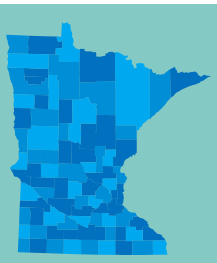
Eutrophication regions

January 2019

Regionalization of Minnesota's Rivers for Application of River Nutrient Criteria

MINNESOTA POLLUTION CONTROL AGENCY



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Revisions:
March 2016: The document was revised to reflect refinements in the use of River Nutrient Regions for application of total suspended solids water quality standards.

January 2019: This document was revised based on an analysis of soils and other parameters relevant to natural background concentration of phosphorus in surface waters. This analysis demonstrated that it is more appropriate for the southern lobe of the Central River Nutrient Region be included with the Southern River Nutrient Region.

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Contents

Introduction and background

We have long recognized regional patterns in the water quality of Minnesota's lakes and rivers (e.g., Heiskary and Wilson 1989 and McCollor and Heiskary 1993). U.S. Environmental Protection Agency (EPA) recommends its aggregated level III "Nutrient Ecoregions" as one basis for regionalizing nutrient criteria (http://www.epa.gov/waterscience/criteria/nutrient/ecoregions/). In Minnesota's promulgated lake nutrient criteria, EPA level III ecoregions were grouped as follows to allow for three distinct "regional' sets of criteria: 1) Northern Lakes and Forests (NLF); 2) North Central Hardwood Forests (CHF), and 3) Western Corn Belt Plains (WCP) and Northern Glaciated Plains (NGP). Lakes in the three "lake-poor" regions – Northern Minnesota Wetlands (NMW), Red River Valley (RRV; also referred to as Lake Agassiz Plain [LAP]), and Driftless Area (DA; also referred to as Paleozoic Plateau) are evaluated on a site specific basis but in most instances the NLF criteria are used to assess NMW lakes and CHF criteria are used to assess RRV and DA lakes.

As with lakes, there are some relatively distinct differences in river water quality in Minnesota among the various ecoregions. An early effort by McCollor and Heiskary (1993) examined distributions for various water quality parameters based on typical and minimally-impacted river sites in each ecoregion. An example of that analysis is provided in Table 2a. The EPA (2000) provided distributions for various nutrient ecoregions as a part of guidance on developing river nutrient criteria and an example of that work is provided in Table 2b.

Defining the appropriate ecoregion a lake should be assigned to is a relatively simple task, with the exception of those at or near an ecoregion boundary and/or where the lake or reservoir may have a very large watershed that drains multiple ecoregions (e.g. Lake Pepin). In those instances, reach specific decisions are often called for and a weight of evidence approach (e.g. relative percentage contribution by ecoregion) is used to guide the appropriate region and criteria. With rivers, this is more complicated as the river may originate in one region but eventually flow through and receive drainage from multiple ecoregions. The Mississippi River is a good example as it originates in the NLF and weaves its way through central Minnesota where drainage from CHF (e.g. Sauk, Rum, and Elk Rivers) and even WCP ecoregions (e.g. South Fork Crow) enter before it reaches the Twin Cities Metro area and merges with the Minnesota and St. Croix Rivers.

Considering patterns in Table 2 and monitoring and data analysis conducted to-date in development of river nutrient criteria (Heiskary and Markus 2001, Heiskary and Markus 2003, and Heiskary et al. 2013), criteria are needed for three river nutrient regions (RNR): North, Central and South. These regions generally correspond to the EPA aggregated Level III Nutrient ecoregions (Figure 5) with aggregations as follows:

- North – NLF and NMW ecoregions
- Central – CHF and DA ecoregions
- South – WCP, NGP, and LAP ecoregions

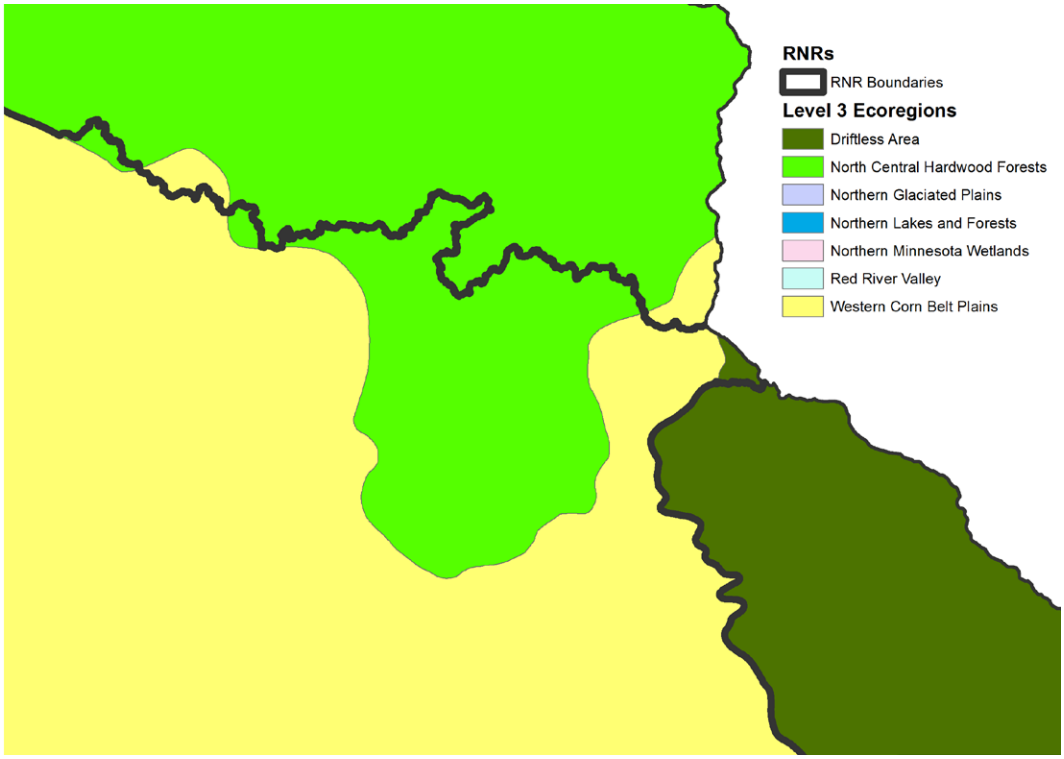
One minor adjustment was made to the ecoregion framework described above for setting RNRs. This modification to the RNR boundary is consistent with the underlying regionalization model. While the basic model underlying the original RNR map remains sound, this modification has been made to better represent natural factors that influence total phosphorus concentrations in rivers and streams in an area of the CHF. The CHF ecoregion has a southern lobe that extends into the WCP which based on sampling has higher river total phosphorus concentrations than expected for the Central RNR. To evaluate if this area has natural background concentrations of phosphorus that are more similar to the South or Central RNR, soil and other parameters associated with background concentrations of phosphorus in surface

waters were evaluated. Four of the six parameters analyzed which are associated with higher phosphorus in surface waters indicate the southern lobe of the CHF (Central → South) ecoregion is more closely affiliated to the South RNR than to the Central RNR (Table 1). For two of these parameters (soil water capacity and soil k factor), average values actually indicated soil types that would be associated with higher phosphorus in surface waters compared to the South RNR. One of these four parameters (soil organic carbon) is associated with higher phosphorus uptake and immobilization. Two parameters (percent alfisols and percent open water) in the southern lobe of the CHF were more similar to the Central RNR than to the South RNR. However, one of these parameters (percent alfisols) is associated with higher phosphorus concentrations in surface waters. Based on these results, the southern lobe of the CHF has more affinity with the South RNR as it has soil and other characteristics associated with higher phosphorus concentrations in surface waters compared to the Central RNR. As a result, this area will be included in the South RNR (Figure 1).

Table 1. Summary of soil and other features impacting natural background concentrations of phosphorus in surface waters for the Central and South RNRs and the southern lobe of the Central Hardwood Forests (Central → South).

Parameter	Direction of Effect on Phosphorus	Central	Central → South	South
Percent Area Alfisols	↑	60.39%	88.39%	19.54%
Average Soil Water Capacity, all layers (volume fraction)	↑	0.1355	0.1708	0.1654
Average Soil K Factor (all layers)	↑	0.2871	0.3446	0.3172
Average Soil Organic Carbon (gC/m2)	↓	2518	3054	3268
Average Stream Slope	↓	0.0216	0.0050	0.0033
Percent Area Open Water	↓	3.15%	3.79%	1.08%

Figure 1. Revised River Nutrient Region boundaries showing the existing River Nutrient Regions.



Methods, results, and maps

Recognizing that rivers traverse various regions and landscapes from their origin to their confluence with another river, some means was needed to specifically identify which rivers (assessment reaches) correspond to which RNR for the purpose of applying the river nutrient criteria. To help frame this, river-watersheds at the eight digit HUC (HUC8) level (80 watersheds) were selected as a primary basis to develop this framework (Figure 2b). These 80 watersheds, as derived from Minnesota Department of Natural Resources' (MDNR) major watershed (MDNR Catchments) layer, are also a focus of the Minnesota Pollution Control Agency's (MPCA) "pour-point" monitoring program (http://www.pca.state.mn.us/water/monitoring/monitoring-watersheds.html)and several of these rivers were included in our river nutrient studies (Figure 2a). In terms of watershed size the HUC8s (Table 3) and fourth order and higher streams (Table 4) are most similar to the rivers that were used in our river nutrient research and as such are likely to be an appropriate scale for assessment and application of the criteria. Based on a comparison of Table 3 and Table 4, HUC8s are most similar to fifth order streams, while HUC11s are most similar to third order streams.

When a HUC8 is located completely within a RNR or where a vast majority of the watershed is within a single RNR, the assignment to that RNR is rather straightforward, (e.g. Otter Tail, North Fork and South Fork of the Crow River; Figure 3). However, when a HUC8 traverses multiple ecoregions, the appropriate designation may be less apparent (e.g. Wild Rice, Buffalo and Red Lake Rivers; Figure 3). In these cases, closer inspection was required and 11 digit HUCs (HUC11; Watershed 99 HUC 11 layer) were incorporated into the mapping coverage to allow for refinement of boundaries. The process for defining the appropriate RNR for each is summarized as follows:

1. MDNR's coverage for the 80 major watersheds (HUC8) was overlain on a level III ecoregion map (**Figure** 2b). The areal ecoregion composition (percent and total area) of each watershed was determined using GIS. These maps and statistical summaries serve as an initial basis for sorting rivers (watersheds) into the three RNRs.
2. HUC11 layer was added to allow for more detailed examination and determining appropriate breakpoints within a HUC8.
3. Fourth order and higher stream reaches were noted in bold, while third order or less were noted by a finer line to show general flow patterns and linkages among the HUCs. The stream traces were later color coded by RNR.
4. The 80 watersheds were then sorted by HUC8 within each basin. HUCs corresponding to the main-stem of the Mississippi, Minnesota, Red and St. Croix Rivers were sorted separately (Table 5c) to allow for individual assessment and assignment to a RNR.
5. Ecoregion composition and maps were reviewed at the HUC8 level to define the ecoregion(s) that accounted for the majority of the watershed. When a HUC8 was completely within a single ecoregion (e.g. Cloquet River, Table 5a) it was assigned to the corresponding RNR (North in this case). Also, when the vast majority of a HUC8 was characterized by one or more ecoregions within a common RNR and the remaining portion represented a very small area, the predominant RNR was assigned, e.g. Long Prairie with 88% in CHF ecoregion and 12% in NLF was assigned to the Central RNR (Table 5a).
6. HUC8 watersheds, characterized by multiple ecoregions, were sorted out separately (Table 5b). For these, a closer evaluation at the HUC11 level was conducted to discern the appropriate RNR for that HUC11 and/or portion thereof. This evaluation considered the relative percentage ecoregion contribution within and upstream of that HUC11 and water quality data from the river nutrient

study (e.g. Heiskary et al. 2013) or as summarized from MPCA Environmental Data Access (e.g., Figure 4). When coding streams, AUIDs were used as a basis for specifying where a stream transitioned from one RNR designation to the next downstream RNR. In general, the upstream RNR was maintained until the confluence with a downstream AUID (typically second or third order or higher), which was fully within the downstream RNR. Where possible, specific locations near cities, major highways and/or river confluences were used to help define the transition from one RNR to the next. Fourth order and larger tributaries were color coded and in bold, while third order or lower were represented with finer lines.

The North RNR is comprised by the NLF and NMW ecoregions and includes 20 watersheds (un-aggregated HUC8s) plus two main-stem reaches on the Mississippi. The NLF ecoregion accounts for the highest percentage by area (Table 5a). The North RNR watersheds range from 277 mi^2 (Beartrap) to 2,859 mi^2 (St. Louis).

The Central RNR is characterized by a wide mix of ecoregions and no single ecoregion was dominant across all the rivers included in this region (Table 5). This is a function of the "transitional" nature (change from forest-dominated to agricultural-dominated landscape) and that many of the rivers drain from adjacent ecoregions (e.g. NLF or WCP) into the Central RNR. The Central RNR includes 12 HUC8 watersheds. These watersheds are smaller than those of the northern RNR and range from 93 mi^2 (LaCresent) to 1,909 mi^2 (Otter Tail).The Central and South RNRs include pooled reaches on the Mississippi River, which were called out separately for pool (reach) specific nutrient criteria development (Heiskary and Wasley 2010).

The majority of the 26 watersheds in the South RNR are in the Minnesota River Basin where the WCP and NGP ecoregions are dominant. South RNR watersheds range from 41 mi^2 (Big Sioux) to 2,082 mi^2 (Hawk-Yellow Medicine). In two of the Minnesota River Basin watersheds: Pomme de Terre and Chippewa, the CHF ecoregion comprises a significant portion of the upper watershed and these HUC8s were included with those characterized by multiple ecoregions (Table 5b). Several HUC8s in the Red River Basin that are characterized primarily by the LAP ecoregion were included in the South RNR as well.

The above described approach is applied to a majority of the HUC8s in Minnesota and RNR assignments were made (Table 5). Figure 5 is a statewide representation of the RNR boundaries and assignments. This map demonstrates the general boundaries of the three RNRs and the assignments of major (fourth order and higher) rivers that drain the respective HUC8s and basins. In addition to this statewide map, working maps were developed at the HUC8 and HUC11 level as needed to discern transitions from one RNR to the next for rivers that drain multiple RNRs. Basin-scale maps, for basins represented by multiple RNRs (Upper Mississippi, Lower Mississippi, St. Croix, Minnesota and Red River Basins) are included in Appendix I. All major rivers have been coded in this process with the exception of the Mississippi River navigational pools 1-8, which includes Lake Pepin.

Mississippi River navigation Pools 1-8, which range from St. Anthony Falls in the northern Metro area to Pool 8 near the Iowa border, require reach (pool) specific eutrophication criteria. Reach specific criteria are desired for the following reasons: waters entering pools 2-8 contributed from all three RNRs, nutrient and chlorophyll-a relationships may be quite different from more free-flowing rivers (because of increased residence time, deeper mixed layer, and related factors) and these pooled reaches are of a higher order (eighth order) than most of the rivers used in development of the river nutrient criteria (typically fourth-seventh order). Draft criteria have been developed in collaboration with Wisconsin MDNR and Minnesota MDNR (Heiskary and Wasley 2010). The broader application of the RNR maps and eutrophication criteria for each RNR is addressed in Heiskary et al. (2013).

Summary

As with lakes, there are some relatively distinct among-region differences in river water quality in Minnesota. An early effort by McCollor and Heiskary (1993) examined distributions for various water quality variables based on typical and minimally-impacted river sites in each ecoregion. The EPA (2000a, b, and 2001) provided distributions for various nutrient ecoregions (that further reinforce regional patterns) as a part of guidance on developing regionally-based river nutrient criteria.

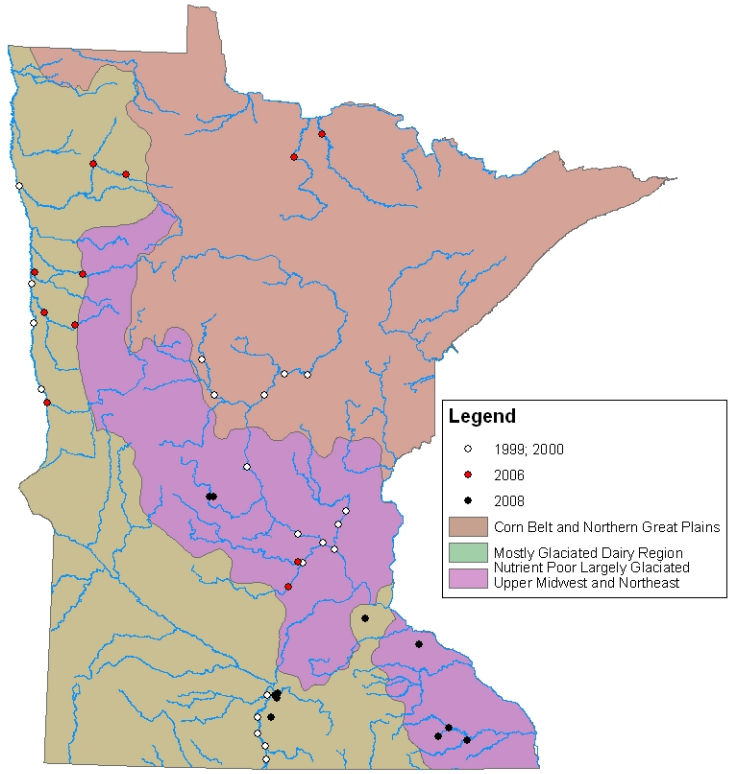
Determining which ecoregion a lake is located in (for purposes of applying appropriate criteria) is relatively straightforward. However, designating which ecoregion a river should be associated with is more complicated as rivers may originate in one region but eventually flow through and receive drainage from multiple ecoregions. Recognizing the regional water quality patterns and monitoring and data analysis conducted to-date in development of river nutrient criteria (Heiskary & Markus 2001, 2003; Heiskary et al. 2013) criteria are needed for three river nutrient regions: North, Central and South. These regions correspond loosely to the EPA aggregated Level III Nutrient ecoregions with aggregations as follows:

- North – NLF and NMW ecoregions
- Central – CHF and DA ecoregions
- South – WCP, NGP and LAP ecoregions

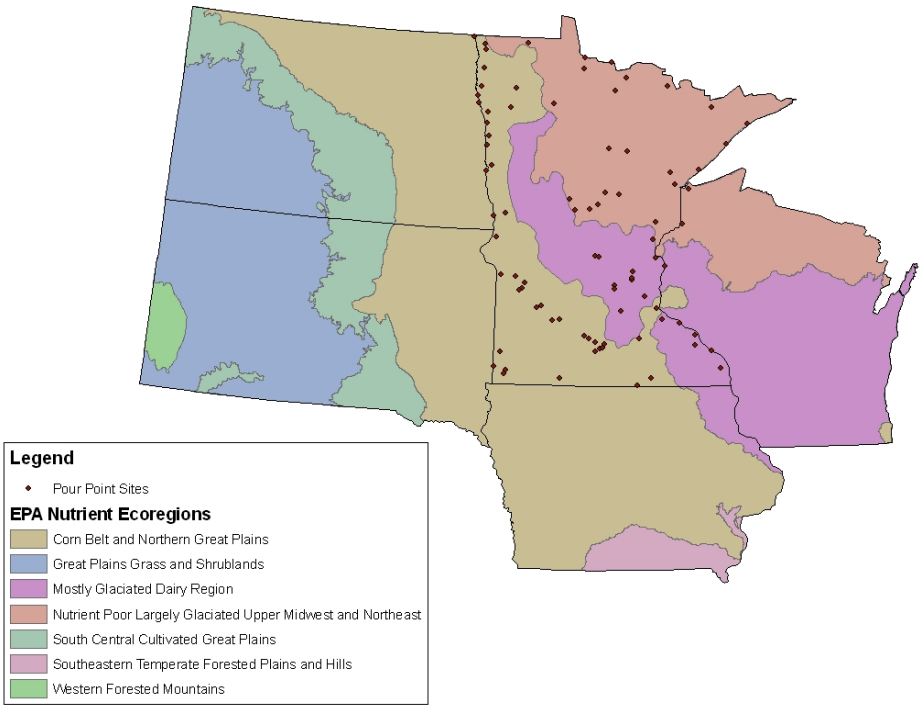
River-watersheds at the HUC8 level were selected as a primary basis to develop the regional framework. These 80 watersheds, as derived from MDNR's major watershed (MDNR Catchments) layer, are also a focus of MPCA's "pour-point" monitoring program. The rivers that drain these watersheds are of a similar order as those used in MPCA's river nutrient studies. When a HUC8 is located completely within an RNR or where a vast majority of the watershed is within a single RNR, the assignment to that RNR is rather straightforward, (e.g., North Fork and South Fork of the Crow River). This also applies to any low order streams that are wholly within a single RNR. However, when a HUC8 is characterized by multiple ecoregions the appropriate designation may be less apparent (e.g., Wild Rice, Buffalo and Red Lake Rivers). In these cases, closer inspection was required and HUC11s (Watershed 99 HUC 11 layer) were incorporated into the mapping coverage to allow for refinement of boundaries. In a few instances, where two HUC8s meet prior to entering the major mainstem river (e.g. North Fork and South Fork Crow Rivers) a "blended" or reach-specific criterion was recommended and these reaches were noted on the RNR map.

Figures and tables

Figure 2. Location of: a) 1999, 2000, 2006 and 2008 study sites overlain on EPA aggregated level 3 "nutrient" ecoregions and b) location of 86 major watershed "pour-points."



a) river nutrient study sites

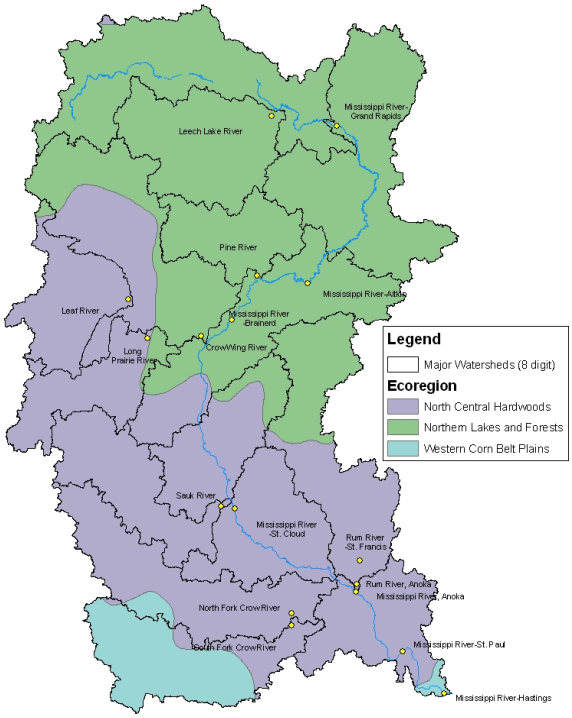


b) 86 pour-points

Figure 3. Major watershed "pour points" and level 3 ecoregion composition for Red and Upper Mississippi River Basins. Percent ecoregion composition noted for select rivers and corresponding RNR for each river at pour-point noted. Rivers marked with * were evaluated at HUC11 level and river is comprised of more than one RNR.

RNR | -------N----------| ----C----|-------S----------|

River (pour point)	% NLF	% NMW	% CHF	% LAP	% WCP	RNRReg.
Miss. (Brainerd)	99%					N
Pine	100%					N
Rum (mouth)	43%		57%			C*
Sauk			100%			C
Crow (N. Fork)			94%		6%	C
Crow (S. Fork)			24%		76%	S
Miss. (Anoka)	52%		42%		6%	C
Red River						S
Red Lake	10%	44%	5%	41%		S*
Wild Rice	21%		15%	64%		S*
Buffalo	2%		32%	66%		S*
Otter Tail	16%		78%	6%		C



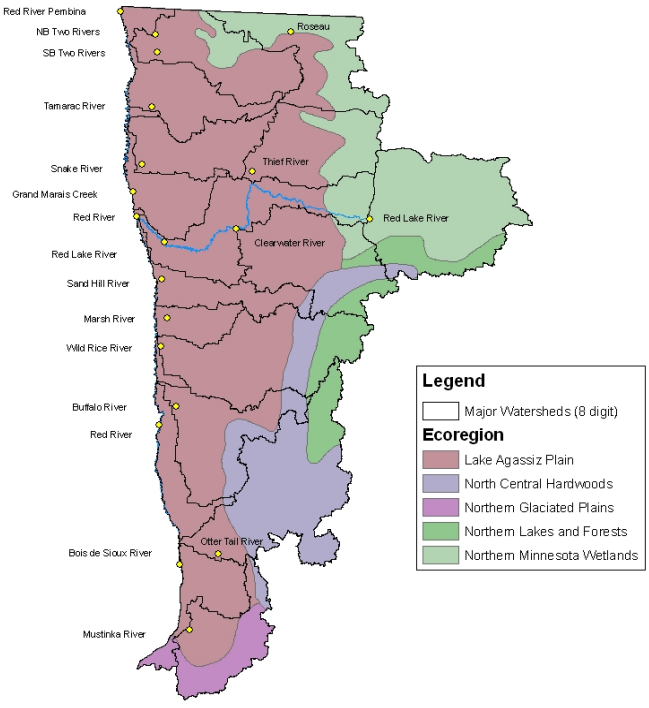


Figure 4. River total phosphorus data as derived from STORET. Based on 64,514 TP measurements from 1,994 stations. Values represent mean for each station based on year-round data collected between Jan. 1, 1995-March 24, 2009. Shaded regions approximate the three RNRs as grouped by ecoregions. Map provided by John Sandberg (MPCA EAO).

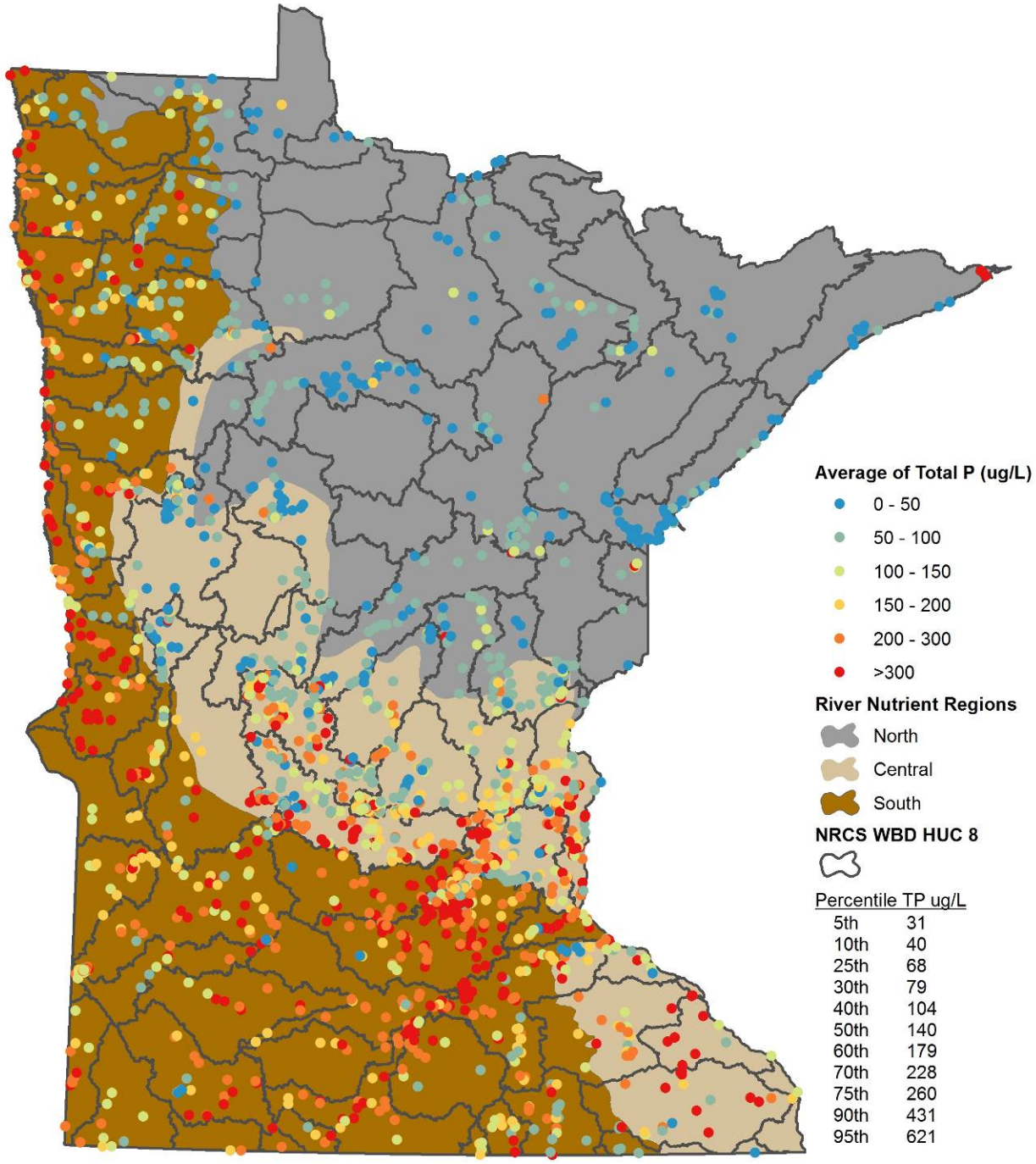


Figure 5. River nutrient regions (RNR). Classification developed at the 8 digit and 11 digit HUC level as needed. Fourth order and larger rivers coded with their respective RNR.

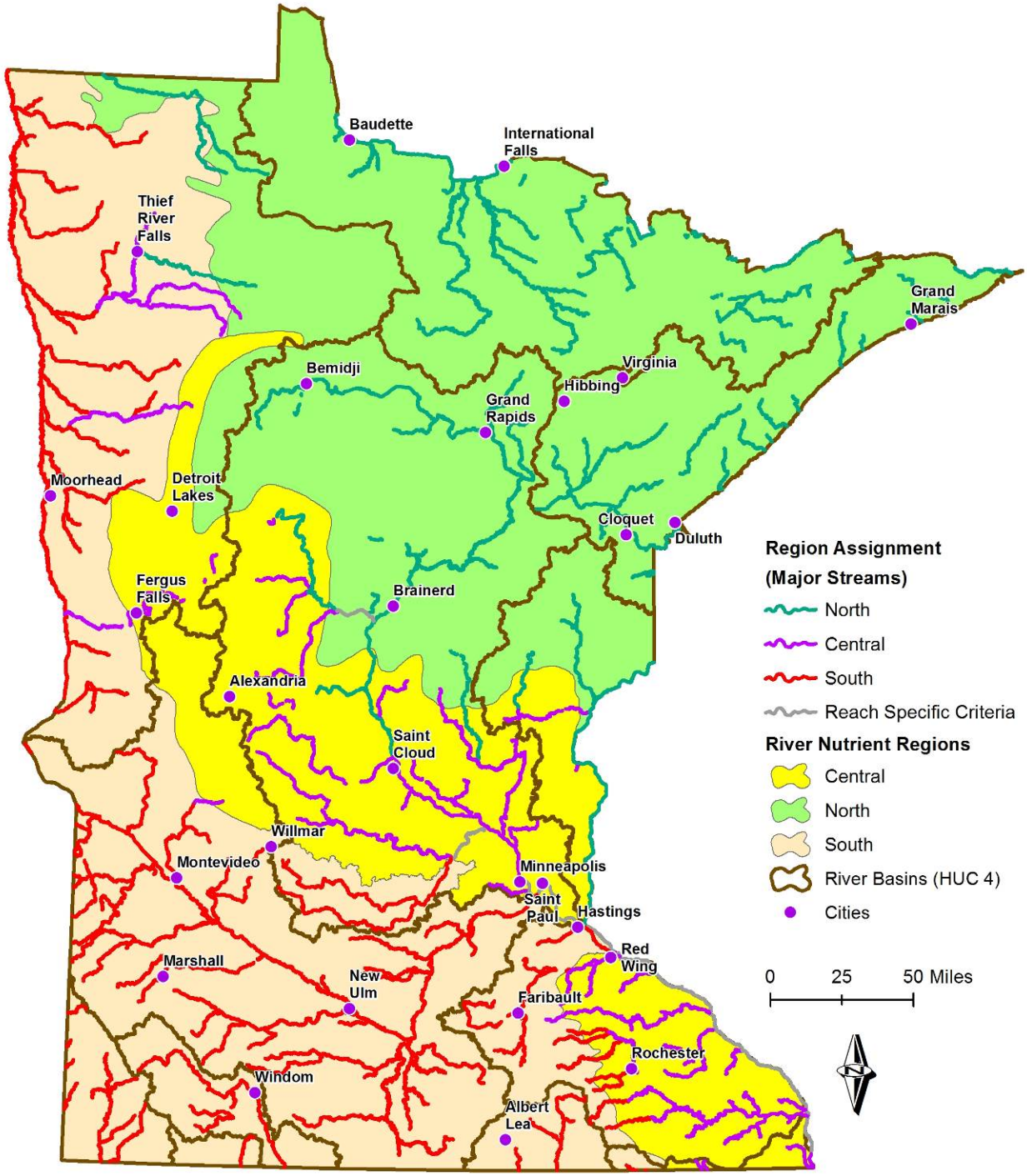


Table 2a. Interquartile range (25th – 75th percentiles) of summer-mean concentrations for minimally impacted streams in Minnesota, by Level III ecoregion. Data from 1970-1992. TP = total phosphorus, TSS = total suspended solids, BOD=5-day biochemical oxygen demand (McCollor and Heiskary 1993).

Eco-region	TP (µg/l)			Turbidity (NTU)			TSS (mg/l)			BOD (mg/L)		
	25%	50%	75%	25%	50%	75%	25%	50%	75%	25%	50%	75%
NLF	30	40	50	2	2	4	2	4	6	0.9	1.2	1.6
NMW	50	60	90	5	7	12	7	11	20	1.2	1.5	1.9
CHF	70	100	170	5	7	10	8	10	18	1.6	2.2	3.3
NGP	160	220	290	20	23	37	37	55	89	2.6	3.8	5.6
RRV	140	220	330	13	19	28	28	50	74	2.0	2.8	4.5
WCP	210	270	350	14	19	27	26	47	76	2.2	4.3	6.6

Table 2b. Interquartile range of summer-mean concentrations. Derived from EPA (2000) nutrient criteria guidance documents (level III ecoregion # noted in parenthesis)

Region	TP (µg/l)			Turbidity (NTU)		
	25%	50%	75%	25%	50%	75%
NLF (50)	15	30	60			
NMW (49)	50	60	80			
CHF (51)	40	95	200	2.6	3.9	5.8
NGP (46)	210	314	448	-	-	-
RRV (48)	170	230	285			
WCP (47)	130	240	359	15.0	40.0	55.0

Table 3. Watershed area as a function Hydrologic Unit Code: comparison of HUC8 and HUC11 watersheds. 8 digit statistics are for un-aggregated 8 digits HUCs exclusive of main-stem HUCs for the Red, Mississippi, Minnesota and St. Croix Rivers. Watershed area for river nutrient (RN) data set offered for comparison.

Area (mi2)

HUC	N	Mean	25th	50th	75th	min	max
8 digit	70	1,036	600	1,016	1,405	14	2,589
11 digit	931	91	29	69	126	<1	882
RN	43	3,816	563	1,435	3,600	45	25,450

Table 4. Watershed area as a function of stream order. Analysis based on ~1,560 biological monitoring stream sites.

Area (mi2)

Order	10th	25th	50th	75th	90th
2nd	5	8	14	28	44
3rd	15	26	49	85	176
4th	56	104	162	278	521
5th	411	662	1,002	1,508	3,487
6th	1,186	3,432	6,238	7,443	14,490

Table 5. Ecoregion classification for Minnesota rivers at the HUC8 level. Watersheds are sorted by River Nutrient Region (RNR) [N=North (NLF & NMW), C=Central (CHF & DA), S=South (LAP, WCP, & NGP)]. The total area of the HUC8s and % composition by ecoregion is for the specific HUC8 and does not consider upstream contributing watersheds. Ecoregion abbreviations: NLF=Northern Lakes and Forests, NMW=northern Minnesota Wetlands, CHF=North Central Hardwoods Forests, DA=Driftless Area, LAP=Lake Agassiz Plain, NGP=Northern Glaciated Plains, and WCP=Western Corn Belt Plains.

Table 5a. HUC8s characterized by a single or vast majority of watershed area in a single RNR

HUC8	Name	Area (mi^2)	% NLF	% NMW	% CHF	% DA	% LAP	% NGP	% WCP	RNR
04010101	Baptism-Brule	1,581	100	0	0	0	0	0	0	**N**
04010102	Beaver-Lester	624	100	0	0	0	0	0	0	**N**
04010201	St. Louis	2,859	100	0	0	0	0	0	0	**N**
04010202	Cloquet	793	100	0	0	0	0	0	0	**N**
04010301	Beartrap-Nemadji	277	100	0	0	0	0	0	0	**N**
07010103	Prairie-Willow	2,082	100	0	0	0	0	0	0	**N**
07010104	Elk-Nokasippi	1,686	81	0	19	0	0	0	0	**N**
07010105	Pine	780	100	0	0	0	0	0	0	**N**
07030001	Upper St. Croix	547	100	0	0	0	0	0	0	**N**
07030003	Kettle	1,051	97	0	3	0	0	0	0	**N**
09020302	Red Lakes	1,940	18	80	2	0	0	0	0	**N**
09020314	Roseau	1,055	0	72	0	0	28	0	0	**N**
09030001	Rainy Headwaters	2,499	100	0	0	0	0	0	0	**N**
09030002	Vermilion	1,033	100	0	0	0	0	0	0	**N**
09030003	Rainy Lake	904	82	18	0	0	0	0	0	**N**
09030005	Little Fork	1,872	36	64	0	0	0	0	0	**N**
09030006	Big Fork	2,055	39	61	0	0	0	0	0	**N**
09030007	Rapid	944	0	100	0	0	0	0	0	**N**
09030008	Lower Rainy	811	0	100	0	0	0	0	0	**N**
09030009	Lake of the Woods	1,142	0	100	0	0	0	0	0	**N**
North	**Count**	**20**								
07010107	Redeye	894	2	0	98	0	0	0	0	**C**
07010108	Long Prairie	883	12	0	88	0	0	0	0	**C**
07010201	Platte-Spunk	1,026	20	0	80	0	0	0	0	**C**
07010202	Sauk	1,042	0	0	100	0	0	0	0	**C**
07010203	Clearwater-Elk	1,121	0	0	100	0	0	0	0	**C**
07010204	North Fork Crow	1,476	0	0	94	0	0	0	6	**C**
07030005	Lower St. Croix	915	2	0	92	0	0	0	6	**C**
07040003	Buffalo-Whitewater	651	0	0	0	100	0	0	0	**C**
07040006	La Crosse-Pine	93	0	0	0	100	0	0	0	**C**
07040008	Root	1,659	0	0	0	89	0	0	11	**C**
07060001	Coon-Yellow	184	0	0	0	100	0	0	0	**C**
09020103	Otter Tail	1,909	16	0	74	0	10	0	0	**C**
Central	**Count**	**12**								

HUC8	Name	Area (mi^2)	% NLF	% NMW	% CHF	% DA	% LAP	% NGP	% WCP	RNR
07010205	South Fork Crow	1,278	0	0	25	0	0	0	75	**S**
07020004	Hawk-Yellow Medicine	2,082	0	0	2	0	0	15	83	**S**
07020006	Redwood	699	0	0	0	0	0	46	54	**S**
07020008	Cottonwood	1,314	0	0	0	0	0	14	86	**S**
07020009	Blue Earth	1,220	0	0	0	0	0	0	100	**S**
07020010	Watonwan	873	0	0	0	0	0	0	100	**S**
07020011	Le Sueur	1,111	0	0	8	0	0	0	92	**S**
07060002	Upper Iowa	224	0	0	0	47	0	0	53	**S**
07080102	Upper Wapsipinicon	14	0	0	0	0	0	0	100	**S**
07080201	Upper Cedar	713	0	0	0	0	0	0	100	**S**
07080202	Shell Rock	248	0	0	0	0	0	0	100	**S**
07080203	Winnebago	73	0	0	0	0	0	0	100	**S**
07100001	Des Moines Headwaters	1,248	0	0	0	0	0	15	85	**S**
07100002	Upper Des Moines	89	0	0	0	0	0	0	100	**S**
07100003	East Fork Des Moines	204	0	0	0	0	0	0	100	**S**
09020101	Bois De Sioux	554	0	0	0	0	86	14	0	**S**
09020102	Mustinka	861	0	0	7	0	43	50	0	**S**
09020107	Elm-Marsh	362	0	0	0	0	100	0	0	**S**
09020301	Sandhill-Wilson	619	0	0	5	0	95	0	0	**S**
09020306	Grand Marais-Red	592	0	0	0	0	100	0	0	**S**
09020309	Snake	779	0	0	0	0	100	0	0	**S**
09020312	Two Rivers	1,100	0	19	0	0	81	0	0	**S**
10170202	Upper Big Sioux	41	0	0	0	0	0	100	0	**S**
10170203	Lower Big Sioux	510	0	0	0	0	0	40	60	**S**
10170204	Rock	914	0	0	0	0	0	5	95	**S**
10230003	Little Sioux	326	0	0	0	0	0	0	100	**S**
South	**Count**	**26**								

Table 5b. Multiple regions

HUC8	Name	Area (mi^2)	% NLF	% NMW	% CHF	% DA	% LAP	% NGP	% WCP	RNR
07010106	Crow Wing	1,981	59	0	41	0	0	0	0	
07010207	Rum	1,583	43	0	57	0	0	0	0	
07020002	Pomme De Terre	875	0	0	38	0	0	61	0	
07020005	Chippewa	2,078	0	0	55	0	0	14	31	
07030004	Snake	1,006	50	0	50	0	0	0	0	
07040001	Rush-Vermillion	594	0	0	13	46	0	0	41	
07040002	Cannon	1,470	0	0	33	18	0	0	49	
07040004	Zumbro	1,421	0	0	0	70	0	0	30	
09020106	Buffalo	1,131	1	0	28	0	70	0	0	

HUC8	Name	Area (mi^2)	% NLF	% NMW	% CHF	% DA	% LAP	% NGP	% WCP	RNR
09020108	Eastern Wild Rice	1,636	20	0	15	0	65	0	0	
09020303	Red Lake River	1,340	0	21	0	0	79	0	0	
09020304	Thief	1,048	0	37	0	0	63	0	0	
09020305	Clearwater	1,359	15	7	17	0	61	0	0	
	Count	**13**								

Table 5c. Main stems1

HUC8	Name	Area[2] (mi^2)	% NLF	% NMW	% CHF	% DA	% LAP	% NGP	% WCP	RNR
07010101	Mississippi Headwaters	1,920	100	0	0	0	0	0	0	**N**
07010102	Leech Lake	1,341	100	0	0	0	0	0	0	**N**
07010206	Twin Cities	1,007	0	0	95	0	0	0	5	**C**
07020001	Upper Minnesota	786	0	0	0	0	0	83	17	**S**
07020003	Lac Qui Parle	760	0	0	0	0	0	31	69	**S**
07020007	Middle Minnesota	1,347	0	0	9	0	0	0	91	**S**
07020012	Lower Minnesota	1,835	0	0	66	0	0	0	34	**S**
09020104	Upper Red	500	0	0	5	0	95	0	0	**S**
09020311	Lower Red	883	0	0	0	0	100	0	0	**S**
	count	**9**								

1. Mississippi River pools to be addressed separately in site specific efforts
2. Reflects immediate drainage of the unaggregated HUC8

Rivers or river reaches comprised of multiple ecoregions and RNR assignments

		Area	% area by ecoregion						
HUC8	Name	(mi^2)	NLF	NMW	CHF	DA	LAP	NCG	WCP
07010106	Crow Wing	1,981	59	0	41	0	0	0	0
07010107	Redeye	894	2	0	98	0	0	0	0
07010108	Long Prairie	883	12	0	88	0	0	0	0
-	Crow Wing R. (aggregated)	3,758							

Crow Wing River headwaters drain from the NLF ecoregion, an area with numerous lakes and wetlands, and include a series of lakes on the mainstem of the Crow Wing. Two major watersheds: Red Eye and Long Prairie Rivers drain from CHF ecoregion. As the river flows eastward near Motley it again receives drainage from the NLF ecoregion. Based on river nutrient monitoring in 1999 and 2000 the Crow Wing maintained relatively low total phosphorus (TP) and chlorophyll-a (Chl-a) at CWR-72 (Nimrod above Red Eye; watershed area ~1,030 mi^2) and CWR-35 (Staples below Red Eye; watershed area ~2,130 mi^2). The portion of the Crow Wing above the confluence with the Long Prairie is assigned to the North RNR. Below the confluence with the Long Prairie (below Motley) the CHF influence increases and the relative ecoregion composition at Pillager is ~66% CHF and ~34% NLF. This "shift" and observed data at Pillager argues for a "blended" standard (intermediate between Northern and Central RNR) for the final reach of the Crow Wing River from the Long Prairie confluence to the mouth at the Mississippi (07010106-507 (Long Prairie River to Seven Mile Creek), the middle one is 07010106-506 (Seven Mile Creek to Gull River) and the downstream one is 07010106-501 (Gull River to Mississippi River); Appendix II).

The HUC11s that comprise much of the upper watershed: Shell, Straight, Two Inlets, Fish Hook, Mantrap Lake and Upper Crow Wing Rivers are assigned to the North RNR. Some of the small HUC11s (third order or lower streams) that are primarily characterized by the CHF ecoregion: Blueberry River, Kettle Creek, Cat River, Swan Creek and Farnham Creek are assigned to the Central RNR. Upper Gull Lake, Gull Lake and Lower Crow Wing Rivers are assigned to the North RNR.

		Area	% area by ecoregion						
HUC8	**Name**	**(mi^2)**	**NLF**	**NMW**	**CHF**	**DA**	**LAP**	**NCG**	**WCP**
07010204	North Fork Crow	1,476	0	0	94	0	0	0	6
07010205	South Fork Crow	1,278	0	0	25	0	0	0	75
-	Crow (aggregated)	2,754	0	0	62	0	0	0	38

The **North Fork of the Crow**, above the confluence with the South Fork, is in Central RNR and the South Fork is in the South RNR. The North Fork has higher flows on average as compared to the South Fork because of the numerous lakes and wetlands in its upper reaches. The final ~25 mile reach of the Crow River from the confluence of the North Fork (~1,477 mi^2) and South Fork (~1,279 mi^2) to the mouth at the Mississippi River (considered part of North Fork HUC) represents a "blending" of the two 8 digits HUCS; whereby ~62% drains from the CHF ecoregion and ~38% from WCP ecoregion. This final reach (AUID 07010204-502) does not fit "cleanly" into either the Central or South so a blended standard is proposed for this AUID (Appendix II).

		Area	% area by ecoregion						
HUC8	**Name**	**(mi^2)**	**NLF**	**NMW**	**CHF**	**DA**	**LAP**	**NCG**	**WCP**
07010207	Rum	1,583	43	0	57	0	0	0	0

The **Rum River** has its headwaters in Mille Lacs Lake in the NLF ecoregion. The HUC11s: Bradbury Brook, Tibbets Brook and Upper Rum River to the confluence with the West Branch of the Rum near Princeton are assigned to the North RNR. The West Branch of the Rum, Rum main-stem below the confluence with the Upper Rum and all HUC11s to the south and east are assigned to the Central RNR.

		Area	% area by ecoregion						
HUC8	**Name**	**(mi^2)**	**NLF**	**NMW**	**CHF**	**DA**	**LAP**	**NCG**	**WCP**
07020002	Pomme De Terre	875	0	0	38	0	0	61	0

The **Pomme de Terre** headwaters are in the CHF ecoregion. The HUC11s that comprise the "headwaters" area are the Upper Pomme de Terre and Pelican Creek (drained by third order or lower streams) and both are assigned to the Central RNR. The transition to the NGP ecoregion occurs near Barrett and U.S. Geological Survey (USGS) gage (05293365). Since no major tributaries enter near this point the outlet of Barrett Lake can serve as a basis for transitioning from the Central RNR to the South RNR. All HUC11s to the south of this point are assigned to the South RNR. However, the main stem AUID of the Pomme de Terre down to Upper Pomme de Terre Lake remains in the Central RNR because the majority of its watershed drains from the Central RNR.

HUC8	Name	Area (mi^2)	% area by ecoregion						
			NLF	NMW	CHF	DA	LAP	NCG	WCP
07020005	Chippewa	2,078	0	0	55	0	0	14	31

The **Chippewa** headwaters are in a lake rich portion of the CHF ecoregion in Pope and Douglas Counties. Lake Emily is located on the CHF – NGP transition and has been assessed for 303(d) as a NGP lake. The transition in lake morphometry and land form is quite distinct as one travels from Lake Minnewaska in central Pope to Emily in the southern Pope County. The portion of the Chippewa north and northeast of Lake Emily and city of Cyrus is assigned to the Central RNR. This would include the following HUC11s: Upper West Branch, Middle West Branch, Little Chippewa, Trappers Run, East Branch, North Mud Creek, and Upper Shakopee Creek, which are drained by third order or lower streams. The Lower West Branch below Lake Emily and south of Cyrus and all HUC11s to the south, e.g. Chippewa River, Moore Township Branch Chippewa, Shakopee Creek, etc. to the outlet at the Minnesota River are assigned to the South RNR.

HUC8	Name	Area (mi^2)	% area by ecoregion						
			NLF	NMW	CHF	DA	LAP	NCG	WCP
07030004	Snake	1,006	50	0	50	0	0	0	0

The **Snake River** headwaters are in the NLF ecoregion just east of Mille Lacs. The HUC11s that are east of Mille Lacs and north of Knife Lake including the Upper Snake, Lower Upper Snake, Knife River above Knife Lake, the upper Ann River to the outlet of Ann Lake, and the Groundhouse River north of Ogilvie are assigned to the North RNR. The upper portion of the Middle Snake down to the confluence with the outlet of Fish Lake/Ann River south of Mora is assigned to the North RNR and below that point is assigned to Central RNR. The HUC11s to the south and east including South Fork Groundhouse, Middle Snake (east of Knife Lake), Mud Creek, Pokegama Creek, Mission Creek and Lower Snake to the outlet at the St. Croix are assigned to the Central RNR. With the exception of the Snake mainstem, most streams are 3rd order or lower.

HUC8	Name	Area (mi^2)	% area by ecoregion						
			NLF	NMW	CHF	DA	LAP	NCG	WCP
07040001	Rush-Vermillion	594	0	0	13	46	0	0	41

The **Vermillion River** is a small watershed on the southern edge of the Twin Cities Metro area that consists of two areas which are separated by the Cannon River. The northern area consists of the Vermillion River watershed which is largely in the WCP ecoregion. Although some of the headwaters are located in the CHF, this area is part of the southern lobe of the CHF and all of the Vermillion watershed is assigned to the South RNR. The southern portion of the Rush-Vermillion consists of several streams that flow directly into the Mississippi River (e.g., Wells Creek, Hay Creek). The entirety of this subwatershed is within the DA and is assigned to the Central RNR.

		Area	% area by ecoregion						
HUC8	Name	(mi^2)	NLF	NMW	CHF	DA	LAP	NCG	WCP
07040002	Cannon	1,470	0	0	33	18	0	0	49

The **Cannon River** watershed is divided among three ecoregions that encompass both the Central and South RNRs. The Upper Cannon is in the CHF ecoregion and the Straight River in the WCP ecoregion. Lake Byllesby on the Lower Cannon are in the DA. RNR assignments are as follows:

1. Watershed of Upper Cannon River (~295 mi^2) drains from the CHF. This is part of the southern lobe of the CHF and analysis of soils and other parameters relevant to natural background concentrations of phosphorus in surface waters indicate it is more appropriately classified as part of the South RNR. The Upper Cannon River and tributaries that flow directly from the CHF ecoregion to the Cannon main-stem are assigned to South RNR.
2. Straight River drains from WCP and is assigned to South RNR (~435 mi^2 at Faribault USGS gage 05353800).
3. The Middle Cannon, which lies below the confluence of the Upper Cannon and Straight (near Faribault) and includes Lake Byllesby, is assigned to the South RNR. Prairie Creek, which flows parallel to the Cannon, is in the WCP and is assigned to the South RNR as well. The main-stem of Chub Creek, which drains from the north, is in the WCP and is assigned to the south RNR.
4. Lake Byllesby resets the Cannon River. The Cannon River below Lake Byllesby receives much of its direct drainage from the DA ecoregion (264 mi^2). This reach of the Cannon to the mouth and tributaries (e.g. Belle Creek and Little Cannon) from the DA are assigned to Central RNR.

		Area	% area by ecoregion						
HUC8	Name	(mi^2)	NLF	NMW	CHF	DA	LAP	NCG	WCP
07040004	Zumbro	1,421	0	0	0	70	0	0	30

The **Zumbro River** has three relatively distinct "forks" and one, the Middle Fork, is comprised of three branches. The headwaters of the various forks/branches originate in the WCP ecoregion, while the higher order portions (and 70% of the watershed) are in the DA ecoregion. While the overall contribution from the WCP ecoregion is 30% -- its relative influence (% contribution) may vary among the four branches. Lake Zumbro is a prominent reservoir on the South Fork immediately downstream of the confluence with the Middle Fork and was assessed for 303(d) as a WCP lake. A majority of the WCP portion of Zumbro's watershed is within Lake Zumbro's watershed. The five branches/forks and main-stem are assigned as follows:

1. North Fork – The upper portion of the North Fork (e.g. upstream from Kenyon) is assigned to the South RNR. The main-stem of the North Fork east of Kenyon to the confluence with Zumbro main-stem and Trout Brook portion is assigned to Central RNR.
2. North Branch of the Middle Fork – The upper reach of this HUC11 is quite small, drains from the WCP and is assigned to the South RNR. The lower reach from the confluence with the Middle Fork to the WCP transition drains from the DA and is assigned to the Central RNR.
3. Middle Fork – The WCP comprises much of this HUC11 and this branch to the confluence with the North Branch is assigned to the South RNR. The Middle Fork downstream from the confluence with the North Branch receives significant drainage from the DA and is assigned to the Central RNR.
4. South Branch of the Middle Fork – The WCP comprises much this branch and the entire branch from Dodge Center Creek to confluence of North Branch of Middle Fork is assigned to the South RNR.
5. South Fork – The two unnamed branches of the South Fork drain from the WCP and are assigned to the South RNR. At the confluence of the two branches, southwest of Rochester, the relative

percentage of watershed from the DA increases and this fourth order stream merges with a fourth order that drains the SE portion of the South Zumbro. From this confluence (immediately SE of Rochester to Lake Zumbro the DA is the dominant ecoregion and this reach is assigned to the Central RNR.

6. Outlet of Lake Zumbro to the confluence with North Fork and continuing to the outlet of the Zumbro is all within the DA ecoregion and is assigned to the Central RNR.

		Area	% area by ecoregion						
HUC8	**Name**	**(mi^2)**	**NLF**	**NMW**	**CHF**	**DA**	**LAP**	**NCG**	**WCP**
09020106	Buffalo	1,131	1	0	28	0	70	0	0

The headwaters of the **Buffalo River** are in the CHF ecoregion; however a vast majority of the watershed is in the LAP. Since the portion in the CHF is very small (~300 mi^2) and there are no major tributaries (4^{th} order or more) draining this portion of the watershed and the entire main-stem is assigned to the South RNR. Stream reaches within the following HUC11s are assigned to the Central RNR: Upper Buffalo, Lake Park, Olaf-Grove Lakes and eastern portions of Hawley-South Buffalo and Deerhorn-Buffalo. The remaining HUC11s, through-which the main branches of the Buffalo River flow, are assigned to the South RNR: Middle Buffalo, Lower Buffalo, and western portions of the Hawley-South and Deerhorn-Buffalo. The ecoregion boundaries as drawn represent the transition from the Central to the South RNR in each case.

		Area	% area by ecoregion						
HUC8	**Name**	**(mi^2)**	**NLF**	**NMW**	**CHF**	**DA**	**LAP**	**NCG**	**WCP**
09020108	Eastern Wild Rice	1,636	20	0	15	0	65	0	0

The headwaters of the **Wild Rice** are in the NLF and CHF ecoregions; however the majority of the watershed (65%) is in the LAP ecoregion. The HUC11s, east of Mahnomen, including: Rice Lake, Upper Wild Rice, Twin Lakes Creek, and White Earth River south of Mahnomen; and Wauban Creek south of Mahnomen are assigned to the Central RNR. Based on river nutrient monitoring in 2006 the Wild Rice remains relatively low in TP at Twin Valley, which suggests that the waters from the upstream HUC's in the CHF and NLF ecoregions extend their influence at least this far down the main-stem. Based on this the main-stem of the Upper Wild Rice to the confluence with the South Branch Wild Rice is assigned to the Central RNR. Individual HUC11s that are fully within the LAP ecoregion and tributary to this reach: Marsh Creek, Moshaug, Flom Creek, Coon Creek and Lower Wild Rice are assigned to the South RNR. The South Branch Wild Rice and all HUC11 tributaries that drain to it: Felton Ditch and Hendrum, downstream of confluence with Upper Wild Rice, are assigned to the South RNR.

		Area	% area by ecoregion						
HUC8	**Name**	**(mi^2)**	**NLF**	**NMW**	**CHF**	**DA**	**LAP**	**NCG**	**WCP**
09020303	Red Lake River	1,340	0	21	0	0	79	0	0

The immediate upstream HUC8 from the **Red Lake River** is comprised of Upper and Lower Red Lakes and their direct watershed (09020302). Based on 2006 river nutrient monitoring and long-term data TP remains low in the Red Lake River (consistent with North RNR) below the confluence with the Thief River at Thief River Falls, which suggests the portion from Thief River Falls and upstream to Upper and Lower Red Lake can be assigned to the North RNR. This would include the main-stem of the Red Lake River and Upper Red Lake. The tributaries within the HUC11s: High Landing, Kratka and CD #120 is a transition between regions and is assigned to the Central RNR. The reach of the Red Lake River from Thief River Falls to Red Lake Falls is assigned to the Central RNR because of the increasing portion of the watershed

that drains the LAP ecoregion. The next major downstream confluence is with the Clearwater River, which drains portions of four different ecoregions and is assigned to the Central RNR over much of its watershed. The main-stem at Red Lake Falls is assigned to the Central RNR. All of the HUC11s from Red Lake Falls to the outlet at East Grand Forks lie fully within the LAP (e.g. Burnham, Crookston, and Lower Red Lake River) and are assigned to the South RNR. Monitoring data suggest the main-stem from Red Lake Falls to just above Fischer can be assigned to the Central RNR. The lower reach of the Red Lake River, from the confluence with Burnham Creek to the mouth at East Grand Forks, is assigned to the South RNR. Water quality data at Fischer (S000-031) indicate much higher TP and TSS as compared to upstream sites at Red Lake Falls.

		Area	% area by ecoregion						
HUC8	**Name**	**(mi^2)**	**NLF**	**NMW**	**CHF**	**DA**	**LAP**	**NCG**	**WCP**
09020304	Thief	1,048	0	37	0	0	63	0	0

The **Thief River** drains portions of the NMW and LAP ecoregions. The entire watershed has extensive drainage networks and wetlands appear to be a dominant feature throughout the watershed. While the majority of the watershed is in the LAP the dominance of water and wetlands throughout the entire watershed could allow this HUC8 to be assigned to the North RNR. Monitoring data from a site 6 miles north of Thief River Falls (S004-495) indicates low to moderate TP, which suggests the influence of the NMW portion of the watershed is extended downstream. The HUC11S in the NMW portion of the watershed: Moose, Mud and Lost Rivers are assigned to the North RNR. The remaining HUC11s: Goodridge, CD 120, Branch 200, and Thief River are all or mostly in the LAP ecoregion. Given the "blending" of waters from both ecoregions, the prominence of Thief Lake, and the TP concentrations at the downstream end of this HUC8 these HUC11s are assigned to the Central RNR.

		Area	% area by ecoregion						
HUC8	**Name**	**(mi^2)**	**NLF**	**NMW**	**CHF**	**DA**	**LAP**	**NCG**	**WCP**
09020305	Clearwater	1,359	15	7	17	0	61	0	0

The **Clearwater River** drains portions of four ecoregions with the LAP being dominant in the western portion of the watershed. The upper portion of the Clearwater drains through four of the ecoregions and has a watershed area of about 550 mi2. The HUC11s in the upper portion: Upper Clearwater and Clearwater Rivers drain primarily NLF and NMW ecoregions and are assigned to the North RNR. The next downstream HUC11 is the Plummer, which is in the LAP ecoregion: however low TP from the upstream HUCs moderate the influence of the potentially more nutrient rich runoff within this HUC. Monitoring data collected at Plummer (S002-124) indicate moderate TP concentrations for this reach of the Clearwater and the Plummer HUC is assigned to the Central RNR. The Lost River is the other large tributary in this HUC8 and drains portions of NLF, CHF and LAP ecoregions. Likewise the Poplar and Hill Rivers drain from the CHF to the LAP ecoregions. All three HUC11s are assigned to the Central RNR.

Adaptations of the regions for application of the total suspended solids water quality standards

The RNR regionalization model has been specifically modified for the application of the Minnesota total suspended solids (TSS) water quality standards. These modifications to the RNR boundaries for the purpose of applying the TSS water quality standards are consistent with the underlying basic regionalization model. Modifications to the boundary lines of the RNRs have been made to better represent natural factors specific to the generation of TSS concentrations in rivers and streams (Figure 6). While the basic model underlying the original RNR map (described elsewhere in this document) remains sound, the adjustments shown in Figure 6 better reflect natural TSS concentrations resulting from

elements such as soil type, texture, and grain size, and terrain and position in the landscape as interpreted from surficial geology and geomorphology. In addition, the RNR boundaries as adapted for application of the TSS standards have been adjusted to match watershed boundaries. These fall along HUC8 lines or, where finer distinctions better match the factors influencing TSS concentrations as outlined above, along HUC10 lines.

Figure 6 is a statewide representation of the RNR boundaries and assignments as adapted for application of the Minnesota TSS water quality standards.

Assignments for rivers or river reaches crossing RNRs as adapted for application of the TSS standards.

Tamarac River – Headwaters to Florian Park Reservoir (09020311-511). This portion of the Tamarac River, while lying partially in the South Region, has most of its watershed in and is assigned to the Central Region.

Red Lake River – Clearwater River to Mouth (09020303-510, -511, -502, -512, -506, -501, -503). This portion of the Red Lake River, while lying in the South Region, has most of its watershed in the Clearwater River, Thief River, and upper Red Lake River systems in the Central Region, and is assigned to the Central Region.

Wild Rice River – Marsh Creek to South Branch Wild Rice River (09020108-503). This portion of the Wild Rice River, while lying partially in the South Region, has most of its watershed in and is assigned to the Central Region.

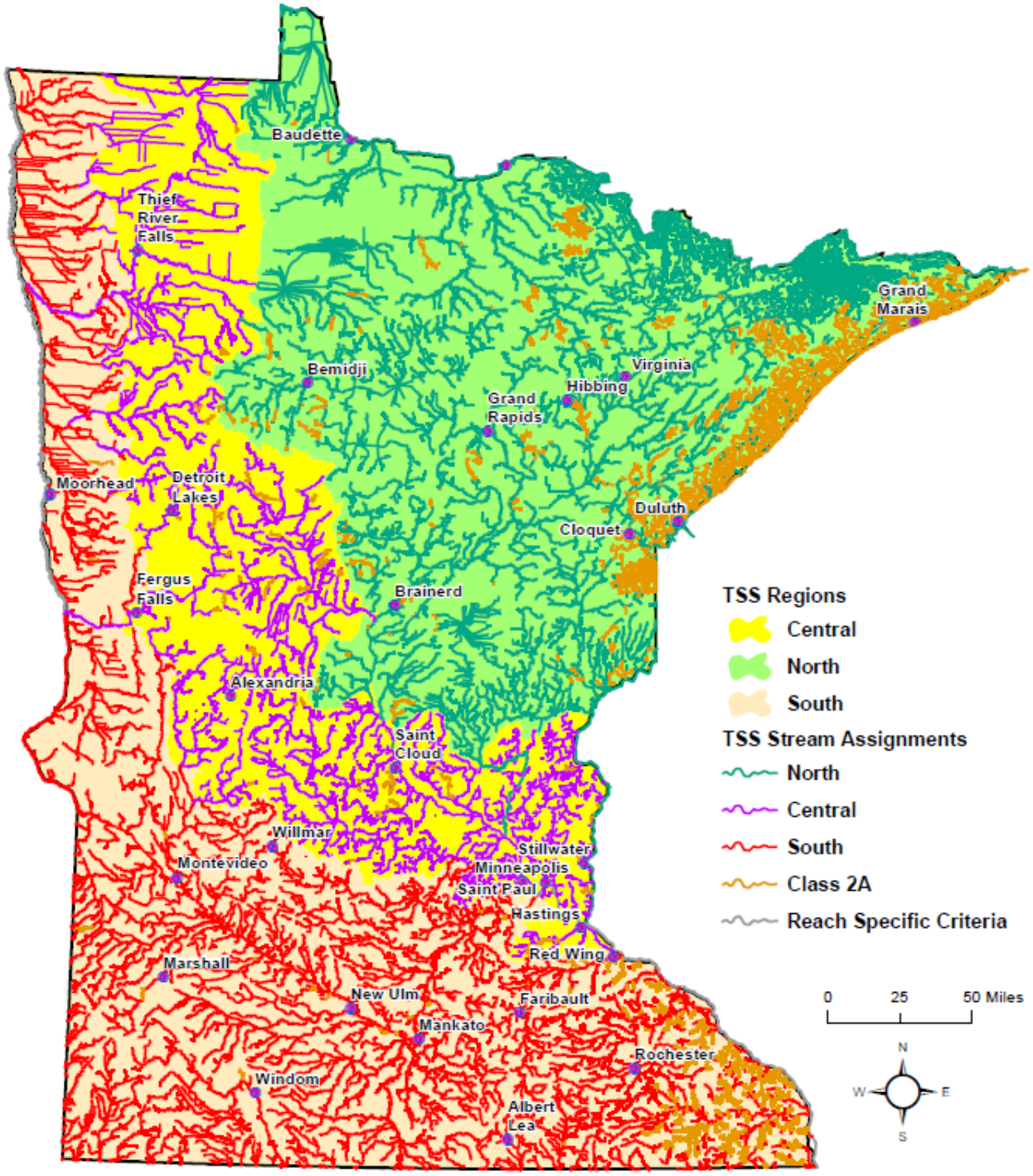
Wild Rice River, South Branch – Otto Lake to Unnamed Creek (09020108-637). This upper portion of the Wild Rice River, South Branch, while lying partially in the South Region, has most of its watershed in and is assigned to the Central Region.

Otter Tail River – Orwell Dam to Mouth (09020103-506, -504, -509, -502). This lower portion of the Otter Tail River, while lying in the South Region, has most of its watershed in and is assigned to the Central Region.

Rum River – West Branch Rum River to Mouth (07010207-512, -504, -503, -502, -666, -665, -556). This lower portion of the Rum River, while lying in the Central Region, has most of its watershed in and is assigned to the North Region.

St. Croix River – Snake River to Mouth (07030005-782, -783, 784, 785). This lower portion of the St. Croix River, while lying in the Central Region, has most of its watershed in the Snake River, Kettle River, and upper St. Croix River systems in the North Region and Wisconsin's Namekagon River system, which shares similar characteristics in regard to factors influencing TSS concentrations, and is assigned to the North Region.

Figure 6. River Nutrient Regions (RNR) as adapted for application of the TSS standards. Classification developed at the 8 digit and 10 digit HUC levels. Rivers coded with their respective RNR as adapted for application of the TSS standards.



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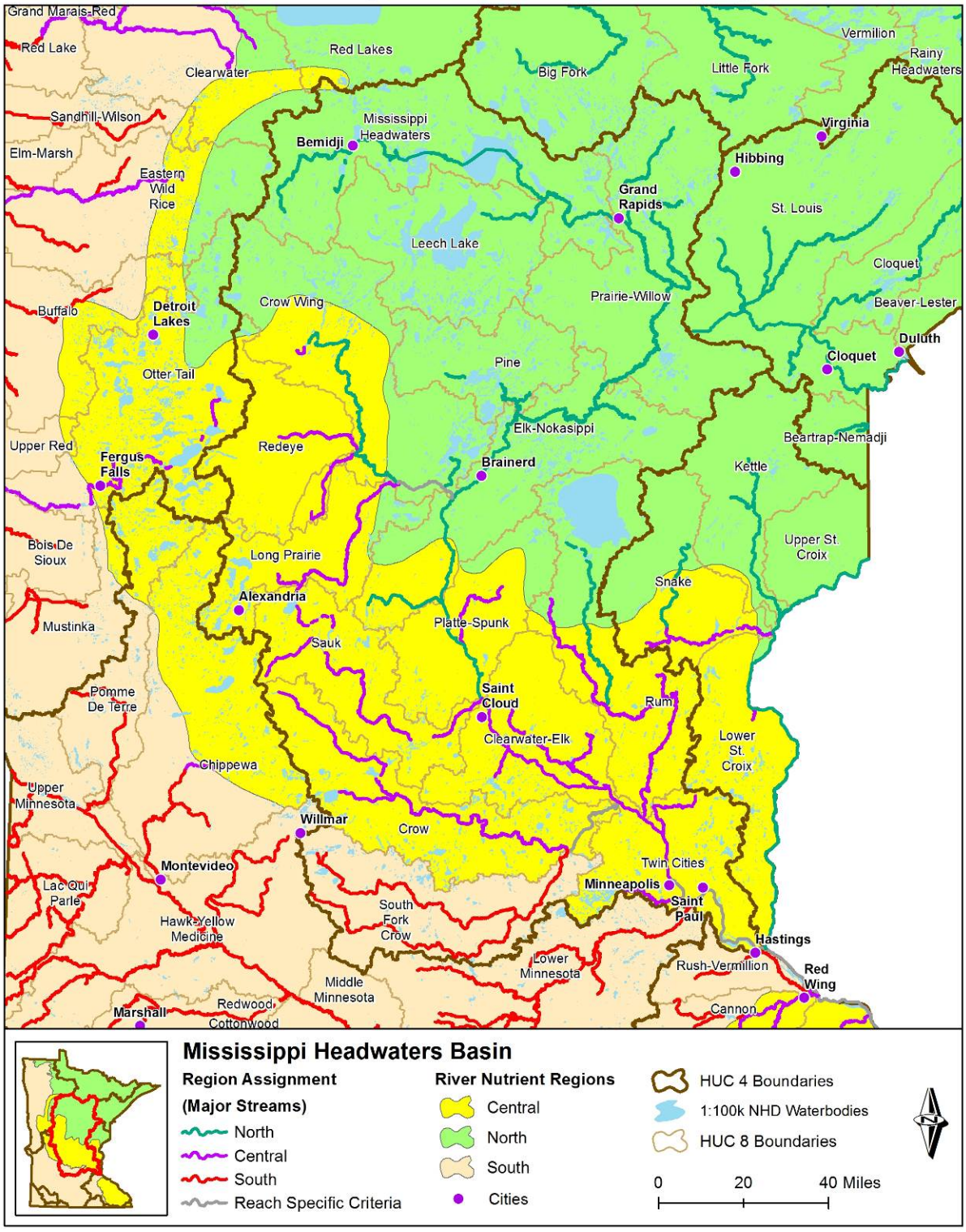
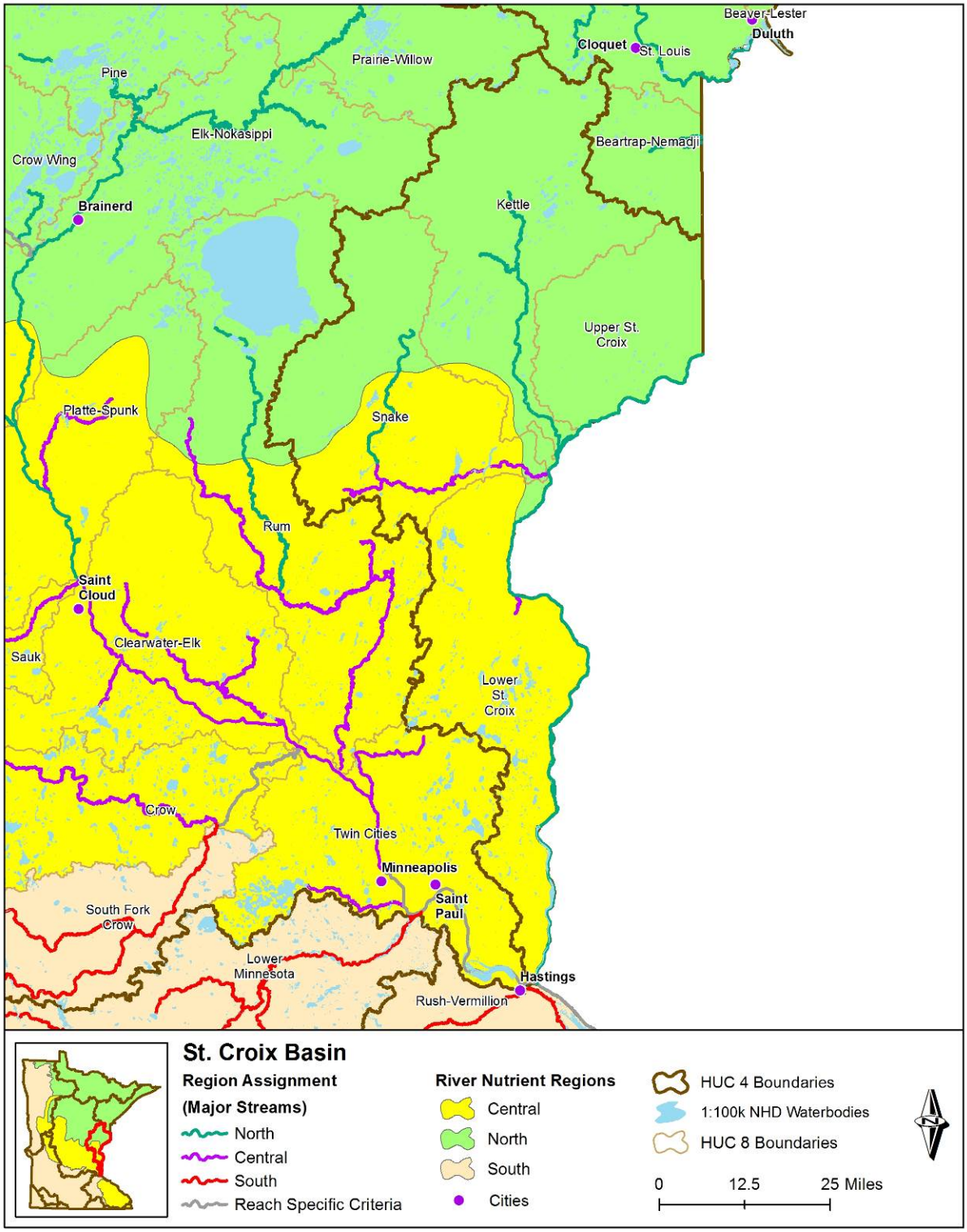
Appendix

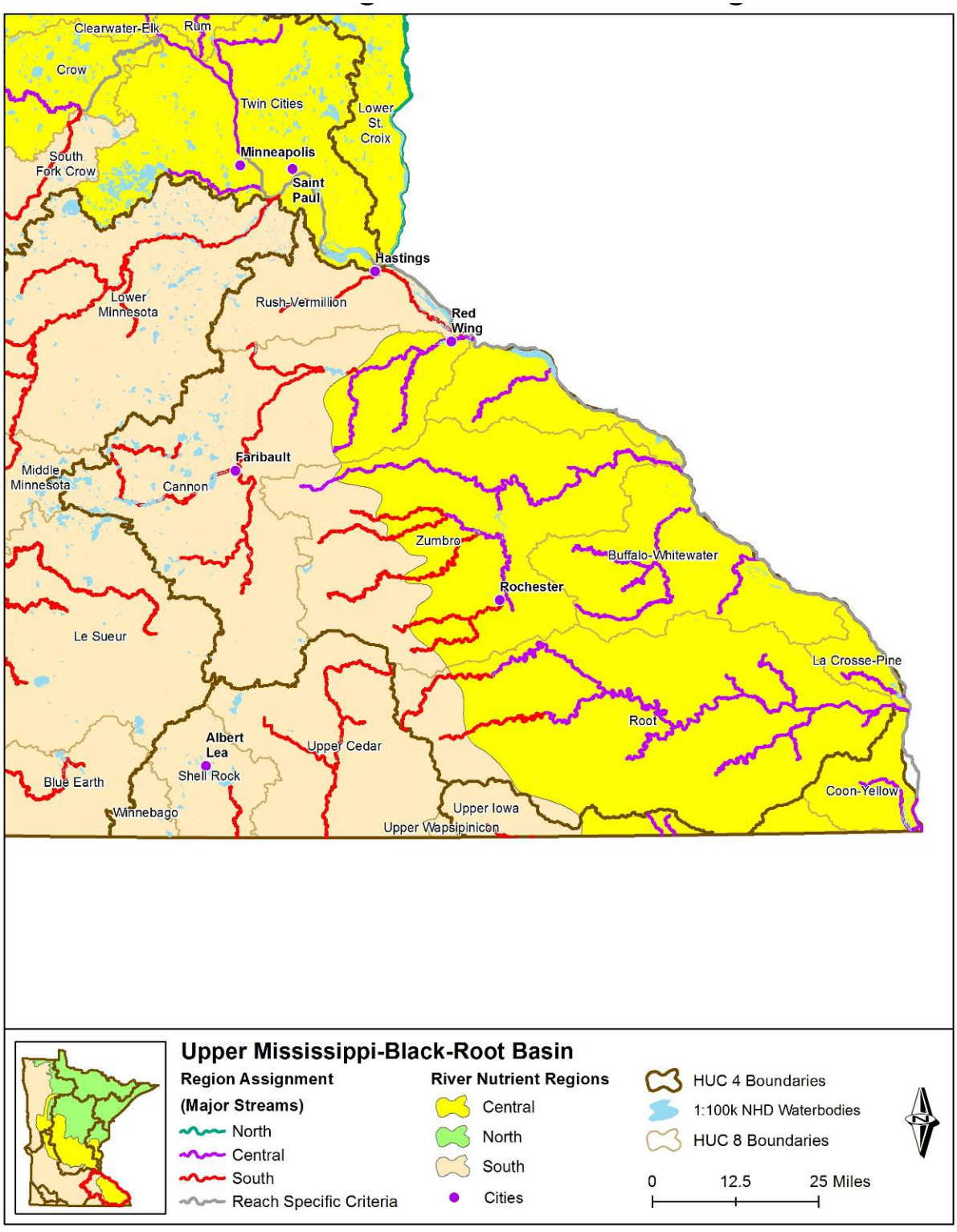
I. Basin-scale RNR maps: Upper Mississippi, St. Croix, Lower Mississippi, Minnesota, Red River, Rainy, and Lake Superior Basins

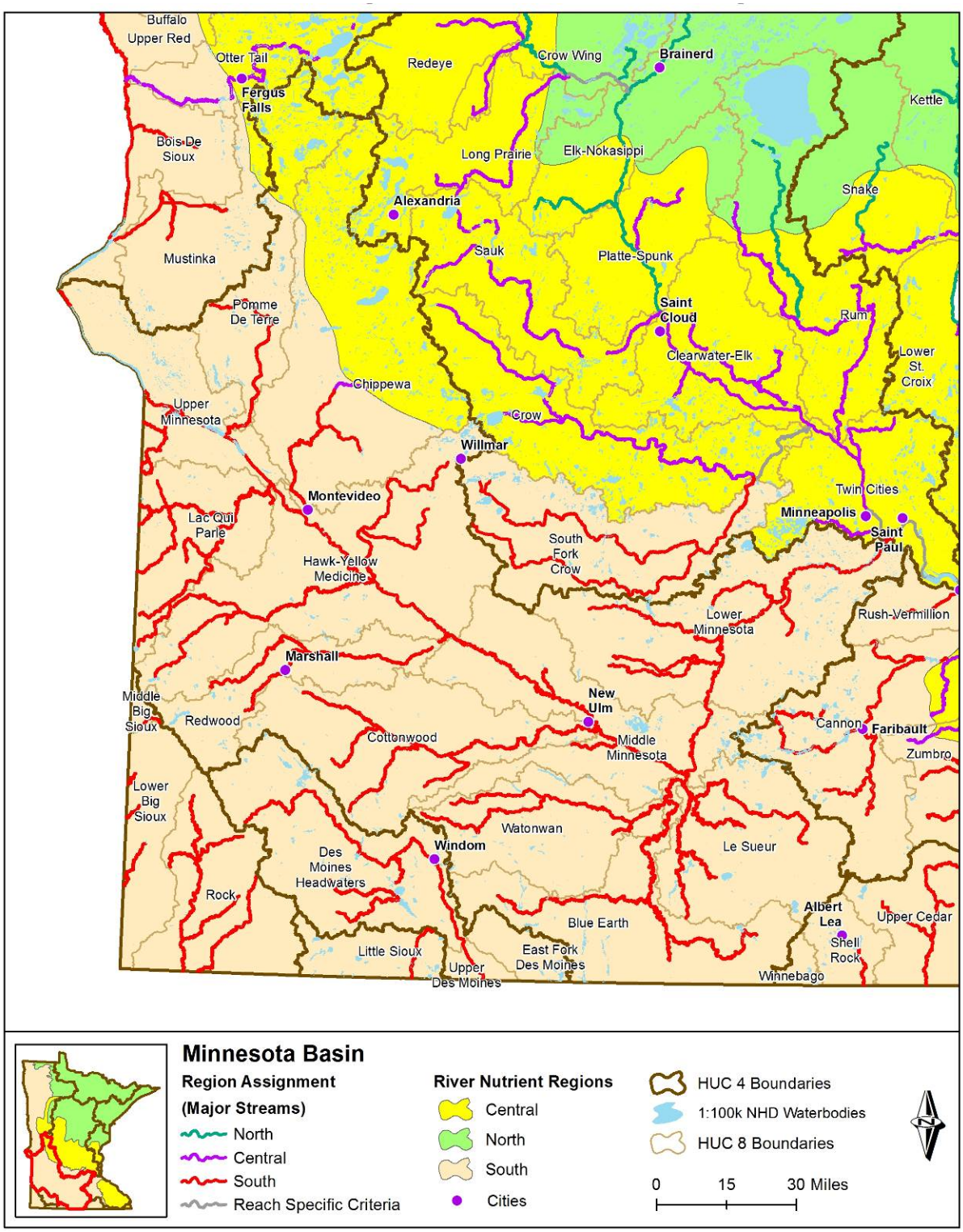
II. HUC8s with multiple RNRs and AUID specific designations: Crow Wing River, North Fork Crow River, Upper Mississippi River: Twin Cities Pools 1-3, and Upper Mississippi River: Pool 4 (Lake Pepin) – Pool 8

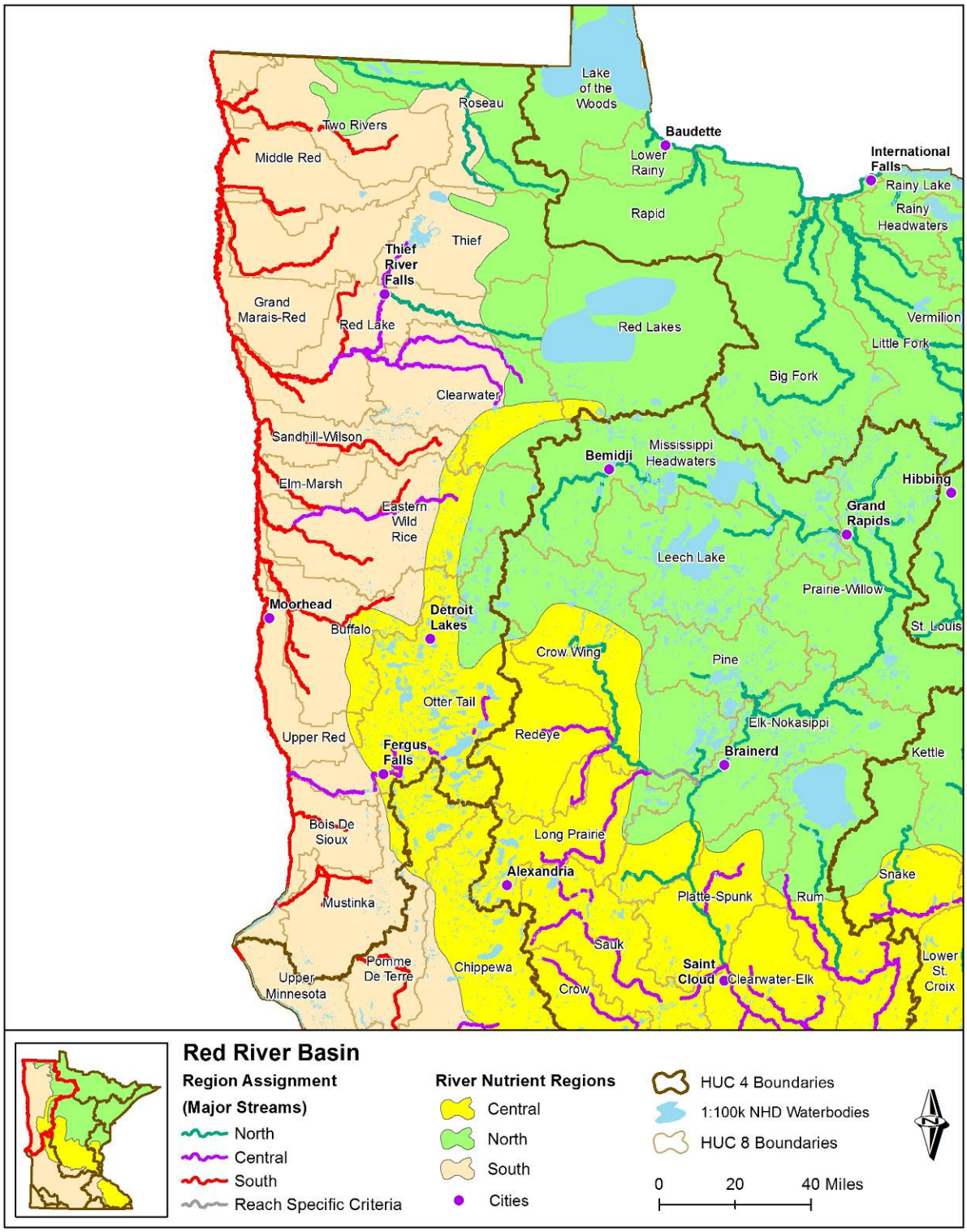
Appendix I. Basin-scale maps

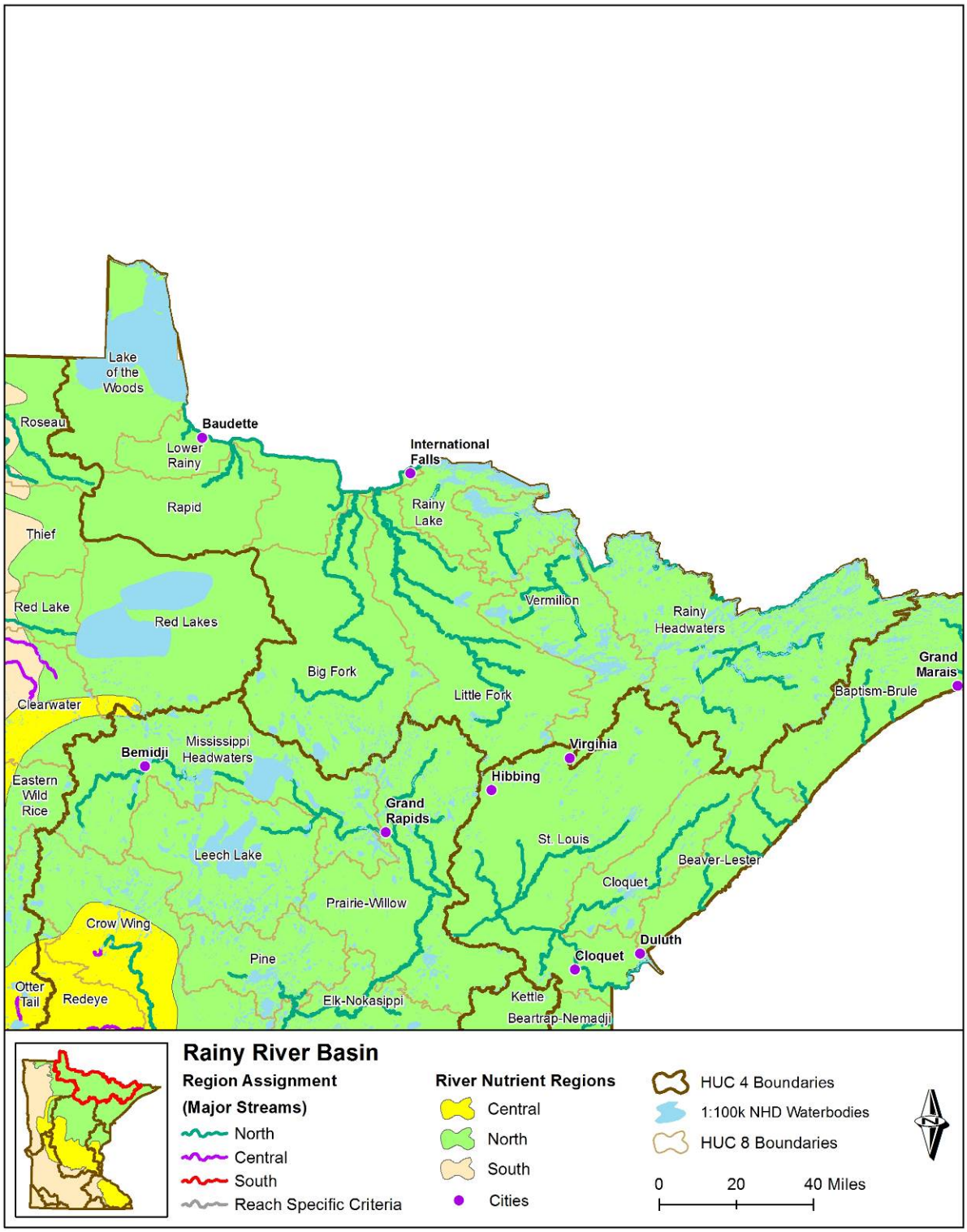


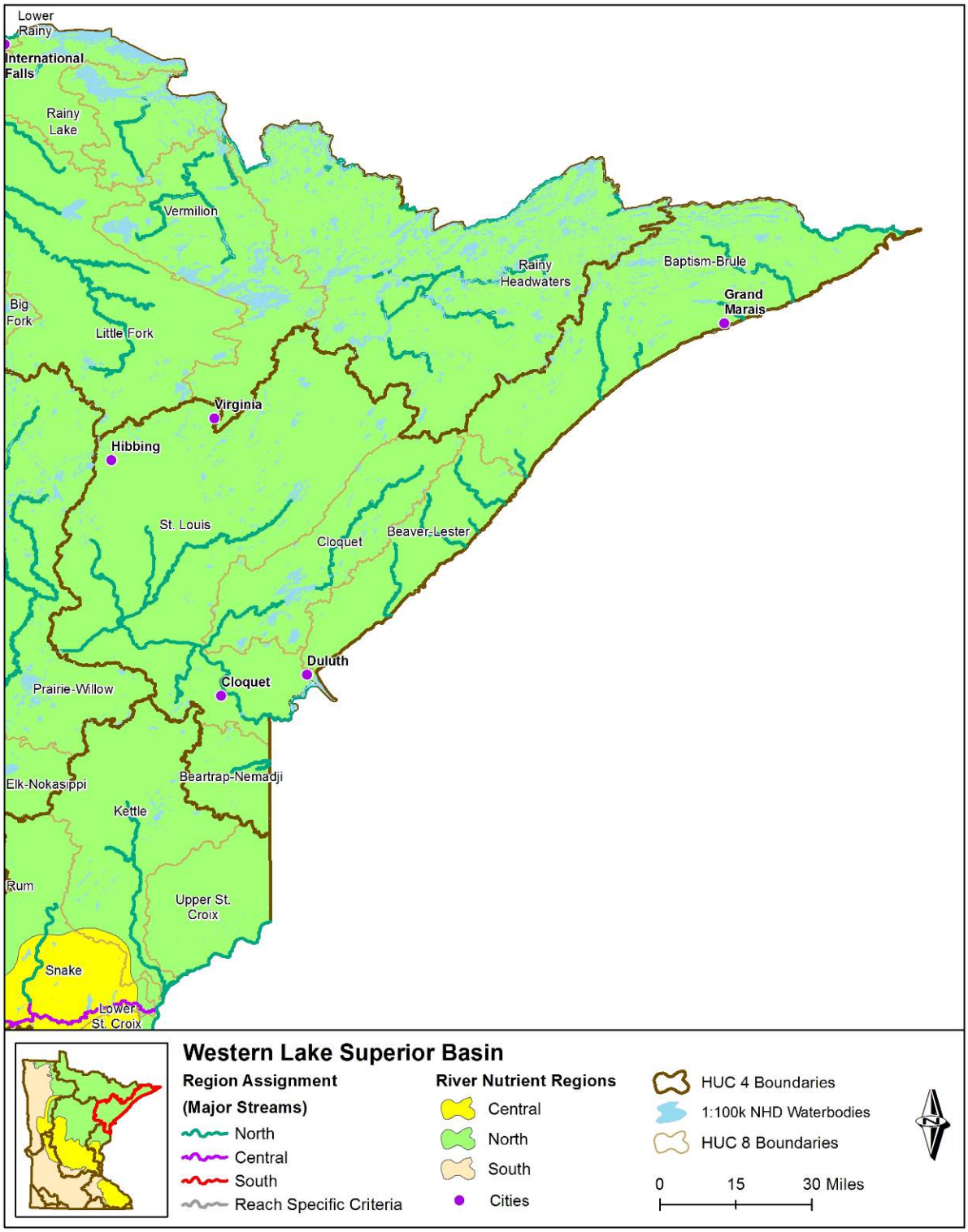

Beaver-Lester
Duluth
Cloquet
St. Louis
Prairie-Willow
Pine
Elk-Nokasippi
Crow Wing
Brainerd
Beartrap-Nemadji
Kettle
Upper St. Croix
Platte-Spunk
Snake
Rum
Saint Cloud
Clearwater-Elk
Sauk
Lower St. Croix
Crow
Twin Cities
Minneapolis
Saint Paul
South Fork Crow
Lower Minnesota
Hastings
Rush-Vermillion
St. Croix Basin
Region Assignment
(Major Streams)
North
Central
South
Reach Specific Criteria
River Nutrient Regions
Central
North
South
Cities
HUC 4 Boundaries
1:100k NHD Waterbodies
HUC 8 Boundaries
0
12.5
25 Miles


Clearwater-Elk
Rum
Crow
Twin Cities
Lower St. Croix
South Fork Crow
Minneapolis
Saint Paul
Hastings
Lower Minnesota
Rush-Vermillion
Red Wing
Faribault
Middle Minnesota
Cannon
Zumbro
Buffalo-Whitewater
Rochester
Le Sueur
La Crosse-Pine
Root
Albert Lea
Upper Cedar
Shell Rock
Blue Earth
Coon-Yellow
Winnebago
Upper Iowa
Upper Wapsipinicon
Upper Mississippi-Black-Root Basin
Region Assignment
(Major Streams)
North
Central
South
Reach Specific Criteria
River Nutrient Regions
Central
North
South
Cities
HUC 4 Boundaries
1:100k NHD Waterbodies
HUC 8 Boundaries
0
12.5
25 Miles


Buffalo
Upper Red
Otter Tail
Fergus Falls
Redeye
Crow Wing
Brainerd
Kettle
Bois De Sioux
Long Prairie
Elk-Nokasippi
Shake
Alexandria
Mustinka
Sauk
Platte-Spunk
Pomme De Terre
Saint Cloud
Rum
Clearwater-Elk
Lower St. Croix
Chippewa
Upper Minnesota
Crow
Willmar
Montevideo
Twin Cities
Minneapolis
Saint Paul
Lac Qui Parle
South Fork Crow
Hawk-Yellow Medicine
Lower Minnesota
Rush-Vermillion
Marshall
New Ulm
Middle Big Sioux
Redwood
Cottonwood
Middle Minnesota
Cannon
Faribault
Zumbro
Lower Big Sioux
Watonwan
Windom
Le Sueur
Des Moines Headwaters
Rock
Albert Lea
Upper Cedar
Blue Earth
Shell Rock
Little Sioux
East Fork Des Moines
Upper Des Moines
Winnebago
Minnesota Basin
Region Assignment
(Major Streams)
North
Central
South
Reach Specific Criteria
River Nutrient Regions
Central
North
South
Cities
HUC 4 Boundaries
1:100k NHD Waterbodies
HUC 8 Boundaries
0
15
30 Miles

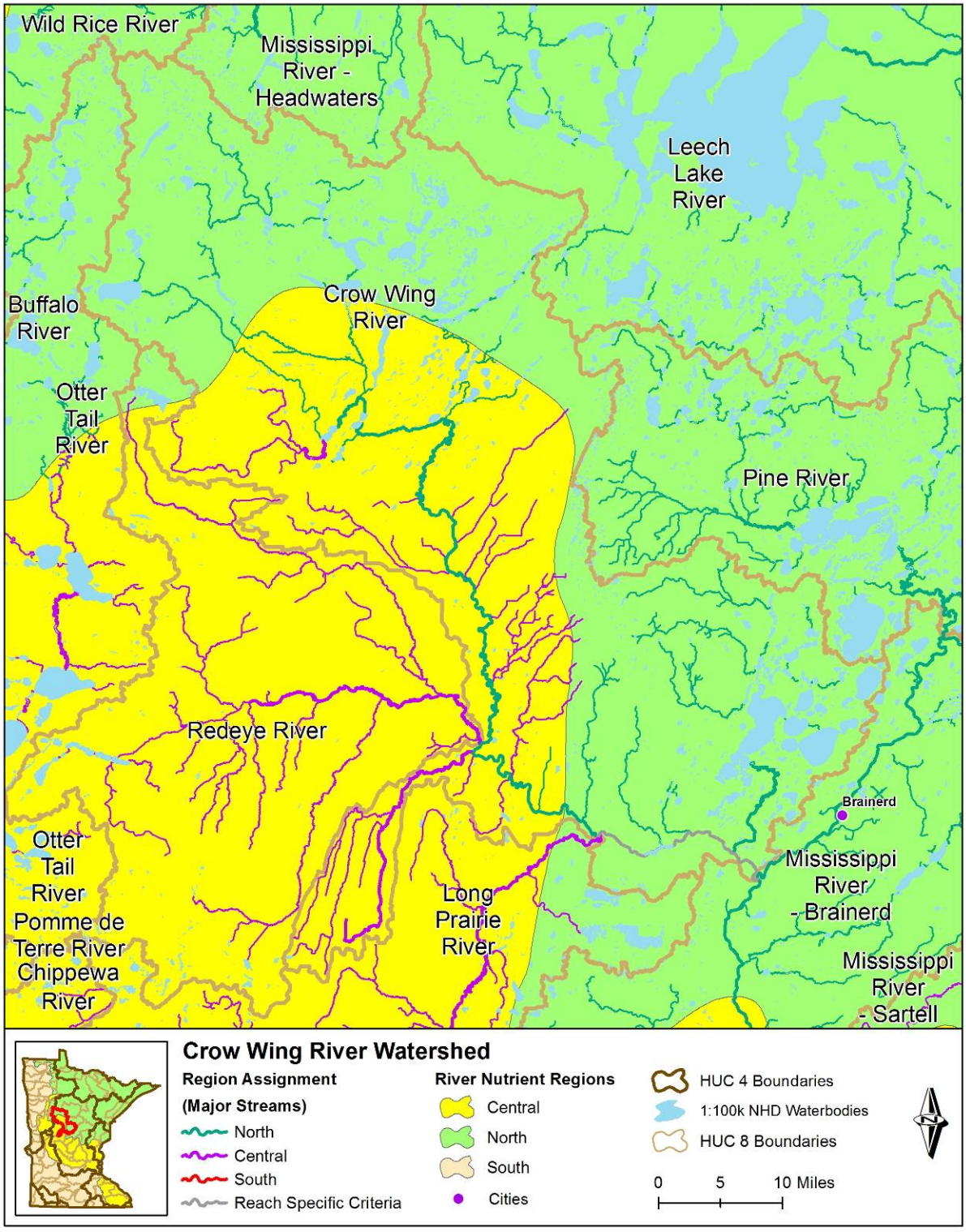

Lake of the Woods
Roseau
Two Rivers
Middle Red
Baudette
Lower Rainy
International Falls
Rainy Lake
Rainy Headwaters
Rapid
Thief
Thief River Falls
Grand Marais-Red
Red Lake
Red Lakes
Vermilion
Little Fork
Big Fork
Clearwater
Sandhill-Wilson
Bemidji
Mississippi Headwaters
Hibbing
Elm-Marsh
Eastern Wild Rice
Grand Rapids
Leech Lake
Prairie-Willow
Moorhead
Buffalo
Detroit Lakes
St. Louis
Crow Wing
Pine
Otter Tail
Upper Red
Redeye
Elk-Nokasippi
Fergus Falls
Brainerd
Kettle
Bois-De Sioux
Long Prairie
Alexandria
Snake
Mustinka
Platte-Spunk
Rum
Sauk
Pomme De Terre
Chippewa
Saint Cloud
Clearwater-Elk
Lower St. Croix
Upper Minnesota
Crow
Red River Basin
Region Assignment
(Major Streams)
North
Central
South
Reach Specific Criteria
River Nutrient Regions
Central
North
South
Cities
HUC 4 Boundaries
1:100k NHD Waterbodies
HUC 8 Boundaries
0
20
40 Miles


Lake of the Woods
Roseau
Baudette
Lower Rainy
International Falls
Rainy Lake
Rapid
Thief
Red Lake
Red Lakes
Vermilion
Rainy Headwaters
Grand Marais
Big Fork
Little Fork
Baptism-Brule
Clearwater
Mississippi Headwaters
Bemidji
Virginia
Hibbing
Eastern Wild Rice
Grand Rapids
St. Louis
Leech Lake
Beaver-Lester
Cloquet
Prairie-Willow
Crow Wing
Duluth
Pine
Cloquet
Otter Tail
Redeye
Elk-Nokasippi
Kettle
Beartrap-Nemadji
Rainy River Basin
Region Assignment
(Major Streams)
North
Central
South
Reach Specific Criteria
River Nutrient Regions
Central
North
South
Cities
HUC 4 Boundaries
1:100k NHD Waterbodies
HUC 8 Boundaries
0
20
40 Miles
N

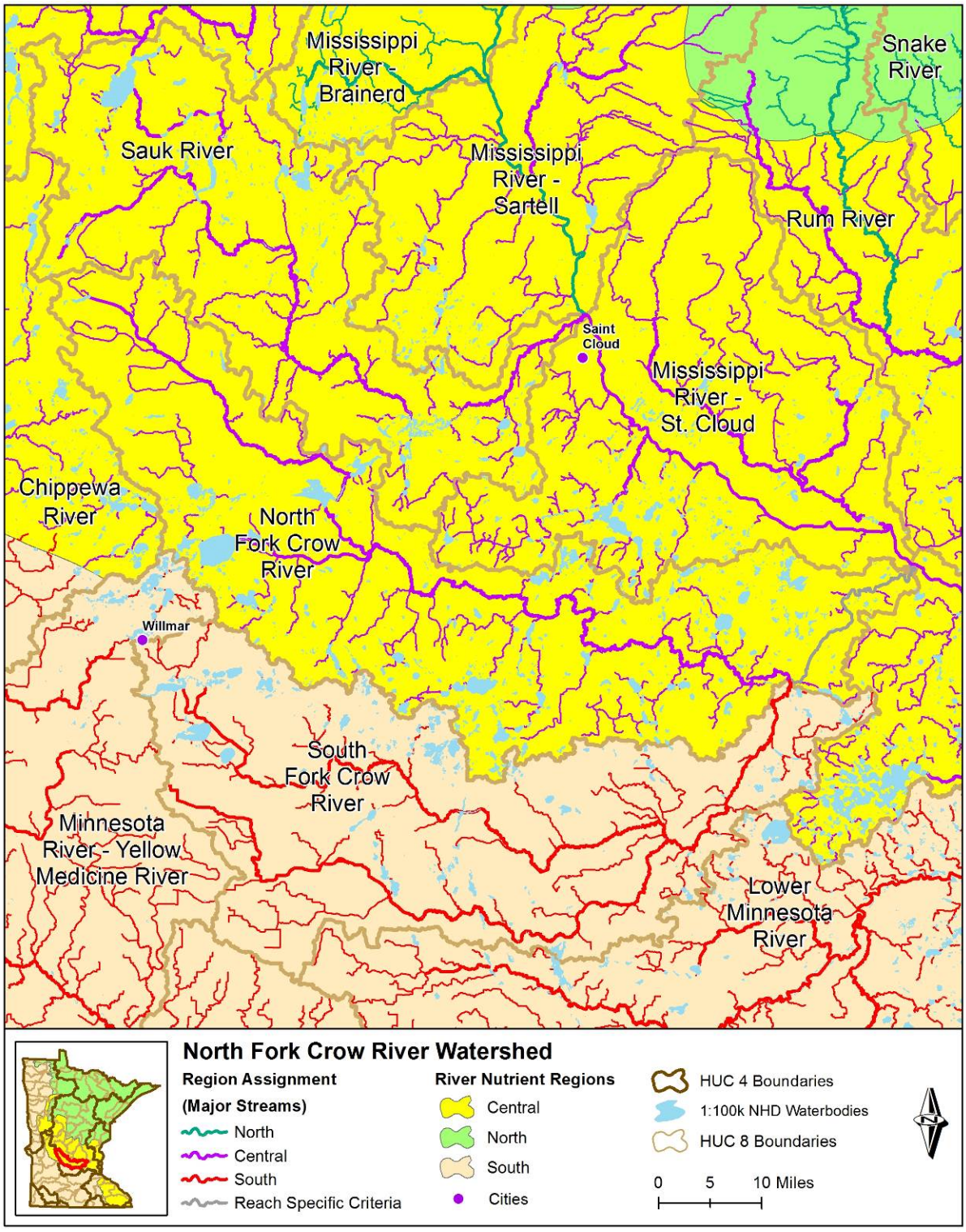

Lower Rainy
International Falls
Rainy Lake
Vermilion
Big Fork
Little Fork
Rainy Headwaters
Baptism-Brule
Grand Marais
Virginia
Hibbing
St. Louis
Cloquet
Beaver-Lester
Duluth
Cloquet
Prairie-Willow
Elk-Nokasippi
Beartrap-Nemadji
Kettle
Rum
Upper St. Croix
Snake
Lower St. Croix
Western Lake Superior Basin
Region Assignment
(Major Streams)
North
Central
South
Reach Specific Criteria
River Nutrient Regions
Central
North
South
Cities
HUC 4 Boundaries
1:100k NHD Waterbodies
HUC 8 Boundaries
0
15
30 Miles

Appendix II. HUC8s with multiple RNRs and AUID specific designations

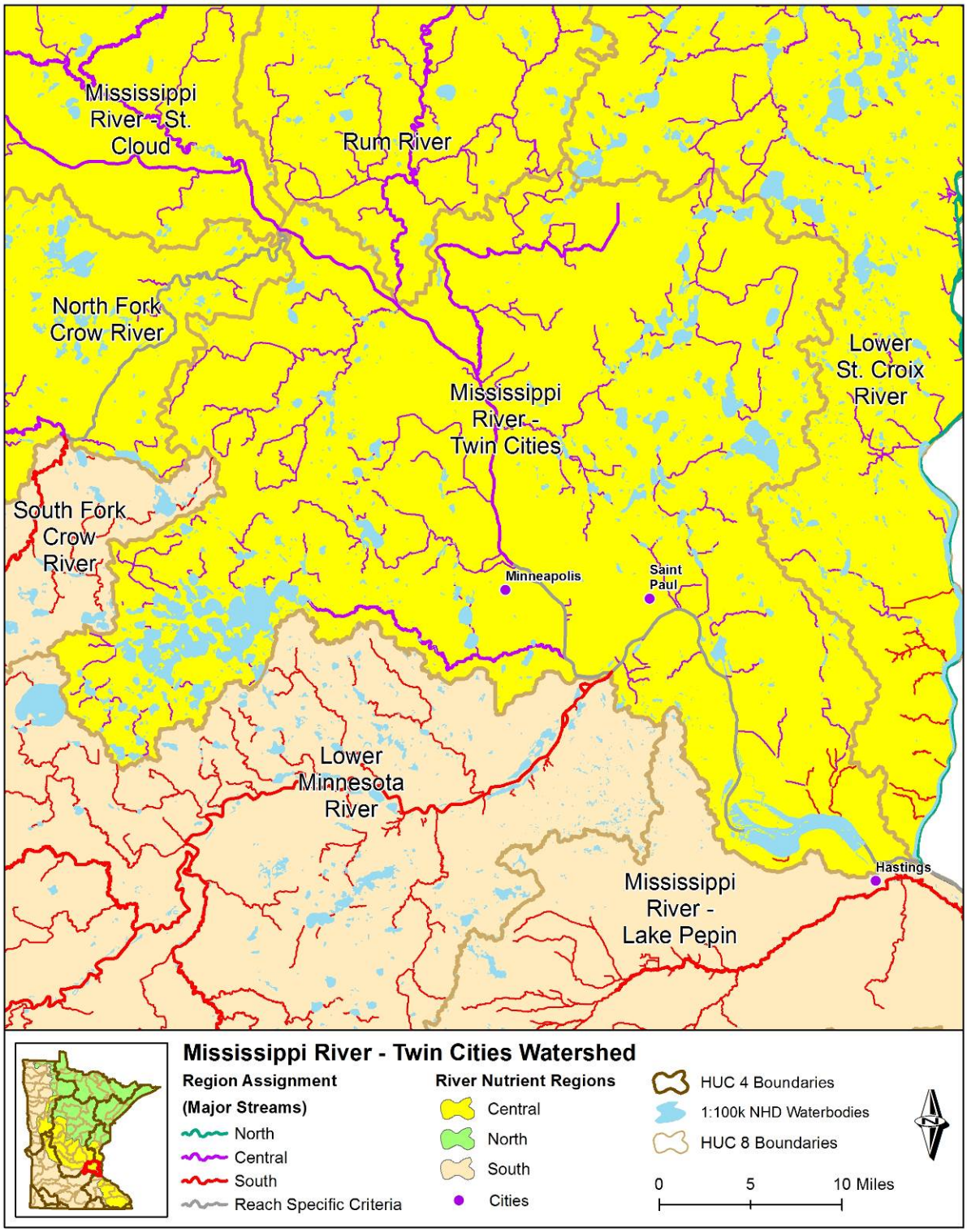
Crow Wing River



North Fork Crow River



Mississippi River – Twin Cities Pools 1-3



Mississippi River: Pool 4 (Lake Pepin) – Pool 8