177.83	0.06	0.06	176.73
J030	177.98	177.91	177.94	**177.98**	Ex	0.07	0.00	178.05	0.07	0.07	176.81
J031	178.03	177.96	177.99	**178.03**	Ex	0.07	0.00	178.06	0.03	0.03	176.81
J032	178.07	178	178.03	**178.07**	Ex	0.07	0.00	178.10	0.03	0.03	176.82
J033	178.09	178.03	178.06	**178.09**	Ex	0.06	0.00	178.13	0.04	0.04	176.85
J034	178.11	178.05	178.07	**178.11**	Ex	0.06	0.00	178.15	0.04	0.04	176.87
J035	178.16	178.1	178.13	**178.16**	Ex	0.06	0.00	178.21	0.05	0.05	176.92
J036	178.22	178.16	178.19	**178.22**	Ex	0.06	0.00	178.27	0.05	0.05	176.98
J037	178.3	178.24	178.27	**178.30**	Ex	0.06	0.00	178.35	0.05	0.05	177.09
J038	178.37	178.32	178.34	**178.37**	Ex	0.05	0.00	178.43	0.06	0.06	177.18
J039	178.5	178.44	178.47	**178.50**	Ex	0.06	0.00	178.43	-0.07	-	177.19
J040	178.5	178.45	178.47	**178.50**	Ex	0.05	0.00	178.43	-0.07	-	177.19
J041	178.73	178.65	178.68	**178.73**	Ex	0.08	0.00	178.43	-0.30	-	177.20
J042	178.76	178.68	178.71	**178.76**	Ex	0.08	0.00	178.51	-0.25	-	177.25
J043	178.8	178.72	178.75	**178.80**	Ex	0.08	0.00	178.59	-0.21	-	177.30
J044	178.83	178.76	178.79	**178.83**	Ex	0.07	0.00	178.65	-0.18	-	177.35
J045	178.89	178.82	178.84	**178.89**	Ex	0.07	0.00	178.75	-0.14	-	177.53
J046	178.94	178.87	178.9	**178.94**	Ex	0.07	0.00	178.83	-0.11	-	177.56
J047	179.03	178.96	178.99	**179.03**	Ex	0.07	0.00	178.96	-0.07	-	177.65
J048	179.1	179.02	179.05	**179.10**	Ex	0.08	0.00	179.04	-0.06	-	177.66
J048.5	179.15	179.07	179.1	**179.15**	Ex	0.08	0.00	179.10	-0.05	-	177.70
J049	179.18	179.1	179.14	**179.18**	Ex	0.08	0.00	179.15	-0.03	-	177.71
J050	179.22	179.14	179.17	**179.22**	Ex	0.08	0.00	179.19	-0.03	-	177.74
J051	179.3	179.22	179.25	**179.30**	Ex	0.08	0.00	179.29	-0.01	-	177.81
J052	179.43	179.36	179.39	**179.43**	Ex	0.07	0.00	179.45	0.02	0.02	177.98
J053	179.6	179.5	179.55	**179.60**	Ex	0.10	0.00	179.45	-0.15	-	177.99
J054	179.68	179.58	179.63	**179.68**	Ex	0.10	0.00	179.58	-0.10	-	178.27
J055	179.72	179.62	179.67	**179.72**	Ex	0.10	0.00	179.63	-0.09	-	178.32
J056	179.92	179.85	179.88	**179.92**	Ex	0.07	0.00	179.91	-0.01	-	178.67
J057	180.07	180	180.03	**180.07**	Ex	0.07	0.00	180.08	0.01	0.01	178.79
J058	180.22	180.16	180.19	**180.22**	Ex	0.06	0.00	180.24	0.02	0.02	179.06
J059	180.33	180.27	180.3	**180.33**	Ex	0.06	0.00	180.35	0.02	0.02	179.23
J060	180.48	180.42	180.45	**180.48**	Ex	0.06	0.00	180.50	0.02	0.02	179.45
J061	180.6	180.55	180.58	**180.60**	Ex	0.05	0.00	180.63	0.03	0.03	179.66
J062	180.76	180.7	180.73	**180.76**	Ex	0.06	0.00	180.79	0.03	0.03	179.98
J063	180.85	180.8	180.83	**180.85**	Ex	0.05	0.00	180.89	0.04	0.04	180.04
J064	181.2	181.15	181.17	**181.20**	Ex	0.05	0.00	181.23	0.03	0.03	180.36
J065	181.25	181.2	181.23	**181.25**	Ex	0.05	0.00	181.28	0.03	0.03	180.41
J066	181.36	181.31	181.34	**181.36**	Ex	0.05	0.00	181.39	0.03	0.03	180.55
J067	181.56	181.51	181.54	**181.56**	Ex	0.05	0.00	181.59	0.03	0.03	180.99

Landmark

Name	100-YEAR 6-HOUR STORM										AES 12-HOUR 32mm STORM
	Ex	Pr1	Pr2	Max.	Max. Scenario	Range	Max - Ex	No Culvert Scenario	Diff.	Increase	
J068	181.66	181.61	181.63	**181.66**	Ex	0.05	0.00	181.68	0.02	0.02	181.05
J069	181.98	181.94	181.96	**181.98**	Ex	0.04	0.00	182.01	0.03	0.03	181.34
J070	182.09	182.04	182.07	**182.09**	Ex	0.05	0.00	182.11	0.02	0.02	181.41
J071	182.13	182.08	182.11	**182.13**	Ex	0.05	0.00	182.16	0.03	0.03	181.45
J072	182.17	182.12	182.14	**182.17**	Ex	0.05	0.00	182.19	0.02	0.02	181.48
J073	182.38	182.34	182.36	**182.38**	Ex	0.04	0.00	182.41	0.03	0.03	181.64
J074	182.51	182.46	182.49	**182.51**	Ex	0.05	0.00	182.53	0.02	0.02	181.69
J075	182.76	182.7	182.73	**182.76**	Ex	0.06	0.00	182.79	0.03	0.03	181.79
J076	182.84	182.77	182.81	**182.84**	Ex	0.07	0.00	182.79	-0.05	-	181.79
J077	182.88	182.81	182.85	**182.88**	Ex	0.07	0.00	182.84	-0.04	-	181.80
J078	182.9	182.83	182.86	**182.90**	Ex	0.07	0.00	182.86	-0.04	-	181.88
J079	182.94	182.88	182.91	**182.94**	Ex	0.06	0.00	182.92	-0.02	-	182.01
J080	182.96	182.89	182.93	**182.96**	Ex	0.07	0.00	182.94	-0.02	-	182.12
J081	183	182.93	182.96	**183.00**	Ex	0.07	0.00	182.99	-0.01	-	182.20
J082	183.11	183.07	183.08	**183.11**	Ex	0.04	0.00	183.12	0.01	0.01	182.31
J083	183.3	183.29	183.29	**183.30**	Ex	0.01	0.00	183.32	0.02	0.02	182.52
J084	183.5	183.49	183.48	**183.50**	Ex	0.02	0.00	183.52	0.02	0.02	182.61
J085	183.78	183.76	183.76	**183.78**	Ex	0.02	0.00	183.79	0.01	0.01	182.68
J086	183.92	183.9	183.9	**183.92**	Ex	0.02	0.00	183.94	0.02	0.02	182.74
J087	183.96	183.94	183.94	**183.96**	Ex	0.02	0.00	183.96	0.00	-	182.74
J088	184.05	184.03	184.02	**184.05**	Ex	0.03	0.00	184.06	0.01	0.01	182.76
J089	184.43	184.4	184.39	**184.43**	Ex	0.04	0.00	184.07	-0.36	-	182.77
J090	184.5	184.46	184.45	**184.50**	Ex	0.05	0.00	184.21	-0.29	-	182.82
J091	184.56	184.52	184.51	**184.56**	Ex	0.05	0.00	184.34	-0.22	-	182.88
J092	184.61	184.58	184.56	**184.61**	Ex	0.05	0.00	184.45	-0.16	-	183.13
J093	184.76	184.74	184.72	**184.76**	Ex	0.04	0.00	184.71	-0.05	-	183.35
J094	184.86	184.85	184.82	**184.86**	Ex	0.04	0.00	184.85	-0.01	-	183.47
J095	185.1	185.09	185.07	**185.10**	Ex	0.03	0.00	185.13	0.03	0.03	183.62
J096	185.24	185.24	185.2	**185.24**	Ex	0.04	0.00	185.29	0.05	0.05	183.75
J097	185.31	185.31	185.27	**185.31**	Ex	0.04	0.00	185.37	0.06	0.06	183.83
J098	185.41	185.41	185.37	**185.41**	Ex	0.04	0.00	185.47	0.06	0.06	184.04
J099	185.55	185.55	185.51	**185.55**	Ex	0.04	0.00	185.63	0.08	0.08	184.18
J100	185.79	185.79	185.74	**185.79**	Ex	0.05	0.00	185.86	0.07	0.07	184.52
J101	185.92	185.93	185.88	**185.93**	Pr1	0.05	0.01	186.00	0.07	0.07	184.64
J102	186.13	186.14	186.08	**186.14**	Pr1	0.06	0.01	186.21	0.07	0.07	184.74
J103	186.22	186.23	186.17	**186.23**	Pr1	0.06	0.01	186.31	0.08	0.08	184.94
J104	186.52	186.53	186.48	**186.53**	Pr1	0.05	0.01	186.60	0.07	0.07	185.34
J105	186.66	186.67	186.62	**186.67**	Pr1	0.05	0.01	186.75	0.08	0.08	185.42
J106	186.93	186.95	186.88	**186.95**	Pr1	0.07	0.02	187.01	0.06	0.06	185.63
J107	187.14	187.16	187.09	**187.16**	Pr1	0.07	0.02	187.24	0.08	0.08	185.83
J108	187.2	187.22	187.15	**187.22**	Pr1	0.07	0.02	187.29	0.07	0.07	186.01
J109	187.26	187.28	187.2	**187.28**	Pr1	0.08	0.02	187.30	0.02	0.02	186.02
J110	187.34	187.35	187.28	**187.35**	Pr1	0.07	0.01	187.39	0.04	0.04	186.15
J111	187.57	187.58	187.52	**187.58**	Pr1	0.06	0.01	187.66	0.08	0.08	186.64
J112	187.72	187.73	187.67	**187.73**	Pr1	0.06	0.01	187.81	0.08	0.08	186.71
J113	188.04	188.05	188	**188.05**	Pr1	0.05	0.01	188.13	0.08	0.08	186.95
J114	188.09	188.1	188.04	**188.10**	Pr1	0.06	0.01	188.13	0.03	0.03	186.96
J115	188.17	188.18	188.12	**188.18**	Pr1	0.06	0.01	188.23	0.05	0.05	187.03
J116	188.33	188.34	188.28	**188.34**	Pr1	0.06	0.01	188.40	0.06	0.06	187.19
J117	188.53	188.54	188.48	**188.54**	Pr1	0.06	0.01	188.64	0.10	0.10	187.38
J118	188.62	188.64	188.56	**188.64**	Pr1	0.08	0.02	188.74	0.10	0.10	187.46
J119	188.85	188.85	188.78	**188.85**	Ex	0.07	0.00	188.96	0.11	0.11	187.67
J120	188.88	188.89	188.81	**188.89**	Pr1	0.08	0.01	188.97	0.08	0.08	187.67
J121	188.97	188.98	188.9	**188.98**	Pr1	0.08	0.01	189.08	0.10	0.10	187.76
J122	189.05	189.06	188.97	**189.06**	Pr1	0.09	0.01	189.17	0.11	0.11	187.86
J123	189.25	189.24	189.14	**189.25**	Ex	0.11	0.00	189.44	0.19	0.19	188.03
J124	189.29	189.27	189.16	**189.29**	Ex	0.13	0.00	189.46	0.17	0.17	188.03
J125	189.49	189.51	189.32	**189.51**	Pr1	0.19	0.02	189.72	0.21	0.21	188.16
J126	189.58	189.6	189.4	**189.60**	Pr1	0.20	0.02	189.82	0.22	0.22	188.25
J127	189.67	189.73	189.5	**189.73**	Pr1	0.23	0.06	189.93	0.20	0.20	188.36
J128	189.77	189.9	189.61	**189.90**	Pr1	0.29	0.13	190.09	0.19	0.19	188.51
J129	189.88	189.96	189.67	**189.96**	Pr1	0.29	0.08	190.15	0.19	0.19	188.56
J130	189.95	190.04	189.74	**190.04**	Pr1	0.30	0.09	190.16	0.12	0.12	188.57
J131	189.97	190.06	189.76	**190.06**	Pr1	0.30	0.09	190.19	0.13	0.13	188.61
J132	190.1	190.16	189.86	**190.16**	Pr1	0.30	0.06	190.29	0.13	0.13	188.73
J133	190.18	190.23	189.95	**190.23**	Pr1	0.28	0.05	190.39	0.16	0.16	188.83
J134	190.23	190.28	190.02	**190.28**	Pr1	0.26	0.05	190.44	0.16	0.16	188.93
J135	190.27	190.34	190.05	**190.34**	Pr1	0.29	0.07	190.48	0.14	0.14	189.00
J136	190.32	190.38	190.09	**190.38**	Pr1	0.29	0.06	190.51	0.13	0.13	189.07
J137	190.46	190.5	190.21	**190.50**	Pr1	0.29	0.04	190.62	0.12	0.12	189.30

Name	100-YEAR 6-HOUR STORM										AES 12-HOUR 32mm STORM
	Ex	Pr1	Pr2	Max.	Max. Scenario	Range	Max - Ex	No Culvert Scenario	Diff.	Increase	
J138	190.62	190.65	190.37	**190.65**	Pr1	0.28	0.03	190.77	0.12	0.12	189.52
J139	190.73	190.76	190.48	**190.76**	Pr1	0.28	0.03	190.86	0.10	0.10	189.68
J140	190.87	190.88	190.62	**190.88**	Pr1	0.26	0.01	190.98	0.10	0.10	189.88
J141	191.01	191.02	190.77	**191.02**	Pr1	0.25	0.01	191.11	0.09	0.09	190.03
J142	191.12	191.13	190.88	**191.13**	Pr1	0.25	0.01	191.22	0.09	0.09	190.17
J143	191.19	191.2	190.95	**191.20**	Pr1	0.25	0.01	191.28	0.08	0.08	190.24
J144	191.3	191.3	191.06	**191.30**	Ex	0.24	0.00	191.38	0.08	0.08	190.34
J145	191.46	191.47	191.23	**191.47**	Pr1	0.24	0.01	191.54	0.07	0.07	190.52
J146	191.59	191.6	191.35	**191.60**	Pr1	0.25	0.01	191.67	0.07	0.07	190.61
J147	191.7	191.71	191.46	**191.71**	Pr1	0.25	0.01	191.78	0.07	0.07	190.72
J148	191.81	191.82	191.57	**191.82**	Pr1	0.25	0.01	191.90	0.08	0.08	190.82
J149	192.09	192.1	191.71	**192.10**	Pr1	0.39	0.01	191.91	-0.19	-	190.84
J150	192.12	192.13	191.74	**192.13**	Pr1	0.39	0.01	191.96	-0.17	-	190.86
J151	192.24	192.25	191.84	**192.25**	Pr1	0.41	0.01	192.21	-0.04	-	190.98
J152	192.3	192.3	191.91	**192.30**	Ex	0.39	0.00	192.28	-0.02	-	191.03
J153	192.35	192.35	191.98	**192.35**	Ex	0.37	0.00	192.33	-0.02	-	191.10
J154	192.51	192.51	192.09	**192.51**	Ex	0.42	0.00	192.33	-0.18	-	191.10
J155	192.54	192.53	192.12	**192.54**	Ex	0.42	0.00	192.37	-0.17	-	191.14
J156	192.58	192.59	192.21	**192.59**	Pr1	0.38	0.01	192.45	-0.14	-	191.26
J157	192.65	192.67	192.31	**192.67**	Pr1	0.36	0.02	192.55	-0.12	-	191.39
J158	192.66	192.68	192.32	**192.68**	Pr1	0.36	0.02	192.55	-0.13	-	191.39
J159	192.71	192.72	192.38	**192.72**	Pr1	0.34	0.01	192.63	-0.09	-	191.47
J160	192.85	192.83	192.54	**192.85**	Ex	0.31	0.00	192.81	-0.04	-	191.74
J161	192.87	192.85	192.56	**192.87**	Ex	0.31	0.00	192.81	-0.06	-	191.74
J162	192.93	192.9	192.6	**192.93**	Ex	0.33	0.00	192.89	-0.04	-	191.79
J163	193	192.95	192.67	**193.00**	Ex	0.33	0.00	192.97	-0.03	-	191.85
J164	193.05	192.99	192.74	**193.05**	Ex	0.31	0.00	193.04	-0.01	-	191.92
J165	193.13	193.04	192.81	**193.13**	Ex	0.32	0.00	193.07	-0.06	-	191.93
J166	193.15	193.06	192.84	**193.15**	Ex	0.31	0.00	193.09	-0.06	-	191.98
J167	193.17	193.08	192.86	**193.17**	Ex	0.31	0.00	193.09	-0.08	-	191.98
J168	193.25	193.11	192.93	**193.25**	Ex	0.32	0.00	193.14	-0.11	-	192.13
J169	193.33	193.18	193	**193.33**	Ex	0.33	0.00	193.14	-0.19	-	192.13
J170	193.38	193.2	193.05	**193.38**	Ex	0.33	0.00	193.20	-0.18	-	192.23
J171	193.45	193.25	193.12	**193.45**	Ex	0.33	0.00	193.28	-0.17	-	192.32
J172	193.5	193.28	193.17	**193.50**	Ex	0.33	0.00	193.32	-0.18	-	192.37
J173	193.52	193.31	193.21	**193.52**	Ex	0.31	0.00	193.36	-0.16	-	192.43
J174	193.6	193.37	193.27	**193.60**	Ex	0.33	0.00	193.36	-0.24	-	192.44
J175	193.61	193.39	193.3	**193.61**	Ex	0.31	0.00	193.39	-0.22	-	192.52
J176	193.67	193.47	193.41	**193.67**	Ex	0.26	0.00	193.52	-0.15	-	192.76
J176.5	193.73	193.55	193.5	**193.73**	Ex	0.23	0.00	193.62	-0.11	-	192.87
J177	193.74	193.56	193.51	**193.74**	Ex	0.23	0.00	193.64	-0.10	-	192.88
J178	193.85	193.69	193.66	**193.85**	Ex	0.19	0.00	193.79	-0.06	-	193.00
J179	193.89	193.71	193.69	**193.89**	Ex	0.20	0.00	193.84	-0.05	-	193.01
J180	193.93	193.77	193.75	**193.93**	Ex	0.18	0.00	193.90	-0.03	-	193.27
J181	194.1	193.96	193.96	**194.10**	Ex	0.14	0.00	194.10	0.00	-	193.44
J182	194.11	193.97	193.96	**194.11**	Ex	0.15	0.00	194.10	-0.01	-	193.44
J183	194.17	194.03	194.03	**194.17**	Ex	0.14	0.00	194.16	-0.01	-	193.51
J184	194.33	194.2	194.2	**194.33**	Ex	0.13	0.00	194.33	0.00	-	193.70
J185	194.41	194.28	194.28	**194.41**	Ex	0.13	0.00	194.41	0.00	-	193.72
J186	194.52	194.4	194.4	**194.52**	Ex	0.12	0.00	194.53	0.01	0.01	193.85
J187	194.72	194.59	194.59	**194.72**	Ex	0.13	0.00	194.73	0.01	0.01	193.72
J188	194.79	194.64	194.64	**194.79**	Ex	0.15	0.00	194.73	-0.06	-	193.79
J189	194.89	194.75	194.75	**194.89**	Ex	0.14	0.00	194.87	-0.02	-	194.16
J190	194.99	194.86	194.86	**194.99**	Ex	0.13	0.00	194.99	0.00	-	194.34
J191	195.15	195.04	195.04	**195.15**	Ex	0.11	0.00	195.15	0.00	-	194.24
J192	195.55	195.24	195.24	**195.55**	Ex	0.31	0.00	195.16	-0.39	-	194.24
J193	195.56	195.26	195.26	**195.56**	Ex	0.30	0.00	195.25	-0.31	-	194.62
J194	195.59	195.34	195.34	**195.59**	Ex	0.25	0.00	195.42	-0.17	-	194.73
J195	195.63	195.41	195.41	**195.63**	Ex	0.22	0.00	195.52	-0.11	-	194.86
J196	195.82	195.7	195.7	**195.82**	Ex	0.12	0.00	195.81	-0.01	-	195.25
J197	196.09	195.91	195.91	**196.09**	Ex	0.18	0.00	195.93	-0.16	-	195.29
J198	196.35	196.2	196.2	**196.35**	Ex	0.15	0.00	196.35	0.00	-	195.54
J199	196.6	196.45	196.45	**196.60**	Ex	0.15	0.00	196.60	0.00	-	195.71
J200	196.72	196.57	196.57	**196.72**	Ex	0.15	0.00	196.72	0.00	-	195.95
J201	196.8	196.64	196.64	**196.80**	Ex	0.16	0.00	196.80	0.00	-	196.01
J202	196.89	196.74	196.74	**196.89**	Ex	0.15	0.00	196.89	0.00	-	196.17
J203	196.98	196.83	196.83	**196.98**	Ex	0.15	0.00	196.98	0.00	-	196.17
J204	197.08	196.93	196.93	**197.08**	Ex	0.15	0.00	197.08	0.00	-	196.31
J205	197.18	197.03	197.03	**197.18**	Ex	0.15	0.00	197.18	0.00	-	196.41
J206	197.18	197.03	197.03	**197.18**	Ex	0.15	0.00	197.18	0.00	-	197.03

Name	100-YEAR 6-HOUR STORM										AES 12-HOUR 32mm STORM
	Ex	Pr1	Pr2	Max.	Max. Scenario	Range	Max - Ex	No Culvert Scenario	Diff.	Increase	
J207	177.47	177.36	177.45	**177.47**	Ex	0.11	0.00	177.52	0.05	0.05	176.58
J208	177.54	177.53	177.56	**177.56**	Pr2	0.03	0.02	177.62	0.06	0.06	176.95
J209	177.79	177.77	177.8	**177.80**	Pr2	0.03	0.01	177.87	0.07	0.07	177.11
J210	178.01	177.98	178.04	**178.04**	Pr2	0.06	0.03	177.87	-0.17	-	177.14
J211	178.03	178	178.07	**178.07**	Pr2	0.07	0.04	177.92	-0.15	-	177.15
J212	178.05	178.02	178.09	**178.09**	Pr2	0.07	0.04	177.96	-0.13	-	177.17
J213	178.07	178.04	178.1	**178.10**	Pr2	0.06	0.03	177.99	-0.11	-	177.19
J214	178.13	178.1	178.17	**178.17**	Pr2	0.07	0.04	178.07	-0.10	-	177.24
J215	178.21	178.18	178.25	**178.25**	Pr2	0.07	0.04	178.21	-0.04	-	177.35
J216	178.81	178.74	178.9	**178.90**	Pr2	0.16	0.09	179.04	0.14	0.14	177.48
J217	178.85	178.79	178.93	**178.93**	Pr2	0.14	0.08	179.07	0.14	0.14	177.55
J218	178.88	178.83	178.96	**178.96**	Pr2	0.13	0.08	179.09	0.13	0.13	177.61
J219	179	178.95	179.07	**179.07**	Pr2	0.12	0.07	179.22	0.15	0.15	177.82
J220	179.05	179.01	179.12	**179.12**	Pr2	0.11	0.07	179.26	0.14	0.14	177.87
J221	179.16	179.12	179.24	**179.24**	Pr2	0.12	0.08	179.41	0.17	0.17	177.94
J222	179.21	179.16	179.29	**179.29**	Pr2	0.13	0.08	179.44	0.15	0.15	177.95
J223	179.27	179.22	179.37	**179.37**	Pr2	0.15	0.10	179.54	0.17	0.17	177.99
J224	179.57	179.54	179.63	**179.63**	Pr2	0.09	0.06	179.82	0.19	0.19	178.28
J225	179.67	179.64	179.74	**179.74**	Pr2	0.10	0.07	179.89	0.15	0.15	178.35
J226	179.87	179.84	179.93	**179.93**	Pr2	0.09	0.06	180.12	0.19	0.19	178.57
J227	180.06	180.02	180.13	**180.13**	Pr2	0.11	0.07	180.39	0.26	0.26	178.72
J228	180.19	180.14	180.25	**180.25**	Pr2	0.11	0.06	180.48	0.23	0.23	178.80
J229	180.2	180.15	180.26	**180.26**	Pr2	0.11	0.06	180.48	0.22	0.22	179.42
J230	180.22	180.17	180.28	**180.28**	Pr2	0.11	0.06	180.48	0.20	0.20	179.42
J231	180.56	180.5	180.56	**180.56**	Ex	0.06	0.00	180.64	0.08	0.08	179.96
J232	180.73	180.66	180.73	**180.73**	Ex	0.07	0.00	180.81	0.08	0.08	180.07
J233	181.06	180.96	181.05	**181.06**	Ex	0.10	0.00	180.84	-0.22	-	180.21
J234	181.12	181.03	181.12	**181.12**	Ex	0.09	0.00	181.04	-0.08	-	180.50
J235	181.33	181.22	181.32	**181.33**	Ex	0.11	0.00	181.06	-0.27	-	180.55
J236	181.34	181.23	181.34	**181.34**	Ex	0.11	0.00	181.12	-0.22	-	180.57
J237	181.59	181.46	181.58	**181.59**	Ex	0.13	0.00	181.15	-0.44	-	180.65
J238	181.66	181.55	181.66	**181.66**	Ex	0.11	0.00	181.54	-0.12	-	180.91
J239	182.03	181.86	182.02	**182.03**	Ex	0.17	0.00	181.65	-0.38	-	181.00
J240	182.1	181.97	182.1	**182.10**	Ex	0.13	0.00	181.98	-0.12	-	181.37
J241	182.39	182.22	182.39	**182.39**	Ex	0.17	0.00	182.00	-0.39	-	181.42
J242	182.42	182.26	182.42	**182.42**	Ex	0.16	0.00	182.12	-0.30	-	181.50
J243	182.84	182.57	182.83	**182.84**	Ex	0.27	0.00	182.16	-0.68	-	181.55
J245	182.9	182.68	182.88	**182.90**	Ex	0.22	0.00	182.65	-0.25	-	182.06
J246	182.96	182.78	182.93	**182.96**	Ex	0.18	0.00	182.83	-0.13	-	182.18
J247	183.04	182.9	183	**183.04**	Ex	0.14	0.00	182.98	-0.06	-	182.35
J248	183.15	183.04	183.1	**183.15**	Ex	0.11	0.00	183.15	0.00	-	182.49
J249	183.22	183.11	183.16	**183.22**	Ex	0.11	0.00	183.15	-0.07	-	182.50
J250	183.24	183.13	183.17	**183.24**	Ex	0.11	0.00	183.17	-0.07	-	182.51
J251	183.53	183.37	183.4	**183.53**	Ex	0.16	0.00	183.18	-0.35	-	182.52
J252	183.55	183.39	183.42	**183.55**	Ex	0.16	0.00	183.24	-0.31	-	182.55
J253	183.58	183.45	183.47	**183.58**	Ex	0.13	0.00	183.33	-0.25	-	182.61
J254	183.64	183.51	183.52	**183.64**	Ex	0.13	0.00	183.47	-0.17	-	182.75
J255	183.7	183.59	183.59	**183.70**	Ex	0.11	0.00	183.61	-0.09	-	182.88
J256	183.94	183.76	183.76	**183.94**	Ex	0.18	0.00	183.63	-0.31	-	182.90
J257	183.98	183.81	183.8	**183.98**	Ex	0.18	0.00	183.73	-0.25	-	183.00
J258	184.03	183.9	183.9	**184.03**	Ex	0.13	0.00	183.88	-0.15	-	183.21
J259	184.21	184.03	184.03	**184.21**	Ex	0.18	0.00	184.28	0.07	0.07	183.46
J260	184.24	184.05	184.05	**184.24**	Ex	0.19	0.00	184.30	0.06	0.06	183.46
J261	184.39	184.23	184.23	**184.39**	Ex	0.16	0.00	184.40	0.01	0.01	183.57
J262	184.46	184.4	184.4	**184.46**	Ex	0.06	0.00	184.47	0.01	0.01	183.89
J263	184.56	184.57	184.57	**184.57**	Pr1	0.01	0.01	184.60	0.03	0.03	184.03
J264	184.63	184.68	184.68	**184.68**	Pr1	0.05	0.05	184.71	0.03	0.03	184.11
J265	184.67	184.74	184.74	**184.74**	Pr1	0.07	0.07	184.71	-0.03	-	184.11
J266	184.74	184.83	184.83	**184.83**	Pr1	0.09	0.09	184.82	-0.01	-	184.22
J267	184.86	184.91	184.91	**184.91**	Pr1	0.05	0.05	184.91	0.00	-	184.40
J268	184.94	184.98	184.98	**184.98**	Pr1	0.04	0.04	184.98	0.00	-	184.50
J269	185.08	185.06	185.06	**185.08**	Ex	0.02	0.00	185.09	0.01	0.01	184.57
J270	185.29	185.2	185.2	**185.29**	Ex	0.09	0.00	185.31	0.02	0.02	184.65
J271	185.46	185.27	185.27	**185.46**	Ex	0.19	0.00	185.47	0.01	0.01	184.76
J272	185.7	185.52	185.52	**185.70**	Ex	0.18	0.00	185.72	0.02	0.02	184.82
J273	185.83	185.7	185.7	**185.83**	Ex	0.13	0.00	185.85	0.02	0.02	184.90
J274	186.01	185.86	185.86	**186.01**	Ex	0.15	0.00	186.03	0.02	0.02	185.01
J275	186.12	185.96	185.96	**186.12**	Ex	0.16	0.00	186.14	0.02	0.02	185.16
J276	186.21	186.11	186.11	**186.21**	Ex	0.10	0.00	186.23	0.02	0.02	185.34
J277	186.36	186.33	186.33	**186.36**	Ex	0.03	0.00	186.38	0.02	0.02	185.77

Name	100-YEAR 6-HOUR STORM										AES 12-HOUR 32mm STORM
	Ex	Pr1	Pr2	Max.	Max. Scenario	Range	Max - Ex	No Culvert Scenario	Diff.	Increase	
J278	186.61	186.61	186.61	**186.61**	Ex	0.00	0.00	186.63	0.02	0.02	185.88
J279	186.74	186.75	186.75	**186.75**	Pr1	0.01	0.01	186.64	-0.11	-	185.89
J280	186.77	186.79	186.79	**186.79**	Pr1	0.02	0.02	186.69	-0.10	-	185.92
J281	186.89	186.91	186.91	**186.91**	Pr1	0.02	0.02	186.86	-0.05	-	186.16
J282	187.5	187.51	187.51	**187.51**	Pr1	0.01	0.01	186.86	-0.65	-	186.20
J283	187.51	187.53	187.53	**187.53**	Pr1	0.02	0.02	187.01	-0.52	-	186.41
J284	187.62	187.64	187.64	**187.64**	Pr1	0.02	0.02	187.34	-0.30	-	186.76
J285	187.7	187.72	187.72	**187.72**	Pr1	0.02	0.02	187.57	-0.15	-	187.09
J286	187.82	187.84	187.84	**187.84**	Pr1	0.02	0.02	187.76	-0.08	-	187.28
J287	188.26	188.27	188.27	**188.27**	Pr1	0.01	0.01	187.77	-0.50	-	187.31
J288	188.29	188.29	188.29	**188.29**	Ex	0.00	0.00	188.04	-0.25	-	187.57
J289	188.36	188.36	188.36	**188.36**	Ex	0.00	0.00	188.19	-0.17	-	187.66
J290	188.43	188.43	188.43	**188.43**	Ex	0.00	0.00	188.33	-0.10	-	187.76
J291	188.43	188.43	188.43	**188.43**	Ex	0.00	0.00	188.33	-0.10	-	187.76
J292	188.43	188.43	188.43	**188.43**	Ex	0.00	0.00	188.33	-0.10	-	187.76
J293	184.49	184.46	184.45	**184.49**	Ex	0.04	0.00	184.21	-0.28	-	183.50
J294	184.86	184.6	184.81	**184.86**	Ex	0.26	0.00	184.22	-0.64	-	183.71
J295	184.91	184.66	184.88	**184.91**	Ex	0.25	0.00	184.84	-0.07	-	184.24
J296	185.27	184.8	185.24	**185.27**	Ex	0.47	0.00	184.86	-0.41	-	184.25
J297	185.28	184.83	185.26	**185.28**	Ex	0.45	0.00	184.96	-0.32	-	184.33
J298	185.66	184.98	185.65	**185.66**	Ex	0.68	0.00	184.97	-0.69	-	184.33
J299	185.68	185.17	185.68	**185.68**	Ex	0.51	0.00	185.36	-0.32	-	184.74
J300	185.97	185.28	185.97	**185.97**	Ex	0.69	0.00	185.36	-0.61	-	184.74
J301	186	185.44	186	**186.00**	Ex	0.56	0.00	185.62	-0.38	-	184.93
J302	186.03	185.54	186.03	**186.03**	Ex	0.49	0.00	185.75	-0.28	-	185.01
J303	186.26	185.67	186.26	**186.26**	Ex	0.59	0.00	185.76	-0.50	-	185.02
J304	186.27	185.73	186.27	**186.27**	Ex	0.54	0.00	185.84	-0.43	-	185.18
J305	186.28	185.81	186.28	**186.28**	Ex	0.47	0.00	185.92	-0.36	-	185.36
J306	186.42	185.9	186.42	**186.42**	Ex	0.52	0.00	185.93	-0.49	-	185.36
J307	186.43	185.95	186.43	**186.43**	Ex	0.48	0.00	186.02	-0.41	-	185.49
J308	186.57	186.03	186.57	**186.57**	Ex	0.54	0.00	186.02	-0.55	-	185.49
J309	186.57	186.06	186.57	**186.57**	Ex	0.51	0.00	186.07	-0.50	-	185.53
J310	186.6	186.24	186.6	**186.60**	Ex	0.36	0.00	186.33	-0.27	-	185.80
J311	186.64	186.44	186.64	**186.64**	Ex	0.20	0.00	186.53	-0.11	-	185.51
J312	186.77	186.49	186.77	**186.77**	Ex	0.28	0.00	186.53	-0.24	-	185.65
J313	186.88	186.79	186.88	**186.88**	Ex	0.09	0.00	186.87	-0.01	-	185.72
J314	187.1	186.88	187.1	**187.10**	Ex	0.22	0.00	186.88	-0.22	-	185.76
J315	187.16	187.11	187.16	**187.16**	Ex	0.05	0.00	187.12	-0.04	-	186.69
J316	187.46	187.47	187.46	**187.47**	Pr1	0.01	0.01	187.47	0.00	-	186.46
J317	187.54	187.55	187.54	**187.55**	Pr1	0.01	0.01	187.47	-0.08	-	186.50
J318	187.6	187.6	187.6	**187.60**	Ex	0.00	0.00	187.58	-0.02	-	187.26
J319	188.03	188.03	188.03	**188.03**	Ex	0.00	0.00	188.04	0.01	0.01	187.56
J320	188.24	188.25	188.24	**188.25**	Pr1	0.01	0.01	188.25	0.00	-	187.58
J321	188.33	188.33	188.33	**188.33**	Ex	0.00	0.00	188.27	-0.06	-	187.58
J322	188.47	188.47	188.47	**188.47**	Ex	0.00	0.00	188.46	-0.01	-	188.05
J323	188.74	188.74	188.74	**188.74**	Ex	0.00	0.00	188.74	0.00	-	188.42
J324	188.96	188.96	188.96	**188.96**	Ex	0.00	0.00	188.96	0.00	-	188.59
J325	189.36	189.36	189.36	**189.36**	Ex	0.00	0.00	189.36	0.00	-	188.88
J326	189.76	189.76	189.76	**189.76**	Ex	0.00	0.00	189.76	0.00	-	189.34
J327	187.17	187.19	187.12	**187.19**	Pr1	0.07	0.02	187.26	0.07	0.07	186.09
J328	187.21	187.23	187.16	**187.23**	Pr1	0.07	0.02	187.30	0.07	0.07	186.20
J329	187.34	187.37	187.28	**187.37**	Pr1	0.09	0.03	187.32	-0.05	-	186.23
J330	187.47	187.52	187.42	**187.52**	Pr1	0.10	0.05	187.50	-0.02	-	186.59
J331	187.65	187.71	187.6	**187.71**	Pr1	0.11	0.06	187.72	0.01	0.01	186.78
J332	187.81	187.89	187.77	**187.89**	Pr1	0.12	0.08	187.91	0.02	0.02	186.93
J333	187.98	188.05	187.94	**188.05**	Pr1	0.11	0.07	188.08	0.03	0.03	187.23
J334	188.36	188.43	188.32	**188.43**	Pr1	0.11	0.07	188.46	0.03	0.03	187.64
J335	188.5	188.58	188.47	**188.58**	Pr1	0.11	0.08	188.60	0.02	0.02	187.77
J336	188.6	188.68	188.56	**188.68**	Pr1	0.12	0.08	188.71	0.03	0.03	187.82
J337	188.68	188.77	188.64	**188.77**	Pr1	0.13	0.09	188.80	0.03	0.03	187.88
J338	188.75	188.85	188.71	**188.85**	Pr1	0.14	0.10	188.88	0.03	0.03	187.93
J339	188.95	189.04	188.91	**189.04**	Pr1	0.13	0.09	189.07	0.03	0.03	188.22
J340	189.17	189.27	189.12	**189.27**	Pr1	0.15	0.10	189.30	0.03	0.03	188.41
J341	189.37	189.48	189.32	**189.48**	Pr1	0.16	0.11	189.51	0.03	0.03	188.55
J342	189.52	189.63	189.47	**189.63**	Pr1	0.16	0.11	189.67	0.04	0.04	188.65
J343	189.66	189.78	189.61	**189.78**	Pr1	0.17	0.12	189.82	0.04	0.04	188.74
J344	189.75	189.87	189.7	**189.87**	Pr1	0.17	0.12	189.91	0.04	0.04	188.81
J345	189.86	189.98	189.81	**189.98**	Pr1	0.17	0.12	190.02	0.04	0.04	188.89
J346	189.91	190.05	189.86	**190.05**	Pr1	0.19	0.14	190.09	0.04	0.04	188.93
J347	189.94	190.08	189.88	**190.08**	Pr1	0.20	0.14	190.12	0.04	0.04	188.95

Name	100-YEAR 6-HOUR STORM										AES 12-HOUR 32mm STORM
	Ex	Pr1	Pr2	Max.	Max. Scenario	Range	Max - Ex	No Culvert Scenario	Diff.	Increase	
J348	189.96	190.11	189.91	**190.11**	Pr1	0.20	0.15	190.15	0.04	0.04	188.97
J349	190.02	190.17	189.96	**190.17**	Pr1	0.21	0.15	190.21	0.04	0.04	189.03
J350	190.03	190.19	189.98	**190.19**	Pr1	0.21	0.16	190.22	0.03	0.03	189.03
J351	190.12	190.28	190.06	**190.28**	Pr1	0.22	0.16	190.31	0.03	0.03	189.15
J352	190.19	190.36	190.13	**190.36**	Pr1	0.23	0.17	190.39	0.03	0.03	189.21
J353	190.24	190.41	190.17	**190.41**	Pr1	0.24	0.17	190.44	0.03	0.03	189.25
J354	190.29	190.46	190.22	**190.46**	Pr1	0.24	0.17	190.49	0.03	0.03	189.29
J355	190.34	190.51	190.27	**190.51**	Pr1	0.24	0.17	190.54	0.03	0.03	189.33
J356	190.39	190.55	190.31	**190.55**	Pr1	0.24	0.16	190.59	0.04	0.04	189.38
J357	190.43	190.61	190.35	**190.61**	Pr1	0.26	0.18	190.65	0.04	0.04	189.40
J358	190.51	190.68	190.42	**190.68**	Pr1	0.26	0.17	190.72	0.04	0.04	189.49
J359	190.58	190.77	190.53	**190.77**	Pr1	0.24	0.19	190.80	0.03	0.03	189.55
J360	190.62	190.82	190.56	**190.82**	Pr1	0.26	0.20	190.81	-0.01	-	189.55
J361	190.66	190.87	190.59	**190.87**	Pr1	0.28	0.21	190.86	-0.01	-	189.59
J362	190.71	190.93	190.64	**190.93**	Pr1	0.29	0.22	190.93	0.00	-	189.64
J363	190.77	191	190.72	**191.00**	Pr1	0.28	0.23	191.01	0.01	0.01	189.70
J364	190.83	191.05	190.78	**191.05**	Pr1	0.27	0.22	191.06	0.01	0.01	189.75
J365	190.87	191.1	190.8	**191.10**	Pr1	0.30	0.23	191.06	-0.04	-	189.76
J366	190.9	191.13	190.83	**191.13**	Pr1	0.30	0.23	191.11	-0.02	-	189.79
J367	190.95	191.17	190.88	**191.17**	Pr1	0.29	0.22	191.15	-0.02	-	189.84
J368	191	191.21	190.94	**191.21**	Pr1	0.27	0.21	191.20	-0.01	-	189.92
J369	191.04	191.25	190.96	**191.25**	Pr1	0.29	0.21	191.20	-0.05	-	189.92
J370	191.07	191.27	191	**191.27**	Pr1	0.27	0.20	191.23	-0.04	-	189.96
J371	191.11	191.3	191.04	**191.30**	Pr1	0.26	0.19	191.28	-0.02	-	190.02
J372	191.15	191.36	191.07	**191.36**	Pr1	0.29	0.21	191.28	-0.08	-	190.03
J373	191.21	191.41	191.16	**191.41**	Pr1	0.25	0.20	191.36	-0.05	-	190.13
J374	191.27	191.46	191.22	**191.46**	Pr1	0.24	0.19	191.42	-0.04	-	190.21
J375	191.34	191.51	191.29	**191.51**	Pr1	0.22	0.17	191.49	-0.02	-	190.26
J376	191.38	191.55	191.32	**191.55**	Pr1	0.23	0.17	191.49	-0.06	-	190.27
J377	191.44	191.61	191.35	**191.61**	Pr1	0.26	0.17	191.58	-0.03	-	190.33
J378	191.48	191.64	191.36	**191.64**	Pr1	0.28	0.16	191.62	-0.02	-	190.37
J379	191.52	191.69	191.37	**191.69**	Pr1	0.32	0.17	191.62	-0.07	-	190.37
J380	191.55	191.72	191.39	**191.72**	Pr1	0.33	0.17	191.67	-0.05	-	190.40
J381	191.58	191.75	191.4	**191.75**	Pr1	0.35	0.17	191.71	-0.04	-	190.44
J382	191.62	191.79	191.41	**191.79**	Pr1	0.38	0.17	191.72	-0.07	-	190.45
J383	191.67	191.83	191.43	**191.83**	Pr1	0.40	0.16	191.78	-0.05	-	190.51
J384	191.75	191.87	191.45	**191.87**	Pr1	0.42	0.12	191.83	-0.04	-	190.57
J385	191.79	191.91	191.48	**191.91**	Pr1	0.43	0.12	191.88	-0.03	-	190.63
J386	191.83	191.94	191.49	**191.94**	Pr1	0.45	0.11	191.88	-0.06	-	190.64
J387	191.83	191.94	191.49	**191.94**	Pr1	0.45	0.11	191.88	-0.06	-	190.64
J388	191.89	191.98	191.51	**191.98**	Pr1	0.47	0.09	191.88	-0.10	-	190.65
J389	191.94	192.01	191.56	**192.01**	Pr1	0.45	0.07	191.92	-0.09	-	190.72
J390	191.98	192.03	191.59	**192.03**	Pr1	0.44	0.05	191.97	-0.06	-	190.79
J391	192.08	192.11	191.63	**192.11**	Pr1	0.48	0.03	192.09	-0.02	-	190.88
J392	192.12	192.15	191.65	**192.15**	Pr1	0.50	0.03	192.10	-0.05	-	190.88
J393	192.19	192.22	191.68	**192.22**	Pr1	0.54	0.03	192.17	-0.05	-	190.95
J394	192.22	192.23	191.72	**192.23**	Pr1	0.51	0.01	192.20	-0.03	-	191.04
J395	192.25	192.25	191.75	**192.25**	Ex	0.50	0.00	192.25	0.00	-	191.12
J396	192.29	192.28	191.77	**192.29**	Ex	0.52	0.00	192.25	-0.04	-	191.12
J397	192.32	192.29	191.81	**192.32**	Ex	0.51	0.00	192.29	-0.03	-	191.20
J398	192.35	192.3	191.84	**192.35**	Ex	0.51	0.00	192.34	-0.01	-	191.24
J399	192.37	192.31	191.9	**192.37**	Ex	0.47	0.00	192.37	0.00	-	191.32
J400	192.4	192.33	191.92	**192.40**	Ex	0.48	0.00	192.38	-0.02	-	191.33
J401	192.43	192.34	191.98	**192.43**	Ex	0.45	0.00	192.41	-0.02	-	191.42
J402	192.47	192.36	192.05	**192.47**	Ex	0.42	0.00	192.47	0.00	-	191.56
J403	192.52	192.38	192.13	**192.52**	Ex	0.39	0.00	192.54	0.02	0.02	191.66
J404	192.57	192.4	192.15	**192.57**	Ex	0.42	0.00	192.55	-0.02	-	191.67
J405	192.62	192.42	192.21	**192.62**	Ex	0.41	0.00	192.62	0.00	-	191.74
J406	192.69	192.45	192.25	**192.69**	Ex	0.44	0.00	192.63	-0.06	-	191.76
J407	192.72	192.46	192.29	**192.72**	Ex	0.43	0.00	192.68	-0.04	-	191.82
J408	192.77	192.5	192.35	**192.77**	Ex	0.42	0.00	192.75	-0.02	-	191.88
J409	192.81	192.52	192.4	**192.81**	Ex	0.41	0.00	192.81	0.00	-	191.93
J410	192.82	192.53	192.41	**192.82**	Ex	0.41	0.00	192.82	0.00	-	191.93
J411	192.83	192.54	192.42	**192.83**	Ex	0.41	0.00	192.83	0.00	-	191.95
J412	192.84	192.54	192.42	**192.84**	Ex	0.42	0.00	192.85	0.01	0.01	191.95
J413	192.85	192.55	192.44	**192.85**	Ex	0.41	0.00	192.86	0.01	0.01	191.99
J414	192.86	192.56	192.45	**192.86**	Ex	0.41	0.00	192.93	0.07	0.07	192.00
J415	192.88	192.58	192.49	**192.88**	Ex	0.39	0.00	192.95	0.07	0.07	192.14
J416	193.02	192.63	192.56	**193.02**	Ex	0.46	0.00	192.96	-0.06	-	192.15
J417	193.03	192.65	192.58	**193.03**	Ex	0.45	0.00	192.98	-0.05	-	192.20

Name	100-YEAR 6-HOUR STORM										AES 12-HOUR 32mm STORM
	Ex	Pr1	Pr2	Max.	Max. Scenario	Range	Max - Ex	No Culvert Scenario	Diff.	Increase	
J418	193.06	192.66	192.6	**193.06**	Ex	0.46	0.00	192.98	-0.08	-	192.20
J419	193.06	192.67	192.6	**193.06**	Ex	0.46	0.00	192.99	-0.07	-	192.21
J420	193.09	192.68	192.62	**193.09**	Ex	0.47	0.00	192.99	-0.10	-	192.22
J421	193.09	192.69	192.63	**193.09**	Ex	0.46	0.00	192.99	-0.10	-	192.25
J422	193.13	192.7	192.65	**193.13**	Ex	0.48	0.00	193.00	-0.13	-	192.25
J423	193.13	192.73	192.69	**193.13**	Ex	0.44	0.00	193.02	-0.11	-	192.40
J424	193.16	192.75	192.71	**193.16**	Ex	0.45	0.00	193.02	-0.14	-	192.40
J425	193.16	192.76	192.73	**193.16**	Ex	0.43	0.00	193.04	-0.12	-	192.42
J426	193.2	192.78	192.75	**193.20**	Ex	0.45	0.00	193.04	-0.16	-	192.43
J427	193.21	192.83	192.81	**193.21**	Ex	0.40	0.00	193.09	-0.12	-	192.52
J428	193.24	192.85	192.83	**193.24**	Ex	0.41	0.00	193.10	-0.14	-	192.52
J429	193.26	192.88	192.87	**193.26**	Ex	0.39	0.00	193.14	-0.12	-	192.57
J430	193.29	192.91	192.89	**193.29**	Ex	0.40	0.00	193.15	-0.14	-	192.57
J431	193.31	192.95	192.94	**193.31**	Ex	0.37	0.00	193.21	-0.10	-	192.64
J432	193.35	192.97	192.96	**193.35**	Ex	0.39	0.00	193.22	-0.13	-	192.64
J433	193.36	193.02	193.01	**193.36**	Ex	0.35	0.00	193.27	-0.09	-	192.70
J434	193.39	193.03	193.03	**193.39**	Ex	0.36	0.00	193.28	-0.11	-	192.70
J435	193.41	193.08	193.07	**193.41**	Ex	0.34	0.00	193.34	-0.07	-	192.76
J436	193.46	193.1	193.1	**193.46**	Ex	0.36	0.00	193.34	-0.12	-	192.76
J437	193.47	193.14	193.14	**193.47**	Ex	0.33	0.00	193.40	-0.07	-	192.82
J438	193.52	193.16	193.16	**193.52**	Ex	0.36	0.00	193.40	-0.12	-	192.83
J439	193.52	193.18	193.18	**193.52**	Ex	0.34	0.00	193.43	-0.09	-	192.85
J440	193.57	193.2	193.2	**193.57**	Ex	0.37	0.00	193.44	-0.13	-	192.85
J441	193.59	193.25	193.25	**193.59**	Ex	0.34	0.00	193.50	-0.09	-	192.93
J442	193.62	193.26	193.26	**193.62**	Ex	0.36	0.00	193.50	-0.12	-	192.93
J443	193.63	193.29	193.29	**193.63**	Ex	0.34	0.00	193.54	-0.09	-	192.97
J444	193.71	193.33	193.32	**193.71**	Ex	0.39	0.00	193.54	-0.17	-	192.98
J445	193.72	193.35	193.35	**193.72**	Ex	0.37	0.00	193.58	-0.14	-	193.05
J446	193.86	193.42	193.41	**193.86**	Ex	0.45	0.00	193.58	-0.28	-	193.05
J447	193.88	193.45	193.45	**193.88**	Ex	0.43	0.00	193.65	-0.23	-	193.11
J448	194.01	193.51	193.51	**194.01**	Ex	0.50	0.00	193.66	-0.35	-	193.11
J449	194.02	193.55	193.55	**194.02**	Ex	0.47	0.00	193.74	-0.28	-	193.17
J450	194.14	193.6	193.6	**194.14**	Ex	0.54	0.00	193.74	-0.40	-	193.17
J451	194.14	193.61	193.61	**194.14**	Ex	0.53	0.00	193.77	-0.37	-	193.20
J452	194.3	193.68	193.68	**194.30**	Ex	0.62	0.00	193.77	-0.53	-	193.20
J453	194.3	193.68	193.68	**194.30**	Ex	0.62	0.00	193.77	-0.53	-	193.20
J454	194.29	193.68	193.68	**194.29**	Ex	0.61	0.00	193.77	-0.52	-	193.20
J455	194.29	193.68	193.68	**194.29**	Ex	0.61	0.00	193.77	-0.52	-	193.20
J456	194.29	193.68	193.68	**194.29**	Ex	0.61	0.00	193.77	-0.52	-	193.20
J457	194.29	193.68	193.68	**194.29**	Ex	0.61	0.00	193.77	-0.52	-	193.20
J458	194.29	193.68	193.68	**194.29**	Ex	0.61	0.00	193.77	-0.52	-	193.20
J459	194.29	193.68	193.68	**194.29**	Ex	0.61	0.00	193.77	-0.52	-	193.20
J460	194.29	193.68	193.68	**194.29**	Ex	0.61	0.00	193.77	-0.52	-	193.20
J461	194.29	193.68	193.68	**194.29**	Ex	0.61	0.00	193.77	-0.52	-	193.20
J462	194.29	193.68	193.68	**194.29**	Ex	0.61	0.00	193.77	-0.52	-	193.26
J463	194.29	193.99	193.99	**194.29**	Ex	0.30	0.00	193.99	-0.30	-	193.99
J464	189.5	189.52	189.33	**189.52**	Pr1	0.19	0.02	189.72	0.20	0.20	188.16
J465	189.5	189.52	189.33	**189.52**	Pr1	0.19	0.02	189.72	0.20	0.20	188.16
J466	189.5	189.52	189.34	**189.52**	Pr1	0.18	0.02	189.72	0.20	0.20	188.16
J467	189.51	189.52	189.35	**189.52**	Pr1	0.17	0.01	189.73	0.21	0.21	188.21
J468	189.52	189.53	189.37	**189.53**	Pr1	0.16	0.01	189.73	0.20	0.20	188.28
J469	189.53	189.54	189.4	**189.54**	Pr1	0.14	0.01	189.73	0.19	0.19	188.34
J470	189.54	189.55	189.43	**189.55**	Pr1	0.12	0.01	189.73	0.18	0.18	188.51
J471	189.56	189.57	189.47	**189.57**	Pr1	0.10	0.01	189.74	0.17	0.17	188.57
J472	189.57	189.58	189.49	**189.58**	Pr1	0.09	0.01	189.74	0.16	0.16	188.61
J473	189.58	189.59	189.5	**189.59**	Pr1	0.09	0.01	189.74	0.15	0.15	188.61
J474	189.59	189.61	189.52	**189.61**	Pr1	0.09	0.02	189.74	0.13	0.13	188.75
J475	189.61	189.63	189.56	**189.63**	Pr1	0.07	0.02	189.75	0.12	0.12	188.80
J476	189.63	189.64	189.57	**189.64**	Pr1	0.07	0.01	189.75	0.11	0.11	188.86
J477	189.65	189.66	189.61	**189.66**	Pr1	0.05	0.01	189.76	0.10	0.10	189.01
J478	189.69	189.7	189.66	**189.70**	Pr1	0.04	0.01	189.76	0.06	0.06	189.01
J479	189.7	189.71	189.68	**189.71**	Pr1	0.03	0.01	189.76	0.05	0.05	189.06
J480	190.75	190.76	190.76	**190.76**	Pr1	0.01	0.01	190.77	0.01	0.01	190.29
J481	191.85	191.85	191.85	**191.85**	Ex	0.00	0.00	191.85	0.00	-	191.59
J482	192.81	192.81	192.81	**192.81**	Ex	0.00	0.00	192.81	0.00	-	192.46
J483	194.15	194.15	194.15	**194.15**	Ex	0.00	0.00	194.15	0.00	-	193.94
J484	194.71	194.71	194.71	**194.71**	Ex	0.00	0.00	194.71	0.00	-	194.52
J485	190.23	190.3	190.01	**190.30**	Pr1	0.29	0.07	190.44	0.14	0.14	188.93
J486	190.27	190.35	190.06	**190.35**	Pr1	0.29	0.08	190.45	0.10	0.10	188.94
J487	190.28	190.36	190.08	**190.36**	Pr1	0.28	0.08	190.47	0.11	0.11	189.12

Name	100-YEAR 6-HOUR STORM										AES 12-HOUR 32mm STORM
	Ex	Pr1	Pr2	Max.	Max. Scenario	Range	Max - Ex	No Culvert Scenario	Diff.	Increase	
J488	190.63	190.64	190.5	**190.64**	Pr1	0.14	0.01	190.48	-0.16	-	189.14
J489	190.64	190.65	190.51	**190.65**	Pr1	0.14	0.01	190.50	-0.15	-	189.23
J490	190.65	190.67	190.56	**190.67**	Pr1	0.11	0.02	190.61	-0.06	-	189.39
J491	190.68	190.7	190.62	**190.70**	Pr1	0.08	0.02	190.68	-0.02	-	189.60
J492	190.92	190.93	190.89	**190.93**	Pr1	0.04	0.01	190.69	-0.24	-	189.61
J493	190.95	190.96	190.94	**190.96**	Pr1	0.02	0.01	190.82	-0.14	-	189.77
J494	190.98	191	190.99	**191.00**	Pr1	0.02	0.02	190.90	-0.10	-	189.91
J495	191.22	191.28	191.27	**191.28**	Pr1	0.06	0.06	190.90	-0.38	-	189.91
J496	191.23	191.29	191.29	**191.29**	Pr1	0.06	0.06	190.95	-0.34	-	189.98
J497	191.25	191.31	191.3	**191.31**	Pr1	0.06	0.06	191.01	-0.30	-	190.14
J498	191.27	191.34	191.33	**191.34**	Pr1	0.07	0.07	191.01	-0.33	-	190.14
J499	191.28	191.34	191.34	**191.34**	Pr1	0.06	0.06	191.01	-0.33	-	190.15
J500	191.55	191.64	191.64	**191.64**	Pr1	0.09	0.09	191.01	-0.63	-	190.15
J501	191.57	191.66	191.66	**191.66**	Pr1	0.09	0.09	191.11	-0.55	-	190.25
J502	191.61	191.69	191.69	**191.69**	Pr1	0.08	0.08	191.28	-0.41	-	190.40
J503	191.64	191.72	191.72	**191.72**	Pr1	0.08	0.08	191.39	-0.33	-	190.54
J504	191.71	191.78	191.77	**191.78**	Pr1	0.07	0.07	191.57	-0.21	-	190.78
J505	191.88	191.96	191.96	**191.96**	Pr1	0.08	0.08	191.57	-0.39	-	190.78
J506	191.94	192.01	192.01	**192.01**	Pr1	0.07	0.07	191.76	-0.25	-	190.94
J507	191.98	192.05	192.04	**192.05**	Pr1	0.07	0.07	191.85	-0.20	-	191.11
J508	192.03	192.09	192.09	**192.09**	Pr1	0.06	0.06	191.97	-0.12	-	191.38
J509	192.16	192.24	192.23	**192.24**	Pr1	0.08	0.08	191.98	-0.26	-	191.38
J510	192.17	192.25	192.25	**192.25**	Pr1	0.08	0.08	192.02	-0.23	-	191.39
J511	192.3	192.44	192.44	**192.44**	Pr1	0.14	0.14	192.02	-0.42	-	191.39
J512	192.3	192.44	192.42	**192.44**	Pr1	0.14	0.14	192.05	-0.39	-	191.39
J513	192.32	192.45	192.44	**192.45**	Pr1	0.13	0.13	192.13	-0.32	-	191.51
J514	192.33	192.46	192.45	**192.46**	Pr1	0.13	0.13	192.17	-0.29	-	191.54
J515	192.34	192.47	192.46	**192.47**	Pr1	0.13	0.13	192.21	-0.26	-	191.59
J516	192.47	192.61	192.61	**192.61**	Pr1	0.14	0.14	192.21	-0.40	-	191.59
J517	192.48	192.62	192.62	**192.62**	Pr1	0.14	0.14	192.27	-0.35	-	191.63
J518	192.52	192.65	192.65	**192.65**	Pr1	0.13	0.13	192.40	-0.25	-	191.89
J519	193.97	193.82	193.82	**193.97**	Ex	0.15	0.00	193.94	-0.03	-	193.50
J520	194.18	194.05	194.05	**194.18**	Ex	0.13	0.00	194.18	0.00	-	193.78
J521	194.52	194.21	194.21	**194.52**	Ex	0.31	0.00	194.23	-0.29	-	193.80
J522	194.57	194.34	194.34	**194.57**	Ex	0.23	0.00	194.45	-0.12	-	194.08
J523	194.82	194.45	194.45	**194.82**	Ex	0.37	0.00	194.46	-0.36	-	194.09
J524	194.88	194.62	194.62	**194.88**	Ex	0.26	0.00	194.73	-0.15	-	194.34
J525	195.01	194.87	194.87	**195.01**	Ex	0.14	0.00	194.99	-0.02	-	194.60
J526	195.24	194.93	194.93	**195.24**	Ex	0.31	0.00	194.99	-0.25	-	194.60
J527	195.26	194.97	194.97	**195.26**	Ex	0.29	0.00	195.07	-0.19	-	194.68
J528	195.33	195.17	195.17	**195.33**	Ex	0.16	0.00	195.29	-0.04	-	195.02
J529	195.53	195.38	195.38	**195.53**	Ex	0.15	0.00	195.53	0.00	-	195.20
J530	195.79	195.45	195.45	**195.79**	Ex	0.34	0.00	195.53	-0.26	-	195.20
J531	195.85	195.73	195.73	**195.85**	Ex	0.12	0.00	195.83	-0.02	-	195.60
J532	196.07	195.94	195.94	**196.07**	Ex	0.13	0.00	196.07	0.00	-	195.78
J533	196.77	196.43	196.43	**196.77**	Ex	0.34	0.00	196.07	-0.70	-	195.83
J534	196.78	196.43	196.43	**196.78**	Ex	0.35	0.00	196.24	-0.54	-	195.91
J535	196.79	196.44	196.44	**196.79**	Ex	0.35	0.00	196.35	-0.44	-	195.99
J536	194.33	194.21	194.2	**194.33**	Ex	0.13	0.00	194.33	0.00	-	193.92
J537	194.36	194.27	194.27	**194.36**	Ex	0.09	0.00	194.36	0.00	-	194.11
J538	194.36	194.27	194.27	**194.36**	Ex	0.09	0.00	194.36	0.00	-	194.11
J539	194.39	194.32	194.32	**194.39**	Ex	0.07	0.00	194.39	0.00	-	194.16
J540	194.42	194.37	194.37	**194.42**	Ex	0.05	0.00	194.42	0.00	-	194.21
J541	194.45	194.41	194.41	**194.45**	Ex	0.04	0.00	194.45	0.00	-	194.26
J542	177.79	177.78	177.81	**177.81**	Pr2	0.03	0.02	177.87	0.06	0.06	177.12
J543	177.81	177.8	177.82	**177.82**	Pr2	0.02	0.01	177.87	0.05	0.05	177.13
J544	177.83	177.82	177.83	**177.83**	Ex	0.01	0.00	177.88	0.05	0.05	177.14
J545	177.93	177.93	177.93	**177.93**	Ex	0.00	0.00	177.94	0.01	0.01	177.16
J546	178.02	178.02	178.02	**178.02**	Ex	0.00	0.00	178.01	-0.01	-	177.17
J547	178.08	178.08	178.08	**178.08**	Ex	0.00	0.00	178.06	-0.02	-	177.18
J548	178.21	178.21	178.21	**178.21**	Ex	0.00	0.00	178.20	-0.01	-	177.25
J549	178.55	178.55	178.55	**178.55**	Ex	0.00	0.00	178.57	0.02	0.02	177.66
J550	179.04	179.04	179.04	**179.04**	Ex	0.00	0.00	179.06	0.02	0.02	178.08
J551	179.12	179.12	179.12	**179.12**	Ex	0.00	0.00	179.14	0.02	0.02	178.57
J552	179.38	179.38	179.38	**179.38**	Ex	0.00	0.00	179.39	0.01	0.01	178.87
J553	179.57	179.57	179.57	**179.57**	Ex	0.00	0.00	179.57	0.00	-	179.03
J554	180.18	180.18	180.18	**180.18**	Ex	0.00	0.00	179.59	-0.59	-	179.10
J555	180.26	180.26	180.26	**180.26**	Ex	0.00	0.00	180.14	-0.12	-	179.72
J556	180.4	180.4	180.4	**180.40**	Ex	0.00	0.00	180.36	-0.04	-	179.88
J557	180.49	180.49	180.49	**180.49**	Ex	0.00	0.00	180.48	-0.01	-	179.90

Name	100-YEAR 6-HOUR STORM										AES 12-HOUR 32mm STORM
	Ex	Pr1	Pr2	Max.	Max. Scenario	Range	Max - Ex	No Culvert Scenario	Diff.	Increase	
J558	180.85	180.85	180.85	**180.85**	Ex	0.00	0.00	180.48	-0.37	-	179.91
J559	180.86	180.86	180.86	**180.86**	Ex	0.00	0.00	180.52	-0.34	-	179.91
J560	180.98	180.98	180.98	**180.98**	Ex	0.00	0.00	180.52	-0.46	-	179.91
J561	181	181	181	**181.00**	Ex	0.00	0.00	180.57	-0.43	-	179.94
J562	181.01	181.01	181.01	**181.01**	Ex	0.00	0.00	180.65	-0.36	-	180.06
J563	180.08	180.05	180.15	**180.15**	Pr2	0.10	0.07	180.40	0.25	0.25	179.32
J564	180.97	180.97	180.98	**180.98**	Pr2	0.01	0.01	180.40	-0.58	-	179.37
J565	180.98	180.97	180.98	**180.98**	Ex	0.01	0.00	180.49	-0.49	-	179.81
J566	181.06	181.06	181.07	**181.07**	Pr2	0.01	0.01	180.92	-0.15	-	180.16
J567	181.27	181.27	181.27	**181.27**	Ex	0.00	0.00	181.36	0.09	0.09	180.75
J568	181.6	181.6	181.6	**181.60**	Ex	0.00	0.00	181.71	0.11	0.11	180.94
J569	181.94	181.94	181.94	**181.94**	Ex	0.00	0.00	182.04	0.10	0.10	181.35
J570	182.16	182.16	182.16	**182.16**	Ex	0.00	0.00	182.22	0.06	0.06	181.57
J571	182.18	182.18	182.18	**182.18**	Ex	0.00	0.00	182.22	0.04	0.04	181.59
J572	182.23	182.23	182.23	**182.23**	Ex	0.00	0.00	182.27	0.04	0.04	181.64
J573	182.31	182.31	182.31	**182.31**	Ex	0.00	0.00	182.37	0.06	0.06	181.68
J574	182.44	182.44	182.44	**182.44**	Ex	0.00	0.00	182.37	-0.07	-	181.70
J575	182.44	182.44	182.44	**182.44**	Ex	0.00	0.00	182.39	-0.05	-	181.71
J576	182.45	182.45	182.45	**182.45**	Ex	0.00	0.00	182.40	-0.05	-	181.72
J577	182.45	182.45	182.45	**182.45**	Ex	0.00	0.00	182.42	-0.03	-	181.75
J578	182.46	182.46	182.46	**182.46**	Ex	0.00	0.00	182.49	0.03	0.03	181.90
J579	182.47	182.47	182.47	**182.47**	Ex	0.00	0.00	182.51	0.04	0.04	181.92
J580	182.49	182.49	182.49	**182.49**	Ex	0.00	0.00	182.61	0.12	0.12	182.07
J581	182.54	182.54	182.54	**182.54**	Ex	0.00	0.00	182.70	0.16	0.16	182.17
J582	182.6	182.6	182.6	**182.60**	Ex	0.00	0.00	182.81	0.21	0.21	182.28
J583	183.23	183.23	183.23	**183.23**	Ex	0.00	0.00	182.81	-0.42	-	182.32
J584	183.23	183.23	183.23	**183.23**	Ex	0.00	0.00	182.90	-0.33	-	182.45
J585	183.24	183.24	183.24	**183.24**	Ex	0.00	0.00	183.10	-0.14	-	182.63
J586	180.22	180.17	180.28	**180.28**	Pr2	0.11	0.06	180.49	0.21	0.21	178.80
J587	180.35	180.3	180.39	**180.39**	Pr2	0.09	0.04	180.56	0.17	0.17	179.29
J588	180.58	180.54	180.62	**180.62**	Pr2	0.08	0.04	180.86	0.24	0.24	179.50
J589	180.95	180.87	180.98	**180.98**	Pr2	0.11	0.03	180.87	-0.11	-	179.52
J590	180.96	180.89	181	**181.00**	Pr2	0.11	0.04	180.89	-0.11	-	179.54
J591	181.18	181.12	181.21	**181.21**	Pr2	0.09	0.03	180.89	-0.32	-	179.55
J592	181.23	181.17	181.26	**181.26**	Pr2	0.09	0.03	181.00	-0.26	-	179.78
J593	181.34	181.27	181.37	**181.37**	Pr2	0.10	0.03	181.15	-0.22	-	179.92
J594	181.34	181.27	181.38	**181.38**	Pr2	0.11	0.04	181.15	-0.23	-	179.96
J595	181.34	181.28	181.38	**181.38**	Pr2	0.10	0.04	181.18	-0.20	-	179.98
J596	181.45	181.39	181.5	**181.50**	Pr2	0.11	0.05	181.43	-0.07	-	180.18
J597	181.52	181.47	181.57	**181.57**	Pr2	0.10	0.05	181.55	-0.02	-	180.28
J598	181.61	181.57	181.66	**181.66**	Pr2	0.09	0.05	181.67	0.01	0.01	180.58
J599	182.02	181.94	182.1	**182.10**	Pr2	0.16	0.08	181.67	-0.43	-	180.58
J600	182.04	181.95	182.11	**182.11**	Pr2	0.16	0.07	181.72	-0.39	-	180.64
J601	182.41	182.28	182.51	**182.51**	Pr2	0.23	0.10	181.72	-0.79	-	180.65
J602	182.41	182.29	182.51	**182.51**	Pr2	0.22	0.10	181.77	-0.74	-	180.70
J603	182.45	182.33	182.54	**182.54**	Pr2	0.21	0.09	181.96	-0.58	-	180.84
J604	182.5	182.39	182.58	**182.58**	Pr2	0.19	0.08	182.13	-0.45	-	180.98
J605	182.55	182.46	182.61	**182.61**	Pr2	0.15	0.06	182.37	-0.24	-	181.13
J606	182.59	182.51	182.68	**182.68**	Pr2	0.17	0.09	182.48	-0.20	-	181.24
J607	182.67	182.61	182.76	**182.76**	Pr2	0.15	0.09	182.61	-0.15	-	181.48
J608	182.75	182.72	182.86	**182.86**	Pr2	0.14	0.11	182.63	-0.23	-	181.49
J609	182.82	182.81	182.93	**182.93**	Pr2	0.12	0.11	182.75	-0.18	-	181.62
J610	182.88	182.89	183.04	**183.04**	Pr2	0.16	0.16	182.86	-0.18	-	181.95
J611	183.05	183.09	183.17	**183.17**	Pr2	0.12	0.12	183.10	-0.07	-	182.11
J612	183.22	183.26	183.3	**183.30**	Pr2	0.08	0.08	183.29	-0.01	-	182.34
J613	183.28	183.33	183.36	**183.36**	Pr2	0.08	0.08	183.30	-0.06	-	182.34
J614	183.37	183.42	183.44	**183.44**	Pr2	0.07	0.07	183.41	-0.03	-	182.46
J615	183.59	183.64	183.64	**183.64**	Pr1	0.05	0.05	183.66	0.02	0.02	182.77
J616	183.78	183.84	183.84	**183.84**	Pr1	0.06	0.06	183.87	0.03	0.03	182.99
J617	183.95	184.01	184.01	**184.01**	Pr1	0.06	0.06	184.07	0.06	0.06	183.10
J618	184.01	184.08	184.08	**184.08**	Pr1	0.07	0.07	184.08	0.00	-	183.10
J619	184.13	184.2	184.2	**184.20**	Pr1	0.07	0.07	184.21	0.01	0.01	183.24
J620	184.24	184.31	184.31	**184.31**	Pr1	0.07	0.07	184.33	0.02	0.02	183.44
J621	184.43	184.5	184.5	**184.50**	Pr1	0.07	0.07	184.53	0.03	0.03	183.56
J622	184.66	184.72	184.72	**184.72**	Pr1	0.06	0.06	184.76	0.04	0.04	183.81
J623	184.74	184.81	184.81	**184.81**	Pr1	0.07	0.07	184.86	0.05	0.05	183.88
J624	184.84	184.92	184.92	**184.92**	Pr1	0.08	0.08	184.96	0.04	0.04	183.98
J625	184.96	185.04	185.04	**185.04**	Pr1	0.08	0.08	185.09	0.05	0.05	184.15
J626	185.13	185.22	185.22	**185.22**	Pr1	0.09	0.09	185.27	0.05	0.05	184.30
J627	185.27	185.36	185.36	**185.36**	Pr1	0.09	0.09	185.41	0.05	0.05	184.48

Name	100-YEAR 6-HOUR STORM										AES 12-HOUR 32mm STORM
	Ex	Pr1	Pr2	Max.	Max. Scenario	Range	Max - Ex	No Culvert Scenario	Diff.	Increase	
J628	185.5	185.58	185.58	**185.58**	Pr1	0.08	0.08	185.63	0.05	0.05	184.80
J629	185.75	185.84	185.84	**185.84**	Pr1	0.09	0.09	185.90	0.06	0.06	185.06
J630	185.84	185.92	185.92	**185.92**	Pr1	0.08	0.08	185.97	0.05	0.05	185.14
J631	186.01	186.05	186.05	**186.05**	Pr1	0.04	0.04	186.08	0.03	0.03	185.32
J632	186.25	186.32	186.32	**186.32**	Pr1	0.07	0.07	186.37	0.05	0.05	185.50
J633	186.36	186.45	186.45	**186.45**	Pr1	0.09	0.09	186.49	0.04	0.04	185.78
J634	186.6	186.69	186.69	**186.69**	Pr1	0.09	0.09	186.72	0.03	0.03	186.08
J635	186.83	186.93	186.93	**186.93**	Pr1	0.10	0.10	186.96	0.03	0.03	186.24
J636	186.94	187.04	187.04	**187.04**	Pr1	0.10	0.10	187.07	0.03	0.03	186.44
J637	186.97	187.07	187.07	**187.07**	Pr1	0.10	0.10	187.07	0.00	-	186.44
J638	187.19	187.27	187.27	**187.27**	Pr1	0.08	0.08	187.29	0.02	0.02	186.78
J639	187.34	187.42	187.42	**187.42**	Pr1	0.08	0.08	187.45	0.03	0.03	186.85
J640	188.1	187.78	187.78	**188.10**	Ex	0.32	0.00	187.45	-0.65	-	186.86
J641	188.11	187.86	187.86	**188.11**	Ex	0.25	0.00	187.67	-0.44	-	187.08
J642	188.13	188.07	188.07	**188.13**	Ex	0.06	0.00	187.68	-0.45	-	187.09
J643	188.13	188.09	188.09	**188.13**	Ex	0.04	0.00	187.77	-0.36	-	187.20
J644	188.17	188.12	188.12	**188.17**	Ex	0.05	0.00	188.01	-0.16	-	187.58
J645	188.53	188.53	188.53	**188.53**	Ex	0.00	0.00	188.02	-0.51	-	187.60
J646	188.54	188.55	188.55	**188.55**	Pr1	0.01	0.01	188.28	-0.27	-	187.84
J647	188.64	188.65	188.65	**188.65**	Pr1	0.01	0.01	188.57	-0.08	-	188.11
J648	188.68	188.68	188.68	**188.68**	Ex	0.00	0.00	188.69	0.01	0.01	188.30
J649	188.82	188.82	188.82	**188.82**	Ex	0.00	0.00	188.69	-0.13	-	188.31
J650	189.08	189.08	189.08	**189.08**	Ex	0.00	0.00	189.12	0.04	0.04	188.75
J651	189.3	189.3	189.3	**189.30**	Ex	0.00	0.00	189.32	0.02	0.02	188.85
J652	189.46	189.46	189.46	**189.46**	Ex	0.00	0.00	189.47	0.01	0.01	188.93
J653	189.51	189.51	189.51	**189.51**	Ex	0.00	0.00	189.52	0.01	0.01	188.96
J654	189.78	189.78	189.78	**189.78**	Ex	0.00	0.00	189.52	-0.26	-	188.97
J655	189.79	189.79	189.79	**189.79**	Ex	0.00	0.00	189.55	-0.24	-	188.98
J656	189.83	189.83	189.83	**189.83**	Ex	0.00	0.00	189.62	-0.21	-	189.03
J657	189.87	189.87	189.87	**189.87**	Ex	0.00	0.00	189.70	-0.17	-	189.10
J658	189.89	189.89	189.89	**189.89**	Ex	0.00	0.00	189.74	-0.15	-	189.12
J659	189.94	189.94	189.94	**189.94**	Ex	0.00	0.00	189.83	-0.11	-	189.22
J660	189.99	189.99	189.99	**189.99**	Ex	0.00	0.00	189.91	-0.08	-	189.31
J661	190.06	190.06	190.06	**190.06**	Ex	0.00	0.00	190.01	-0.05	-	189.43
J662	190.95	190.96	190.94	**190.96**	Pr1	0.02	0.01	190.82	-0.14	-	189.77
J663	190.95	190.96	190.94	**190.96**	Pr1	0.02	0.01	190.82	-0.14	-	189.81
J664	190.95	190.96	190.94	**190.96**	Pr1	0.02	0.01	190.82	-0.14	-	189.84
J665	190.95	190.96	190.94	**190.96**	Pr1	0.02	0.01	190.82	-0.14	-	189.82
J666	190.95	190.96	190.94	**190.96**	Pr1	0.02	0.01	190.82	-0.14	-	189.80
J667	190.95	190.96	190.94	**190.96**	Pr1	0.02	0.01	190.82	-0.14	-	189.82
J668	190.95	190.96	190.94	**190.96**	Pr1	0.02	0.01	190.82	-0.14	-	190.12
J669	194.02	193.86	193.86	**194.02**	Ex	0.16	0.00	193.95	-0.07	-	193.50
J670	194.07	193.96	193.96	**194.07**	Ex	0.11	0.00	194.02	-0.05	-	193.73
J671	194.1	193.99	193.99	**194.10**	Ex	0.11	0.00	194.02	-0.08	-	193.73
J672	194.2	194.15	194.15	**194.20**	Ex	0.05	0.00	194.18	-0.02	-	193.95
J673	194.39	194.36	194.36	**194.39**	Ex	0.03	0.00	194.39	0.00	-	194.10
J674	194.54	194.5	194.5	**194.54**	Ex	0.04	0.00	194.54	0.00	-	194.24
J675	194.68	194.64	194.64	**194.68**	Ex	0.04	0.00	194.68	0.00	-	194.38
J676	194.77	194.73	194.73	**194.77**	Ex	0.04	0.00	194.77	0.00	-	194.44
J677	194.79	194.74	194.74	**194.79**	Ex	0.05	0.00	194.77	-0.02	-	194.44
J678	194.8	194.75	194.75	**194.80**	Ex	0.05	0.00	194.78	-0.02	-	194.44
J679	194.82	194.76	194.76	**194.82**	Ex	0.06	0.00	194.80	-0.02	-	194.45
J680	194.84	194.78	194.78	**194.84**	Ex	0.06	0.00	194.82	-0.02	-	194.46
J681	194.86	194.8	194.8	**194.86**	Ex	0.06	0.00	194.85	-0.01	-	194.53
J682	194.9	194.83	194.83	**194.90**	Ex	0.07	0.00	194.88	-0.02	-	194.59
J683	194.93	194.86	194.86	**194.93**	Ex	0.07	0.00	194.92	-0.01	-	194.61
J684	194.94	194.87	194.87	**194.94**	Ex	0.07	0.00	194.92	-0.02	-	194.61
J685	182.6	182.51	182.68	**182.68**	Pr2	0.17	0.08	182.49	-0.19	-	181.37
J686	182.61	182.51	182.69	**182.69**	Pr2	0.18	0.08	182.50	-0.19	-	181.65
J687	182.69	182.51	182.76	**182.76**	Pr2	0.25	0.07	182.50	-0.26	-	181.65
J688	182.69	182.51	182.77	**182.77**	Pr2	0.26	0.08	182.52	-0.25	-	181.71
J689	182.71	182.51	182.78	**182.78**	Pr2	0.27	0.07	182.55	-0.23	-	181.83
J690	182.74	182.52	182.8	**182.80**	Pr2	0.28	0.06	182.61	-0.19	-	182.04
J691	182.77	182.52	182.83	**182.83**	Pr2	0.31	0.06	182.61	-0.22	-	182.04

APPENDIX F

POND DRAWDOWN ASSESSMENT

1.0 POND DRAWDOWN ASSESSMENT

As mentioned in the main report, a sluggish pond drawdown could be too slow to restore storage volume required to handle successive rainfall events. This Appendix presents an assessment of pond drawdown times based on over 80 years (i.e., 1940 to 2021) of historical rainfall data from Environment Canada's Windsor Airport rain gauge.

1.1 METHODOLOGY

The assessment consisted of a coarse model setup where the foregoing historical daily rainfall was applied to a representative 1.0-hectare (ha) development area with conservatively assumed 100% imperviousness. The resulting runoff hydrograph was input to storage nodes with a constant 1.0-ha surface area. Thus, the resulting storage node levels can be compared to the established 100-year 24-hour rainfall amount of 0.108m to evaluate the potential for successive rainfall events to exceed storage pond capacity. Two outflow rate scenarios were considered as follows:

Design Scenario – The model considered the following constant release rates for storage node SU01

- Storage depth 0 to 0.05m: 1.5 Litres per second (L/s) – equal to allowable lower tier rate;
- Storage depth > 0.05m: 3 L/s – half of allowable upper tier rate outside of service area.

Extreme Scenario – The model considered the following constant release rates for storage node SU02

- Storage depth 0 to 0.05m: 0.5 Litres per second (L/s) – one third of allowable lower tier rate;
- Storage depth > 0.05m: 2 L/s – one third of allowable upper tier rate outside of service area.

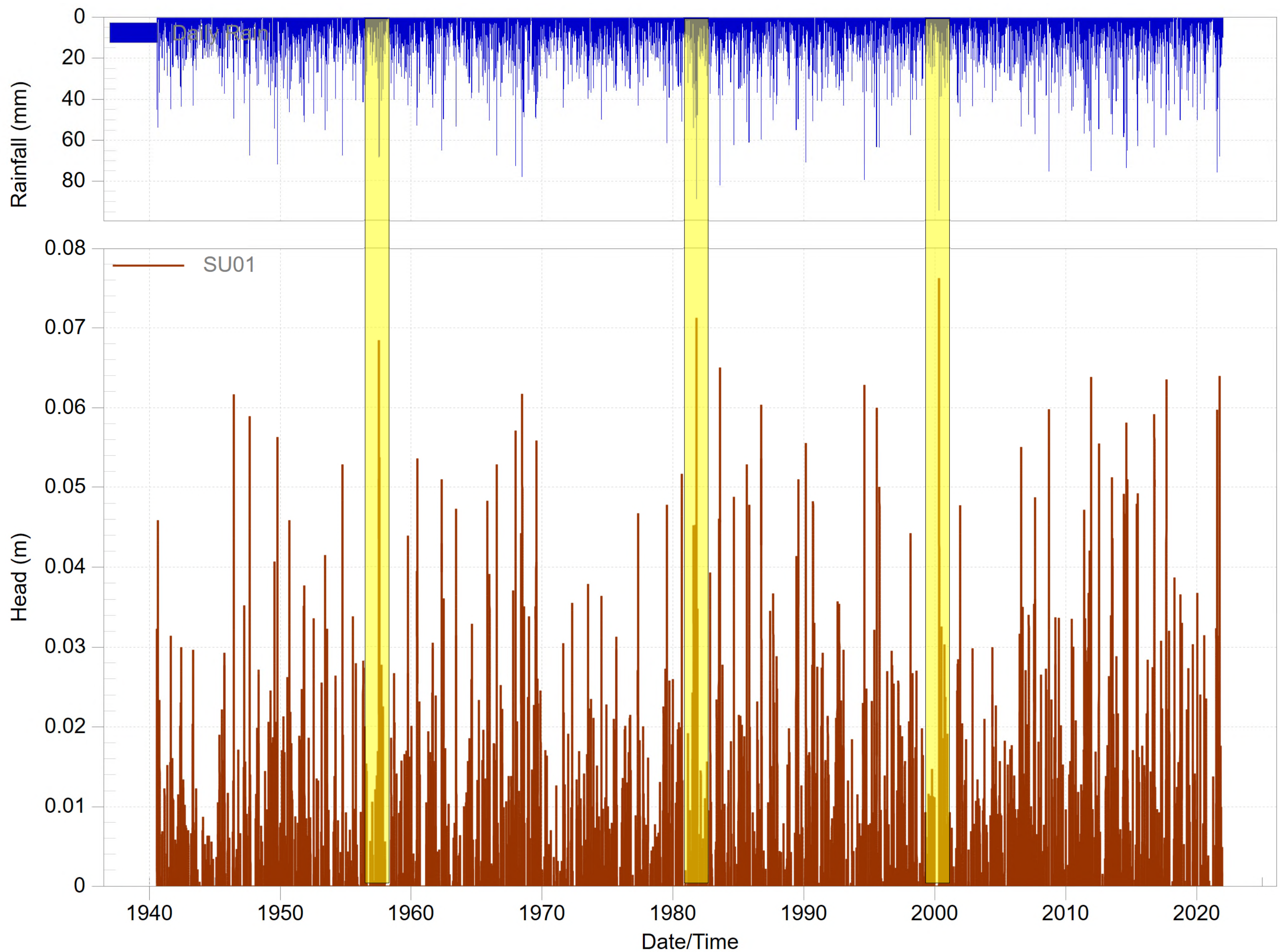
1.2 RESULTS

Figure F1 depicts the daily rainfall amounts and varying simulated storage levels throughout the historical rainfall data period. The three largest simulated levels were highlighted and focused on in **Figure F2**. These levels correspond to the three largest 24-hour rainfall amounts recorded at Windsor Airport from 1946 to 2016, as summarized below:

- July 7-8, 1957 – 100.3mm
- September 30-October 1, 1981 – 92.3mm
- April 20, 2000 – 94.6mm

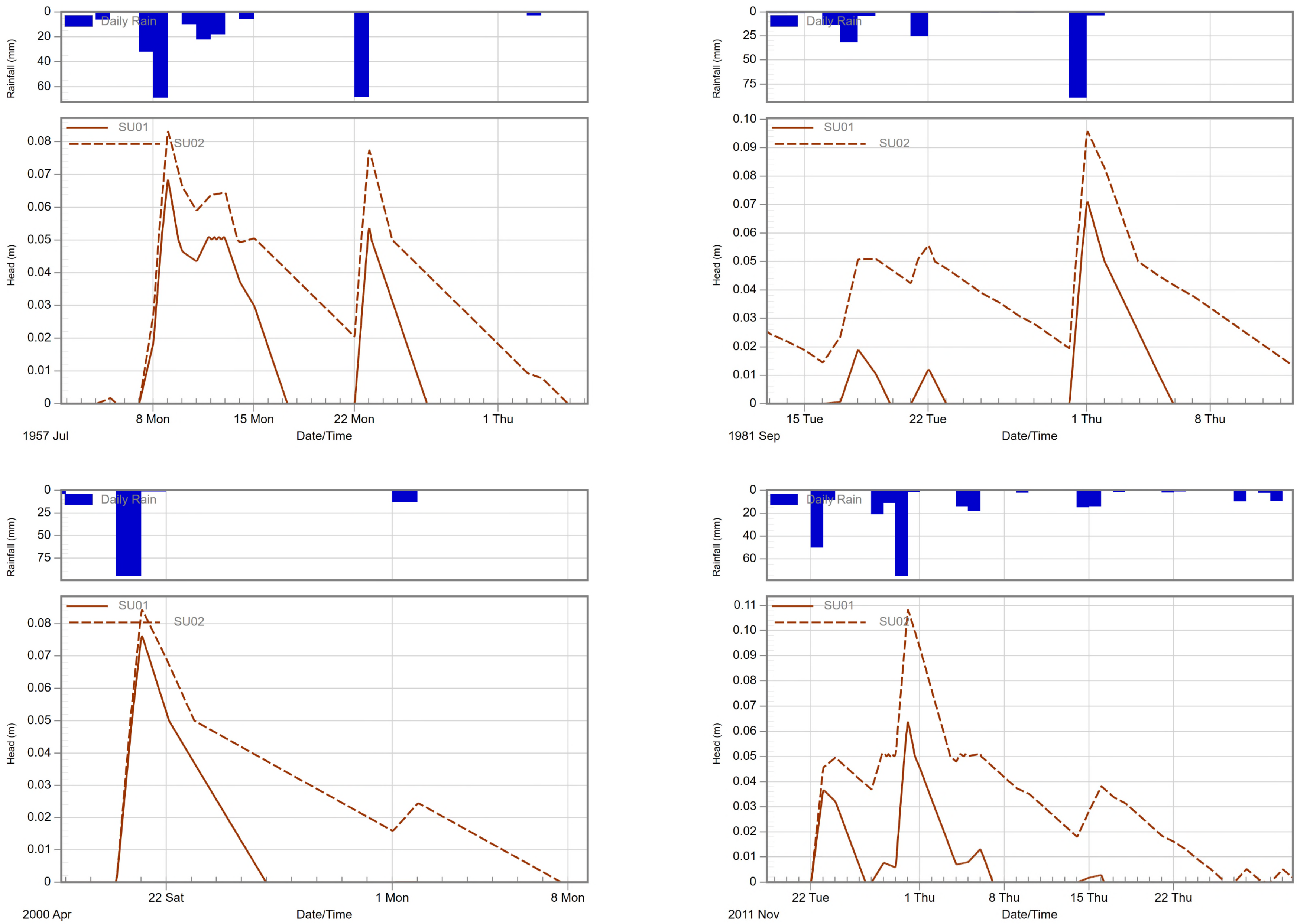
Based on the design scenario, the largest simulated level is 0.076m in April 2000, with a simulated pond drawdown time of approximately 5 days.

Figure F2 also includes the extreme scenario levels for the foregoing events as well as the maximum simulated level of 0.108m reached in November 2011 as a result of sluggish pond drawdown and cumulative impacts from successive storm events. The extreme scenario clearly illustrates the potential extended drawdown time resulting from reduced gravity outflow, and correspondingly, the importance of considering average head conditions when sizing flow controls – as discussed in section 3.3 of the report.



Landmark Engineers Inc.

Title: HISTORICAL RAINFALL AND STORAGE DEPTHS	Date: JUN 2022	FIGURE F1
	Scale: NTS	
Project: LEBO CREEK MASTER DRAINAGE STUDY	Project No. 19-023	



Landmark Engineers Inc.

SU01 (Solid Red Line) = Design Scenario
SU02 (Dashed Red Line) = Extreme Scenario

Title	MAJOR RAINFALL EVENTS AND DEPTHS
Project	LEBO CREEK MASTER DRAINAGE STUDY
Date	JUN 2022
Scale	NTS
Project No.	19-023

FIGURE F2