Red River Balanced Hydrograph Analysis (Peak Flow Frequency, Volume Frequency, and Balanced Hydrographs) - Inventory Spreadshee															
						Drainage Area		Available Period of Record (Water Years)							
No.	Watershed	Type	Gage Number	Gage Location	Previous Analysis	Total D.A (sq. mi.)	Contributing D.A. (sq. mi.)	Start Date	Stop Date	Gaps	Analysis Type	Record Extension	Analysis Challenges	Status	Site Notes
1	Bois de Sioux	Headwater	USGS 05050000	White Rock, SD	No	1,160	NA	1942	2016	No	Graphical	No	Regulation	Complete	Regulated by the Lake Traverse Project which operates for Wahpeton, ND. Flows are sometimes impacted by backwater from the Rabbit River.
2	Bois de Sioux	Headwater	USGS 05051300	Doran, MN	Yes	1,880	NA	1990	2016	No	Graphical	Yes	Regulation	Complete	Flow regulated by Lake Traverse-Bois de Sioux Flood Control and Water Conservation project near White Rock, S.D.
3	Otter Tail River	Headwater	USGS 05046000	Fergus Falls Blw Orwell Dam, MN	No	1,730	NA	1931	2016	No	Graphical	No	Regulation	Complete	Flow regulated at outlet of Orwell Lake beginning March 21st, 1953, and by power plants upstream. Prior to October 1952, gage published as "Otter Tail River below Pelican River, near Fergus Falls".
4	Red River of the North	Mainstem	USGS 05051500	Wahpeton, ND	Yes	3,880	NA	1942	2016	Jan-Apr 1942; Nov-Feb 1943	Graphical	No	Regulation	Complete	Adopt analysis from LSER or Hickson Analysis downstream of where the Otter Tail Diversion rejoins with the Red River of the North (Total Red Flow). Flow regulated by: Orwell Reservoir and the Lake Traverse Project. Since June 2005, Otter Tail River flows are partially diverted around Breckenridge, MN. The diverted flows are measured at streamflow station Otter Tail River Diversion at Breckenridge, MN (USGS station 05046475). A stage of 17.0 ft, discharge, 10,500 ft^3/s, occurred in the spring of 1897 (historic event). Flow regulated by: Orwell Reservoir, flood storage capacity, 13,300 acre-ft at elevation 1,070 ft above mean sea level, adjustment of 1912; Mud Lake, flood storage capacity, 78,600 acre-ft at elevation 981 ft above mean sea level, adjustment of 1912; Lake Traverse, flood storage capacity, 75,100 acre-ft at elevation 981 ft above mean sea level, adjustment of 1912; and numerous other controlled lakes, ponds and several power plants.
5	Red River of the North	Mainstem	USGS 05051522	Hickson, ND	Yes	4,170	NA	1976	2016	No	Graphical	No	Regulation	Complete	Adopt analysis done for the Hickson Analysis done in support of the FMM project. Flow regulated by: Orwell Reservoir and the Lake Traverse Project. Improve upon analysis to produce a consistent set of hydrographs along the main stem of the Red River. Flow regulated by: Orwell Reservoir, flood storage capacity, 13,300 acre-ft at elevation 1,070 ft above mean sea level, adjustment of 1912; Mud Lake, flood storage capacity, 78,600 acre-ft at elevation 981 ft above mean sea level, adjustment of 1912; Lake Traverse, flood storage capacity, 75,100 acre-ft at elevation 981 ft above mean sea level, adjustment of 1912; and numerous other controlled lakes, ponds and several power plants.
6	Wild Rice River-ND	Tributary	USGS 05053000	Abercrombie, ND	Yes, but requires Review	2,080	1,490	1932	2016	Jan-May 1932	Graphical		Breakout Flows. Breakout flows are present in the basin. Need a RAS modeler to develop breakout flows relationship before hydrologic analysis can be completed.	Not Started	There are Fish and Wildlife Service reservoirs upstream - but impacts would be minimal on high flows. There is a historic peak in spring 1897. There are significant breakout flows from the Wild Rice River to the mainstem of the Red River of the North. Breakout flows from the Wild Rice River start becoming substantial when flows observed at the USGS gage near Abercrombie, North Dakota (USGS gage 05053000) exceed 14,000 cfs - See Hickson Analysis. Historically, no significant breakout flows have been observed from the Wild Rice River (North Dakota) to the Red River of the North between Wahpeton and Hickson. This should be noted when carrying out analysis. Analytical analysis used when carrying out the FMM study see Figure 20 (Appendix A-2).
7	Red River of the North	Mainstem	USGS 05054000	Fargo, ND	Yes	4,000		1901	2016	Jan-May 1901	Graphical		Regulation	Complete	Adopt from analysis carried out by HEC and Chanel Mueller in support of the FMMFS-EIS. Flow regulated by: Orwell Reservoir and the Lake Traverse Project. Historic flood information from 1897. Improve upon analysis as needed to produce a consistent set of hydrographs for the main stem of the Red River of the North. Flow regulated by: Orwell Reservoir, flood storage capacity, 13,300 acre-ft at elevation 1,070 ft above mean sea level, adjustment of 1912; Mud Lake, flood storage capacity, 78,600 acre-ft at elevation 981 ft above mean sea level, adjustment of 1912; Lake Traverse, flood storage capacity, 75,100 acre-ft at elevation 981 ft above mean sea level, adjustment of 1912; and numerous other controlled lakes, ponds and several power plants.
8	Upper Sheyenne River	Tributary	USGS 05059000	Kindred, ND	No	8,800	3,020	1950	2016	No	Graphical		Regulation/Breakout Flows. Breakout flows are present in the basin. Need a RAS modeler to develop breakout flows relationship before hydrologic analysis can be completed.	Not Started	Downstream extent of the Upper Sheyenne Watershed Model. Analysis has previously been carried out upstream at Valley City, ND. Lake Ashtabula is upstream of Kindred, ND - but it may be far enough downstream for regulatory impacts to be negligible. There are significant breakout flows just downstream of the GoI Bridge and just upstream of Kindred (requires graphical approach). Breakouts appear to impact flows of 5,000 cfs and higher (confirm with HEC-RAS). Total D.A includes closed Devil's Lake Basin. Large event in 1947 recorded outside of the systematic period of record. Spring flood in 1947 or 1948 reached a stage of 22.1 ft from flood marks, peak flow about 3,600 ft^3/s. Flow regulated to a large degree by Lake Ashtabula (station 05057500), 202 mi upstream, and several small reservoirs.

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						Total D.A (sq. mi.)	Contributing D.A. (sq. mi.)	Start Date	Stop Date	Gaps					
9	Lower Sheyenne River	Tributary	USGS 05059500	West Fargo, ND	No	8,870	3,090	1930	2016	Add'l data: 1903-05, 1919	Graphical		Breakout Flows. Breakout flows are present in the basin. Need a RAS modeler to develop breakout flows relationship before hydrologic analysis can be completed.	Not Started	Flow regulated to a degree by Lake Ashtabula (USGS station 05057500), 246 mi upstream. Since March 1993, flood flows that are diverted from the Sheyenne River just downstream from gaging station Sheyenne River above Sheyenne River Diversion near Horace (USGS station 05059300) bypass this station. These flows are measured at streamflow station Sheyenne River Diversion at West Fargo (station 05059480). Figures of discharge given here include flow of the bypass. USGS gage 05059500 Sheyenne River at West Fargo, ND is therefore representative of natural channel flow + diverted flows at West Fargo, ND + diverted flows at Horace.
10	Maple River	Tributary	05060000/05060100	Mapleton, ND	No	1,450	1,380	1944	2016	1976-1994	Graphical		Regulation/Breakout Flows. Breakout flows are present in the basin. Need a RAS modeler to develop breakout flows relationship before hydrologic analysis can be completed.	Not Started	Breakout flow occur on the Maple River above Mapleton, ND. The majority of breakout flows occur near Durbin, ND. There are two gages located near the city of Mapleton, ND on the Maple River. The original gage is (USGS 50561000) located downstream of Mapleton. An additional gage was installed upstream of Mapleton (USGS 50560000) in order to avoid recording breakout flows. There is evidence of flow being lost between Enderlin and Mapleton in the 1997 and 2009 flood events. The Maple River Dam was constructed in 2006 for flood control purposes - began impacting flood flows in summer 2007. The dam is located approximately 59 mi upstream with a flood storage capacity of 60,000 acre-ft. It is important to homogenize the flow record on the Maple River for regulatory impacts. A homogenized flow record was developed for the FMM study.
11	Rush River	Tributary	USGS 05060500	Amenia, ND	No	116	NA	1947	2016		Analytical		NA	Complete	NA
12	Buffalo River	Tributary	USGS 05062000	Dilworth, MN	Yes, but requires Review	975		1931	2016	Jan-Mar 1931	Analytical		NA	Complete	Analysis done in support of the FMM Study - verify statistics smoothing. Update analysis to be consistent with period of record incorporating the 2016 event.
13	Elm River	NA	Field Gages Only - Not enough data available to do balanced hydrograph analysis	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	Field Gages Only - Not enough data available to do balanced hydrograph analysis.
14	Wild Rice River-MN	Tributary	USGS 05064000	Hendrum, MN	Yes, but requires Review	1,560		1944	2016	Jan-Mar 1944, Oct 1984- Apr 1985	Graphical		Breakout/Diversion Flows. Breakout/diversion flows are present in the basin. Need a RAS modeler to develop breakout/diversion flows relationship before hydrologic analysis can be completed.	Not Started	Analytical Analysis done in support of the FMM Study- check statistics smoothing. Also, the curve does not appear to fit a LP3 distribution. According to the water report for USGS gage 05067500- Marsh River near Shelly a large part of high flow off of the Wild Rice River is diverted into Marsh River Basin at overflow section 4.6 mi east of Ada. - Investigate breakout/diversion flows. Large part of high flow upstream is diverted into Marsh River Basin at overflow section approximately 15 miles upstream and 3.5 mi east of Ada. Another diversion into the Marsh River basin formed in 1947, 1.5 mi southeast of Ada and diverted water at all stages 1947-51, after which it was closed except for a small regulated flow diverted for abatement of contamination from Ada sewage plant effluent. Exact amount of diversion not known.
15	Red River of the North	Mainstem	USGS 05064500	Halstad, MN	Yes, but requires Review	21,800	18,000	1936	2016	Jan-May 1961	Analytical	Yes	NA	Complete	Analysis done in support of the FMM Study- check statistics smoothing, the impacts of upstream reservoirs are assumed to be negligible by the time you get to Halstad, MN. Improve upon analysis as needed to produce a consistent set of hydrographs for the main stem of the Red River of the North. Historic Information: Flood in 1897 reached a stage of about 38.5 ft
16	Goose River	Tributary	USGS 05066500	Hillsboro, ND	Yes, but requires Review	1,203	1,093	1931	2016	Seasonal 1932-1934	Analytical		NA	Complete	Data doesn't appear to fit a LP3 distribution very well - but there is no known source of regulation or breakout flows. There is a historic record at this site with high flows recorded in 1882, 1897, 1904 and 1916. Consider using HMS models to estimate storage in the watershed to inform the analysis, if necessary.
17	Marsh River	Tributary	USGS 05067500	Shelly, MN	Yes, but requires Review	220		1944	2016	Oct 1983-Mar 1984, no winter records since 1989	Graphical		Breakout/Diversion Flows. Breakout/diversion flows are present in the basin. Need a RAS modeler to develop breakout/diversion flows relationship before hydrologic analysis can be completed.	Not Started	Diversion/breakout flows from the Wild Rice River (MN) to the Marsh River. Large part of high flow of Wild Rice River diverted into Marsh River Basin at overflow section 4.6 mi east of Ada. Another diversion from Wild Rice River Basin formed in 1947, 1.5 mi southeast of Ada and diverted water at all stages from 1947-51, after which it was closed except for a small regulated flow diverted for abatement of pollution from Ada sewage plant effluent.

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						Total D.A (sq. mi.)	Contributing D.A. (sq. mi.)	Start Date	Stop Date	Gaps					
18	Sand Hill River	Tributary	USGS 05069000	Climax, MN	No	420		1943	2016	Oct 1984-May 1985, no winter records prior 1947	Analytical		Data does not fit analytical distribution.	Not Started	Data doesn't appear to fit a LP3 distribution - but there is no known source of regulation or breakout flows. Appears to asymptotically approach a basin maximum - similar effect in the Red Lake Watershed just north, use HMS model for insight. Is there a lot of distributed storage? Soils? Verify if an analytical or graphical approach is more appropriate for this site.
19	Clearwater River	Tributary	USGS 05078500	at Red Lake Falls, MN	Yes, but requires Review	1,380		1935	2016	Add'l data: 1909-1917; Winter 1982 is missing	Graphical		Data does not fit analytical distribution.	Not Started	Data doesn't appear to fit a LP3 distribution - but there is no known source of significant regulation or breakout flows. Appears to asymptotically approach a basin maximum - similar effect throughout the Red Lake Watershed just north, use HMS model for insight. Is there a lot of distributed storage? Soils? There was an analysis done for Crookston recently - review & use as a reference.
20	Thief River	Tributary	USGS 05076000	Thief River Falls, MN	Yes, but requires Review	985		1929	2016	Add'l data: 1909-1917 & 1920-21, 23-24; Winter 1982 is missing	Analytical		NA	Complete	Very negatively skewed, note some regulation by Thief and Mud Lake - but these are not likely flood control structures so their impacts on high flows are likely negligible. There was an analysis done for Crookston recently - review & use as a reference. USGS waters year summary notes that there is some regulation from Thief and Mud Lakes at this site. The amount of regulation and its impacts on peak flows is not known. Data appears to fit an analytical distribution.
21	Upper Red Lake River (Red Lake)	Tributary	USGS 05074500	Red Lake, MN	No	1,950		1933	2016	1995-1999	Graphical		Regulated. ResSim Model May be required.	Not Started	Flow completely regulated by outlet dam on Lower Red Lake.
22	Lower Red Lake River	Tributary	USGS 05079000	Crookston, MN	Yes, but requires Review	5,270		1901	2016		Graphical		Potential Breakout. If breakout flows are present, a RAS modeler will need to develop the breakout flow function.	Not Started	Data doesn't appear to fit a LP3 distribution very well - Red Lake is upstream - but Red Lake behaves almost like a closed basin. It is possible that the distribution is asymptotically approaching a basin maximum due to extensive storage. Use the HMS models to assist in analysis. There was an analysis done for Crookston recently - review & use as a reference. Headwaters of Red Lake River is completely controlled by dam at outlet of Lower Red Lake. Runoff from 1,950 mi² of the watershed in the headwaters of Red Lake River is completely controlled by dam at outlet of Lower Red Lake. Flow partially affected by occasional regulation at Thief and Mud Lakes in Thief River basin (see station 05076000). Historic information is available in 1897. Verify if an analytical approach is justified at this location. Diurnal fluctuation prior to 1975 caused by power plant 1,000 ft upstream. USACE engineer indicated that there are gages downstream of the Lower Red Lake to Grand Marais Diversion which is a potential breakout flow area. Upstream of Red Lake River at Crookston, MN USGS gage, a diversion routes flow to a sink called "Parnell". In the Grand Marais model, there is a source called "RedLaketoParnell". This suggests there is a breakout flow from Lower Red Lake HMS model to Grand Marais HMS model. Verify extent of breakouts and if a graphical or analytical approach is more appropriate.
23	Wilson Creek/Cole Creek/Buffalo Coulee	NA	No USGS gages- Not enough data available to do balanced hydrograph analysis	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	No USGS gages- Not enough data available to do balanced hydrograph analysis.
24	Red River of the North	Mainstem	USGS 05082500	Grand Forks, ND	Yes, but requires Review	30,100	26,300	1882	2016		Analytical		NA	Complete	Analysis done in support of the FMM Study - check stat smoothing, long historic record, some of the flows associated with 1997 flood are not reported by the USGS correctly - check FMM report. Improve upon analysis as needed to produce a consistent set of hydrographs for the main stem of the Red River of the North.
25	Grand Marais Creek	NA	No USGS gages- Not enough data available to do balanced hydrograph analysis. Upstream of Turtle River.	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	No USGS gages- Not enough data available to do balanced hydrograph analysis. USACE engineer indicates that breakout flows occur between the Lower Red Lake River and Grand Marais Diversion. Upstream of Red Lake River at Crookston, MN USGS gage a diversion routes flow to a sink called "Parnell". In the Grand Marais model, there is a source called "RedLaketoParnell". This suggests there is a breakout flow from Lower Red Lake HMS model to Grand Marais HMS model.

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26	Turtle River	Tributary	USGS 05082625	Arvilla, ND	Yes, but requires Review	311		1993	2016		Analytical	Yes	Short period of record requires record extension. Nearby sites do not correlate well (poor R^2 value) or produce poor Nash-Sutcliffe Score (low R_{NS}). Potential Regulated site.	In Progress	Some regulation by Larimore Dam located 4 mi upstream on the south branch of the Turtle River. Need to determine the extents of regulation that Larimore dam has on discharge. With the readily available data from 1993-2015 you don't really have enough data (23 years) to produce a good flow-frequency curve (the shape is really strange). Try to augment the period of record. One option is to apply a drainage area ratio to the historic USGS gage located on the Turtle River at Manvel. Another option would be to assess the relationship between flows on the Turtle River and the Snake/Middle River or Park River.
27	Red River of the North	Mainstem	USGS 05083500	Oslo, MN	Yes, but requires revision	31,200	27,400	1936	2016	1938-1940, 1944, 1961-1973, Multiple Gaps, Seasonal	Analytical	Yes	NA	Complete	Discontinued daily flow record. Augment the flow record. Use MOVE.3 analysis with another mainstem gage, use the stage record and a USGS rating curve, peak flow data and daily stage data available from April 2002-present. At minimum, need to reconstitute daily flow record for 2002-2015. Improve upon analysis as needed to produce a consistent set of hydrographs for the main stem of the Red River of the North.
28	Forest River	Tributary	USGS 05085000	Minto, ND	Yes, but requires Review	740	620	(1932), 1944	2016		Analytical	Yes	Breakout flows. Flows breakout from Forest River above Minto? Further investigation required.	In Progress	Occasionally during high stages, particularly when the channel is filled with snow, overflow occurs 0.5 mi below the municipality of Forest River and bypasses the gage 3 mi south of Minto and flows into Lake Ardoch. Bypass flow is not included in computation of discharge record for station at Minto. The curve doesn't show evidence of this so it may still be computed analytically. Original gage was USGS 05084500. This gage has a record of 1932-1944. Augment the flow record. Consider combing the two records based on D.A . The drainage area for the discontinued gage: 578 square miles with a contributing drainage area of 442 square miles. Flows breakout from the River upstream of Minto (Zach Herrmann, HEI). According to a review of the HMS model, there are no sources, extra sinks, or diversions in the Forest river HMS model; so breakout flow was not included in the model. Breakout flow is also not mentioned in the Phase 2 report (in the Forest River Section). Further investigation is required to assess if breakout flows occur in this watershed and their impact on peak flow frequency. The magnitude of breakout flows and how often they occur will determine if an analytical or graphical approach is more appropriate.
29	Snake River	Tributary	USGS 05085450	Warren, MN	Yes, but requires Review	176		2009	2016		Analytical	Yes	NA	Complete	Use the USGS gage on the Middle River at Argyle to extend the record as long as there appears to be a good relationship. Apply MOVE.3.
30	Middle River	Tributary	USGS 05087500	Argyle, MN	Yes, but requires Review	255		1950	2016	Add'l data: 1945; Winter 1982 is missing	Analytical		NA	Complete	Highly negative station skew. Existing period of record is sufficient to perform the analysis.
31	Park River	Tributary	USGS 05090000	Grafton, ND	No	695		1931	2016		Graphical		Potential graphical analysis. Verify if and how Homme Dam is regulated for flood control	Not Started	Grafton is downstream of Homme Dam. Both Barr Engineering and USACE did an analysis for the Park River - review these analyses and use them to guide your strategy. You can also use HEC-HMS models to help inform the decision graphical versus analytical . Are the impacts of regulation significant? Annual peaks are coded with a "6" indicating that they are impacted by regulation - but not discussed in water summary report. Homme Dam doesn't have a huge amount of storage available so maybe impacts of regulation can be considered negligible and you can do an analytical analysis. Verify if an analytical or graphical analysis is appropriate.
32	Park River	Tributary	USACE HOMN8	Homme Dam and Reservoir	Yes, discharge frequency analysis in water control manual	226		1950	2016	Many years where outflows from the dam are quite small compared to large flood years, no missing data	Graphical		Regulation.	Not Started	Outflow from Homme Dam should be analyzed as part of the tributary flow frequency analysis scope of work. According to the USACE water control manual for Homme Dam, the dam is authorized for Flood Control and likely impacts peak streamflow. The Homme Reservoir is constrained by its limited flood control storage capacity. A published discharge frequency curve for Homme Reservoir is available in the Water Control Manual, Figure 8-2. The published frequency curve is a graphical flow frequency curve.
33	Tamarac River	NA	No USGS gages- Not enough data available to do balanced hydrograph analysis	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	No USGS gages- Not enough data available to do balanced hydrograph analysis.

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34	Red River of the North	Mainstem	USGS 05092000	Drayton, ND	Yes, but requires revision	34,800	31,000	1941	2016	1897, Add'l data: 1936-1937; Fragmented prior to 1949	Analytical	Yes	NA	Complete	Improve upon analysis as needed to produce a consistent set of hydrographs for the main stem of the Red River of the North.
35	South Branch Two Rivers	Tributary	USGS 05094000	Lake Bronson, MN	No	422		1929	2016	1938-1940, 1948-1953, 1982-1984	Graphical		Potential Breakout Flows. Need to verify if breakout flows occur by working with a hydraulic modeler. If breakout flows occur, hydraulic modeler is needed to develop a breakout flow relationship.	Not Started	Flow partly regulated since 1937 at Bronson Lake; usable capacity, 3,700 acre-ft. Not a lot of capacity, so it is surprising that you would be seeing regulatory impacts - could consider doing an analytical analysis. The Lake Bronson gage is the only active gage in the Two Rivers watershed. There are discontinued gages downstream (below the confluence of the Middle and South Forks at Hallock, MN (D.A. = 644 sq mi) and on the North Fork at Northcote (D.A. = 386 sq mi) & Lancaster (D.A. = 209 sq mi). It might be more beneficial to develop a combined balanced hydrograph representative of total flow for the Two Rivers Watershed? Below the confluence of the North Branch of the Two Rivers and the mainstem the total drainage area is about 1,060 sq. mi thus the Lake Bronson gage captures less than half the drainage area. Not sure this will be possible given the limited data and the flood control project just upstream of the only currently active gage? Potential graphical analysis? USACE engineer indicated that there is a HMS diversion element between the Roseau watershed and Two Rivers watershed, indicating a potential breakout analysis may be required. Need to verify this relationship, and if it occurs above a gage of interest. Upstream of the Roseau River near Dominion City, Canada gage and the Roseau River below State Dich 52 near Caribou, MN USGS gage, a diversion routes flow to a sink called “TwoRiversSD72” in the HMS model. Again, the sink isn’t connected to any sources, but at the appropriate location in the Two Rivers HMS model there is a source called "RoseauRiver". So the models were probably set up assuming that breakout flow flows from the Roseau River HMS model to the Two Rivers HMS model.
36	Tongue River (Pembina River)	Tributary	USGS 05101000	Akra, ND	No	160		1939	2016	1951 Missing, 1983-Present Seasonal (Apr-Jun), Substantial emergency measures installed in 2013	Graphical		Regulation.	Not Started	There are a series of 10 NRCS structures upstream of the Akra gage in the Tongue River Basin, four of which have slow release outlet structures to regulate the flow. Retarding basins were completed during the period l955 to l961 and have a combined capacity of l9,245 acre-ft. The data does not fit an analytical distribution. The largest - Renwick Dam is just 300 feet upstream. During the 2013 event, a temporary dike was constructed across the emergency spillway at Renwick Dam. This lowered the maximum discharge at Renwick dam to the capacity of the principal spillway outlet (should be adjusted if to be included in homogenous record?).
37	Pembina River	Tributary	USGS 05099600	Walhalla, ND	Yes, but requires Review	3,350		1940	2016	1991-1993, 1996-1999	Analytical		Part of breakout analysis with Pembina River - Neche gage. Breakout flows occur downstream of Walhalla. Balanced hydrograph to be developed in concert with Neche balanced hydrographs.	In Progress	The data does not appear to fit an analytical distribution very well. There are some upstream lakes and control structures. For the river reach between Walhalla, ND and Leroy, ND there is a defined river channel that contains spills. The closest structures are located on the Little Pembina River (Mt. Carmel Dam), Mary Jane Creek (Manitou Dam) and Swan Lake located near Swan Lake, MB. These three impoundments are operated for recreation and water supply so I wouldn't expect them to have a major impact on high flows. Verify if analytical analysis is justified. Based on further investigation, determine if an analytical or graphical approach is advised.

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38	Pembina River	Tributary	USGS 05100000	Neche, ND	No	3,410		1903	2016	Spring 1909, 1916-1918	Graphical		Breakout Flows. Breakout flows are present in the basin. Need a RAS modeler to develop breakout flows relationship before hydrologic analysis can be completed. Coordinating with Matt Dircksen to develop breakout flow relationship.	In Progress	In the portion of the Pembina River basin between the Walhalla, ND on the Pembina River and Akra, ND on the Tongue River and the Pembina's confluence with the Red River of the North, breakout flows, off-channel storage, backwater effects, and interactions between the Red River of the North, Pembina River and the Tongue River are hydraulically complex. Upstream of Neche, ND most of the water is still within the confines of the Pembina River with only minor breakouts between the Highway 55 crossing and Neche, ND. Breakouts to the north are contained within the sections. Breakouts to the south cross highway 55 through culverts (breakout volume is negligible) or across the pavement during larger events (breakout volume can be substantial during large events). Downstream of where Highway 18 crosses the Pembina River at Neche, ND, breakout flows occur towards the north and south in approximately equal quantities. North and south breakouts are discussed below: Breakout to the North: Breakouts flow northward until they are interrupted by high ground at the U.S-Canada international border and then move gradually eastward to Switzer Ridge. The breakout forms a storage pool behind Switzer Ridge. The pool rises until is spills eastward through an eroded gully. After crossing Switzer Ridge, the water enters a large storage pool bordered by Switzer Ridge to the west and the Pembina-Red River of the North confluence on the East. The storage area extends to just past highway 55 to the south. Breakout to the South: Flows breaking out from the south bank enter the OJ/Louden Coulee and several tributaries of the Tongue River. Consequently, the southward breakouts re-enter the mainstem of the Pembina River via the Tongue River. During large floods the Tongue River contributes to the large, flooded area described above. USACE engineer indicated breakout flows may occur between Pembina River watershed and Aux Marais River watershed. Need additional information.
39	Joe River	NA	No USGS gages- Not enough data available to do balanced hydrograph analysis	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	No USGS gages- Not enough data available to do balanced hydrograph analysis.
40	Red River of the North	Mainstem	ENVCA 05OC001/ USGS gage 05102500	Emerson, Manitoba, Canada	No	40,200	36,400	1930	2016	Add'l data 1902	Analytical		NA	Complete	International gaging station, 0.8 miles downstream of international border, records provided by water survey of Canada. Improve upon analysis as needed to produce a consistent set of hydrographs for the main stem of the Red River of the North.
41	Aux Marais River	Tributary	ENVCA 05OC022	Christie, Manitoba, Canada	No	75		1971	2016	Seasonal	Graphical		Breakout flow. Breakout flows from the neighboring Pembina River watershed may affect flows at the Christie, MB gage. Coordinate with HEC-RAS modeler to develop breakout flow relationship. Relationship must be defined before hydrologic analysis can be completed.	Not Started	The Aux Marais River is a natural stream so it should fit an analytical distribution; however, the effect of breakout flows must be investigated. USACE engineer indicated that this area is modeled in HMS with a diversion, which indicates a potential breakout flow analysis may be required. Breakout flows can occur from the nearby Pembina River; however, there is a border dike along the US-Canada border. Breakout flows may only flow through a set of culverts - need to verify how these culverts restrict breakout flows. USACE engineer indicated breakout flows may be present between the Pembina River watershed and Aux Marais River watershed. Need to verify. It is believed breakout flows occur on the Pembina River above the Neche gage and flow to the Aux Marais Basin. The amount of breakout flows from the Pembina to the Aux Marais watershed is not known, a relationship should be developed to estimate breakout flows. A graphical analysis approach is recommended if impact from breakout flows is significant. Otherwise, an analytical approach may potentially be justified in this case.

No.	Watershed	Type	Gage Number	Gage Location	Previous Analysis	Drainage Area		Available Period of Record (Water Years)			Analysis Type	Record Extension	Analysis Challenges	Status	Site Notes
						Total D.A (sq. mi.)	Contributing D.A. (sq. mi.)	Start Date	Stop Date	Gaps					
42	Roseau River	Tributary	ENVCA 05OD001	Dominion City, Manitoba, Canada	No	1,938		1913	1913	1915, portions of the record are seasonal	Analytical		Potential Breakout? Verify with RAS modeler	Complete	The Roseau River is classified as a natural watershed, 05107500 Roseau River at Ross, MN appears to fit a log pearson type III distribution (this is the closest flow gage on the U.S side of the basin). USACE engineer indicated breakout flows occur between the Two Rivers Watershed and the Roseau River Watershed (need to verify). Upstream of the Roseau River near Dominion City, Canada gage and the Roseau River below State Dich 52 near Caribou, MN USGS gage, a diversion routes flow to a sink called "TwoRiversSD72". Again, the sink isn't connected to any sources, but at the appropriate location in the Two Rivers model there is a source called RoseauRiver. So the models were probably set up assuming that breakout flow flows from the Roseau River HMS model to the Two Rivers HMS model. Additional investigation should be performed to assess how large and how frequent breakout flows occur in this watershed.
43	Roseau River	Tributary	USGS 05112000	Below State Ditch 51 near Caribou, MN	No	1,420		1917	2016	1918, 1919 Missing daily data during winter months is common	Analytical		Investigate potential breakout flows	Not Started	Some regulation from wildlife management impoundments several miles upstream of gage. Investigate is graphical approach is warranted. Regulation may or may not be substantial from a wildlife management impoundment with respect to peak flows. Further investigation is required. For this and other sites along the Roseau River, some of the large magnitude flood events do not conform to an analytical statistical distribution. Try to put the large events into a historic context and investigate potential breakout flow interactions with other watersheds.