Stormwater Management Plan and Basin Study

Village of Rycroft

SE 16-78-05-W6M

August 2019

ASSESSMENT

MPA ENGINEERING LTD

August 23rd, 2019

File: **291.Rycroft**

Village of Rycroft
4703-51 Street
Box 360
Rycroft, AB
T0H 3A0

Attention: **Mr. Jim Uhl, P.Eng.**
Infrastructure Projects Consultant

Dear Jim,

RE: Stormwater Management Plan and Basin Study,
<u>Village of Rycroft, SE 16-78-05-W6M</u>

As requested, we have completed a stormwater management plan and basin study for the Village of Rycroft located near the intersection of Highway 49 and Highway 2. Attached is a final copy of the report for your file.

Please call if you have any further questions in this regard.

Sincerely,

MPA Engineering Ltd.

Per:

PROFESSIONAL ENGINEER BRIAN M. COTE ALBERTA

Aug 23, 2019

Brian Cote, P.Eng.

PROFESSIONAL ENGINEER STEWART HAGAN ALBERTA

Stewart Hagan, P.Eng.

PERMIT TO PRACTICE
MPA ENGINEERING LTD.
Signature
Date Aug 23, 2019
PERMIT NUMBER: P 6432
The Association of Professional Engineers, Geologists and Geophysicists of Alberta

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MPA Engineering Ltd. – Third Party Disclaimer

1.0 INTRODUCTION

MPA Engineering Ltd. (MPA) was retained by the Village of Rycroft (The Village) to complete a Stormwater Management Plan and Basin Study (SMP) to address drainage problems within the Village (SE 16-78-05-W6M). The purpose of the report is to determine the impacts surrounding drainage networks and basin topography have on Village infrastructure. The study provides background information requested by the 2018/2019 Alberta Community Partnership Grant agency in the form of a Stormwater Management Plan. The intention is to potentially secure grant funding in order to resolve recurring flooding events within the Village. The study includes a review of the past engineering assessment reports completed by various Consultants as well as a hydrology review of both the internal drainage and runoff from surrounding watersheds. These discharges are then utilized to evaluate the performance of the existing culvert structures within the Village basins. Lastly, the effects of future developments and recommendations for any required action are also addressed.

2.0 BACKGROUND

Flooding of the Village of Rycroft has been a recurring problem, predating the 1960's. The Village is bordered by highway embankments on both the north and east boundaries (Highway 49 and Highway 2 respectively) and CN railway embankments on both the north and west boundaries. It has been noted that flooding takes place during spring run-off and during heavy rainfall events as overland flow travelling in a northeasterly direction converges into the center of the Village. Flooding of the Village arises from the backwater impounded by these transportation corridors.

There are three main culvert locations crossing through these embankments which handle most of the natural runoff. One of the locations is at the west side of the intersection of Highway 2 and Highway 49 which carries ditch flow from alongside Highway 2 into the Village. The other crossing location is between 48th street and 49th street, north of 48th avenue, and passes under the railway and Highway 49. The Rycroft Drainage Line (RDL) feeds into this crossing. The third crossing passes under the railway west of 51 Street.

The Village drainage infrastructure primarily consists of a network of open channels and culverts to address surface drainage. The outflows from developed areas of the Village are largely controlled by infrastructure associated with the transportation related embankments noted above. There are currently 17 smaller centreline culverts and one bridge sized culvert at 9 different crossing locations along the RDL. There are 3 smaller centreline culverts at 3 different crossing locations in the intersection of Highway 2 and Highway 49. Culvert locations within the Village are shown on Figure 7 in in the Appendix.

3.0 FILE REVIEW AND HISTORICAL REPORTS

A number of previous engineering studies (dating all the way back to 1985) have been completed in an attempt to resolve the flooding issues that have plagued the Village since at least the 1960's. The scope of these historical studies has been compiled and summarized as noted below in order to provide context for the current storm water management plan.

3.1 Drainage Assessment by MPA (2018)

MPA completed at drainage assessment in 2018 to help address the flooding occurring within the Village, which has been a reoccurring problem predating the 1960's. The report noted that flooding typically takes place during spring run-off and during heavy rainfall events as overland flow travelling in a northeasterly direction from outside the village converges into the center of the Village. Flooding has occurred within developed areas of the Village on a number of occasions from the backwater impounded by the transportation corridors which encircle the west, north, and east perimeters of the Village.

3.1.1 Hydrology

MPA reviewed basin hydrology for the RDL and Hwy 2 lines in the 2018 assessment. The flows estimated by the frequency analysis, basin potential analysis and the channel capacity method were compared to determine the most appropriate design flow. It was noted that the channel capacity method would yield relatively high flow values and would likely overestimate the design discharge. The frequency analysis and basin potential analysis were noted to yield relatively similar design flows with the frequency analysis being slightly higher and more conservative but would be expected to more accurately represent the discharge for these sites. As such, the discharges represented by the frequency analysis would be used for the recommended design flows and were based on the historical drainage area (i.e not influence by infrastructure).

$$Q_{RDL} = 7.8\ m^3/s\ (0.867\ m^3/s/km^2)$$
$$Q_{Hwy\ 2} = 2.4\ m^3/s\ (1.000\ m^3/s/km^2)$$

3.1.2 Results and Recommendations

The intent of this assessment by MPA was to determine the capacity of the Rycroft Drainage Line (RDL), as well as the ditch along Highway 2 (Hwy. 2); both of which travels northward through the Village (shown on Figure 7 in the Appendix). The report then also assessed the ability of the Village to reduce flooding within the Village by either upgrading the channel sections and crossings along these two lines, or by intercepting the flow as it enters the village and directing it away from Village infrastructure. Based on the report, the recommended option is to divert flow away from the RDL, westard along the south side of 45th avenue (shown as Figure 1 in the Appendix), into the Spirit River. Along Hwy 2, it was recommended to upgrade the culvert crossings at the intersection of Highway 2 and Highway 49, as well as two CN structures.

A summary of the costs associated with each of these options is summarized below.

Alternative	Description	Year 2018/2019 Capital Costs	Combined Capital Cost
Alternative #1	Culvert Replacements Along the Rycroft Drainage Channel	$5,550,000	$5,900,000
	Culvert Replacements Along the Highway 2 Ditch	$350,000	
Alternative #2	Diversion of Flow West Along 45th Avenue	$3,100,000	$3,450,000
	Culvert Replacements Along the Highway 2 Ditch	$350,000	

It was noted that there is a substantial cost difference between the two alternatives and with Alternative #2 being the recommended option in the 2018 report. It was far more cost effective to divert flows away from the Village (Alternative #2) than it was to upgrade the drainage infrastructure along the RDL (Alternative #1).

3.2 Rycroft Drainage Project - Preliminary Design Summary by MPA (2016)

MPA Engineering Ltd. (MPA) was retained by the MD of Spirit River (the MD) to complete a preliminary design in order to construct a drainage channel which intercepted flood waters prior to entering the Village of Rycroft. The initial intent was to intercept surface runoff along the west side of Range Road 54 (RR 54) and prevent it from flowing freely towards Rycroft. The intercepted flow would flow directly north into the Spirit River. A copy of this alignment can be found on Figure 2 in the Appendix.

3.2.1 Hydrology

MPA reviewed basin hydrology to establish a design flow. The flows estimated by the frequency analysis, basin potential analysis and the channel capacity method were compared to determine the most appropriate design flow. It was noted that the channel capacity method would yield relatively high flow values and would likely overestimate the design discharge. The frequency analysis and basin potential analysis both yielded relatively similar design flows with the frequency analysis being slightly higher and more conservative but would be expected to more accurately represent the discharge for the project. As such, the discharges represented by the 1:25 year flood frequency were recommended to be used as design flows along each individual sub basin. Shown below is the design flow used on the cumulative design area:

$$\mathbf{Q_{Max} = 1.70\ m^3/s\ (0.850\ m^3/s/km^2)}$$

3.2.2 Results and Recommendations

Based on the report, the recommended option was to intercept the flow along the west side of RR 54 and redirect northward toward the Spirit River. The estimated cost for this work would be approximately $414,000 not including utility or right-of-way costs. It was noted to the Municipal District of Spirit River (MD) that there could be substantial cost associated with moving the powerpoles along the length of the project.

It is understood that one of the main reasons this project did not proceed to detailed design is that although it would reduce flooding in the Village, it was only expected to marginally reduce peak flows in the Village by less than 20%. Based on this, the Village elected to find more effective options that could be considered.

3.3 Infrastructure Assessment Report by TeckEra Consulting Ltd. (2016)

In 2016, TeckEra Consulting Ltd. was commissioned to complete an assessment report of the Village's core infrastructure, including the water system, sanitary sewer system, water drainage system, road network and municipal buildings. Although many of these items are independent of the flooding issues occurring in the Village and outside of the scope of this report, the water drainage infrastructure performs an important function in the Village's ability to eliminate stormwater. A copy of the existing drainage infrastructure from the report is shown on Figure 3 in the Appendix.

MPA reviewed the report to extract any information that could be pertinent to managing stormwater within the Village. After reviewing the report, the key points of their findings and discussions, as summarized by MPA, can be described as follows:

- The main channel (RDL) which flows through the village drains a substantial amount of water from the south of the Village and a large volume of water enters the Village during stormwater events. A bottleneck occurs at the CN tracks and South of Hwy 49
- A small segment of underground storm piping exists near the core area (47th Ave and 49th Street). TeckEra recommended extending this underground storm sewer 1 block further west to help drain the commercial core of the Village.
- Future areas of Village growth include a 32 Acre parcel of undeveloped land west of the CN railway. Additionally, growth could expand south of 45th avenue, though it's not currently within the Village boundary.

3.3.1 Results and Recommendations

Based on TeckEra's report, their key recommendations as they relate to the drainage systems were as follows:

- Work with the MD to divert all or some of the offsite drainage that enters the village from the South.
- Remedy drainage "bottleneck" points at the CN tracks and Hwy 49 by increasing culvert capacity (along lines now referred to as RDL and Hwy 2 ditch)
    - The Village was working with CN and AT on this initiative.

- Improve several drainage components throughout the Village including replacement of swales, ditch re-grading, culvert installations, and extensions of the underground piping network.

3.4 Rycroft Flood Hazard Mapping Study by AECOM Canada Ltd. (2009)

In 2009, AECOM Canada Ltd. was commissioned by Alberta Environment and Parks (AEP) to complete Flood Hazard Mapping Study along 3.6 km of the Spirit River and 1.5 km of the main watercourse which passes through the Village (RDL). MPA reviewed the report to extract information that could be pertinent to managing stormwater within the Village. The key points of their findings and discussions, as they relate to this report are summarized as follows:

The main objectives of AECOM's study was to:

- Identify flood prone areas and minimize the risks and costs associated with flooding.
- Provide guidance for the non-use of flood prone lands.
- Increase public awareness of existing flood hazards in the communities.

This was to be accomplished by:

- Reviewing report documents, studies, surveys, and other available information. This includes references to floods in the 1960's and 1980's as well as photographs of the flooding in 1990, 1996, 1997.
- Conducting a hydrology study
- Developing a hydraulic computer model for the specified reach of the Spirit River and RDL.

The report by AECOM was comprehensive in regards to their scope and provides a significant amount of useful information regarding the history and flooding within the Village. This report should be reviewed by anyone seeking to understand the specific history and risks associated with flooding within the Village along the RDL. The report includes these specific sections:

- History of flooding including recent floods and ice jams.
- Available hydrological data such as topography, highwater marks, rating curves for both watercourses, flood photography

- River valley features, such as channel and floodplain characteristics, man-made features in the river valley and along RDL.
- Calculation of flood levels using HEC-RAS.
- Determination of the floodway for both watercourses
- Flood hazard maps

3.4.1 Hydrology

Based on the AECOM report the maximum estimated discharge along the RDL was calculated using frequency analysis and regional analysis. The analysis can be found in full in the appendix of their report. It should be noted that the drainage basin was calculated using graphical methods and was reported to be approximately 6.1 km^2 by AECOM and likely represented historical drainage area. For the purposes of this report, the maximum estimated discharge for select return periods along the RDL are summarized below:

$$\mathbf{Q_{10} = 2.0\ m^3/s\ (0.328\ m^3/s/km^2)}$$
$$\mathbf{Q_{20} = 2.6\ m^3/s\ (0.426\ m^3/s/km^2)}$$
$$\mathbf{Q_{50} = 3.7\ m^3/s\ (0.607\ m^3/s/km^2)}$$

3.4.2 Results and Recommendations

One of the primary findings of the report completed by AECOM was that the Spirit River did not contribute to flooding within the Village. Flooding was associated with water entering the Village without adequate outlets in place to accommodate the external flows. From the study it was apparent that the Spirit River would be an adequate outlet for flows passing through or arising from the Village.

Additionally, the following results along RDL were determined:

- North of the railway line, flood flow is generally contained within the stream valley and most of the hazard area is considered floodway, which indicates that there is more capacity available should crossing capacity through Hwy 49 and the CN rail be increased.
- South of the railway line, the flow spills over the banks affecting residential and commercial properties and these are considered to be within the flood fringe area. However, the floodway is contained within the designated channel. A map which

indicates the flood hazard area for the 10, 50 and 100 year floods is contained in the Appendix as Figure 4.

3.5 Rycroft Flood Control Report by GPEC Consulting Ltd. (1997)

In 1997, GPEC Consulting Ltd. was commissioned by the MD of Spirit River (MD) to determine the benefits and constraints of developing several drainage lines south of the Village which could help divert flow away from the Village and reduce flooding of the Village and surrounding agricultural land. A map of these drainage lines and their locations is shown as Figure 5 and contained in the Appendix. MPA reviewed the report to extract any information that could be pertinent to managing stormwater within the Village which is summarized below.

3.5.1 Hydrology

Based on the GPEC report the maximum estimated discharge at several outflow locations defined as a part of their design were calculated using frequency analysis. For the purposes of this report, the maximum estimated basin potentials for select return periods are summarized below:

$$\mathbf{q_{10} = 0.350\ m^3/s/km^2}$$
$$\mathbf{q_{25} = 0.485\ m^3/s/km}$$
$$\mathbf{q_{100} = 0.955\ m^3/s/km^2}$$

3.5.2 Results and Recommendations

Based on GPEC's report, their key recommendations were as follows:

- Flooding has caused extensive and repetitive erosion damage to the roadways, as well as Bremner Creek.
- Flooding culminates at the Hwy 2 and Hwy 49 intersection.
- Problems could be reduced by upgrading existing drainage channels in and around the Village.
- Line 5, Line 1 (north of Line 5), Line 7 should be constructed.
- Line 3, and 4 should be upgraded.

3.6 Rycroft Flood Control Drawings for Line 1 – 5 by Keneema Engineering (1985)

Drawings were completed by Keneema Engineering in 1985 for the construction of Line 1 through 5 as defined by the drainage lines depicted in the GPEC Consulting report. It is unclear how much or if any of that work has ever been completed.

4.0 CURRENT HYDROLOGY

4.1 Drainage Basins

Drainage basins inside and outside the village were assessed to determine the natural path of flows as well as how existing infrastructure affects natural drainage patterns. For this report, MPA used Lidar15 topographical data outside of the village and high density Lidar within the village to calculate the natural drainage areas of each basin.

4.2 Outside of Village

There is approximately 10.4 km^2 of drainage area that flows toward, or has potential to flow toward the Village, from agricultural land, located south of the Village. These basins are relatively flat, are not well defined, and have been affected by infrastructure construction such as municipal and provincial roads, CN Rail, and agricultural land improvements. There are several areas where basin crossover is possible due to the low relief and poor definition of the natural topography. This crossover would likely occur at locations where existing crossings or channels are undersized, or have become iced during spring runoff. Examples of this would include Outlets W, and X as shown on Figure 6 in the Appendix. The terrain in these basins has been almost entirely cleared for agricultural purposes with nearly no tree cover. There are no notable depressions or sloughs within the basin that would create storage of flood waters. As such, it is expected that the basin would be well drained. A plan of the drainage basin areas are shown on Figure 6 and is included in the Appendix.

4.3 Inside of Village

There is approximately 2.45 km^2 of drainage area within the Village, which generates flow from predominately developed land. Developed areas within these basins typically consist of paved, or graveled surfaces or composed of commercial and residential buildings. The relatively dense development combined with the flat topography results in a high potential for basin crossover. This can be aggravated during the spring runoff due to several different factors such as locations of snow piles, frozen channels, as well as frozen culverts. However, the majority of the basins are generally well defined and as drainage infrastructure improves, less crossover should be expected. A plan of the drainage basin areas within the Village are shown on Figure 7 and is included in the Appendix.

4.4 Summary of Drainage Basins

Using satellite imagery, current drainage patterns and channels were estimated, locations where outflows exist were mapped onto the drainage basins that they represent, and drainage areas for each outflow was calculated. Additionally, percentages of developed areas compared to undeveloped (such as agricultural) areas were estimated in order to better understand potential future changes. Typically it is found that developed lands shed water much quicker than undeveloped areas due to factors such as paved surfaces, rooftops, surfaces landscaped for drainage and reduced infiltration into the soil. These factors help generate much higher basin intensities and should be considered when any urban area transitions from undeveloped to developed land. The results tabulated in the table shown below.

Table Summarizing Drainage Areas					
Inflow / Outflow Point	**Flows into or out of Village**	**Drainage Area (km^2)**	**Drainage Area of Inflow (km^2)**	**Total Drainage Area (km^2)**	**Landuse (% Developed)**
Outside of Village Boundary					
Z	In	3.00	-	3.00	0%
Y	In	2.60	-	2.60	0%
V	Out	0.91	-	0.91	0%
W	Out	2.34	-	2.34	0%
X	Out	1.52	-	1.52	15%
Inside of Village Boundary					
A	Out	0.08	0.91	0.99	0%
B	Out	0.02	-	0.02	0%
C	Out	0.04	-	0.04	0%
D	Out	0.11	-	0.11	0%
E	Out	0.34	-	0.34	40%
F	Out	0.05	-	0.05	15%
G	Out	0.03	-	0.03	75%
H	Out	0.03	-	0.03	85%
I	Out	0.08	-	0.08	40%
J	Out	0.07	-	0.07	10%
K	Out	0.01	-	0.01	90%
L	Out	0.05	-	0.05	25%
M	Out	0.01	-	0.01	10%
N	Out	0.54	3.00	3.54	55%
O	Out	0.29	2.60	2.89	75%
P	Out	0.11	-	0.11	45%
Q	Out	0.09	-	0.09	20%
R	Out	0.15	-	0.15	15%
S	Out	0.02	-	0.02	0%
T	Out	0.14	-	0.14	10%
U	Out	0.19	-	0.19	30%

4.5 Recommended Design Flow

Extensive basin hydrology and analysis has been completed for these basins in the past by various consultants, including two separate projects completed by MPA in 2016 and 2018. When completing the file review, it was noted that the basin intensity (q) recommended by MPA was typically higher than those recommended by other consultants. In MPA's experience on other projects similar to this, most severe flooding occurs during spring runoff which is a function of that years' snowpack as well as blockages in channels and culverts due to ice. Using historical snow pack is more conservative than frequency analysis, and should be used when there is a strong potential for property damage, and occur most often during spring runoff. Frequency analysis would be more suitable for basins that are exclusively rural in nature or when flooding is a result of post spring runoff events. As such, MPA recommends continuing to use the basin intensities developed in MPA's past reports for this project which are summarized below for both developed and undeveloped parcels of land:

$$q_{undeveloped} = 0.867 \text{ m}^3/\text{s}/\text{km}^2$$

$$q_{developed} = 1.000 \text{ m}^3/\text{s}/\text{km}^2$$

4.6 Summary of Exiting Design Flows

Using the drainage areas and basin potentials noted above, the following design flows for each drainage area is recommended in the following table.

Table Summarizing Existing Peak Flows Inside and Outside of Village					
Inflow / Outflow Point	Total Drainage Area (km^2)	Landuse (% Developed)	Flow Generated by Developed Areas (m^3/s)	Flow Generated by Undeveloped Areas (m^3/s)	Total Flow Generated by Basin (m^3/s)
Outside of Village Boundary					
Z	3.00	0%	0.00	2.60	**2.60**
Y	2.60	0%	0.00	2.25	**2.25**
V	0.91	0%	0.00	0.79	**0.79**
W	2.34	0%	0.00	2.03	**2.03**
X	1.52	15%	0.23	1.12	**1.35**
Inside of Village Boundary					
A	0.99	0%	0.00	0.86	**0.86**
B	0.02	0%	0.00	0.01	**0.01**
C	0.04	0%	0.00	0.03	**0.03**
D	0.11	0%	0.00	0.10	**0.10**
E	0.34	40%	0.13	0.17	**0.31**
F	0.05	15%	0.01	0.04	**0.05**
G	0.03	75%	0.02	0.01	**0.03**
H	0.03	85%	0.03	0.00	**0.03**
I	0.08	40%	0.03	0.04	**0.07**
J	0.07	10%	0.01	0.06	**0.06**
K	0.01	90%	0.01	0.00	**0.01**
L	0.05	25%	0.01	0.03	**0.04**
M	0.01	10%	0.00	0.01	**0.01**
N	3.54	55%	0.30	2.81	**3.11**
O	2.89	75%	0.21	2.32	**2.53**
P	0.11	45%	0.05	0.05	**0.10**
Q	0.09	20%	0.02	0.06	**0.08**
R	0.15	15%	0.02	0.11	**0.13**
S	0.02	0%	0.00	0.02	**0.02**
T	0.14	10%	0.01	0.11	**0.12**
U	0.19	30%	0.06	0.12	**0.18**

4.7 Summary of Potential Future Design Flows

After reviewing each of the basins, inside and outside of the Village, MPA estimated the potential for each basin to become more developed, increasing the ability for each basin to shed stormwater on a more efficient basis. This helps determine the areas that are more likely to exhibit flooding concerns in the future, as well as areas that they should focus on when issuing development permits. A contingency of 10% was also added to agricultural areas in order to approximate the increase in drainage efficiency and improvements that landowners will likely continue to make to the drainage of their land in the future. Since one of the major recommendations that has been made by several of the latest reports, including MPA's most recent report, is to complete a stormwater diversion south of the Village, future peak flows were estimated with and without a diversion in place so the effects of the diversion could be noted. The location of this diversion is shown on Figure 7 in the Appendix.

4.7.1 Design Flow - Without Diversion along South Border of Village

The table below shows the approximate design flows and approximate increases in peak flow that should be accounted for in future developments assuming that the RDL is upgraded and flows from south of the Village continue to pass through the Village.

Table Summarizing Potential Future Peak Flows Inside and Outside of Village without Diversion away from Village

Inflow / Outflow Point	Total Drainage Area (km^2)	Existing Landuse (% Developed)	Potential Landuse (% Developed)	Increase in Developed Landuse	Existing Flow Generated by Basin (m^3/s)	Potential Future Flow Generated by Basin (m^3/s)	Increase in Design Flow Due to Change in Landuse (%)
Outside of Village Boundary							
Z	3.00	0%	0%	0%	**2.60**	**2.86**	**10%**
Y	2.60	0%	0%	0%	**2.25**	**2.48**	**10%**
V	0.91	0%	0%	0%	**0.79**	**0.87**	**10%**
W	2.34	0%	0%	0%	**2.03**	**2.23**	**10%**
X	1.52	15%	15%	0%	**1.35**	**1.48**	**10%**
Inside of Village Boundary							
A	0.99	0%	60%	60%	**0.86**	**0.94**	**10%**
B	0.02	0%	20%	20%	**0.01**	**0.01**	**3%**
C	0.04	0%	50%	50%	**0.03**	**0.04**	**8%**
D	0.11	0%	85%	85%	**0.10**	**0.11**	**13%**
E	0.34	40%	40%	0%	**0.31**	**0.31**	**0%**
F	0.05	15%	65%	50%	**0.05**	**0.05**	**7%**
G	0.03	75%	80%	5%	**0.03**	**0.03**	**1%**
H	0.03	85%	90%	5%	**0.03**	**0.03**	**1%**
I	0.08	40%	90%	50%	**0.07**	**0.08**	**7%**
J	0.07	10%	10%	0%	**0.06**	**0.06**	**0%**
K	0.01	90%	90%	0%	**0.01**	**0.01**	**0%**
L	0.05	25%	25%	0%	**0.04**	**0.04**	**0%**
M	0.01	10%	90%	80%	**0.01**	**0.01**	**12%**
N	3.54	55%	90%	35%	**3.11**	**3.39**	**9%**
O	2.89	75%	85%	10%	**2.53**	**2.76**	**9%**
P	0.11	45%	65%	20%	**0.10**	**0.10**	**3%**
Q	0.09	20%	85%	65%	**0.08**	**0.09**	**10%**
R	0.15	15%	90%	75%	**0.13**	**0.15**	**11%**
S	0.02	0%	90%	90%	**0.02**	**0.02**	**14%**
T	0.14	10%	90%	80%	**0.12**	**0.14**	**12%**
U	0.19	30%	60%	30%	**0.18**	**0.18**	**4%**

Based on the expected increase in design flow, there are several areas that should be noted as well as key points to consider going forward which are:

- Flow from outside of the Village that travels through the Village (Z,Y,V) is expected to increase into the future, worsening probability and severity of flooding within the Village.
- The two major areas which have ongoing flooding issues (N, O) would expect to see a 9% increase in flow going into the future.

- Outflows A, D, M, Q, R, S, T are expected to increase by >10%. This means that outflow values will increase as development increases in low developed areas, potentially risking those developments. However, this could can be planned for when those developments are constructed through the permitting process (eg. incorporating onsite retention features into the development permit requirements).
- Partially developed areas such as F, I would expect to see an increase in design flow between 7-9%.
- Areas B, E, G, H, J, K, L, P, and U are not expected to increase their design flow in significantly into the future (<4%).

4.7.2 Design Flow - With Diversion along South Border of Village

The table below shows the approximate design flows and approximate increases in peak flow that should be accounted for in future developments assuming a diversion is constructed along the south border of the Village to redirect flows from outside of the Village to by-pass the Village altogether.

Table Summarizing Potential Future Peak Flows Inside and Outside of Village with Diversion away from Village							
Inflow / Outflow Point	Total Drainage Area (km^2)	Existing Landuse (% Developed)	Potential Landuse (% Developed)	Increase in Developed Landuse	Existing Flow Generated by Basin (m^3/s)	Potential Future Flow Generated by Basin (m^3/s)	Increase in Design Flow Due to Change in Landuse (%)
Outside of Village Boundary							
Z -Diverted	3.00	0%	0%	0%	**2.60**	**0.00**	**-100%**
Y - Diverted	2.60	0%	0%	0%	**2.25**	**0.00**	**-100%**
V	0.91	0%	0%	0%	**0.79**	**0.00**	**-100%**
W	2.34	0%	0%	0%	**2.03**	**2.23**	**10%**
X	1.52	15%	15%	0%	**1.35**	**1.48**	**10%**
Inside of Village Boundary							
A	0.08	0%	60%	60%	**0.86**	**0.07**	**-91%**
B	0.02	0%	20%	20%	**0.01**	**0.01**	**3%**
C	0.04	0%	50%	50%	**0.03**	**0.04**	**8%**
D	0.11	0%	85%	85%	**0.10**	**0.11**	**13%**
E	0.34	40%	40%	0%	**0.31**	**0.31**	**0%**
F	0.05	15%	65%	50%	**0.05**	**0.05**	**7%**
G	0.03	75%	80%	5%	**0.03**	**0.03**	**1%**
H	0.03	85%	90%	5%	**0.03**	**0.03**	**1%**
I	0.08	40%	90%	50%	**0.07**	**0.08**	**7%**
J	0.07	10%	10%	0%	**0.06**	**0.06**	**0%**
K	0.01	90%	90%	0%	**0.01**	**0.01**	**0%**
L	0.05	25%	25%	0%	**0.04**	**0.04**	**0%**
M	0.01	10%	90%	80%	**0.01**	**0.01**	**12%**
N	0.54	55%	90%	35%	**0.51**	**0.53**	**5%**
O	0.29	75%	85%	10%	**0.28**	**0.28**	**1%**
P	0.11	45%	65%	20%	**0.10**	**0.10**	**3%**
Q	0.09	20%	85%	65%	**0.08**	**0.09**	**10%**
R	0.15	15%	90%	75%	**0.13**	**0.15**	**11%**
S	0.02	0%	90%	90%	**0.02**	**0.02**	**14%**
T	0.14	10%	90%	80%	**0.12**	**0.14**	**12%**
U	0.19	30%	60%	30%	**0.18**	**0.18**	**4%**

Based on the expected increase in design flow many of the previous noted issues (from without diversion) remain the same. However, there are several key differences:

- Flow from outside the Village (Z, Y, V) would no longer pass through the village, eliminating the design flow that needs to be considered by these basins.
- The two major areas which have the most predominant ongoing flooding issues (N,O) would decrease to 16% and 10% of their original design flows respectively.

5.0 PERFORMANCE OF EXISTING INFRASTRUCTURE

In order to better understand how the existing infrastructure within the Village is expected to perform going into the future, MPA compared the expected future design flows with the approximate capacity of the infrastructure within each basin. This was also compared the expected design flows assuming diversion along the south side of 45th avenue would be completed. The table below summarizes the approximate capacity of each basin to convey flow, the design flows for both the 'with' and 'without' diversion cases, and a determination on the performance of the existing infrastructure and whether or not the infrastructure is undersized.

Table Summarizing Undersized and Adequately Sized Infrastructure Based on Future Flows, With and Without a Diversion along 45th Ave

Inflow / Outflow Point	Culvert Outflow Diameter (mm)	Generalized Culvert Outflow Capacity @ 1.2 m/s (m^3/s)	Future Design Flow, Without Diversion (m^3/s)	Future Flow, With Diversion (m^3/s)	Undersized Without Diversion?	Undersized With Diversion?	Comments
Outside of Village Boundary							
Z	2 x 800 mm CSP	1.20	2.86	0.00	Y	N	Culverts undersized, consistent with roadway overtopping. Potential for diversion along 45th Ave investigated in 2018 report. Cost is approximately $3.2M
Y	1 x 900 mm CSP	0.76	2.48	0.00	Y	N	Culverts undersized, consistent with roadway overtopping, likely receives basin transfer from Outflow X. Could be tied into proposed diversion of Outflow Z which should be reviewed for financial cost.
V	2 x 600 mm CSP	0.67	0.87	0.00	Y	N	Somewhat undersized, especially if frozen. No historical information regarding flooding or overtopping
W	1200 mm (Approx)	1.35	2.23	2.23	Y	Y	Culvert is undersized, likely results in some overtopping of TWP 780, resulting in transfer to Outflow X and Y.
X	2 x 900 mm (Approx)	1.52	1.48	1.48	Y-due to transfer	Y-due to transfer	Culvert likely flows full and may be undersized if additional water received from Outflow W. Excess water likely diverted to Outflow Y.
Inside of Village Boundary							
A	None	Natural Flow	0.86	0.07	Y- due to Inflow	N	If diversion not completed: - there is risk of farmland flooding and erosion, but not aware of any current issues. -Should development proceed, there is a concern that developments will be affected by flooding, unless they are designed to accomodate the design flow, but this may result in issues similar to current issues occuring in the Village. If diversion completed: -Minor risk to future farmland flooding or erosion. -Minimal risk to future development.
B	None	Natural Flow	0.01	0.01	Y-due to transfer	N	If diversion not completed: - there is risk of farmland flooding and erosion, due to transfer from Outflow A, but not aware of any current issues. -Should development proceed, there is a concern that developments will be affected by flooding due to outflow from A, unless they are designed to accomodate the design flow, but this may result in issues similar to current issues occuring in the Village. If diversion completed: -Minimal risk of transfer from outflow A -Minor risk to future farmland flooding or erosion. -Minimal risk to future development.
C	None	Natural Flow	0.03	0.04	Y-due to transfer	N	If diversion not completed: - there is risk of farmland flooding and erosion, due to transfer from Outflow A and B, but not aware of any current issues. -Should development proceed, there is a concern that developments will be affected by flooding due to outflow from A and B, unless they are designed to accomodate the design flow, but this may result in issues similar to current issues occuring in the Village.. If diversion completed: - Minimal risk of transfer from outflow A or B -Minor risk to future farmland flooding or erosion. -Minimal risk to future development.
D	None	Natural Flow	0.10	0.11	Y-due to transfer	N	If diversion not completed: - there is risk of farmland flooding and erosion, due to transfer from Outflow A, B, and C but not aware of any current issues. -Should development proceed, there is a concern that developments will be affected by flooding due to outflow from A, B, and C unless they are designed to accomodate the design flow, but this may result in issues similar to current issues occuring in the Village.. If diversion completed: -Minimal risk of transfer from outflow A, B, or C -Minor risk to future farmland flooding or erosion. -Minimal risk to future development.

Table Summarizing Undersized and Adequately Sized Infrastructure Based on Future Flows, With and Without a Diversion along 45th Ave

Inflow / Outflow Point	Culvert Outflow Diameter (mm)	Generalized Culvert Outflow Capacity @ 1.2 m/s (m^3/s)	Future Design Flow, Without Diversion (m^3/s)	Future Flow, With Diversion (m^3/s)	Undersized Without Diversion?	Undersized With Diversion?	Comments
Inside of Village Boundary (cont.)							
E	1 x 600 mm CSP	0.34	0.31	0.31	N	N	Would flow full during future potential design flow, some risk associated with icing and capacity during spring runoff. Should be upsized to provide freeboard since blockage would have direct effect on homes located upstream.
F	None	Natural Flow	0.05	0.05	N	N	Ensure that existing channels and culverts remain clean and in good condition.
G	None	Natural Flow	0.03	0.03	N	N	Ensure that existing channels and culverts remain clean and in good condition.
H	None	Natural Flow	0.03	0.03	N	N	Ensure that existing channels and culverts remain clean and in good condition.
I	None	Natural Flow	0.07	0.08	N	N	Lots appear to be subdivided for commercial developments. Permitting should require appropriate channelization for surface water runoff in order to prevent future flooding issues.
J	None	Natural Flow	0.06	0.06	N	N	Ensure that existing channels and culverts remain clean and in good condition.
K	None	Natural Flow	0.01	0.01	N	N	Ensure that existing channels and culverts remain clean and in good condition.
L	None	Natural Flow	0.04	0.04	N	N	Ensure that existing channels and culverts remain clean and in good condition.
M	None	Natural Flow	0.01	0.01	N	N	Ensure that existing channels and culverts remain clean and in good condition.
N	1 x 1120 mm CSP at CN 1 x 600, 800, 900 mm CSP on Service Road 1 x 1200 mm CSP on Hwy 49	1.18 1.70 1.35	3.11	0.53	Y- due to Inflow	N	If diversion not completed: -Culverts are significantly undersized with the CN structure being the most restrictive. -Inflow from Outflow Z poses a signigicant issue for the Village, and would require costly upgrades along its full length (estimated $5.9M in 2018) in order to adequately convey the design flow through the Village. - Since the main bottleneck occurs at CN and Hwy 49 crossings, it is difficult for the Village to have control over infrstructure upgrades. If diversion completed: -The existing infrastructure along RDL would be able to handle future potential inflow without upgrading capacity (not including maintenance related upgrades) -2018 report a diversion cost of $3.5M which is significantly less than upgrading the RDL -Reduces AT and CN stakeholder involvement which helps the Village control costs and schedule.
O	1 x 600, 700 mm CSP at CN 1 x 800 mm CSP on Hwy 49	0.80 0.60	2.53	0.28	Y- due to Inflow	N	If diversion not completed: -Culverts are significantly undersized with the Hwy 49 structure being the most restrictive. -Inflow from Outflow Y poses a signigicant issue for the Village, and would require moderately costly upgrades along its full length (estimated $350k in 2018) in order to adequately convey the design flow through the Village. - Since the main bottleneck occurs at CN and Hwy 49 crossings, it is difficult for the Village to have control over infrstructure upgrades. Diversion could be considered at the same time as the RDL diversion. If the Diversion is completed: -The existing infrastructure along the Hwy 2 Ditch would be able to handle future potential inflow without upgrading capacity (not including maintenance related upgrades) -Likely that diversion costs would be equal or less than $350k which is the cost of upgrading crossings -Reduces AT and CN stakeholder involvement which helps the Village control costs and schedule.
P	1 x 1000 mm CSP at CN 1 x 1000 mm CSP on Hwy 49	0.94 0.94	0.10	0.10	N	N	There is an undefined amount of ditch flow that enters the Village from the south along the Hwy 2 ditch but it is controlled by a 1000 mm CSP culvert inlet. The Village should ensure that existing channels and culverts remain clean and in good condition.
Q	None	Natural Flow	0.08	0.09	N	N	Lots appear to be subdivided for commercial developments. Permitting should require appropriate channelization for surface water runoff in order to prevent future flooding issues.
R	None	Natural Flow	0.13	0.15	N	N	Lots appear to be subdivided for commercial developments. Permitting should require appropriate channelization for surface water runoff in order to prevent future flooding issues.
S	None	Natural Flow	0.02	0.02	N	N	Lots appear to be subdivided for commercial developments. Permitting should require appropriate channelization for surface water runoff in order to prevent future flooding issues.
T	None	Natural Flow	0.12	0.14	N	N	Lots appear to be subdivided for commercial developments. Permitting should require appropriate channelization for surface water runoff in order to prevent future flooding issues.
U	None	Natural Flow	0.18	0.18	N	N	Lots appear to be subdivided for commercial developments. Permitting should require appropriate channelization for surface water runoff in order to prevent future flooding issues.

6.0 STUDY SUMMARY

The key findings of the study and review of historical information is summarized below and should be considered when planning future action by the Village:

- Major flood related issues within Village would be resolved with the installation of a diversion. This is one of the most consistent recommendations made by MPA and past Consultants.
- Current flooding issues are consistent with the findings of the 2009 AECOM report.
- If the diversion is completed, the existing infrastructure within the Village would not need to be upgraded to handle future design flows (except for outflow E). Infrastructure would be upgraded on an end of service life basis.
- Outflow E flows full and the culvert located at the CN crossing should be upgraded to allow for some additional capacity and freeboard to accommodate issues of icing during the winter.
- If the diversion is completed, there would be excess capacity in the drainage lines that outflow at N, and O. This would allow the Village capacity to address any smaller localized drainage issues thereby creating some flexibility going forward. This would also allow additional capacity for the future extension of the underground stormwater line to 52nd Street, which would help resolve some of the smaller more localized drainage issues in the center of the Village.
- The diversion is significantly more cost effective than upgrading the existing infrastructure along drainage paths that outflow at N, or O. Alternative alignment options may be available for investigation.
- There are concerns that the diversion may worsen flooding to a landowner who already floods, west of the CN. This should be investigated at the detailed design stage.
- Completing the diversion would allow the Village to reduce AT and CN stakeholder involvement providing them more direct control of their cost and schedule. However, some landowner and land access issues will likely be of concern.
- There is likely some basin crossover coming towards the village from outflow W and X. The Village should coordinate upgrading those crossings with AT if possible.
- Completing the diversion would reduce the risk of flooding in the future development west of 55th street by eliminating Outflow V.

- Diverting the Highway 2 ditch into the same diversion as RDL should be investigated as it will likely be similar in price as upgrading the crossings along Hwy 2. However, if the diversion is not completed then the Village will need to upgrade the CN and Hwy 49 crossings as describe in the 2018 report completed by MPA.
- Planning for surface water drainage for future developments should be completed during the permitting process but is not expected to require the upgrading of existing infrastructure.

7.0 CONCLUSIONS AND RECOMMENDATIONS

7.1 Recommended Action

The recommended option is to divert flow from the Rycroft Drainage Line and the Hwy 2 ditch, west along 45th avenue, into the Spirit River. These works include the replacement of one Alberta Transportation Structure and two CN structures. This will resolve the immediate concerns related to flooding within the village.

Over the short term, the Village may want to consider the following in order to reduce the risk or severity of the flooding. However, it should be noted that these are not expected to resolve the flooding concerns:

- Ensure that damaged ends of culverts are bent open or cut away to ensure that openings of culvert are not blocked prior to runoff. Sharp ends of culverts can catch debris, reducing culvert efficiency.
- Ensure that the culverts are not frozen with ice prior to runoff.
- Clean important channels of snow and ice approximately 2 weeks before spring runoff, especially downstream of Hwy 49.
- Through ongoing discussions with CN and AT, try to ensure that the culverts along RDL and Hwy 2 ditch are replaced with culverts which have additional capacity.
- Try to acquire grant funding to complete the diversion.

As the Village develops, permitting requirements should include that the developer complete surface water drainage planning to ensure that the developments don't negatively affect other developments.

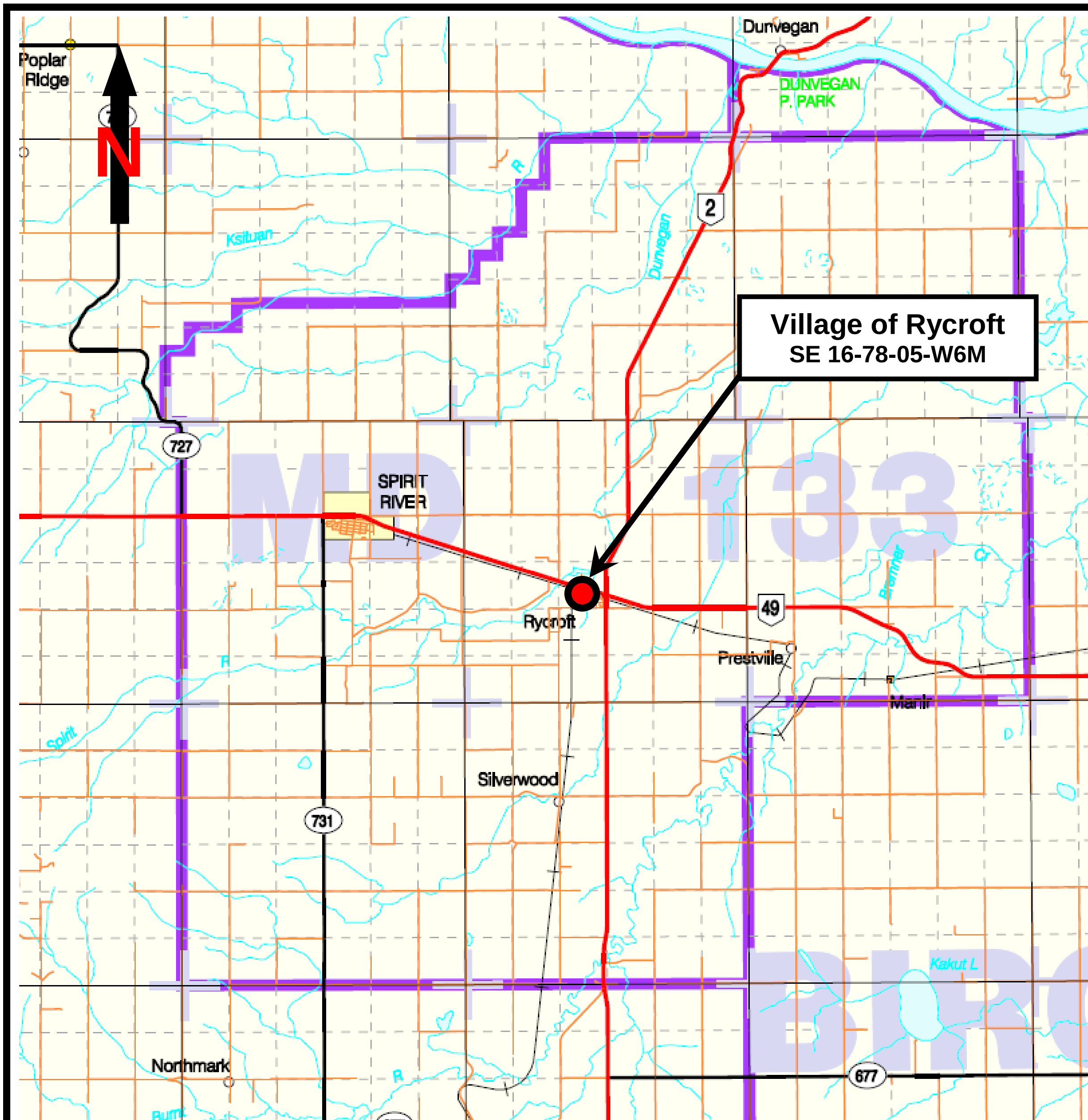
7.2 Proposed Timing for Recommendations

Improvements to control the flood waters in the vicinity of the Village of Rycroft should be completed as soon as possible to mitigate this recurring issue. The flood related risks will increase in the future if left unaddressed. .

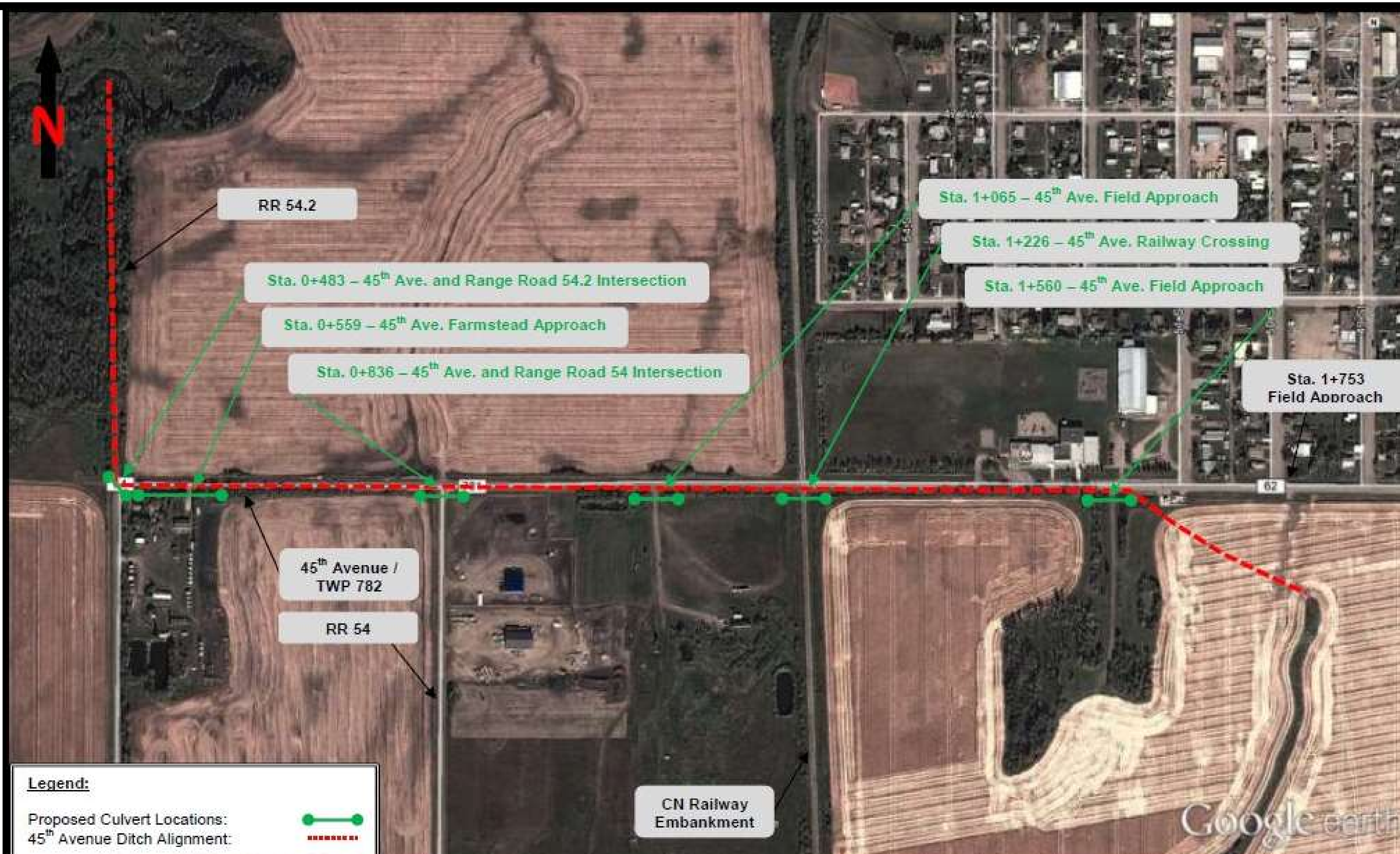
7.3 Estimated Costs

The cost to divert flow from Hwy 2 and the Rycroft Drainage Line around the Village would be in the order of $3,400,000 including engineering and contingencies as per the 2018 report completed by MPA.

APPENDIX



RYCROFT ALTA HUB OF THE PEACE	MPA ENGINEERING LTD		LOCATION PLAN			
	STREAM: Drainage Channel	LOCATION: SE 16-78-05-W6M	DRAWN: DBV	DATE: May 2018	SHEET: 1	DRAWING NO.: Location

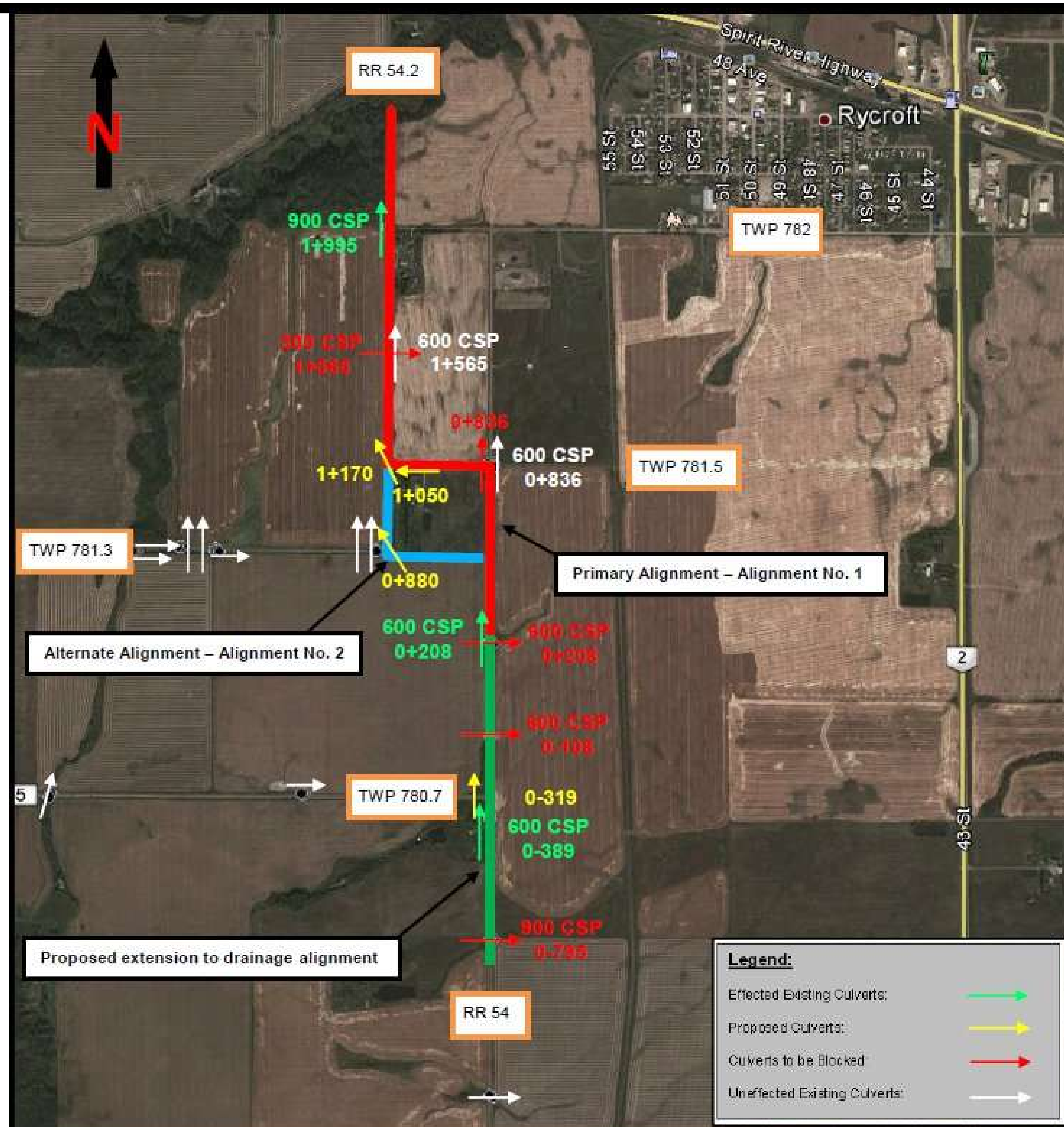


MPA ENGINEERING LTD

Figure 1: Proposed Drainage Alignment from Assessment Report by MPA (2018)

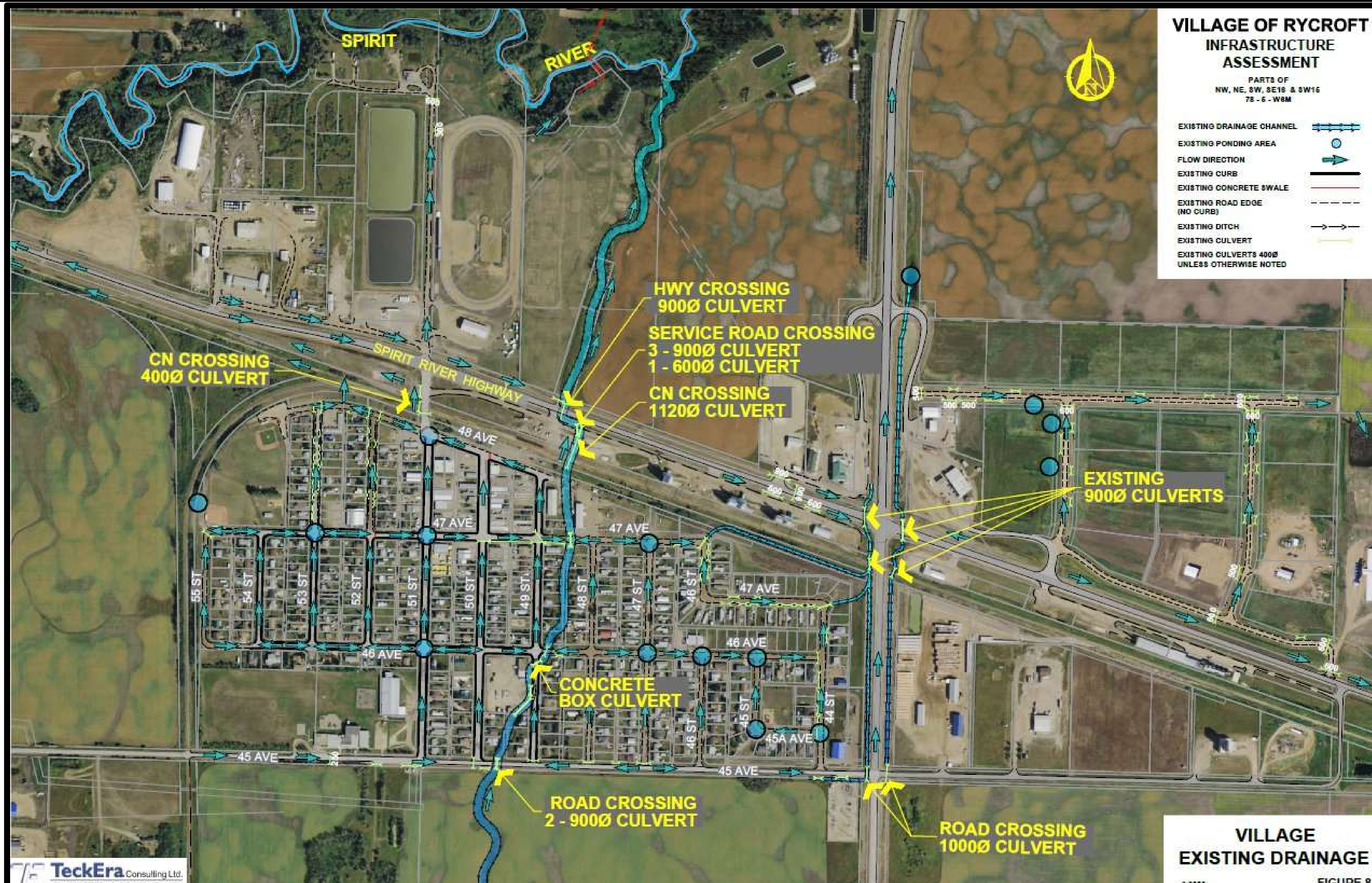
Village of Rycroft – Basin Study and Stormwater Management Plan

Drawn:	Date:	Sheet :	Dwg No:
BMC	Jul 2019		



NORTH

MPA ENGINEERING LTD		Figure 2: Proposed Drainage Alignment from Preliminary Design Summary by MPA (2016)		
Village of Rycroft – Basin Study and Stormwater Management Plan	Drawn: BMC	Date: Jul 2019	Sheet :	Dwg No:



MPA ENGINEERING LTD

Figure 3: Existing Village Drainage – from TeckEra Report (2016)

Village of Rycroft – Basin Study and Stormwater Management Plan

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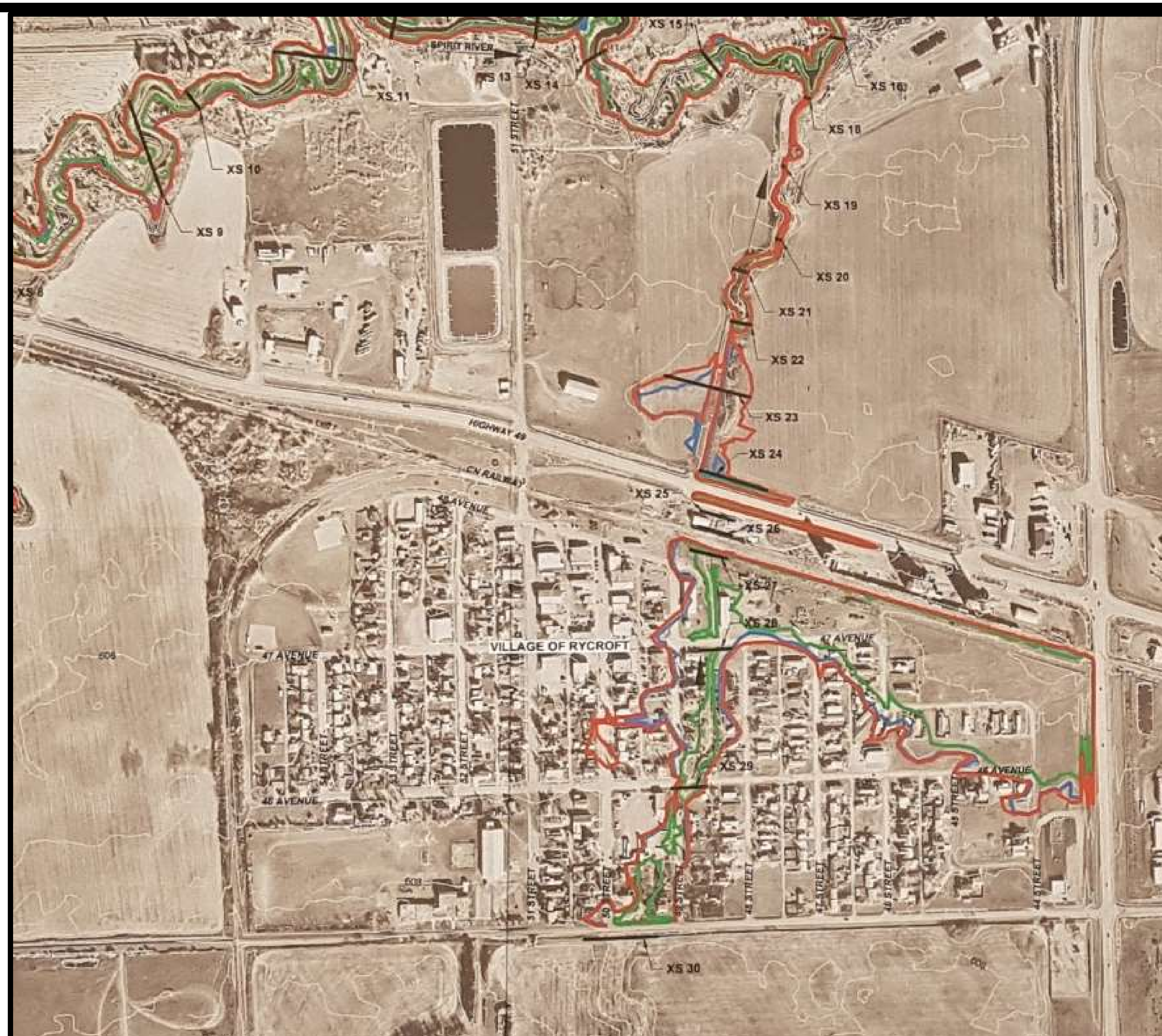
BMC	Jul 2019		



ENGINEERING LTD

Figure 4: Flood Hazard Map– from AECOM Report (2009)

Village of Rycroft – Basin Study and Stormwater Management Plan

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BMC	Jul 2019		

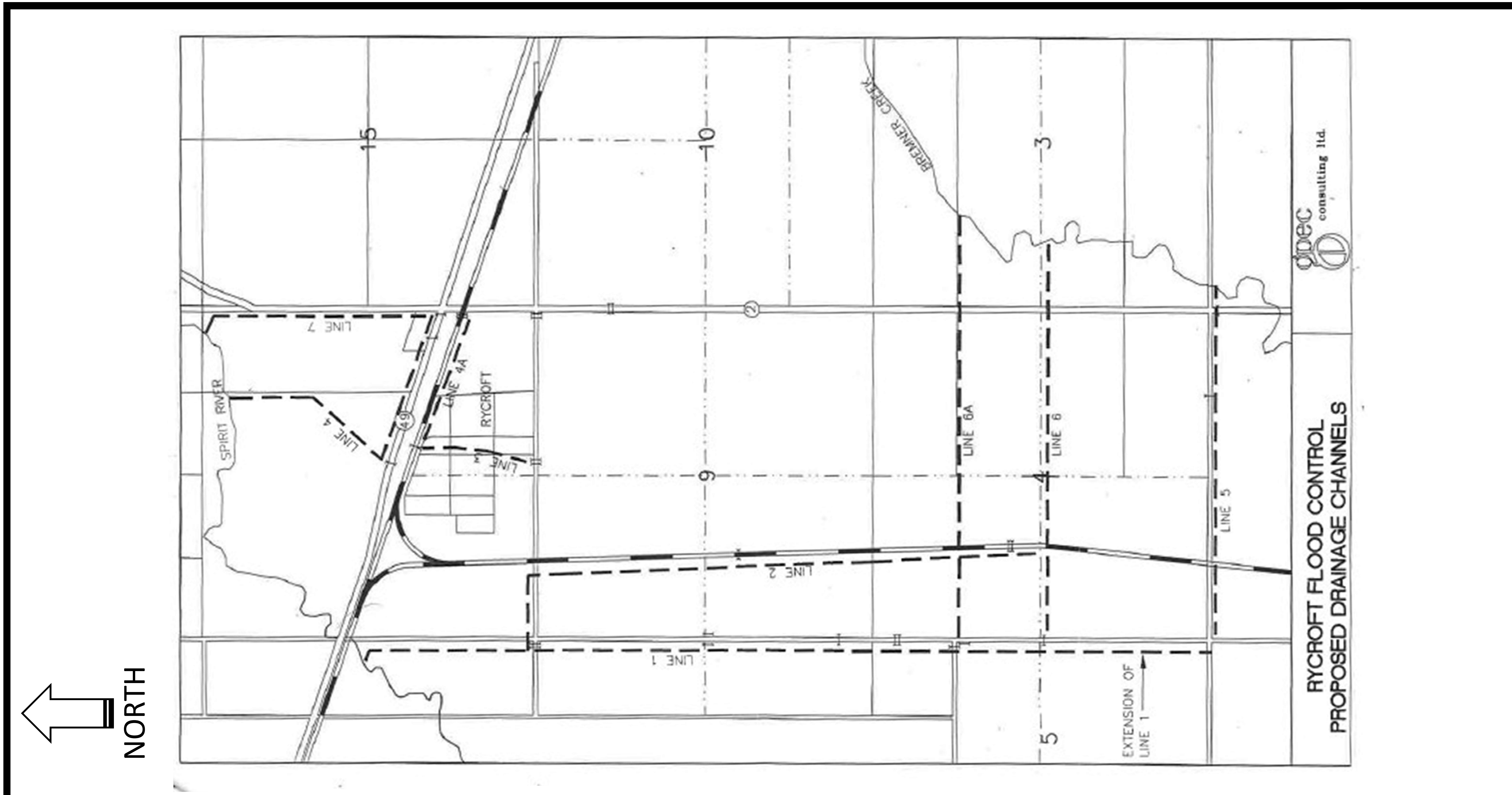

Figure 5: Proposed Drainage Line Upgrades – from GPEC Report (1997)

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Village of Rycroft – Basin Study and Stormwater Management Plan

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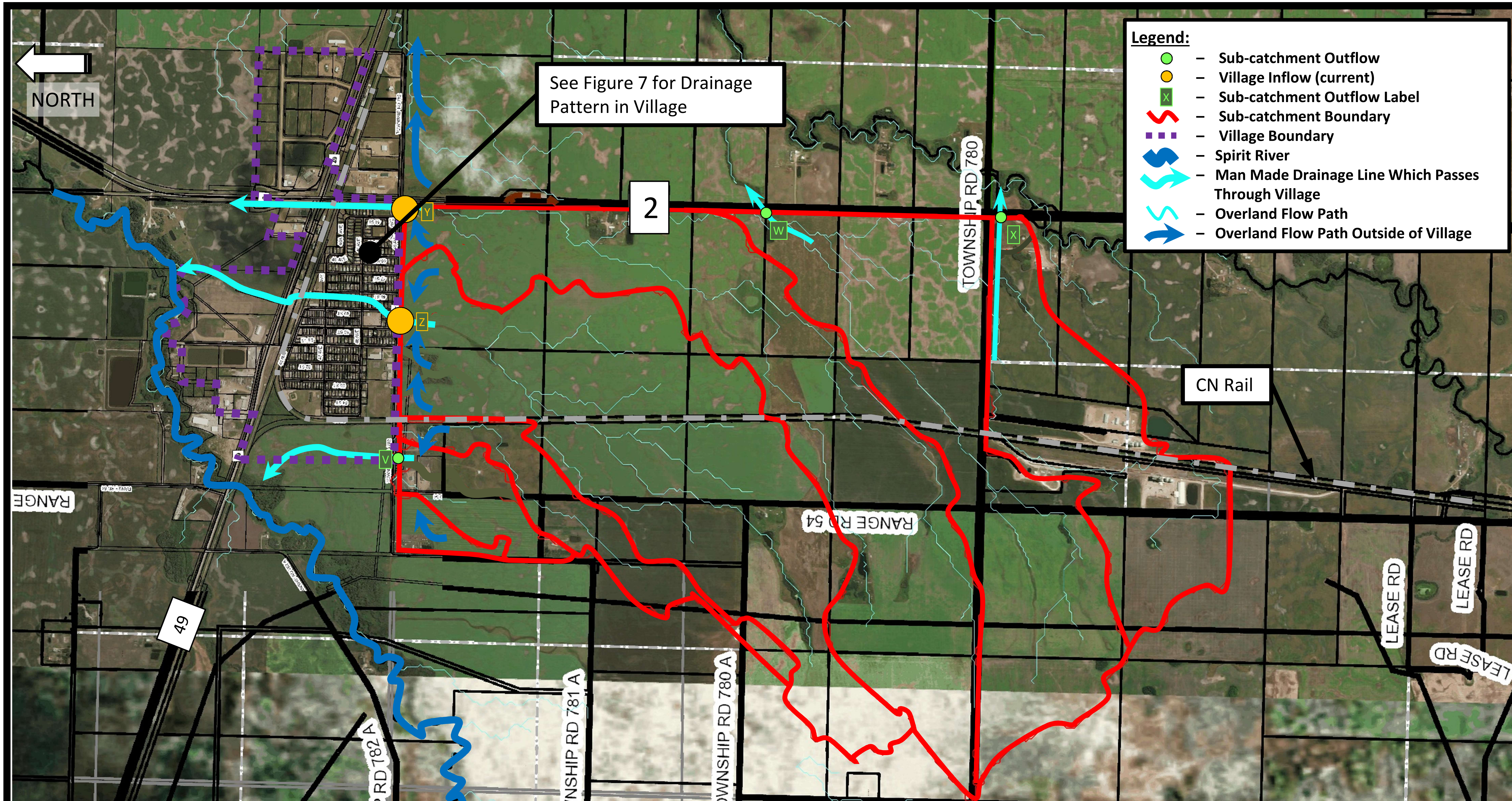
BMC	Jul 2019		



RYCROFT ALTA HUB OF THE PEACE

MPA ENGINEERING LTD

Figure 6: Sub-catchment, Inflow and Outflow Plan (Outside Village)

Village of Rycroft – Basin Study and Stormwater Management Plan

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BMC	Jul 2019		

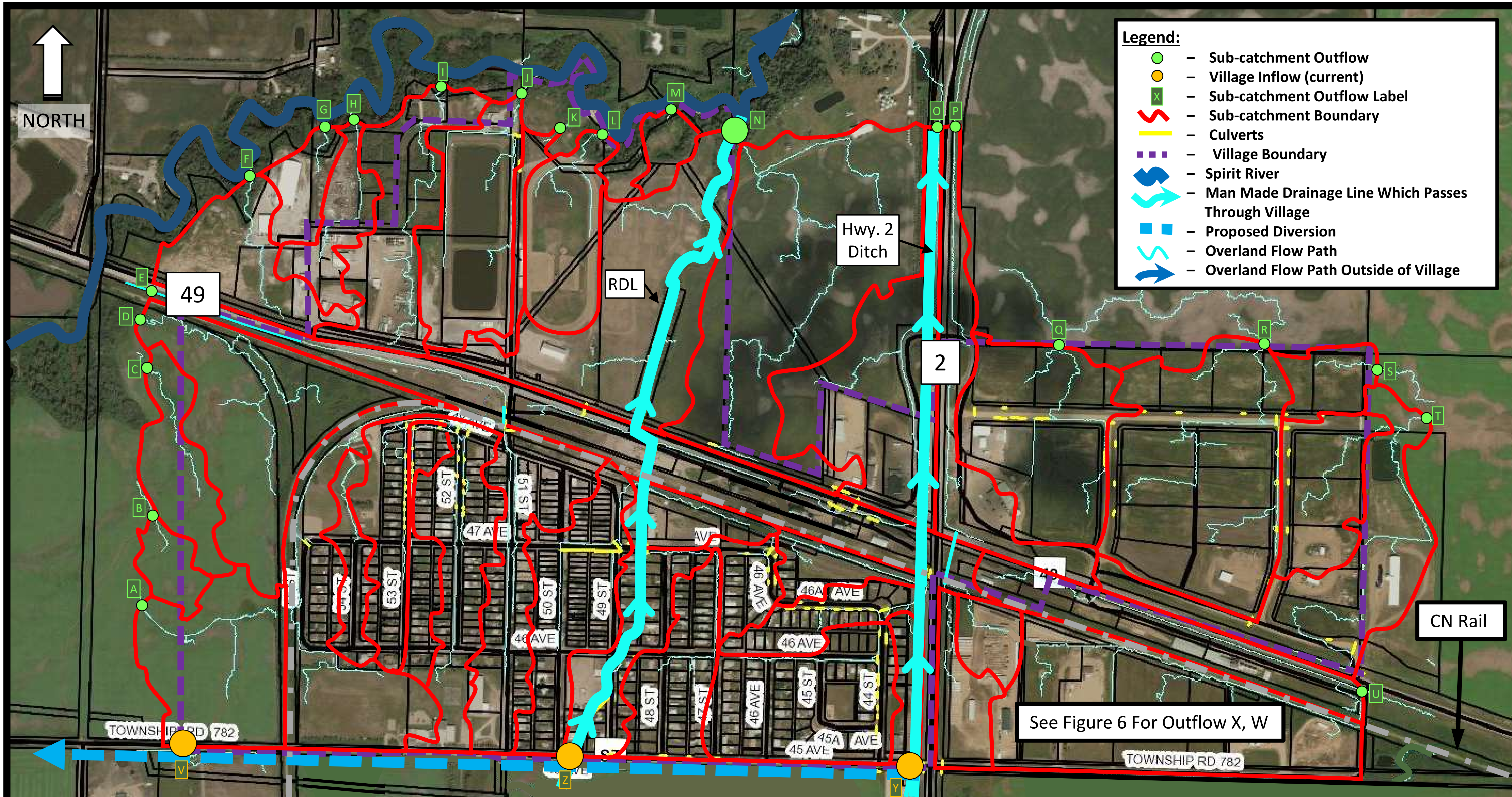

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Figure 7: Sub-catchment, Inflow and Outflow Plan (Within Village)

Village of Rycroft – Basin Study and Stormwater Management Plan

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BMC	July 2019		