



DRUMHELLER RIVER HAZARD STUDY

FLOOD RISK INVENTORY AND ASSESSMENT FINAL REPORT



Prepared for:

Alberta 



08 December 2022

NHC Ref. No. 1003877

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FINAL REPORT

Prepared for:

Alberta Environment and Parks
Edmonton, Alberta

Prepared by:

Northwest Hydraulic Consultants Ltd.
Edmonton, Alberta

08 December 2022

NHC Ref No. 1003877

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DISCLAIMER

This report has been prepared by Northwest Hydraulic Consultants Ltd. (NHC) in accordance with generally accepted engineering practices, for the benefit of Alberta Environment and Parks for specific application to the Drumheller River Hazard Study in Alberta. The information and data contained herein represent the best professional judgment of NHC, based on the knowledge and information available to NHC at the time of preparation.

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EXECUTIVE SUMMARY

Alberta Environment and Parks retained Northwest Hydraulic Consultants Ltd. in June 2018 to complete a river hazard study for the Town of Drumheller and surrounding areas of Kneehill County, Starland County, Wheatland County, and Special Area No. 2. The river hazard study area includes 56.1 km of the Red Deer River, 7.9 km of Kneehills Creek, 5.3 km of Michichi Creek, 10.7 km of the Rosebud River, and 3.0 km of Willow Creek. The study is being conducted under the provincial Flood Hazard Identification Program; the overall objectives are to enhance public safety and to reduce future flood damages and disaster assistance costs.

The Drumheller River Hazard Study has been structured into six major components. This report summarizes the work of the fifth component: **Flood Risk Inventory and Assessment**. This component includes the compilation and interpretation of available spatial data, infrastructure inventory and categorization, and flood risk statistics assessment.

Design details for planned flood control structures that were provided by the Town of Drumheller were incorporated into the calibrated hydraulic model, which was used to calculate water surface profiles and inundation extents for the 13 regulated flood frequency return periods and the design flood. It is worth noting that if flood control structure plans change, this report may not accurately reflect future conditions.

The goal of this study component is to provide quantitative information on the infrastructure, property, and populated areas impacted under the various flood scenarios in order to help define flood risks in the project study area. Flood risks in the study area are identified by combining the flood extent information for the various scenarios with inventoried spatial data. The spatial data are denoted in this report as receptors and they include: land parcels, residential and non-residential buildings and facilities, roadways and railways, bridges, culverts, and census blocks. Statistics were generated for each of these receptors for various flood scenarios, including the 13 regulated open water flood frequency scenarios (2-year through 1000-year open water floods) and the design flood hazard areas. The statistics are summarized by municipality.

CREDITS AND ACKNOWLEDGEMENTS

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The following NHC personnel were part of the study team and participated in the flood risk inventory and assessment component of the study:

- Robyn Andrishak (Project Manager) – responsible for the overall direction of the project and provided advice and senior review throughout the flood risk inventory and assessment.
- Md Makamum Mahmood (Project Engineer) – authored this report and assisted with the inventory and assessment.
- Rebecca Himsl (GIS Analyst) – conducted the spatial data inventory and assessment.
- Jerry Yan (GIS Analyst) – conducted the risk assessment.

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1 INTRODUCTION

1.1 Study Background

The Drumheller River Hazard Study was initiated by Alberta Environment and Parks (AEP) to identify and assess river and flood hazards along the Red Deer River, Kneehills Creek, Michichi Creek, Rosebud River, and Willow Creek within the Town of Drumheller and surrounding areas of Kneehill County, Starland County, Wheatland County, and Special Area No. 2. A flood hazard mapping study was previously completed for the Drumheller area by Matrix Solutions (2007); however, the present study covers an expanded study reach and will represent a significant update to the prior work.

Results from this study are designed to inform local land use planning decisions, flood mitigation projects, and emergency response planning. This study is being undertaken as part of the Flood Hazard Identification Program (FHIP) with the intent of enhancing public safety and reducing future flood damages within the province of Alberta.

This river hazard study is comprised of six major study components:

- 1) Survey and Base Data Collection
- 2) Open Water Hydrology Assessment
- 3) Hydraulic Modelling and Flood Inundation Mapping
- 4) Design Flood Hazard Mapping
- 5) Flood Risk Inventory and Assessment
- 6) Channel Stability Investigation

Each component includes a separate report and associated deliverables for that portion of the study.

1.2 Objectives

This report summarizes the work of the fifth component – ***Flood Risk Inventory and Assessment***. The primary tasks, services, and deliverables associated with this report are:

- Compilation and interpretation of available spatial data,
- Inventory and categorization of buildings and infrastructure, and
- Computation of flood risk statistics for different flood scenarios.

The main goal of this component is to help define flood risks in the study area. The open water flood inundation and design flood hazard maps were combined with the available spatial data to compute flood risk statistics for land parcels, buildings, infrastructure, and population at risk.

1.3 Study Area and Reach

The Town of Drumheller is located along the Red Deer River, approximately 100 km northeast of the City of Calgary and 115 km southeast of the City of Red Deer. **Figure 1** shows the location and boundaries of the river hazard study area and provides an overview of the upstream watershed boundaries. The study area includes the following river reaches and Alberta Township System quarter section boundaries:

- 56.1 km of the Red Deer River from the northern boundary of NW/NE-27-29-21-W4M to the southern boundary of SW/SE-3-27-17-W4M,
- 7.9 km of Kneehills Creek from the western boundary of SE-15-29-21-W4M to the Red Deer River,
- 5.3 km of Michichi Creek from the eastern boundary of SE-13-29-20-W4M to the Red Deer River,
- 10.7 km of the Rosebud River from the southern boundary of SW-7-28-19-W4M to the Red Deer River, and
- 3.0 km of Willow Creek from the eastern boundary of NE-7-28-18-W4M to the Red Deer River.

River cross section surveys extended beyond these boundaries to accommodate hydraulic modelling and inundation mapping requirements. Local authorities within the study area include the Town of Drumheller, Kneehill County, Starland County, Wheatland County, and Special Area No. 2.

The contributing watershed covers a total area of about 29,970 km², extending from the headwaters of the Red Deer River in the Rocky Mountains to the downstream boundary of the river hazard study area. The Kneehills Creek, Michichi Creek, Rosebud River, and Willow Creek sub-basins account for 2,440 km², 1,170 km², 4,360 km², and 400 km² of the total watershed area, respectively. Floods are typically derived from rapid spring snowmelt augmented by heavy rainfall events, although the nature and timing of flooding on the tributary reaches is typically unique and independent of those experienced by the Red Deer River.

Flows in the Red Deer River have been regulated since 1983 by Dickson Dam, which impounds Gleniffer Reservoir, and is located about 50 km upstream of Red Deer. The drainage area upstream of the reservoir (5,590 km²) accounts for about 22% of the area upstream of Drumheller.

2 AVAILABLE SPATIAL DATA

Available spatial data assembled and used for this analysis are summarized below. Supporting information and digital files are provided as **Appendix A**. The geographic distribution of the spatial data is illustrated in **Appendix B**.

2.1 Cadastral

Cadastral data for this study area was acquired from Alberta Environment and Parks and Altalis Ltd. This data was provided as a set of linear features identifying the boundaries of each land parcel. These linear features were converted to polygons, and areas located within watercourses, as defined by Natural Resources Canada's (NRCan) National Hydrographic Network (NHN) dataset (NRCan, 2018b), were removed.

2.2 Infrastructure

The National Road Network (NRN) (Statistics Canada, 2018) provides a comprehensive geospatial record of road centerline data covering the entire country. The NRN did not capture the road geometry in areas that had undergone recent development. In these locations, NHC manually digitized the roads based on the 2019 orthoimagery and, if information was available, the names of these roads were included using information from Google Maps. In addition, some topological errors were found in the NRN dataset such that certain road segments were duplicated or had significant overhangs; these were manually corrected by NHC.

Rail network spatial data was sourced from the National Railway Network (NRWN) – a GIS product created and maintained by National Resources Canada (NRCan, 2018a). However, as all railways within the study area are inactive and all tracks have been removed at the time of this study, statistics for at-risk railways are not reported here.

Bridges and culverts were mapped by NHC based on field surveys (NHC, 2020) and reference data acquired from Alberta Transportation. The maximum low chord elevation and flood level at each bridge was extracted from the HEC-RAS model in order to determine whether a given structure would be impacted by flooding at each flood scenario. In order to determine whether a culvert will be affected, the approach road elevation – as determined by the bare earth DEM – was joined with the flood level at each culvert (extracted from the HEC-RAS model).

2.3 Census

The most recent census results available at the time of creating the flood risk inventory were compiled in 2016. Census results and the corresponding spatial units were downloaded from Statistics Canada (2016) and merged. Census dissemination blocks are the smallest spatial unit for which census results are

published; they are areas defined as “bounded on all sides by roads and/or boundaries of standard geographic areas” (Statistics Canada, 2016).

In order to maintain confidentiality, if the total population in a census dissemination block is less than 15, the population count is rounded to a base of 5. A random rounding algorithm is used to either round the population count up or down so that the value will always end in a 0 or 5. As a result, the given value will always be within 5 of the true population counts.

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3 INTERPRETED SPATIAL DATA

3.1 Aerial Photography

OGL Engineering Ltd. completed the acquisition of new aerial imagery in May 2019 and used this imagery to generate colour-balanced ortho-rectified mosaics. A complete description of the aerial imagery acquisition and data processing procedures are provided in the *Survey and Base Data Collection Report* (NHC, 2020) provided under a separate cover. This 2019 orthoimage was used to interpret spatial data for the flood risk assessment.

3.2 Structure Classification

3.2.1 Digitization

Building centroids were required to statistically analyze the impact of the different flood scenarios on residential and non-residential structures. A previous flood damage assessment study (IBI Group, 2015) already identified and categorized a number of the buildings located within the 1000-year flood extent. The work from this previous study has been adopted so that it could be used in the current risk assessment. Buildings that had not been identified in the previous study were digitized by referencing the 2019 aerial imagery, and centroids identifying garages, sheds, or other accessory structures were deleted. Some other building centroids identified in the previous study had been misclassified; these were re-classified by NHC based on Google Street View and the 2019 ortho-imagery. Referring to the aerial imagery, additional centroids were added if it was deemed that a single building contained multiple residences or businesses. Outside the areas inventoried in the 2015 study, centroids identifying primary structures were manually digitized by NHC based on the 2019 orthoimage and Google Street View. Structure centroids were only digitized if the building was located within the 1000-year flood inundation extent.

3.2.2 Classification

Structures were categorized as either residential or non-residential and further sub-categorized as summarized in **Table 1**.

Table 1 Classification scheme for structures

Category	Sub-Category
Residential	Single-family residence
	Multi-family residence
	Retirement home
Non-residential	Hospital
	School
	Commercial building
	Industrial building
	Government building
	Water treatment facility
	Wastewater treatment facility
	Other non-residential building

Within the study area, multi-family residential structures are typically multi-story buildings or apartments where a flooding event would more disproportionately impact the residences located at ground level. Single-family homes typically consisted of detached or mobile homes. Retirement homes were identified through an online search and confirmed with reference to the orthoimage and Google Street View.

The distinction between commercial and industrial buildings was made based on reference to Google Street View: if a non-residential building did not seem to have any commercial activities associated with it, it was categorized as industrial. For schools, government, and industrial buildings, as well as the water and wastewater treatment plants, only one building was digitized per land parcel. If a commercial property seemed to have more than one storefront associated with it, multiple commercial points were digitized. The Drumheller Health Centre is located within the 1000-year open water flood extent and is classified as a hospital. However, the numerous medical clinics located within 1000-year open water flood extent were classified as commercial structures. Non-residential buildings that did not fit in the defined sub-categories were classified as other. Examples of non-residential buildings classified as other included churches and community centres and halls.

4 FLOOD RISK INVENTORY AND ASSESSMENT

4.1 Methodology

Inventory data for the flood risk assessment were assembled into a geodatabase with the following feature classes: administrative boundaries, bridges, buildings, cadastral data, census dissemination blocks, culverts, rail network, and road network. A description of these data, their spatial attributes, and relevant digital file information is detailed in **Appendix A**. The geographic distribution of the spatial data is illustrated in **Appendix B**.

Flood risk statistics were computed for thirteen regulated open water flood inundation extents (2-, 5-, 10-, 20-, 35-, 50-, 75-, 100-, 200-, 350-, 500-, 750-, and 1000-year return period open water floods) according to the following inundation scenarios:

- **Direct Inundation:** Corresponds to areas that are part of, or directly connected to, the river channel.
- **Potential flood control structure failure:** Corresponds to areas that would flood in the event of the failure of a flood control structure (FCS) resulting in inundation of the area behind the FCS. When water surface elevations indicated that all or a portion of a FCS were overtopped, inundated areas behind the FCS were categorized as direct inundation areas.

Statistics were also computed for the design flood hazard areas, where flood risk statistics associated with the floodway, high hazard flood fringe, protected flood fringe, and flood fringe were computed separately.

For each flood inundation scenario, the extent of inundation was overlain over the flood risk assessment inventory data to evaluate the following statistics:

- Number of at-risk land parcels,
- Number of at-risk residential buildings,
- Number of at-risk non-residential buildings,
- Number of at-risk bridges,
- Number of at-risk culverts,
- Length of at-risk roadway, and
- Estimated population at risk.

Risk statistics are provided as an aggregate total for the entire study area and are also summarized according to local municipal authority, as this provides more meaningful information to the stakeholders. The municipal authorities included in the study area are:

- Town of Drumheller,
- Kneehill County,
- Starland County,
- Wheatland County, and
- Special Area No. 2.

For a given flood scenario, a land parcel was deemed to be at risk if it was intersected by the corresponding flood extent polygon. Portions of land parcels located within the channel, as defined by the NHN basins 05CE000 and 05CG000, were removed. At-risk land parcels were counted for a municipality whether they lay fully or partially within its boundaries. As illustrated in **Figure 2**, the land parcels were not always coincident with administrative boundaries so that a single parcel might be counted in the risk statistics for more than one municipality. As a result, the total number of at-risk land parcels is not always equal to the sum of the land parcels at risk within each local municipal authority or flood hazard area.

Buildings were considered at risk if the building centroid fell within a given flood extent. Results were classified by primary category (i.e. residential or non-residential) and sub-category (e.g. single-family, multi-family, commercial, industrial). Accessory structures, such as garages, that were located on land parcels with a primary structure were not included in this analysis.

Bridges were considered at risk if the flood levels reach the low chord elevation of the structure. Culverts were considered at risk if the flood level exceeded the approach road elevation. Culverts conveying local drainage or watercourses other than the Red Deer River, Kneehills Creek, Michichi Creek, the Rosebud River or Willow Creek were not included in this analysis.

The risk to roadways was quantified by determining the total length within the extent of inundation for each flood scenario. Road segments associated with bridges were removed from the spatial inventory.

The population at risk was estimated by multiplying the total population within each census dissemination block by the percentage of the area of the block that falls within the flood extent. Some census blocks contain water features, such as rivers or lakes, that are not populated. These areas were identified from the NHN datasets (NRCan, 2018b) and were masked out of the census blocks. The area of the dissemination blocks was recomputed after erasing the wetted areas for a more representative risk estimate.

4.2 Results

The results of the flood risk assessment are summarized into statistics based on the number of at-risk land parcels, residential and non-residential buildings, culverts and bridges, as well as the length of

roadway and estimated affected population. Statistics are evaluated according to municipality for all thirteen regulated flood frequencies under both direct inundation and flood control structure failure conditions (if applicable); statistics for the design flood are also presented. The risk statistics presented are based on flood extents described in the *Hydraulic Modelling and Flood Inundation Mapping Report* (NHC, 2022a) and the *Design Flood Hazard Mapping Report* (NHC, 2022b), respectively. Both reports provide a summary of the data and methodology used to derive the flood extents and prepare the accompanying maps.

The calibrated hydraulic model and accompanying inundation mapping, as well as subsequent hazard mapping, includes consideration of planned flood control structure upgrades which are to be constructed beginning in 2022. Although the proposed upgrades were not constructed at the time of this report, it is expected that they will be completed in the near future. Therefore, it was deemed appropriate to include their hydraulic impact to ensure the results are relevant when the upgrades are complete and for future planning. It is worth noting that if flood control structure plans change, this report may not accurately reflect future conditions.

4.2.1 Land Parcels

Table 2 and **Figure 3a** provide summary statistics for the number of land parcels at risk due to direct inundation in the study area.

The Town of Drumheller has the most land parcels at risk for all flood scenarios. Land parcels along the river are at risk for the 2-year and higher return periods. As the magnitude of the flood scenario increases, so does the number of land parcels at risk. The rate of increase of the number of land parcels at risk increases significantly at the 100-year and 200-year return period and mostly in the communities of Nacmine, Midland, Newcastle, North Drumheller, Riverside, and East Coulee. Above the 200-year return period, the risk then gradually increases to the 1000-year return period.

Land parcels adjacent to the river/creek in Kneehill County, Starland County, Wheatland County, and Special Area No. 2 are at risk starting at the 2-year return period. Due to the size of the land parcels in these areas, even though the area of inundation increases with the return period, the rate of increase of the number of land parcels at risk is relatively consistent across return periods. Land parcels in Kneehill County are at risk immediately adjacent to Kneehills Creek and Red Deer River in the Dunphy and Kirkpatrick areas. At-risk land parcels in Starland County, Wheatland County, and Special Area No. 2 are located predominantly along Red Deer River.

Table 2 Land parcels at risk for various flood scenarios due to direct inundation

Return Period	Number of Parcels by Local Municipal Authority					Total ¹
	Town of Drumheller	Kneehill County	Starland County	Wheatland County	Special Area No. 2	
2-yr	289	46	30	49	54	468
5-yr	351	56	31	53	57	548
10-yr	395	66	35	53	59	608
20-yr	454	71	36	53	60	674
35-yr	565	77	38	58	65	803
50-yr	670	81	38	60	65	914
75-yr	874	88	38	61	65	1126
100-yr	1443	92	38	61	65	1699
200-yr	2245	97	40	64	71	2517
350-yr	2774	101	42	66	77	3060
500-yr	2971	101	42	66	81	3261
750-yr	3206	101	42	67	83	3499
1000-yr	3283	103	42	68	84	3580

Notes:

1. The total is derived from a separate count of at-risk land parcels across the total study area and is not necessarily equivalent to the sum of the land parcels in each local authority.

Table 3 and **Figure 3b** provide summary statistics for the number of additional land parcels at risk due to potential flood control structure failure in the study area. Some land parcels may be at risk due to both direct inundation and potential flood control structure failure. Values reported in **Table 3** and **Figure 3b** correspond to parcels inundated only under potential flood control structure failure and not through direct inundation; these are in addition to those reported previously.

All flood control structures are located within the Town of Drumheller. Potential flood control structure failure mainly affects the Nacmine Dike for the 5- to 100-year return periods, the Midland Dike for the 35- to 75-year return periods, the Newcastle Dike for the 20- to 75-year return periods, the Hospital Dike/Dike A for the 2- to 100-year return periods, Dike B for the 10- to 50-year return periods, Dike C for the 50-year return periods, Dike D for the 10- to 100-year return periods, Willow Estate Dike for the 20- to 100-year return periods, and the East Coulee Dike for the 35- to 75-year return periods.

Most land parcels that are at risk solely due to the potential flood control structure failure are affected at the 35- to 100-year return periods. Only one additional land parcel is at risk due to the potential failure of the flood control structure for the 5-year return period. No additional land parcels at risk when all the dikes are overtopped during the 200-year flood.

Table 3 Additional land parcels at risk for various flood scenarios due to potential flood control structure failure

Return Period	Number of Parcels by Local Municipal Authority					Total
	Town of Drumheller	Kneehill County	Starland County	Wheatland County	Special Area No. 2	
2-yr	0	0	0	0	0	0
5-yr	1	0	0	0	0	1
10-yr	39	0	0	0	0	39
20-yr	48	0	0	0	0	48
35-yr	404	0	0	0	0	404
50-yr	579	0	0	0	0	579
75-yr	689	0	0	0	0	689
100-yr	299	0	0	0	0	299
200-yr	0	0	0	0	0	0
350-yr	0	0	0	0	0	0
500-yr	0	0	0	0	0	0
750-yr	0	0	0	0	0	0
1000-yr	0	0	0	0	0	0

Table 4 and **Figure 3c** provide summary statistics for the number of land parcels at risk for the design flood scenario in the study area.

The majority of land parcels at risk for the design flood are in the Town of Drumheller. Developed land parcels in the communities of Newcastle, Rosedale, Cambria, Lehigh, and Wayne are situated in the floodway. Additional land parcels in Nacmine, Midland, Newcastle, North Drumheller, Central Drumheller, Riverside, Willow Estates, Rosedale, Cambria, Lehigh, East Coulee, Dunphy, Kirkpatrick, and Wayne areas are in the flood fringe. Among these land parcels located in the flood fringe, the following include portions with protected flood fringe adjacent to dedicated flood berms that are not overtopped or outflanked: Nacmine, Central Drumheller, and Willow Estates. Additionally, the following areas include portions with high hazard flood fringe adjacent to overtopped or outflanked dedicated flood berms: Midland, Newcastle, North Drumheller, and East Coulee.

The second most land parcels at risk for the design flood are in Kneehill County and are adjacent to the Red Deer River and Kneehills Creek. The land parcels at risk for the design flood scenario in Starland County, Wheatland County, and Special Area No. 2 are mostly located immediately adjacent to the Red Deer River.

Table 4 Land parcels at risk for the design flood scenario

Classification	Number of Parcels by Local Municipal Authority					Total ³
	Town of Drumheller	Kneehill County	Starland County	Wheatland County	Special Area No. 2	
Design Flood ¹	1742	92	38	61	65	1998
Floodway	582	67	36	54	65	804
Flood Fringe ²	1589	80	22	42	33	1766
High Hazard Flood Fringe	624	31	5	8	2	670
Protected Flood Fringe	326	0	0	0	0	326

Notes:

1. The number of land parcels at risk for the Design Flood scenario is not necessarily equivalent to the sum of the land parcels at risk for all zones because a single land parcel can be at risk for the floodway, flood fringe, and flood fringe sub-zones.
2. Flood fringe includes high hazard and protected flood fringe-sub zones.
3. The total is derived from a separate count of at-risk land parcels across the total study area and is not necessarily equivalent to the sum of the land parcels in each local authority.

4.2.2 Residential Buildings

Table 5 and **Figure 4a** provide summary statistics for the number of residential buildings at risk due to direct inundation in the study area.

The risk to residential buildings due to direct inundation is most significant in the Town of Drumheller with inundation mainly beginning in the communities of Rosedale and Lehigh during the 35-year return period from the Red Deer River. No residential buildings are at risk for the 2- to 10-year return periods and only one is at risk for the 20-year return period. The number of residential buildings at risk increases at the 35- and 50-year return periods, when the communities of North Drumheller, Rosedale, and Lehigh become affected. By the 200-year return period, residential areas in most of the riverside communities including Nacmine, Midland, Newcastle, North Drumheller, Central Drumheller, Willow Estates, Rosedale, Cambria, Lehigh, and East Coulee are affected. Within the 100- to 350-year return periods, the number of residential buildings at risk increases significantly because of a large increase in the inundation extent in the communities of Nacmine, Midland, Newcastle, Central Drumheller, and Riverside. Up to three retirement homes are at risk for the 1000-year return period.

Kneehill County has the second most residential buildings at risk due to direct inundation. In Kneehill County, residential buildings located near Kirkpatrick along the Red Deer River, and near Dunphy along Kneehills Creek, are at risk during the 75-year return period.

Very few (only one to three) residential buildings in Starland County, Wheatland County, and Special Area No. 2 are at risk for the analyzed return periods.

Table 5 Residential buildings at risk for various flood scenarios due to direct inundation

Return Period	Number of Residential Buildings by Local Municipal Authority					Total
	Town of Drumheller	Kneehill County	Starland County	Wheatland County	Special Area No. 2	
2-yr	0	0	0	0	0	0
5-yr	0	0	0	0	0	0
10-yr	0	1	0	0	0	1
20-yr	1	1	0	0	0	2
35-yr	16	2	0	0	0	18
50-yr	64	3	0	0	0	67
75-yr	294	4	0	0	0	298
100-yr	717	8	0	0	0	725
200-yr	1152	16	0	1	0	1169
350-yr	1509	27	1	1	1	1539
500-yr	1728	32	3	2	2	1767
750-yr	1875	34	3	2	3	1917
1000-yr	1946	34	3	3	3	1989

Table 6 and **Figure 4b** provide summary statistics for the number of residential buildings at risk due to potential flood control structure failure in the study area. Residential buildings at risk due to potential flood control structure failure are in addition to those that are at risk due to direct inundation. Flood control structures are only located within the Town of Drumheller.

Most additional residential buildings are at risk due to the potential flood control structure failure at 35- to 100-year return periods. Only one additional residential building is at risk due to the potential failure of the flood control structure for the 20-year return period.

Table 6 Additional residential buildings at risk for various flood scenarios due to potential flood control structure failure

Return Period	Number of Residential Buildings by Local Municipal Authority					Total
	Town of Drumheller	Kneehill County	Starland County	Wheatland County	Special Area No. 2	
2-yr	0	0	0	0	0	0
5-yr	0	0	0	0	0	0
10-yr	0	0	0	0	0	0
20-yr	1	0	0	0	0	1
35-yr	148	0	0	0	0	148
50-yr	290	0	0	0	0	290
75-yr	377	0	0	0	0	377
100-yr	124	0	0	0	0	124
200-yr	0	0	0	0	0	0
350-yr	0	0	0	0	0	0
500-yr	0	0	0	0	0	0
750-yr	0	0	0	0	0	0
1000-yr	0	0	0	0	0	0

Table 7 and **Figure 4c** provide summary statistics for the number of residential buildings at risk for the design flood in the study area.

The majority of residential buildings at risk for the design flood are in Drumheller, with most being in the communities of Nacmine, Midland, Newcastle, North Drumheller, Riverside, Rosedale, Lehigh, and East Coulee. There are a small number of at-risk residential buildings in Kneehill County. There are no residential buildings at risk for the design flood in Starland County, Wheatland County, and Special Area No. 2.

Table 7 Residential buildings at risk for the design flood scenario

Classification	Number of Residential Buildings by Local Municipal Authority					Total
	Town of Drumheller	Kneehill County	Starland County	Wheatland County	Special Area No. 2	
Design Flood	842	8	0	0	0	850
Floodway	62	2	0	0	0	64
Flood Fringe ¹	780	6	0	0	0	786
High Hazard Flood Fringe	277	0	0	0	0	277
Protected Flood Fringe	122	0	0	0	0	122

Notes:

1. Flood fringe includes high hazard and protected flood fringe sub-zones.

4.2.3 Non-residential Buildings

Table 8 and **Figure 5a** provide summary statistics for the number of non-residential buildings at risk due to direct inundation in the study area.

In the Town of Drumheller, there are no non-residential buildings at risk for the 2- to 20-year return periods, and very few non-residential buildings (up to three) are at risk up to and including the 50-year return period. The number of non-residential buildings at risk gradually increases between the 100-year and the 1000-year return periods. The following key non-residential buildings are at-risk for various return period floods throughout the Town of Drumheller:

- During the 200-year return period, the RCMP building in the Central Drumheller community area is at risk of flooding from the Red Deer River.
- In total, four schools are at risk of flooding in the Town of Drumheller. During the 350-year return period, the Drumheller Composite High School in Riverside, Drumheller Learning Centre, and Drumheller Outreach School are at risk of flooding from the Red Deer River. Hope College is at risk during the 500-year return period.
- During the 350-year return period, the Town Hall in the Central Drumheller community is at risk from the Red Deer River.
- During the 350-year return period, the Drumheller Health Centre located in North Drumheller is at risk from the Red Deer River.

Twelve of the at-risk non-residential buildings are located outside of the Town of Drumheller. No non-residential buildings in Kneehill County are at risk for the analyzed return periods. In Starland County, 11 commercial buildings are at risk for the 1000-year return period. No non-residential buildings in Wheatland County are at risk for the analyzed return periods. In Special Area No. 2, a single commercial building is at-risk during the 350-year return period.

Table 8 Non-residential buildings at risk for various flood scenarios due to direct inundation

Return Period	Number of Non-residential Buildings by Local Municipal Authority					Total
	Town of Drumheller	Kneehill County	Starland County	Wheatland County	Special Area No. 2	
2-yr	0	0	0	0	0	0
5-yr	0	0	0	0	0	0
10-yr	0	0	0	0	0	0
20-yr	0	0	0	0	0	0
35-yr	3	0	0	0	0	3
50-yr	3	0	0	0	0	3
75-yr	18	0	0	0	0	18
100-yr	22	0	0	0	0	22
200-yr	45	0	2	0	0	47
350-yr	87	0	8	0	0	95
500-yr	118	0	10	0	1	129
750-yr	158	0	11	0	1	170
1000-yr	182	0	11	0	1	194

Table 9 and **Figure 5b** provide summary statistics for the number of non-residential buildings at risk due to potential flood control structure failure in the study area. Non-residential buildings at risk due to potential flood control structure failure are in addition to those that are at risk due to direct inundation. Flood control structures are only located within the Town of Drumheller.

Among the flood control structures in Drumheller, the Midland Dike and the Newcastle Dike protects two non-residential buildings, Dike B protects one non-residential building, and Dike D protects ten non-residential buildings.

Table 9 Additional non-residential buildings at risk for various flood scenarios due to potential flood control structure failure

Return Period	Number of Non-residential Buildings by Local Municipal Authority					Total
	Town of Drumheller	Kneehill County	Starland County	Wheatland County	Special Area No. 2	
2-yr	0	0	0	0	0	0
5-yr	0	0	0	0	0	0
10-yr	1	0	0	0	0	1
20-yr	3	0	0	0	0	3
35-yr	2	0	0	0	0	2
50-yr	0	0	0	0	0	0
75-yr	0	0	0	0	0	0
100-yr	0	0	0	0	0	0
200-yr	0	0	0	0	0	0
350-yr	0	0	0	0	0	0
500-yr	0	0	0	0	0	0
750-yr	0	0	0	0	0	0
1000-yr	0	0	0	0	0	0

Table 10 and **Figure 5c** provide summary statistics for the number of non-residential buildings at risk for the design flood scenario in the study area.

The majority of non-residential buildings at risk for the design flood are in the Town of Drumheller, with most being in the communities of Midland, Newcastle, North Drumheller, Riverside, Rosedale, and East Coulee. There are no non-residential buildings at risk for the design flood in Kneehill County, Starland County, Wheatland County, and Special Area No. 2. There are only four non-residential buildings in the floodway and three in high hazard flood fringe. There are also 10 non-residential buildings within the protected flood fringe area, which are protected by Dike D.

Table 10 Non-residential buildings at risk for the design flood scenario

Classification	Number of Non-residential Buildings by Local Municipal Authority					Total
	Town of Drumheller	Kneehill County	Starland County	Wheatland County	Special Area No. 2	
Design Flood	32	0	0	0	0	32
Floodway	4	0	0	0	0	4
Flood Fringe ¹	28	0	0	0	0	28
High Hazard Flood Fringe	3	0	0	0	0	3
Protected Flood Fringe	10	0	0	0	0	10

Notes:

1. Flood fringe includes high hazard and protected flood fringe sub-zones.

4.2.4 Bridges

Table 11 and **Figure 6a** provide summary statistics for the number of bridges at risk due to direct inundation in the study area.

In the Town of Drumheller, no bridges are at risk until the 10-year return period. On the Rosebud River, one abandoned railway bridge and one highway bridge are at risk for the 20-year return period. One bridge on the Red Deer River is at risk for the 50-year return period. The number of bridges at risk gradually increases with return period until the 1000-year return period. Within the Town of Drumheller, 29 bridges are at risk for the 350-year return period and 31 bridges for the 1000-year return period. The Highway 10 Bridge at East Coulee is not at risk for any of the analyzed return periods.

In Kneehill County, the following bridges on Kneehills Creek are at risk: the Range Road 211 Bridge starting at the 35-year return period and the Highway 575 Bridge starting at the 500-year return period.

In Special Area No. 2, the Highway 848 Bridge at Dorothy is not at risk for any of the analyzed return periods.

There are no bridges located in Starland County or Wheatland County within the study area.

Table 11 Number of bridges at risk for various flood scenarios due to direct inundation

Return Period	Number of Bridges by Local Municipal Authority					Total
	Town of Drumheller	Kneehill County	Starland County	Wheatland County	Special Area No. 2	
2-yr	0	0	0	0	0	0
5-yr	0	0	0	0	0	0
10-yr	0	0	0	0	0	0
20-yr	2	0	0	0	0	2
35-yr	9	1	0	0	0	10
50-yr	13	1	0	0	0	14
75-yr	16	1	0	0	0	17
100-yr	18	1	0	0	0	19
200-yr	27	1	0	0	0	28
350-yr	29	1	0	0	0	30
500-yr	30	2	0	0	0	32
750-yr	30	2	0	0	0	32
1000-yr	31	2	0	0	0	33

There are no bridges at risk due to potential flood control structure failure.

Table 12 and **Figure 6c** provide summary statistics for the number of bridges at risk for the design flood in the study area.

The majority of at-risk bridges due to the design flood are in the Town of Drumheller. Of the 19 at-risk bridges, 18 are in the Town of Drumheller. One bridge in Kneehill County is at-risk due to the design flood.

Table 12 Number of bridges at risk for the design flood scenario

Classification	Number of Bridges by Local Municipal Authority					Total
	Town of Drumheller	Kneehill County	Starland County	Wheatland County	Special Area No. 2	
Design Flood	18	1	0	0	0	19
Floodway	18	1	0	0	0	19
Flood Fringe ¹	0	0	0	0	0	0
High Hazard Flood Fringe	0	0	0	0	0	0
Protected Flood Fringe	0	0	0	0	0	0

Notes:

1. Flood fringe includes high hazard and protected flood fringe sub-zones.

4.2.5 Culverts

Only one culvert is located within the study area. The culvert is at Highway 9 over Michichi Creek and is located within the Town of Drumheller. The culvert is at risk starting at the 200-year return period.

There are no culverts at risk due to potential flood control structure failure.

There are no culverts at risk due to the design flood.

4.2.6 Roadway

Table 13 and **Figure 7a** provide summary statistics for length of roadway at risk due to direct inundation in the study area.

Within the Town of Drumheller, small segments of roadway are at risk of inundation from the Red Deer River beginning at the 10-year return period. Inundation is restricted to service roads or access roads near the McMullen Island and Newcastle Beach. Residential roads in the communities of Nacmine and Riverside are mostly at risk from the 200-year direct inundation, and for Midland and Newcastle from the 100-year flood. Residential roads in East Coulee are at risk starting from 50-year flood and in Lehigh from 35-year flood. Some local roads in Nacmine are at risk starting from the 20-year return period and in Rosedale starting from the 35-year return period. Residential roads in Cambria are not affected until the 100-year return period.

North Dinosaur Trail is at risk of flooding from Michichi Creek starting at the 75-year flood. Flooding from the Rosebud River begins to affect Highway 10X at the 35-year flood. By the 1000-year flood, significant portions of major roads within the Town of Drumheller limits are at risk of inundation, with arterial roads and highways constituting 24% of the 96 km of at-risk roadway.

A small segment of service road in Kneehills County is inundated from Kneehills Creek during the 2-year flood, with the length and number of at-risk roads along Kneehills Creek increasing gradually thereafter. A small portion of service road in Kirkpatrick is at risk due to the 35-year flood from the Red Deer River. By the 350-year flood, nearly all roads in the locality are affected to some degree. Finally, segments of the major arterials, Highway 837 and Highway 575, are at risk from the 200-year flood.

The risk to roadways in Starland County, Wheatland County, and Special Area No. 2 is comparatively low. In Starland County, no roads are affected by inundation until the 100-year flood. For the 1000-year flood, less than 1.5 km of roadway is at risk, the majority of which is located within the grounds of the Dinosaur Trail RV Resort. In Wheatland County, there is minor roadway flooding for the 35-year and 50-year floods; the flooding is restricted to the area surrounding the Atlas Coal Mine Historic Site and remote access roads. Finally, in Special Area No. 2, roadway inundation is limited to private access roads near Dorothy, as well as some flooding along Range Road 172 near the downstream study limit.

Table 13 Roadway at risk for various flood scenarios due to direct inundation

Return Period	Length of Roadway by Local Municipal Authority (km)					Total
	Town of Drumheller	Kneehill County	Starland County	Wheatland County	Special Area No. 2	
2-yr	0.0	0.1	0.0	0.0	0.0	0.1
5-yr	0.0	0.1	0.0	0.0	0.0	0.1
10-yr	0.7	0.6	0.0	0.0	0.0	1.3
20-yr	1.5	0.7	0.0	0.0	0.0	2.2
35-yr	5.1	0.9	0.0	0.1	0.0	6.1
50-yr	11	1.3	0.0	0.1	0.0	12
75-yr	19	1.6	0.0	0.3	0.0	21
100-yr	32	1.7	0.1	0.3	0.0	34
200-yr	55	3.5	0.8	0.4	0.1	60
350-yr	71	5.3	1.1	0.6	0.7	79
500-yr	79	6.2	1.2	0.8	1.4	89
750-yr	90	7.4	1.3	1.1	2.3	102
1000-yr	96	7.9	1.4	1.2	2.4	109

Table 14 and **Figure 7b** provide summary statistics for the length of roadway at risk due to potential flood control structure failure in the study area. The length of roadway at risk due to potential flood control structure failure is in addition to the length at risk due to direct inundation. Flood control structures are only located within the Town of Drumheller.

Potential flood control structure failure increases the risk to roadway inundation particularly for the 35- to 100-year flood.

Potential failure of the Nacmine Dike would place up to an additional 2.8 km of residential road at risk for the 100-year flood, while the Midland Dike would place up to an additional 3.9 km of residential road

at risk for the 75-year flood. The Newcastle Dike is overtopped by the 100-year flood, and for the 75-year flood, flood control structure failure would place an additional 2.7 km of roadway at risk. Roads behind the Hospital Dike are only at risk from potential flood control structure failure due to the 35-year flood; in which case, only 0.1 km of additional roadway is at risk of inundation. Potential failure of Dike B would place up to an additional 2.2 km road at risk for the 50-year flood. No roadways are protected by Dike C. Dike D is overtopped by the 200-year flood, and for the 100-year flood, flood control structure failure would place an additional 2.2 km of roadway at risk. Potential failure of the Willow Estate Dike would place only less than 1 km of roadway at risk. Finally, the failure of East Coulee Dike would place an additional 1.5 km of roadway at risk for the 75-year flood.

Table 14 Additional roadway at risk for various flood scenarios due to potential flood control structure failure

Return Period	Length of Roadway by Local Municipal Authority (km)					Total
	Town of Drumheller	Kneehill County	Starland County	Wheatland County	Special Area No. 2	
2-yr	0.0	0.0	0.0	0.0	0.0	0.0
5-yr	0.0	0.0	0.0	0.0	0.0	0.0
10-yr	0.0	0.0	0.0	0.0	0.0	0.0
20-yr	0.0	0.0	0.0	0.0	0.0	0.0
35-yr	6.6	0.0	0.0	0.0	0.0	6.6
50-yr	10	0.0	0.0	0.0	0.0	10
75-yr	12	0.0	0.0	0.0	0.0	12
100-yr	5.5	0.0	0.0	0.0	0.0	5.5
200-yr	0.0	0.0	0.0	0.0	0.0	0.0
350-yr	0.0	0.0	0.0	0.0	0.0	0.0
500-yr	0.0	0.0	0.0	0.0	0.0	0.0
750-yr	0.0	0.0	0.0	0.0	0.0	0.0
1000-yr	0.0	0.0	0.0	0.0	0.0	0.0

Table 15 and **Figure 7c** provide summary statistics for the length of roadway at risk for the design flood.

The largest length of roadway at risk for the design flood is in the Town of Drumheller, with 22% of the at-risk roadway being located within the floodway and predominantly are service roads or access roads. Some residential roads within the Rosedale and Lehigh communities are also within the floodway. In Kneehill County, small sections of residential roadway near Kirkpatrick are located within the floodway, whereas in Starland Country and Wheatland County, all at-risk roadways are located within the flood fringe. No roadways area at risk for the design flood for Special Area No. 2.

Table 15 Roadway at risk for the design flood scenario

Classification	Length of Roadway by Local Municipal Authority (km)					Total
	Town of Drumheller	Kneehill County	Starland County	Wheatland County	Special Area No. 2	
Design Flood	38	1.7	0.1	0.3	0.0	40
Floodway	8.4	0.8	0.0	0.0	0.0	9.1
Flood Fringe	29	1.0	0.1	0.3	0.0	31
High Hazard Flood Fringe	8.9	0.2	0.0	0.1	0.0	9.1
Protected Flood Fringe	5.5	0.0	0.0	0.0	0.0	5.5

Notes:

1. Flood fringe includes high hazard and protected flood fringe sub-zones.

4.2.7 Railway

All railways in the study area are abandoned, and the tracks have been removed from the embankments. No statistics are reported for these abandoned rail lines.

4.2.8 Population

Table 16 and **Figure 8a** provide summary statistics for the estimated population at risk due to direct inundation in the study area.

The Town of Drumheller has the majority of the at-risk population across all flood scenarios, with estimates ranging between 28 and 4,244 people for the 2-year and 1000-year floods, respectively. Most of the at-risk population resides in the communities of Nacmine, Midland, Newcastle, North Drumheller, Central Drumheller, Riverside, Rosedale, and East Coulee. Due to an increase in the Red Deer River inundation extent, the number of people at risk increases significantly for the 100-year return period in the communities of Midland and Newcastle and in the community of East Coulee for the 75-year return period. At the 200- and 350-year return periods, the number also increases significantly because of a large increase in the inundation extents in the communities of Nacmine, Central Drumheller, and Riverside.

The populations at risk in other municipalities are very small. In Kneehill County, the estimated population at risk ranges from 0 to 10 people for the 2-year to 1000-year return periods, respectively. The estimated at-risk population in Starland County ranges from 0 to 4 people for the 2-year to 1000-year return periods, respectively. No people are at risk in Wheatland County. In Special Area No. 2, up to three people are at risk.

Table 16 Population at risk for various flood scenarios due to direct inundation

Return Period	Estimated Population by Local Municipal Authority					Total
	Town of Drumheller	Kneehill County	Starland County	Wheatland County	Special Area No. 2	
2-yr	28	0	0	0	0	28
5-yr	52	1	0	0	0	53
10-yr	109	1	1	0	0	111
20-yr	236	2	1	0	0	239
35-yr	371	4	1	0	1	377
50-yr	480	4	2	0	1	487
75-yr	870	5	2	0	1	878
100-yr	1638	6	2	0	1	1647
200-yr	2582	8	4	0	2	2596
350-yr	3364	9	4	0	2	3379
500-yr	3758	9	4	0	3	3774
750-yr	4113	10	4	0	3	4130
1000-yr	4244	10	4	0	3	4261

Table 17 and **Figure 8b** provide summary statistics for the estimated population at risk due to potential flood control structure failure in the study area. The estimated population at risk due to potential flood control structure failure is in addition to the estimated population at risk due to direct inundation. Flood control structures are only located within the Town of Drumheller.

Potential flood control structure failure would have the largest impact on populations during the 35- to 100-year return periods, resulting in 337 to 871 additional people being affected. Only two additional people are at risk due to the potential failure of the flood control structures for the 10-year return period, and 13 additional people for the 100-year return period.

Table 17 Additional population at risk for various flood scenarios due to potential flood control structure failure

Return Period	Estimated Population by Local Municipal Authority					Total
	Town of Drumheller	Kneehill County	Starland County	Wheatland County	Special Area No. 2	
2-yr	0	0	0	0	0	0
5-yr	0	0	0	0	0	0
10-yr	2	0	0	0	0	2
20-yr	13	0	0	0	0	13
35-yr	439	0	0	0	0	439
50-yr	750	0	0	0	0	750
75-yr	871	0	0	0	0	871
100-yr	337	0	0	0	0	337
200-yr	0	0	0	0	0	0
350-yr	0	0	0	0	0	0
500-yr	0	0	0	0	0	0
750-yr	0	0	0	0	0	0
1000-yr	0	0	0	0	0	0

Table 18 and **Figure 8c** provide summary statistics for the estimated population at risk for the design flood in the study area.

The largest number of people at risk for the design flood reside in the Town of Drumheller. Most of the at-risk people live in the communities of Nacmine, Midland, Newcastle, North Drumheller, Riverside, Rosedale, Lehigh, and East Coulee. A small number of at-risk people reside in Kneehill County, Starland County, and Special Area No. 2. In Wheatland County, there is no population at risk for the design flood.

Table 18 Population at risk for the design flood scenario

Classification	Estimated Population by Local Municipal Authority					Total
	Town of Drumheller	Kneehill County	Starland County	Wheatland County	Special Area No. 2	
Design Flood	1965	4	3	0	1	1973
Floodway	453	3	2	0	1	459
Flood Fringe	1512	1	1	0	0	1514
High Hazard Flood Fringe	647	0	0	0	0	647
Protected Flood Fringe	336	0	0	0	0	336

Notes:

1. Flood fringe includes high hazard and protected flood fringe sub-zones.

5 CONCLUSIONS

The objectives of this study were to assess river-flood-related hazards along the Red Deer River, Kneehills Creek, Michichi Creek, Rosebud River, and Willow Creek within the Town of Drumheller and the surrounding areas of Kneehill County, Starland County, Wheatland County, and Special Area No. 2. The Drumheller River Hazard Study was divided into six major components. This report summarizes the work of the **Flood Risk Inventory and Assessment** component in which at-risk populations, land parcels and infrastructure were analyzed and summarized.

Available spatial data were compiled to develop an inventory of potentially at-risk buildings and infrastructure and to compute flood risk statistics for land parcels, buildings, infrastructure, and at-risk populations. Spatial data was compiled from cadastral data, census results, a previous flood damage assessment study in the region (IBI Group, 2015), the National Road Network, as well as bridge and culvert assets surveyed by NHC (2020). The inundation extents for each of the thirteen regulated open water flood return periods and the design flood were superimposed on the inventory data to compute the following statistics according to the boundaries of each local municipal authority:

- Number of at-risk land parcels,
- Number of at-risk residential buildings,
- Number of at-risk non-residential buildings,
- Number of at-risk bridges.
- Number of at-risk culverts,
- Length of at-risk roadway, and
- Estimated population at risk.

A summary of the infrastructure and population at risk by administrative boundary is provided below.

Town of Drumheller

In the Town of Drumheller, residential buildings and population are mainly at risk in the communities of Rosedale and Lehigh during the 35-year return period from the Red Deer River. By the 200-year return period, residential areas, and populations in most of the riverside communities including Nacmine, Midland, Newcastle, North Drumheller, Central Drumheller, Willow Estates, Rosedale, Cambria, Lehigh, and East Coulee are affected. The number of residential buildings and the population at risk increases significantly between the 100- to 350-year return periods; this is due to an increase in inundation extent in Nacmine, Midland, Newcastle, Central Drumheller, and Riverside.

There are no non-residential buildings at risk for the 2- to 20-year return periods, and very few non-residential buildings (up to three) are at risk up to and including the 50-year return period. An increase in risk to non-residential buildings mainly start to occur for the 75-year return period, primarily in the community of North Drumheller. Key buildings that are at-risk in the Town of Drumheller for various return periods include the Town Hall, the Drumheller Health Centre, the RCMP building, and four schools.

In the Town of Drumheller, no bridges are at risk until the 20-year return period. Within the Town of Drumheller, 31 bridges are considered at risk for the 1000-year return period. The only culvert located within the study area is at risk starting at the 200-year return period.

Up to 96 km of roadway are considered at risk within the Town of Drumheller. For the 1000-year return period, significant portions of major roads within the town limits are at risk of inundation, with arterial roads and highways constituting 24% of the total at-risk roadway.

Within Drumheller, potential flood control structure failure mostly affects the areas behind the Nacmine Dike for the 5- to 100-year return periods, the Midland Dike for the 35- to 75-year return periods, the Newcastle Dike for the 20- to 75-year return periods, the Hospital Dike/Dike A for the 2- to 100-year return periods, Dike B for the 10- to 50-year return periods, Dike C for the 50-year return periods, Dike D for the 10- to 100-year return periods, the Willow Estate Dike for the 20- to 100-year return periods, and the East Coulee Dike for the 35- to 75-year return periods.

Most of the infrastructure and people at risk for the design flood are in the communities of Nacmine, Midland, Newcastle, North Drumheller, Riverside, Rosedale, Lehigh, and East Coulee areas.

Kneehill County

The second highest count of at-risk infrastructure (except for non-residential buildings) and population due to direct inundation is attributed to Kneehill County. In Kneehill County, residential buildings and populations residing near Kirkpatrick, along the Red Deer River; and near Dunphy, along Kneehills Creek; are at risk for the 75-year return period. For the 1000-year flood, two bridges over Kneehills Creek and up to 7.9 km of roadway are at risk in the county.

Starland County

Apart from the 11 commercial buildings affected, the quantity of other infrastructure and population at risk in Starland County is minimal.

Wheatland County

At-risk infrastructure and populations in Wheatland County are minimal.

Special Area No. 2

At-risk infrastructure and populations in Special Area No. 2 are minimal.

6 REFERENCES

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Northwest Hydraulic Consultants Ltd. (NHC), 2022a. Drumheller Hazard Study – Hydraulic Modelling and Flood Inundation Mapping Report. Report prepared for Alberta Environment and Parks.

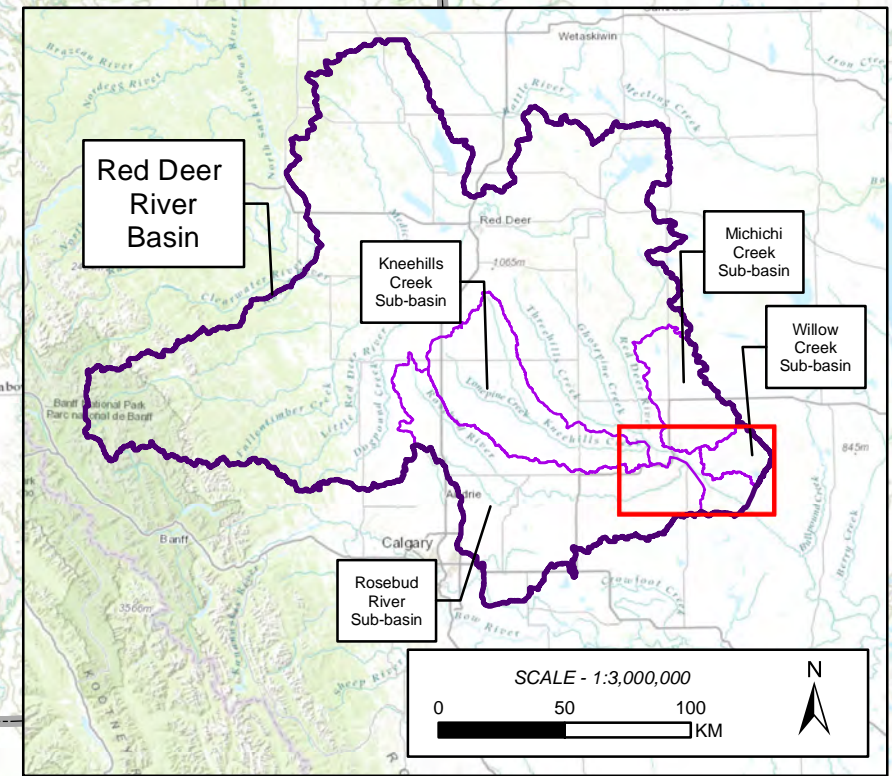
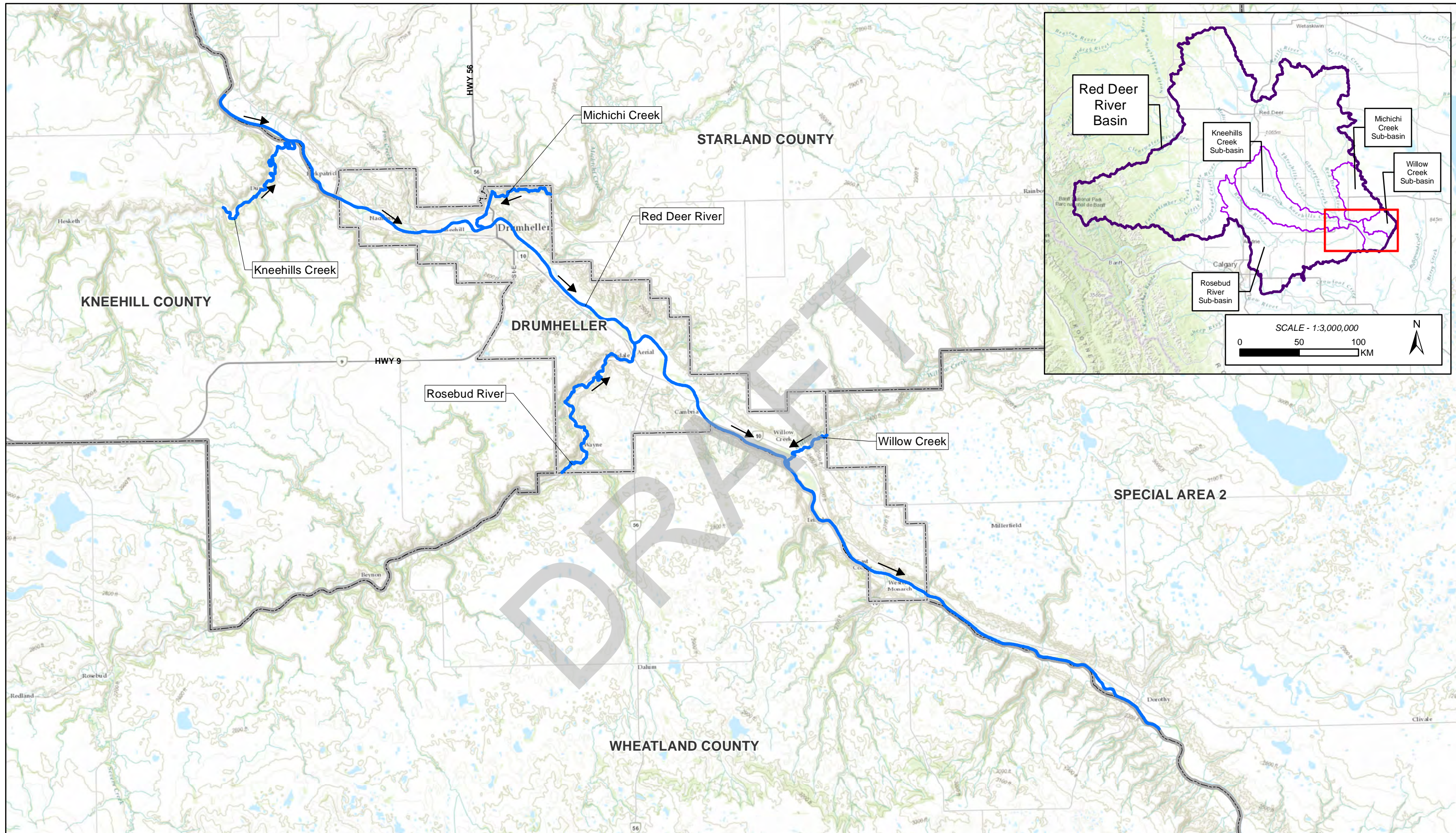
Northwest Hydraulic Consultants Ltd. (NHC), 2022b. Drumheller River Hazard Study – Design Flood Hazard Mapping Report. Report prepared for Alberta Environment and Parks.

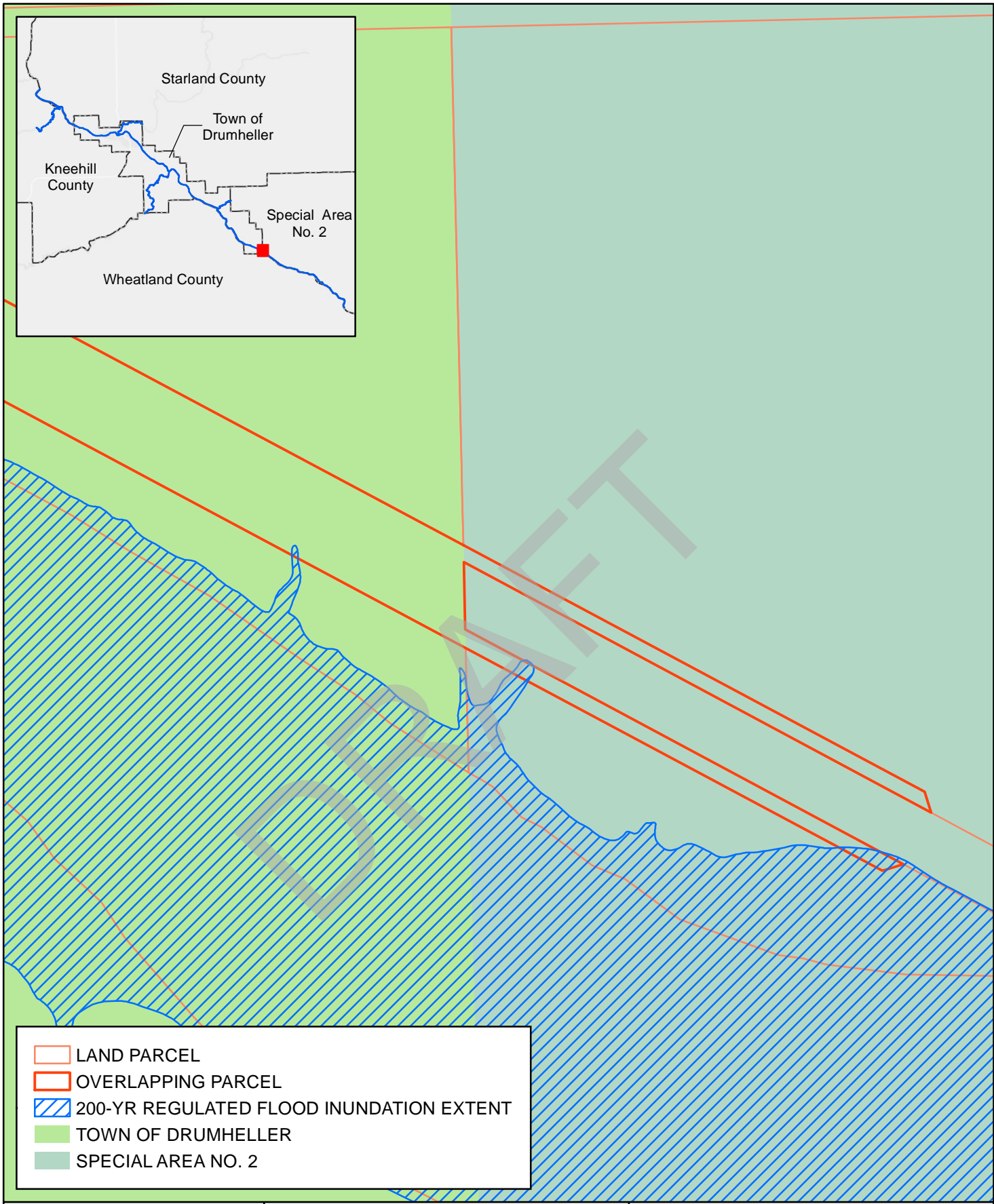
Statistics Canada, 2016. 2016 Census – Boundary Files Statistics Canada. Data set accessed at <https://www12.statcan.gc.ca/census-recensement/2011/geo/bound-limit/bound-limit-2016-eng.cfm>.




Statistics Canada, 2018. National Road Network – NRN – GeoBase Series. Data set accessed at <https://www12.statcan.gc.ca/census-recensement/2011/geo/RNF-FRR/index-j-eng.cfm?year=18>.

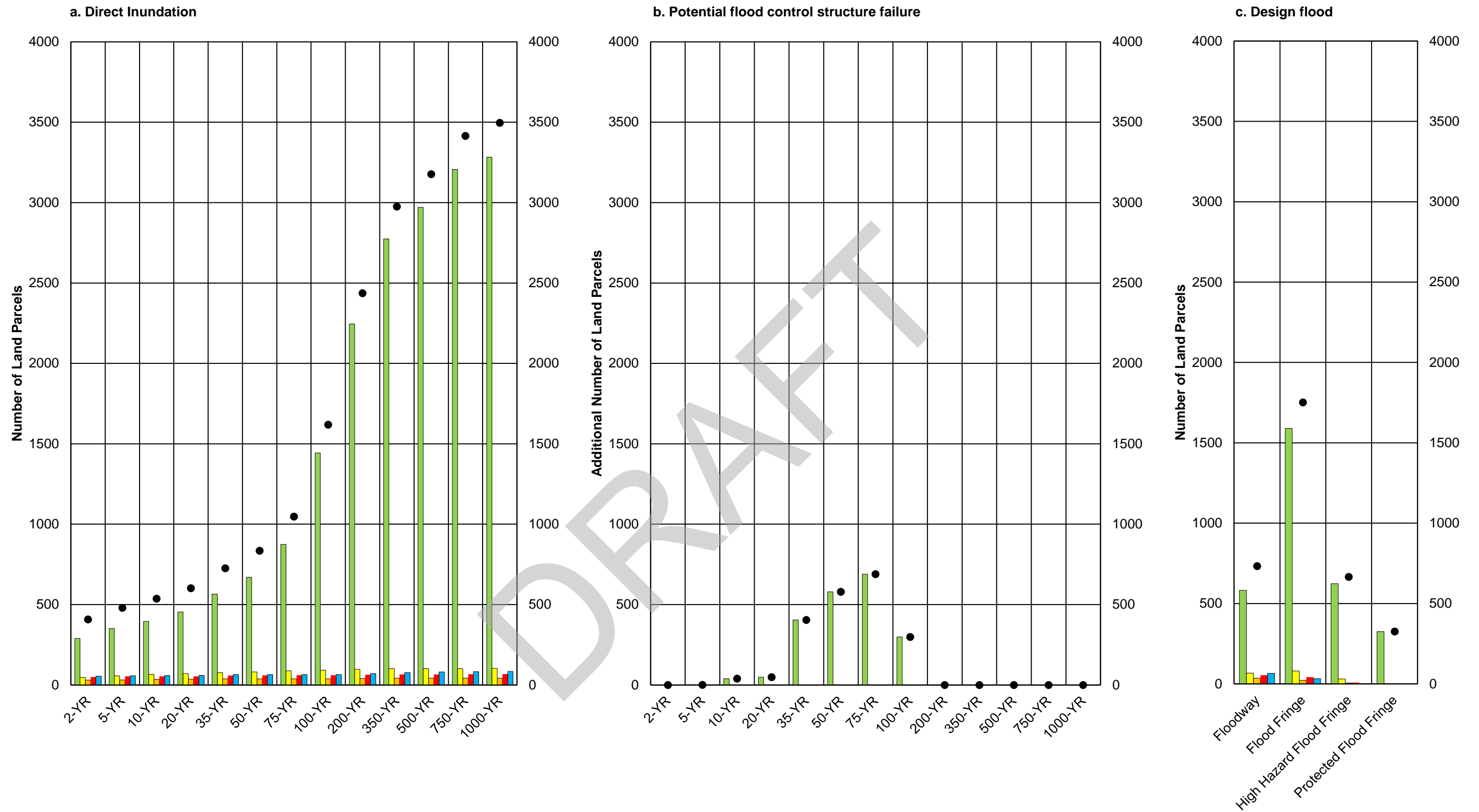
Figures

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	<p>SCALE - 1:3,500</p> <p>0 50 100 M</p> 	<p>DRUMHELLER RIVER HAZARD STUDY FLOOD RISK INVENTORY & ASSESSMENT</p>
	<p>Coordinate System: NAD 1983 CSRS 3TM 114; Vertical Datum: CGVD28 HTv2.0; Units: Metres</p> <p>Job: 1003877 Date: 15-JUN-2022</p>	<p>LAND PARCEL & ADMINISTRATIVE UNIT BOUNDARY OVERLAP</p> <p style="text-align: right;">FIGURE 2</p>



- Town of Drumheller
- Wheatland County
- Kneehill County
- Special Area No. 2
- Starland County
- Total

Notes

1. Flood fringe includes high hazard flood fringe and protected flood fringe.

SCALE - AS SHOWN

Coordinate System:
Units: As Shown

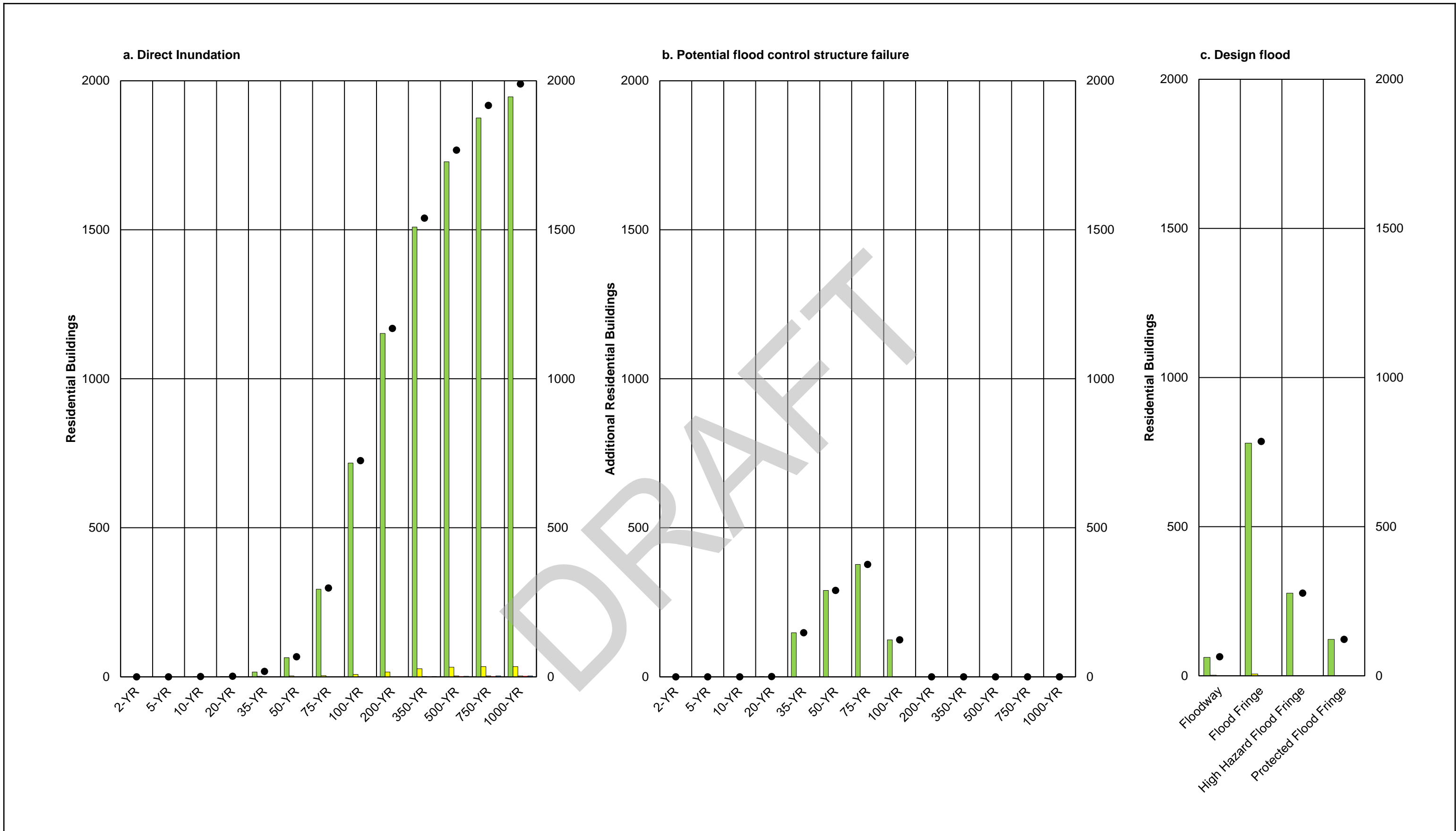
Job: 1003877

Date: 08-DEC-2022

DRUMHELLER RIVER HAZARD STUDY
FLOOD RISK INVENTORY AND ASSESSMENT

LAND PARCELS AT RISK DUE TO FLOODING

FIGURE 3



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■ Town of Drumheller	■ Wheatland County
■ Kneehill County	■ Special Area No. 2
■ Starland County	● Total

Notes
 1. Flood fringe includes high hazard flood fringe and protected flood fringe.

SCALE – AS SHOWN

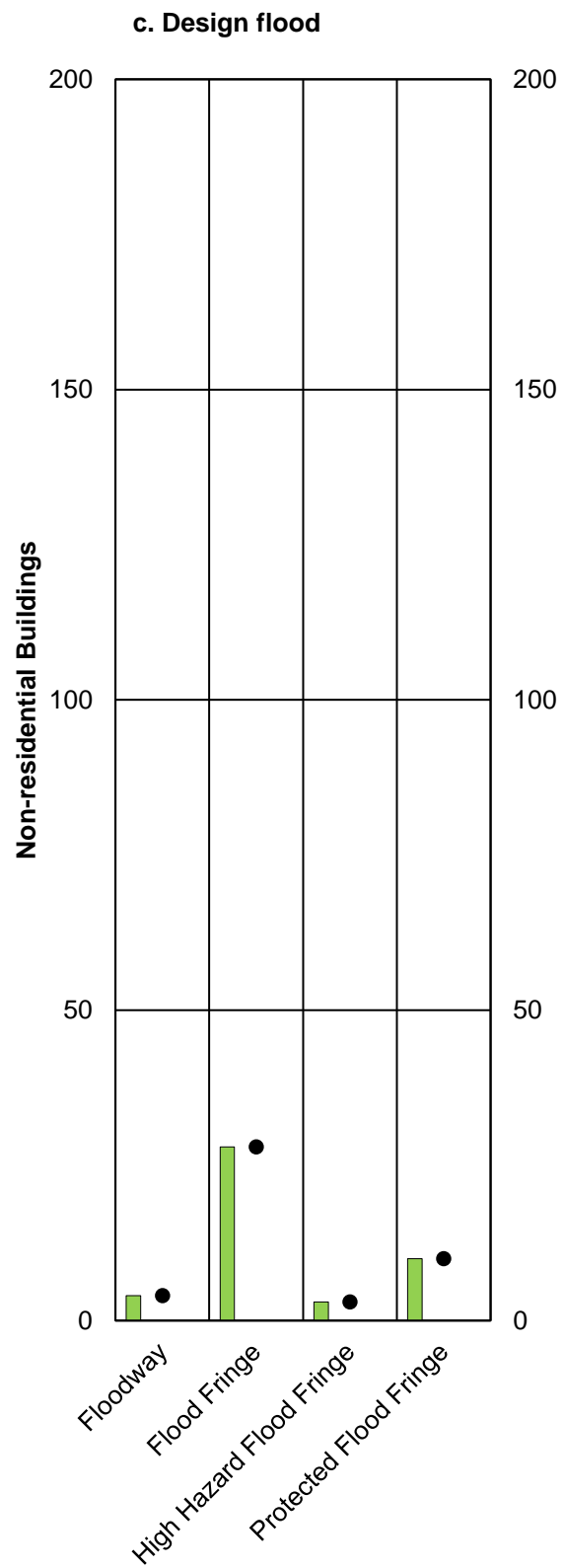
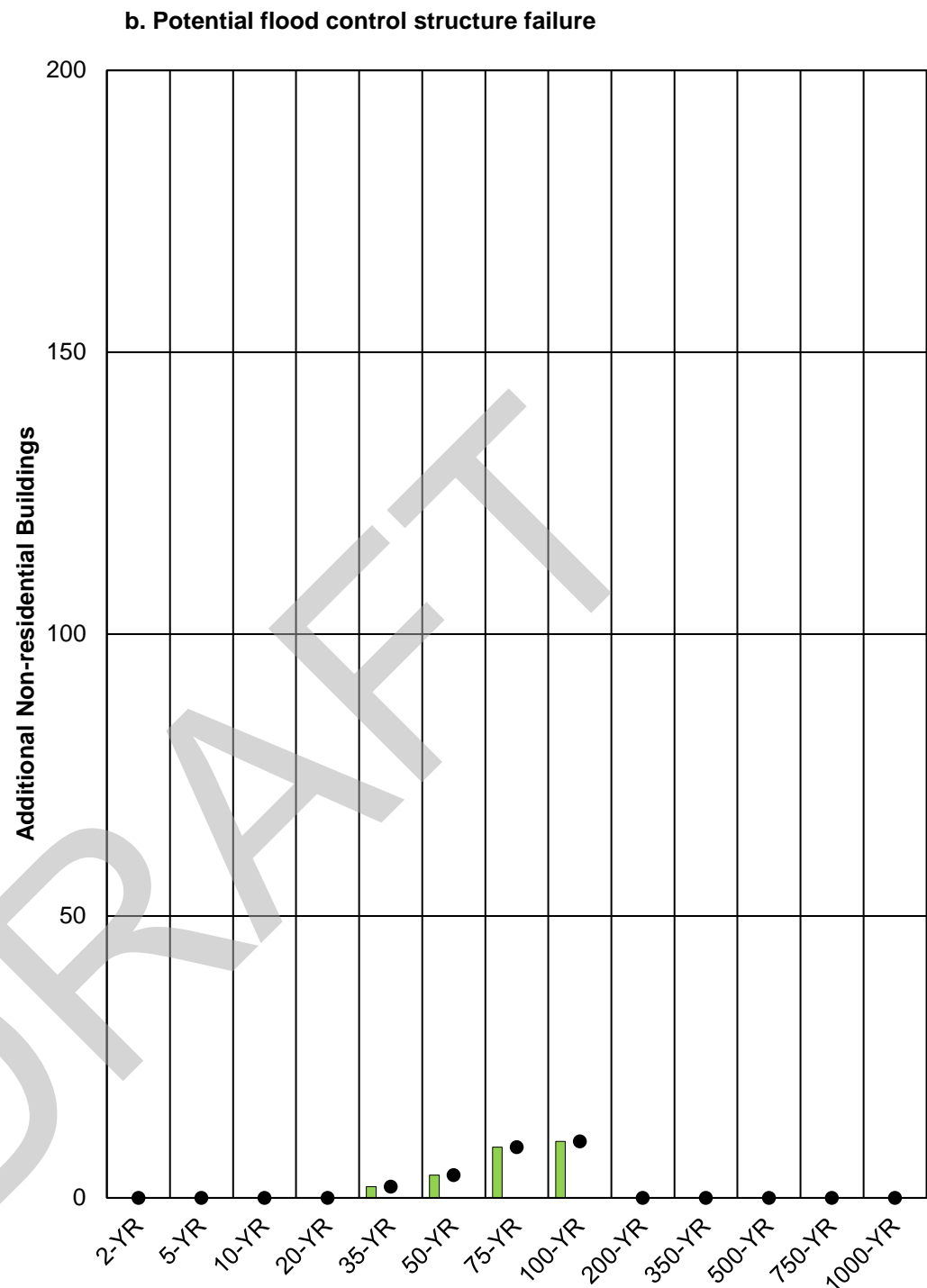
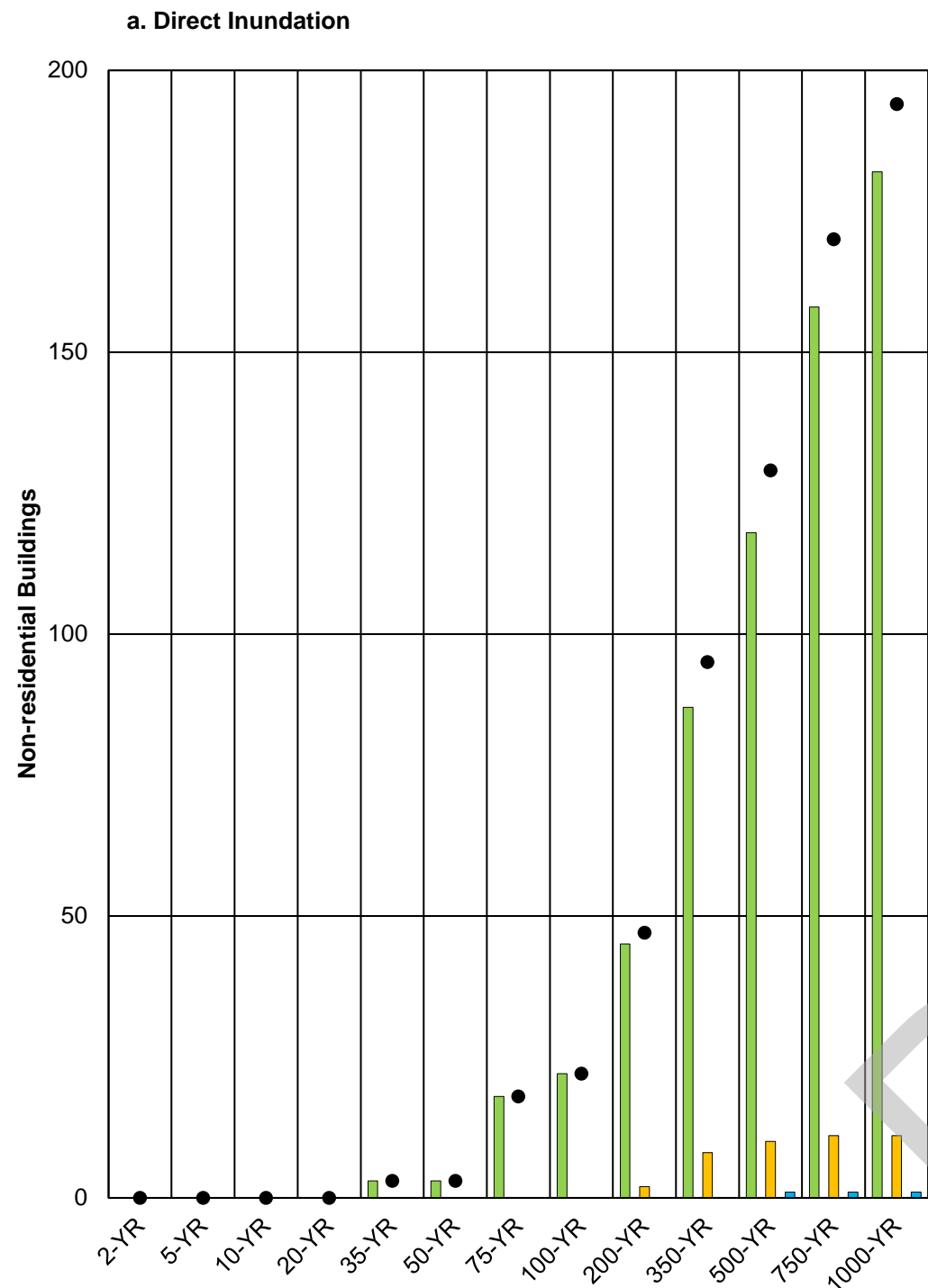
Coordinate System:
Units: As Shown

Job: 1003877 Date: 08-DEC-2022

DRUMHELLER RIVER HAZARD STUDY
 FLOOD RISK INVENTORY AND ASSESSMENT

RESIDENTIAL BUILDINGS AT RISK DUE TO FLOODING

FIGURE 4



- Town of Drumheller
- Wheatland County
- Kneehill County
- Special Area No. 2
- Starland County
- Total

Notes

- Flood fringe includes high hazard flood fringe and protected flood fringe
- No non-residential buildings at risk in Kneehill County and Wheatland County.

SCALE – AS SHOWN

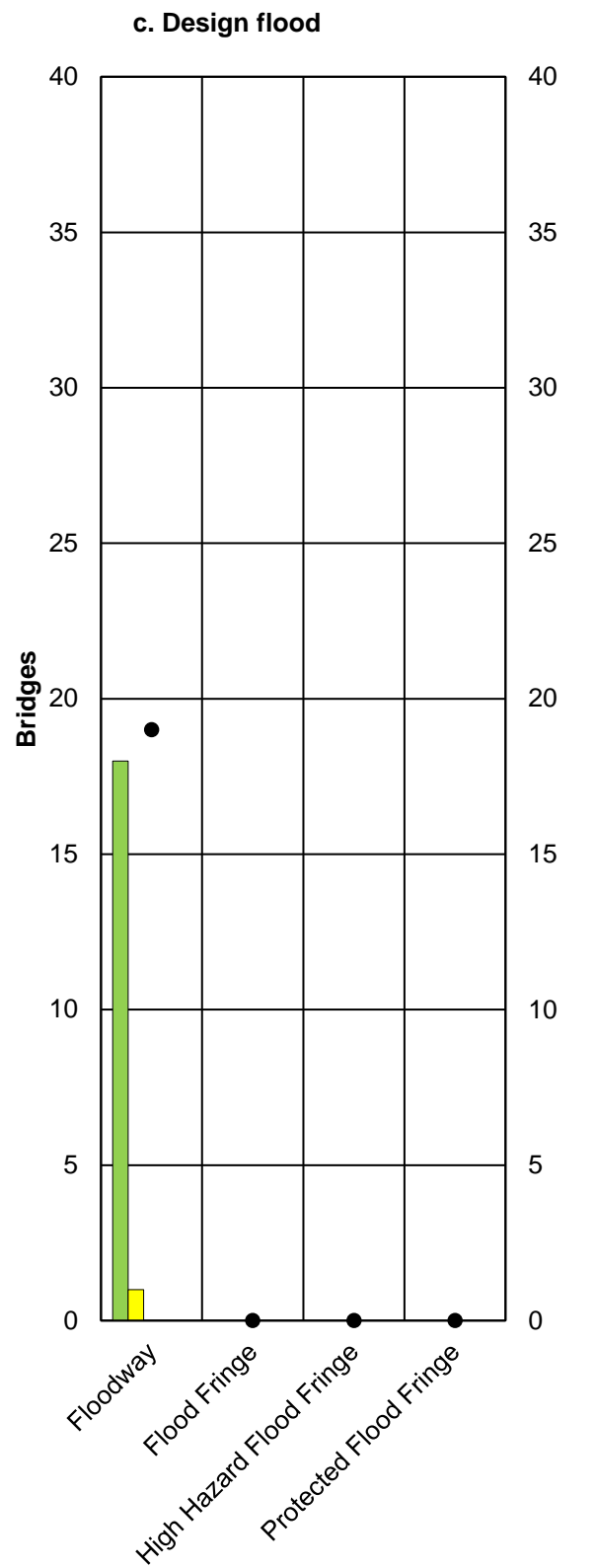
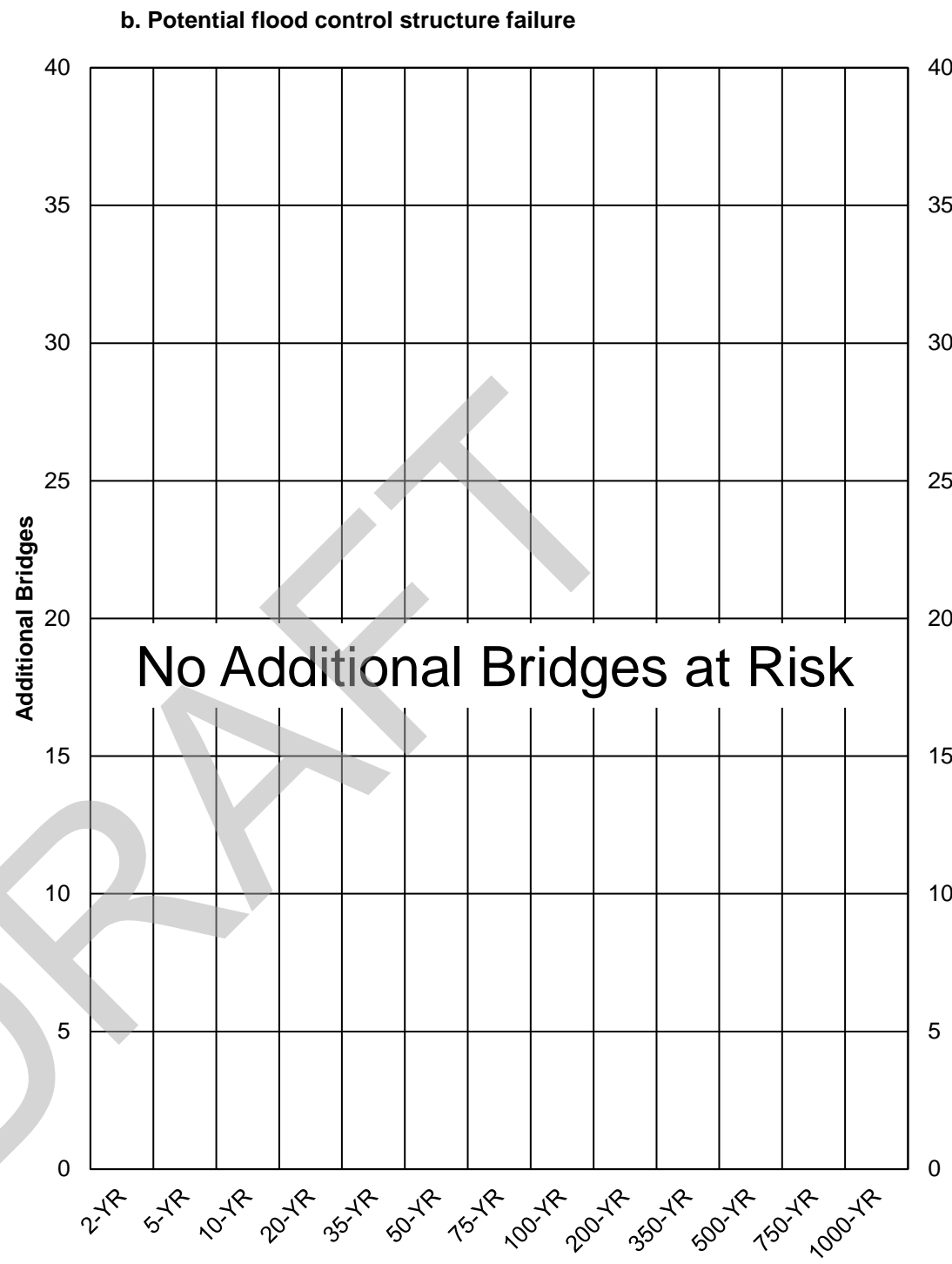
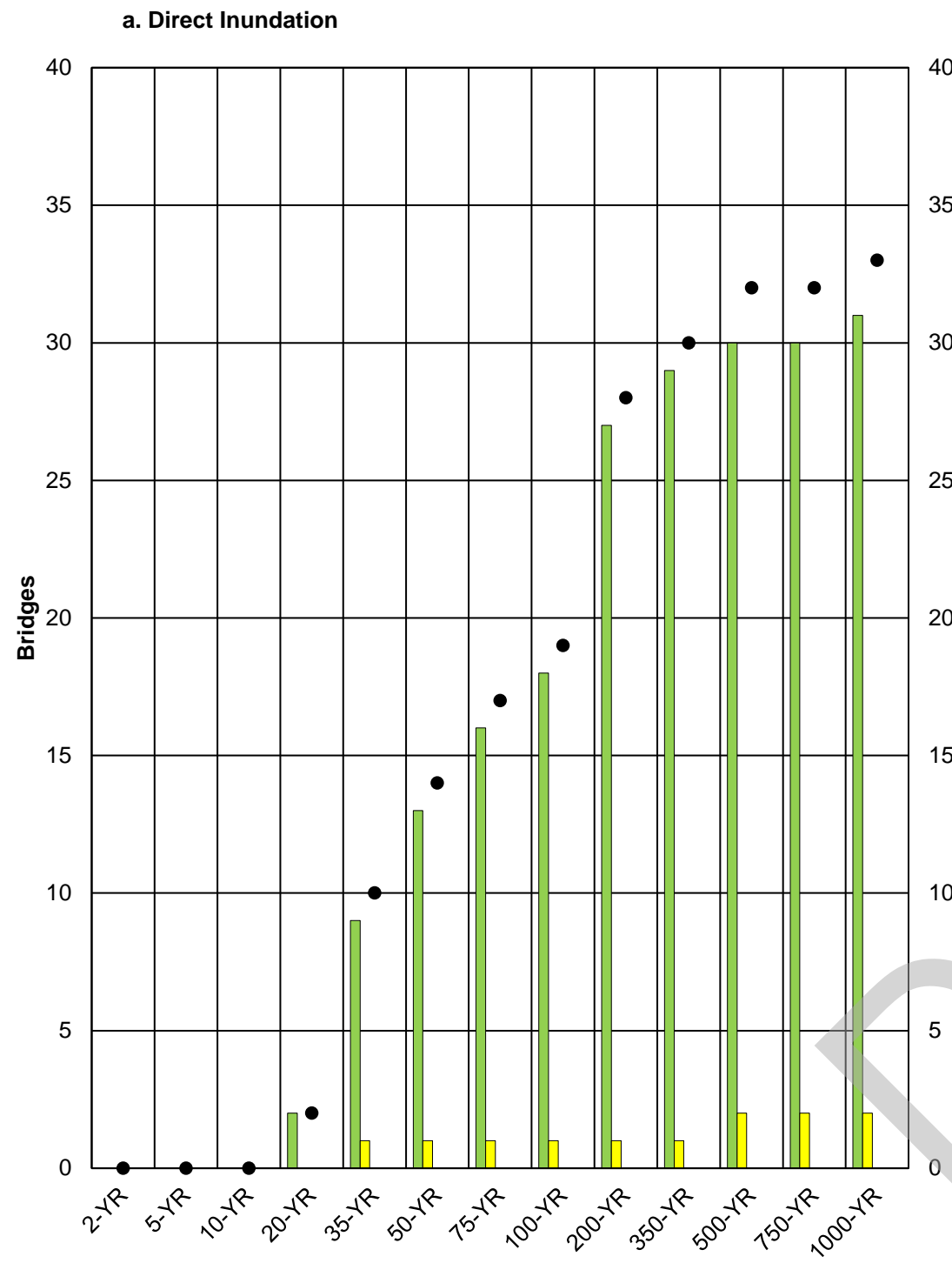
Coordinate System:
Units: As Shown

Job: 1003877 Date: 08-DEC-2022

DRUMHELLER RIVER HAZARD STUDY
FLOOD RISK INVENTORY AND ASSESSMENT

**NON-RESIDENTIAL
BUILDINGS AT RISK DUE TO
FLOODING**

FIGURE 5



- Town of Drumheller
- Kneehill County
- Starland County
- Wheatland County
- Special Area No. 2
- Total

Notes

1. Flood fringe includes high hazard flood fringe and protected flood fringe
2. No bridges at risk in Starland County, Wheatland County and Special Area No. 2.

SCALE – AS SHOWN

Coordinate System:
Units: As Shown

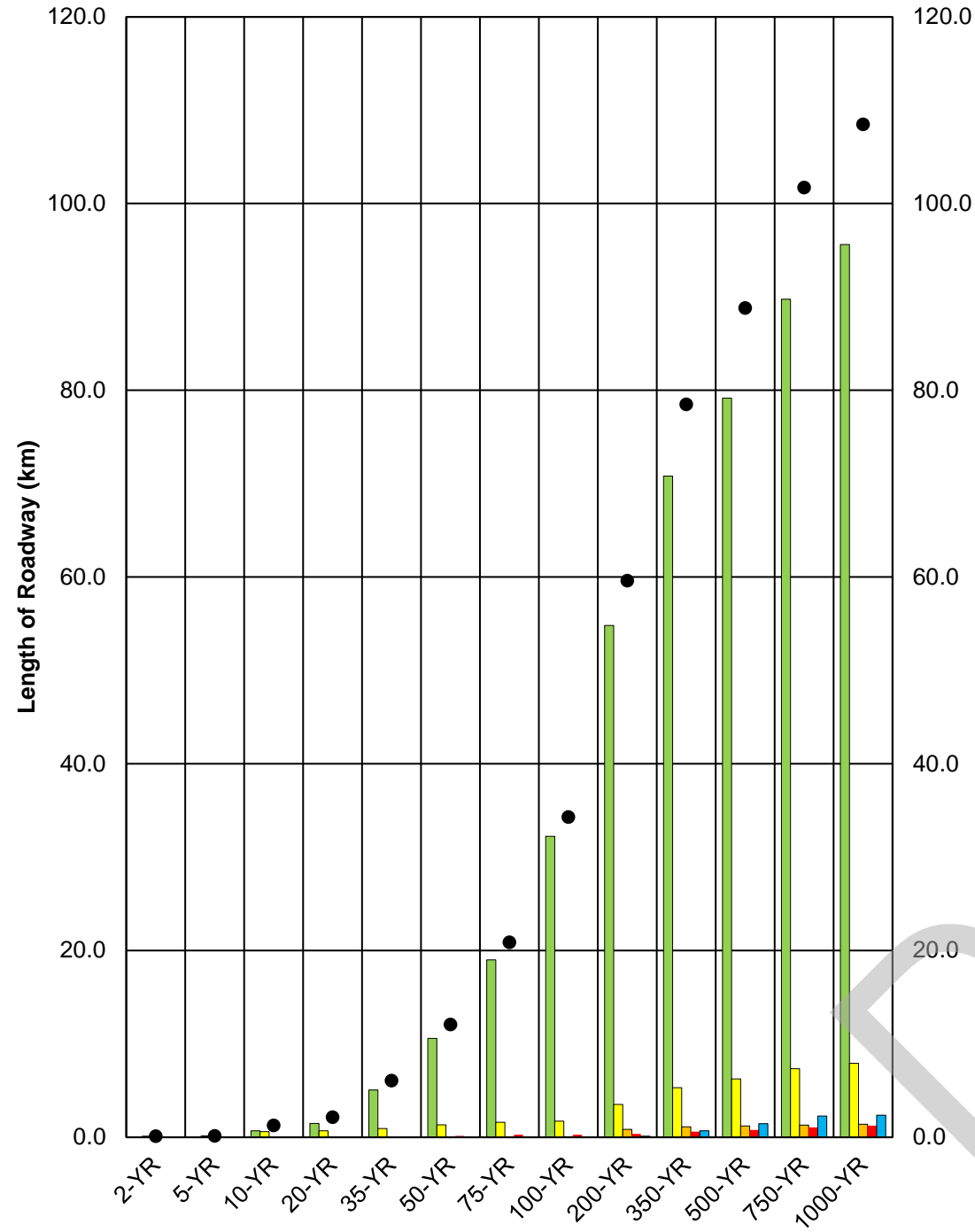
Job: 1003877 Date: 08-DEC-2022

DRUMHELLER RIVER HAZARD STUDY
FLOOD RISK INVENTORY AND ASSESSMENT

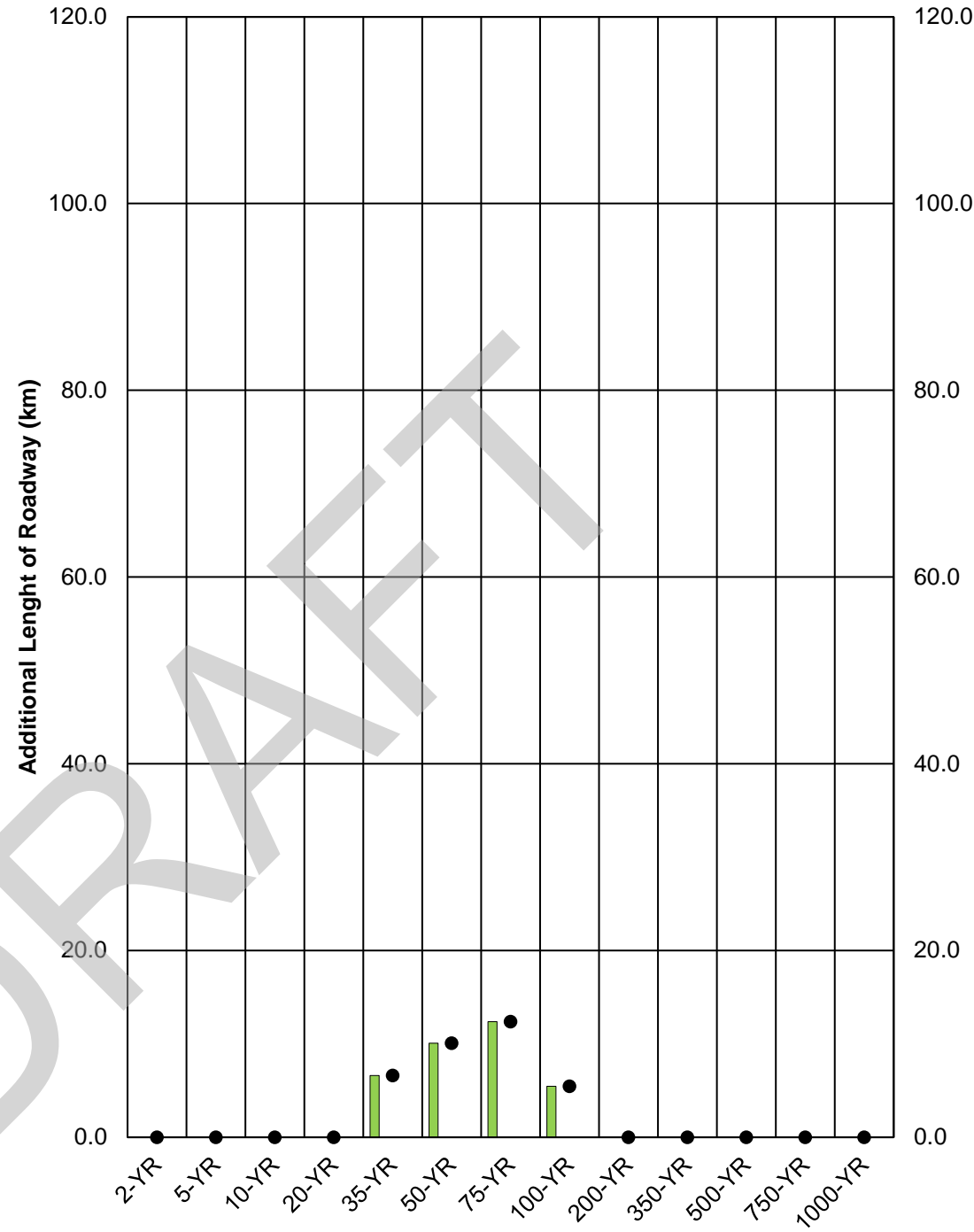
BRIDGES AT RISK DUE TO FLOODING

FIGURE 6

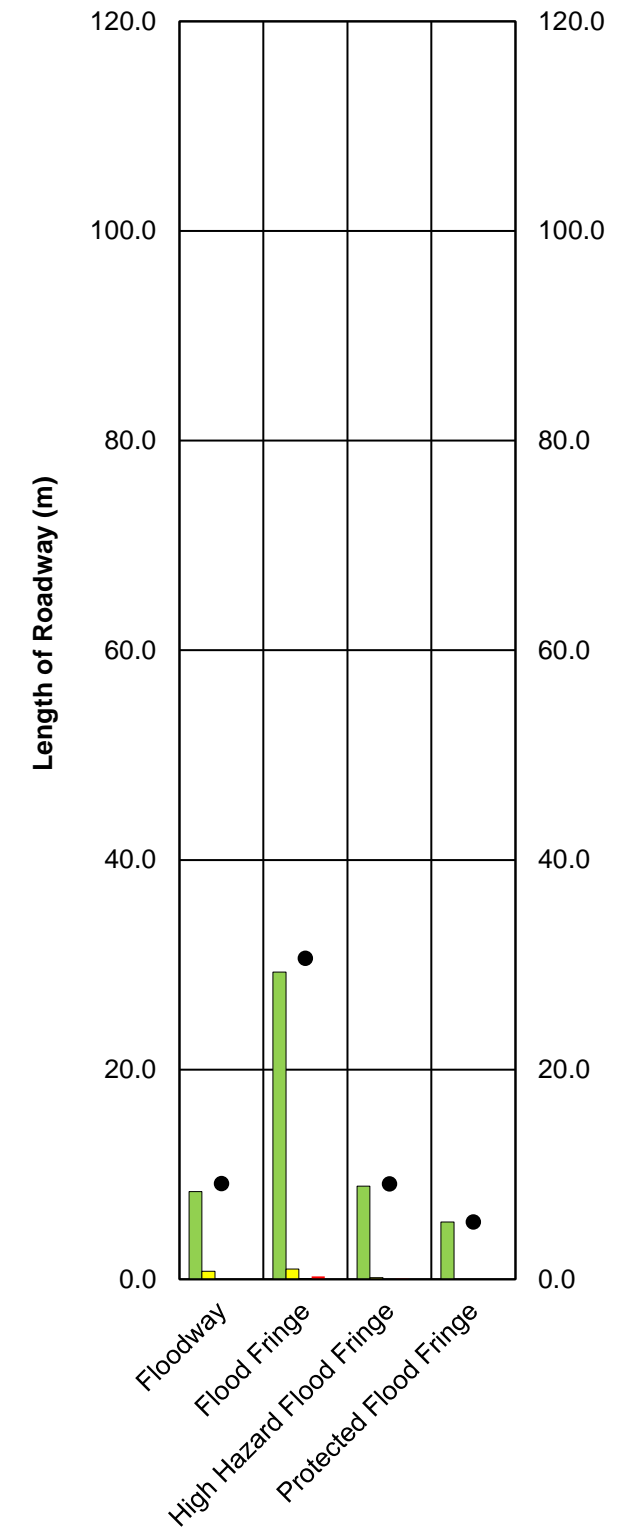
a. Direct Inundation



b. Potential flood control structure failure



c. Design flood



- Town of Drumheller
- Wheatland County
- Kneehill County
- Special Area No. 2
- Starland County
- Total

Notes

1. Flood fringe includes high hazard flood fringe and protected flood fringe.

SCALE - AS SHOWN

Coordinate System:
Units: As Shown

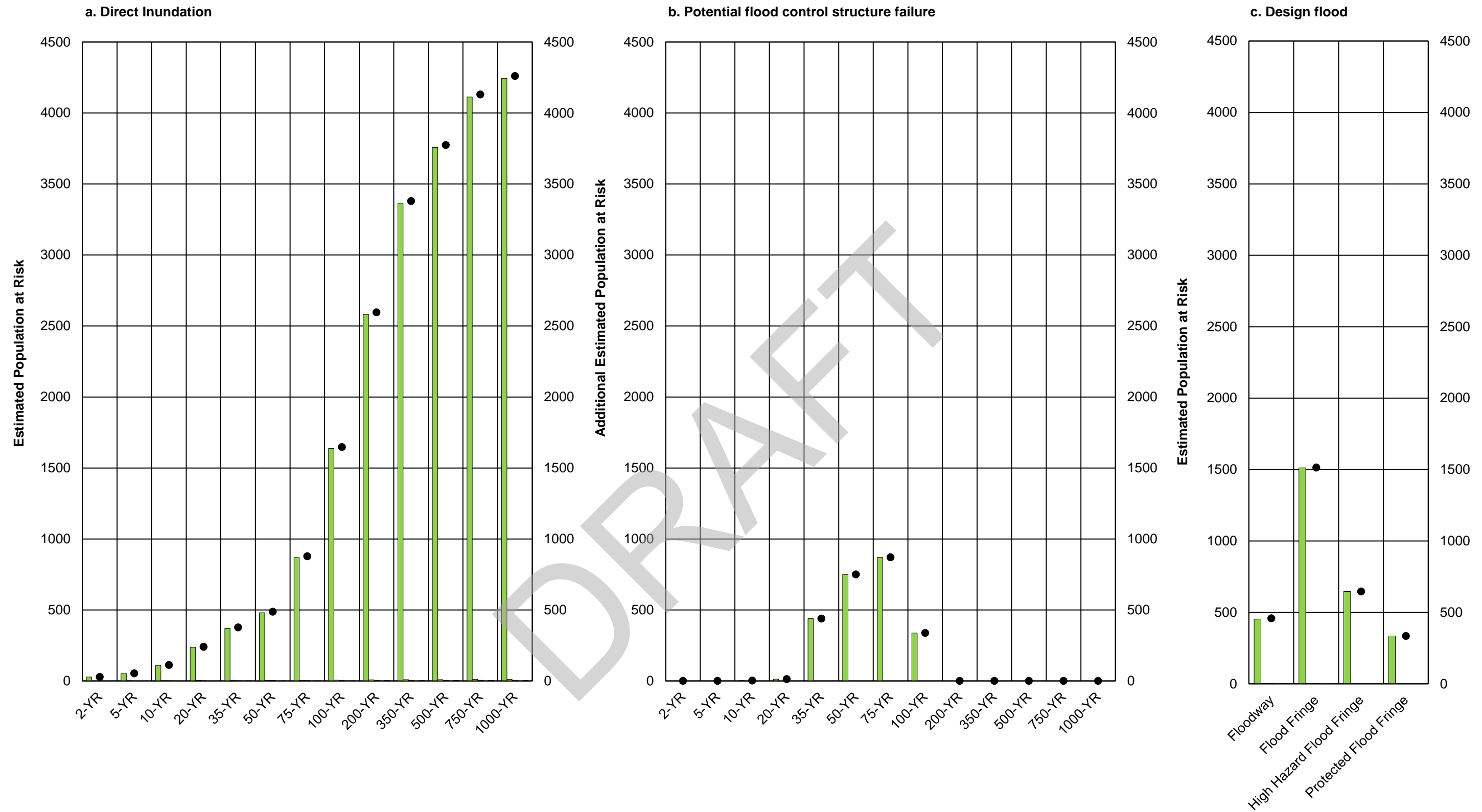
Job: 1003877

Date: 08-DEC-2022

DRUMHELLER RIVER HAZARD STUDY
FLOOD RISK INVENTORY AND ASSESSMENT

**ROADWAY AT RISK DUE TO
FLOODING**

FIGURE 7



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- Town of Drumheller
- Kneehill County
- Starland County
- Wheatland County
- Special Area No. 2
- Total

Notes
 1. Flood fringe includes high hazard flood fringe and protected flood fringe.

SCALE – AS SHOWN

Coordinate System:
 Units: As Shown

Job: 1003877 Date: 08-DEC-2022

DRUMHELLER RIVER HAZARD STUDY
 FLOOD RISK INVENTORY AND ASSESSMENT

POPULATION AT RISK DUE TO FLOODING

FIGURE 8

Appendix A
Spatial Data Digital Files

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Spatial Data Summary - Risk Assessment

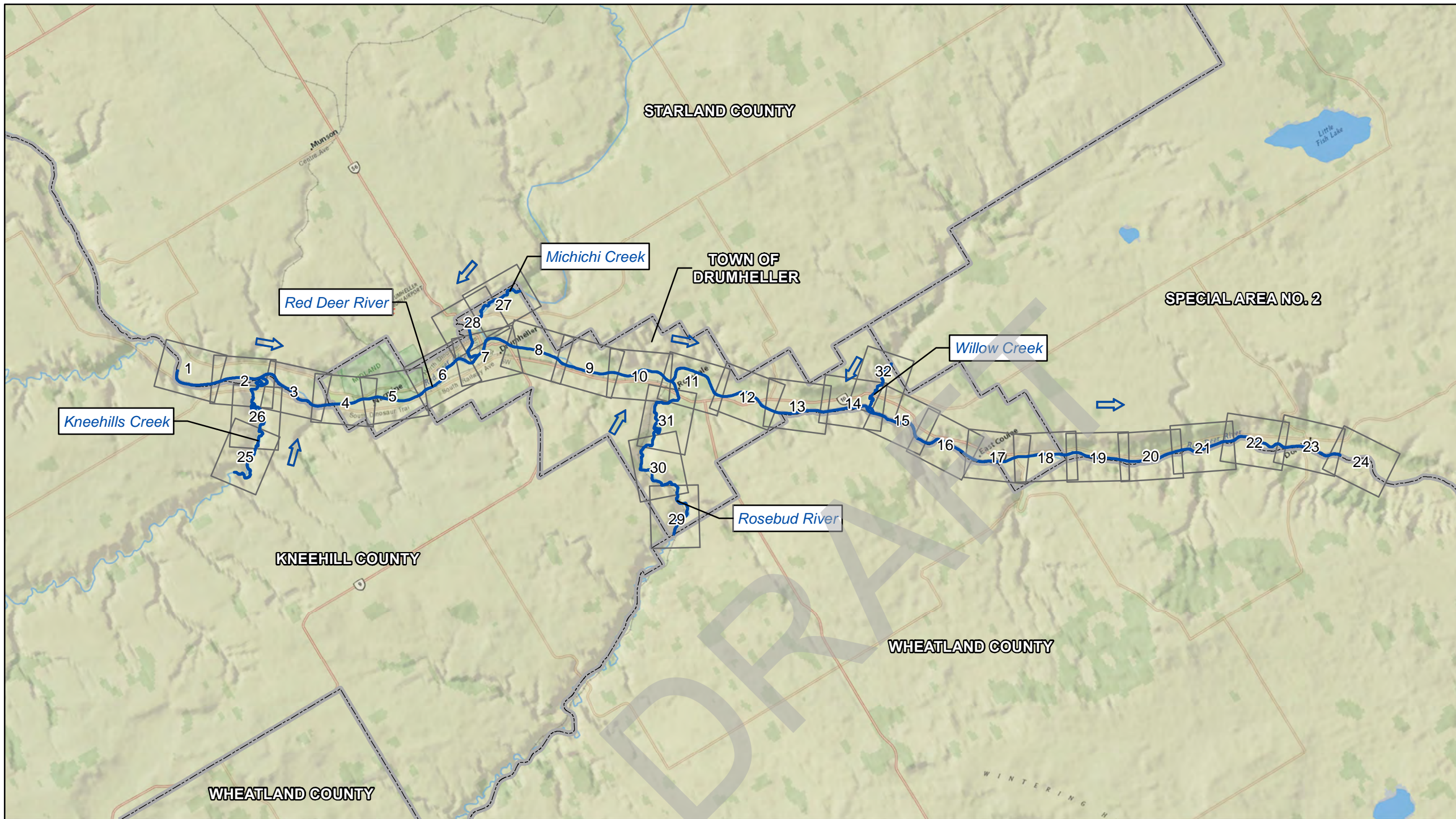
TITLE	DESCRIPTION	KEY ATTRIBUTE DESCRIPTION	SOURCE	FOLDER or GDB	FILE
Cadastral Data	Title of ownership parcels located within a 200m buffer of the 1000-year flood extent. Portions of land parcels located within the main channel, as defined by the waterbodies feature class, are removed. <i>Esri file geodatabase polygon feature class.</i>	PARCELID: unique parcel ID assigned by the Government of Alberta.	Alberta Environment and Parks	/DRHS_RiskAssessment.gdb	Cadastral
Structures	Building centroid of residential and non-residential structures located within the 1000-year flood extent. <i>Esri file geodatabase point feature class.</i>	CATEGORY: building type ("residential" or "non-residential"); SUB_CATEGORY: building sub-type ("retirement home", "single family", "multi-family", "commerical", "government", "hospital", "industrial", "other", "school", "wastewater treatment", or "water treatment"); COMMENT: Additional description provided for certain "government", "school", "commercial", or "other" buildings; ADDRESS: Provided for buildings digitized in 2015 Provincial Flood Damage Assessment Study.	Centroids digitized and classified by NHC based on buildings previously digitized by IBI for the 2015 Provincial Flood Damage Assessment Study, 2019 orthoimagery, and Google Street View.	/DRHS_RiskAssessment.gdb	Buildings
Bridges	Centroids of bridges located along study reaches - as determined by field survey. <i>Esri file geodatabase line feature class.</i>	NAME: Unique ID assigned by NHC; DESCRIP: Bridge description; RIVER: Study reach that the bridge is located on; WIDTH: Bridge width in metres; Shape_Length: Bridge deck length in metres; RS: Bridge river station; OVERTOP_ELV: maximum low chord elevation from HEC-RAS model (in metres). Value is compared with water surface elevation to determine if structure is impacted by flooding - to be extracted from model.	NHC field survey	/DRHS_RiskAssessment.gdb	Bridges
Culverts	Centroids of culverts located along study reaches - as determined by field survey. <i>Esri file geodatabase line feature class.</i>	NAME: Unique ID assigned by NHC; DESCRIP: Culvert description RIVER: Study reach that culvert is located on; DIAMETER: Culvert diameter in metres; Shape_Length: Culvert length in metres; RS: Culvert river station; OVERTOP_ELV: Elevation of approach road determined from bare earth DEM. Value is compared with water surface elevation to determine mine if structure is impacted by flooding - to be extracted form model.	NHC field survey	/DRHS_RiskAssessment.gdb	Culverts
Census Dissemination Blocks	Census dissemination blocks that intersect the 1000-year flood extent with a 200m buffer. Dissemination block geometry and 2016 census results were downloaded from Statistics Canada and merged. Portions of dissemination blocks located within the main channel (as defined by NRCan's National Hydrology Network), were removed. <i>Esri file geodatabase polygon feature class.</i>	DBUID: unique dissemination block ID; POP_2016: population residing in dissemination block as per 2016 census (Statistics Canada); DWELL_2016: number of private dwellings located within dissemination block.	Census dissemination blocks and 2016 census results acquired from StatsCan	/DRHS_RiskAssessment.gdb	Population

Administrative Boundaries	Boundaries of Cypress County, City of Medicine Hat and the Town of Redcliff. Acquired from Altalis. <i>Esri file geodatabase polygon feature class.</i>	NAME: Name of administrative unit ADMIN_ID: unique ID assigned by Altalis Ltd.	Municipal boundaries acquired from Altalis Ltd.	/DRHS_RiskAssessment.gdb	AdminUnits
Rail Network	Railway lines located with a 200m buffer of the 1000-year flood extent. Rail sections that are located on bridges were removed to ensure these areas were not double-counted. <i>Esri file geodatabase line feature class.</i>	TRACKCLASS: type of rail; STATUS: Status = Discontinued for all in study area; Name: Track owner/operator.	National Railway Network with manual edits made by NHC to align railways with 2019 orthoimagery and to remove sections of road network that are coincident with bridges or culverts. Note that all railways in the area are currently abandoned.	/DRHS_RiskAssessment.gdb	Railway
Road Network	Road network segments located within a 200m buffer of the 1000-year flood extent. Sections of roadway that are located on bridges were removed to ensure that they were not double-counted. <i>Esri file geodatabase line feature class.</i>	ROADCLASS: Type of road (Collector, Local / Street, Expressway / Highway, etc...) STR_NAME: Street name ADMIN_UNIT: Administrative unit in which road segment is primarily located.	National Road Network with manual edits made by NHC to align road network with 2019 orthoimagery and to remove sections of road network that are coincident with bridges or culverts.	/DRHS_RiskAssessment.gdb	Roadway

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Appendix B
Flood Risk Assessment and Inventory Spatial Data Maps

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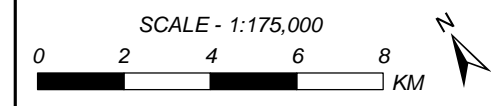
- FLOW DIRECTION
- STUDY REACH
- MAP SHEET
- MUNICIPAL BOUNDARY

Note to Users:

1. Please refer to the accompanying **Drumheller River Hazard Study – Flood Risk Inventory and Assessment Report** (issued June 2022) for important information concerning these maps.

Data Sources and References:

1. Land parcels acquired from Altalis Ltd. and Alberta Environment and Parks.
2. Road data acquired from NRCan (National Road Network).
3. Census dissemination blocks and 2016 census results acquired from Statistics Canada.
4. Residential and non-residential structures were acquired from IBI Group (2015) and updated by NHC based on 2019 orthoimagery and Google Street View.
5. Orthoimagery acquired by OGL Engineering for Alberta Environment and Parks.
6. Additional base spatial data acquired from Altalis Ltd. and NRCan.
7. Additional basemaps from Esri.

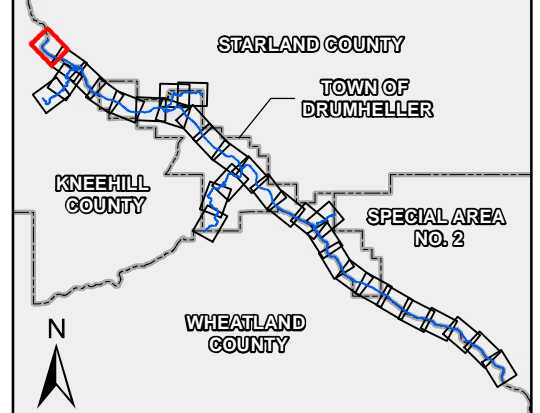
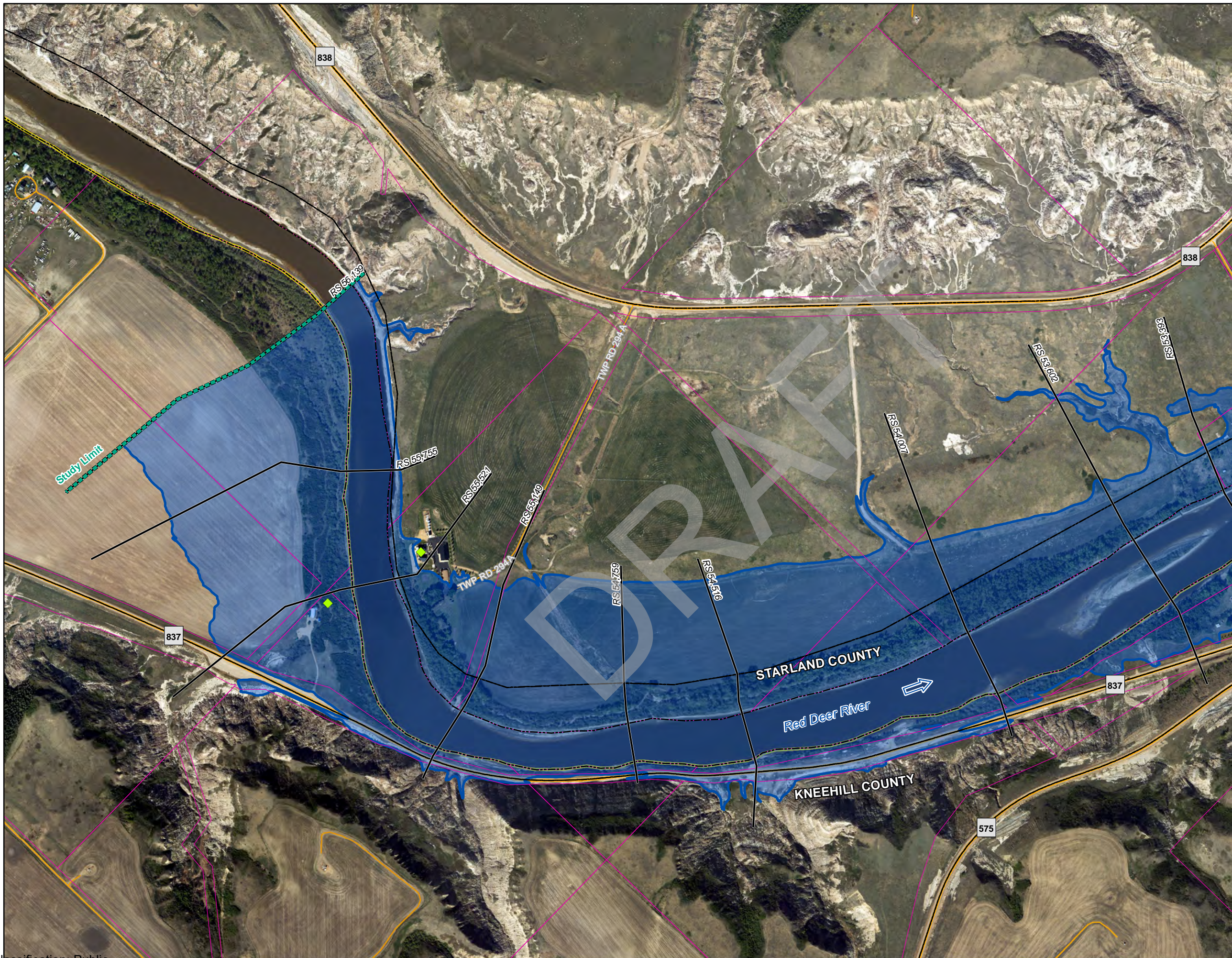


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Vertical Datum: CGVD28 HTV2.0; Units: Metres

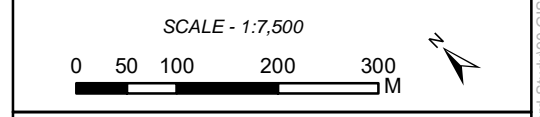
Engineer	GIS	Reviewer
MMM	REH	RBA
Job: 1003877		Date: 15-JUN-2022

**DRUMHELLER RIVER HAZARD STUDY
FLOOD RISK INVENTORY
AND ASSESSMENT**

SPATIAL DATA INVENTORY



- FLOW DIRECTION
 - MODEL CROSS SECTION
 - RIVER STATION
 - FLOOD CONTROL STRUCTURE
 - BRIDGE
 - CULVERT
 - MAJOR ROAD
 - LOCAL ROAD
 - MUNICIPAL BOUNDARY
 - CENSUS UNIT
 - LAND PARCEL
 - 1000-YEAR OPEN WATER REGULATED FLOOD EXTENT
- STRUCTURES**
- School
 - Commercial
 - Government
 - Hospital
 - Water Treatment
 - WW Treatment
 - Industrial
 - Other
 - Retirement Home
 - Single Family
 - Multi-family



Coordinate System: NAD 1983 CSRS 3TM 114
Vertical Datum: CGVD28 HTv2.0; Units: Metres

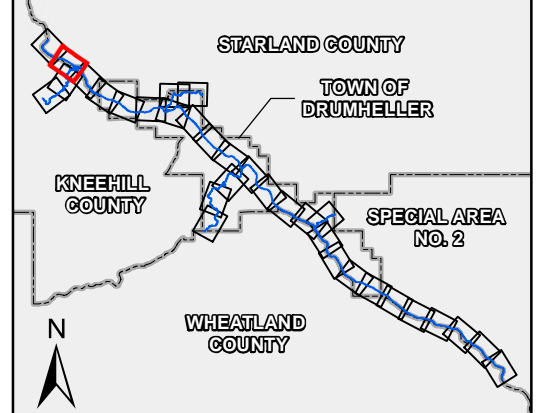
Engineer	GIS	Reviewer
MMM	REH	RBA

Job: 1003877 Date: 15-JUN-2022

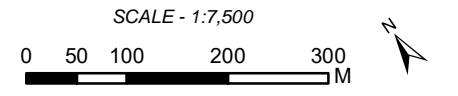
**DRUMHELLER RIVER HAZARD STUDY
FLOOD RISK INVENTORY
AND ASSESSMENT**

SPATIAL DATA INVENTORY

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- FLOW DIRECTION
 - MODEL CROSS SECTION
 - RS 12,345 RIVER STATION
 - FLOOD CONTROL STRUCTURE
 - BRIDGE
 - CULVERT
 - MAJOR ROAD
 - LOCAL ROAD
 - MUNICIPAL BOUNDARY
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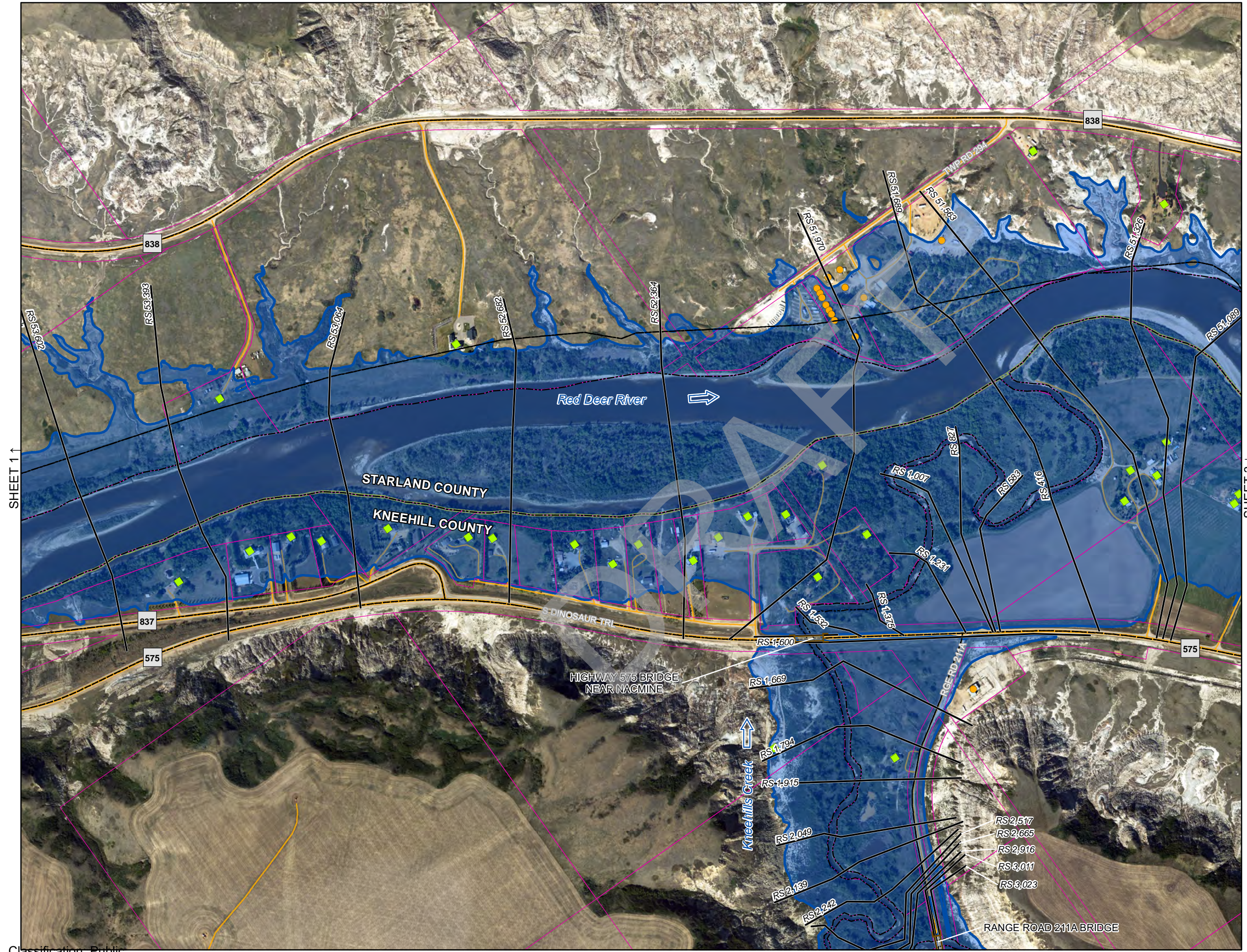
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Engineer	GIS	Reviewer
MMM	REH	RBA

Job: 1003877 Date: 15-JUN-2022

**DRUMHELLER RIVER HAZARD STUDY
FLOOD RISK INVENTORY
AND ASSESSMENT**

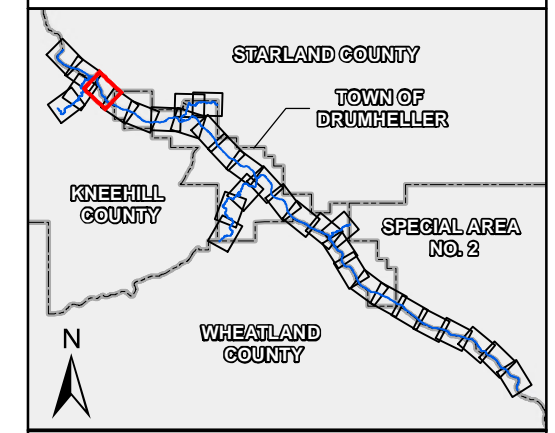
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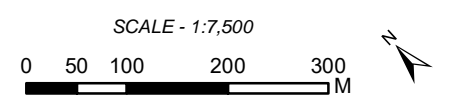
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SHEET 3 ↓

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- FLOW DIRECTION
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Coordinate System: NAD 1983 CSRS 3TM 114
Vertical Datum: CGVD28 HTv2.0; Units: Metres

Engineer	GIS	Reviewer
MMM	REH	RBA

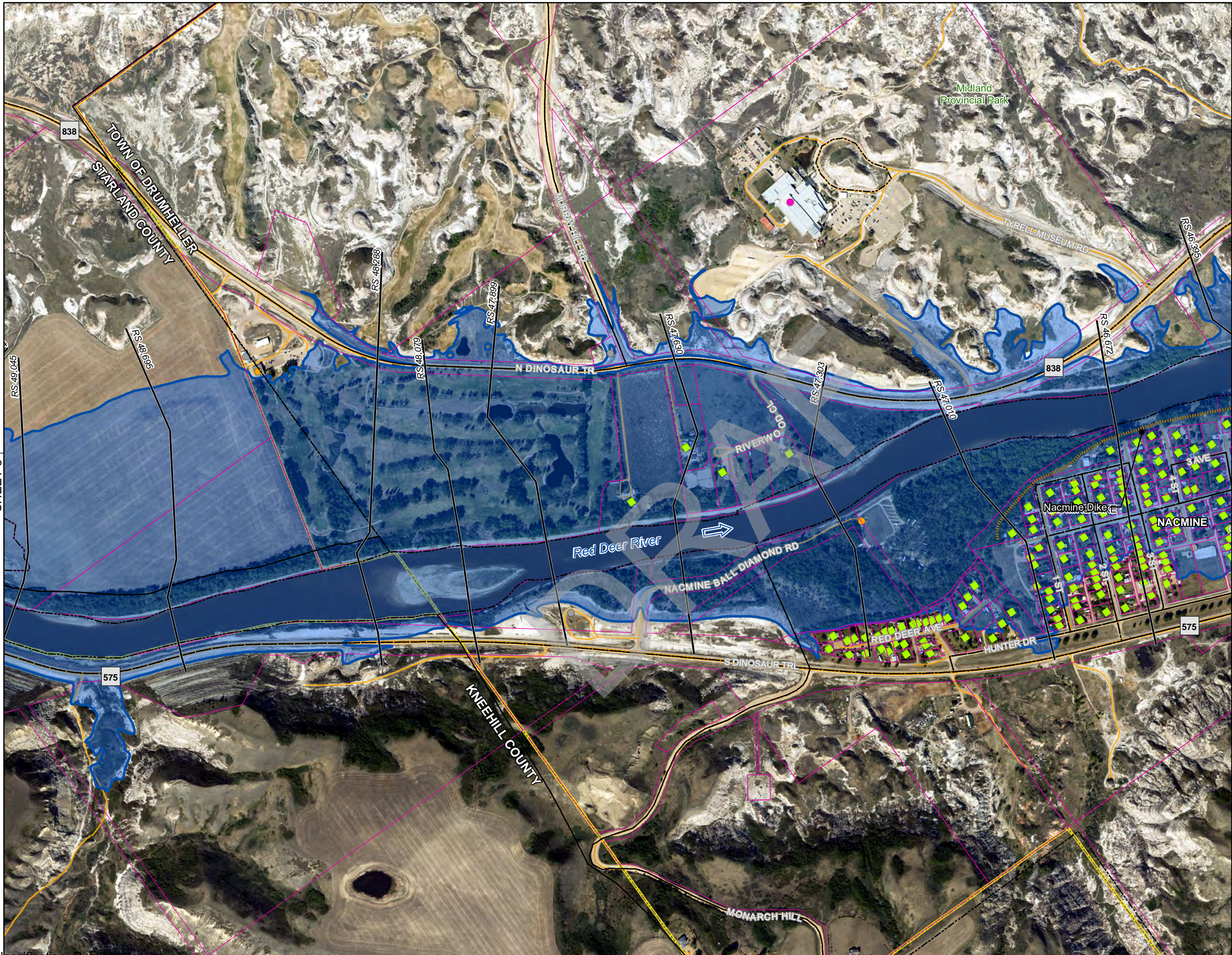
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**DRUMHELLER RIVER HAZARD STUDY
FLOOD RISK INVENTORY
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SPATIAL DATA INVENTORY

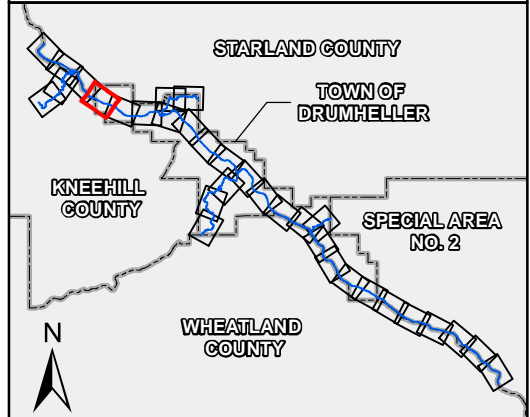
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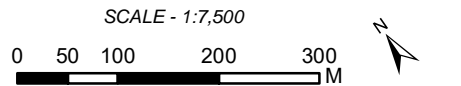


SHEET 3 ↑

↓ SHEET 5



- FLOW DIRECTION
 - MODEL CROSS SECTION
 - RS 12,345 RIVER STATION
 - FLOOD CONTROL STRUCTURE
 - BRIDGE
 - CULVERT
 - MAJOR ROAD
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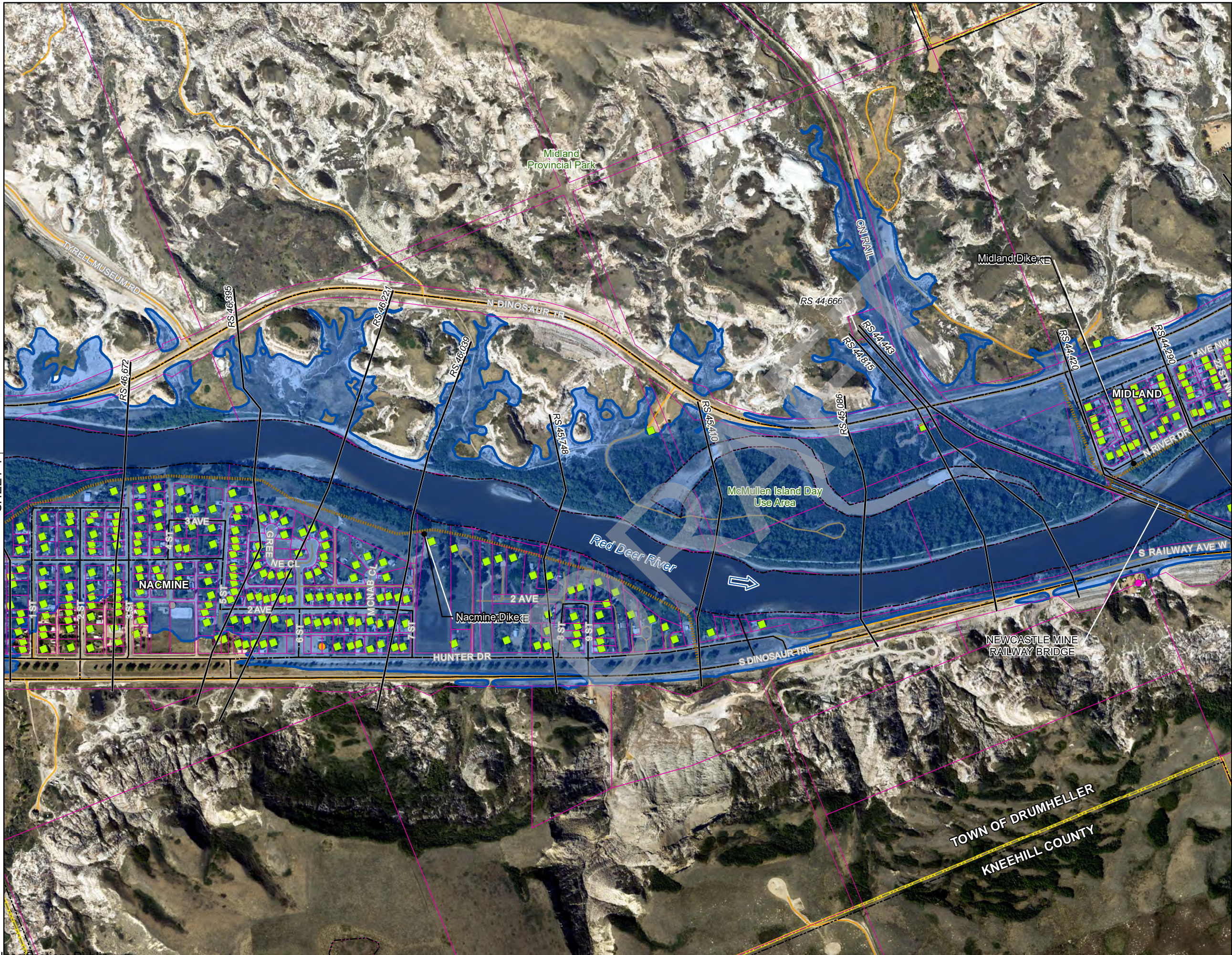
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Engineer	GIS	Reviewer
MMM	REH	RBA

Job: 1003877 Date: 15-JUN-2022

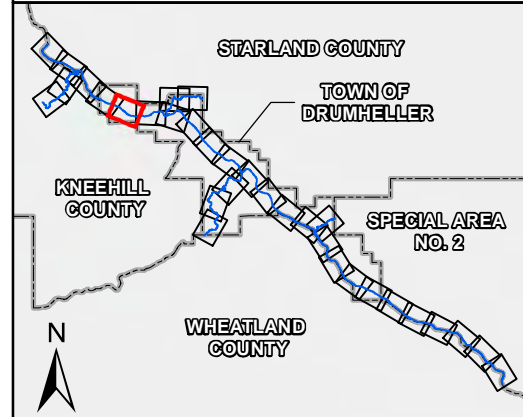
**DRUMHELLER RIVER HAZARD STUDY
FLOOD RISK INVENTORY
AND ASSESSMENT**

SPATIAL DATA INVENTORY

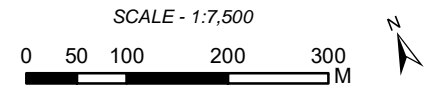


SHEET 4 ↑

↑ SHEET 6



- FLOW DIRECTION
 - MODEL CROSS SECTION
 - RS 12,345 RIVER STATION
 - FLOOD CONTROL STRUCTURE
 - BRIDGE
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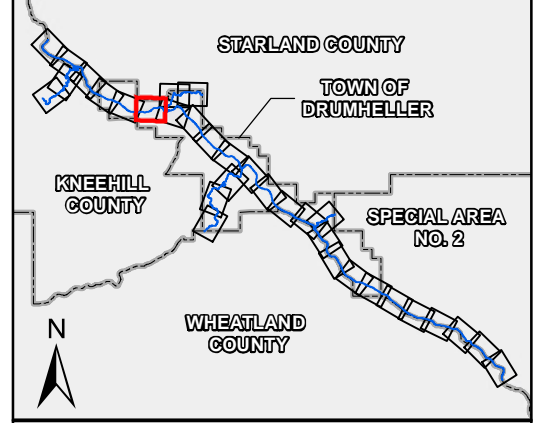
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Engineer	GIS	Reviewer
MMM	REH	RBA

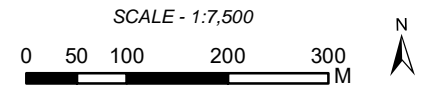
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**DRUMHELLER RIVER HAZARD STUDY
FLOOD RISK INVENTORY
AND ASSESSMENT**

SPATIAL DATA INVENTORY



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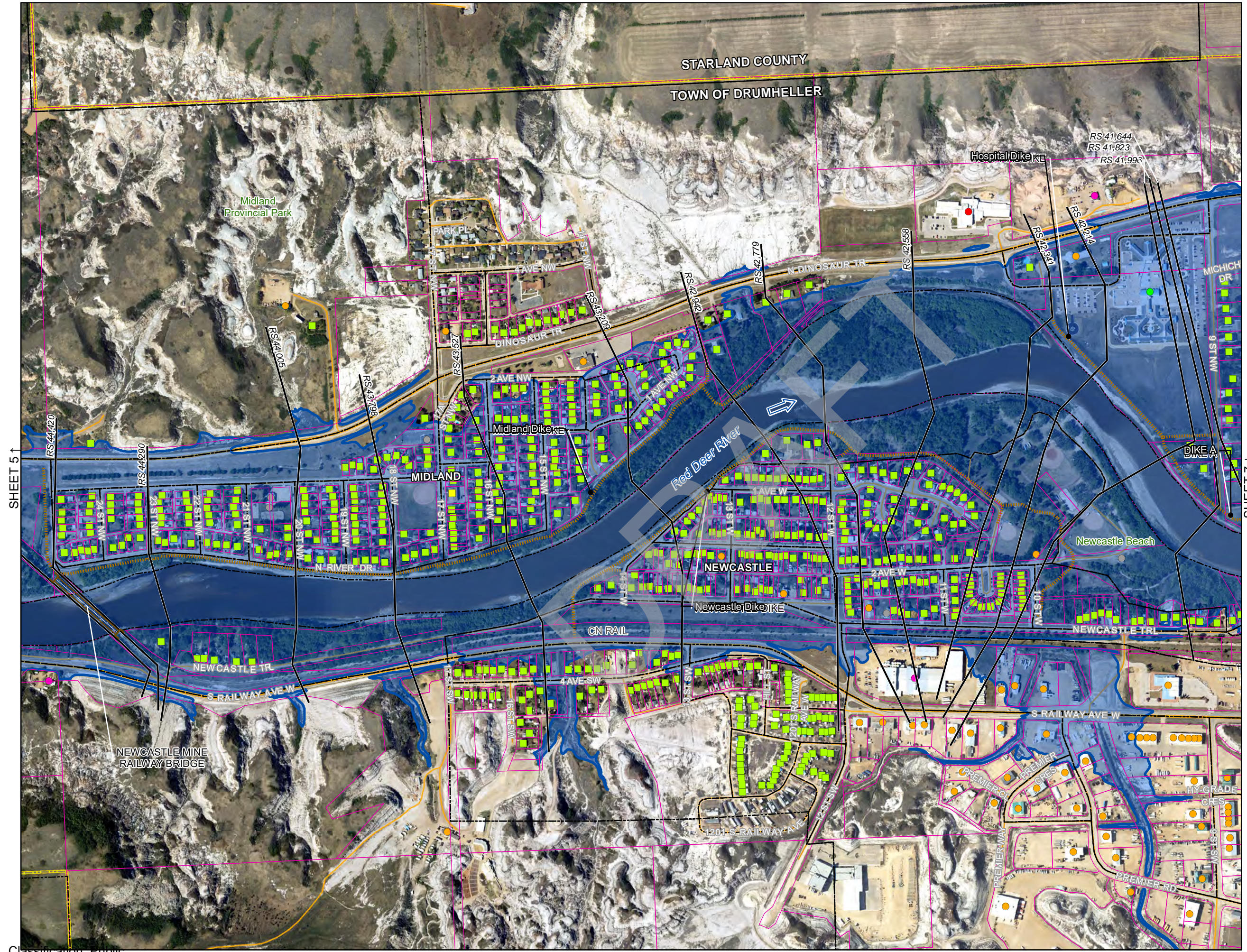


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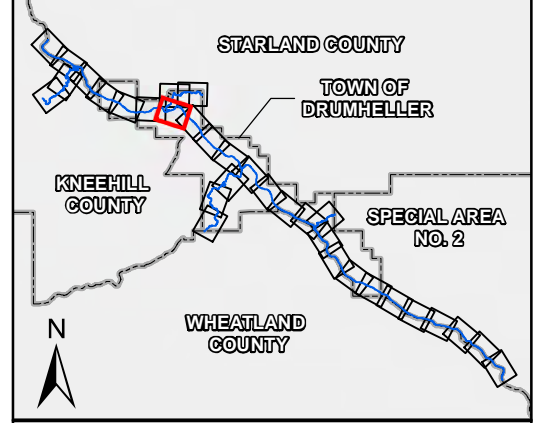
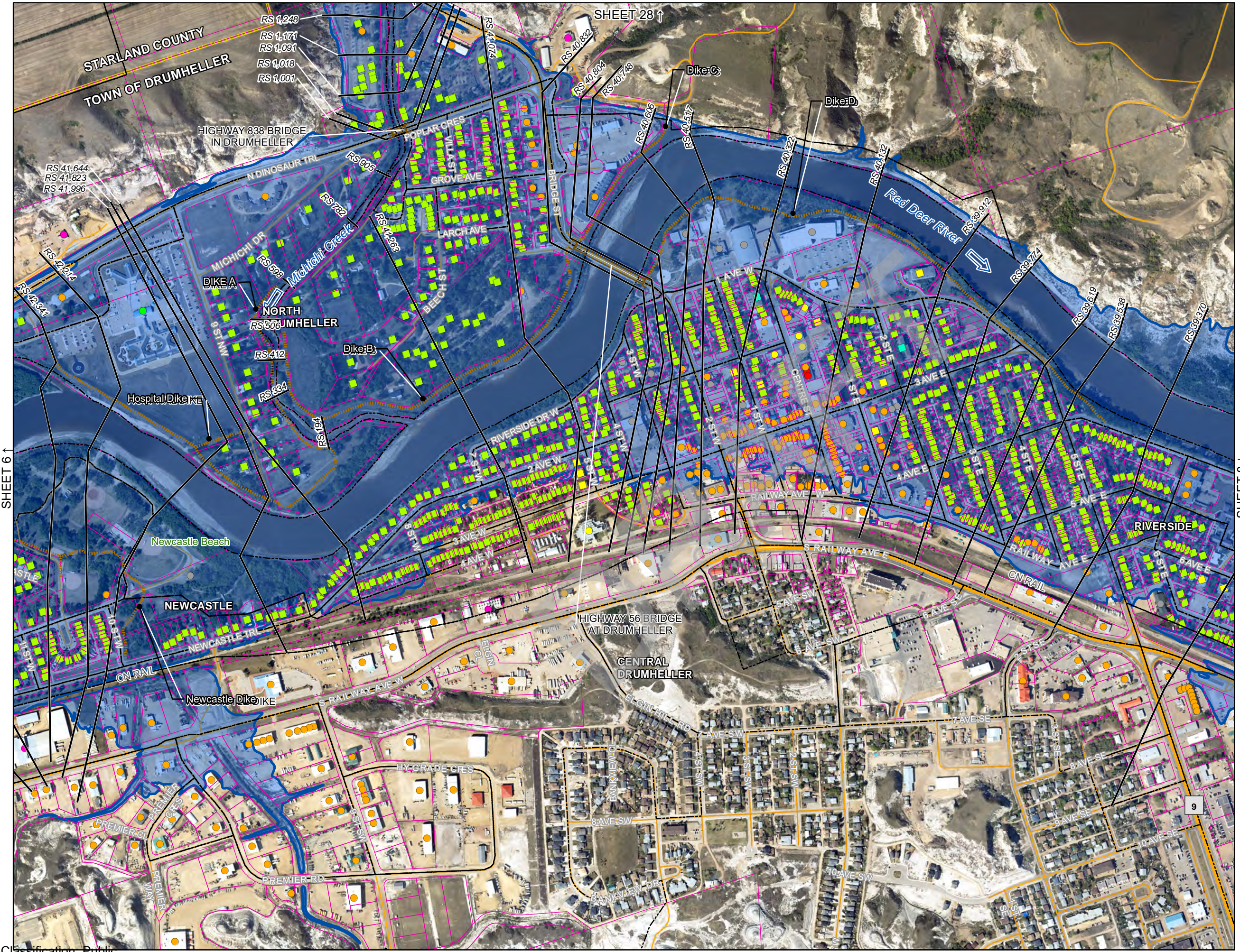
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**DRUMHELLER RIVER HAZARD STUDY
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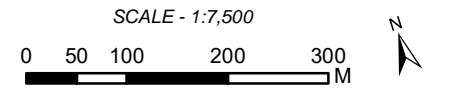
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- School
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 - Government
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 - Water Treatment
 - WW Treatment
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 - Other
 - Retirement Home
 - Single Family
 - Multi-family



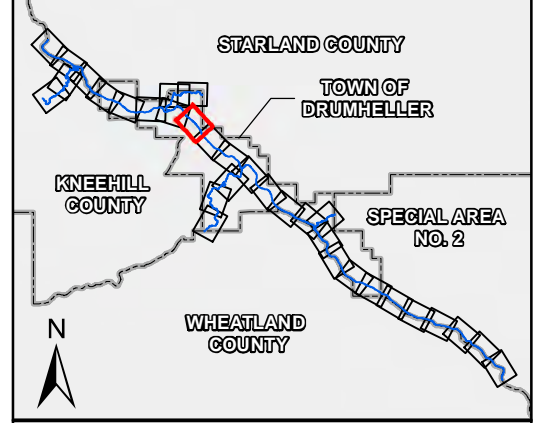
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Vertical Datum: CGVD28 HTv2.0; Units: Metres

Engineer	GIS	Reviewer
MMM	REH	RBA

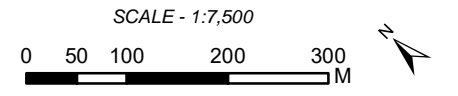
Job: 1003877 Date: 15-JUN-2022

**DRUMHELLER RIVER HAZARD STUDY
FLOOD RISK INVENTORY
AND ASSESSMENT**

SPATIAL DATA INVENTORY



- FLOW DIRECTION
 - MODEL CROSS SECTION
 - RIVER STATION
 - FLOOD CONTROL STRUCTURE
 - BRIDGE
 - CULVERT
 - MAJOR ROAD
 - LOCAL ROAD
 - MUNICIPAL BOUNDARY
 - CENSUS UNIT
 - LAND PARCEL
 - 1000-YEAR OPEN WATER REGULATED FLOOD EXTENT
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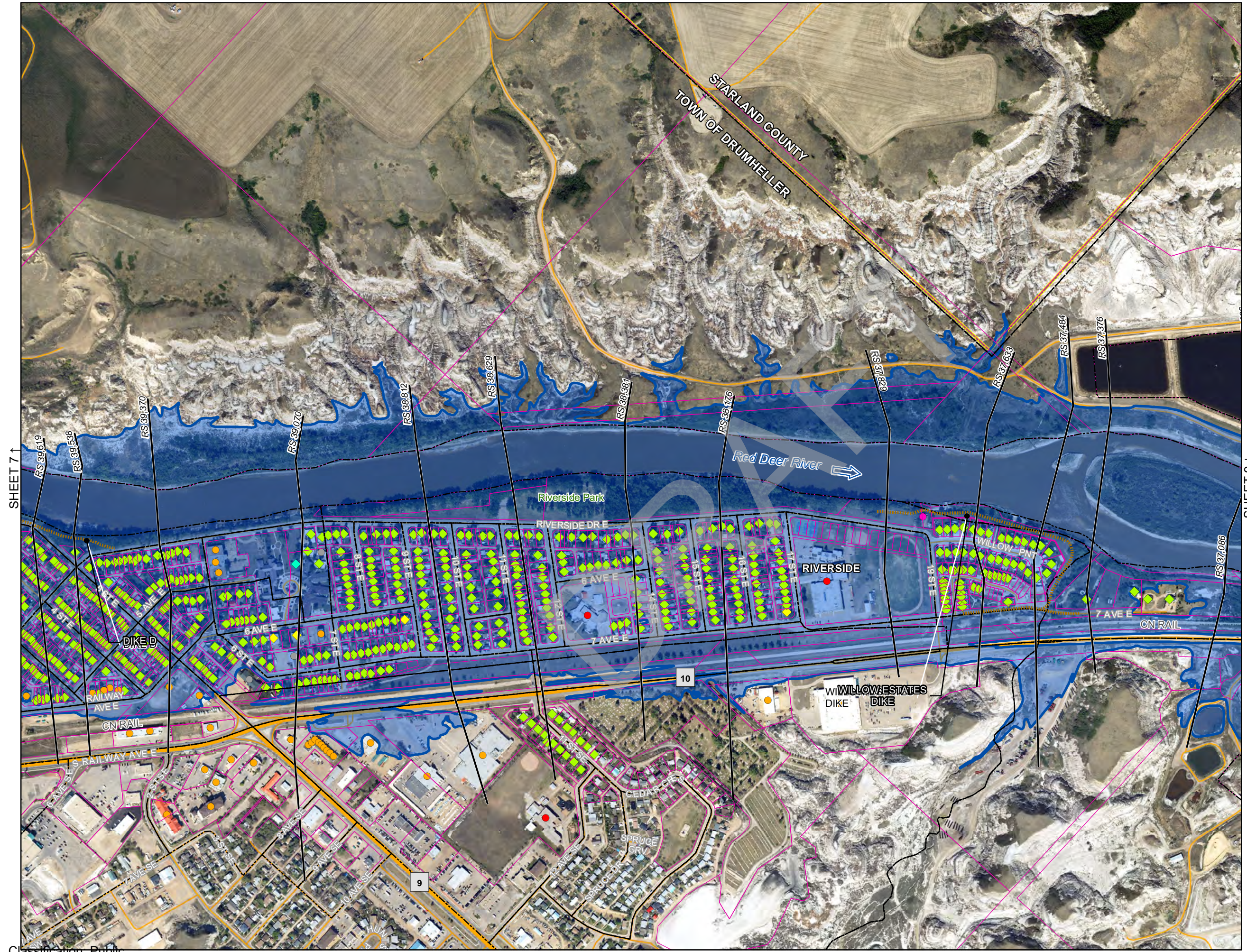


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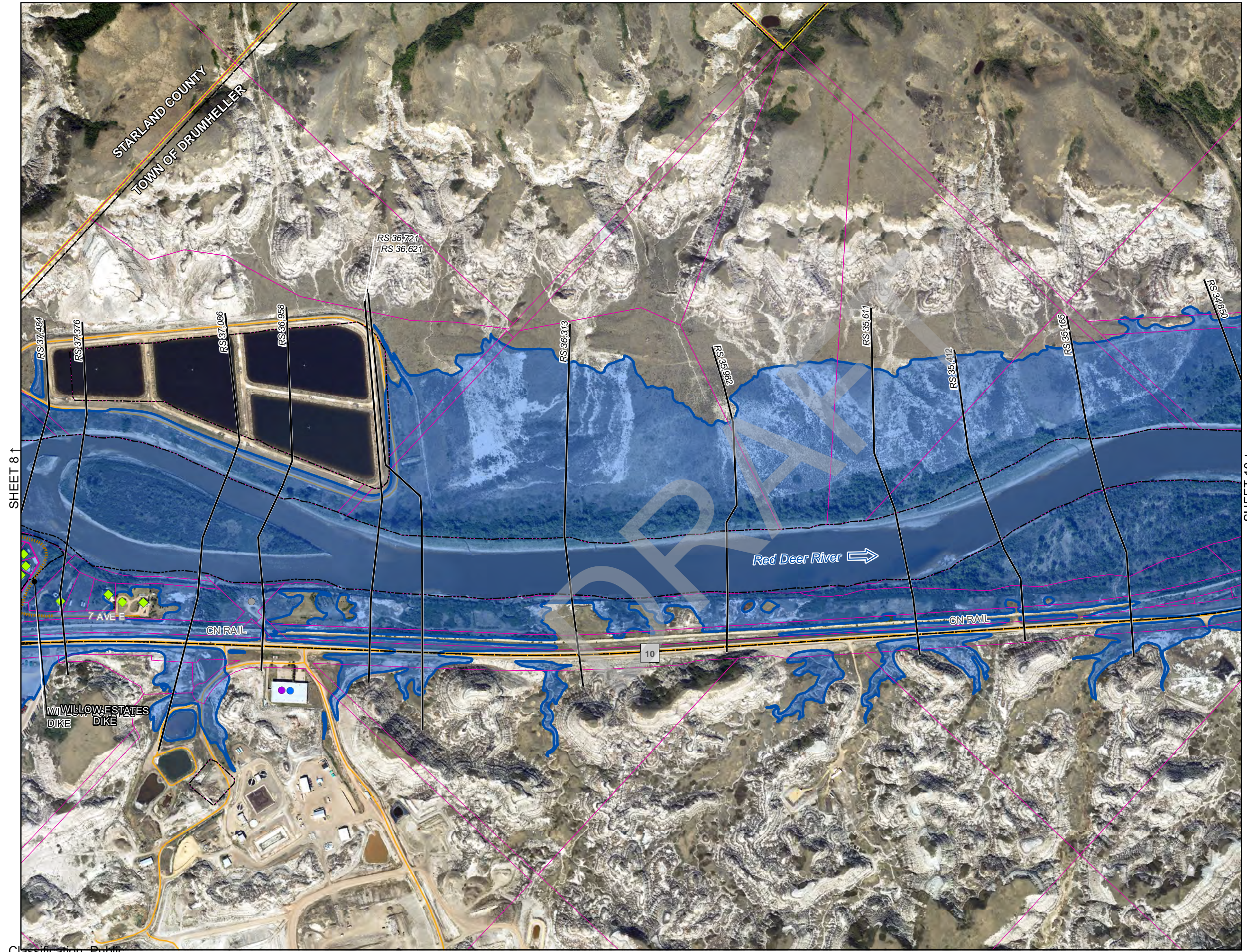
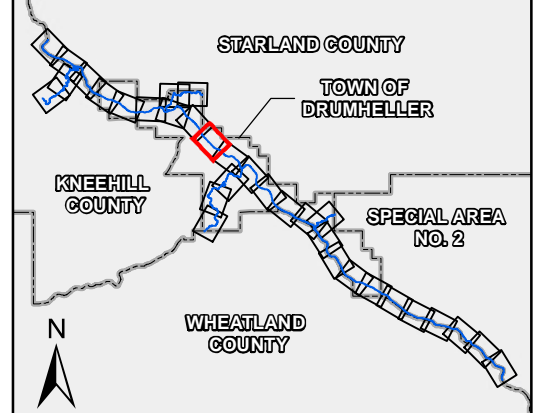
Engineer	GIS	Reviewer
MMM	REH	RBA
Job: 1003877		Date: 15-JUN-2022

**DRUMHELLER RIVER HAZARD STUDY
FLOOD RISK INVENTORY
AND ASSESSMENT**

SPATIAL DATA INVENTORY



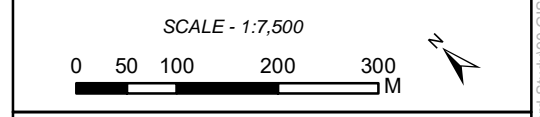
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SHEET 8 ↑

↓ SHEET 10

- FLOW DIRECTION
 - MODEL CROSS SECTION
 - RS 12,345 RIVER STATION
 - FLOOD CONTROL STRUCTURE
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Coordinate System: NAD 1983 CSRS 3TM 114
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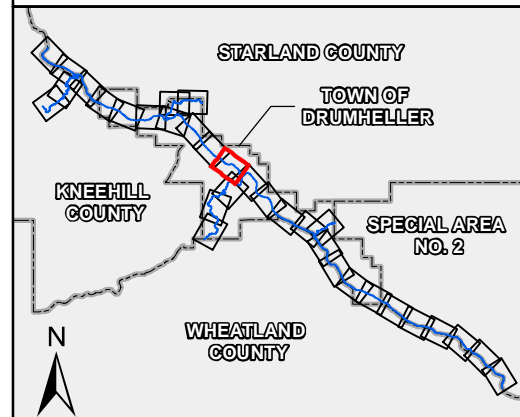
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MMM	REH	RBA

Job: 1003877 Date: 15-JUN-2022

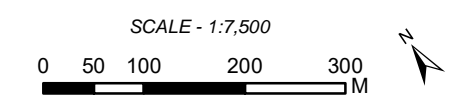
**DRUMHELLER RIVER HAZARD STUDY
FLOOD RISK INVENTORY
AND ASSESSMENT**

SPATIAL DATA INVENTORY

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- FLOW DIRECTION
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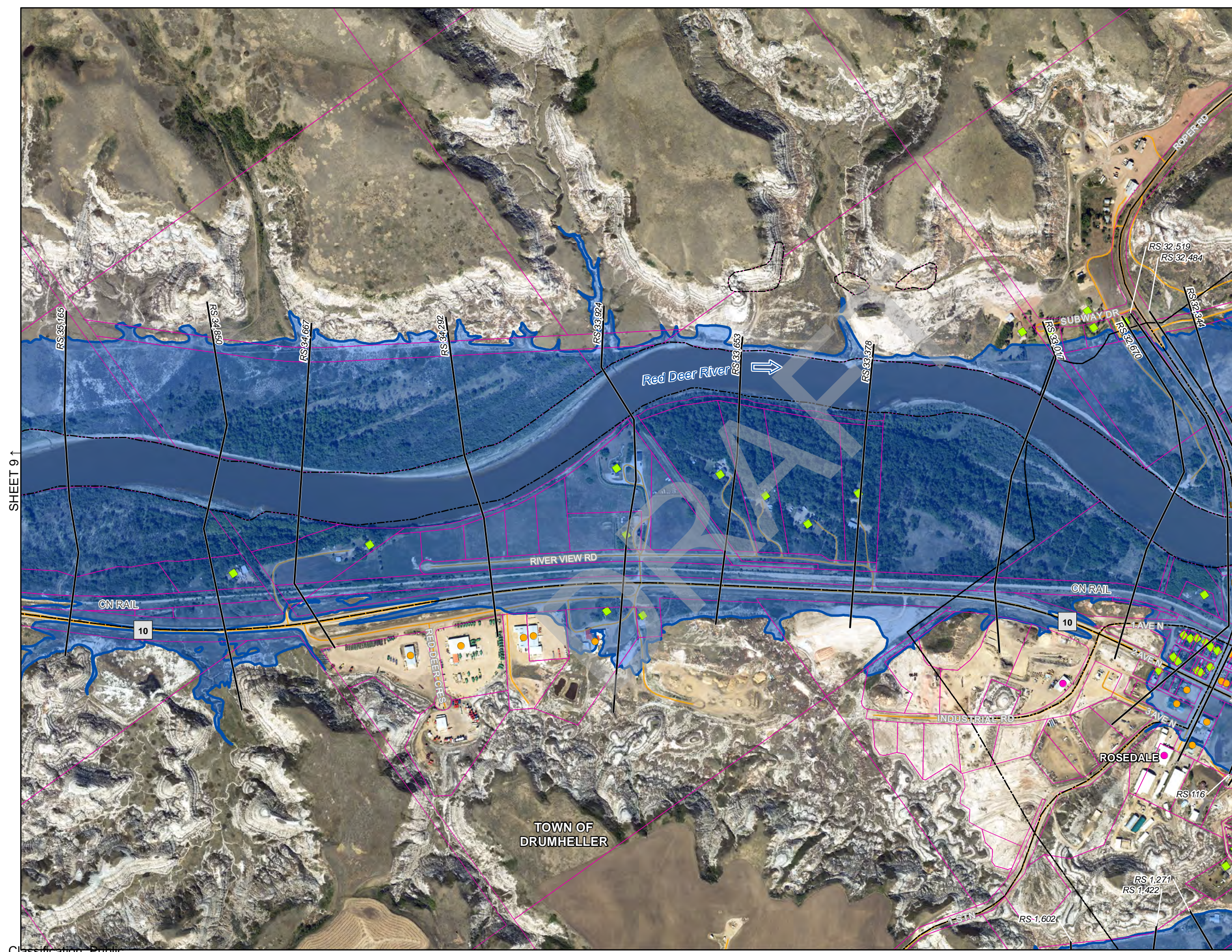
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**DRUMHELLER RIVER HAZARD STUDY
FLOOD RISK INVENTORY
AND ASSESSMENT**

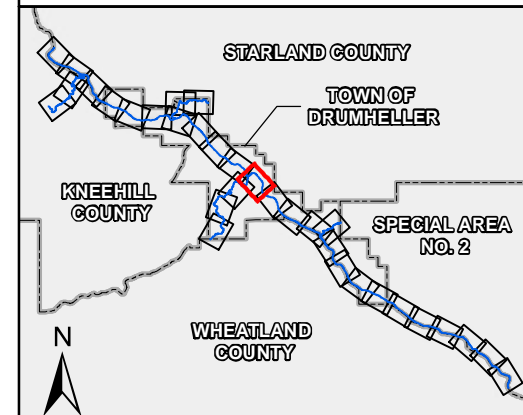
SPATIAL DATA INVENTORY

SHEET 9 ↑

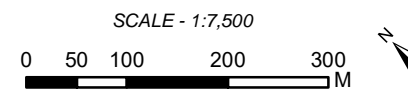
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- FLOW DIRECTION
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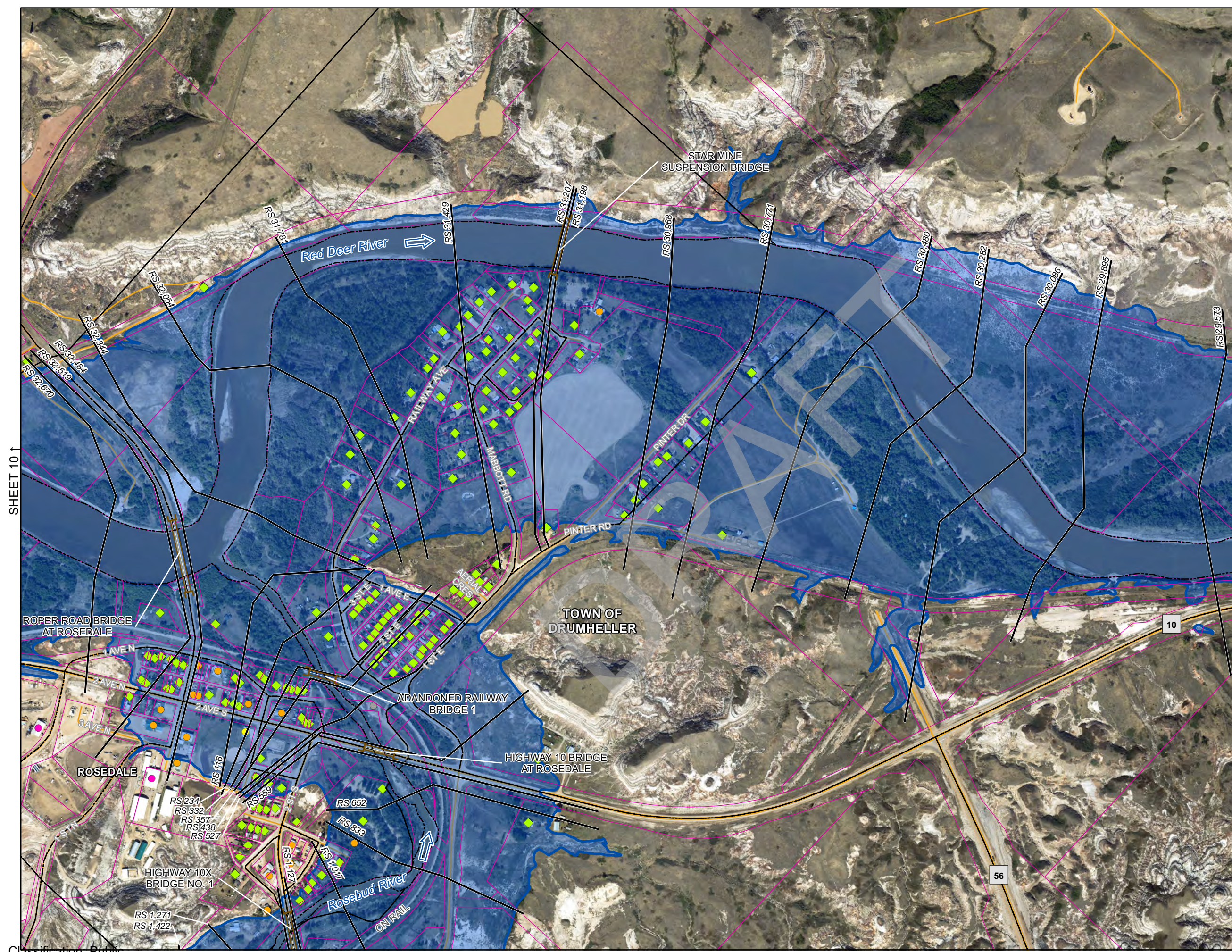
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Engineer	GIS	Reviewer
MMM	REH	RBA

Job: 1003877 Date: 15-JUN-2022

**DRUMHELLER RIVER HAZARD STUDY
FLOOD RISK INVENTORY
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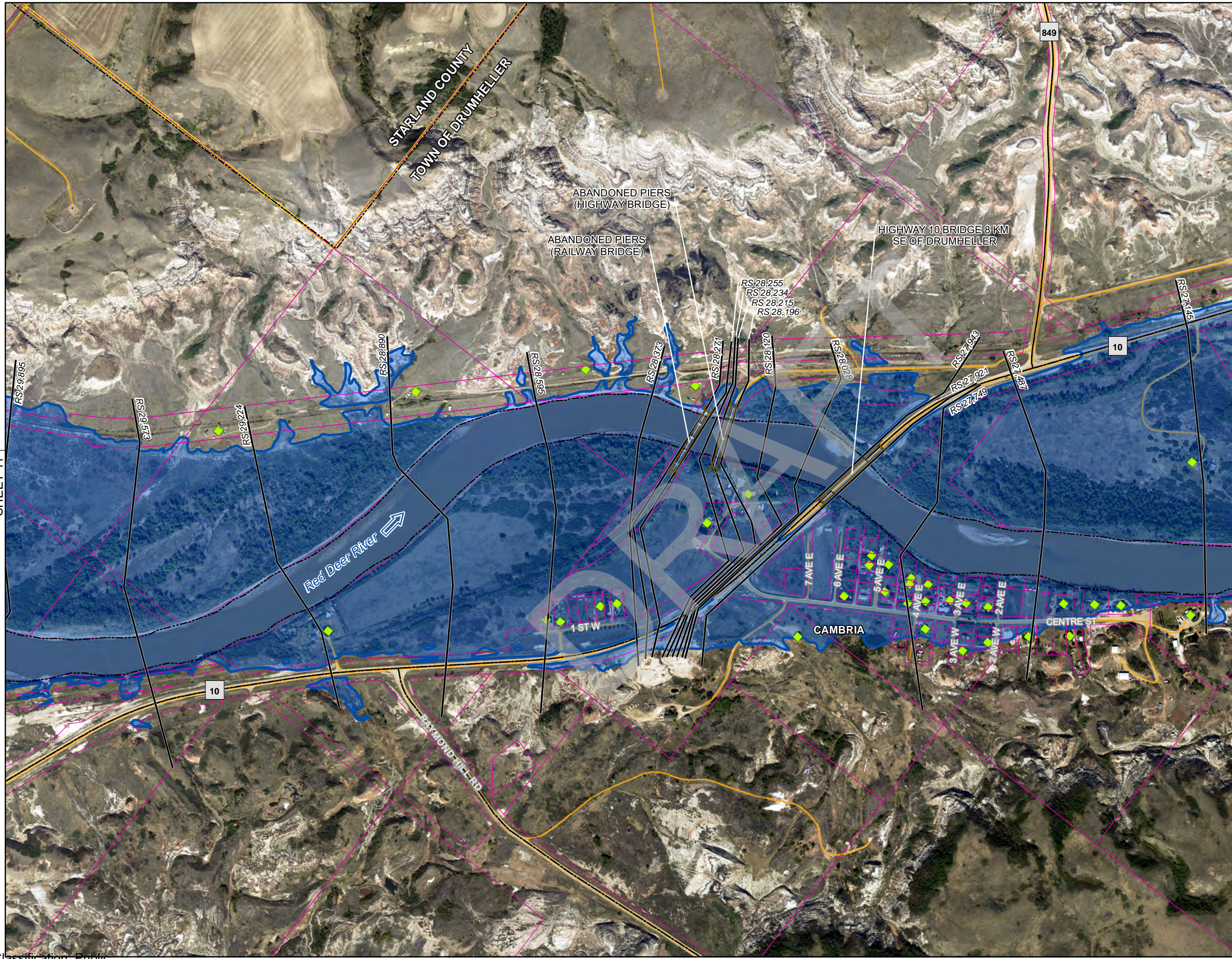
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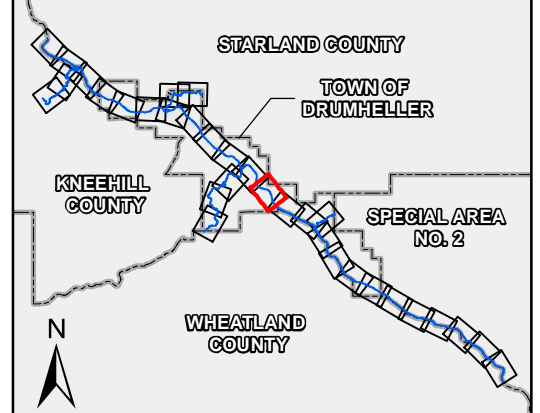
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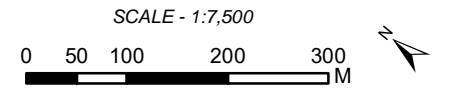


SHEET 11 ↑

↓ SHEET 13



- FLOW DIRECTION
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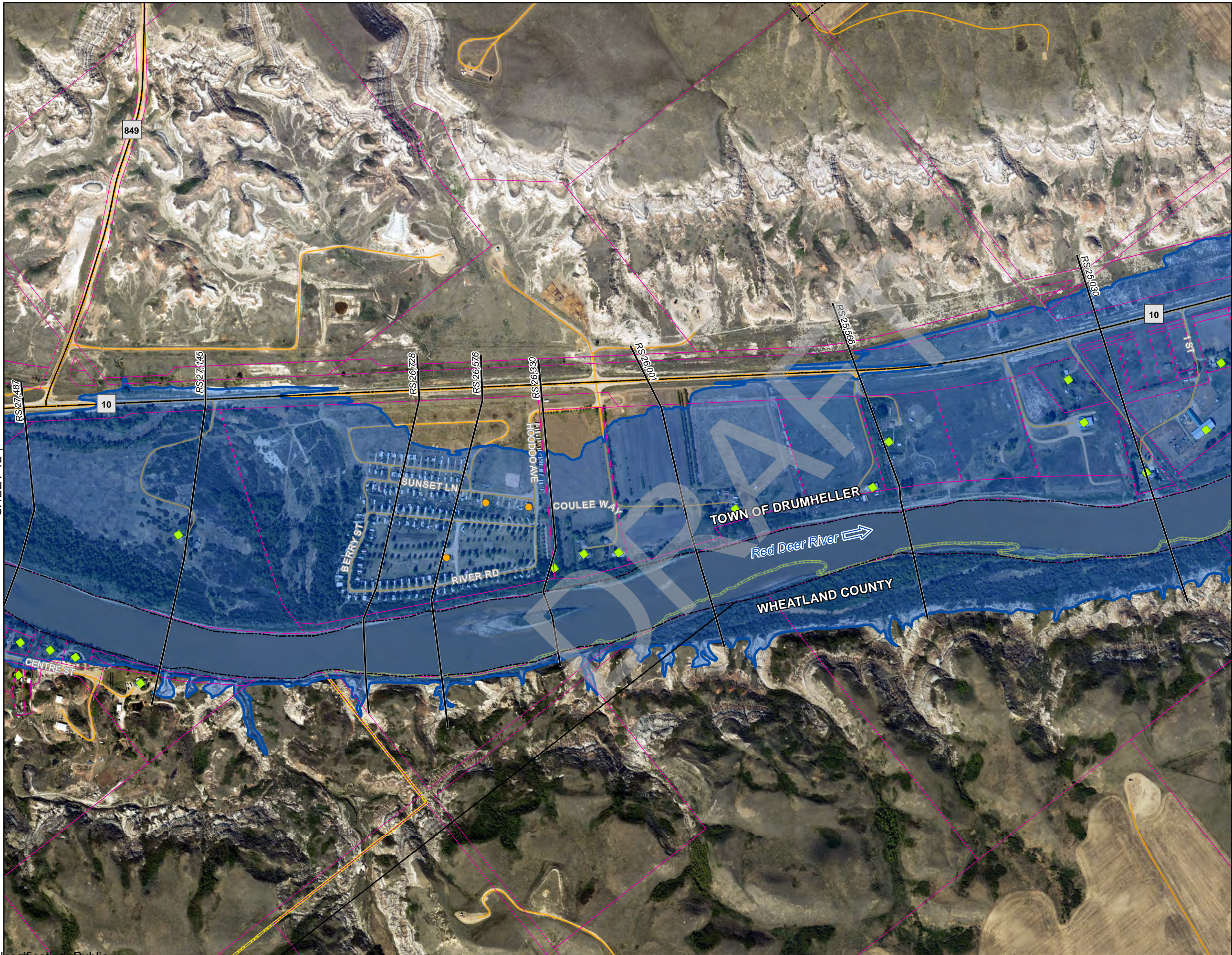
Engineer	GIS	Reviewer
MMM	REH	RBA

Job: 1003877 Date: 15-JUN-2022

**DRUMHELLER RIVER HAZARD STUDY
FLOOD RISK INVENTORY
AND ASSESSMENT**

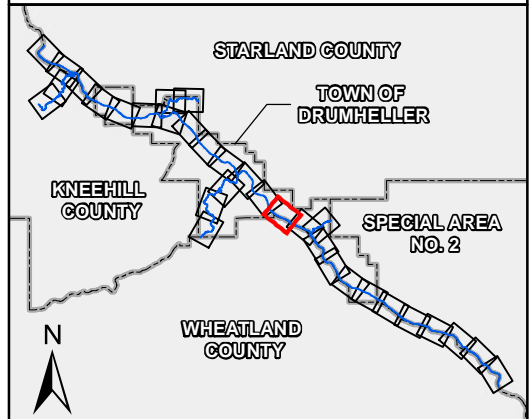
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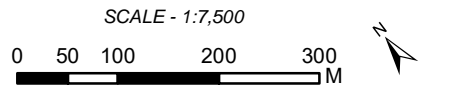


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- FLOW DIRECTION
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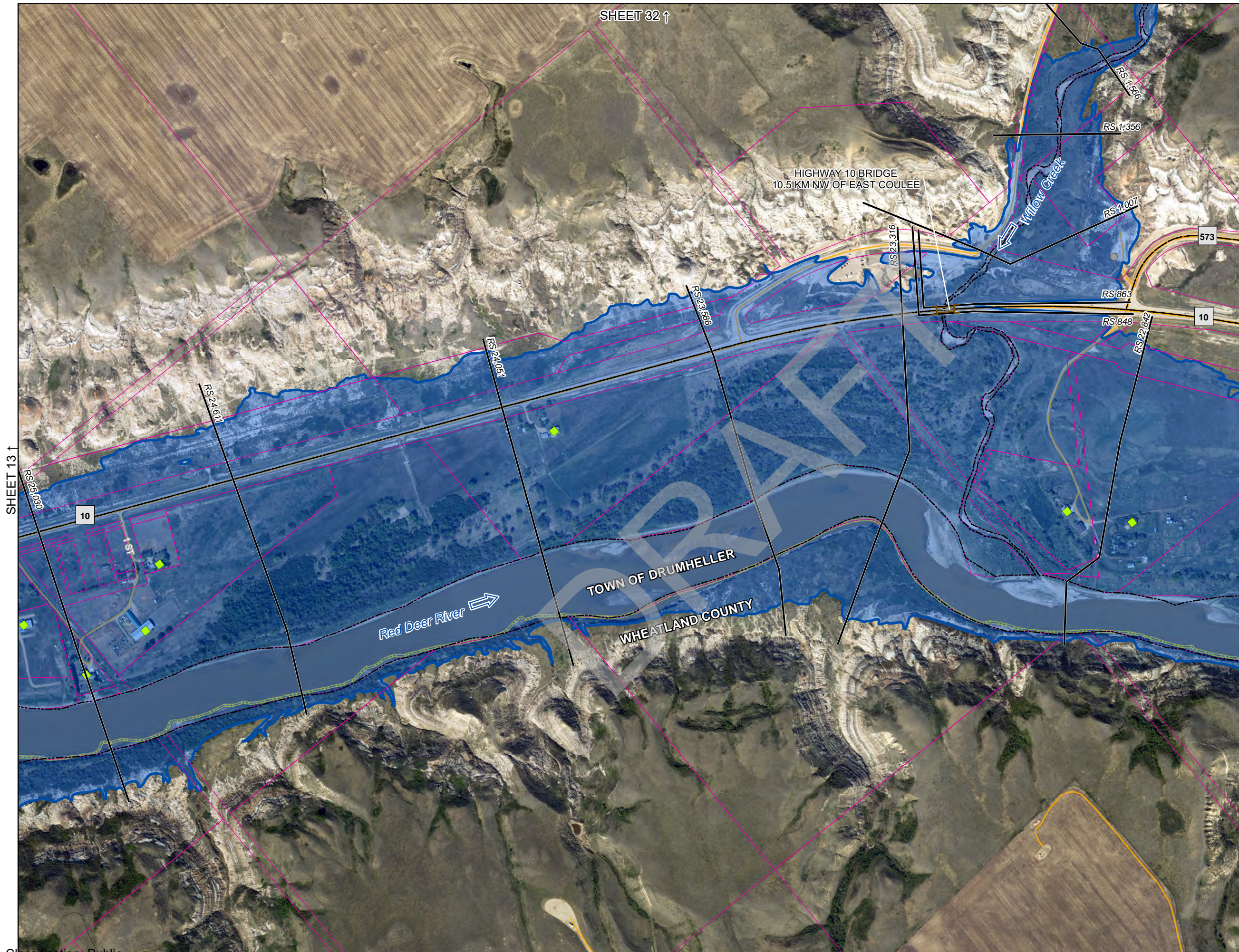
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Engineer	GIS	Reviewer
MMM	REH	RBA

Job: 1003877 Date: 15-JUN-2022

**DRUMHELLER RIVER HAZARD STUDY
FLOOD RISK INVENTORY
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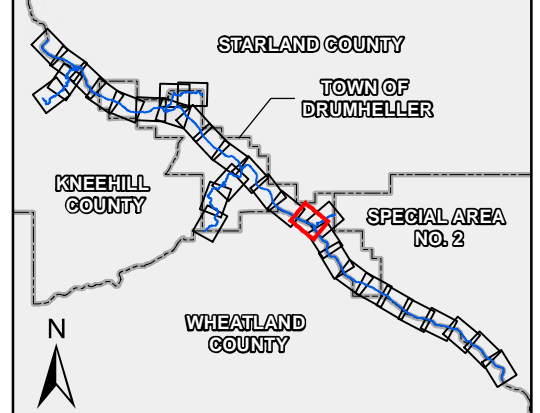
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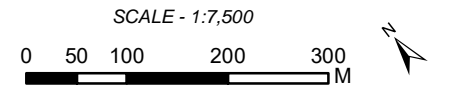
SHEET 32 ↑

SHEET 13 ↑

SHEET 15 ↓



- FLOW DIRECTION
 - MODEL CROSS SECTION
 - RS 12,345 RIVER STATION
 - FLOOD CONTROL STRUCTURE
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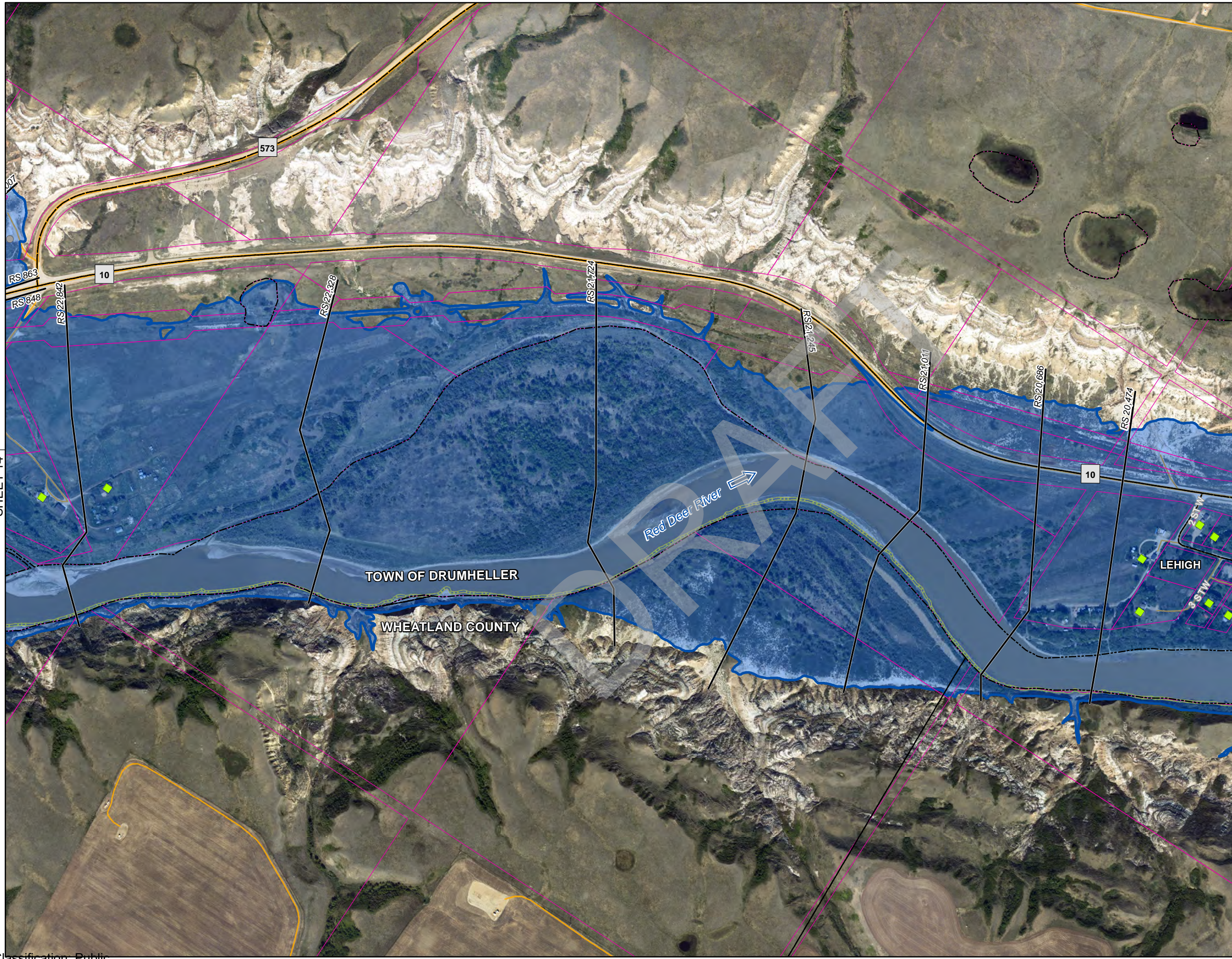
Engineer	GIS	Reviewer
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Job: 1003877 Date: 15-JUN-2022

**DRUMHELLER RIVER HAZARD STUDY
FLOOD RISK INVENTORY
AND ASSESSMENT**

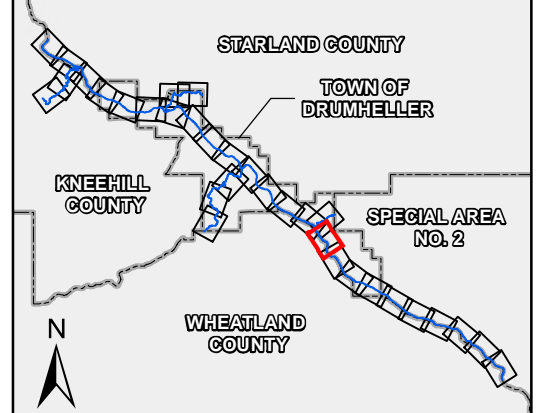
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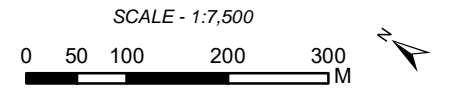


SHEET 14 ↑

↓ SHEET 16



- FLOW DIRECTION
 - MODEL CROSS SECTION
 - RIVER STATION
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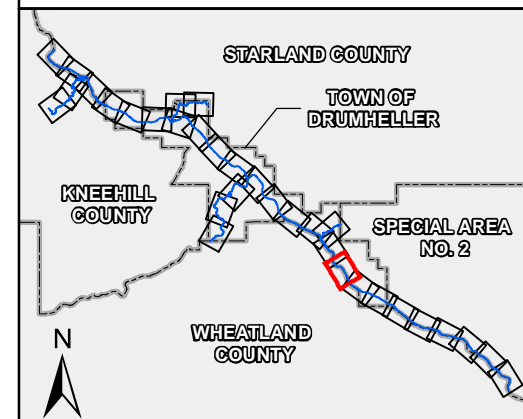
Engineer	GIS	Reviewer
MMM	REH	RBA

Job: 1003877 Date: 15-JUN-2022

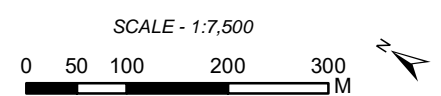
**DRUMHELLER RIVER HAZARD STUDY
FLOOD RISK INVENTORY
AND ASSESSMENT**

SPATIAL DATA INVENTORY

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- FLOW DIRECTION
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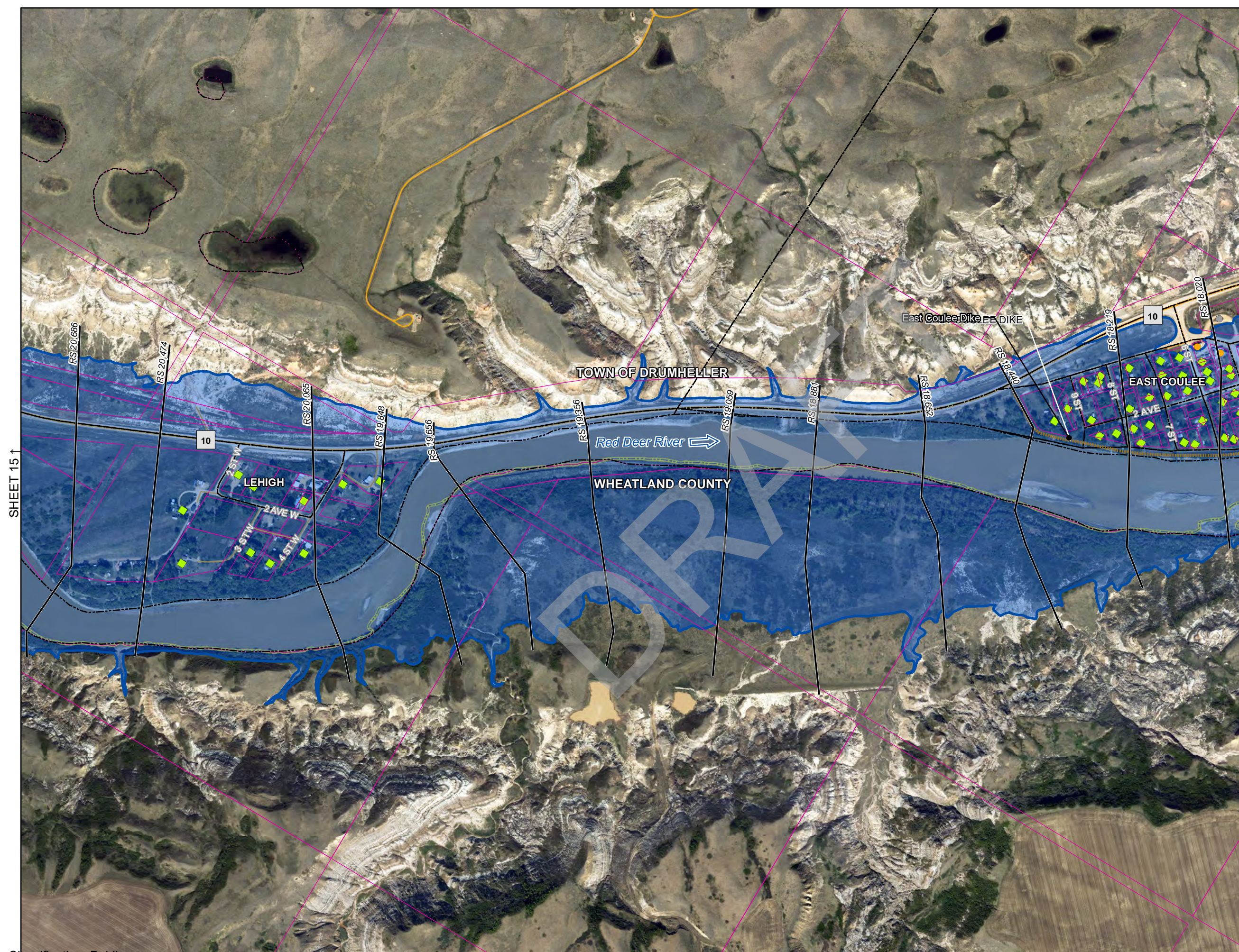
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Engineer	GIS	Reviewer
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Job: 1003877 Date: 15-JUN-2022

**DRUMHELLER RIVER HAZARD STUDY
FLOOD RISK INVENTORY
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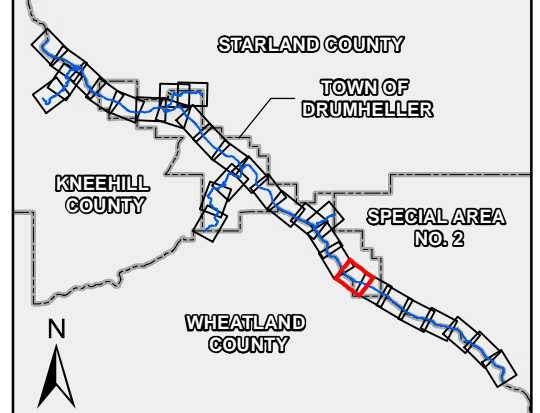
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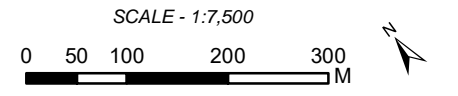
SHEET 15 ↑

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- FLOW DIRECTION
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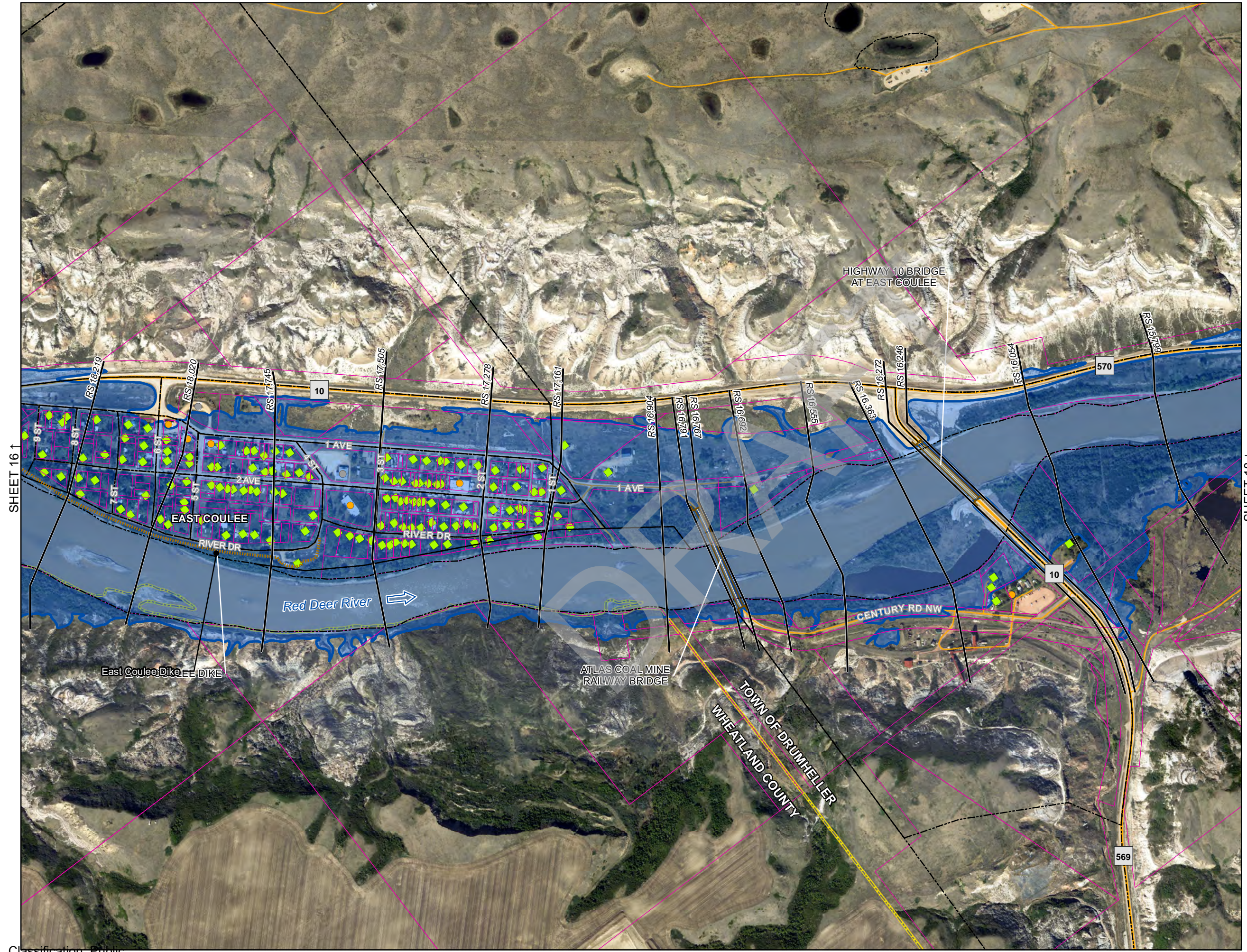


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Engineer	GIS	Reviewer
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Job: 1003877		Date: 15-JUN-2022

**DRUMHELLER RIVER HAZARD STUDY
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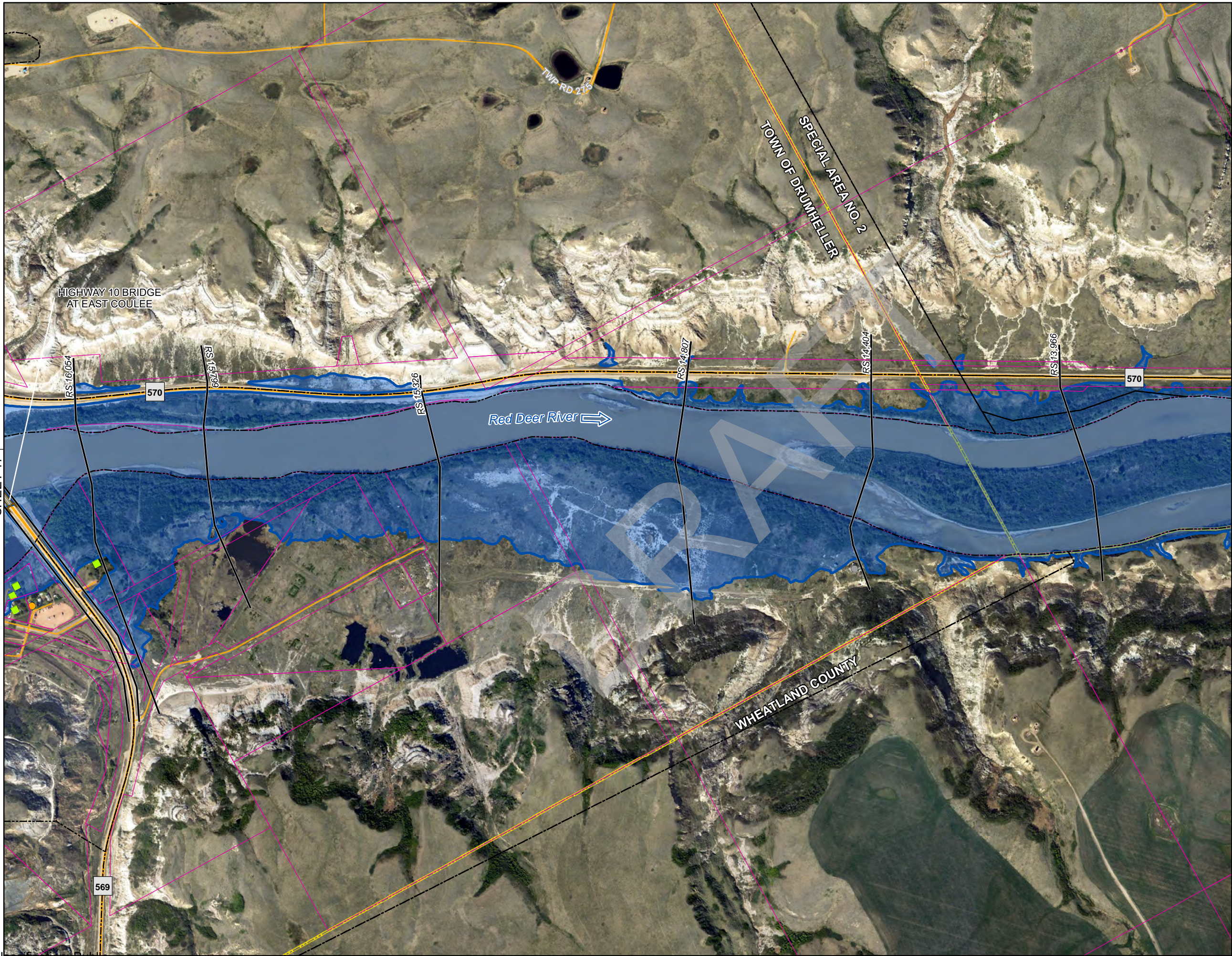
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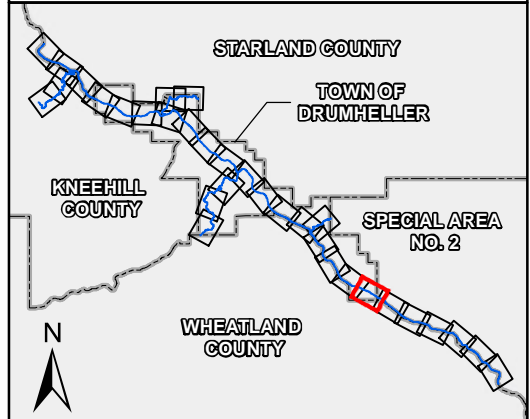
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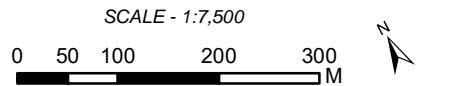


SHEET 17 ↑

↓ SHEET 19



- FLOW DIRECTION
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Engineer	GIS	Reviewer
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Job: 1003877 Date: 15-JUN-2022

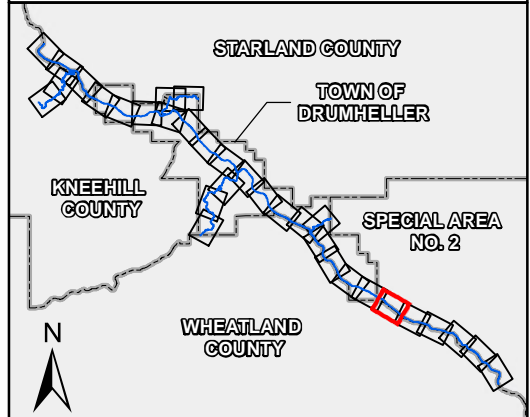
**DRUMHELLER RIVER HAZARD STUDY
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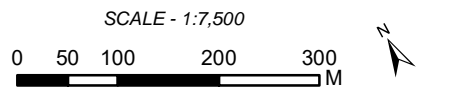


SHEET 18 ↑

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- FLOW DIRECTION
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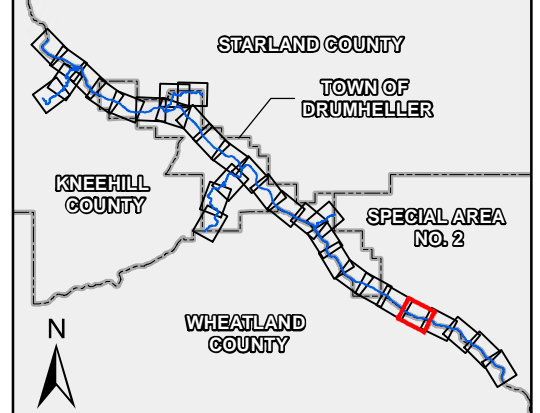
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Engineer	GIS	Reviewer
MMM	REH	RBA

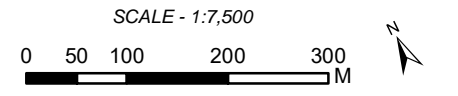
Job: 1003877 Date: 15-JUN-2022

**DRUMHELLER RIVER HAZARD STUDY
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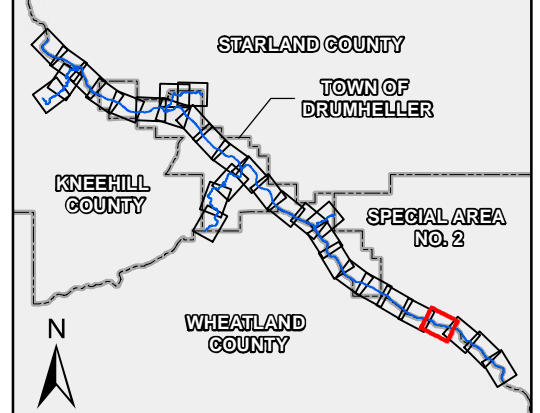
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**DRUMHELLER RIVER HAZARD STUDY
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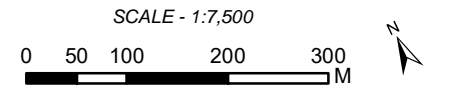
SPATIAL DATA INVENTORY

SHEET 19 ↑

↓ SHEET 21



- FLOW DIRECTION
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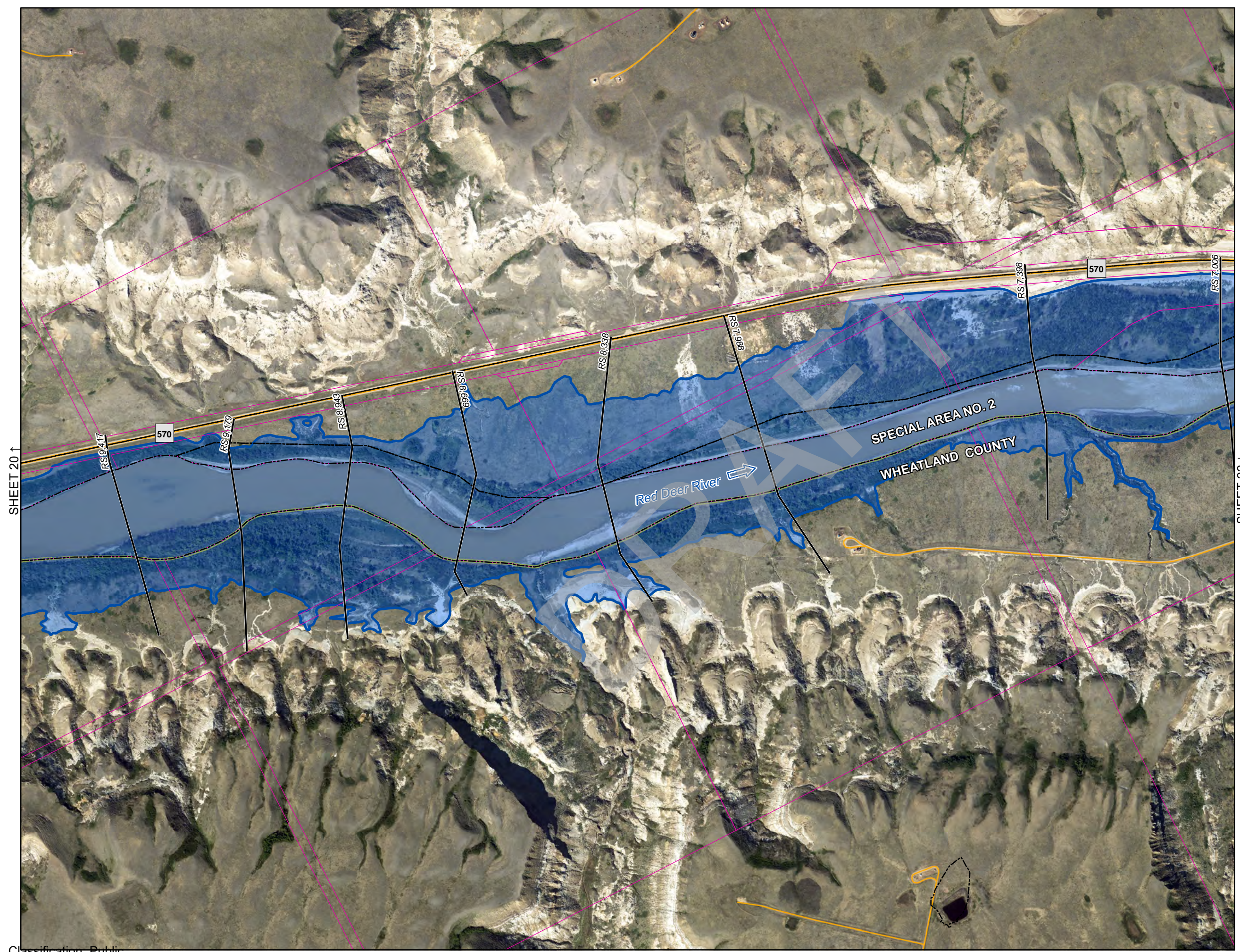
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Engineer	GIS	Reviewer	
MMM	REH	RBA	

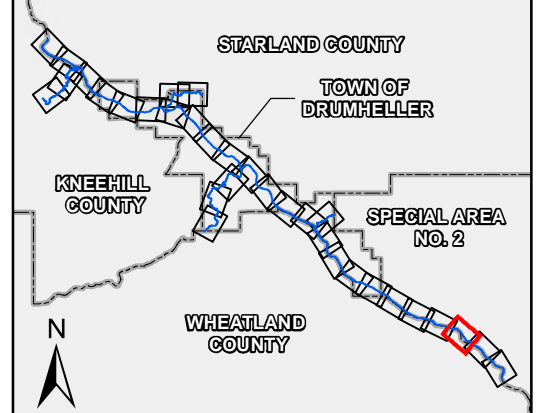
Job: 1003877 Date: 15-JUN-2022

**DRUMHELLER RIVER HAZARD STUDY
FLOOD RISK INVENTORY
AND ASSESSMENT**

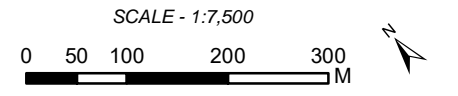
SPATIAL DATA INVENTORY



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- FLOW DIRECTION
 - MODEL CROSS SECTION
 - RIVER STATION
 - FLOOD CONTROL STRUCTURE
 - BRIDGE
 - CULVERT
 - MAJOR ROAD
 - LOCAL ROAD
 - MUNICIPAL BOUNDARY
 - CENSUS UNIT
 - LAND PARCEL
 - 1000-YEAR OPEN WATER REGULATED FLOOD EXTENT
- STRUCTURES**
- School
 - Commercial
 - Government
 - Hospital
 - Water Treatment
 - WW Treatment
 - Industrial
 - Other
 - Retirement Home
 - Single Family
 - Multi-family



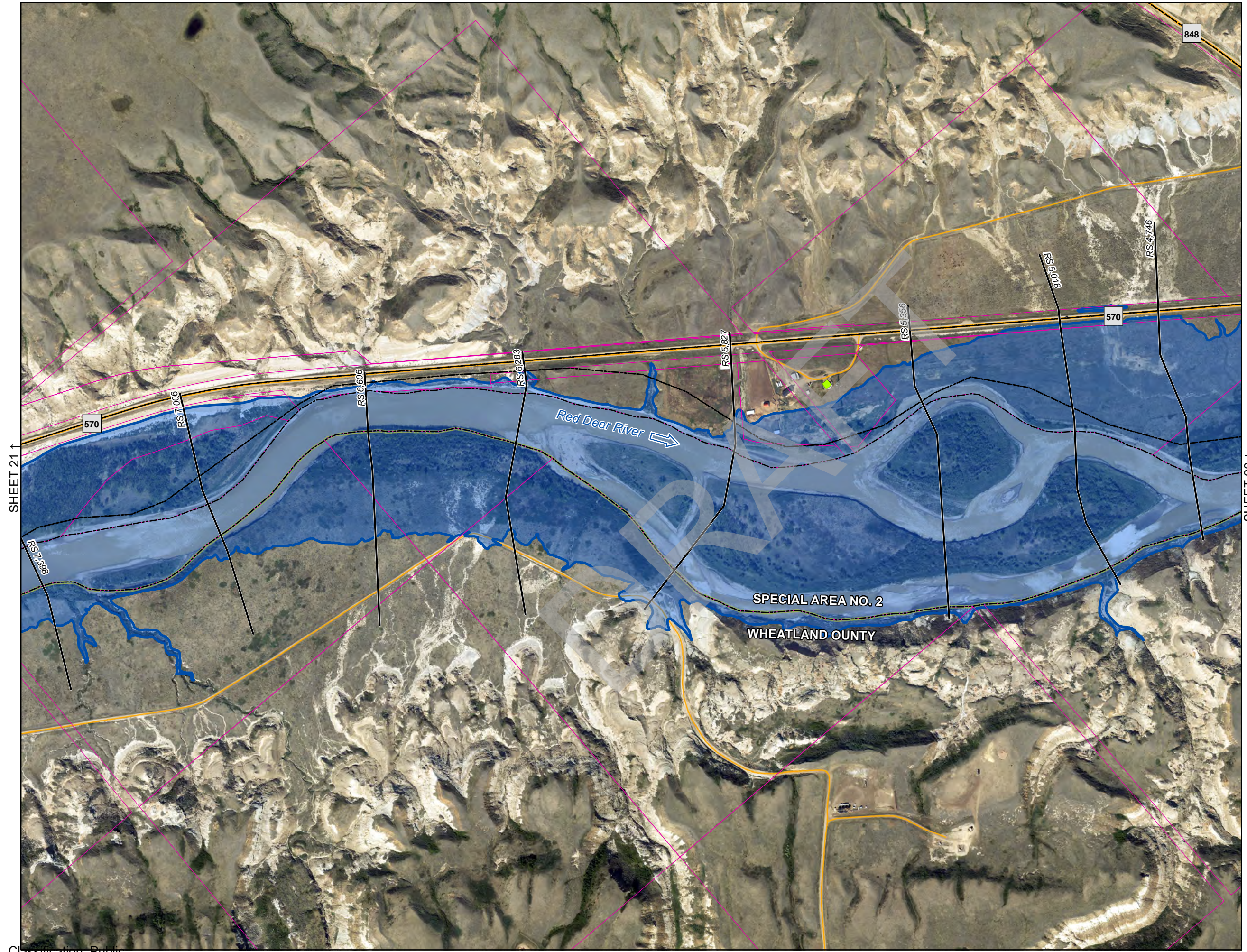
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Vertical Datum: CGVD28 HTv2.0; Units: Metres

Engineer	GIS	Reviewer
MMM	REH	RBA

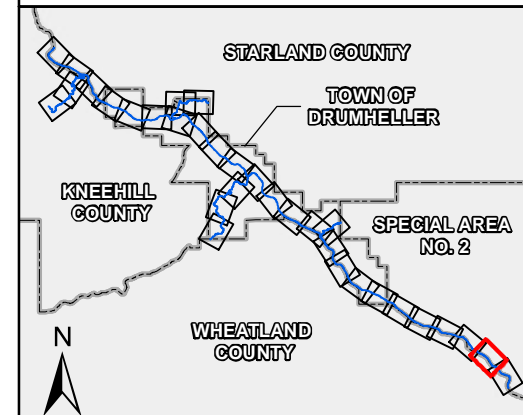
Job: 1003877 Date: 15-JUN-2022

**DRUMHELLER RIVER HAZARD STUDY
FLOOD RISK INVENTORY
AND ASSESSMENT**

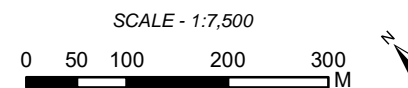
SPATIAL DATA INVENTORY



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- FLOW DIRECTION
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 - Multi-family



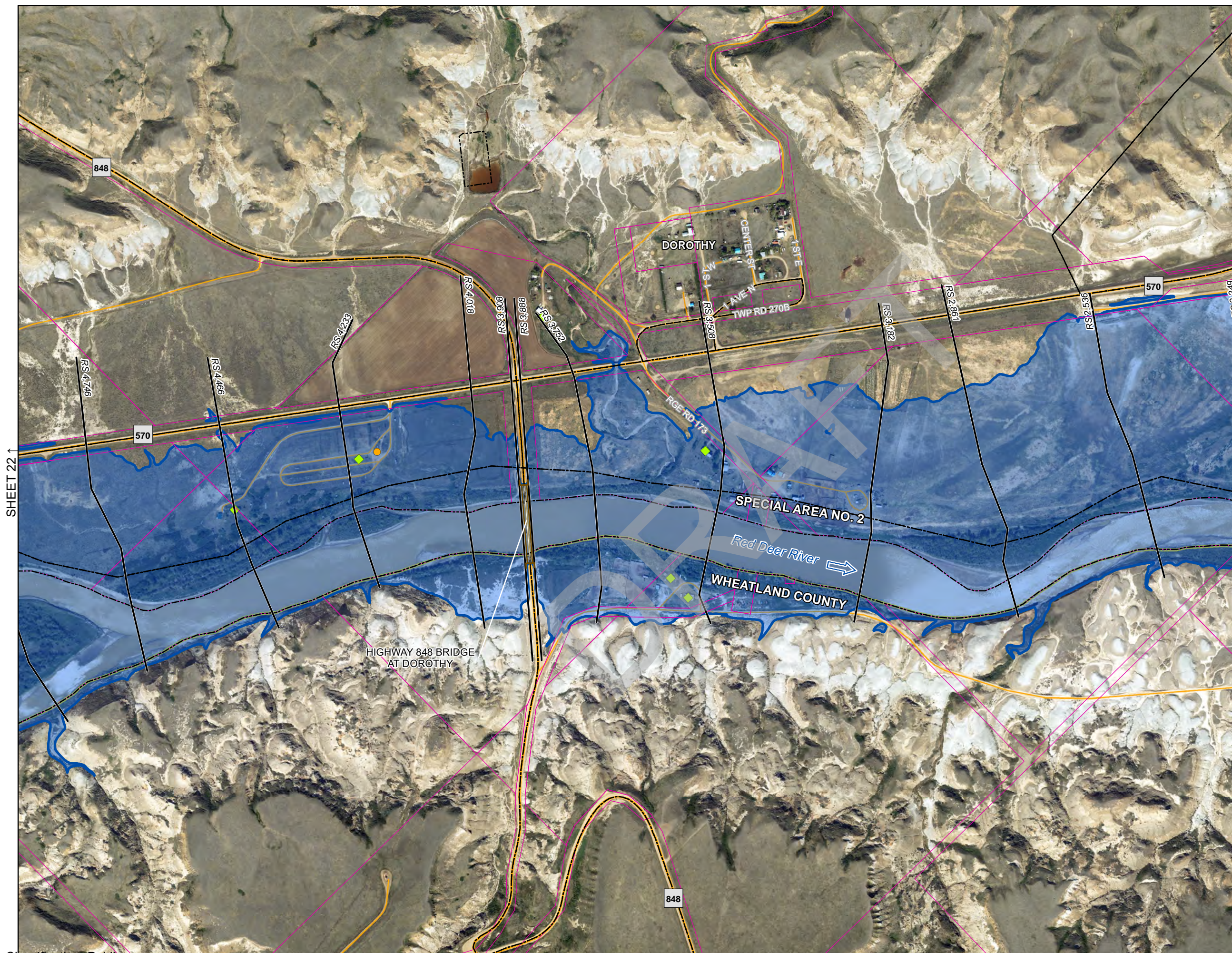
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Engineer	GIS	Reviewer
MMM	REH	RBA

Job: 1003877 Date: 15-JUN-2022

**DRUMHELLER RIVER HAZARD STUDY
FLOOD RISK INVENTORY
AND ASSESSMENT**

SPATIAL DATA INVENTORY

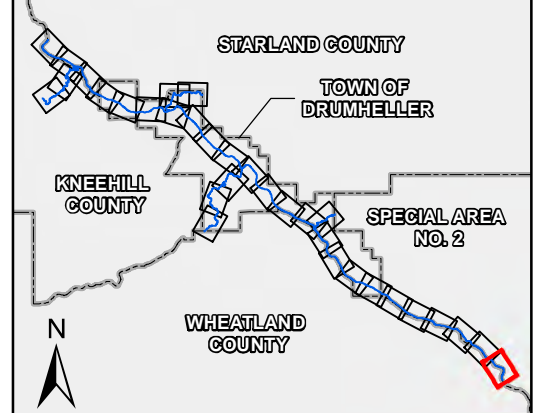


SHEET 22 ↑

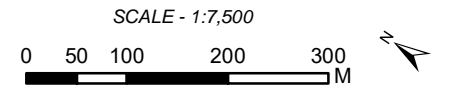
↓ SHEET 24



SHEET 23 ↑



- FLOW DIRECTION
 - MODEL CROSS SECTION
 - RIVER STATION
 - FLOOD CONTROL STRUCTURE
 - BRIDGE
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Coordinate System: NAD 1983 CSRS 3TM 114
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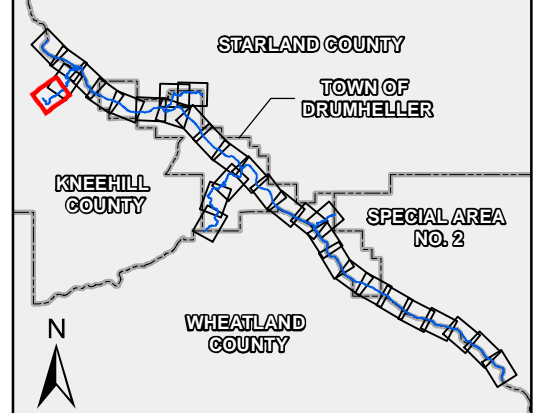
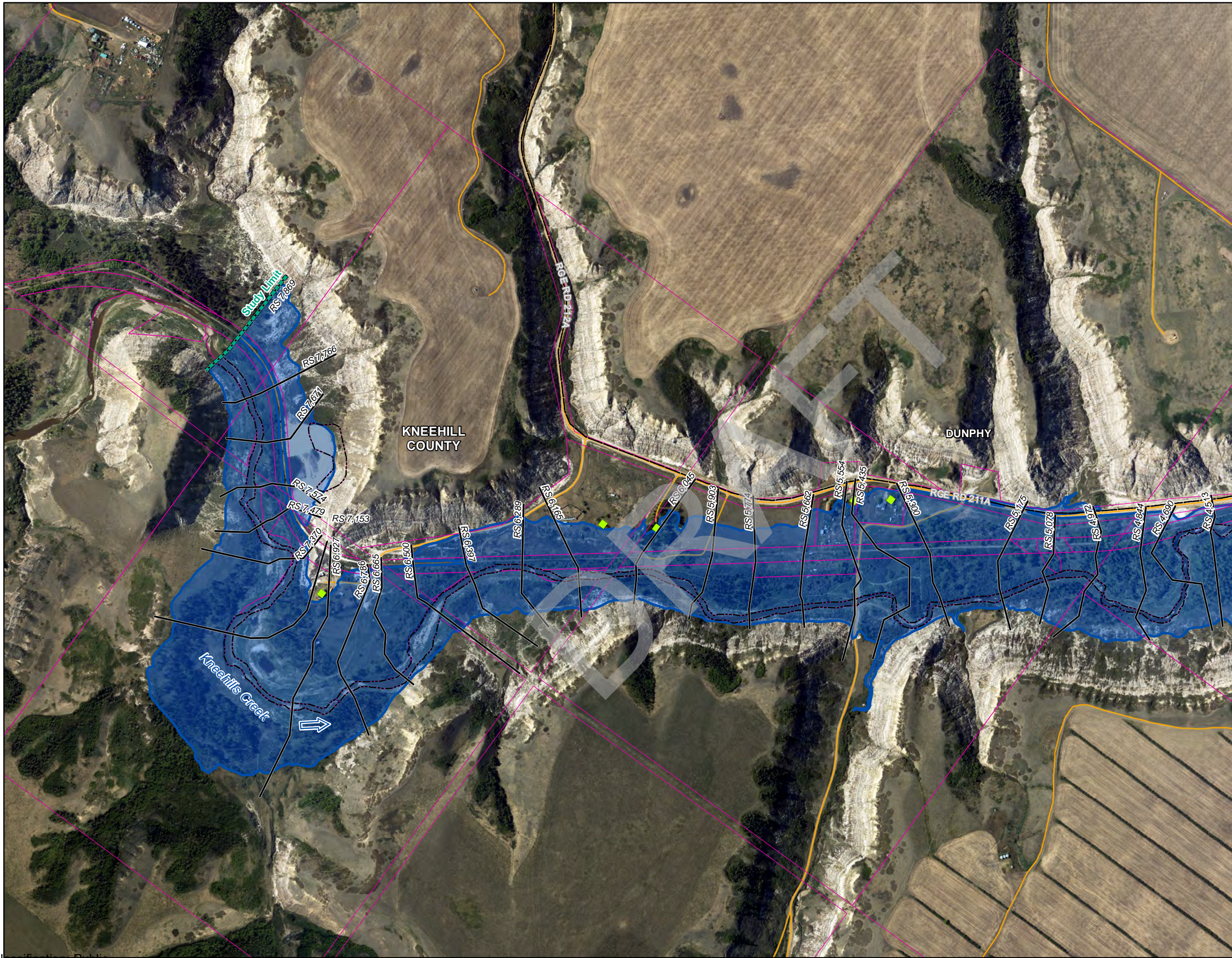
Engineer	GIS	Reviewer
MMM	REH	RBA

Job: 1003877 Date: 15-JUN-2022

**DRUMHELLER RIVER HAZARD STUDY
FLOOD RISK INVENTORY
AND ASSESSMENT**

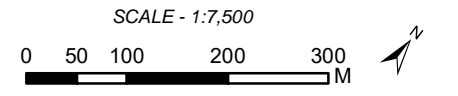
SPATIAL DATA INVENTORY

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- FLOW DIRECTION
 - MODEL CROSS SECTION
 - RS 12,345 RIVER STATION
 - FLOOD CONTROL STRUCTURE
 - BRIDGE
 - CULVERT
 - MAJOR ROAD
 - LOCAL ROAD
 - MUNICIPAL BOUNDARY
 - CENSUS UNIT
 - LAND PARCEL
 - 1000-YEAR OPEN WATER REGULATED FLOOD EXTENT
- STRUCTURES**
- School
 - Commercial
 - Government
 - Hospital
 - Water Treatment
 - WW Treatment
 - Industrial
 - Other
 - Retirement Home
 - Single Family
 - Multi-family

SHEET 26 ↓



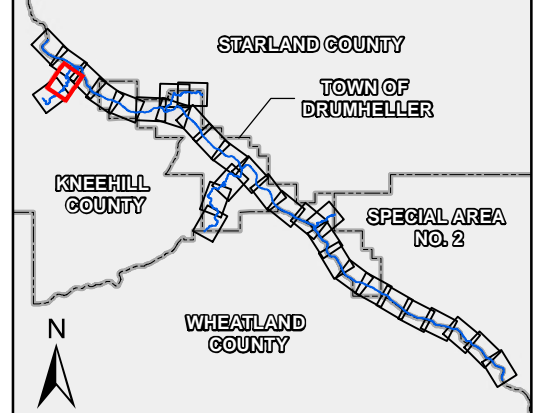
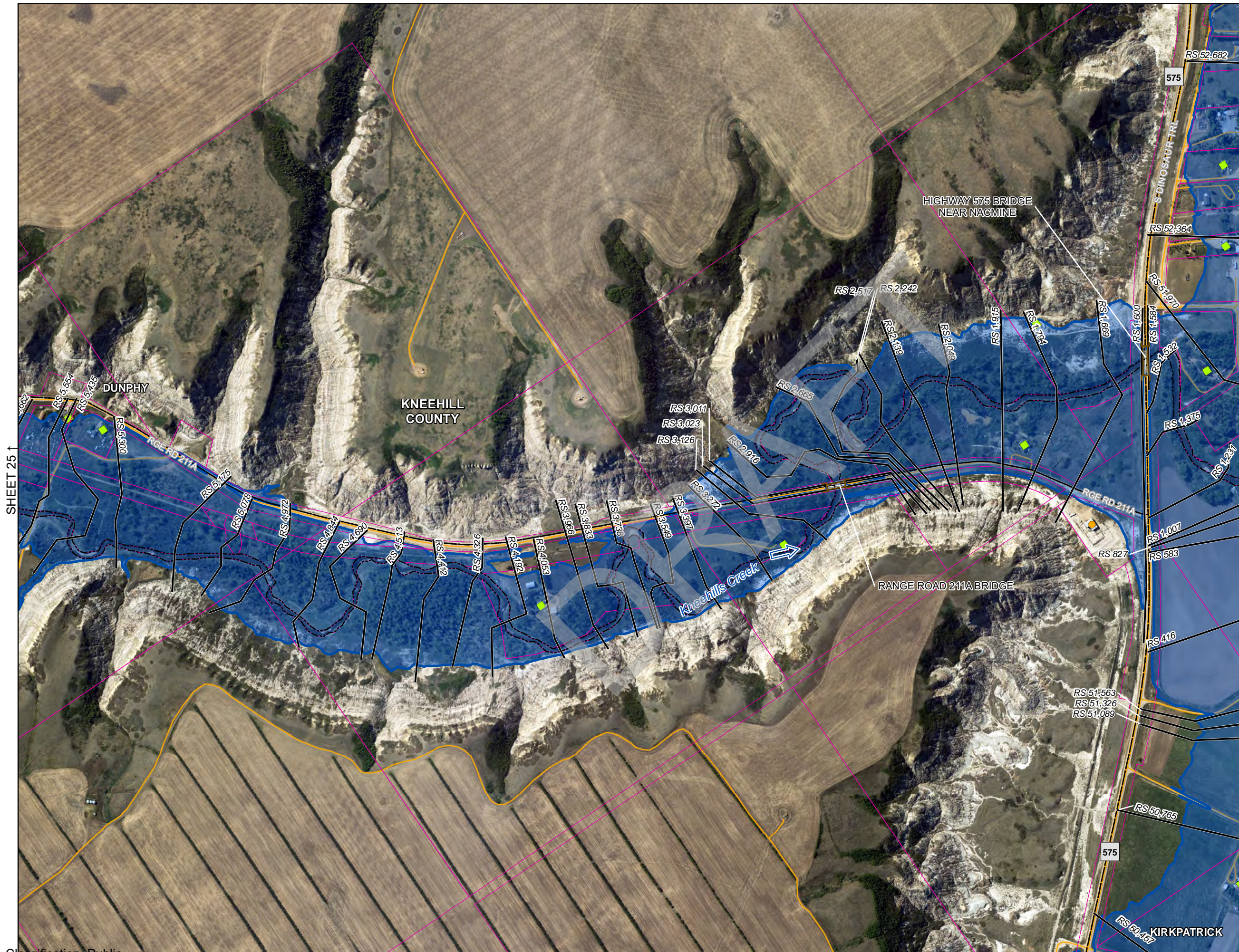
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Engineer	GIS	Reviewer
MMM	REH	RBA

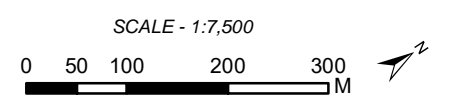
Job: 1003877 Date: 15-JUN-2022

**DRUMHELLER RIVER HAZARD STUDY
FLOOD RISK INVENTORY
AND ASSESSMENT**

SPATIAL DATA INVENTORY



- FLOW DIRECTION
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 - WW Treatment
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 - Multi-family



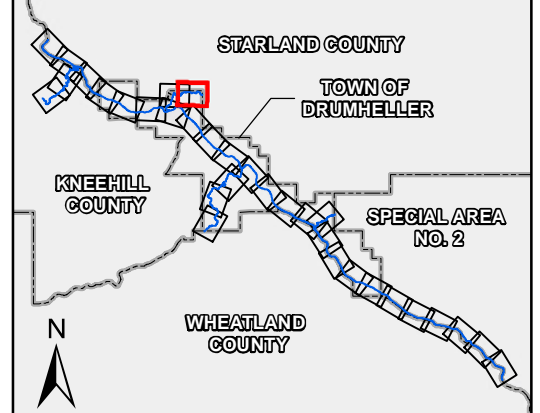
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Engineer	GIS	Reviewer
MMM	REH	RBA

Job: 1003877 Date: 15-JUN-2022

**DRUMHELLER RIVER HAZARD STUDY
FLOOD RISK INVENTORY
AND ASSESSMENT**

SPATIAL DATA INVENTORY

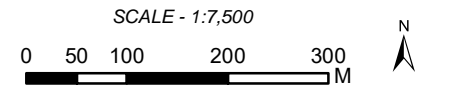


Legend

- Flow Direction (Blue arrow)
- Model Cross Section (Black line)
- River Station (RS 12,345)
- Flood Control Structure (Dashed line)
- Bridge (Brown rectangle)
- Culvert (Green rectangle)
- Major Road (Yellow line)
- Local Road (Orange line)
- Municipal Boundary (Yellow dashed line)
- Census Unit (Black dashed line)
- Land Parcel (Pink outline)
- 1000-Year Open Water Regulated Flood Extent (Blue shaded area)

STRUCTURES

- School (Red dot)
- Commercial (Orange dot)
- Government (Yellow dot)
- Hospital (Green dot)
- Water Treatment (Blue dot)
- WW Treatment (Purple dot)
- Industrial (Pink dot)
- Other (Grey dot)
- Retirement Home (Cyan square)
- Single Family (Light Green square)
- Multi-family (Yellow square)

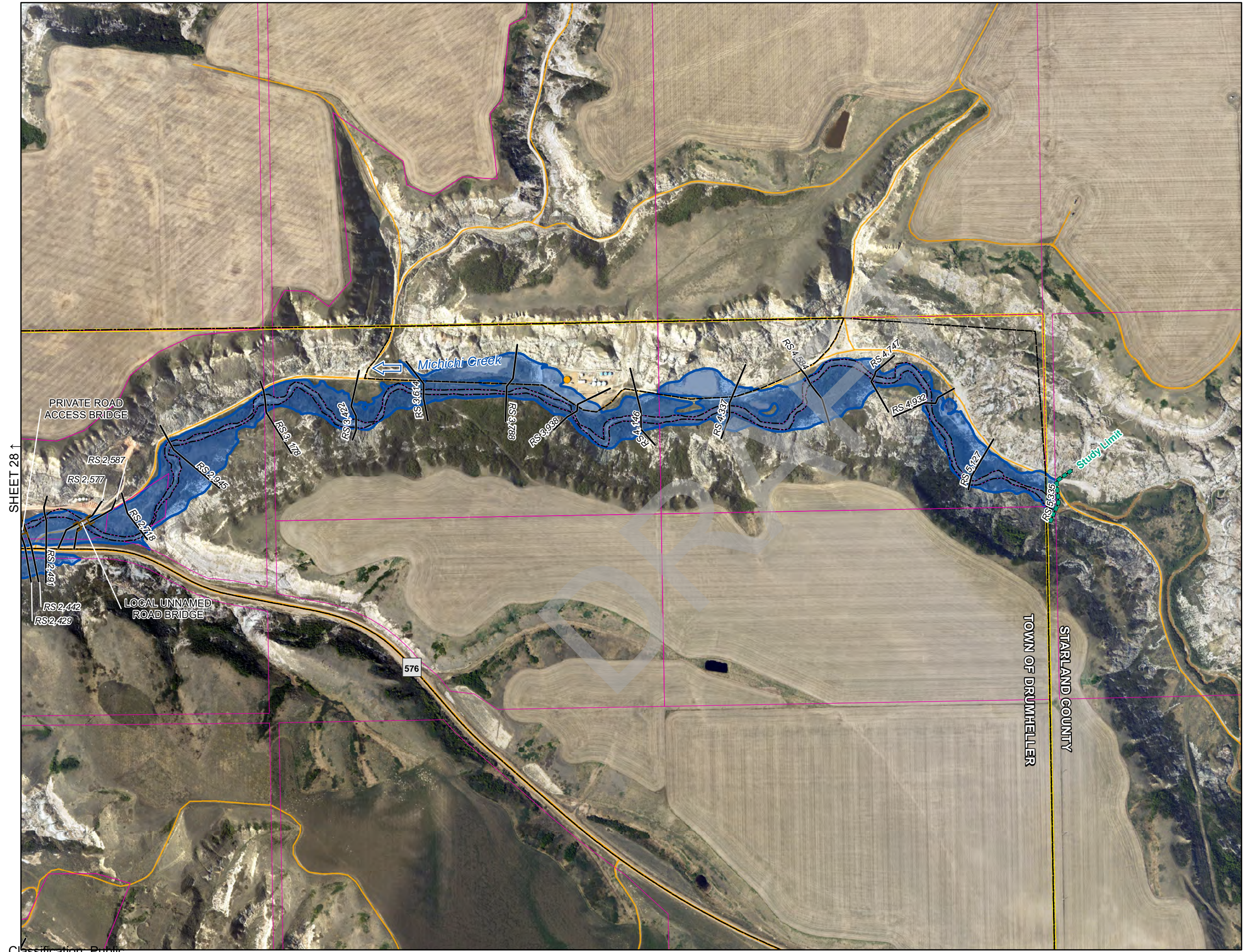


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Engineer	GIS	Reviewer
MMM	REH	RBA
Job: 1003877		Date: 15-JUN-2022

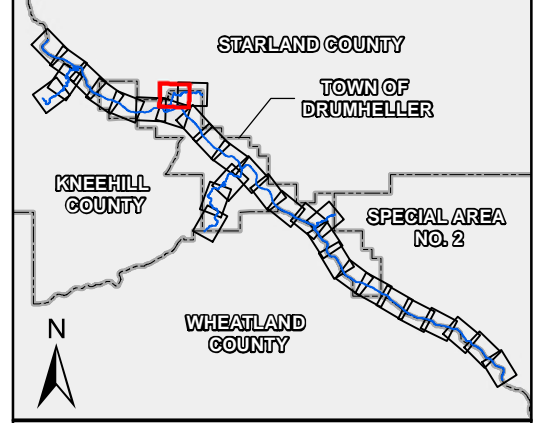
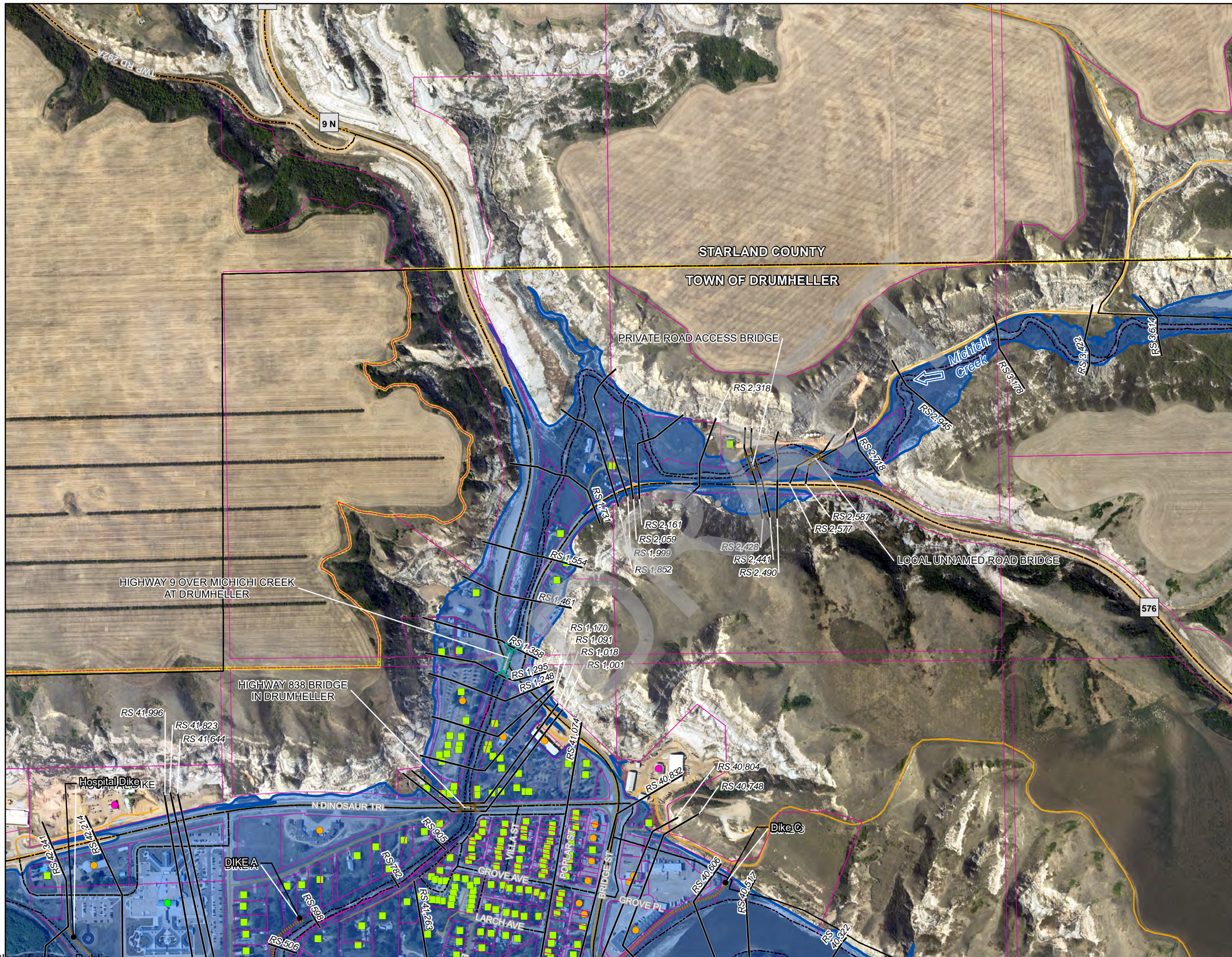
**DRUMHELLER RIVER HAZARD STUDY
FLOOD RISK INVENTORY
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SPATIAL DATA INVENTORY



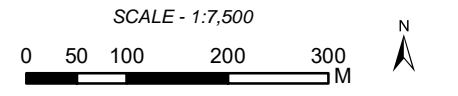
SHEET 28 ↑

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- ➔ FLOW DIRECTION
— MODEL CROSS SECTION
 RS 12,345 RIVER STATION
— FLOOD CONTROL STRUCTURE
— BRIDGE
— CULVERT
— MAJOR ROAD
— LOCAL ROAD
□ MUNICIPAL BOUNDARY
- - - CENSUS UNIT
□ LAND PARCEL
□ 1000-YEAR OPEN WATER REGULATED FLOOD EXTENT
- STRUCTURES**
- | | |
|---|---|
| ● School | ● WW Treatment |
| ● Commercial | ● Industrial |
| ● Government | ● Other |
| ● Hospital | ● Retirement Home |
| ● Water Treatment | ● Single Family |
| | ● Multi-family |

SHEET 27 ↓



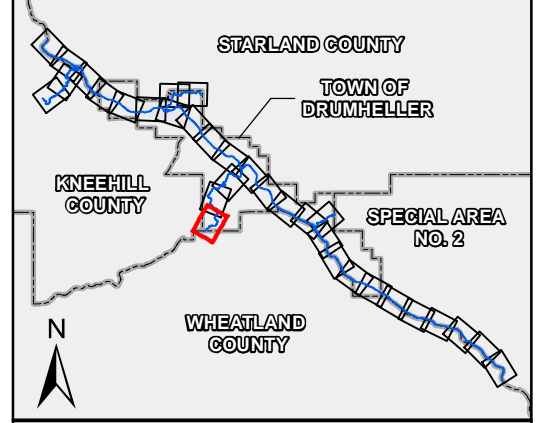
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Engineer	GIS	Reviewer
MMM	REH	RBA

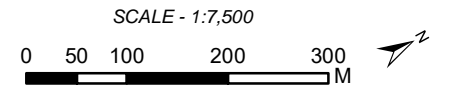
Job: 1003877 Date: 15-JUN-2022

**DRUMHELLER RIVER HAZARD STUDY
FLOOD RISK INVENTORY
AND ASSESSMENT**

SPATIAL DATA INVENTORY



- FLOW DIRECTION
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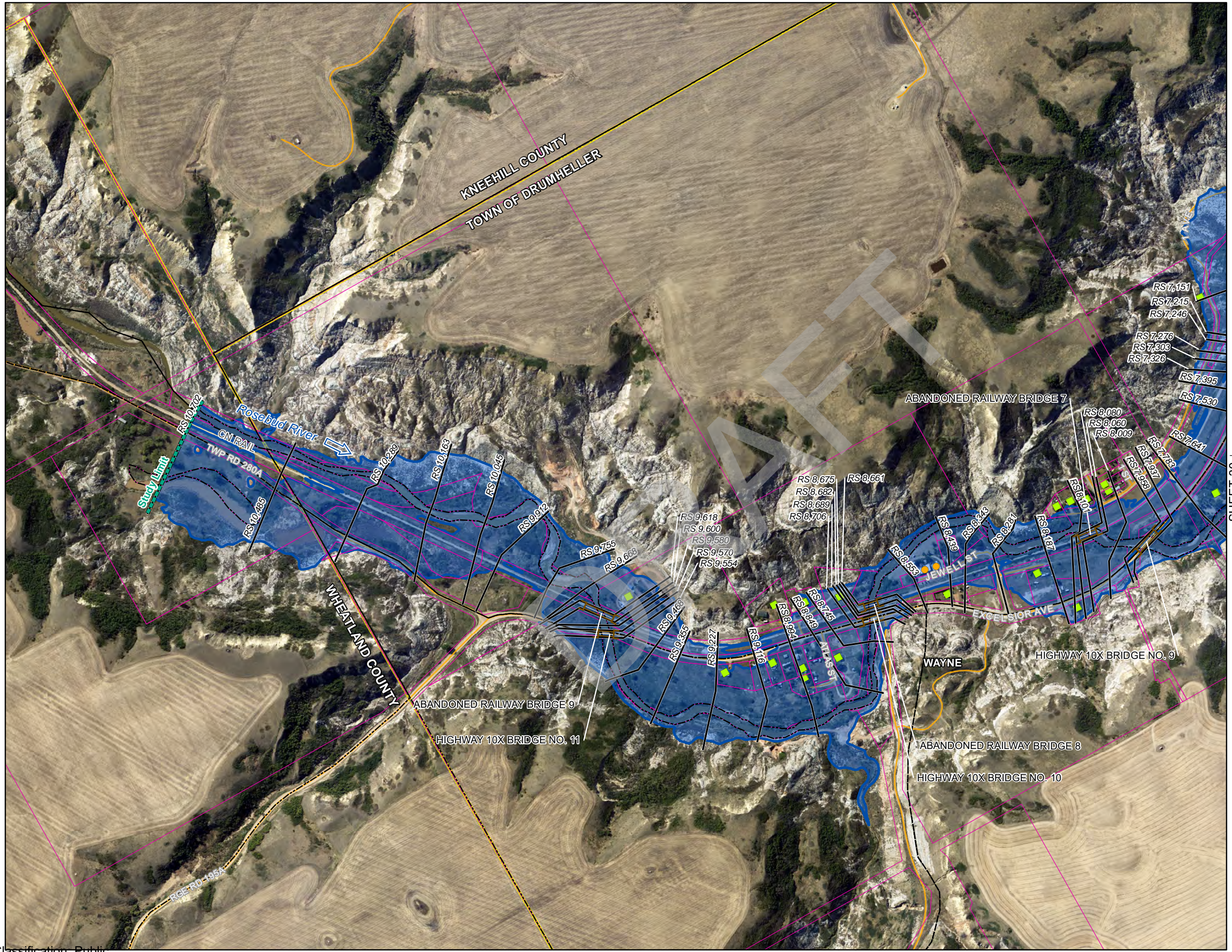
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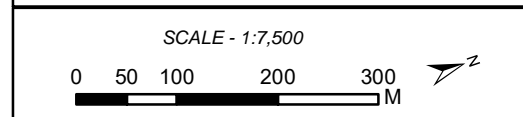
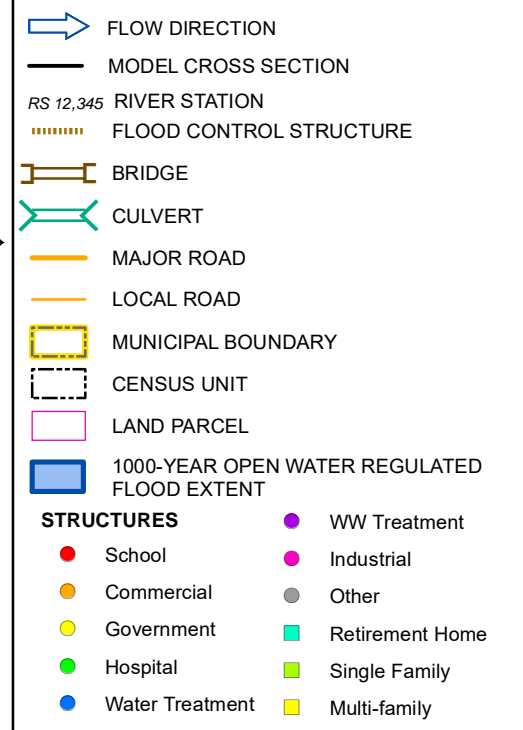
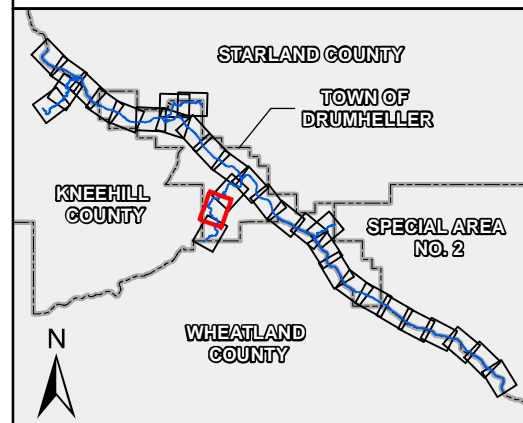
Engineer	GIS	Reviewer
MMM	REH	RBA

Job: 1003877 Date: 15-JUN-2022

**DRUMHELLER RIVER HAZARD STUDY
FLOOD RISK INVENTORY
AND ASSESSMENT**

SPATIAL DATA INVENTORY





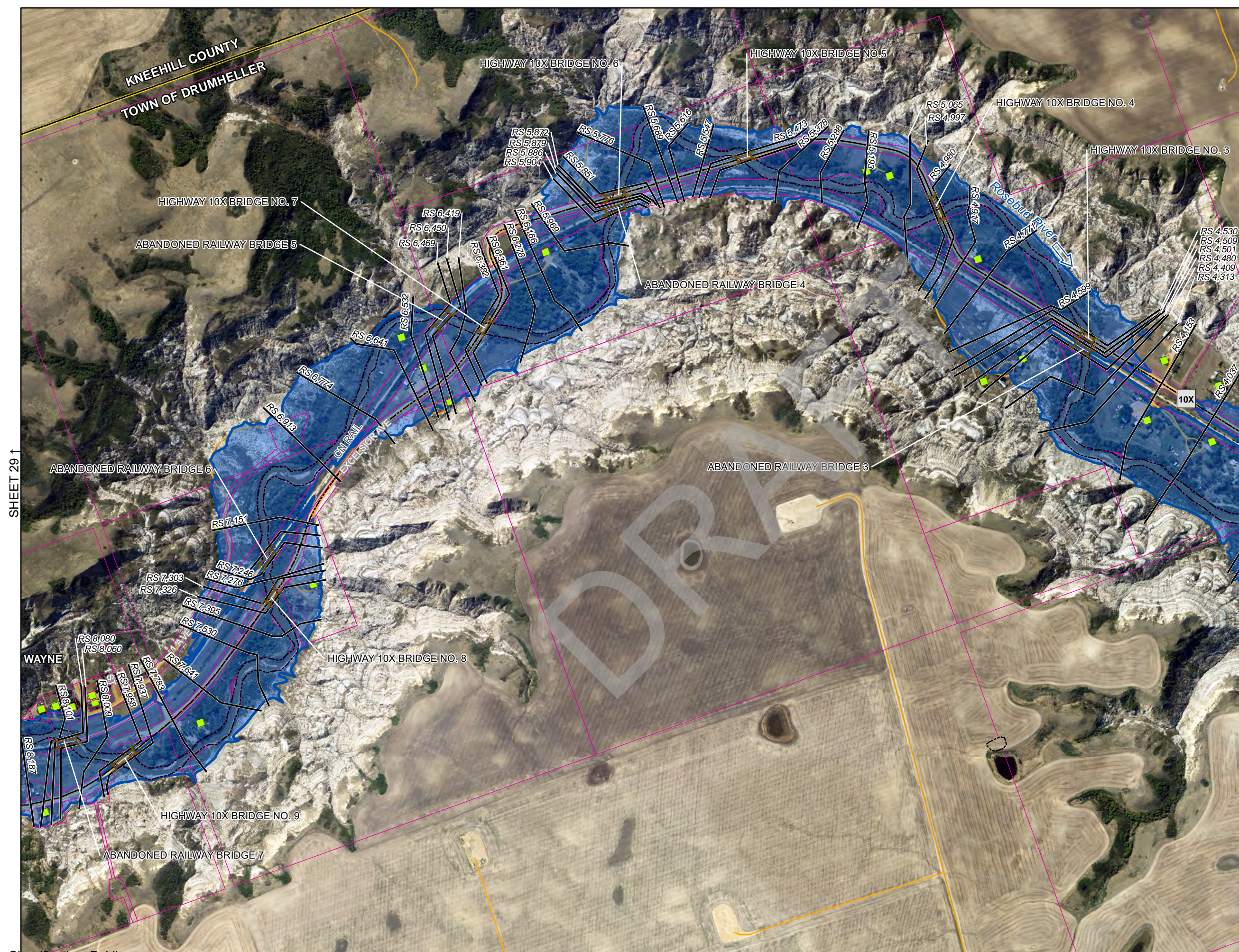
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Engineer	GIS	Reviewer
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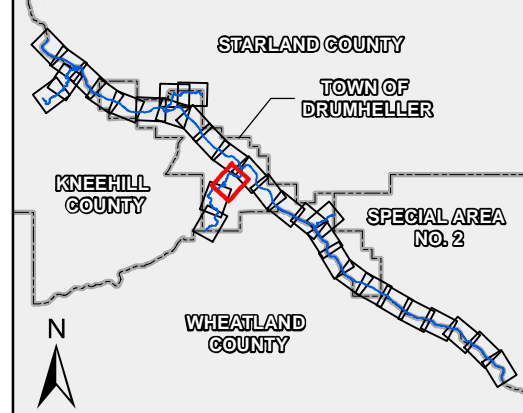
Job: 1003877 Date: 15-JUN-2022

**DRUMHELLER RIVER HAZARD STUDY
FLOOD RISK INVENTORY
AND ASSESSMENT**

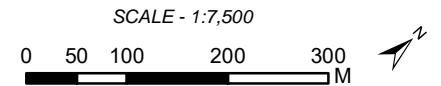
SPATIAL DATA INVENTORY



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- FLOW DIRECTION
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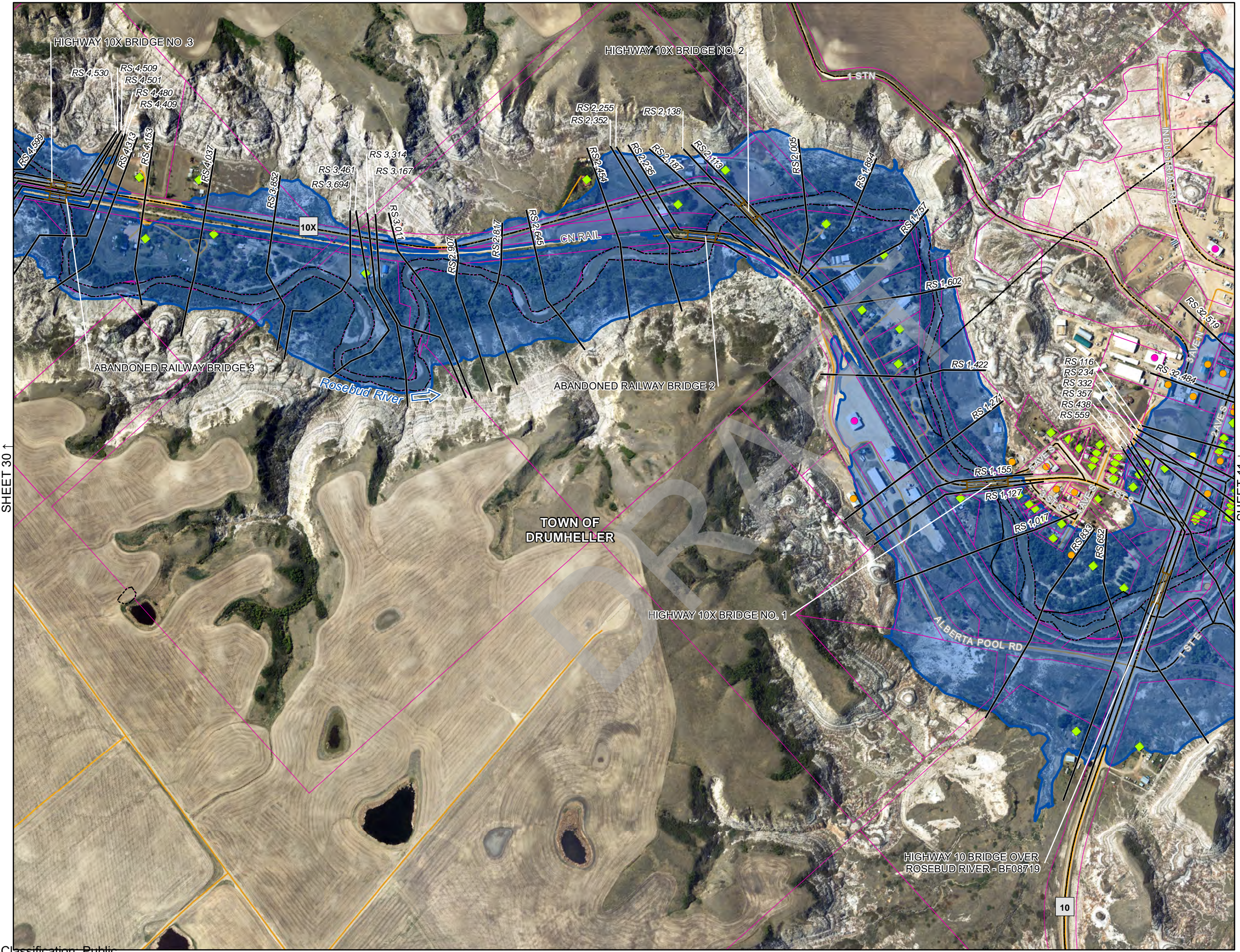
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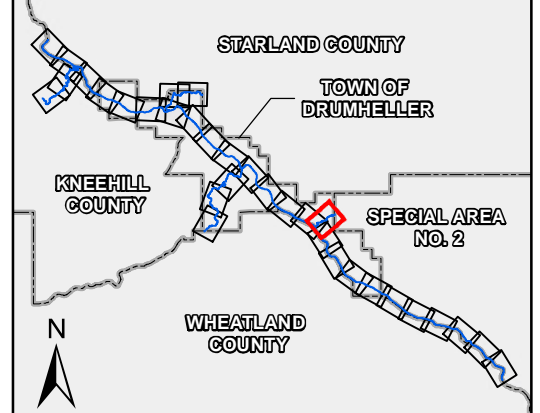
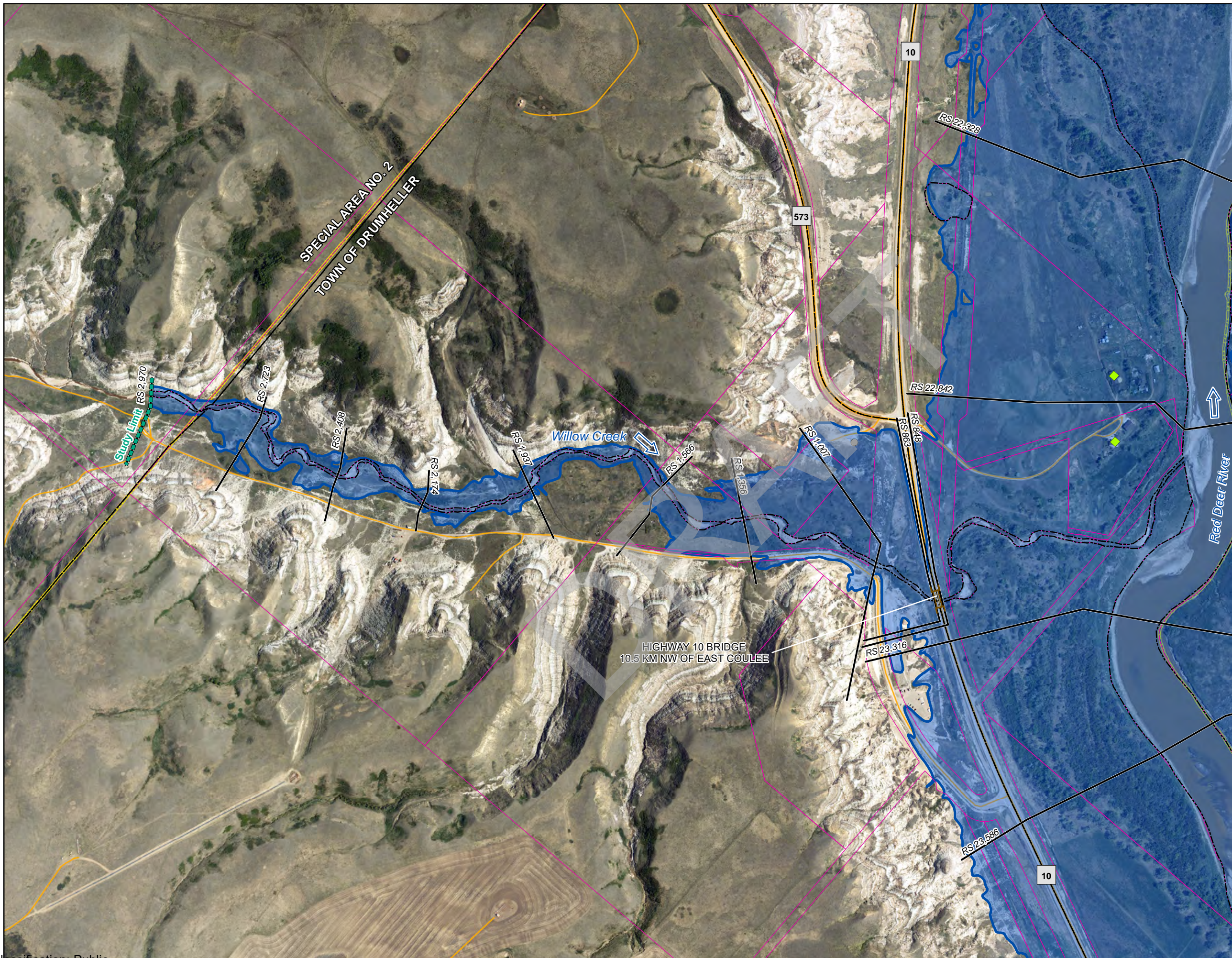
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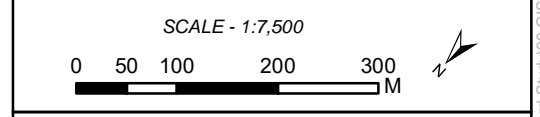
**DRUMHELLER RIVER HAZARD STUDY
FLOOD RISK INVENTORY
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SPATIAL DATA INVENTORY





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Job: 1003877 Date: 15-JUN-2022

**DRUMHELLER RIVER HAZARD STUDY
FLOOD RISK INVENTORY
AND ASSESSMENT**

SPATIAL DATA INVENTORY

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