SASKATCHEWAN

Water Security Agency

Spring Runoff Forecast

April 1st, 2018

Prepared by:

Flow Forecasting & Operations Planning

Water Security Agency

General Overview

The Water Security Agency (WSA) is preparing for 2018 spring runoff by issuing this runoff forecast. The spring runoff potential for the province, as of April 1, 2018, is shown in Figure 1. Forecasted peak levels for select lakes and reservoirs are included in Table 1 and peak flow estimates for select watercourses are included in Table 2.

Fall conditions, snowpack water content, and rate of melt are the primary factors influencing snowmelt runoff. While we have a good understanding of the fall conditions and the snow accumulation season is nearing its end, it is too early to be able to predict the conditions at melt. Therefore, this forecast assumes normal/average conditions going forward through to the conclusion of the spring runoff event. Above average snowmelt over the remaining weeks of winter and/or a rapid melt could increase runoff yields significantly. The converse is true for below normal snowfall going forward and/or a slow melt.

As detailed in the WSA's Conditions at Freeze-up Report, which was released in November of 2017, growing season precipitation last year was extremely low across all of southern Saskatchewan with record low accumulations observed at some locations in south central Saskatchewan. In central and northern Saskatchewan, growing season precipitation was near average with the exception of the Meadow Lake area which received well above average summer rainfall.

Fall precipitation was more variable. In September, rainfall was well below average across all of southern Saskatchewan and near normal in northern Saskatchewan. Rainfall accumulations in October varied from extremely low in southeastern Saskatchewan, to near average over central Saskatchewan, to above average in northeastern Saskatchewan. A band of above average precipitation also occurred from the Cypress Hills to Hudson Bay due to an early October rain/snow event. Fall soil moisture conditions were generally short to very short south of Highway 16 and primarily adequate north of Highway 16 at freeze-up in 2017.

Winter snow accumulation to April 1, 2018, is generally near average across Saskatchewan with the exception of the area south of the Cypress Hills and Frenchman River, which has received above average accumulations. Some losses to mid-winter melt have occurred lessening the snowpack available to generate runoff. There are also pockets of above average accumulated snowfall near Scott, Hudson Bay and north of Prince Albert.

As shown in Figure 1, snowmelt runoff is projected to vary across the province from well below normal in south central areas to well above normal in areas near Prince Albert and Hudson Bay.

Well above normal runoff is expected in areas near Prince Albert, up to Waskesiu Lake and within the Red Deer River Basin southwest of Hudson Bay. While widespread flooding is not expected in these areas, some overtopping of roadways is likely. Assuming near normal conditions going forward to the melt event, peak flows are currently forecasted to be similar to 2017 spring peaks within the basin. These peaks were generated from a smaller snowpack than what currently exists within the basin but were the product of a rapid melt.

With below normal temperatures expected to occur across the province in early April, snowmelt runoff is expected to be later than normal across the province. This increases the risk of a rapid melt which would result in higher than expected runoff yields and potentially some flood related issues.

Some agricultural water supply issues began to emerge in late summer 2017. In the areas where well below average 2018 snowmelt runoff is projected, these water supply shortages may intensify and expand to additional areas.

The snowpack over the eastern slopes of the Rocky Mountains is generally well above average for this time of year. Lake Diefenbaker is currently 0.7 m below its median level for this time of yea; however, assuming near average rainfall, the reservoir is expected to be close to full by the end of August.

WSA will continue to monitor the 2018 spring runoff conditions across Saskatchewan. If warranted, further updates will be issued as the spring runoff progresses.

The following descriptions provide some context to the categories of spring melt runoff potential used to describe the potential for runoff from the spring snow melt in Figure 1.

Category	Description	Approximate Frequency of Expected Flow
Well Below Normal	Little to no runoff is expected.	<< 1:2 year event
Below Normal	Some runoff is expected.	< 1:2 year event
Normal	Flows are expected to be average and will generally not exceed channel capacity in most reaches.	≈ 1:2 year event
Above Normal	Flows from snowmelt runoff will exceed natural channel capacity in some areas.	≈ 1:5 year event
Well Above Normal	Significant out of channel flow and some flooding will likely occur.	≈ 1:10 year event
Very High	Significant flooding is likely to occur.	≈ 1:25 year event or greater

- Above normal precipitation prior to runoff (especially if it occurs as rainfall) and/or a faster than normal melt could result in significantly higher runoff than presently forecasted.
- Mid-winter melt events or rain events on frozen soils can increase runoff yields and estimates from snowmelt accumulation.
- Below normal precipitation prior to runoff and/or a slow melt could result in significantly lower runoff than presently forecasted.
- Figure 1 applies to local runoff as opposed to the main stem river flows on major systems such as the Qu'Appelle and Saskatchewan rivers.
- This forecast is based on limited data and should be used as a general guide for large geographical areas. Local conditions may vary significantly from the regional conditions and boundaries. Figure 1 should be considered as approximate.
- Ice jamming can result in out-of-bank flows and flooding, even for below normal flows.

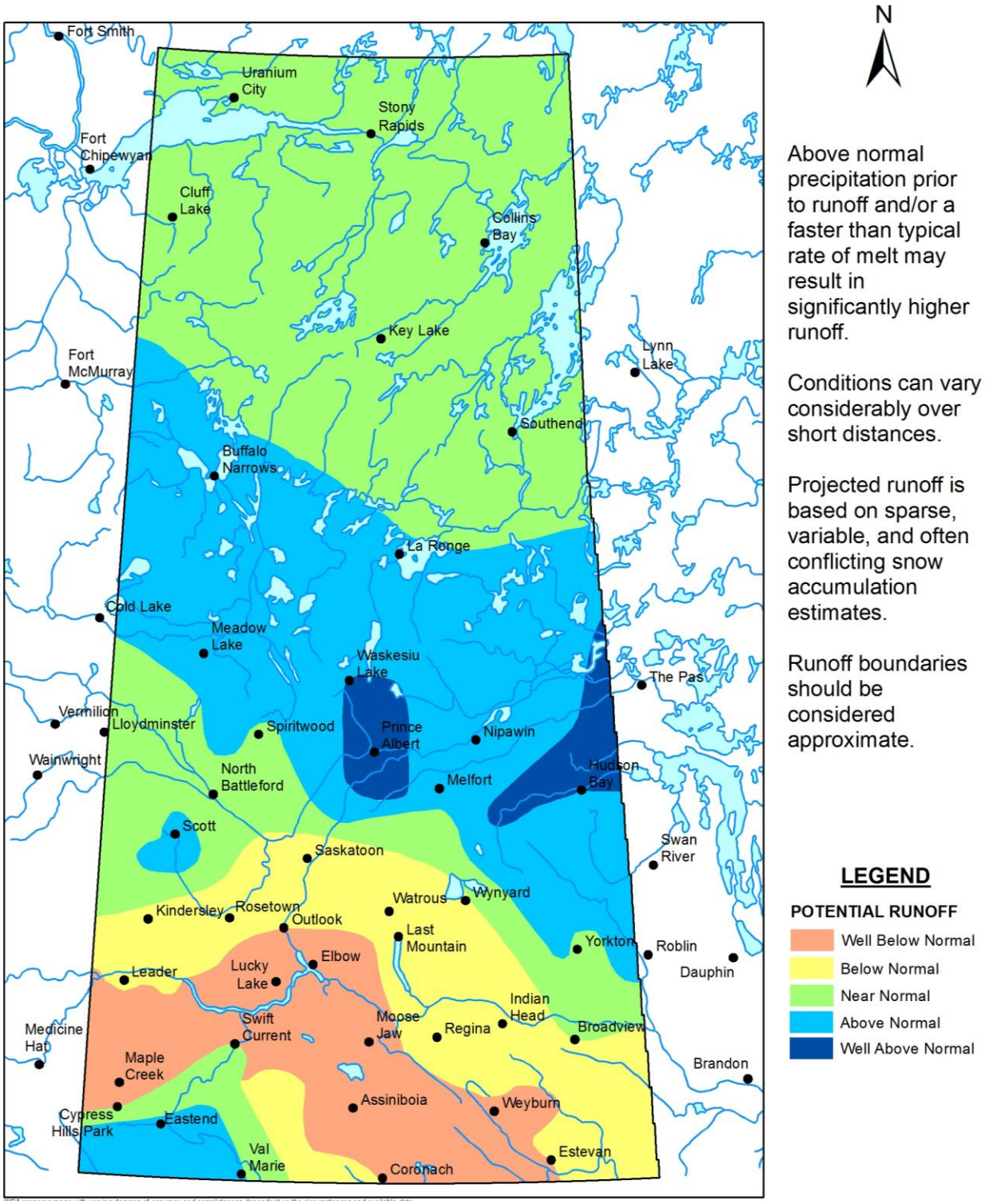

Figure 1: Spring Runoff Potential as of April 1, 2018

Fall Conditions

Fall conditions were detailed in the Conditions at Freeze-up Report released in November of 2017, available at www.wsask.ca. The following is a summary of that report.

2017 growing season precipitation was extremely low across southern Saskatchewan with record low accumulations at a number of locations in south central Saskatchewan. In central and northern Saskatchewan, growing season precipitation was near average with the exception of the Meadow Lake and Buffalo Narrows areas which received well above normal to record high summer rainfall.

Fall precipitation was more variable. In September, rainfall was well below average across all of southern Saskatchewan and near normal in northern Saskatchewan. Rainfall accumulations in October varied from extremely low in southeastern Saskatchewan, to near average over central Saskatchewan, to above average in northeastern Saskatchewan. A band of above average precipitation also occurred from the Cypress Hills to Hudson Bay due to an early October rain/snow event.

Soil moisture conditions were generally dry south of Highway 16 and adequate north of Highway 16 at freeze-up in 2017.

Winter 2017/18 Precipitation

Point snowfall data, mapped as a percent of average, is provided in Figure 2. This map indicates that, as of April 1, a large portion of southern Saskatchewan had received near average winter precipitation. Northern Saskatchewan had also generally received near average winter precipitation. It is important to note that the map in Figure 2 is based on a relatively small number of sites across Saskatchewan and, due to challenges of measuring point snowfall data in a windy environment and losses during the winter period, it may not represent the snowpack water equivalent available for runoff.

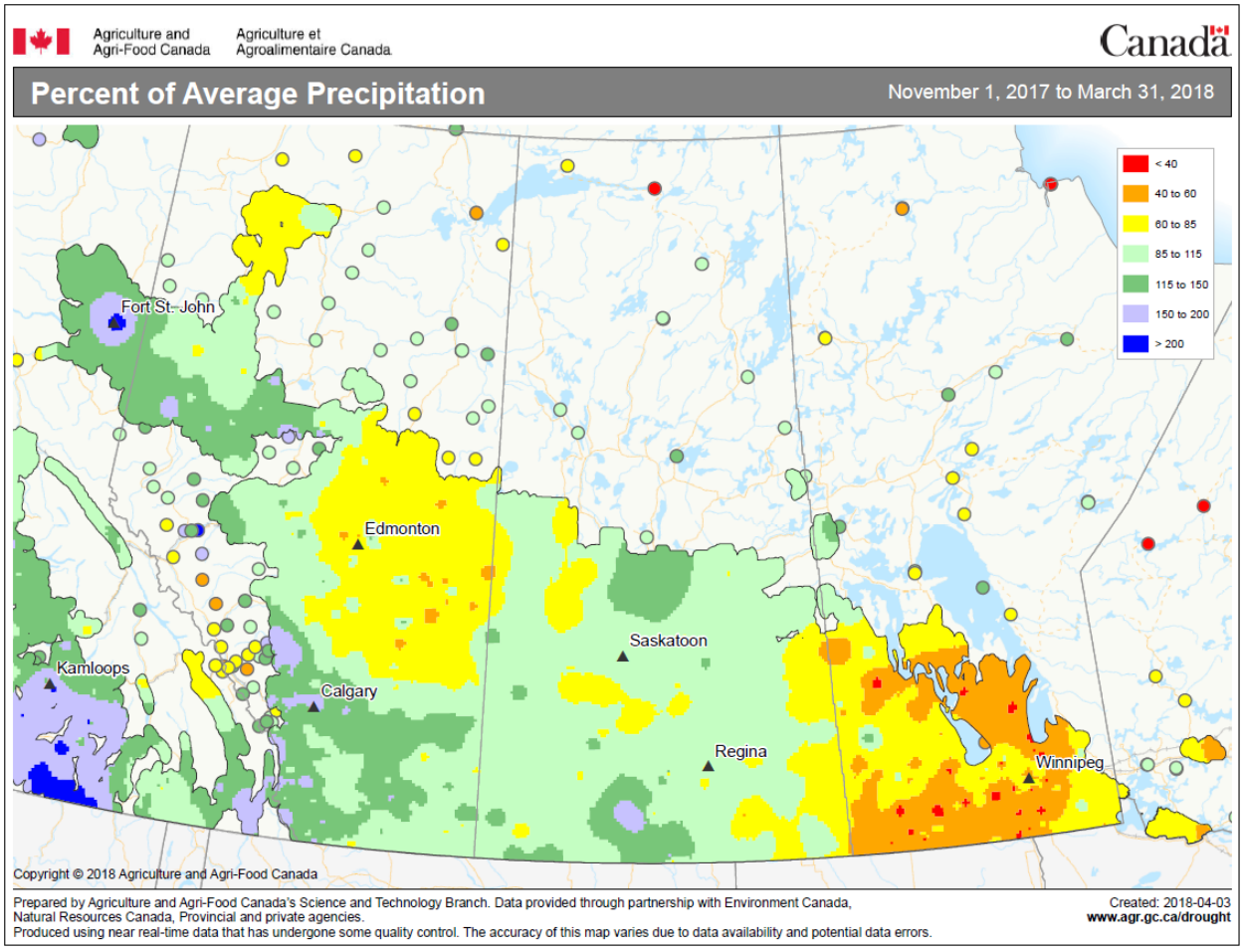

Figure 2: Percent of Average Winter Precipitation Nov. 1, 2017 to March 31, 2018 (Source: Agriculture and Agri-Food Canada)

Environment and Climate Change Canada generates a snow water equivalent (SWE) map which estimates snowpack water equivalent using satellite passive microwave signals. Their April 1, 2018, map is provided as Figure 3.

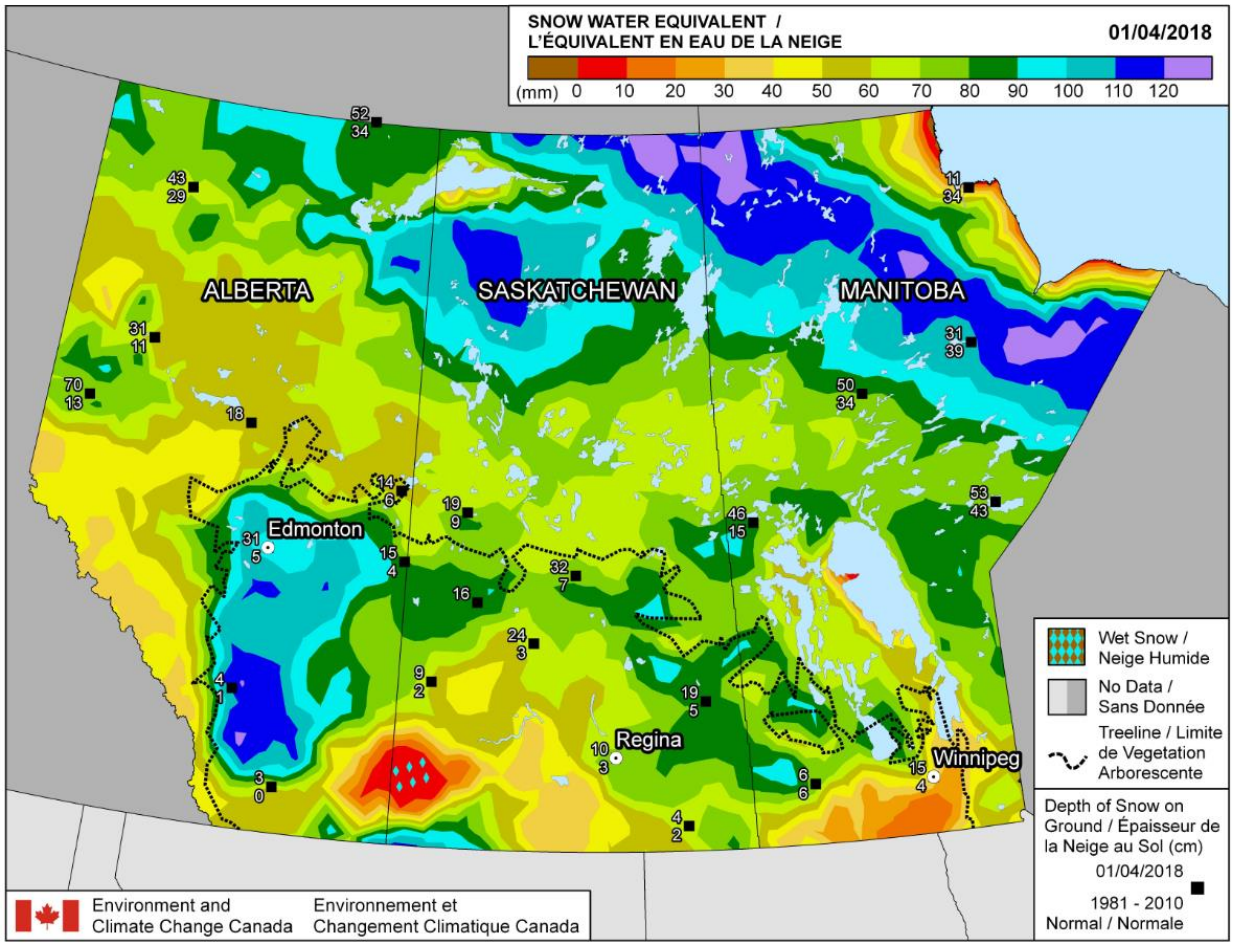

Figure 3: April 1, 2018, Passive Microwave Snow Water Equivalent Map (Source: Environment and Climate Change Canada)

WSA completed point snow course surveys in late February and again at the end of March. The March data, which is provided in Figure 4, is believed to be the best available information on snowpack water equivalents at that time. The background image used for this map is a March 26, 2018, satellite image. Since this image, the area that was nearly snow free in the southwest has received some additional snow.

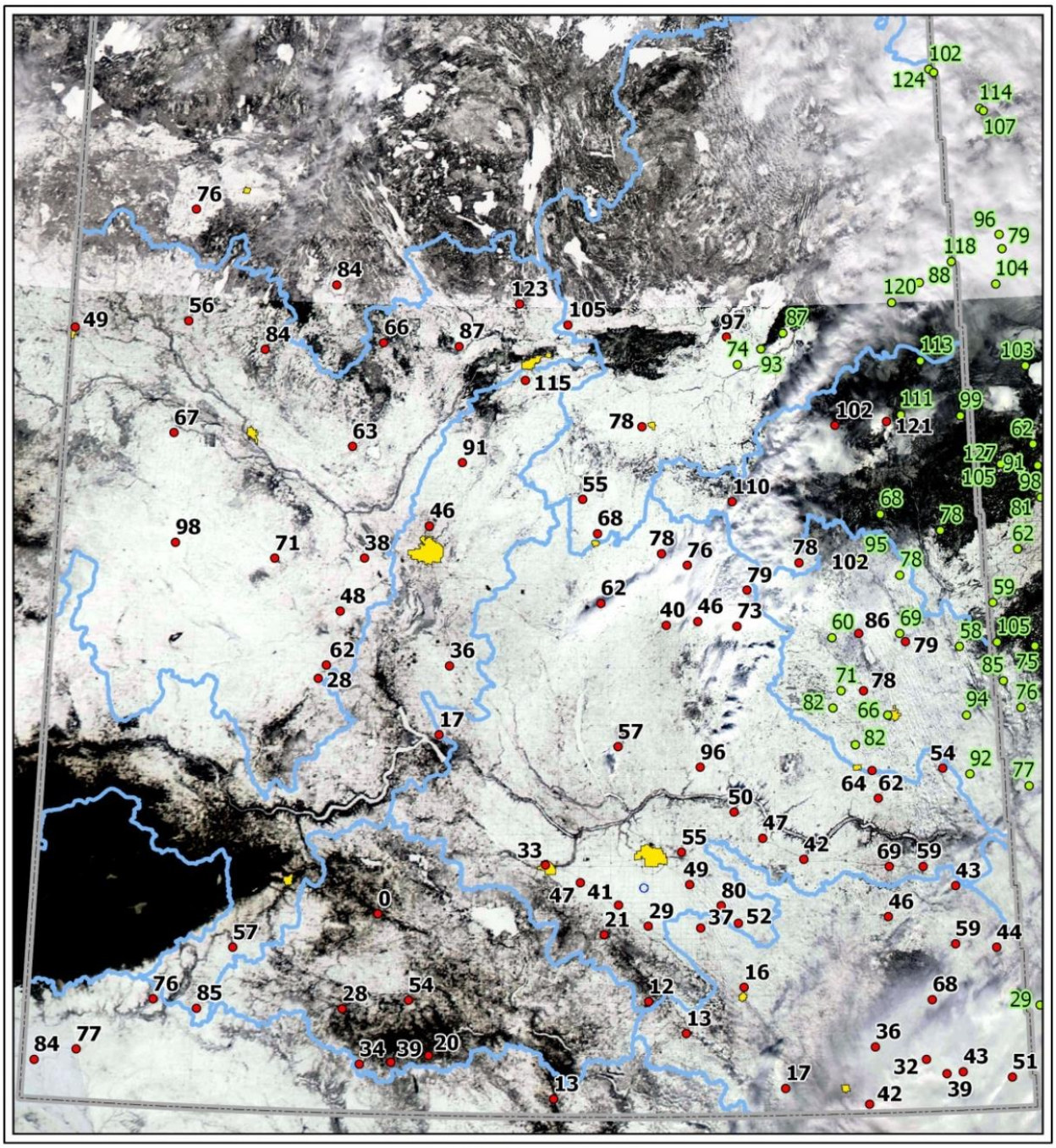

Figure 4: WSA March 27/28, 2018, Snow Survey Data shown in Black and Manitoba Infrastructures March 12-16 Snow Survey Data in Green (mm of SWE)

Overall, on April1, 2018, the snowpack is considered to be below average to well below average across the majority of southern agricultural areas of Saskatchewan, with the exception of the extreme southwest and near Scott where it is above normal. The

snowpack is considered to be near normal within the majority of the northern boreal forest with the exceptions of areas north of Prince Albert and near Hudson Bay where it is above normal.

Long Range Precipitation Forecast

Saskatchewan has experienced a weak La Niña winter (cooler than normal) so far. Due to a number of warm days (temperature above 0°C), mid-winter thaw of accumulated snow has occurred and thus the development of the snowpack was hindered. The weak La Niña conditions are expected to shift toward neutral condition during spring.

The Pacific Decadal Oscillation (PDO) index remained near neutral through the winter with the index slightly positive. The warm/positive phase of the PDO is typically associated with below normal winter precipitation in Saskatchewan and into the eastern slopes of the Rocky Mountains.

The La Niña condition of El Niño Southern Oscillation (ENSO) indicates an opposite signal compared to PDO, although both are currently weak signals, which might have resulted in a weaker combined effect on our winter precipitation to date.

There is considerable variability in the precipitation expectations over the next three months, April 1 to June 31, in the seven long range forecast models examined. Two are forecasting above normal precipitation, two are forecasting below normal precipitation, and the remainder are forecasting near normal precipitation over the province for this period. The ensemble mean results in an expectation of near normal precipitation over the province for this period (Figure 5). There is better model agreement for the eastern slopes of the Rocky Mountains in Alberta, where below normal precipitation is expected over this period. Environment and Climate Change Canada's deterministic precipitation forecast is provided below (Figure 6). Similar variability in precipitation estimates across these same models exists for the month of April. Most long lead models are also expecting above season temperatures over the next three months. With that said, it is important to note that seasonal weather forecasts are largely unreliable.

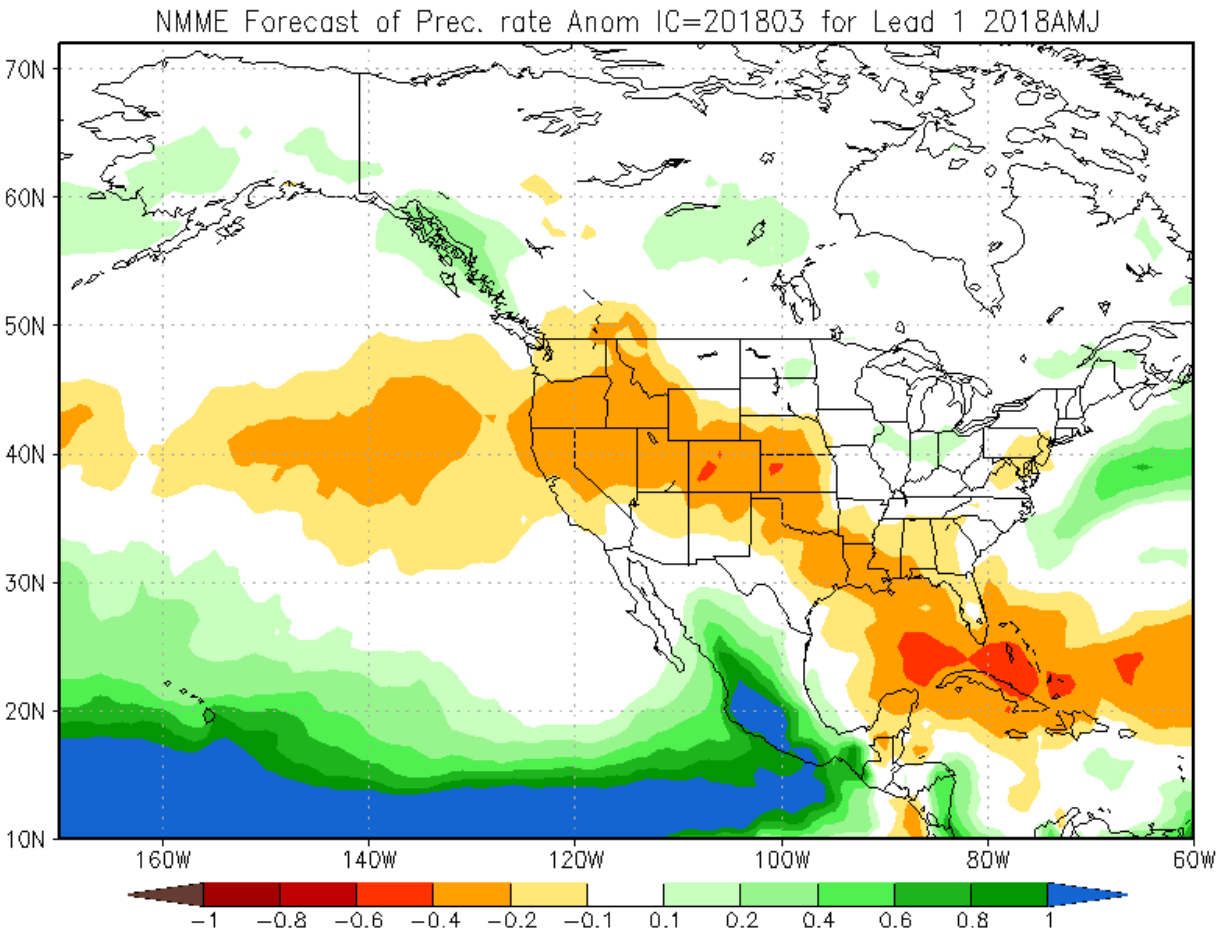

Figure 5: US National Weather Service Multi Model Ensemble Precipitation Anomaly Forecast for April-May-June 2018

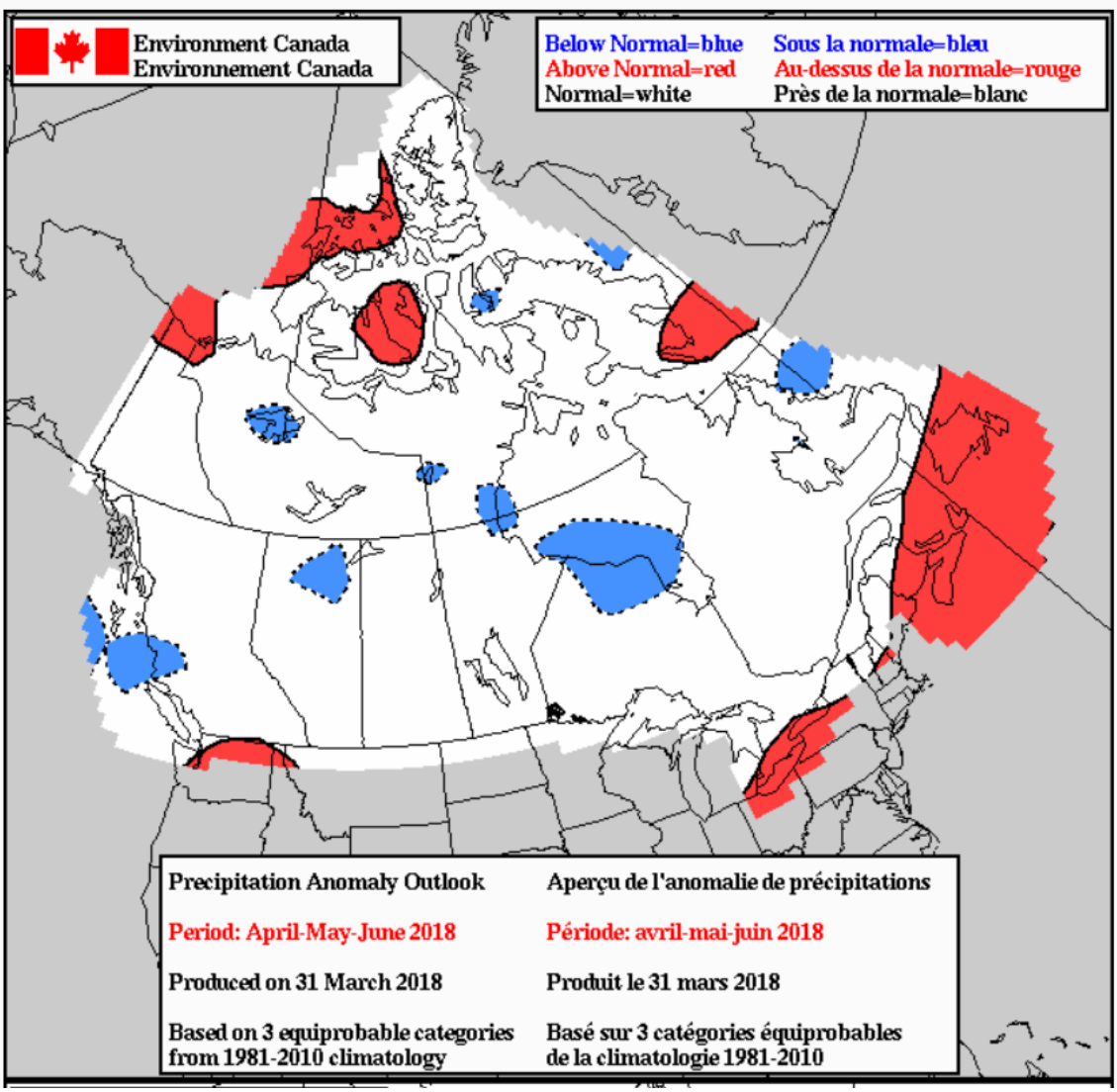

Figure 6: Environment and Climate Change Canada Deterministic Precipitation Anomaly Outlook for April-May-June 2018

Water Supply Outlook

Most reservoirs and dugouts went into winter at slightly below average levels, particularly within south central areas of the province. Consequently, with a below normal runoff, some surface water supplies are expected to be of concern in 2018, particularly in south central areas where below normal snowmelt runoff is expected. It is important to understand that the vast majority of prairie runoff occurs as a result of snowmelt. Summer rains typically only generate appreciable runoff when conditions are wet (approximately 10% of years). When soil conditions are dry it takes significant rainfall to produce runoff. Therefore, unless there is appreciable precipitation in April, it is likely there will be little surface runoff in 2018 in some areas of the southern portion of the province.

Summary of Major River Systems

Souris Basin

Rafferty Reservoirs and Grant Devine Lake were at their normal drawdown levels prior to February 1 and outflows were terminated from both reservoirs in January. With dry conditions at freeze-up in 2017 and near normal snow within the basin, non-flood operations are in effect and additional drawdown of these reservoirs is not expected in 2018. Based on current conditions, WSA does not expect these reservoirs to reach their full supply levels in 2018. It is anticipated that reservoir releases during the spring runoff period will be limited to what may be required to meet international apportionment obligations.

Detailed forecasts for the Souris River Basin are developed on or near the 1st and 15th of each month, beginning in February, up until the snowmelt runoff event. These forecasts can be found on www.wsask.ca.

Saskatchewan River Basin

Winter inflows to Lake Diefenbaker have been below normal this winter. Lake Diefenbaker is presently 0.7 m below median level for this time of year. This is due in part to a late runoff from the plains portion of the watershed. Outflows are currently near normal.

Snow pillows operated by Alberta Environment and Parks at higher elevations within the alpine headwaters of the basin are showing well above average snowpack, generally near upper quartile. Snow courses completed at lower elevations in early March also suggest an average to above average snowpack (about 125% of normal). However, high flows on the system are largely driven by significant summer rainfall events in late May, June and July.

WSA has directed SaskPower to target an elevation of 552 m for May 12 at Lake Diefenbaker, an elevation that is no higher than 553 m for June 1, and an elevation of 555 m for July 1. This will satisfy recreational and most irrigation needs, provide a 1:10 year level of downstream flood protection in June, and meet operational guidelines put in place for the protection of piping plovers nesting on the beaches of Lake Diefenbaker.

Qu'Appelle System

Lakes in the Qu'Appelle Valley downstream of Craven are at near normal levels for this time of year. The exception is Pasqua and Echo lakes which are at above normal levels. With dry conditions within the basin, WSA elected to leave the majority of the logs in the Echo Lake Control structure to increase the likelihood of desirable operating levels in the summer of 2018.

The current expectation is for well below normal snowmelt runoff in upper parts of the basin (Moose Jaw River), below normal runoff through the central portion of the basin, and near normal runoff from the lower portion of the basin (Cutarm Creek). As such, operations may be required in advance of the melt to maximize diversions into storage during the melt. WSA will maximize the use of storage within Last Mountain Lake and will endeavor to bring Pasqua-Echo and Crooked lakes into their desirable summer operating ranges through the storage of snowmelt runoff. If there isn't insufficient runoff to achieve this, additional diversions into the system from Lake Diefenbaker via the Upper Qu'Appelle Conveyance will be initiated. It is anticipated that the control structure located at the outlet of Round Lake likely will not be operated in 2018 as the Government of Canada does not possess full land control.

Churchill System

Flows in the Churchill System remain at above normal levels in response to well above normal rainfall, particularly in upper portions of the basin, during the spring and summer of 2017. While the snowpack is believed to be near normal throughout the basin, the wet conditions at freeze-up over the upper portion of the basin are expected to result in snowmelt runoff volumes that are slightly above normal across the Peter Pond and Churchill lake basins near Buffalo Narrows. Flood flows due to snowmelt runoff are unlikely based on current conditions.

Quill Lakes

Topsoil moisture conditions were near normal at freeze-up in 2017 within the Quill Lakes basin due to the early October 2017 rainfall event. The basin has received near normal snowfall over areas south of the lakes and above normal snowfall north and east of the lakes. The basin has also experienced some mid-winter melt events. As such, slightly higher than normal snowmelt inflows are currently forecasted for the

lakes in 2018. Based on current conditions, the Quill Lakes are expected to peak near 520.75 m in response to snowmelt runoff in 2018, an increase of about 15 cm from the current level.

Red Deer River Basin

Above normal snowpack conditions have developed within the Red Deer River Basin southwest of Hudson Bay. With near normal conditions through the basin at freeze-up in 2017, spring runoff peaks similar to what was observed in the spring of 2017, during the rapid melt that occurred, are expected in 2018. This is likely to result in some overtopping of roadways.

Old Wives Lake

Runoff potential is expected to be below normal for most of the Old Wives Lake basin in spring 2018 due to dry conditions at freeze-up in 2017 and below normal snowpack. Only upper portions of the Wood River are expected to experience near normal snowmelt runoff. Thompson Lake is expected to fill in spring 2018. At this time, a release to clear ice and snow from the Wood River through to Gravelbourg is not planned and the riparian outflow will be kept to a minimum. Similarly, reservoirs on Notekeu Creek are expected to fill in 2018 based on current conditions.

Frenchman River

Runoff yields from the basin's headwaters and areas south of the Frenchman River are expected to be higher than lower portions near Val Marie. The current expectation is for Eastend Reservoir as well as Huff and Newton Lakes to fill in 2018. Diversions into Cypress Lake from Belanger Creek are anticipated.

Battle, Middle, Lodge Creeks

With a heavy snowpack in southeastern Albert and southwestern Saskatchewan, the expectation is that there will be good inflow into both Middle Creek Reservoir and Altawan Reservoir in 2018 with Altawan more likely to fill. With a significant snowpack over the lower portions of the Battle Creek Basin, the current plan is to maximize diversions into Cypress Lake at the Wilson Weir since local runoff below the diversion point is expected to supply Saskatchewan's apportionment obligations to the State of Montana. The West Inflow Canal has been cleared of snow to facilitate this.

Maple Creek

Some runoff occurred within the Maple Creek Basin in March with near normal yields. Thus far McDougald is the only reservoir in the basin to fill. Some snow still remains in the trees and coulees, so slow runoff is still likely in those areas.

Swift Current & Rush Lake Creeks

The snowpack in the basin's headwaters near Shaunavon is heavier than near Reid Lake and the City of Swift Current. While above normal runoff is expected from the headwater areas, near normal runoff yields are expected from lower portions of the basin. Reid Lake is currently at 80% capacity with a normal winter release of about 0.6 m^3/s. The focus initially at Duncairn Dam will be on storage during the snowmelt period.

Highfield Reservoir is near 50% capacity following the release to the Rush Lake backflood project in late March. Diversions to Highfield Reservoir via the Swift Current Main Canal were occurring in March, but with the return of below normal temperatures, they were discontinues in late March. This action prevented the canal from freezing up, which would have hindered further diversions during spring runoff. Transferred water from Swift Current Creek was not used for the backflood on the Rush Lake Project.

Table 1
Provincial Forecast for Saskatchewan – April 2018
LAKE LEVELS AT SELECTED LAKES AND RESERVOIRS IN SASKATCHEWAN

Lake	2018 April 1st Level (metres)	Forecast* 2018 Peak Spring Level (metres)	Shoreline [1] Level/FSL (metres)	Normal Summer Level (metres)	2017 Peak (metres)	Recorded Historical Extreme	
						Level (metres)	Year
Anglin	*515.42*	*515.6*	*515.4*	*515.3*	*515.43*	*516.05***	*2013*
Big Quill	*520.60*	*520.75*	*521.47 (spill)*	*515*	*520.95*	*520.95*	*2017*
Boundary Reservoir	*559.1*	*560.7*	*560.8*	*560.5*	*560.83*	*561.15*	*1979*
Buffalo Pound	*509.33*	*509.5*	*509.9*	*509.4*	*509.6*	*511.45*	*1974*
Candle Lake	*494.27*	*494.5*	*494.5*	*494.4*	*494.5*	*495.25*	*1973*
Cookson Reservoir	*751.46*	*752.0*	*753*	*752.5*	*753.01*	*753.35*	*1979*
Crooked	*450.99*	*451.7*	*452.3*	*451.7*	*451.76*	*454.40***	*2014*
Diefenbaker	*551.11*	*556.3*	*556.86*	*556.5*	*555.77*	*556.9*	*2011*
Echo and Pasqua	*478.8*	*479.3*	*479.3*	*479.1*	*479.17*	*480.98*	*2011*
Fishing	*529.9*	*530.2*	*529.7*	*528.5*	*530.53*	*530.92*	*2011*
Good Spirit	*484.25*	*484.8*	*484.6*	*484.6*	*484.68*	*485.68***	*2010*
Grant Devine	*560.99*	*562.0*	*562.0*	*561.5*	*561.92*	*566.58***	*2011*
Jackfish	*529.42*	*529.7*	*529.4*	*529.4*	*529.79*	*530.0*	*1985*
Katepwa and Mission	*478.20*	*478.4*	*478.7*	*478.3*	*478.37*	*479.58*	*2011*
La Ronge	*364.96*	*364.15*	*364.1*	*364.4*	*364.76*	*364.98***	*2011*
Last Mountain	*489.89*	*490.2*	*490.7*	*490.2*	*490.27*	*492.09*	*1955*
Moose Mountain	*620.0*	*620.6*	*620.3*	*620.4*	*620.70*	*621.9*	*2011*
Rafferty	*549.48*	*549.7*	*550.5*	*550*	*550.51*	*554.05***	*2011*
Reindeer	*336.3*	*336.5*	*336.68*	*336.5*	*336.61*	*336.80***	*1997*
Round	*441.30*	*441.5*	*443.28*	*442.4*	*442.26*	*445.70***	*2014*
Wascana	*570.34*	*570.8*	*570.6*	*570.5*	*570.85*	*572.23*	*1974*

* These forecasted peaks are based on a typical spring precipitation and rate of melt. Above normal precipitation and/or rapid melt may result in significantly higher levels.

** Occurred after spring runoff during summer event(s).

[1] The "Shoreline Level" and "Full Supply Level" refer to the highest elevation before spill occurs

TABLE 2 SPRING RUNOFF FORECAST						
Basin and Location	April 2018 Forecast*		2017 Spring Peak Flow (m^3/s)	Historical		
	Peak Flow (m^3/s)	Peak Flow Frequency		Normal Year	Recorded Maximum Spring	
				Flow (m^3/s)	Flow (m^3/s)	Year
ASSINIBOINE RIVER BASIN						
Assiniboine River at Sturgis	60	1:5	55	30	111	1995
Whitesand River near Canora	70	1:4	85	36	247	1995
Assiniboine River at Kamsack	150	1:4	150	78	488	1995
QU'APPELLE RIVER BASIN						
Qu'Appelle River near Lumsden	17	<1:2	35	30	436	1974
Qu'Appelle River below Craven	5	<1:2	14	19	141	1974
Qu'Appelle River below Loon Creek	10	<1:2	14	24	163	2011
Qu'Appelle River near Hyde	35	1:2	30	32	254	2011
Qu'Appelle River near Welby	40	1:2	65	40	345	2011
Moose Jaw River above Thunder Creek	8	<1:2	25	24	252	1974
Moose Jaw River at Burdick	9	<1:2	18	30	368	1974
Wascana Creek at Regina	10	1:2	11	10	102	1974
Lanigan Creek above Boulder Lake	5	1:2	7	4.7	56	2006
Pheasant Creek near Abernethy	7	1:2	3	6.9	47	1976
Cutarm near Spy Hill	12	1:2	12	5.6	35	1955

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BEAVER RIVER BASIN						
Beaver River near Dorintosh	150	1:4	150	92	654	1962
LAKE WINNIPEGOSIS BASIN						
Red Deer River near Steen	60	1:9	75	20	102	1972
Red Deer River near Erwood	400	1:12	450	150	878	2006
NORTH SASKATCHEWAN RIVER BASIN						
North Saskatchewan River near Deer Creek	1200	1:2	1100	900	1660	1974
Eagle Creek near Environ	10	1:2	27	12	136	1970
North Saskatchewan River at Prince Albert	1000	1:2	1000	1100	3880	1974
SASKATCHEWAN RIVER BASIN						
White Fox River near Garrick	70	1:5	75	26	160	1974
Torch River near Love	90	1:5	110	43	170	1955
Carrot River near Armley	200	1:5	250	71	377	1974
Carrot River near Smoky Burn	500	1:7	700	200	816	1972
SOURIS RIVER BASIN						
Long Creek near Noonan	5	<1:2	3.5	50	183	2011
Yellow Grass Ditch near Yellow Grass	5	<1:2	0.0	12	79	2011
Souris River at Ralph	5	<1:2	0.28	25	118	1979

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				Flow (m^3/s)	Flow (m^3/s)	Year
Jewel Creek	1	<1:2	0.0	2.4	44	2011
Moose Mountain above Grant Devine Lake	15	<1:2	5.4	17	99	2011
Souris River near Sherwood	15	<1:2	6.9	32	388	1976
SWIFT CURRENT CREEK BASIN						
Swift Current Creek below Rock Creek	25	1:2	12	18	85	1955
Rushlake Creek above Highfield Reservoir	3	<1:2	5.7	7.4	38	1969
MISSOURI RIVER BASIN						
Notukeu River near Vangaurd	20	<1:2	19	25	208	1952
Wood River near Lafleche	30	<1:2	49	35	292	1952
Denniel Creek near Val Marie	10	1:2	11	9	43	2011
East Poplar River above Cookson Reservoir	3	<1:2	1.0	5	30	1982

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Next Forecast

The WSA will issue updates as needed during the runoff period.