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# DRAINAGE PLAN

# 4


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4 Drainage Plan

4.1 Future Developments

The County's Municipal Development Plan and Area Structure Plan indicate that future developments in the watershed are only expected to occur in Alberta's Industrial Heartland (AIH) lands within the watershed. At the time of writing, there were no future development plans for other areas in the watershed. As such, the proposed concept is primarily focused on resolving flooding issues at or adjacent to the creek and providing drainage servicing to the existing and future stormwater management facilities (SWMFs) in the AIH lands within the watershed.

4.2 Recommended Unit Area Release Rate for the 100-year Event

As described previously, the current 100-year allowable unit area release rate (UARR) for developments in the watershed is 4.1 l/s/ha. In this study (Section 2), the pre-development UARR of the watershed was determined to be 1.9 l/s/ha.

The allowable UARR generally affects the size and footprint of private and municipal infrastructure. More specifically, the UARR affects the size of SWMFs, SWMF drawdown times and the size of conveyance infrastructure downstream of the SWMFs. The County should adopt the 1.9 l/s/ha UARR for the 100-year event as there is minimal impact on future developments and would require smaller municipal infrastructure. Land requirements (i.e., facility size) for SWMFs in the AIH are not expected to be affected since AER regulated facilities are designed to store the required design event without discharge due to water quality testing requirements. Furthermore, provincial guidelines generally recommend that runoff control measures ensure that the maximum post-development UARR is maintained to pre-development values (Government of Alberta, 2018).

The recommended UARR does result in extended SWMF drawdown times, likely beyond the desired 96-hour range specified to recover 90% of the total active storage in the facility (Strathcona County, 2021b). This drawdown requirement is usually specified to accommodate back-to-back infrequent rainfall events. This occurrence may be mitigated by implementing constant outflow mechanisms (i.e., continuous pumping) at the SWMF outlet, provision of a planned and appropriate overflow route, and/or oversizing the facility. SWMF owners should be encouraged to implement site-specific measures according to their risk-bearing capacity to mitigate the impacts of these occurrences.

Existing facilities in the AIH within the watershed should continue to discharge at the previous allowable UARR (4.1 l/s/ha). As described previously, the existing industrial developments in the AIH lands within the watershed encompass about 7 km^2 of land (about 13% of the total AIH area within the County's portion of the watershed). Therefore, the impact of a few areas discharging at a higher UARR to Astotin Creek is not significant.

4.3 Design Criteria

Design criteria for future developments and drainage infrastructure should follow the latest version of the following documents at a minimum:

- Design and Construction Standards (Strathcona County);
- Best Management Practices for Stormwater Management Facilities (Strathcona County);

- Stormwater Management Guidelines for the Province of Alberta (Alberta Environment and Parks);
- Standards and Guidelines for Municipal Waterworks, Wastewater and Storm Drainage Systems (Alberta Environment and Parks).

In addition to the design criteria outlined in the documents mentioned above, future stormwater management facilities in the watershed are recommended to meet the following criteria:

- Provide storage capacity for stormwater runoff up to the governing 100-year design storm within the high-water level;
- Be wet pond- or constructed wetland-type facilities to provide enhanced water quality treatment;
- Discharge at or below the allowable UARR of 1.9 l/s/ha.

In alignment with the County's standards, the minimum culvert size for rural roadway crossings should be 600 mm. Culvert crossing design should include an appropriate hydrologic analysis that accounts for the contributing drainage area and its characteristics, based on an appropriate design return period. Alberta Environmental Protection (1999) provides the following guidance on appropriate design events for culvert spans greater than 6.0 m:

- 100-year event for freeways;
- 50-year event for rural arterial roads;
- 25-year event for rural local roads.

At a minimum, municipal conveyance infrastructure should be designed to convey the resultant peak flow from applying the UARR (1.9 or 4.1 l/s/ha) over the contributing drainage area. While individual lot culvert crossings are permitted to be a minimum of 400 mm, the design of these crossings should also consider the peak discharges from the corresponding contributing drainage area.

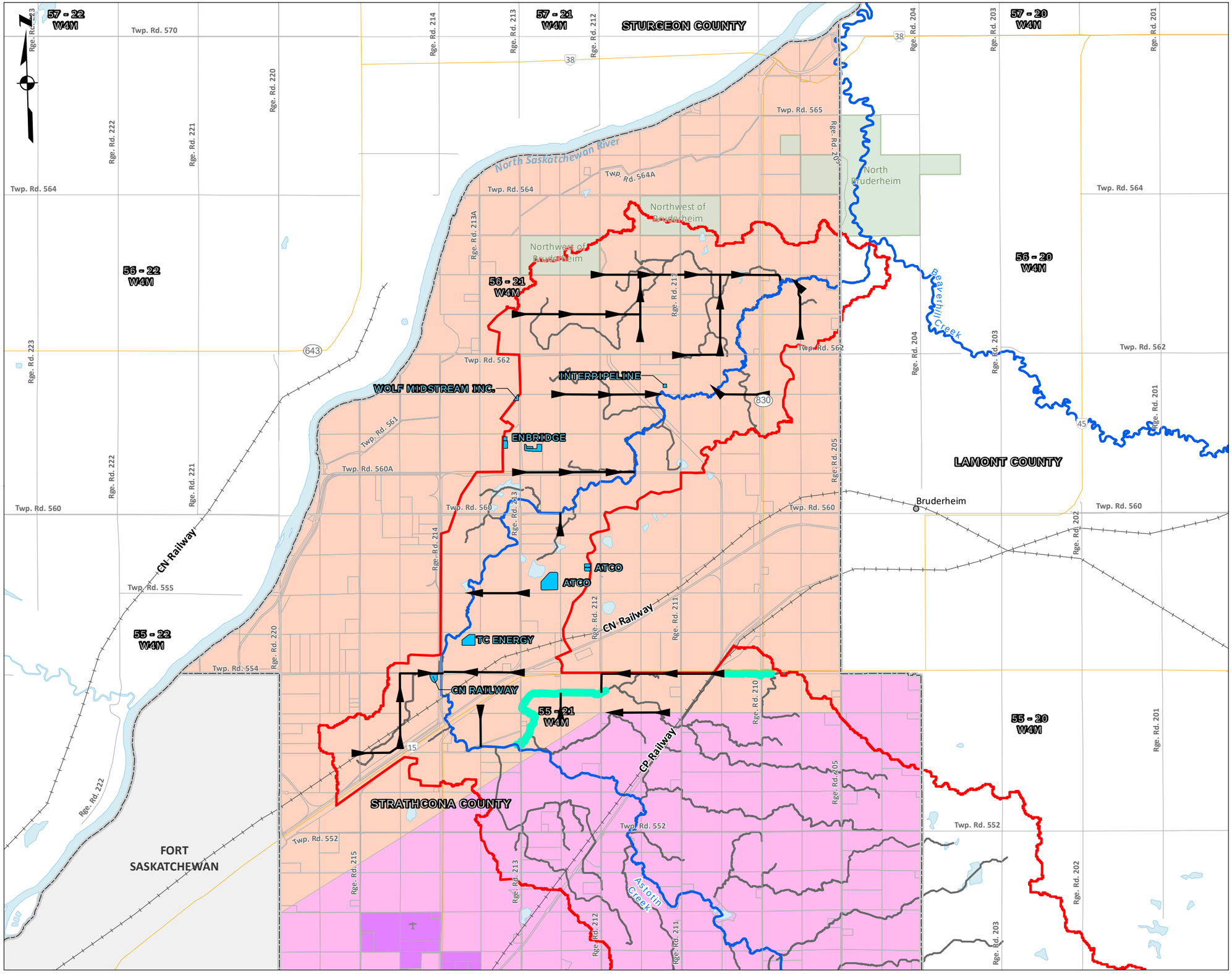
Natural wetlands and areas to be conserved and integrated with future developments should be assessed to maintain sufficient water supply and water quality. Overflows should be provided at natural areas to be conserved such that there is a safe outlet towards a SWMF or conveyance route when the capacity of the feature is exceeded.

4.4 Proposed AIH Drainage Servicing Plan

The proposed drainage plan to service the existing and future developments in the AIH lands is illustrated in Figure 4.1. The proposed concept comprises a series of overland conveyance channels (i.e., ditches) that collect and carry stormwater discharges from privately-owned and operated SWMFs (existing and future) to Astotin Creek. Culvert crossings are expected to be required at locations where the future road network intersects the proposed overland conveyance channel alignments. Where feasible, existing drainageways should be used (and improved as required) to convey stormwater discharges from the SWMFs.

The proposed AIH drainage servicing plan was based on a high-level assessment of the existing topography and potential privately-owned SWMF siting. More detailed drainage servicing plans are recommended to be required at the time of the development proposal. Additional assumptions are listed below:

- SWMFs would be implemented at each quarter section (64 ha of land), although land ownership in the AIH is currently concentrated into a few organizations owning several adjacent quarter sections;
- Future SWMFs would be located generally at the lowest ground elevation within each quarter section;



Legend

- Proposed Overland Drainage Conveyance
- Astotin Creek Watershed
- Existing Stormwater Management Facilities
- Cadastral Survey Boundaries
- Paved Roads
- Railways
- Airfield
- Towns/City
- County Boundaries
- Lakes/Rivers
- Astotin Creek & Beaverhill Creek
- Existing Drainageways (see note)
- Existing Drainageway to be used for Future Drainage Servicing
- Natural Area (Provincial and National)

Policy Area

- Agriculture Large Holdings Policy Area
- Hamlet Policy Area
- Heartland Policy Area

NOTE: THE PROPOSED OVERLAND DRAINAGE CONVEYANCE NETWORK WAS BASED ON DRAINAGE WAYS, WHICH WERE DELINEATED BASED ON A HYDROLOGICALLY CONDITIONED DIGITAL ELEVATION MODEL (ALL DEPRESSIONS REMOVED). THEREFORE, DEPRESSIONS MAY BE PRESENT ALONG THE PROPOSED OVERLAND DRAINAGE CONVEYANCE NETWORK.

Astotin Creek Resiliency Study
Drainage Master Plan

Figure 4.1: Future Stormwater Servicing Concept for Alberta's Industrial Heartland

Astotin Creek
Alberta

Scale: 1:75,000

0 500 1,000 2,000 3,000 4,000 5,000 Meters

Universal Transverse Mercator (Zone 12)
North American Datum (1983)

Report By: JU	WSP Job #: 211-03754-00
Drawn by: JH	Date: August 9, 2021
Reviewed By: JU	Office: Edmonton

Notes:Data provided by Altalis;Natural Resource Canada; ESRI

- The proposed ditch alignments would generally follow the existing drainageways but along quarter section lines (likely) alongside future roadways;
- Private conveyance infrastructure would be required to convey discharges from the SWMFs to the nearest proposed ditch (generally along quarter section lines);
- The AIH lands southeast of Highway 15 could be serviced partly via an existing drainageway;
- Future SWMFs near the creek channel are expected to discharge directly into it at or below the recommended allowable UARR and per AER requirements.

The proposed drainage plan should be updated as information regarding the future road network, and development staging becomes available to ensure effective coordination and implementation of municipal infrastructure or when the State of the Watershed report is updated.

4.5 Stormwater Best Management Practices

Stormwater best management practices (BMPs) are techniques and methods that are implemented to manage stormwater quantity and quality by providing adequate conveyance and flood control. BMPs are implemented to retain the pre-development hydrologic characteristics of an area. Typically, BMPs are categorized as source control BMPs, lot-level BMPs, conveyance system BMPs and end-of-pipe BMPs. Applicable BMPs to existing and future developments in the watershed include based on Strathcona County (2016):

- Source control BMPs such as managing pesticides and fertilizers, especially in the agricultural lands in the watershed, safely discarding hazardous wastes, and erosion and sedimentation control;
- Conveyance system BMPs such as vegetative swales/channels/ditches. Ditch cross-sections to be 2.5 m wide bottom with 4:1 side slope (preferred) as outlined in the County standards for rural roadways (Strathcona County, 2021b). The desirable minimum longitudinal slope is 0.2. The maximum slope should be 3.0 percent or, as dictated by the erodibility potential of the ditch cover;
- Treatment BMPs (SWMFs), specifically wet ponds, constructed wetlands and integration with natural wetlands.

4.6 Drainage Challenges

Drainage servicing challenges in the watershed area generally east of the CP Railway tracks (primarily agricultural lands) include the following:

- Drainageways are located mostly within private property, which may impede proper maintenance work and protection from alterations. Private crossings are present in some existing drainageways within private property;
- Country residential and farmland developments have been established with little or no drainage or flood management practices;
- The adoption of source control stormwater best management practices is highly dependent on the landowners;
- The implementation of any regional-type stormwater best management practice would require land acquisition;

- The eastern areas of the watershed receive runoff from Elk Island National Park and Lamont County. Intermunicipal drainage management plans or strategies should be developed.

Challenges in the remaining portion of the watershed north of the CP Railway tracks, where a portion of the AIH will reside, include:

- The existing topography is very flat, and some areas may not have an adequate outlet to drain toward Astotin Creek. Topography also makes these lands highly susceptible to flooding from Astotin Creek;
- Due to the existing topography, future drainage servicing of the AIH may be difficult;
- Various wetlands are present, where most future development is expected to occur in the watershed;

Finally, the extent and physical condition of drainage infrastructure throughout the watershed is currently unknown, making preventative maintenance and proactive replacement work difficult to implement.

4.7 Flood Risk Reduction Planning

The hydrologic and hydraulic analyses presented in Sections 2 and 3 of this study highlighted flood-prone areas along Astotin Creek. As a response to these findings and the State of the Watershed assessment findings, a Resiliency Action Plan was developed separately to provide a toolbox of actions that Strathcona County can use to build resilience within the Astotin Creek watershed. Flood management is a complex interdisciplinary subject with a high degree of technical complexity and uncertainty. To be effective, resilience initiatives require the support of all stakeholders and a good understanding of the opportunities and constraints for management. The Astotin Creek Resiliency Study is guided by "three E's": engineering, environment, and engagement to reflect this interdisciplinary and holistic approach.

The actions developed to reduce flood risk can be found in the associated Resiliency Action Plan. The action plan has six visions and supporting actions that will support a healthy watershed if implemented.

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# CONCLUSIONS AND RECOMENDATIONS

# 5


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5 Conclusions and Recommendations

5.1 Conclusions

5.1.1 Hydrology and Hydraulic

Flood quantiles were calculated for various return periods on Astotin Creek. The calculations led to a 100-year peak flow of 34.3 m^3/s. Based on this estimate, a unit allowable discharge rate of 1.9 l/s/ha was determined. A climate change analysis was also conducted, which led to a peak flow increase of 40% for a far-future RCP 8.5 scenario. A two-dimensional hydraulic model of Astotin Creek was constructed using LiDAR data collected by Airborne Imaging and survey data collected by WSP. The 45.5 km long model extends from the outlet of Astotin Lake to about 1.5 km upstream of the Beaverhill Creek junction. The 20-year, 50-year and 100-year flood scenarios and the 100-year far-future climate change scenarios were all modelled. Flood maps were produced for each scenario, and flood-prone areas were identified and mapped along the study reach. Flood-prone areas identified along Astotin Creek generally consisted of overtopped roads, flooded agricultural lands and residential lands. Flooding in these areas could generally be attributed to low-elevation floodplains and undersized crossings. The model results also suggest that part of Astotin Creek flow would leave its watershed during large flood events. Some of these outflow locations could be confirmed based on the 2018 flood event photographs. The hydraulic model and the review of historical air photographs indicate that the main outflow is located upstream of Highway 15, along RR 214 towards the North Saskatchewan River and the CN Railway. Flood propagations outside the Astotin Creek watershed were not modelled. The entire flood flow was conveyed through Astotin Creek in the hydraulic model, leading to more conservative flood extents downstream of these outflow locations.

Flood-prone areas identified along Astotin Creek generally consisted of overtopped roads, flooded agricultural lands and residential lands. Flooding in these areas could generally be attributed to low-elevation floodplains and undersized crossings.

The floodway and flood fringe for the 100-year flood were delineated where possible, and flood hazard maps were produced. The simulated water velocities were also reviewed to identify reaches that are more vulnerable to erosion. Higher velocities can be expected in steeper and deeper creek sections, which are mostly located in the middle reach of the creek.

The hydrotechnical information provided in this report feeds into the Resiliency Action Plan to develop a set of structural and non-structural mitigation options to improve resiliency within the Astotin Creek watershed.

5.1.2 Drainage Plan

Future developments in the watershed are expected to be primarily focused on the AIH and comprise industrial-type developments. The County should adopt the 1.9 l/s/ha value UARR for new developments in the watershed. While this value is lower than the current UARR, it is not expected to restrict future developments. Design criteria for developments in the watershed are recommended to follow the municipal and provincial guidelines in addition to AER regulations as applicable.

A proposed drainage servicing plan was provided (Figure 4.1) for the AIH lands in the watershed. The proposed system comprises a network of overland conveyance channels (i.e., ditches) and private SWMFs. Applicable stormwater best management practices for the watershed are also provided. Challenges for current and future drainage servicing in the watershed were also identified.

5.2 Recommendations

Recommendations aimed at building the resiliency of the watershed are covered in the Astotin Creek Resiliency Study document. The following recommendations are specific to the DMP document.

To improve the precision of the hydraulic model, the following actions should be implemented:

- Flow and water levels should be measured along Astotin Creek during large flood events to improve the model calibration at high flows. The hydrometric data currently available on Astotin Creek could only allow for low-flow calibration and high-level validation based on the 2018 flood event photographs. Flow measurements at several locations along the creek and water level profiles would provide valuable information for model calibration. Installing a hydrometric station on Astotin Creek would also provide valuable streamflow data at Astotin Creek that can be used to refine the hydrological and hydrotechnical analyses completed as part of this study;
- Several crossings on Astotin Creek are located on private lands and could not be surveyed due to limited land access permissions. Some of these crossings, such as the local crossing just downstream of RR 210 (quarter section NW18-56-20-4), directly impact flood elevations in areas flooded upstream. A detailed topographic survey of these crossings would improve the model accuracy in these areas.

Regarding drainage infrastructure outside of the creek channel, the following recommendations are provided:

- Commission a study to assess the hydraulic capacity of culverts in agricultural lands observed to have flooded in the past. Infrastructure upgrades should consider climate change;
- Update the drainage servicing plan for future developments in the AIH every 5 to 10 years or when there are changes in land use planning or infrastructure. At a minimum, the overall DMP could be updated when the State of the Watershed and Resiliency Action Plan reports are updated;
- More detailed drainage servicing plans are recommended to be required at the time of development proposal for all developments in the watershed. The plans should consider the impacts of upstream contributing areas and effects on existing downstream infrastructure;
- Develop an intermunicipal drainage servicing plan or strategy with Lamont County and Elk Island National Park to ensure coordinated and effective infrastructure planning. Development in the watershed portion within Lamont County can affect the downstream drainage system within Strathcona County.

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# 6


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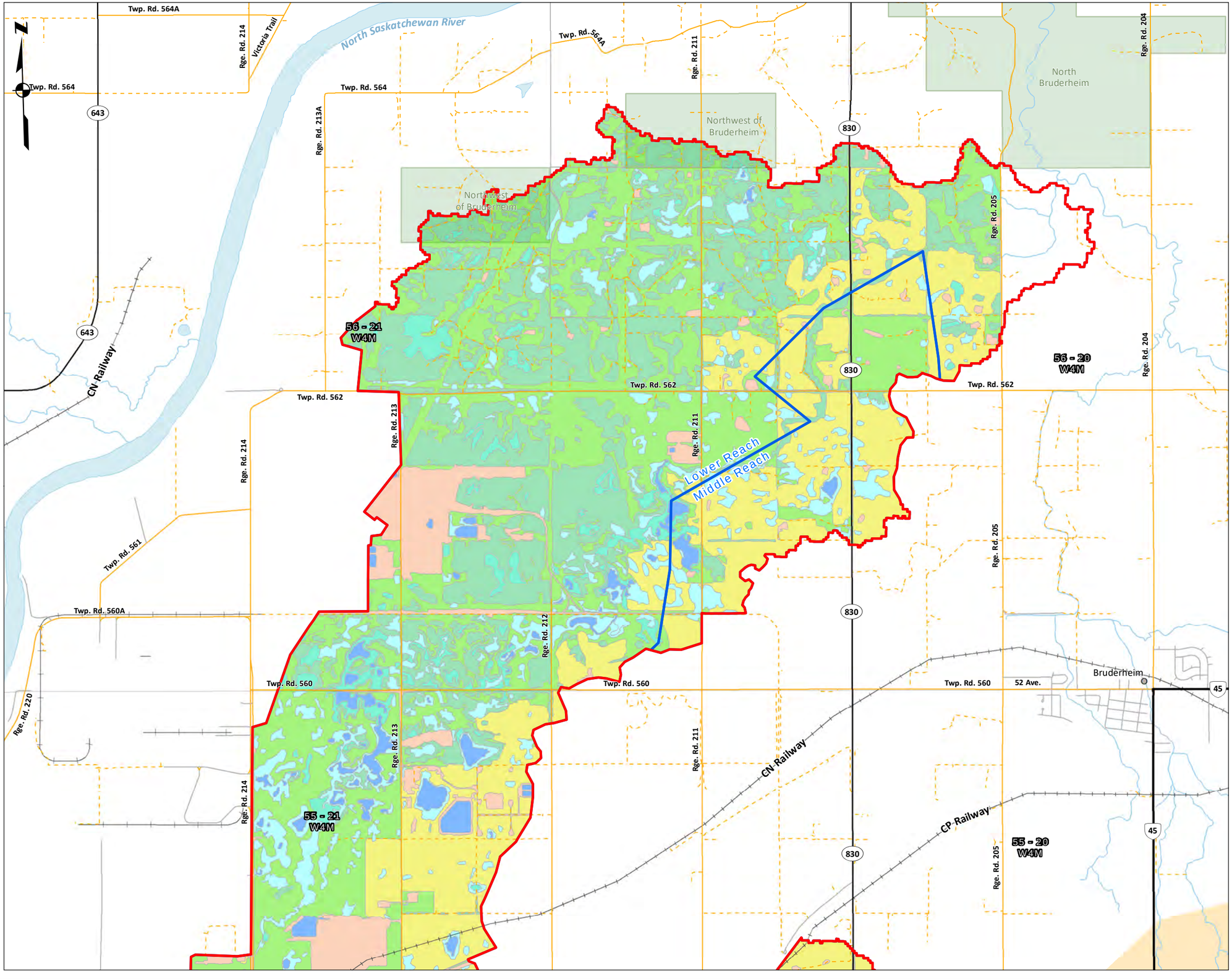
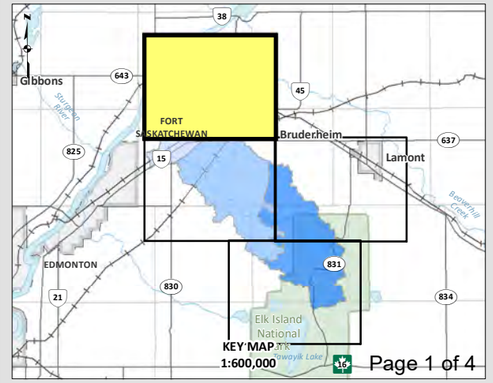
Appendix A Land Cover Map





Legend

Astotin Creek Watershed

Astotin Creek Subwatershed

Land Cover

- Agricultural
- Anthropogenic
- Marsh
- Open water
- Swamp
- Tree cover
- Grass Land

Base Data

- Primary Roads
- Secondary Roads
- Tertiary Roads
- Local Roads
- Gravel Roads
- Railways
- Towns/City
- Lakes/Rivers
- Perennial Creeks/Streams
- Natural Area (Provincial and National)
- Beaverhills Biosphere

Astotin Creek Resiliency Study
Drainage Master Plan

Appendix A1: Land Cover Maps

Astotin Creek
Alberta

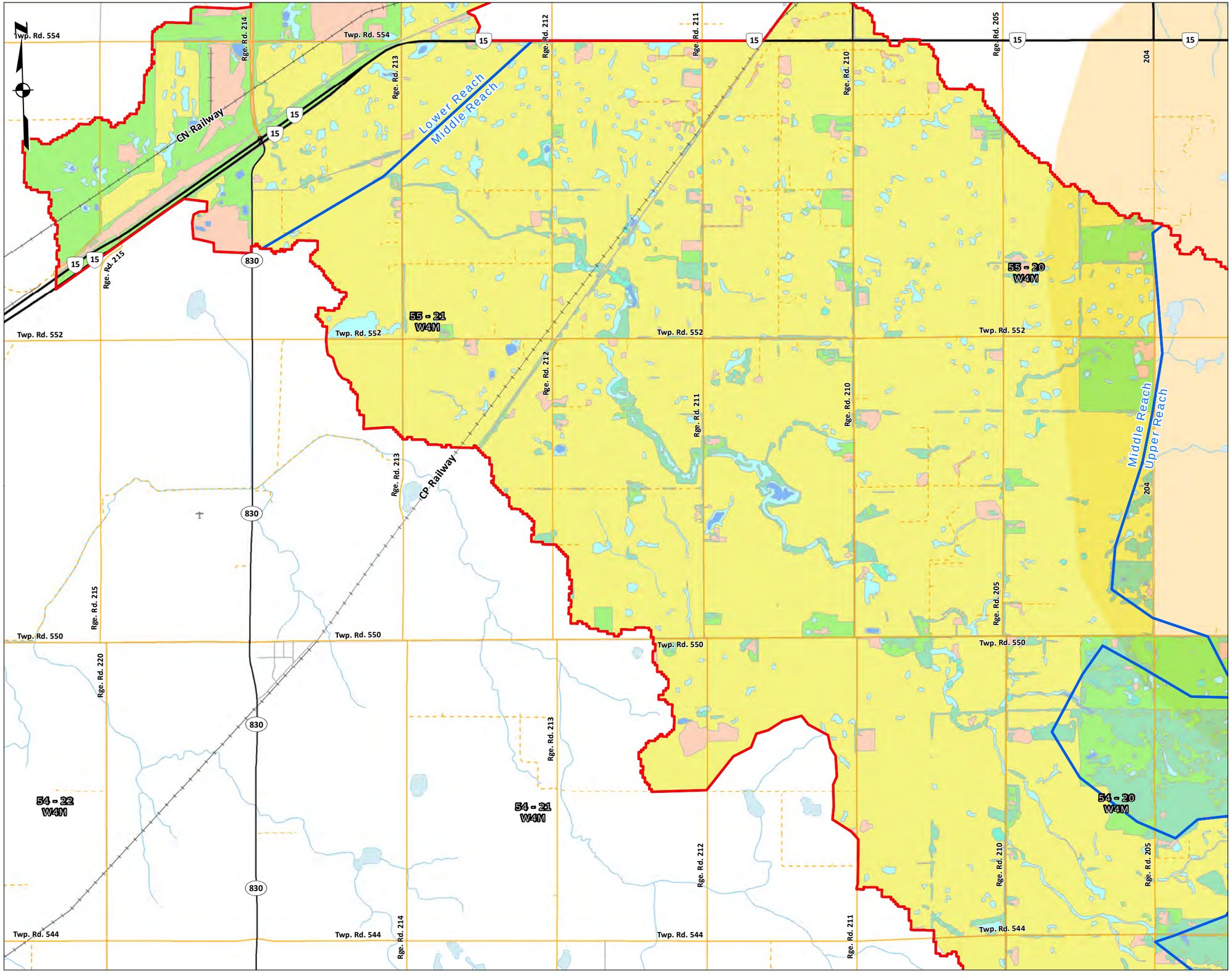
Scale: 1:30,000

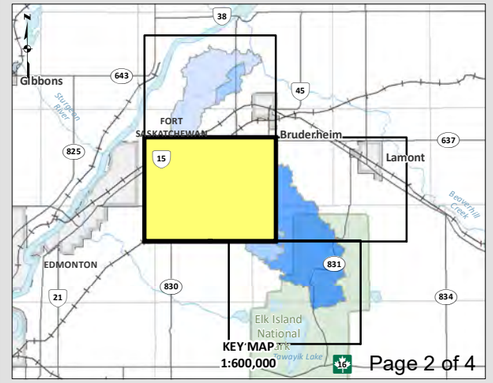
0 0.325 0.65 1.3 1.95 2.6 Kilometers

Universal Transverse Mercator (Zone 12)
North American Datum (1983)

Report By: DP	WSP Job #: 211-03754-00
Drawn by: JH	Date: August 9, 2021
Reviewed By: DP	Office: Edmonton

Notes:Data provided by Altalis;Natural Resource Canada; ESRI





Legend

Astotin Creek Watershed

Astotin Creek Subwatershed

Land Cover

- Agricultural
- Anthropogenic
- Marsh
- Open water
- Swamp
- Tree cover
- Grass Land

Base Data

- Primary Roads
- Secondary Roads
- Tertiary Roads
- Local Roads
- Gravel Roads
- Railways
- Airfield
- Lakes/Rivers
- Perennial Creeks/Streams
- Beaverhills Biosphere

Astotin Creek Resiliency Study
Drainage Master Plan

Appendix A2: Land Cover Maps

Astotin Creek
Alberta

Scale: 1:30,000

0 0.325 0.65 1.3 1.95 2.6 Kilometers

Universal Transverse Mercator (Zone 12)
North American Datum (1983)

Report By: DP
Drawn By: JH
Reviewed By: DP

WSP Job #: 211-03754-00
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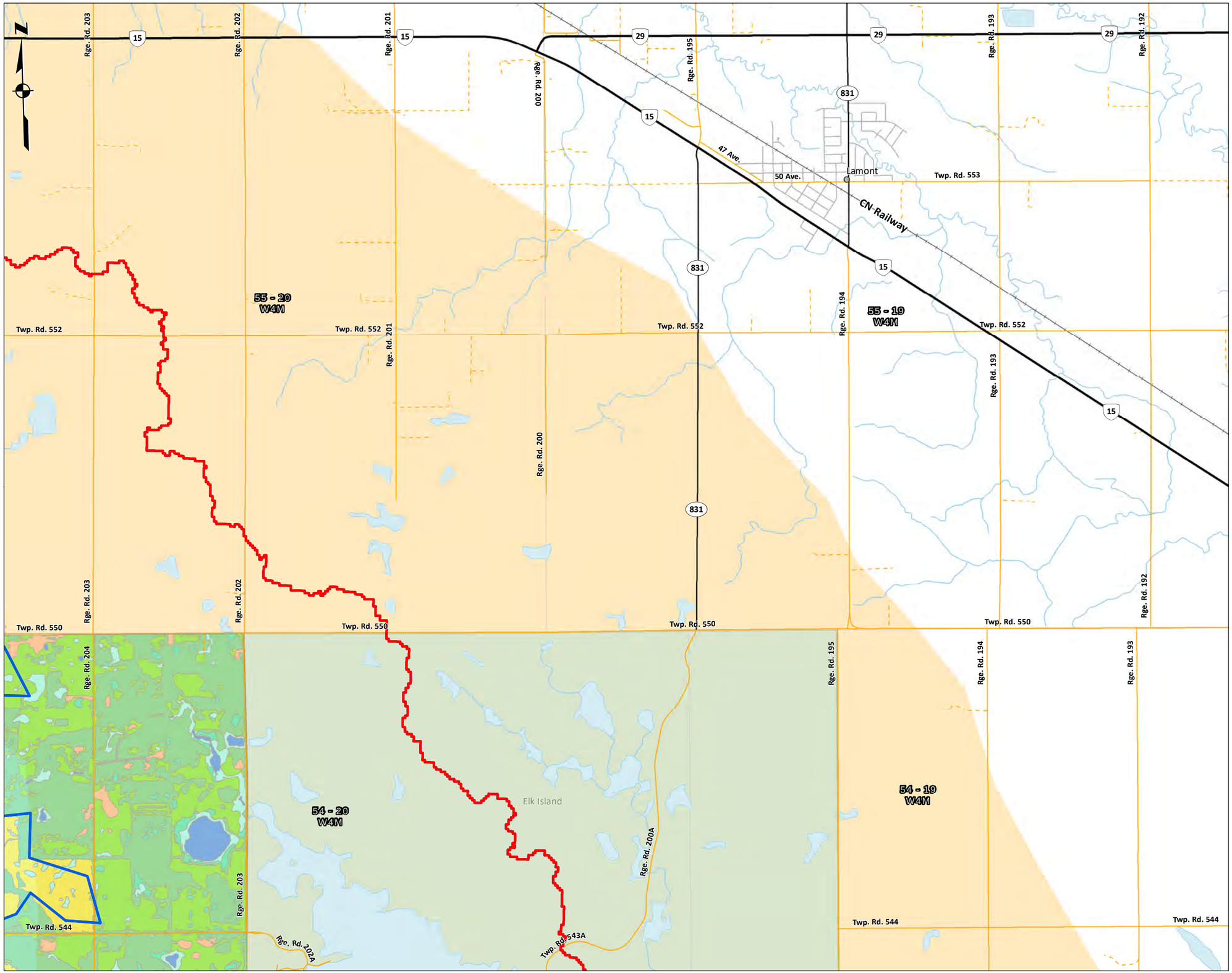
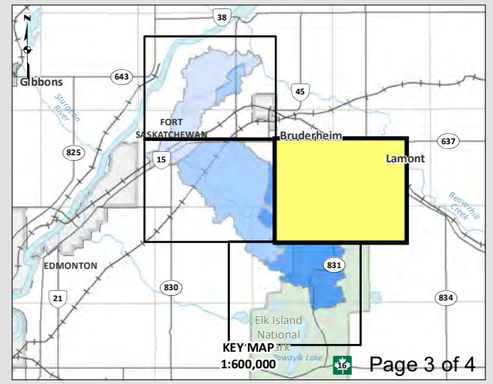




Legend

Astotin Creek Watershed

Astotin Creek Subwatershed

Land Cover

- Agricultural
- Anthropogenic
- Marsh
- Open water
- Swamp
- Tree cover
- Grass Land

Base Data

- Primary Roads
- Secondary Roads
- Tertiary Roads
- Local Roads
- Gravel Roads
- Railways
- Towns/City
- Lakes/Rivers
- Perennial Creeks/Streams
- Natural Area (Provincial and National)
- Beaverhills Biosphere

Astotin Creek Resiliency Study
Drainage Master Plan

Appendix A3: Land Cover Maps

Astotin Creek
Alberta

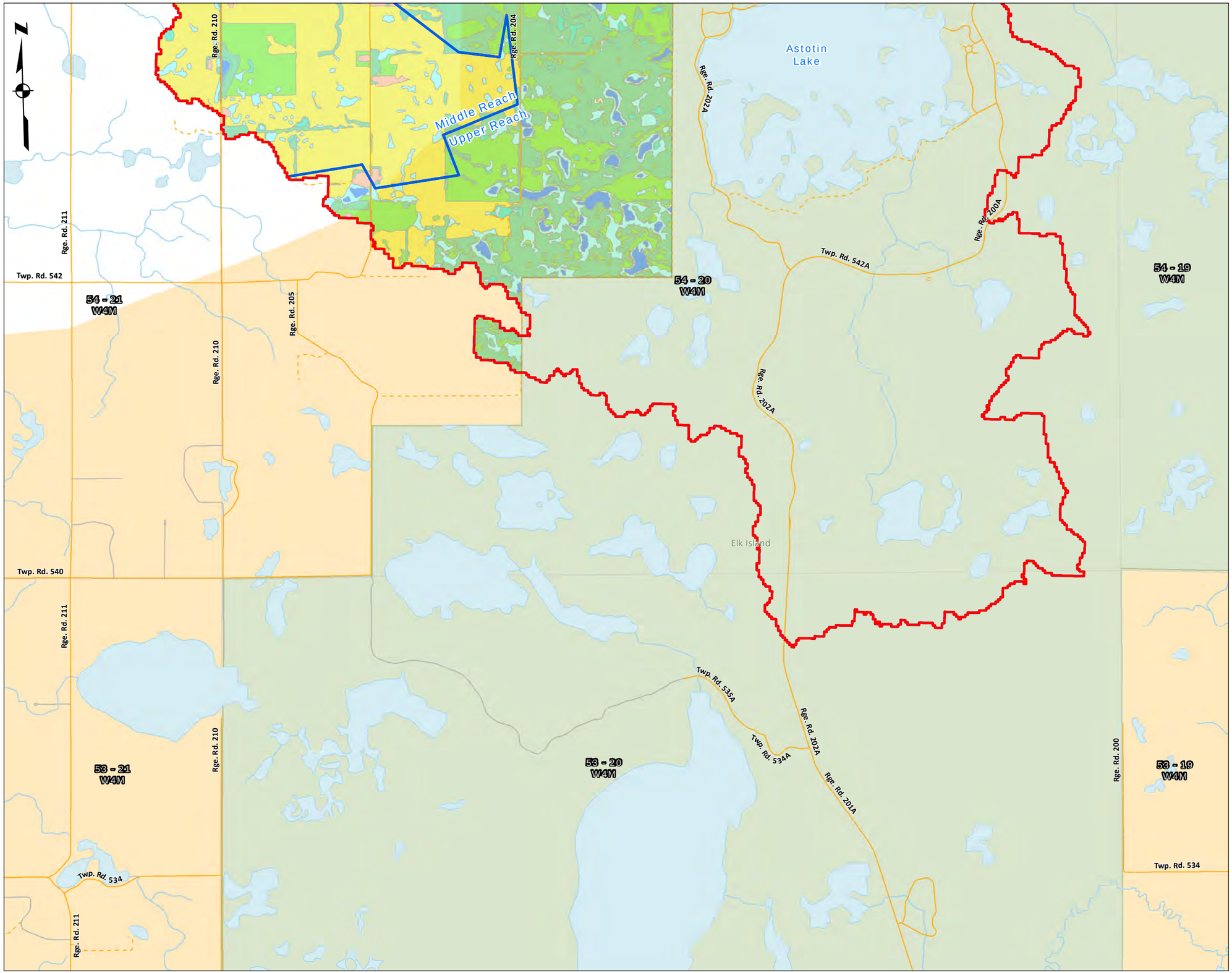
Scale: 1:30,000

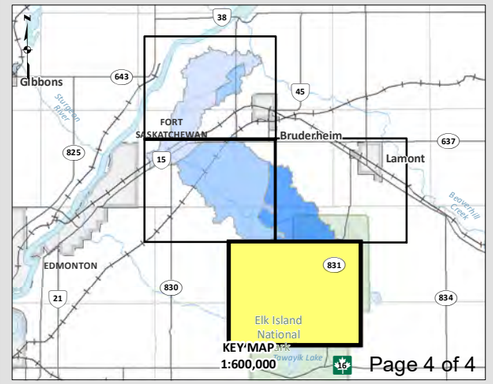
0 0.325 0.65 1.3 1.95 2.6 Kilometers

Universal Transverse Mercator (Zone 12)
North American Datum (1983)

Report By: DP	WSP Job #: 211-03754-00
Drawn by: JH	Date: August 9, 2021
Reviewed By: DP	Office: Edmonton

Notes:Data provided by Altalis;Natural Resource Canada; ESRI





Legend

- Astotin Creek Watershed
- Astotin Creek Subwatershed

Land Cover

- Agricultural
- Anthropogenic
- Marsh
- Open water
- Swamp
- Tree cover
- Grass Land

Base Data

- Tertiary Roads
- Local Roads
- Gravel Roads
- Lakes/Rivers
- Perennial Creeks/Streams
- Natural Area (Provincial and National)
- Beaverhills Biosphere

Astotin Creek Resiliency Study
Drainage Master Plan

Appendix A4: Land Cover Maps

Astotin Creek
Alberta

Scale: 1:30,000

0 0.325 0.65 1.3 1.95 2.6 Kilometers

Universal Transverse Mercator (Zone 12)
North American Datum (1983)

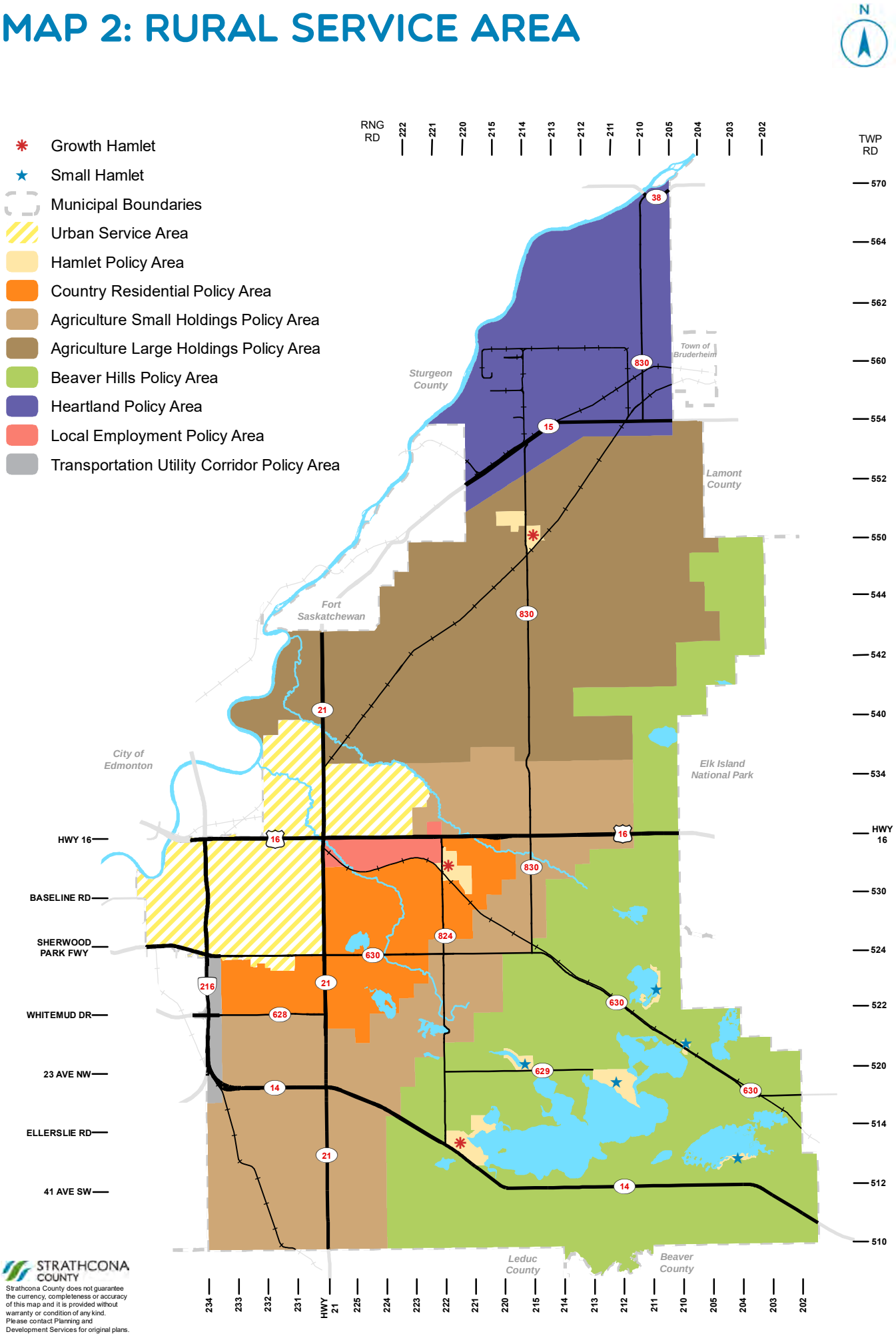
Report By: DP
Drawn by: JH
Reviewed By: DP

WSP Job #: 211-03754-00
Date: August 9, 2021
Office: Edmonton

Notes:Data provided by Altalis;Natural Resource Canada; ESRI

Appendix B Municipal Development Plan Maps

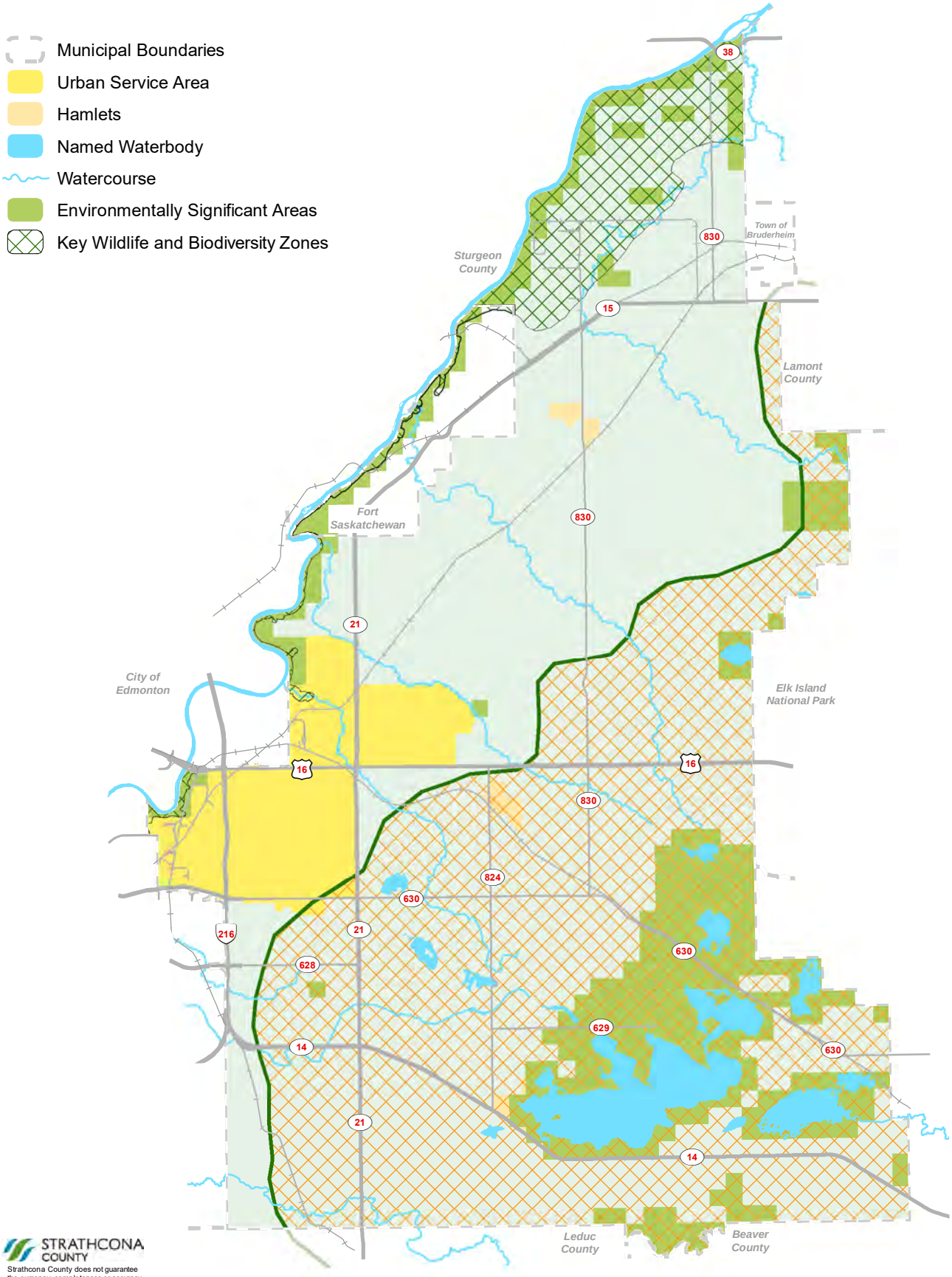
MAP 2: RURAL SERVICE AREA



STRATHCONA COUNTY

Amended by Bylaw 2-2019 & Bylaw 22-2019

MAP 7: ENVIRONMENT



STRATHCONA COUNTY

Amended by Bylaw 2-2019 & Bylaw 22-2019

Appendix C Stormwater Infrastructure Drawing Set Table

Table C.1 **Stormwater infrastructure drawing set**

DRAWING SET TITLE	OWNER	LAND DESCRIPTION	CONSULTANT	ISSUE DATE	ISSUE	STORMWATER INFRASTRUCTURE	OUTLET MECHANISM	CONSTRUCTED (Y/N)
PX6-Polaris Christina Lake Extension	interpipeline	NE-11-56-21-W4M	Stantec Consulting Ltd.	Jun-13	Construction	Stormwater pond discharging to Astotin Creek via a ditch.	Two flow control chambers with gates normally completely closed.	Y
Canadian Diluent Hub 3	Pembina Marketing Ltd.	SE-29-55-21-W4M	Stantec Consulting Ltd.	Jan-16	Development permit	Stormwater pond.	Pumped at 25 L/s.	Y
S.W. Quarter Laydown Area	WHX Investments Inc.	SW-12-56-21-W4M	Opus Stewart Weir	Jan-16	Approval	Stormwater pond discharging directly to Astotin Creek.	Pumped at 209 L/s.	N
Stonefell (AB) Terminal - East	Enbridge	NE-4-56-21-W4M	Jacobs Canada Inc.	Jan-17	As-built	Stormwater management pond.	Pumped at 21.68 L/s.	Y
Stonefell (AB) Terminal - West	Enbridge	NE-4-56-21-W4M	Fluor Canada Ltd.	Mar-20	As-built	Stormwater pond discharging to Astotin Creek via a ditch.	Overflow pipe with control valve. Limited to 30.17 L/s.	Y
TC Terminals/Grand Rapids	TransCanada	SE-28-55-21-W4M	Stantec Consulting Ltd.	Apr-18	As-built	Firewater/hydrotest/stormwater pond.	Pumped	Y
TC Terminals	TransCanada	SE-28-55-21-W4M	Upside Engineering Ltd.	Jul-14	Information	Firewater/hydrotest/stormwater pond.	Pumped	Y
Grand Rapids Heartland Terminal	Grand Rapids Pipeline Project	SE-28-55-21-W4M	Upside Engineering Ltd.	Feb-16	Information	Firewater/hydrotest/stormwater pond.	Pumped	Y
Sedimentation Pond and Pumphouse	ATCO Energy Solutions	SE-34-55-21-W4M	Stantec Consulting Ltd.	May-15	Development permit	Sedimentation ponds (x2) possibly discharging to Astotin Creek.	Pumped	Y
Proposed Laydown Area, Phase 1	CAC Enterprises Group Ltd.	SE-11-56-21-W4M	Opus Stewart Weir	Mar-15	Permitting	Existing wetland.	Overflow from wetland (if exceeding 100-year runoff volume).	N
Strathcona Sulphur Facility	Sulphur Midstream	SW-36-55-21-W4M	BRT Consulting	Feb-20	Approval	Stormwater pond.	Pumped at 18 L/s.	Y

Notes:

1 Construction observations based on review of Google Earth aerial imagery acquired on May 31, 2020.