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

## Environmental Analysis and Outcomes

Minnesota Pollution Control Agency

**December 2013**
**(revised March 2016)**

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

**Prepared by:** Steve Heiskary and Kristofor Parson Environmental Analysis and Outcomes Division (EAO)

**With assistance & review from:**

- Kevin Stroom (EAO), John Sandberg (EAO),Will Bouchard (EAO), Mark Tomasek (EAO) ,Dennis Wasley (EAO), Phil Monson (EAO), Chuck Regan (Watershed Division) and Carrie Jennings (MNDNR) – approach and map development and text review; Pam Anderson (EAO) – text review; and Gary Rott (EAO) – map review
- Basin reviews of maps and text: Justin Watkins (Lower Miss.), Molly MacGregor and Bruce Paakh (Red), Larry Gunderson (Minnesota), Chris Klucas (St. Croix), and Maggie Leach (Upper Mississippi)

**Revisions**

This technical support document was revised in 2013 to reflect refinements in the MPCA's approach to defining River Nutrient Regions for specific HUC-8 and HUC-11 watersheds. The document was revised in 2016 to reflect refinements in the use of River Nutrient Regions for application of total suspended solids (TSS) water quality standards.

## 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). USEPA 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, USEPA 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 1a. USEPA (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 1b.

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 1 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 USEPA aggregated Level III Nutrient ecoregions (Figure 1a) with aggregations as follows:

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

**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 (HUC-8) level (81 watersheds) were selected as a primary basis to develop this framework (Figure 1b). These 81 watersheds, as derived from MDNR's major watershed (DNR Catchments) layer, are also a focus of MPCA's "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 1a). In terms of watershed size the HUC-8s (Table 2) and 4$^{th}$ order and higher streams (Table 3) 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 Tables 2 and 3 HUC-8s are most similar to 5$^{th}$ order streams, while HUC-11s are most similar to 3$^{rd}$ order streams.

When a HUC-8 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 2). However, when a HUC-8 traverses multiple ecoregions the appropriate designation may be less apparent (e.g. Wild Rice, Buffalo and Red Lake Rivers; Figure 2). In these cases closer inspection was required and 11 digit HUCs (HUC-11; 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 81 major watersheds (HUC-8) was overlain on a level III ecoregion map (Figure 1b). The areal ecoregion composition (% 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. HUC-11 layer was added to allow for more detailed examination and determining appropriate breakpoints within a HUC-8.
3. 4$^{th}$ order and higher stream reaches were noted in bold, while 3$^{rd}$ 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 81 watersheds were then sorted by HUC-8 within each basin. HUCs corresponding to the main-stem of the Mississippi, Minnesota, Red and St. Croix Rivers were sorted separately (Table 4c) to allow for individual assessment and assignment to a RNR.
5. Ecoregion composition and maps were reviewed at the HUC-8 level to define the ecoregion(s) that accounted for the majority of the watershed. When a HUC-8 was completely within a single ecoregion (e.g. Cloquet River, Table 4a) it was assigned to the corresponding RNR (North in this case). Also, when the vast majority of a HUC-8 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 4a).

6. HUC-8 watersheds, characterized by multiple ecoregions, were sorted out separately (Table 4b). For these, a closer evaluation at the HUC-11 level was conducted to discern the appropriate RNR for that HUC-11 and/or portion thereof. This evaluation considered the relative percentage ecoregion contribution within and upstream of that HUC-11 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 3). 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 2$^{nd}$ or 3$^{rd}$ 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. 4$^{th}$ order and larger tributaries were color coded and in bold, while 3$^{rd}$ 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 HUC-8s) plus two main-stem reaches on the Mississippi. The NLF ecoregion accounts for the highest percentage by area (Table 4a). 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 4). 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 11 HUC-8 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 HUC-8s were included with those characterized by multiple ecoregions (Table 4b). Several HUC-8s 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 HUC-8s in Minnesota and RNR assignments were made (Table 4). Figure 4 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 (4$^{th}$ order and higher) rivers that drain the respective HUC-8s and basins. In addition to this statewide map, working maps were

developed at the HUC-8 and HUC-11 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 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 ($8^{th}$ order) than most of the rivers used in development of the river nutrient criteria (typically $4^{th}$-$7^{th}$ order). Draft criteria have been developed in collaboration with Wisconsin DNR and Minnesota DNR (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. USEPA (2000a, b, & 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 (RNR): North, Central and South. These regions correspond loosely to the USEPA aggregated Level III Nutrient ecoregions with aggregations as follows:

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

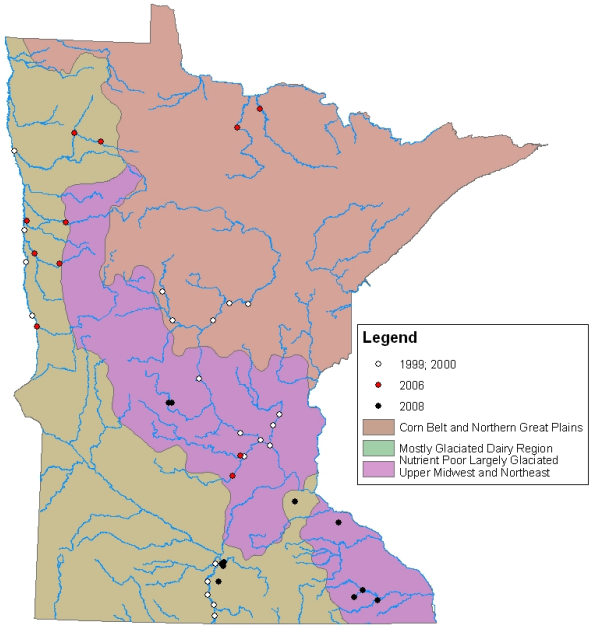
River-watersheds at the HUC-8 level were selected as a primary basis to develop the regional framework. These 81 watersheds, as derived from MDNR's major watershed (DNR Catchments) layer, are also a focus of MPCA's "pour-point" monitoring program. The rivers that drain these watersheds are of a similar order as those used in MPCA's

river nutrient studies. When a HUC-8 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 HUC-8 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 HUC-11s (Watershed 99 HUC 11 layer) were incorporated into the mapping coverage to allow for refinement of boundaries. In a few instances, where two HUC-8s 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 1. Location of: a) 1999, 2000, 2006 and 2008 study sites overlain on USEPA aggregated level 3 "nutrient" ecoregions and b) location of 86 major watershed "pour-points."**

**a) river nutrient study sites**




**b) 86 pour-points**

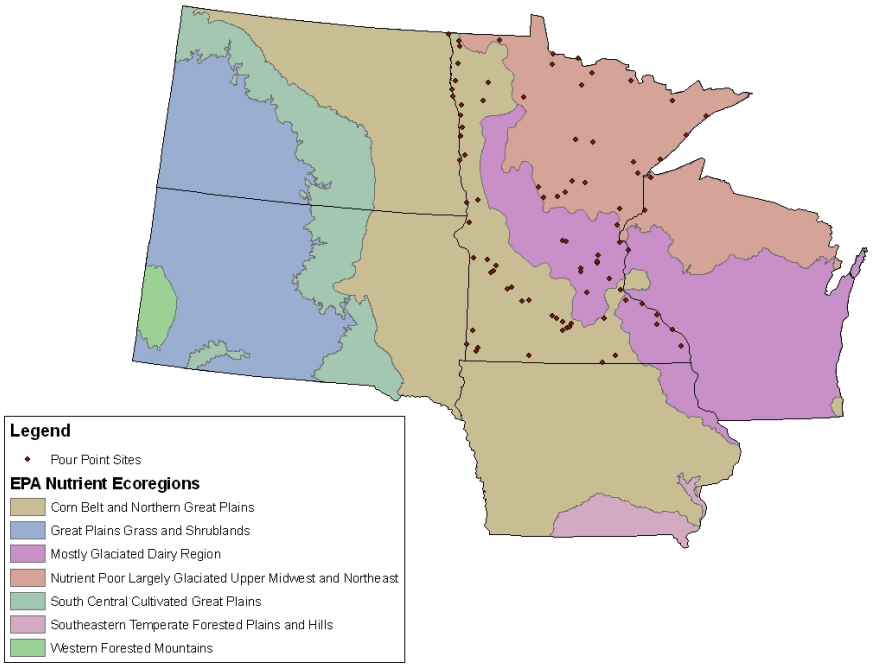
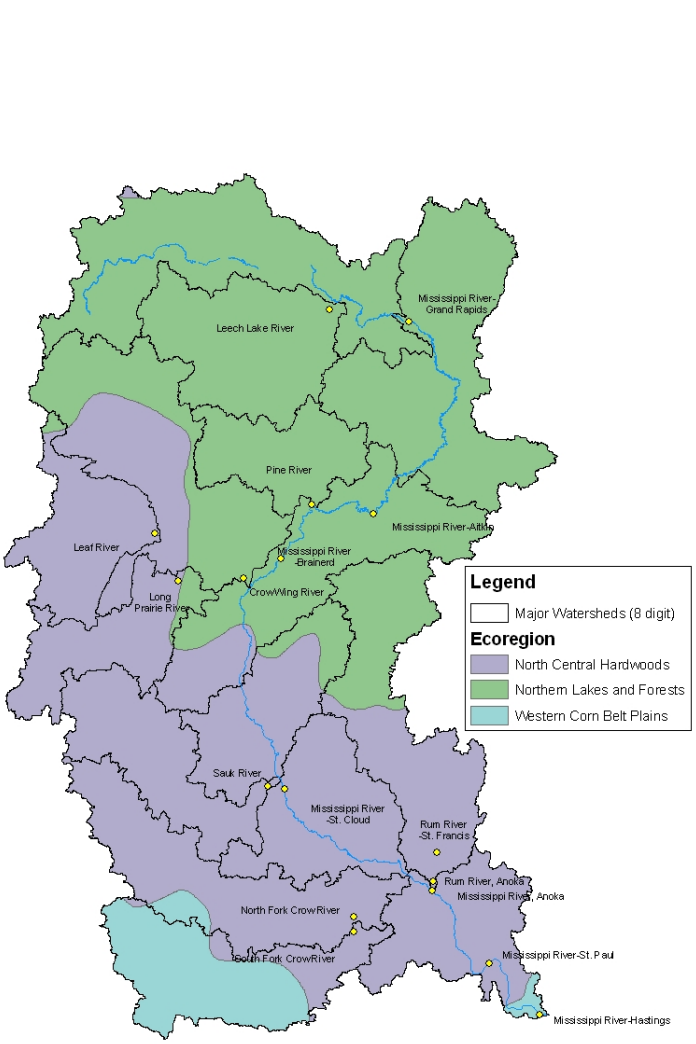


**Figure 2. Major watershed "pour points" and level 3 ecoregion composition for Red and Upper Mississippi River Basins. Percent ecoregion composition noted for select rivers and corresponding RNR for each river at pour-point noted. Rivers marked with * were evaluated at HUC-11 level and river is comprised of more than one RNR.**

| RNR | \| -------N----------\| | ----C----\| | -------S----------\| | | | |
|---|---|---|---|---|---|---|
| River (pour point) | % NLF | % NMW | % CHF | % LAP | % WCP | RNR Reg. |
| 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 |



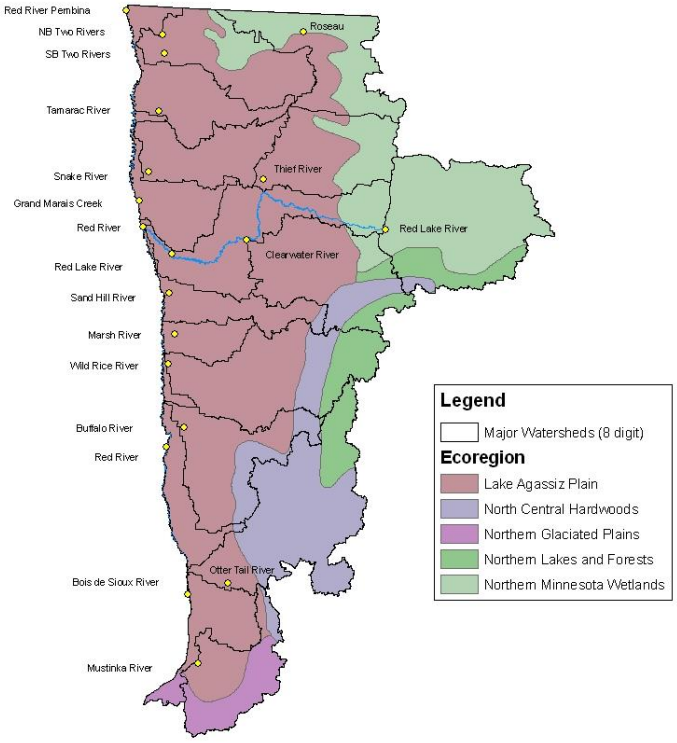
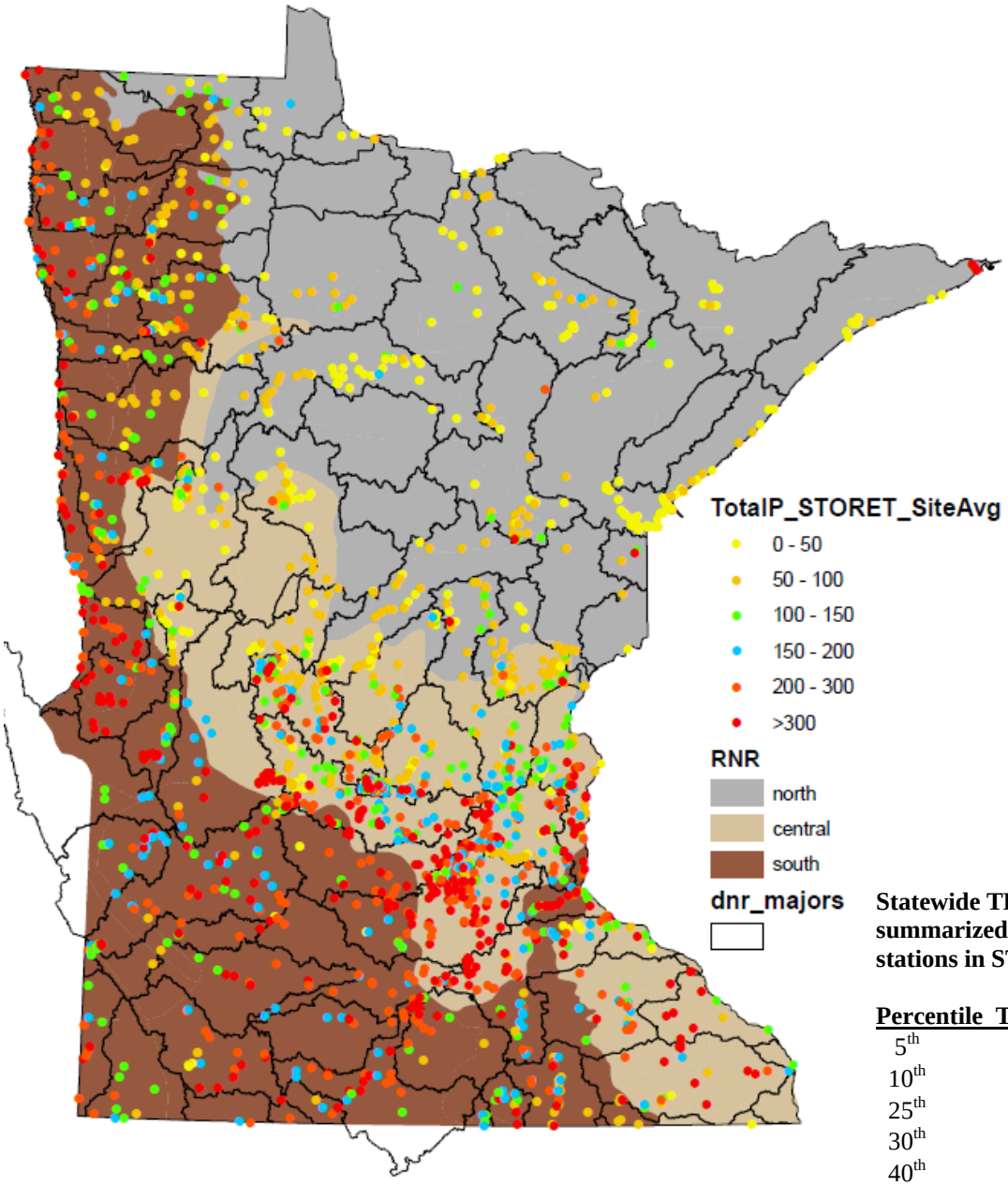



**Figure 3. River total phosphorus data as derived from STORET. Based on 64,514 TP measurements from 1,994 stations. Values represent mean for each station based on year-round data collected between Jan. 1, 1995-March 24, 2009. Shaded regions approximate the three RNRs as grouped by ecoregions. Map provided by John Sandberg (MPCA EAO).**




**Statewide TP distribution based on summarized data from 1,994 stations in STORET.**

| Percentile | TP µg/L |
|---|---|
| 5th | 31 |
| 10th | 40 |
| 25th | 68 |
| 30th | 79 |
| 40th | 104 |
| 50th | 140 |
| 60th | 179 |
| 70th | 228 |
| 75th | 260 |
| 90th | 431 |
| 95th | 621 |

**Figure 4. River Nutrient Regions (RNR). Classification developed at the 8 digit and 11 digit HUC level as needed. 4th order and larger rivers coded with their respective RNR.**

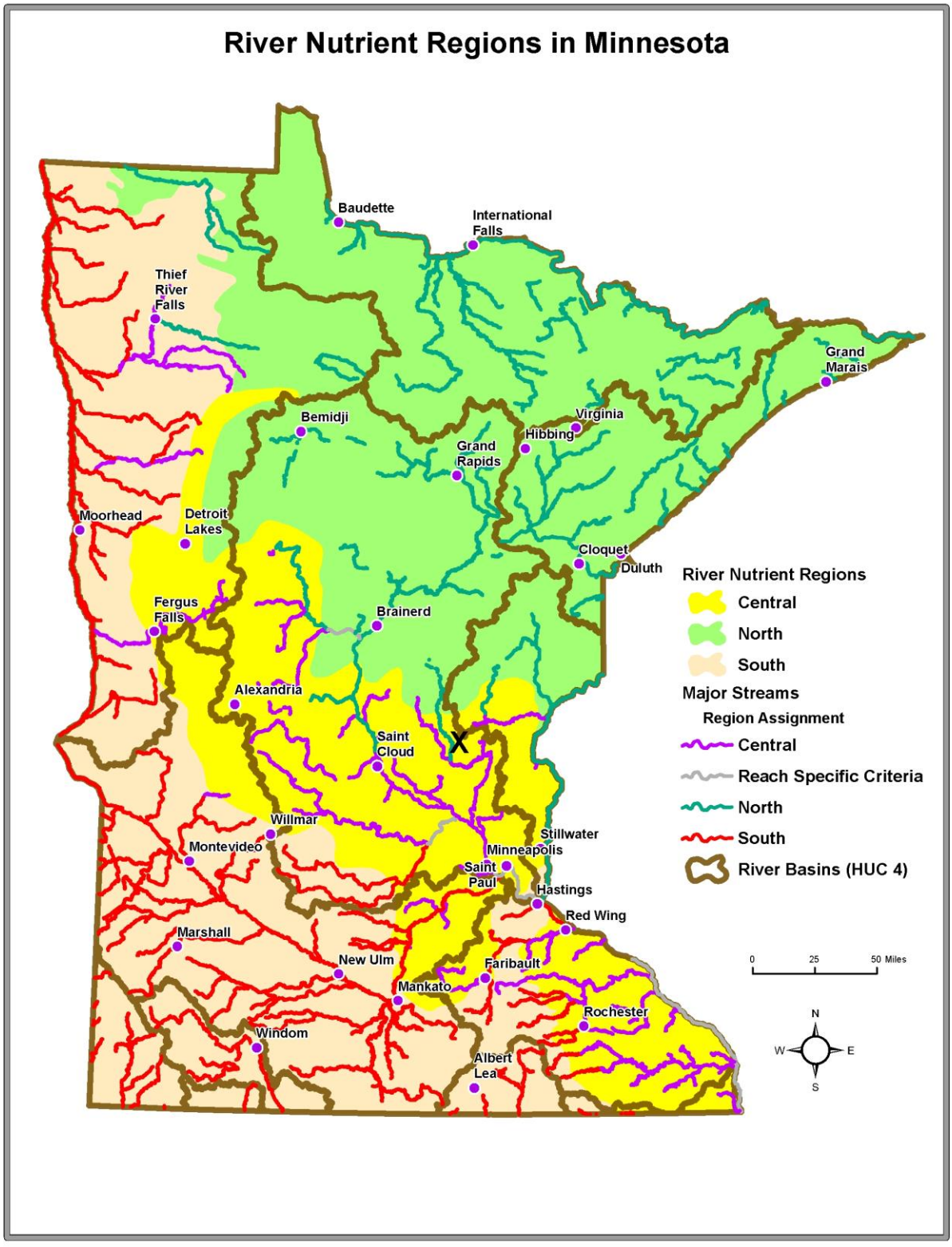


**Table 1a. Interquartile range (25th – 75th percentiles) of summer-mean concentrations for minimally impacted streams in Minnesota, by Level III ecoregion. Data from 1970-1992. TP = total phosphorus, TSS = total suspended solids, BOD=5-day biochemical oxygen demand (McCollor and Heiskary 1993).**

| 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 1b. Interquartile range of summer-mean concentrations. Derived from USEPA (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 2. Watershed area as a function Hydrologic Unit Code: comparison of HUC-8 and HUC-11 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 ($mi^2$) | | | | | | |
|---|---|---|---|---|---|---|---|
| **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 3. Watershed area as a function of stream order. Analysis based on ~1,560 biological monitoring stream sites**

| | Area ($mi^2$) | | | | |
|---|---|---|---|---|---|
| **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 4. Ecoregion classification of Minnesota rivers at HUC-8 level. Sorted by River Nutrient Region (RNR) [N=North (NLF & NMW), C=Central (CHF & DA), S=South (LAP, WCP, & NGP)] and HUC-8. Total area of unaggregated[1] HUC-8 and % composition by ecoregion: NLF=Northern Lakes and Forests, NMW=northern Minnesota Wetlands, CHF=North Central Hardwoods Forests, DA=Driftless Area, LAP=Lake Aggasiz Plain, NGP=Northern Glaciated Plains, and WCP=Western Corn Belt Plains.**

1. Watershed area is for the specific HUC and does not consider upstream contributing watersheds.

**Table 4a. HUC-8s characterized by a single or vast majority of watershed area in a single RNR**

| RNR | | | N | N | C | C | S | S | S | |
|---|---|---|---|---|---|---|---|---|---|---|
| HUC 8 | Name | Area $Mi^2$ | % NLF | % NMW | % CHF | % DA | % LAP | % NGP | % WCP | RNR |
| | **North** | | | | | | | | | |
| 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** |
| 09030004 | Upper Rainy | 506 | 0 | 100 | 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 | 305 | 0 | 100 | 0 | 0 | 0 | 0 | 0 | **N** |
| 09030009 | Lake of the Woods | 1,142 | 0 | 100 | 0 | 0 | 0 | 0 | 0 | **N** |
| | **Count** | **21** | | | | | | | | |
| | **Central** | | | | | | | | | |
| 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** |
| 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** |
| | **Count** | **11** | | | | | | | | |

| HUC 8 | Name | Area $Mi^2$ | % NLF | % NMW | % CHF | % DA | % LAP | % NGP | % WCP | RNR |
|---|---|---|---|---|---|---|---|---|---|---|
| | **South** | | | | | | | | | |
| 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** |
| | **Count** | **27** | | | | | | | | |

| **Table 4b** | **Multiple regions** | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 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 |
| 07030005 | Lower St. Croix | 915 | 2 | 0 | 92 | 0 | 0 | 0 | 6 |
| 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 |
| 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** | **14** | | | | | | | |

| Table 4c | Main stems[1] | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| HUC 8 | 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**

| | | | % composition by ecoregion | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| HUC8 | name | mi$^2$ | NLF | NMW | CHF | DA | LAP | NGP | 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 TP and 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 R to Seven Mile Creek), the middle one is 07010106-506 (Seven Mile Cr to Gull River) and the downstream one is 07010106-501 (Gull R to Mississippi River); Appendix II).

The HUC-11s 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 HUC-11s (3$^{rd}$ 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.

**07010204 North Fork Crow 2,754** (aggregated area includes South Fork)

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).

| HUC8 | name | $mi^2$ | NLF | NMW | CHF | DA | LAP | NGP | WCP |
|---|---|---|---|---|---|---|---|---|---|
| **07010207** | **Rum** | **1,583** | **43** | **0** | **57** | **0** | **0** | **0** | **0** |

The Rum has its headwaters in Mille Lacs Lake in the NLF ecoregion. The HUC-11s: 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 HUC-11s to the south and east are assigned to the Central RNR.

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **07020002** | **Pomme De Terre** | **875** | **0** | **0** | **38** | **0** | **0** | **61** | **0** |

The Pomme de Terre headwaters are in the CHF ecoregion. The HUC-11s that comprise the "headwaters" area are the Upper Pomme de Terre and Pelican Creek (drained by 3rd order or lower streams) and both are assigned to the Central RNR. The transition to the NGP ecoregion occurs near Barrett and 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 HUC-11s 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.

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **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 HUC-11s: Upper West Branch, Middle West Branch, Little Chippewa, Trappers Run, East Branch, North Mud Creek, and Upper Shakopee Creek, which are drained by 3rd order or lower streams. The Lower West Branch below Lake Emily and south of Cyrus and all HUC-11s 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.

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **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 HUC-11s 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 HUC-11s 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 | mi$^2$ | NLF | NMW | CHF | DA | LAP | NGP | WCP |
|---|---|---|---|---|---|---|---|---|---|
| **07030005** | **Lower St. Croix** | **915** | **2** | **0** | **92** | **0** | **0** | **0** | **6** |

The Upper St. Croix flows into this HUC-8. The main-stem of the St. Croix down to Stillwater at the head end of Lake St. Croix is assigned to the North RNR. The remainder of the St. Croix is comprised of Lake St. Croix and that is addressed as a CHF ecoregion lake. All HUC-11s in this HUC-8 are assigned to the Central RNR and are drained by 3rd order or lower streams.

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **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. The majority of the watershed is in the WCP ecoregion that transitions to the DA ecoregion as it enters the Mississippi River. The Vermillion is assigned to the South RNR and any tributaries located in this HUC that flow from the DA ecoregion to the Mississippi River are assigned to the Central RNR; however most of these are quite small (3rd order or less) and generally <50 mi$^2$.

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **07040002** | **Cannon** | **1,470** | **0** | **0** | **33** | **18** | **0** | **0** | **49** |

The Cannon River watershed has two very distinct subwatersheds: the Upper Cannon in the CHF ecoregion and the Straight River in the WCP ecoregion. Lake Byllesby on the Lower Cannon serves to reset the system. RNR assignments are as follows:

1. Watershed of Upper Cannon River (~295 mi$^2$) drains from the CHF. The Upper Cannon River and tributaries that flow directly from the CHF ecoregion to the Cannon main-stem are assigned to Central 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.

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **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 HUC-11 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 HUC-11 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 % of watershed from the DA increases and this 4$^{th}$ order stream merges with a 4$^{th}$ 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.

| HUC8 | name | mi$^2$ | NLF | NMW | CHF | DA | LAP | NGP | 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 HUC-11s 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 HUC-11s, 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.

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **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 HUC-11s, 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 HUC-11s 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 HUC-11 tributaries that drain to it: Felton Ditch and Hendrum, downstream of confluence with Upper Wild Rice, are assigned to the South RNR.

| HUC8 | name | mi$^2$ | NLF | NMW | CHF | DA | LAP | NGP | WCP |
|---|---|---|---|---|---|---|---|---|---|
| **09020303** | **Red Lake River** | **1,340** | **0** | **21** | **0** | **0** | **79** | **0** | **0** |

The immediate upstream HUC-8 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 HUC-11s: 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 HUC-11s 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.

| HUC8 | name | mi$^2$ | NLF | NMW | CHF | DA | LAP | NGP | 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 HUC-8 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 HUC-11S in the NMW portion of the watershed: Moose, Mud and Lost Rivers are assigned to the North RNR. The remaining HUC-11s: 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 HUC-8 these HUC-11s are assigned to the Central RNR.

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **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 mi$^2$. The HUC-11s 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 HUC-11 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 HUC-8 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 HUC-11s are assigned to the Central RNR.

## Adaptations of the Regions for Application of the Total Suspended Solids (TSS) 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 5). While the basic model underlying the original RNR map (described elsewhere in this document) remains sound, the adjustments shown in Figure 5 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 HUC-8 lines or, where finer distinctions better match the factors influencing TSS concentrations as outlined above, along HUC-10 lines.

Figure 5 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.

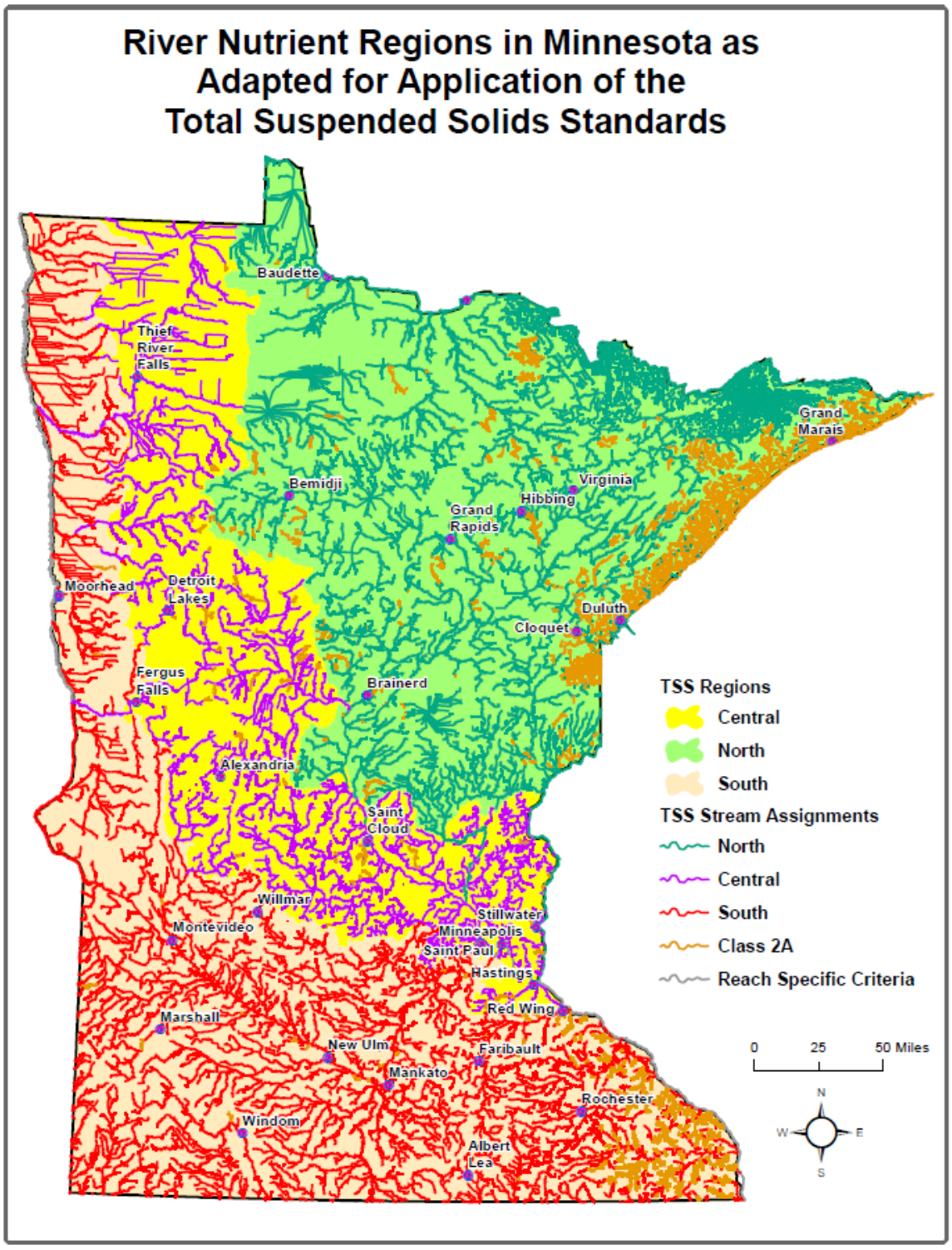
Wild Rice River, South Branch – Otto Lake to Unnamed Creek (09020108-637). This upper portion of the Wild Rice River, South Branch, while lying partially in the South Region, has most of its watershed in and is assigned to the Central Region.

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 (07030005-507, -515, -506, -516, -517, -505, -518, -513, -504, -503, -502). 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 5. 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.**



## References

Heiskary, S. and D. Wasley. 2010. Mississippi River Pools 1 through 8: Developing Assessment Reach Specific Nutrient Criteria and Proposed Draft Criteria. MPCA St. Paul MN

Heiskary, S. 2008. Relation of nutrient concentrations and biological responses in Minnesota streams: applications for river nutrient criteria development. A report based on work conducted as a part of USEPA nutrient criteria grant. MPCA St. Paul MN

Heiskary, S. and H. Markus. 2001. Establishing relationships among nutrient concentrations, phytoplankton abundance, and biochemical oxygen demand in Minnesota USA, rivers. Lake and Reserv. Manage. 17(4):251-262.

Heiskary, S. and H. Markus. 2003. Establishing relationships among in-steam nutrient concentrations, phytoplankton and periphyton abundance and composition, fish and macroinvertebrate indices and biochemical oxygen demand in Minnesota USA, rivers. MPCA St. Paul MN 100 p.

Heiskary, S. and B. Wilson. 2008. Minnesota's approach to lake nutrient criteria development. Lake and Reserv. Manage. 24:282-297.

Heiskary, S., R.W. Bouchard and H. Markus. 2013. Minnesota nutrient criteria development for rivers. MPCA. St. Paul MN. 176 p.

McCollor, S. and S. Heiskary. 1993. Selected water quality characteristics of minimally impacted streams from Minnesota's seven ecoregions. Addendum to: Descriptive characteristics of the seven ecoregions of Minnesota. MPCA St. Paul MN

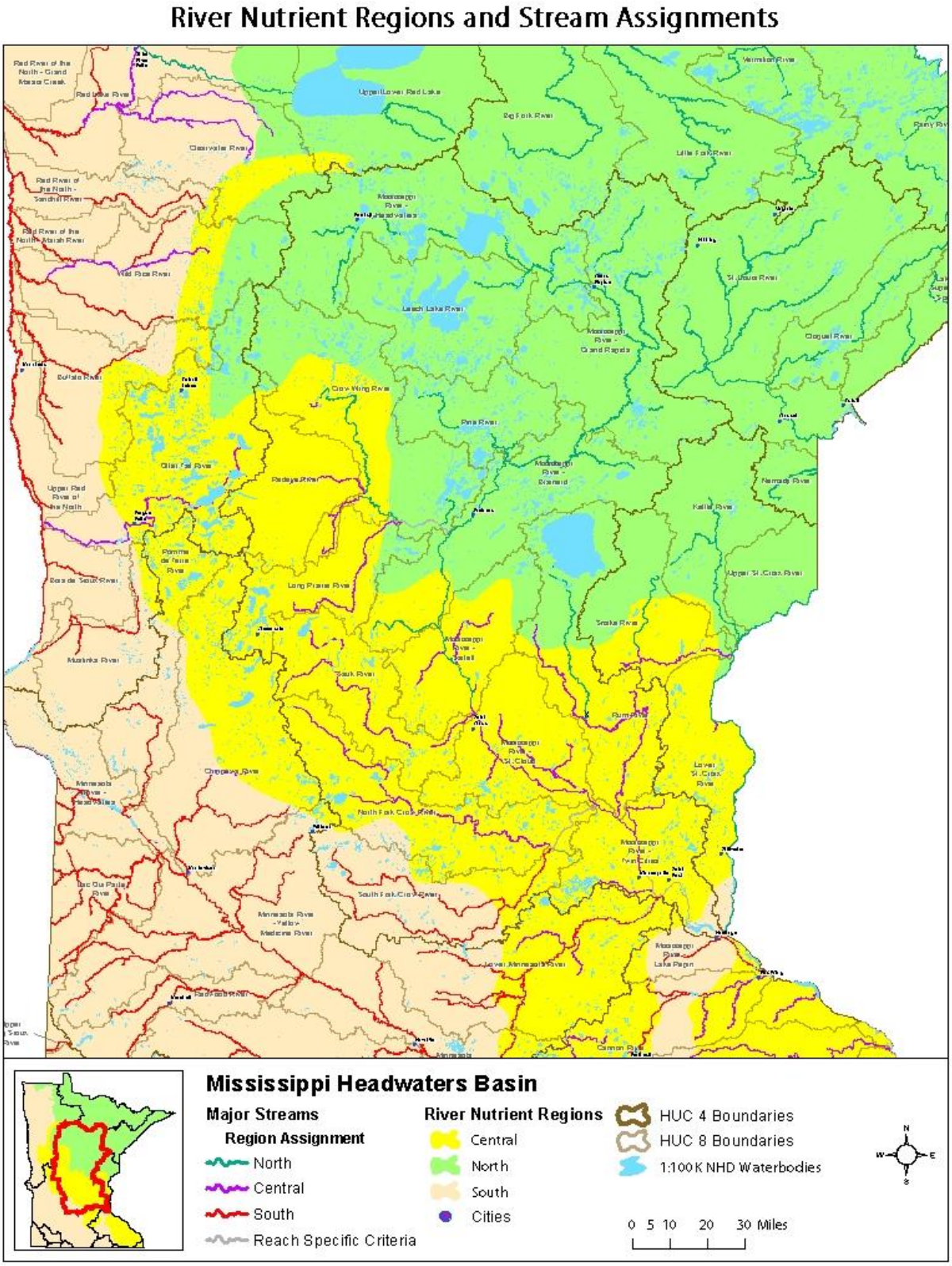
USEPA. 2000. Nutrient criteria technical guidance manual. Rivers and Streams. Office of Water, Washington DC EPA-822-B001-002

## Appendix

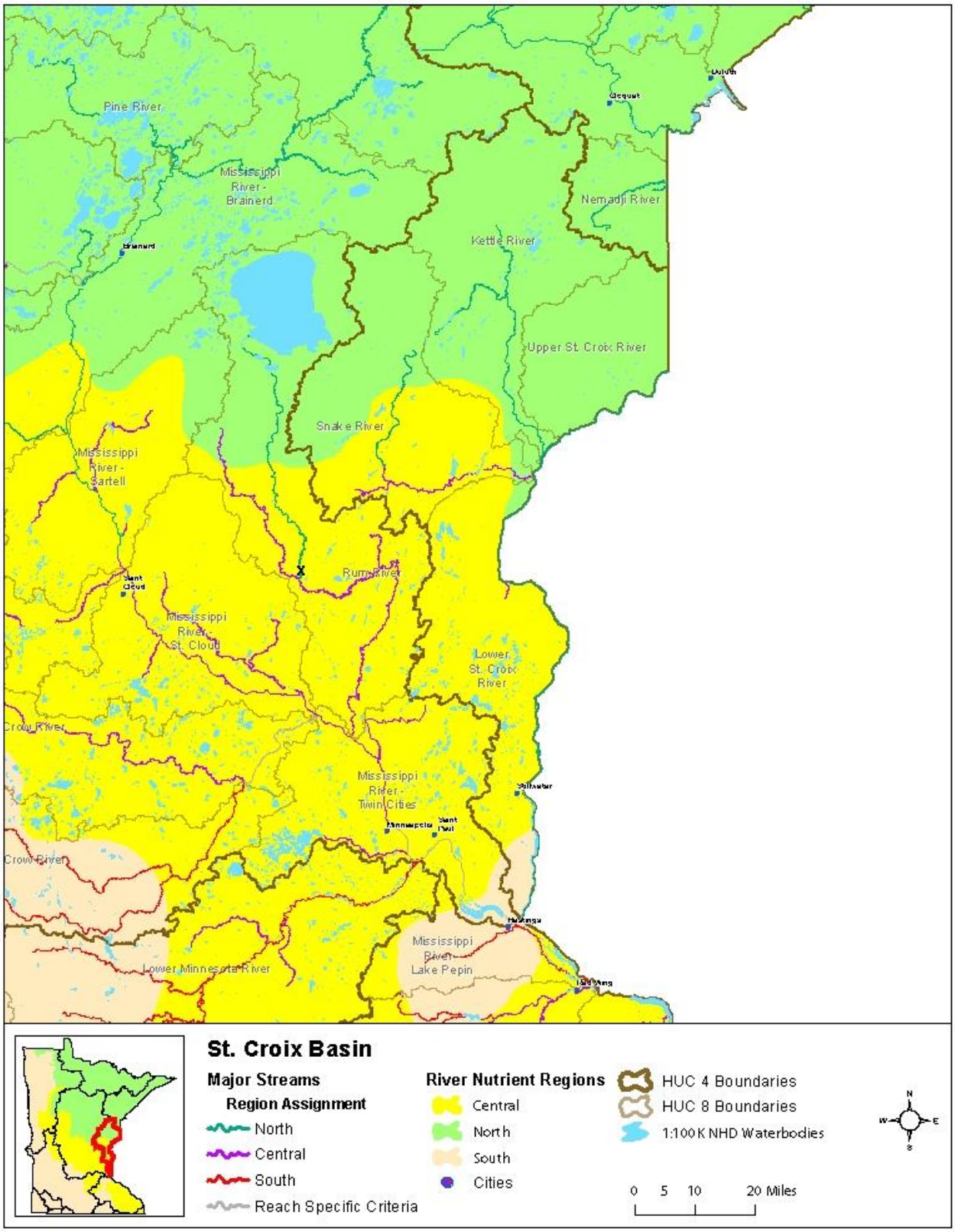
I. Basin-scale RNR maps: Upper Mississippi, St. Croix, Lower Mississippi, Minnesota, Red River, Rainy, and Lake Superior Basins.

II. HUC-8s with multiple RNRs and AUID specific designations: Crow Wing River, North Fork Crow River, Upper Mississippi River: Twin Cities Pools1-3, and Upper Mississippi River: Pool 4 (Lake Pepin) – Pool 8.

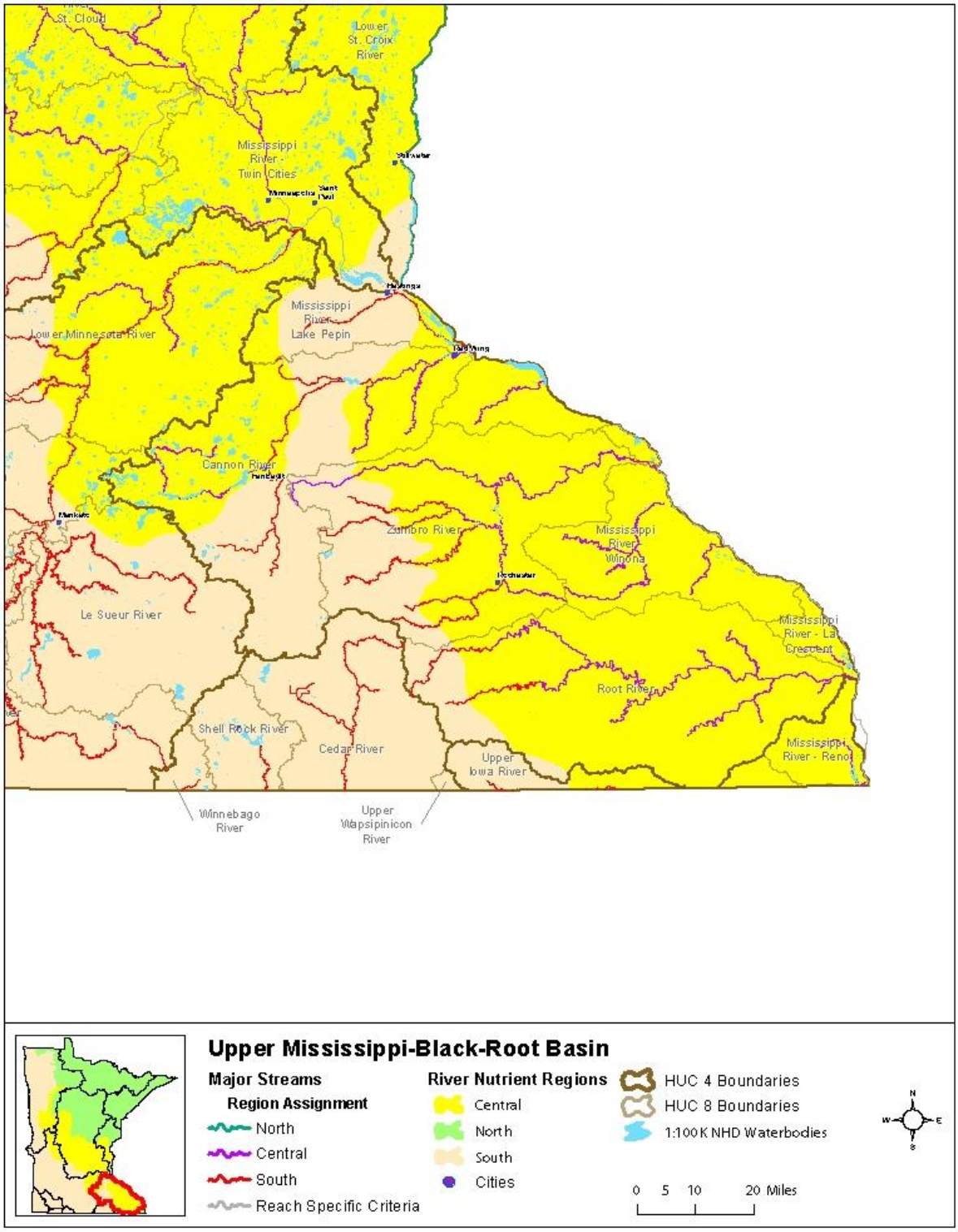
**Appendix I. Basin-scale maps**



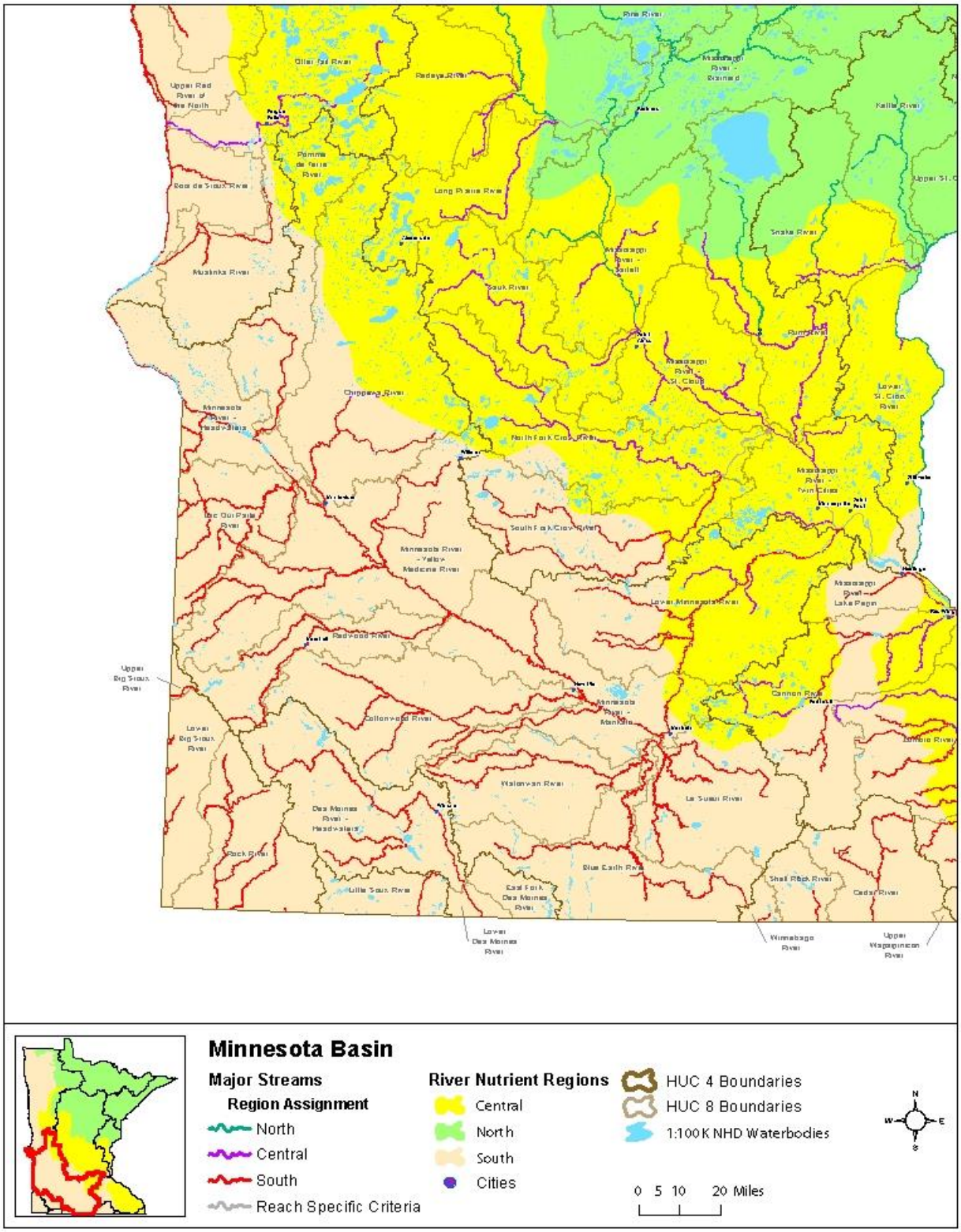
# River Nutrient Regions and Stream Assignments



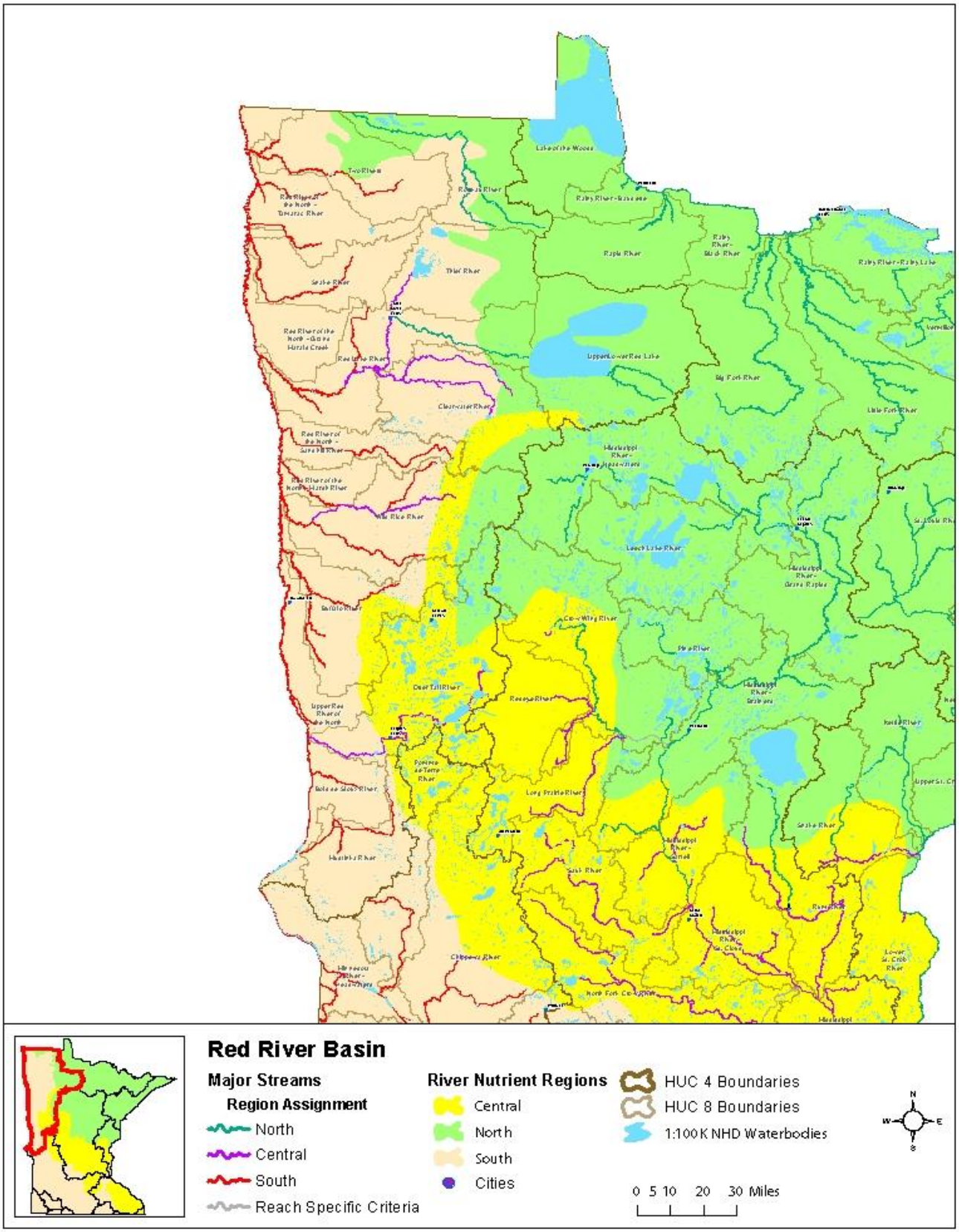
# River Nutrient Regions and Stream Assignments



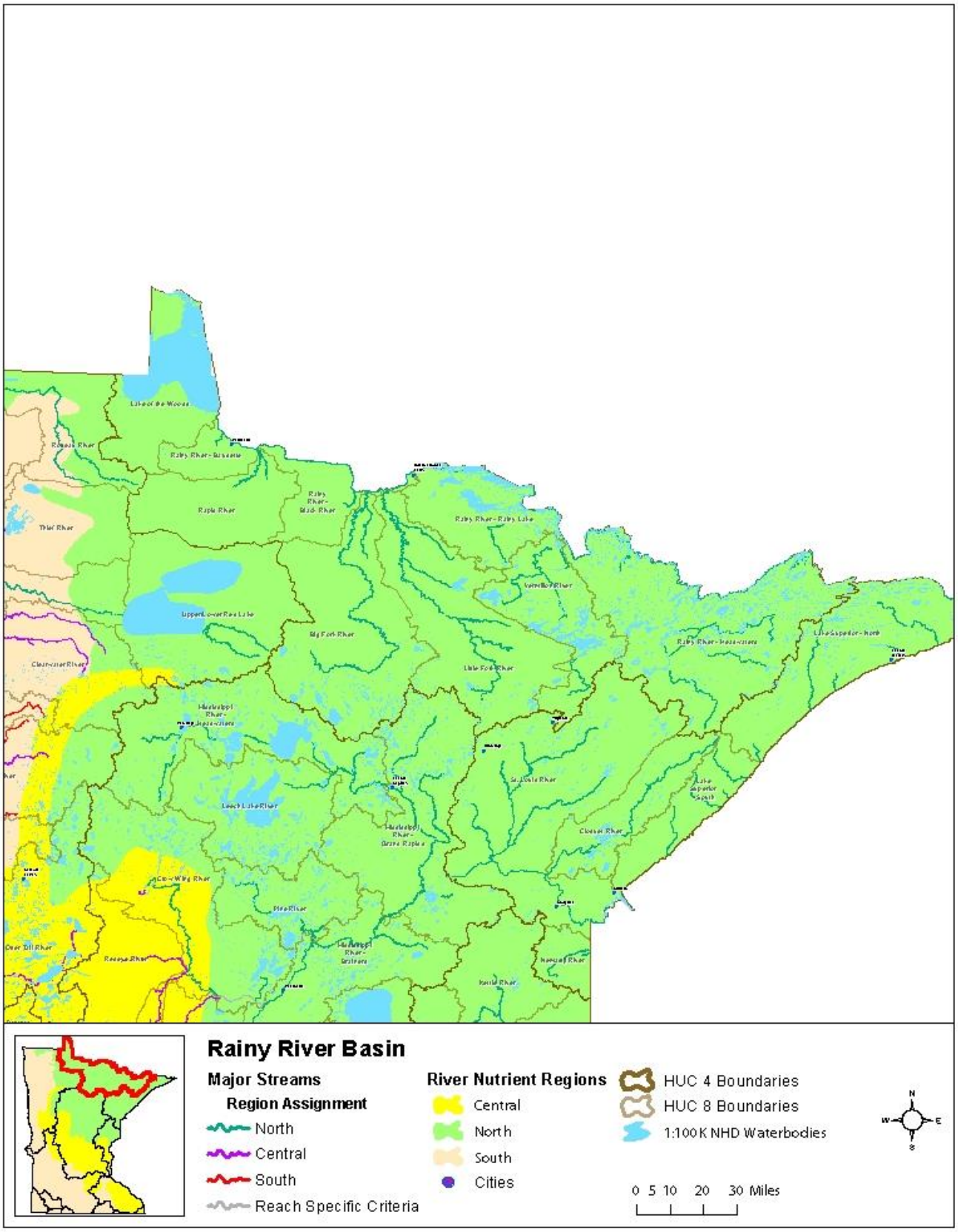
# River Nutrient Regions and Stream Assignments



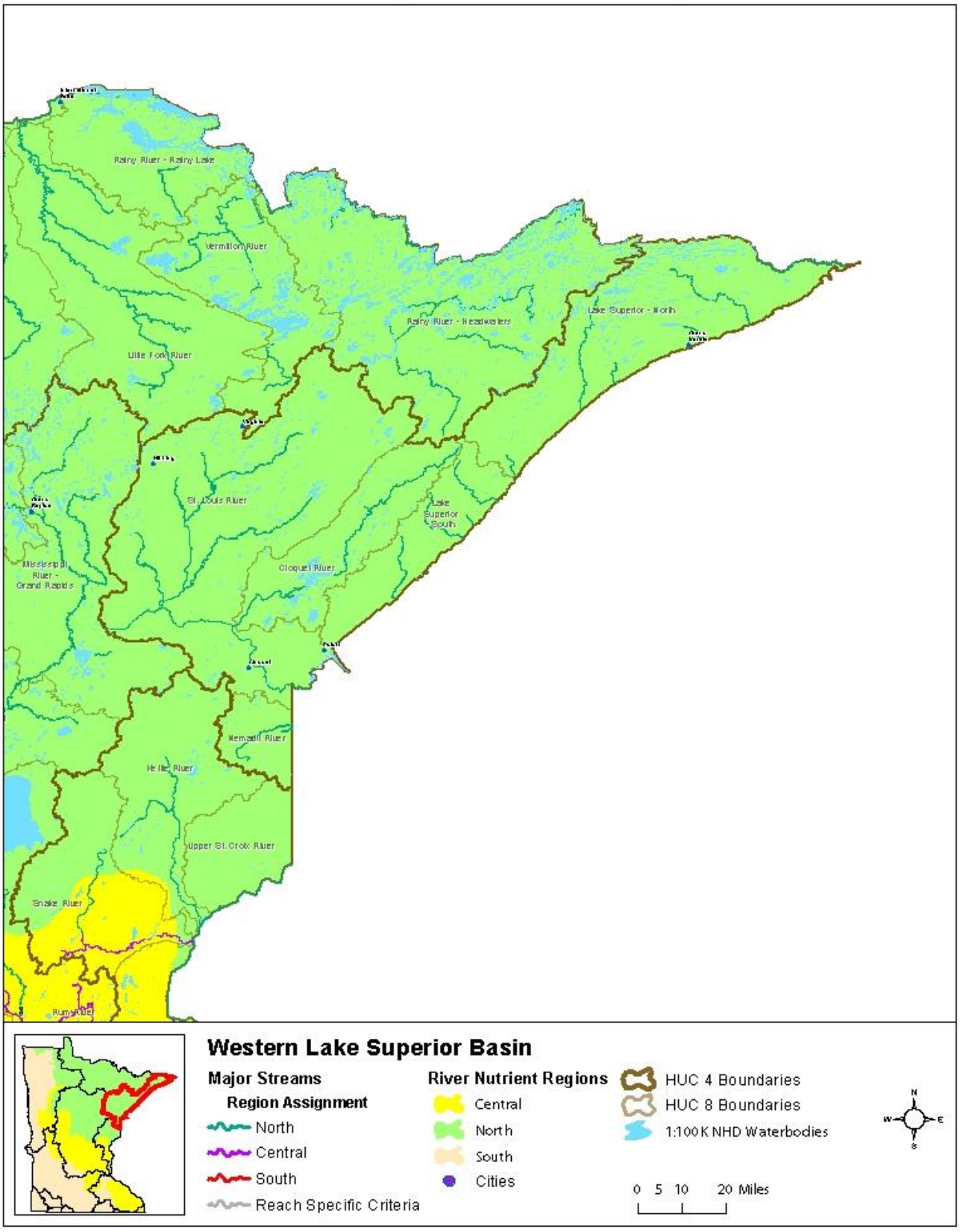
# River Nutrient Regions and Stream Assignments



# River Nutrient Regions and Stream Assignments

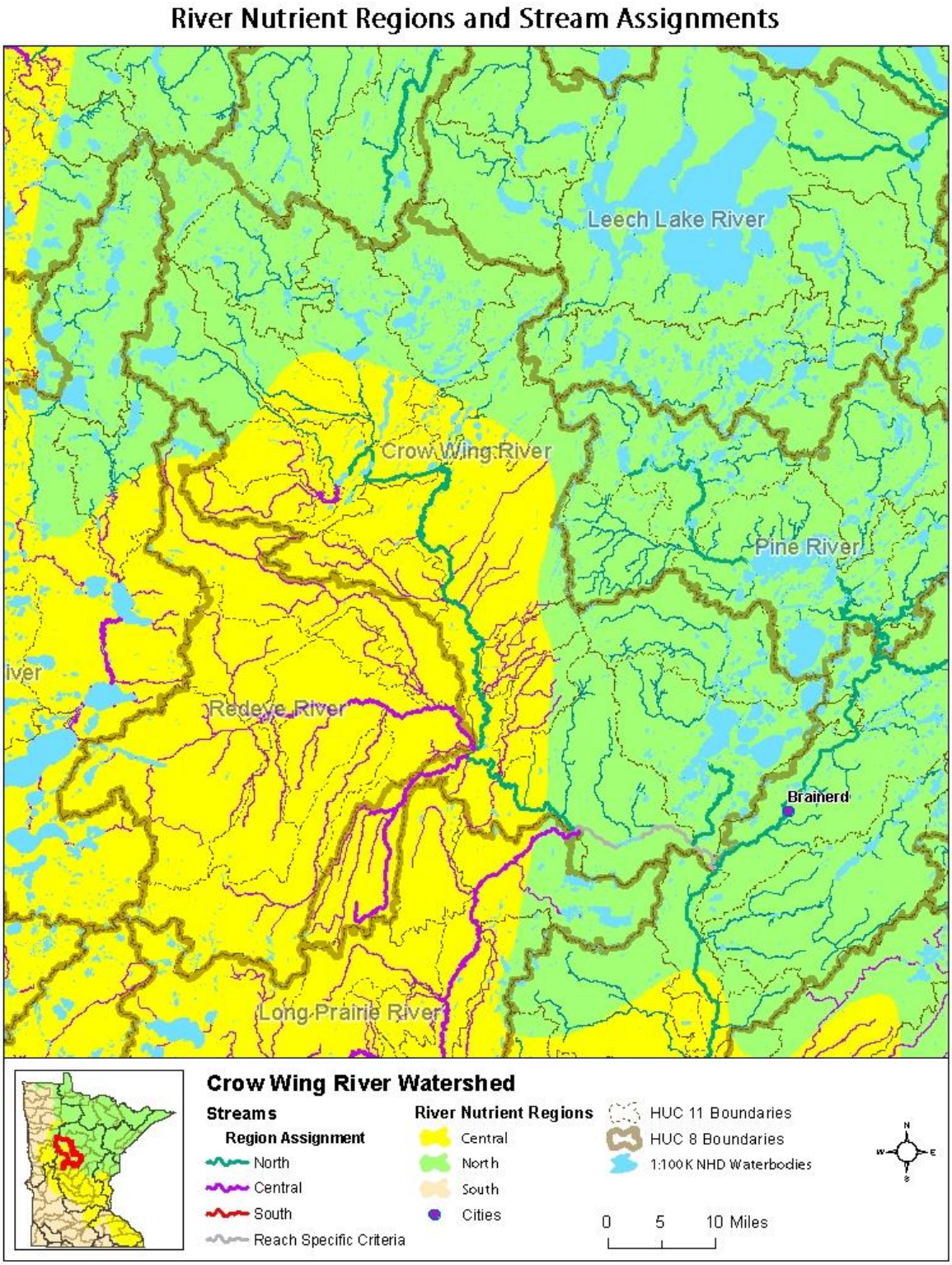


# River Nutrient Regions and Stream Assignments

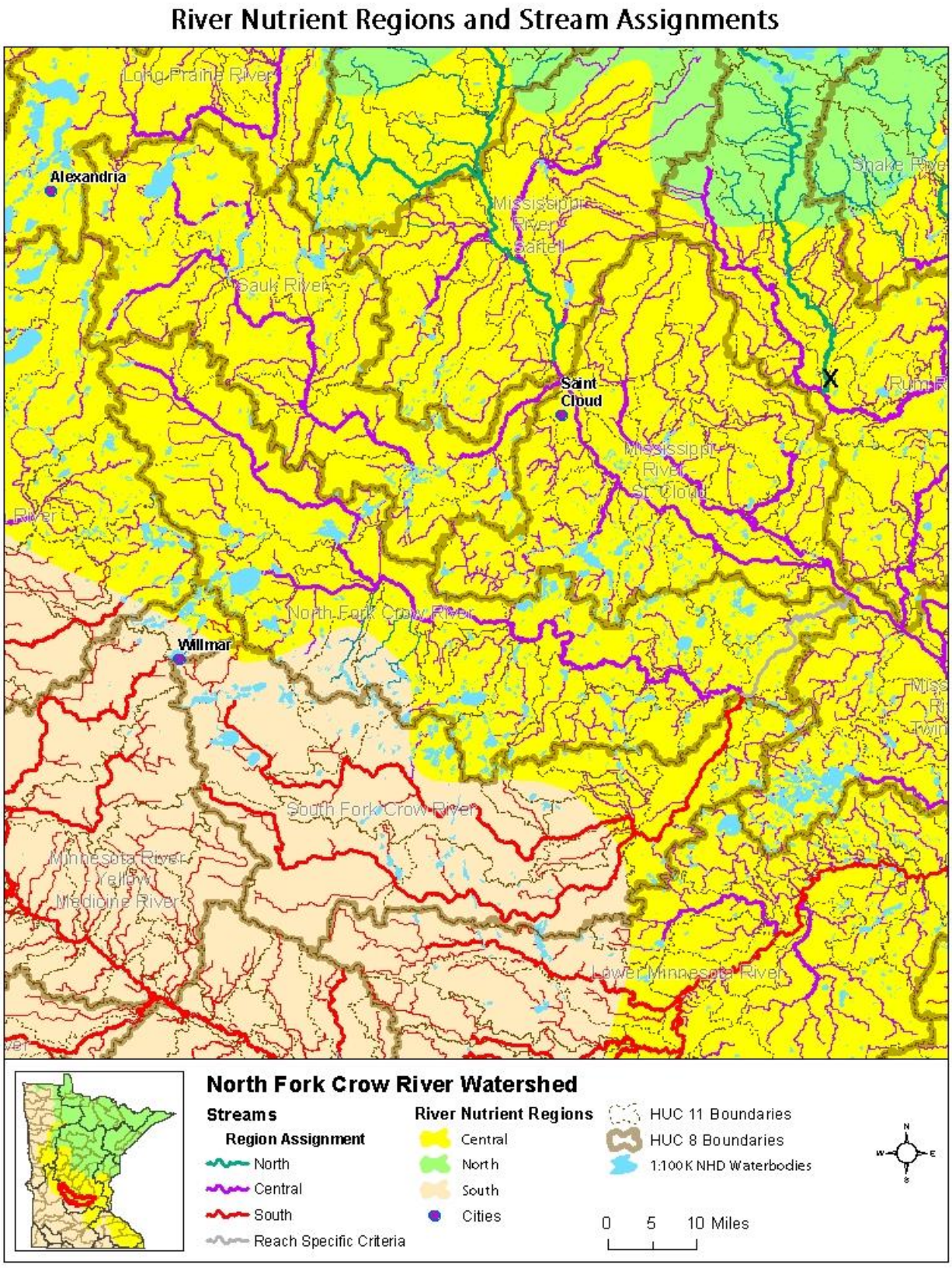


**Appendix II. HUC-8s with multiple RNRs and AUID specific designations**

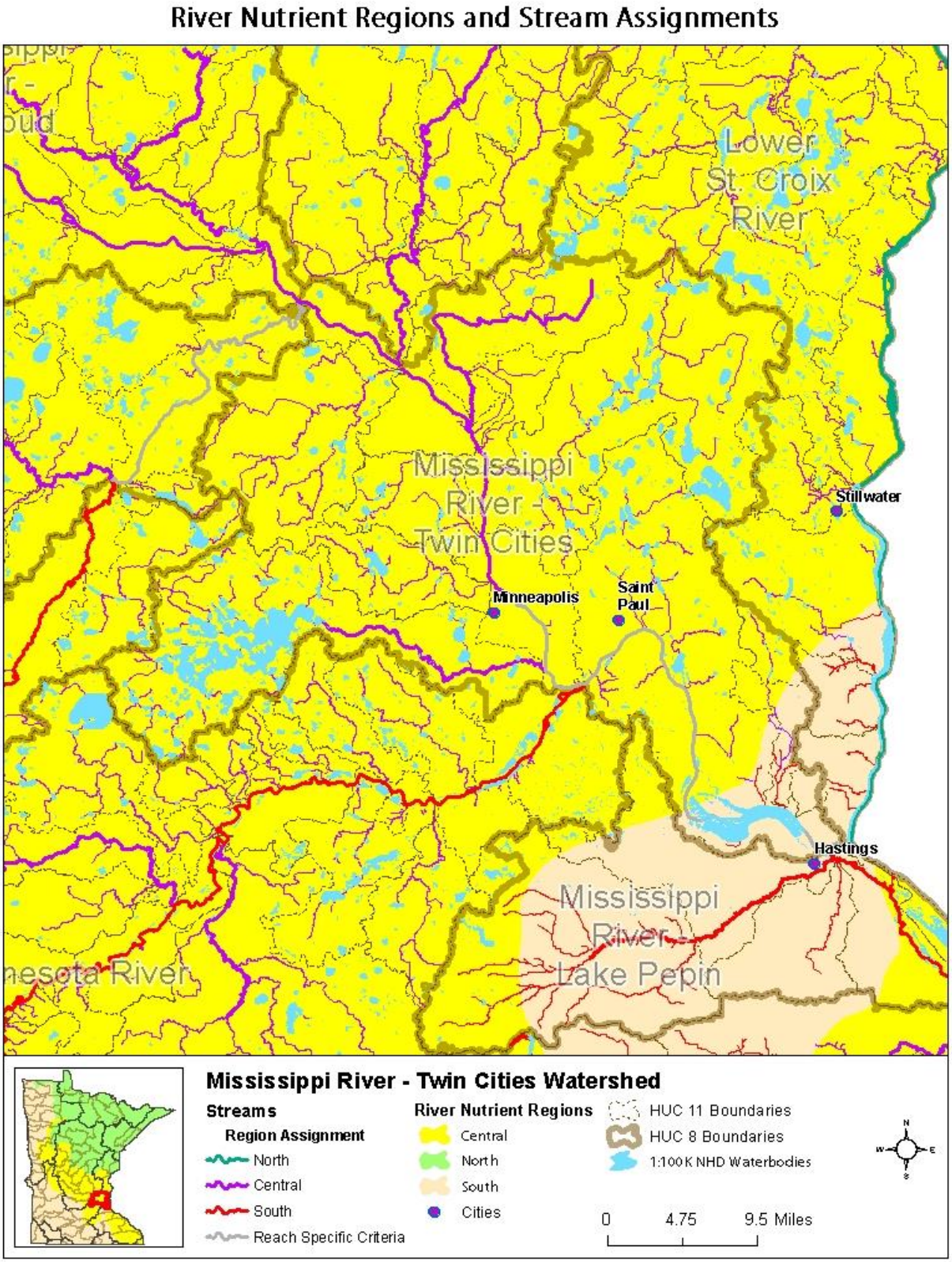
**Crow Wing River**



**North Fork Crow River**



**Mississippi River – Twin Cities Pools 1-3**



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