Water Security Agency

Saskatchewan Memorandum

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To: Leah Clark

Date: January 09, 2023

File: Wetland loss

Re: **Status of wetlands in Saskatchewan**

1.0 Purpose

As the Water Security Agency (WSA) develops an Agricultural Water Stewardship Policy, information about the status of wetlands in Saskatchewan is important to inform consideration of policy options. Three key questions that have emerged are:

- What is the current level of cumulative wetland loss in Saskatchewan?
- When landowners drain, what percentage of wetlands do they typically retain?
- What percentage of pothole wetland area and numbers are in each of the permanence classes?

This memo will provide information on each of these questions which can be used for policy discussion and analysis.

2.0 Cumulative Wetland loss

Development of an Agricultural Water Stewardship Policy for Saskatchewan requires an accurate understanding of the total amount of historic wetland loss. This policy will consider the retention of permanent storage such as wetlands as part of the strategies to address water quality, flooding, habitat and social outcomes. Some estimates of total historic loss have been previously published. Based on a sample of 2,469 wetlands from across the Aspen Parkland of Saskatchewan, Ignatiuk and Duncan (1995) reported a 6% loss in number of wetlands from the 1940s to the late 1980s and early 1990s. They also summarized previous studies which has examined rates of wetland loss across prairie Canada (Table 1). While some studies showed high levels of wetland loss (>40%) across the prairies, studies with a broader sampling area found loss rates closer to those found by the authors (references listed in Table 1).

Table 1: Comparative studies of wetland loss from Ignatiuk and Duncan (1995)

Study Area	Period	Wetland Lost		Comments
		Area (%)	Number (%)	
Alberta Aspen Parkland	1900-1970[13]	61	—	survey plans, drainage maps, air photos and field and air surveys, 109 ha area, 81% drained by 1950, wetlands less than 0.8 ha not included
Minnedosa Pothole Region, Manitoba	1928-1964[6]	27	—	12 roadside transects, air photos and field survey, 3 land use classes
	1964-1974[10]	41	—	updates of Kiel *et al.*[6]
	1974-1982[11]	33	—	
	1928-1982	70	—	overall loss[6,10,11]
Black Soil Zone of the Prairie Provinces	1940-1970[3]	13	4.5	600 quarter sections, air photos and field reconnaissance, individual pond records
Minnedosa Pothole Region, Manitoba	1948-1970[12]	-4	—	air photos and field investigations, 5 cover classes, 23 km²
Newdale Plain, Manitoba	1964-1974[2]	area and perimeter increased	7	20 sample plots at 65 ha each, air photos, 7 cover classes, wetland loss offset by gain in temporary ponds
NAWMP Key Program Areas in Saskatchewan (this study)	1947-1992	—	6	84 quarter sections, air photos

National Wetlands Working Groups (1988) reported on the frequency of disturbance to wetlands from 2 sites in Saskatchewan (Table 2). Types of disturbance included grazing, burning, cultivation, haying, drainage and filling. While the data is only from four sites (2 sites in Saskatchewan), it again reports rates of wetland loss similar to Ignatiuk and Duncan (1995).

Table 2: Frequency of wetlands margins affected by land use practices in 1976 or 1977 from National Wetlands Working Groups (1998).

Area	*Year*	*Wetlands affected (%) by land uses*								*Total no. of wetlands studied*
		Idle land	*Grazing*	*Burn*	*Cultivated*	*Hay harvest*	*Drainage*	*Filling in*	*Clearing*	
Manitoba										
Rapid City	1976	63.6	24.2	5.8	0.6	1.4	3.6	—	0.8	363
	1977	48.7	25.1	21.7	1.3	1.8	—	0.8	0.5	382
Hamiota	1976	74.7	7.5	8.3	1.5	—	0.4	1.1	3.4	265
	1977	52.3	15.1	28.3	3.6	0.7	—	—	—	279
Saskatchewan										
St. Denis	1976	50.7	44.7	0.9	0.5	3.2	—	—	—	217
Carmel–Peterson	1976	60.9	23.6	6.4	3.6	5.0	0.5	—	—	220

More recently, Watmough et al (2017) estimated that cumulative gross wetland area loss to 2011 (i.e. total historic loss) in Saskatchewan to be 8.7% based on 103 long term monitoring transects, though these data may underestimate losses prior to 1985. The amount of cumulative loss varied

from 0-80% between the sampling transects within Saskatchewan. Watmough et al (2017) estimate that the annual wetland area loss rates from 2001-2011 in Saskatchewan wase 0.35%/year.

In recent years, WSA and partners have wetland inventory covering 47 million acres of agricultural Saskatchewan (Figure 1). Access to this new data source provides an opportunity to generate more accurate estimates of wetland loss than have been previously available. The area wetland inventory coverage includes most of the pothole regions of Saskatchewan, where wetlands are prominent landscape features. The wetland inventory delineates drainage works, and both intact and lost wetlands based on a single epoch of digital ortho imagery (Figures 2-3).

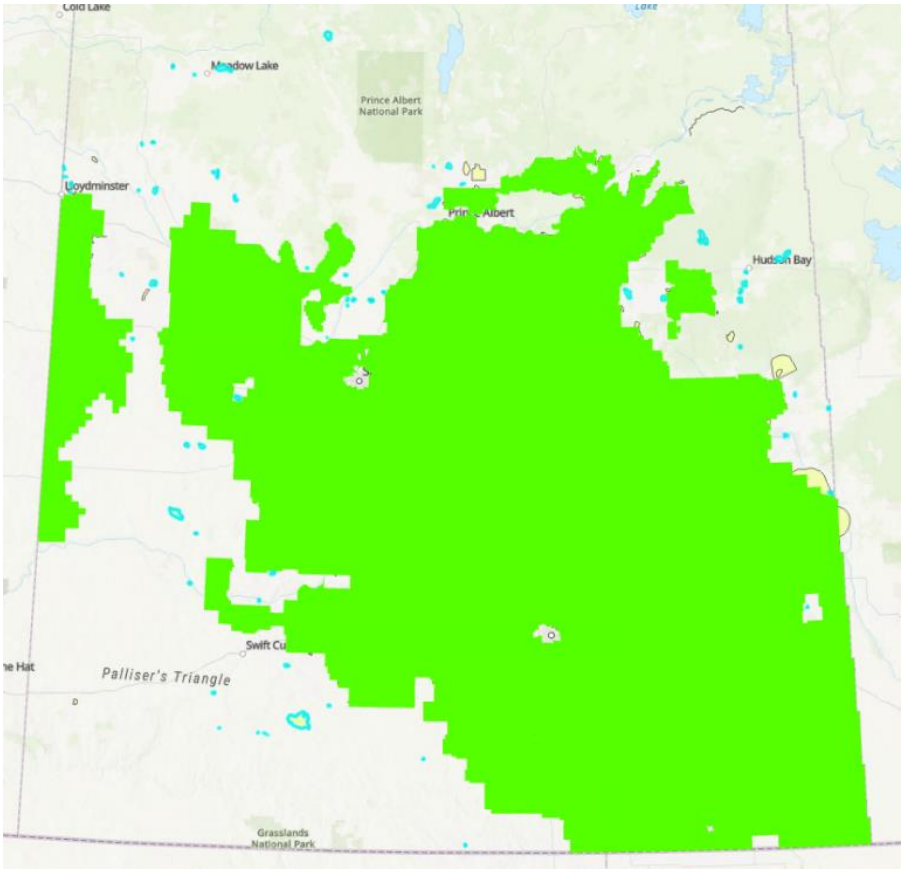

Figure 1: Portion of agricultural Saskatchewan where wetland inventory has been completed (in green and outlined blue areas).

Figure 2: Example of intact wetlands delineated from a single epoch of imagery in the wetland inventory

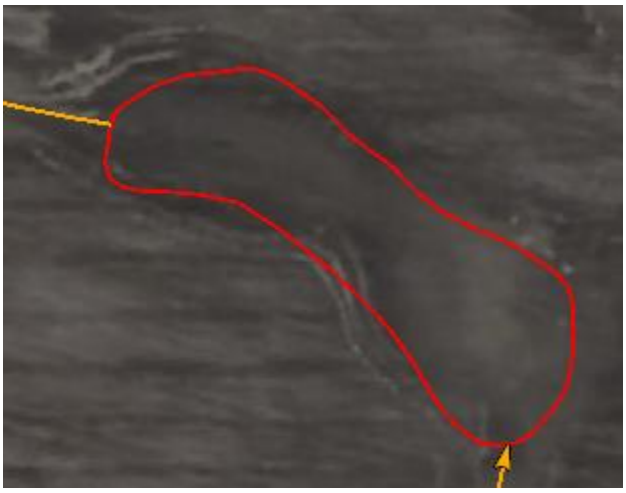

Figure 3: Example of a drained wetlands and drainage works delineated from a single epoch of imagery in the wetland inventory

Because of the wide area of coverage, wetland inventory data provides a valuable data source for calculating total amount of wetland loss. Because impacted wetlands are delineated, loss rates should reflect the total loss since European settlement, however some the limitations of the data need to be understood. Delineations are done with a single epoch of imagery and so errors of omission (wetlands or drainage works left out) and commission (wetlands or drainage works added where there are none) are expected. Errors of omission are especially unknown for wetlands that have been completely infilled for which there is no evidence in recent imagery. Water Security Agency (2016) investigated error rates for the identification of drainage works through ground truthing in the wetland inventory and found that 72% of all drainage works was

detected. Rahman (2021) compared wetland inventory to wetland delineations from 1960s imagery in three areas of interest near the Quill Lakes. While investigating error rates was not the primary purpose of the Rahman (2021) report, the data from this report can be used to calculate the rates of omission in wetland delineation (Table 3). The data included palustrine, riverine and lacustrine wetlands, but the large Quill Lakes were excluded form the analysis. In smaller localized areas, the error of omission rate was report to be 8% and 14% but at the larger landscape scale, the error rate was -8% suggesting that the 2017 inventory actually did a better job of capturing wetlands than the inventory based off the 1960s photos.

Table 3: Rates of omission for wetland inventory by area between three areas near the Quill Lakes. Quill Lakes East Area is included inside of the Larger Portion of the Quill Lakes

Area of interest	Size of area of interest (acres)	1960s acres of wetlands	2017 Acres of wetlands	Rate of error of omission
Quill Lakes West	106,225 acres	10,193	9,426	8%
Quill Lakes East	1062,25 acres	10,6225	5,918	14%
Larger Portion of Quill Lakes watershed	1,054,152 acres	92,393	100,132	-8%

Despite the limitations of this wetland inventory, it represents the best data set available for estimating regional and provincial scale wetland loss. This data can also be compared against other large sampling efforts such as Watmough et al (2017) and Ignatiuk and Duncan (1995).

When estimating wetland loss from wetland inventory three additional key considerations are whether:

- **To report loss of just palustrine (pothole, large marsh) wetlands or to include riverine (flowing water) and lacustrine (lake) system type wetlands.** Palustrine (pothole) type wetlands are by far the dominant wetland feature and the Saskatchewan agricultural landscape; however wetlands also occur with flowing water (riverine) and lakes (more than 2m deep) (National Wetlands Working Group, 1997). Any reporting of wetland loss should be clear about which types of wetlands are included and which are excluded.

- **To report loss by wetland area or number of wetlands (count):** Wetland area is most relevant to understanding the flooding, water quality, soil health, groundwater and habitat impacts of wetland drainage. Wetland number can be an important component of understanding wildlife habitat impacts of wetland drainage.

- **To include farmed but not drained as lost wetlands:** Many small less permanent wetlands are annually cropped but not drained. These wetlands largely perform the flooding abatement, water quality and groundwater recharge functions of intact wetlands but have far less value as wildlife habitat than intact wetlands. Whether or not these wetlands are included in percentage of lost wetlands can change reported numbers substantially.

This memo will summarize the currently available wetland inventory data and report rates of loss by count and area. Results will be presented that 1) include all wetlands 2) include only palustrine wetlands 3) report loss both and without treating farmed but not drained wetlands as lost.

2.1 Methods

Wetland inventory was collected using digital orthophotos and a standardized interpretation guide (Boychuck et al, 2014). Date of imagery used depended on availability and quality of images but generally ranged from 2007-2015. During the inventory process each wetland polygon was attributed with the area of each wetland and an impact code assigned: intact, partly drained, completely drained, partly filled, constructed, and farmed but not drained (Canadian Wetland Inventory Technical Committee, 2016).

> **Intact** – No evidence of drainage
>
> **Partly Drained** - The water level has been artificially lowered, but the area is still classified as wetland because the soil moisture is sufficient to support hydrophytes.
>
> **Farmed but not drained** - The soil surface has been mechanically or physically altered for production of crops, but hydrophytes will become re-established if farming is discontinued.
>
> **Constructed** - The soil surface has been mechanically or physically altered by excavation in order to create an impoundment for holding water.
>
> **Partly Filled –** Basin shows evidence of clearing, brush piles or spoil associated with excavation.
>
> **Completely Drained –** The soil surface has been mechanically or physically altered for production of crops and the water level has been artificially lowered. This impact is identified by the presence of a drainage work.

The data standards for the wetland inventory specify that all features above 200 m^2 are to be captured. A small portion of the data captured small wetlands as point features rather than as polygons (1.7% of total wetland area). These polygons are assigned a nominal size of 600 m^2 for the purpose of this analysis. Wetlands mapped include the full range of system types included in the Canadian Wetland Classification System (National Wetlands Working Group, 1997) including lacustrine (lake types), riverine (flowing water type) and palustrine (marsh, pothole type) wetlands. For many policy discussions the focus is on the drainage of pothole type wetlands, however it is important to understand that channelization of riverine features and lowering of lake features are also common water management activities.

The most current wetland inventory available throughout Saskatchewan was compiled in ArcGIS and exported as a CSV file. The wetland inventory capture includes interior polygons if there is variation in cover type (e.g. shallow water or marsh) or impact code. For the puprose of this

analysis, interior polygons were dissolved to avoid double counting of features. If an interior polygon was dissolved, a single impact code was assigned to the wetland with codes indicating an impact (e.g. completely drained) always given precedence over the "intact" status. This decision rule results in an overestimation of the drained wetland acres especially for partially drained wetlands. This approach was chosen as it results in a more conservative estimate of the amount of undrained wetlands. Additionally, most of the partially drained wetland polygons in the wetland inventory do not have the undrained interior portion of the wetland delineated. This is because capture of this interior is not a standard part of the wetland inventory standard. This again results in a conservative estimate of the amount of undrained wetlands.

2.2 Results

A total of 4,782,560 wetland features were exported representing approximately 1.85 million hectares of wetlands (4.6 million acres). All wetland features were delineated within the inventory area. Wetlands represent approximately 10% of the total landbase area inventoried (18.9 million hectares). Palustrine represent the majority of the wetland area (78%) and number of features (98%) (Figures 4-5). Palustrine type wetlands including features captured as points which can be reliably considered as palustrine type because of their small size a spatial isolation from other wetland features.

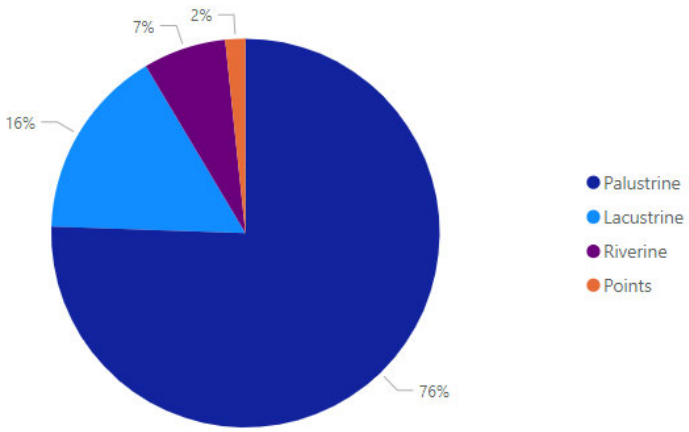

Figure 4: Percent area of wetland features, by system type. Point features are presented separately because they were collected with a different methodology but can reliably considered to be palustrine wetlands.

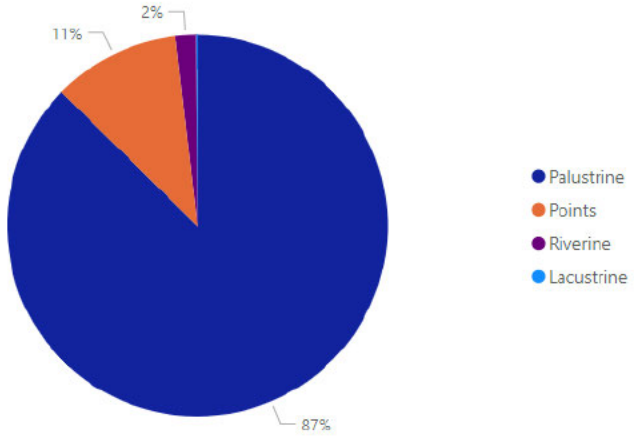

Figure 5: Percent count of wetland features, by system type. Point features are presented separately because they were collected with a different methodology but can reliably considered to be palustrine wetlands.

The majority (71%) of palustrine wetland area (including points) are intact (Figure 6). Completely Drained, Partially Drained and Partly Filled wetlands represent a total of 14% of the wetlands by area. Wetland count data for palustrine wetlands has much higher proportion of wetlands Farmed but not Drained (39%), but a similar percentage of wetlands which are drained (10%) (Figure 7). Both riverine and lacustrine wetlands have low percentages of loss for both percent area and percent count (Figures 8-11).

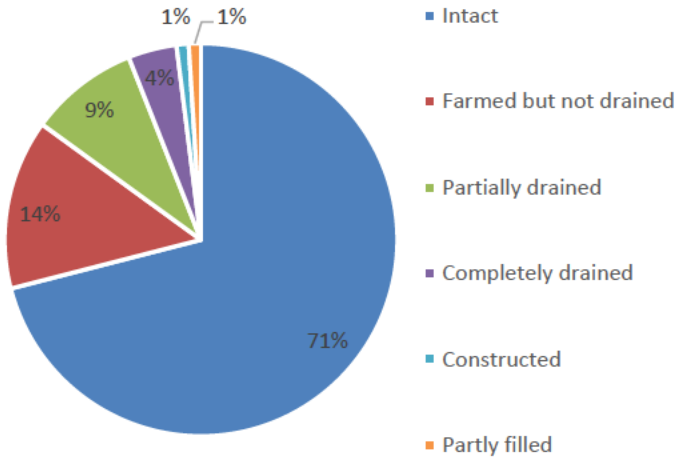

Figure 6: Percent wetland area of palustrine wetlands (including point data) by impact code.

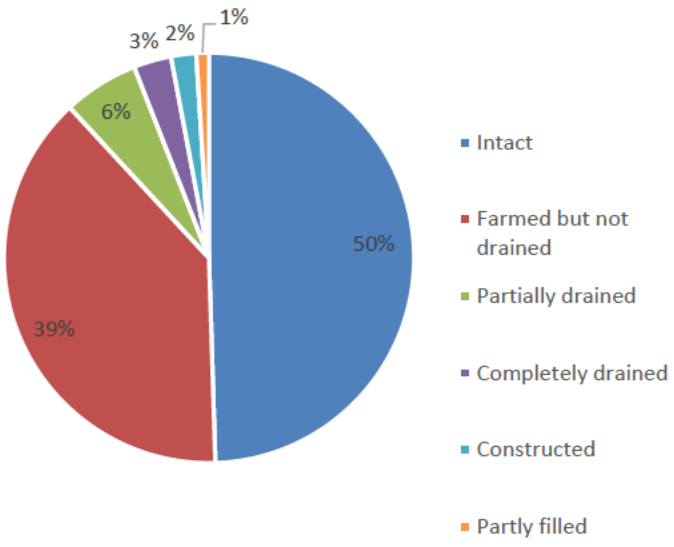

Figure 7: Percent wetland count of palustrine wetlands (including point data) by impact code.

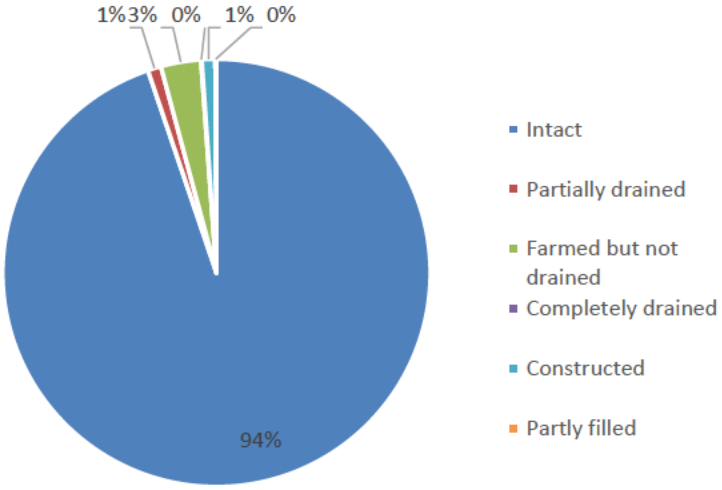

Figure 8: Percent wetland area of riverine wetlands by impact code.

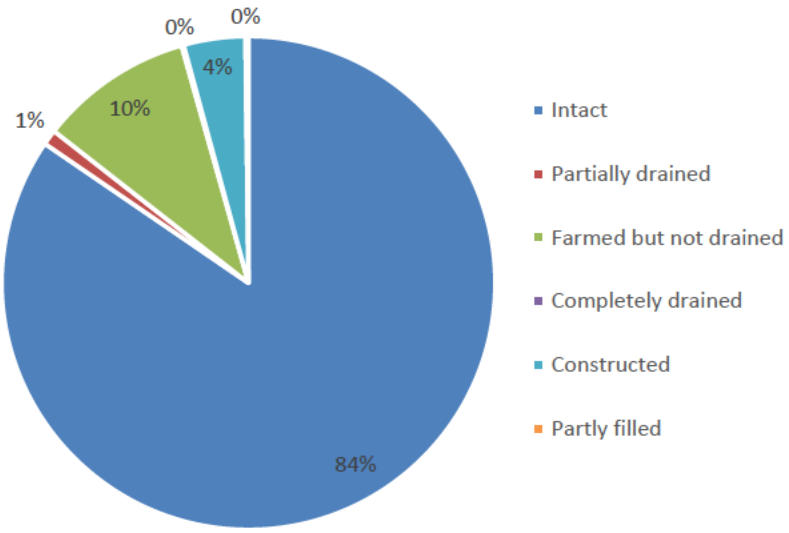

Figure 9: Percent wetland count of riverine wetlands by impact code.

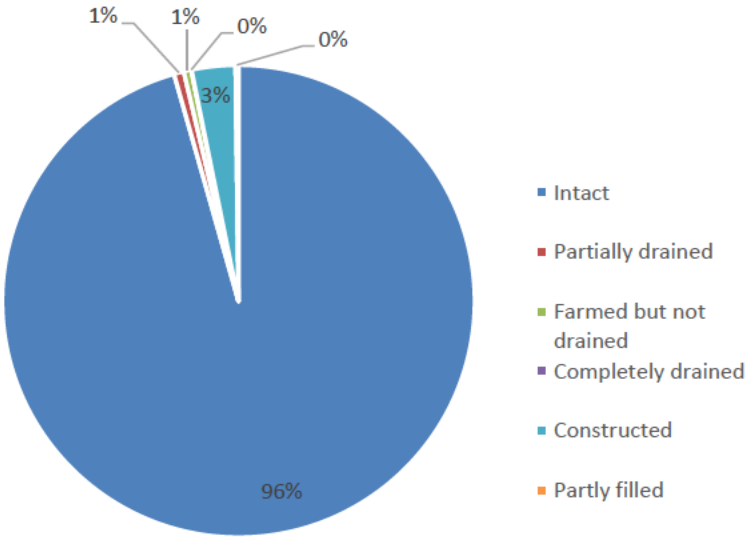

Figure 10: Percent wetland area of lacustrine wetlands by impact code.

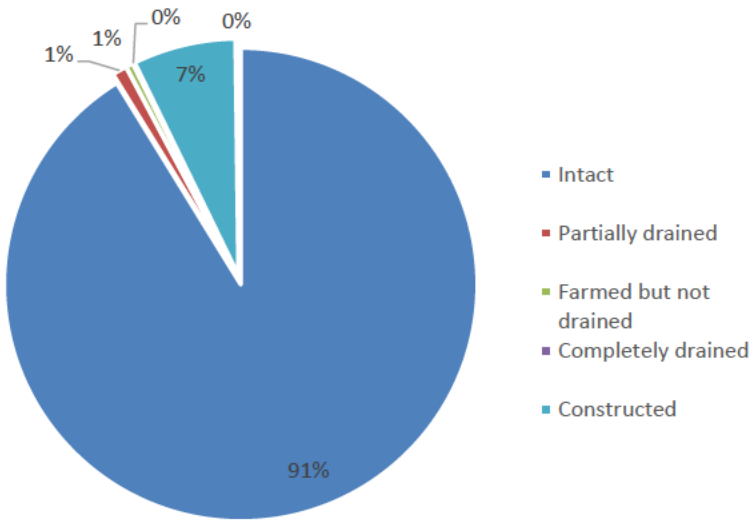

Figure 11: Percent wetland count of lacustrine wetlands by impact code.

Overall loss rates for palustrine and all wetland system type are presented in Table 4. Loss by percent area without "Farmed but drained wetlands" is the likely the most useful indicator for assessing impacts to flooding, water quality and groundwater recharge. This is because Farmed But Not Drained wetlands are hydrologically intact. Loss by percent count and area including farmed but not drained wetlands provides the best information for assessing the impacts to wildlife habitat.

The wetland area percent loss excluding "farmed but not drained" wetlands (14%) is higher than reported by Watmough et al (8.7%) and Ignatiuk and Duncan (6%) however the relative magnitude of loss is similar. They key limitations of this estimate are:

1. This data does not account for wetland loss which has occurred since the date of imagery on which wetland inventory was based. For most of the data imagery was from 2007-2015.
2. Capturing of drainage features may have an error of omission rate of 28%.
3. The error of omission rate in capture for wetlands may be 8-14% in some localized areas.

Ongoing work use multiple epochs to derive wetland inventory data should help address these limitations and derive a more accurate assessment of wetlands loss. While acknowledging the limitations of the wetland inventory data, the current best estimate available would be that 14% of palustrine wetland area has been drained.

Table 4: Percent wetland loss for palustrine and all wetlands.

	Palustrine wetlands		All wetlands (palustrine, riverine, lacustrine)	
	Loss by percent area	Loss by percent count	Loss by percent area	Loss by percent count
Cumulative wetland loss excluding without "Farmed but not drained wetlands" **category** as intact	14%	10%	11%	10%
Cumulative wetland loss including "Farmed but not drained wetlands" category as intact	28%	49%	22%	48%

3.0 Within drainage projects what percentage of wetlands are typically retained

While cumulative wetland loss by area at a provincial scale is relatively low, there are localized regions which have experienced high levels of loss. Ignatiuk and Duncan (1995) reviewed previous studies showing up to 70% wetland loss in some areas of the prairies. Watmough et al (2017) found up to 80% loss in one individual monitoring transect in Saskatchewan. Understanding localized levels of loss are important to understand localized impacts (e.g. flooding of roads) and to inform design of the policy. WSA approves drainage works at a 'network' scale rather than at the individual land parcel scale (Figure 12). The wetland inventory allows an opportunity to examine the percent of wetlands retained at a local scale within drainage projects. WSA current only has about 600 'networks' either approved or in the process of being approved and so it was decided to use the section scale (640 acres) as a proxy for localized drainage projects.

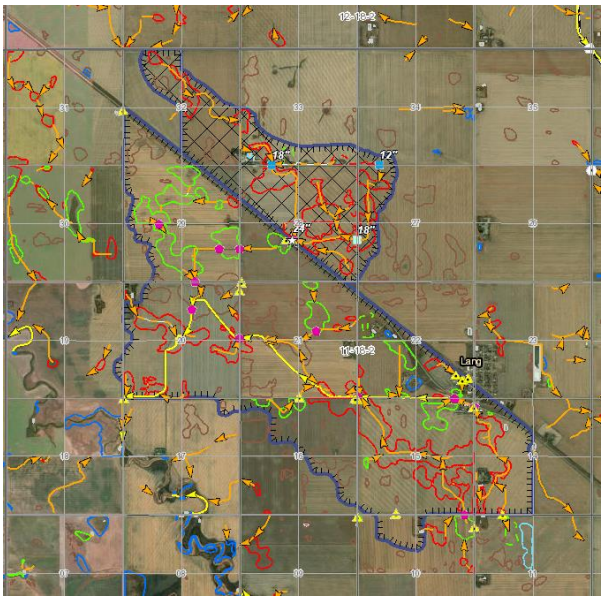

Figure 12: Example of network. Blue hatched line represents the out boundary of the mini-watershed. Other linework is wetlands and drainage inventory.

3.1 Methods

In two watersheds where wetland drainage is fairly common (Assiniboine, Qu'Appelle), the percent of wetland area retained was calculated form the wetland inventory by section. For the purpose of this analysis, wetlands which were farmed but not drained were considered retained. Sections which had zero drainage were then removed since the objective of the analysis was to determine the percent wetland retention among within projects where there was some drainage.

3.2 Results

In the Assiniboine watershed, on average 82% percent of wetlands were retained within a section that had a least some drainage. Variation around this average was heavily skewed left with 4.5% of sections with at least some drainage having less than 40% of wetland area retained (Figure 13).

In the Qu'Appelle watershed, on average 78% percent of wetlands were retained within a section that had a least some drainage. Variation around this average was heavily skewed left with 10% of sections with at least some drainage having less than 40% of wetland area retained (Figure 14).

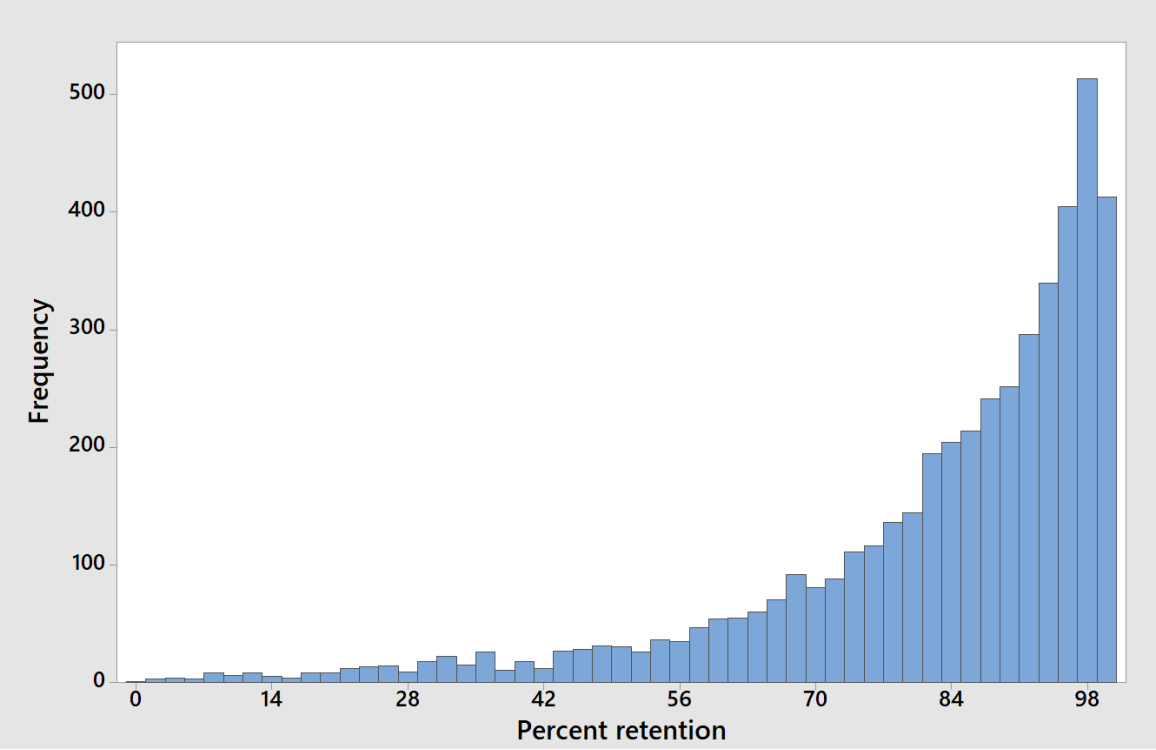

Figure 13: Histogram of percent wetland area retained by section in the Assiniboine watershed

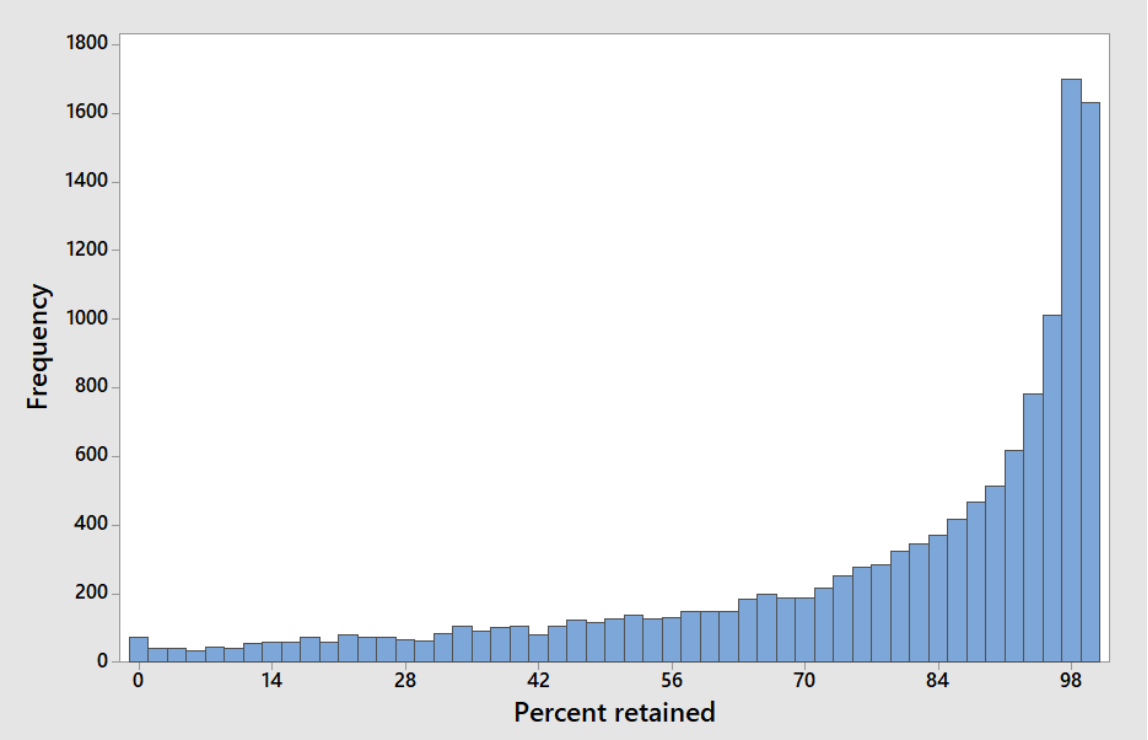

Figure 14: Histogram of percent wetland area retained by section in the Qu'Appelle watershed

4.0 Pothole wetland by permanence class

Pothole wetlands are commonly classified into permanence classes using the Stewart and Kantrud system of wetland classification (S&K). Wetland permanence refers to typical length of time that water is present in a wetland. S&K was developed in the northern prairies in the Central Lowland and Great Plains, covering a large portion of southern Saskatchewan. S&K divides wetlands into five progressive classes, as well as two others for alkali and fen ponds, though alkali and fen classes are not commonly used. These classes list common traits associated with wetland permanence and depth at the deepest part of the wetland. The five classes as well as some common characteristics are listed below:

Class I – Ephemeral Pond	A wetland-low-prairie zone dominates the deepest part of the wetland. The soil is porous in this area therefore bottom seepage is rapid resulting in a short duration of surface water. These features are usually maintained on the landscape for a few days after the spring snowmelt and may retain water for a few days after a heavy summer rainfall event.
Class II – Temporary Pond	A wet-meadow zone dominates the deepest part of the wetland. Water seepage is fairly rapid in this zone and surface water is usually maintained for a few weeks after the spring snowmelt and occasionally for several days after a heavy rain.

Class III – Seasonal Pond or Lake	A shallow-marsh zone dominates the deepest part of the wetland. This area often maintains surface water during the spring and early summer but are often dry in late summer and fall.
Class IV – Semi-permanent Pond or Lake	A deep-marsh zone dominates the deepest part of the wetland. This area typically maintains surface water throughout the summer and typically into fall and winter.
Class V – Permanent Pond or Lake	A permanent open water zone dominates the deepest part of the wetland. This area maintains fairly stable water levels throughout the year.

Despite the economic and environmental importance of wetlands, little is known about the proportion of wetlands in Saskatchewan which fall within various permanence classes. This portion of the memo will explain the methods and results found by Phalen (2022) investigating the percent count, area and volume occupied of pothole wetlands.

4.1 Methods

Phalen (2022) investigated the wetland classes in five sites distributed in contrasting landscapes across the pothole region of Saskatchewan (Figure 15). Wetlands were classified using remote imagery The imagery made available was the WSA historical imagery database as well as four sets of historical imagery, three from 1979 and one from 1986. In addition, there was "Sask SPOT 1.5m 2016" and FlySask Ortho Images from 2008-2011, 2012-2016, and 2017-2021.

A classification guide was developed using the available imagery. Phalen (2022) reviewed imagery for the wetlands looking for permanent open water zones (Class V), a deep-marsh zone (Class IV), a shallow-marsh zone (Class III), and if none of these were present, wetlands were labelled Class II (Figure 16). Class I and II wetlands were lumped together into one category because they are difficult to distinguish from remote imagery.

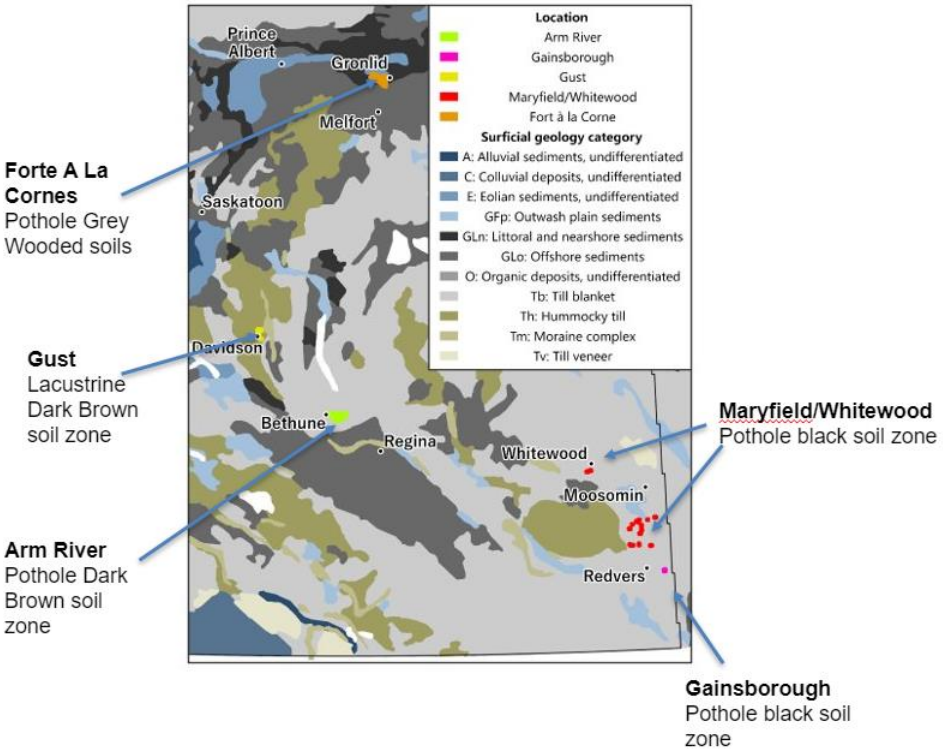

Figure15: Sites where Phalen (2022) classified wetlands

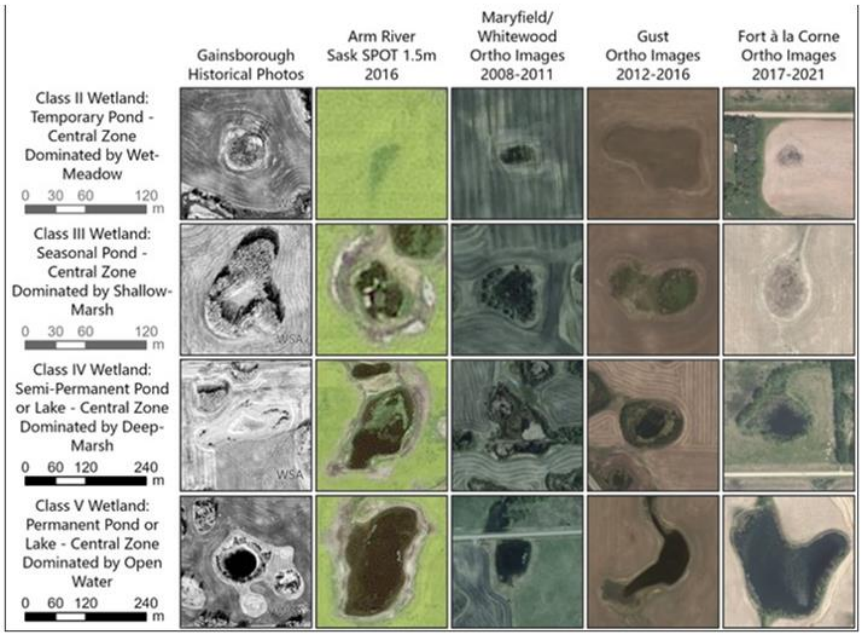

Figure 16: Examples of imagery that was used to classify wetlands by Phalen (2022)

Wetland volumes were calculated using LiDAR provided by the WSA and using ESRI ArcGIS Pro's Cut and Fill tool. This tool provides two metrics used in analysis, fill area and fill volume. The Cut and Fill tool calculates these metrics by allowing the user to add a plane in 3D geometry

and then calculates the volume between the plane and the ground surface below. The tool also provides the area of the plane that is above the ground surface.

Using LiDAR, cut and fill polygons were delineated well beyond the extent of the wetland and then with reference to the previous wetland delineation as well as two selected sets of imagery, the plane was adjusted to the top of the wetland's wet-meadow zone. These planes were then exported into a shapefile and paired to the original wetland layers.

4.2 Results

A total of 6,358 wetlands were classified into permanence classes using historical and recent satellite imagery, and a subset of 1,787 wetlands were analyzed in 3D using LiDAR to determine volume. By count, Class I/II wetlands were the most common (56-65% of counts) (Figure 17).

The percentage of wetland area occupied by each permanence class varied between sites reflecting differences in the localized landscape (Table 4). The drier landscapes from the south tend be more dominated by less permanent wetlands while the Forte A la Corne site in the Boreal Transition area tends to be wetter supporting more permanent type wetlands.For example, the Forte A La Corne site as the wettest of the sites and wetland area is dominated by large Class V wetlands while the Gust, Arm River and Maryfield/Whitewood sites all have Class I/II/III wetlands comprising about 50% of the wetland area (Table 5). Likewise, differences between sites are seen in the percentage of storage volume among the sites (Table 6). At Forte A La Corne, Class V wetlands comprise 78% of the storage volume while at Gust, Arm River and Maryfield/Whitewood sites Class I/II/III wetlands comprise 35-40% of the storage. The Gainsborough site is an outlier of the southern sites and is dominated by more permanent wetlands. This site is significantly smaller than the other sites and so this small sample size may explain the difference with the other sites.

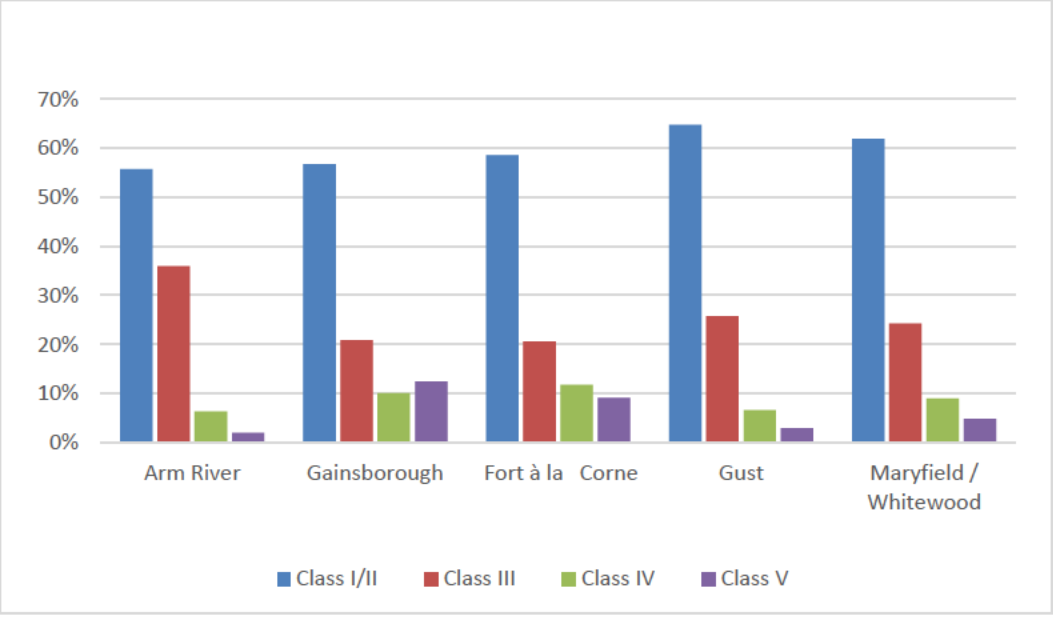

Figure 17: Percent count of wetlands by permanance class for each of the sites

Table 5: Percent area of wetland permanence classes by site

	Arm River	Gust	Whitewood /Maryfield	Gainsborough	Forte A la Corne
Class I/II	20%	19%	25%	15%	11%
Class III	31%	28%	27%	20%	13%
Class IV	17%	14%	26%	18%	16%
Class V	32%	40%	23%	47%	60%

Table 6: Percent storage volume of each wetland permanence class by site

	Arm River	Gainsborough	Fort à la Corne	Gust	Maryfield / Whitewood
Class I/II	7%	6%	3%	7%	13%
Class III	33%	18%	6%	29%	22%
Class IV	20%	18%	13%	21%	32%
Class V	40%	57%	78%	44%	33%

Wetlands from all permanence classes were completely and partly drained; Class I/II and Class III make up the majority (87%) the completely drained wetlands by count (Figure 18). Farmed but not drained wetlands were make up the majority (84%) of Class I/II wetlands by count. Intact wetlands included all permanence classes.

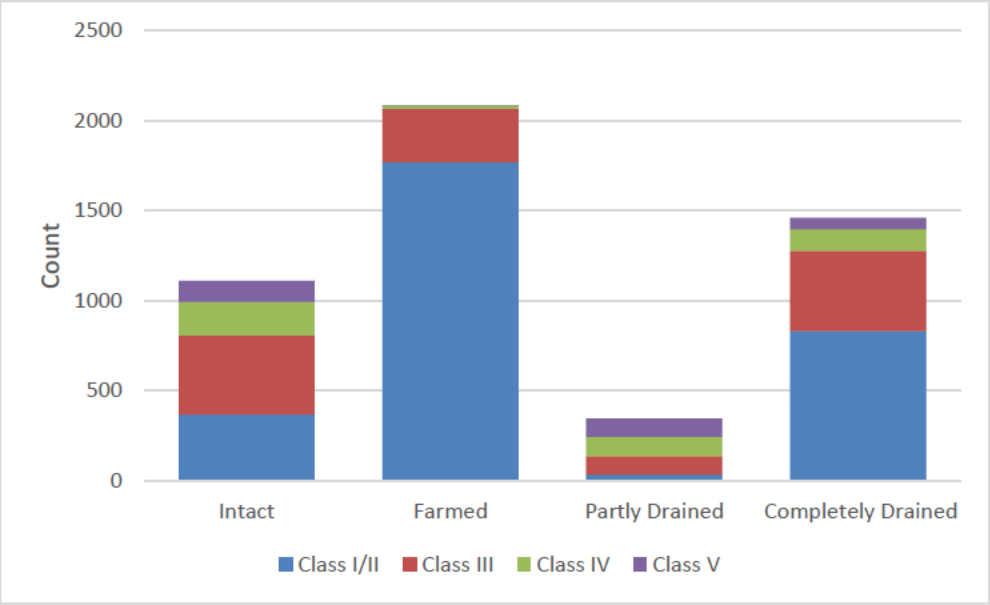

Figure 18: Count of wetlands by impact code ad permanence class across all sites.

Summary

The data in this memo can provide some key high-level results for wetland policy discussions in Saskatchewan:

- Wetland loss by area in Saskatchewan is 14%. (10% by count)
- Within sections that had drainage, 82% of the wetlands were retained in the Assiniboine watershed and 78% were retained in the Qu'Appelle Watershed.
- In the typical pothole regions of Saskatchewan Class I/II/III wetlands comprised 35-40% of the wetland storage volume and 50% of the wetland acres.

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