September 30, 2014

Dr. Charles Regan
Minnesota Pollution Control Agency
520 Lafayette Road North
St. Paul, MN 55155

Dear Dr. Regan:

RE: Model Resegmentation and Extension for Minnesota River Watershed Model Applications

The methodology documentation for updating the User Control Input (UCI) and Watershed Data Management (WDM) files for the HSPF model applications is completed for your review. The memorandum covers an overview of model development, in addition to the model resegmentation and extension for the following major watersheds:

- Hawk-Yellow Medicine (07020004)
- Chippewa (07020005)
- Redwood (07020006)
- Middle Minnesota (07020007)
- Cottonwood (07020008)
- Blue Earth (07020009)
- Watonwan (07020010)
- Le Sueur (07020011)
- Lower Minnesota (07020012).

Individual model applications were created for eight-digit hydrologic unit code (HUC8) watersheds. This memorandum refers to all areas collectively as the Missouri River Watershed. The methodology includes the following:

- Summary of model development
- Resegmentation of existing subwatersheds
- Extension of time-series data.

Model development for the Chippewa and Hawk-Yellow Medicine models has been reported by Tetra Tech [2011; 2012], and the model development documentation for the remaining Minnesota River Watersheds has also been documented [RESPEC, 2011]. Any changes from the methods described in the original documents are explained in the following sections.

MODEL DEVELOPMENT SUMMARY

The procedures followed for delineating subwatersheds, selecting primary reaches/lakes, creating function tables (F-tables), developing time-series data inputs, and determining pervious and impervious land (PERLND and IMPLND) land-cover categories are described in previous reports and memoranda [Tetra Tech, 2011, 2012; RESPEC, 2011]. Updated figures and a brief summary of model development are contained below. Figures for the Chippewa and Hawk-Yellow Medicine Watersheds are generally shown separately because their features are contained in a separate geodatabase.

Subwatershed Delineation and Reach/Lake Selection

The United States Geological Survey (USGS) Hydrologic Unit Code-12 (HUC12) watersheds were used as the basis for the Chippewa and Hawk-Yellow Medicine HSPF model subwatersheds, and the Minnesota Department of Natural Resources (MNDNR) Level 7 watersheds were used as the basis for the remaining models in the Minnesota River Watershed. The NHD flowline and waterbodies layers were used as the HSPF model stream network and lake selection, respectively. Because impaired streams are the highest priority, selecting these streams took precedence over NHD flowlines, regardless of length. In general, lakes were selected based on impairment status and relative size to other lakes in the watershed.

A total of 1,010 subwatersheds, 1,016 reaches, and 142 lakes were delineated, as shown in Table 1. These numbers include subwatersheds, reaches, and lakes that were added or removed during the resegmentation process, which is described later in this memorandum. The number of reaches is higher than subwatersheds because some reaches in the model are used for routing purposes only and do not have any land draining to them in the model. Some lakes were combined if they were hydraulically connected and contained within the same subwatershed. The delineation for the Minnesota River Watershed is shown in Figure 1, and a more detailed delineation for each of the nine model applications is shown in Attachment A.

Table 1. Number of Delineated Subwatersheds, Reaches, and Lakes for Each Model Application in the Minnesota River Watersheds

Model Application	Subwatersheds	Reaches	Lakes
Hawk-Yellow Medicine	78	79	7
Chippewa	66	68	7
Redwood	80	80	5
Middle Minnesota	129	129	13
Cottonwood	108	108	7
Blue Earth	124	124	16
Watonwan	80	80	8
Le Sueur	93	94	12
Lower Minnesota	252	254	67
Total	**1,010**	**1,016**	**142**

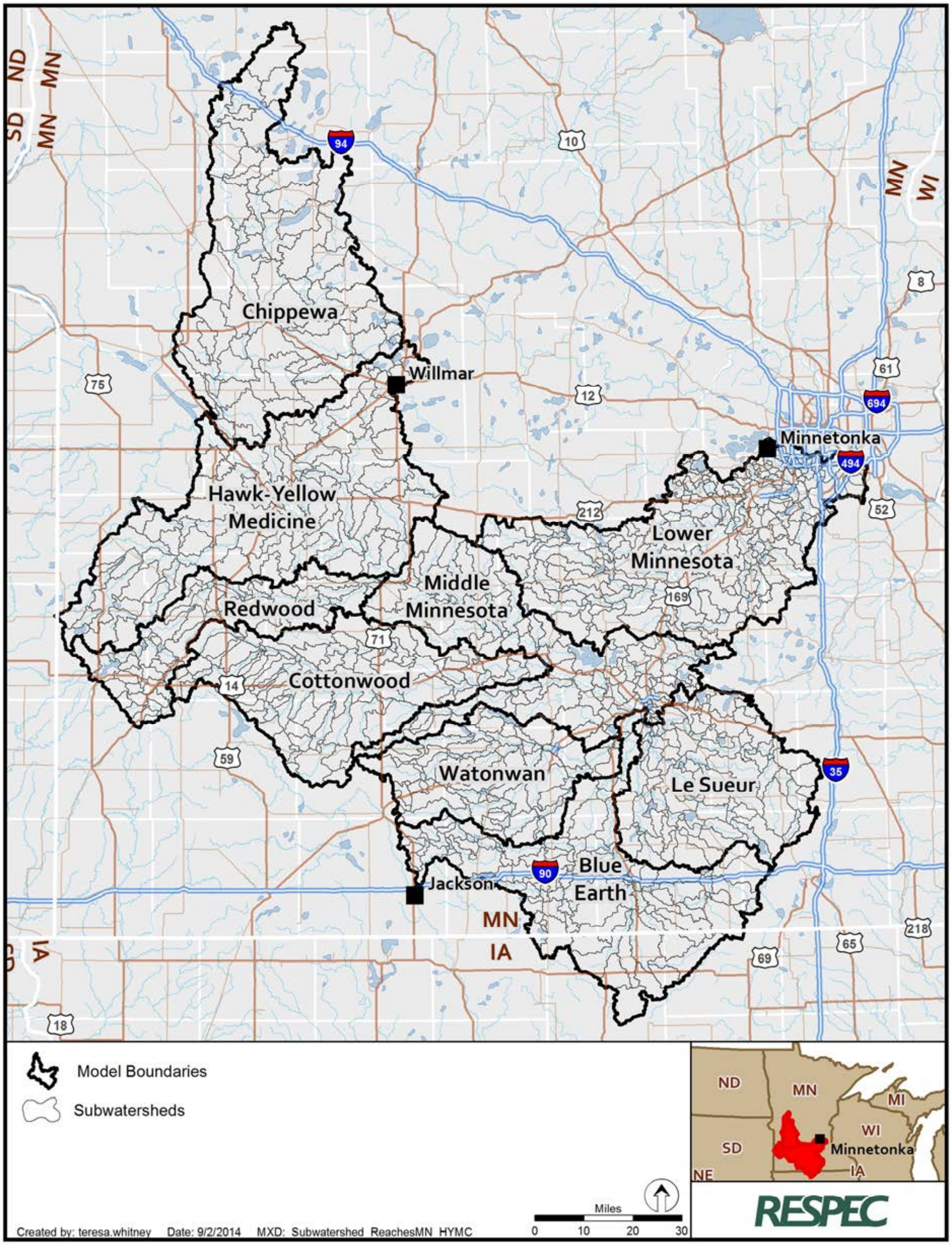

Figure 1. Subwatershed Delineation for the Minnesota River Watershed.

Time-Series Development

Separate WDM files were created for meteorological time series, point sources discharging within the watershed (i.e., added flow time series and pollutant loading), and a model linkage time series. The meteorological and point source WDM files were created for each individual model application, while the model linkage time series contains all model outflows and boundary conditions.

Meteorological data used in the HSPF model application were obtained from the U.S. Environmental Protection Agency's (EPA) BASINS system. Precipitation data were obtained through a combination of sources including BASINS, extensive supplementary HIDEN (HIgh spatial DENsity, daily observations) provided by the Minnesota Pollution Control Agency (MPCA), and Next Generation Radar (NEXRAD) provided by the North Central River Forecasting Center (NCRFC). The Chippewa HSPF model application was the only one that used NEXRAD data. The disaggregated-filled, daily Precipitation (PREC) time series allowed for the use of 147 unique PREC base stations (113 HIDEN, 29 BASINS, and 5 NEXRAD) to provide comprehensive spatial coverage of the watershed. An overall map of PREC stations for HUC8 07020005–07020012 is shown in Figure 2, with more detailed maps of individual model applications shown in Attachment B.

Observed discharge time series data were obtained to compare simulated discharge during model calibration. Observed discharge data were obtained as daily time series from the USGS, the MPCA, and the MNDNR. A summary of gage selection is provided in Table 2.

PERLND and IMPLND Category Development

The following discussion on PERLND and IMPLND category development pertains to HUC8 07020005–07020012 only. The PERLND and IMPLND categorization for the Chippewa and Hawk-Yellow Medicine model applications were previously developed and, therefore, have different land-cover aggregation schemes than the remaining Minnesota River Watershed model applications [Tetra Tech, 2011; 2012]. The main difference was that the model categories for the Chippewa and Hawk-Yellow Medicine Watersheds are further subdivided to include soil type, and slope. Furthermore, Municipal Separate Storm Sewer Systems (MS4), and feedlots were not included.

The 15 categories represented within the modeled area in the National Land-Cover Database (NLCD) 2001 and 2006 (Figure 3), were aggregated into relatively homogeneous model categories (Figure 4) based on the aggregation method in Table 3. Bluffs and ravines were also included as separate PERLND categories in the model applications.

Cropland was the predominant land-cover class in the Minnesota River Watershed. Because this land-cover class accounted for approximately 77 percent of the total area, it was refined to better represent agricultural practices within the watershed.

The remainder of the Minnesota River Watershed is composed of wetlands, forest, pasture, grassland, and developed area. Because of the relatively small areas represented by each of these classes, similar types of land use were aggregated (Table 3). Soil runoff potential was examined and did not result in any additional PERLND categories (Figure 5). Agricultural

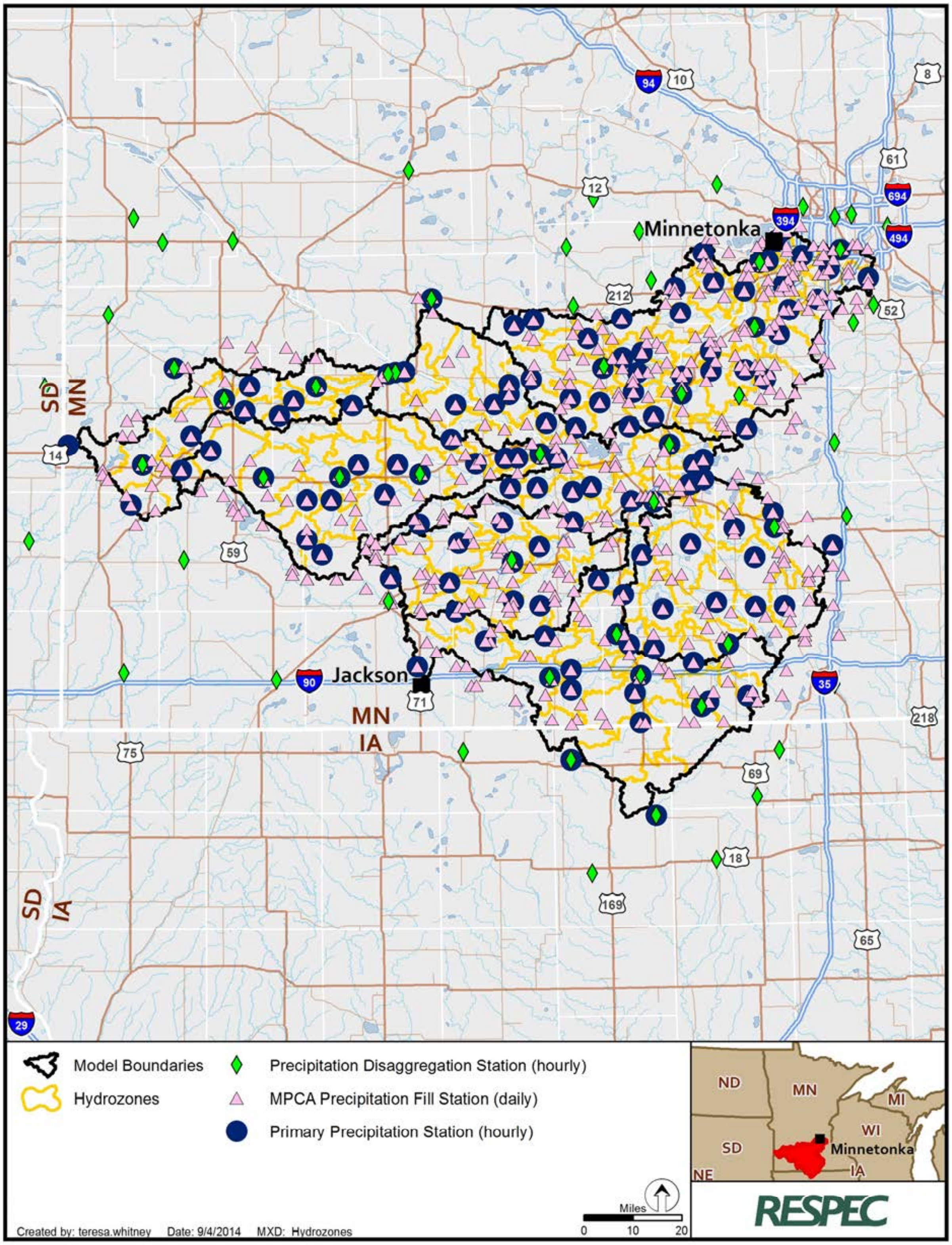

Figure 2. Hydrozones and Meteorological Stations.

Table 2. Summary of Flow Gage Data (Page 1 of 2)

Model Application	Source	Site I.D.	Reach	Longitude	Latitude
Hawk-Yellow Medicine	MNDNR	H25075001	101	–95.54	44.72
Hawk-Yellow Medicine	MNDNR	H25087001	104	–95.71	44.69
Hawk-Yellow Medicine	MNDNR	H25037001	201	–95.43	44.76
Hawk-Yellow Medicine	MNDNR	H25024001	202	–95.48	44.87
Hawk-Yellow Medicine	MNDNR	H25007001	213	–95.15	45.09
Hawk-Yellow Medicine	MNDNR	H25027001	217	–95.43	44.86
Hawk-Yellow Medicine	MNDNR	H25053002	230	–95.05	44.58
Hawk-Yellow Medicine	MNDNR	H25047001	231	–95.02	44.67
Hawk-Yellow Medicine	USGS	5311000	308	–95.73	44.93
Chippewa	USGS	5304500	106	–95.80	45.11
Chippewa	MNDNR	H26037001	115	–95.62	45.31
Chippewa	MNDNR	H26003001	119	–95.76	45.70
Chippewa	MNDNR	H26088001	136	–95.59	45.35
Chippewa	MNDNR	H26038001	150	–95.61	45.20
Chippewa	MNDNR	H26078001	159	–95.77	45.05
Redwood	MNDNR	H27043001	190	–95.95	44.32
Redwood	USGS	5315000	210	–95.85	44.43
Redwood	MPCA	H27039001	313	–95.76	44.54
Redwood	MPCA	H27030001	443	–95.32	44.48
Redwood	USGS	5316500	450	–95.17	44.52
Middle Minnesota	MPCA	H28098001	11	–95.05	44.54
Middle Minnesota	USGS	5316580	30	–95.00	44.55
Middle Minnesota	MPCA	H28102001	75	–94.89	44.51
Middle Minnesota	MPCA	H28095001	151	–94.80	44.46
Middle Minnesota	MPCA	H28094001	191	–94.69	44.40
Middle Minnesota	MPCA	H29017001	353	–95.04	44.11
Middle Minnesota	USGS	5317200	377	–94.34	44.25
Middle Minnesota	MNDNR	E28054001	430	–94.19	44.20
Middle Minnesota	MPCA	H28045001	475	–94.22	44.10
Middle Minnesota	MPCA	H28045002	475	–94.23	44.08
Middle Minnesota	USGS	5325000	530	–94.00	44.17
Middle Minnesota	MPCA	H28062001	573	–94.08	44.29
Middle Minnesota	MPCA	H28066001	577	–94.08	44.28
Middle Minnesota	MPCA	H28063002	579	–94.06	44.25
Middle Minnesota	MPCA	H28063001	583	–94.03	44.26
Cottonwood	MPCA	H29048001	189	–95.41	44.28
Cottonwood	MNDNR	H29053001	215	–95.33	44.22
Cottonwood	MNDNR	H29053002	215	–95.35	44.22

Table 2. Summary of Flow Gage Data (Page 2 of 2)

Model Application	Source	Site I.D.	Reach	Longitude	Latitude
Cottonwood	MNDNR	H29062002	230	–95.24	44.24
Cottonwood	MNDNR	H29065001	279	–95.26	44.17
Cottonwood	MNDNR	H29065005	279	–95.26	44.15
Cottonwood	MNDNR	H29015001	330	–95.05	44.20
Cottonwood	MPCA	H29022001	370	–94.81	44.23
Cottonwood	MPCA	H29011001	407	–94.81	44.25
Cottonwood	USGS	5317000	490	–94.44	44.29
Blue Earth	MPCA	H30028001	243	–94.22	43.72
Blue Earth	MPCA	H30051001	315	–94.29	43.76
Blue Earth	USGS	5320000	410	–94.11	44.10
Watonwan	MNDNR	H31030001	90	–94.66	44.06
Watonwan	MPCA	H31040001	110	–94.55	44.06
Watonwan	MPCA	H31028001	150	–94.50	44.06
Watonwan	MPCA	H31021001	201	–94.47	44.03
Watonwan	USGS	5319500	270	–94.19	44.05
Le Sueur	MNDNR	H32002002	613	–93.61	44.16
Le Sueur	MNDNR	H32002003	613	–93.61	44.16
Le Sueur	MPCA	H32079001	650	–93.85	44.08
Le Sueur	MPCA	H32076001	710	–93.99	44.08
Le Sueur	USGS	5320270	743	–93.91	44.00
Le Sueur	MPCA	H32073001	747	–93.96	44.02
Le Sueur	MPCA	H32071001	749	–94.00	44.05
Le Sueur	MPCA	H32062001	811	–94.07	43.93
Le Sueur	MPCA	H32072001	817	–94.03	44.07
Le Sueur	USGS	5320500	830	–94.04	44.11
Lower Minnesota	MPCA	H33069001	83	–94.15	44.48
Lower Minnesota	MPCA	H33071001	103	–94.09	44.51
Lower Minnesota	MPCA	H33065001	125	–94.15	44.47
Lower Minnesota	MPCA	E33068001	135	–94.12	44.44
Lower Minnesota	MPCA	H33096001	139	–93.91	44.50
Lower Minnesota	MPCA	H33010001	179	–94.47	44.66
Lower Minnesota	MPCA	H33003001	189	–94.32	44.68
Lower Minnesota	MPCA	H33075001	197	–94.09	44.62
Lower Minnesota	MPCA	H33092002	209	–94.05	44.56
Lower Minnesota	MPCA	H33092001	211	–93.93	44.56
Lower Minnesota	USGS	5327000	217	–93.92	44.57
Lower Minnesota	USGS	5330000	310	–93.64	44.69
Lower Minnesota	USGS	5330920	710	–93.19	44.87

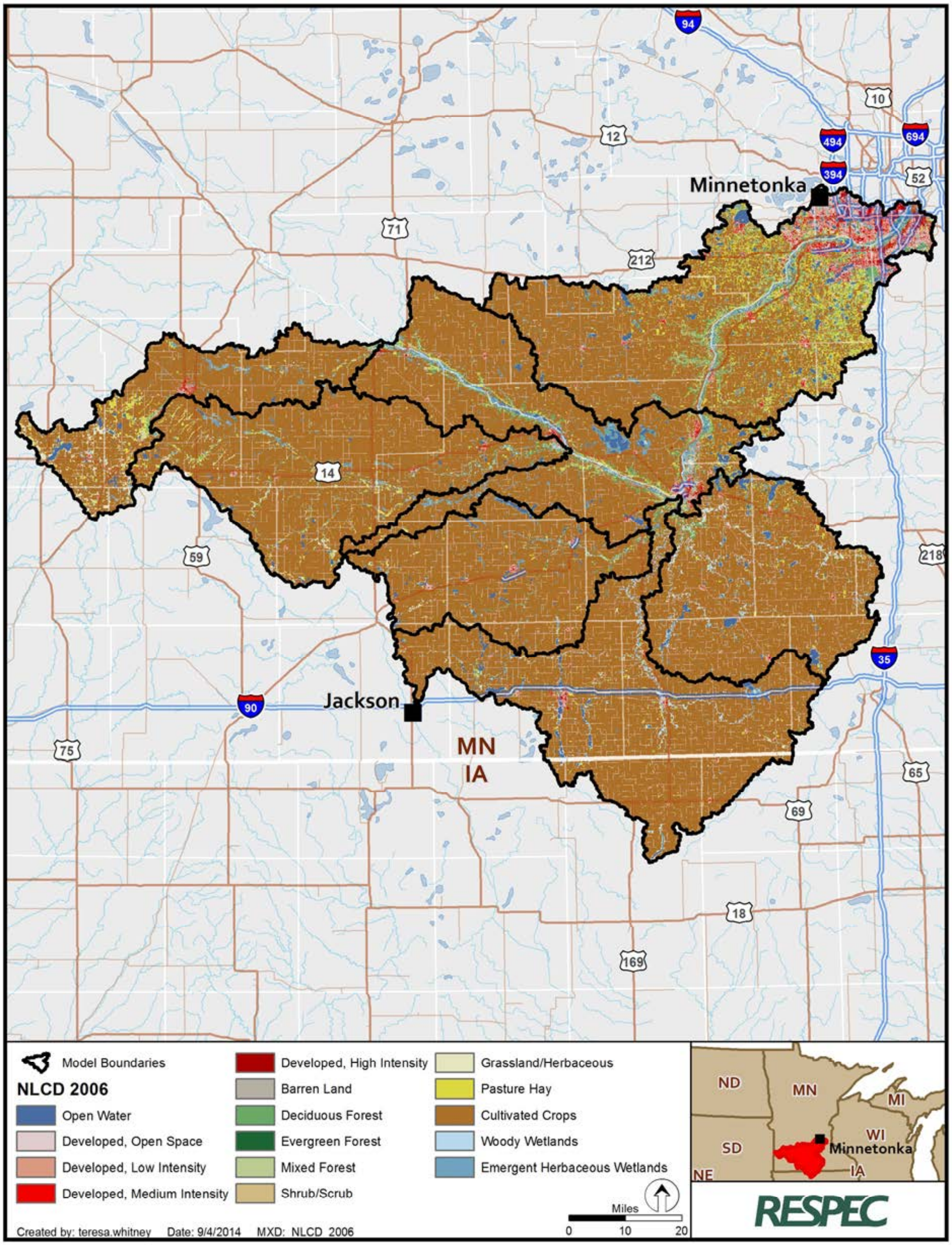

Figure 3. National Land-Cover Database 2006 Land-Cover Distribution Used to Develop Model Land-Cover Categories.

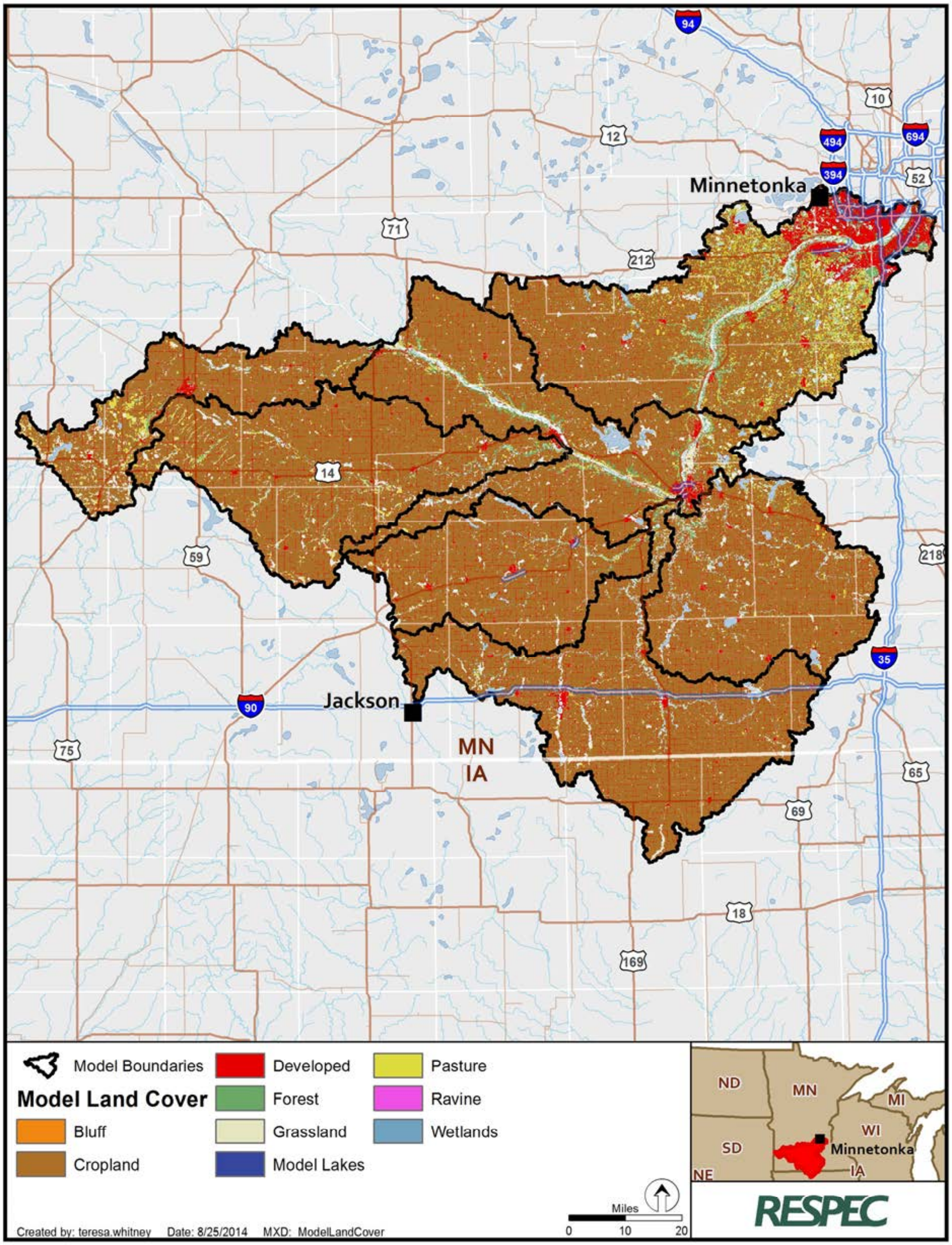

Figure 4. Aggregated Land-Cover Categories Used in the Minnesota River Watershed.

practices such as tillage (Figure 6) and feedlots (Figure 7) took precedence over soil type and were incorporated in the PERLND development procedures. These practices were selected for explicit representation, not only for their influence on hydrologic and water-quality processes, but also for their future use in modeling management scenarios.

Table 3. Summary of 2001 and 2006 National Land-Cover Database Categories Aggregated Into Model Categories for the Minnesota River Watersheds HUC8 07020005–07020012

NLCD Category	Percent of Watershed (2001)	Percent of Watershed (2006)	Model Category	Percent of Watershed (2001)	Percent of Watershed (2006)
Developed, Open Space	5.51	5.52	Developed	8.28	8.51
Developed, Low Intensity	1.71	1.74			
Developed, Medium Intensity	0.76	0.91			
Developed, High Intensity	0.30	0.34			
Barren Land	0.10	0.11	Grassland	2.40	2.39
Shrub/Scrub	0.42	0.42			
Herbaceuous	1.88	1.86			
Deciduous Forest	2.76	2.75	Forest	2.83	2.82
Evergreen Forest	0.04	0.04			
Mixed Forest	0.03	0.03			
Hay/Pasture	3.50	3.40	Pasture	3.50	3.40
Cultivated Crops	77.33	77.11	Cropland	77.33	77.11
Woody Wetlands	0.90	0.92	Wetland	5.66	5.77
Emergent Herbaceuous Wetlands	2.83	2.81			
Open Water	1.93	2.04			

An estimated 5,305 Animal Feeding Operations (AFOs) exist within the watershed. Although AFOs represent a small percentage of the total watershed area (0.19 percent), they are important to represent because of their potential to significantly impact water quality. Spatial location (point features) and animal data (i.e., type and count) for the AFOs were obtained from the MPCA and the Iowa Department of Natural Resources (IDNR). Areas for each AFO were estimated based on the typical design specification of 300 square feet per animal unit [Murphy and Harner, 2001]. The individual calculated areas were removed from the mapped category where each AFO is located and into the feedlot category.

Currently, 51 regulated MS4s are located in the watershed (Figure 7). Those areas were parameterized the same as non-MS4 areas within the same land classification, but were given different mass links in the schematic block. This method was selected because modeling scenarios with MS4s is still possible but does not need the input of additional operations. Unique pervious and impervious classifications were developed based on watershed characteristics described above (Figure 8).

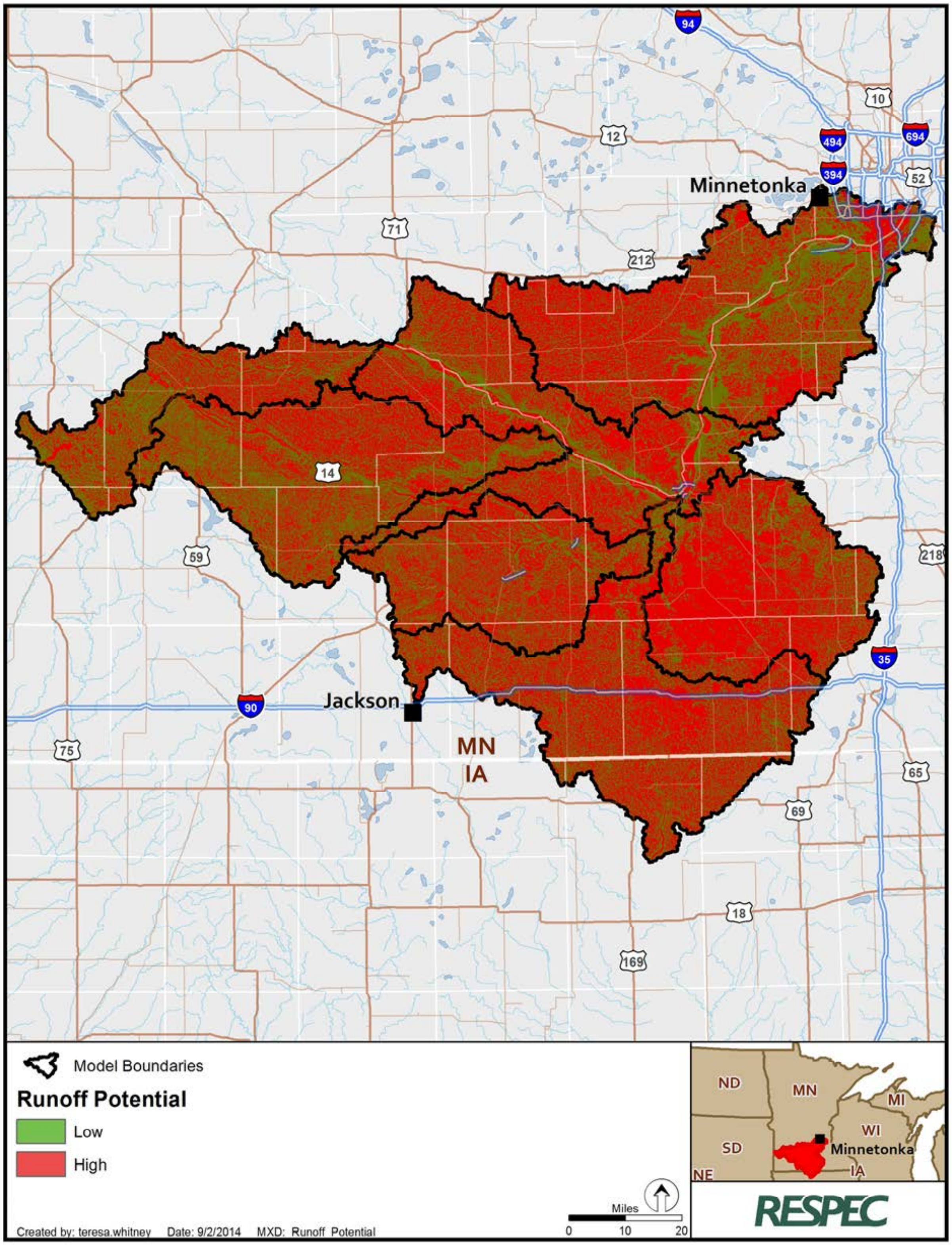

Figure 5. Distribution of Runoff Potential in the Minnesota River Watershed.

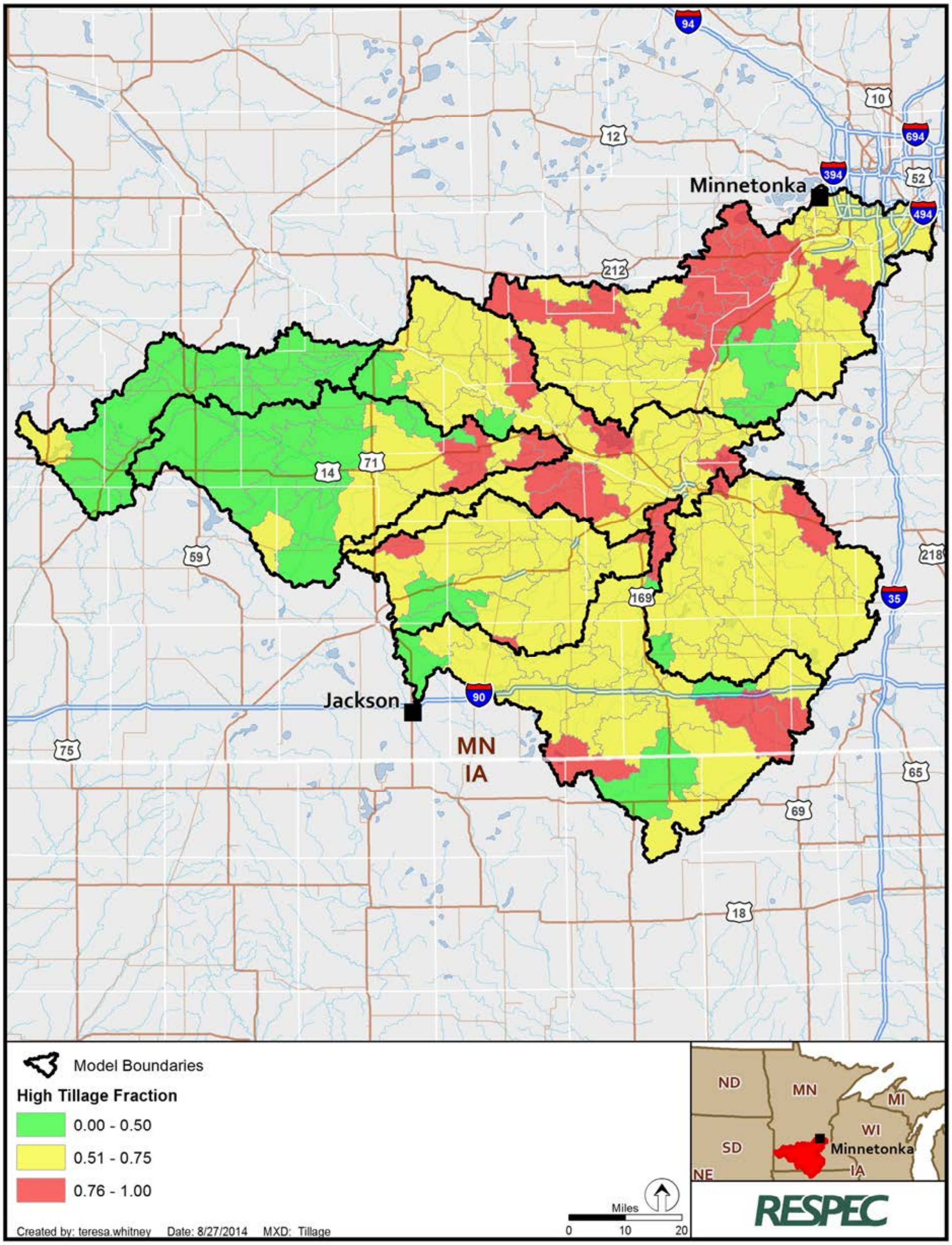

Figure 6. Percent Tillage Estimates Within Each Hydrozone in the Minnesota River Watershed.

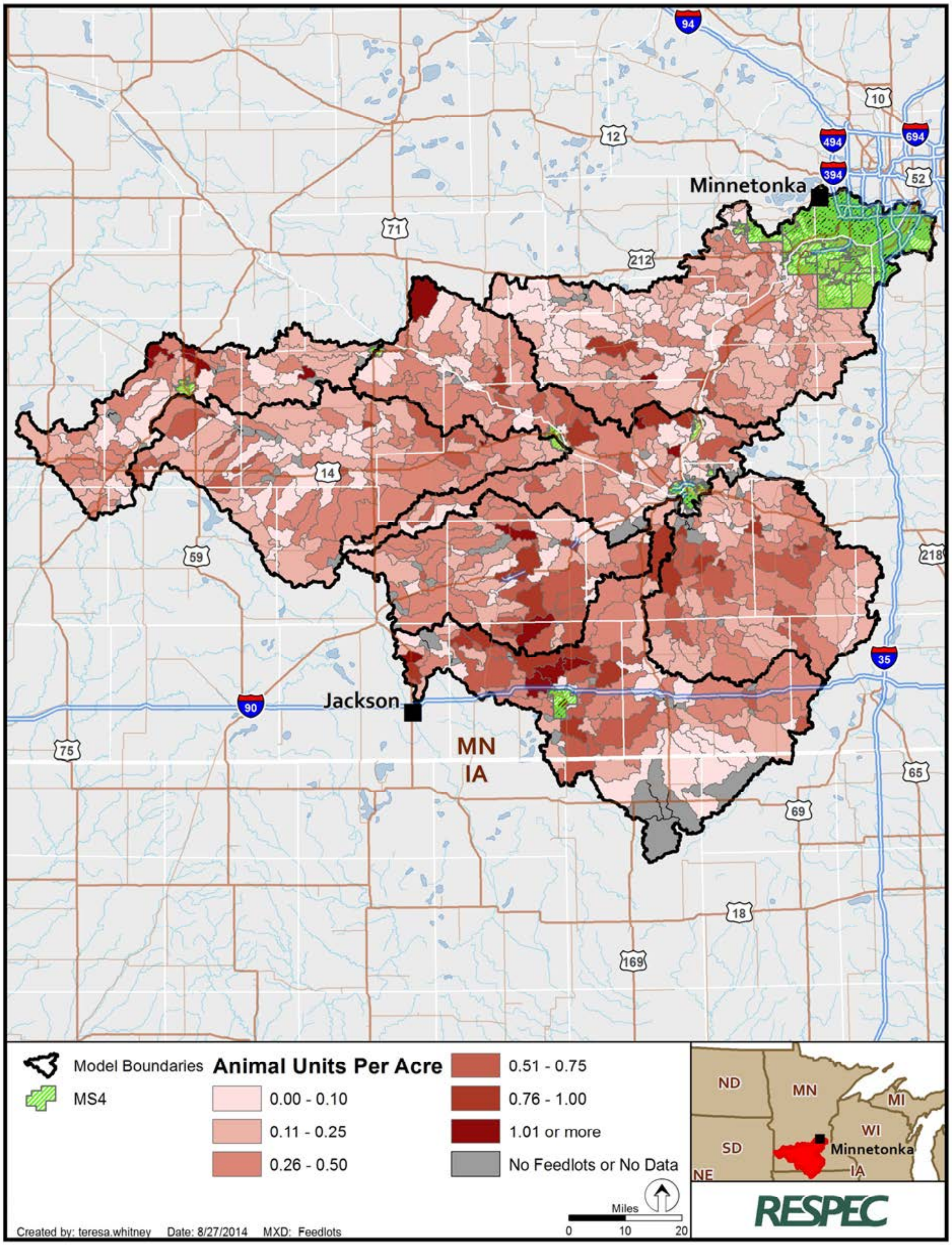

Figure 7. Animal Unit Densities Within Each Subwatershed and the MS4s in the Minnesota River Watershed.

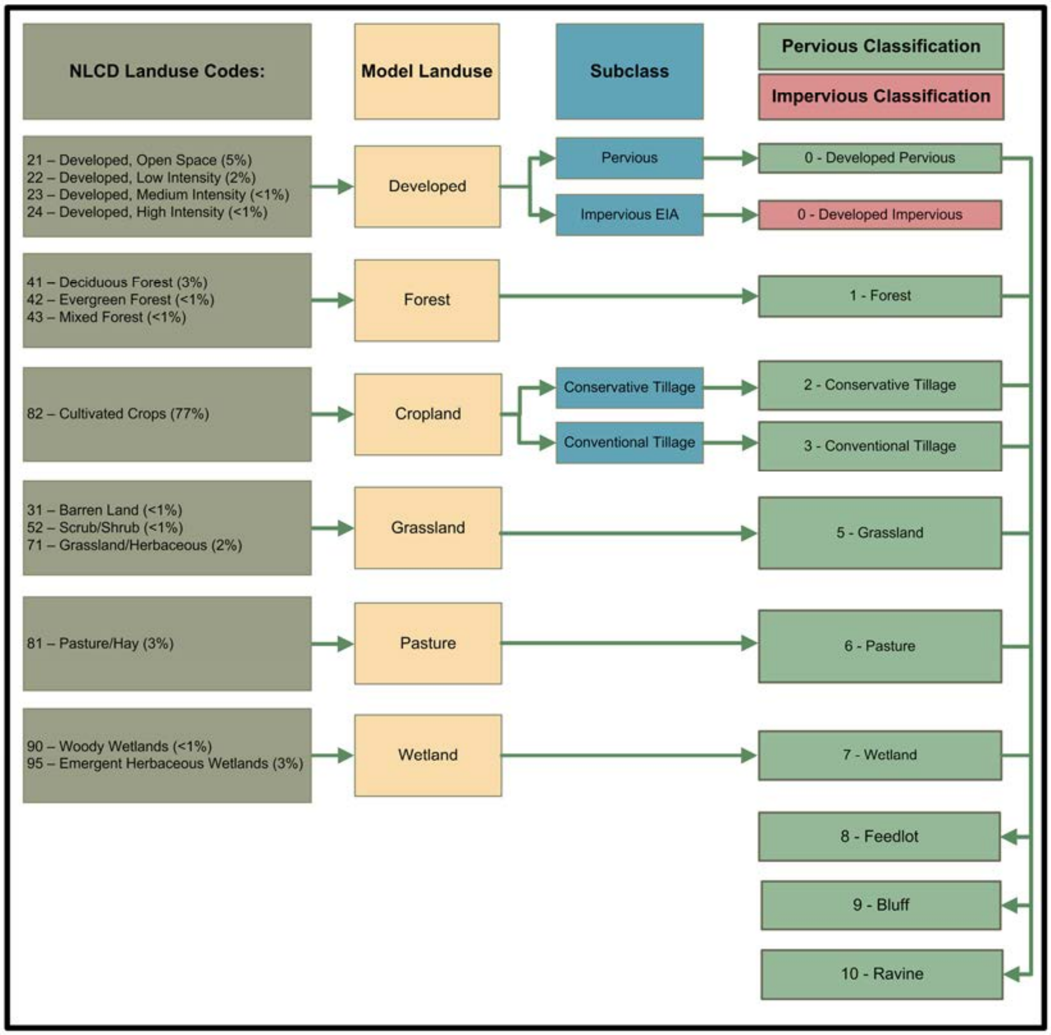

Figure 8. Model Classification for PERLND and IMPLND Development for the Minnesota River Watersheds HUC8 07020005–07020012.

RESEGMENTATION OF EXISTING SUBWATERSHEDS

A total of 88 potential resegmentation locations were initially provided by the MPCA. Fourteen priority locations were identified based on the provided lists of impaired streams, impaired lakes, and sampling location data (Table 4). Selecting watersheds to be further delineated or reaches to be extended was largely based on the impairment type and impairment endpoint location. Resegmentation at monitoring locations only occurred if the site was on an existing model reach and was upstream of a confluence within the same subwatershed. RESPEC [2014] discussed detailed methods and examples for the resegmentation process.

In some cases, reaches and subwatersheds had to be renumbered. Once the resegmentation was completed in Geographic Information System (GIS), physical attributes were recalculated (i.e., slope, area, length, land use distribution) and the UCI updated. Changes made to the UCI files included recalculating SCHEMATIC areas and F-table relationships, as well as updating RCHRES and PERLND parameter blocks.

Table 4. Summary of Resegmentation Actions Taken for the 14 Priority Locations

Model Application	Reach	Action Taken
Hawk-Yellow Medicine	118	Reach length added
Hawk-Yellow Medicine	202	Split subwatersed and reach
Hawk-Yellow Medicine	217	Split subwatershed, add reach
Hawk-Yellow Medicine	306	Split subwatersed and reach
Chippewa	3	Split subwatershed, add reach
Chippewa	50	Split subwatershed twice, add reaches
Chippewa	53	Split subwatersed and reach
Cottonwood	215	Split subwatersed and reach
Lower Minnesota	65	Split subwatersed and reach
Lower Minnesota	365	Split subwatersed and reach
Lower Minnesota	516	Split subwatershed twice, add reaches
Lower Minnesota	556	Routing reach added
Lower Minnesota	582	Routing reach added, renumbered
Lower Minnesota	626	Split subwatersed, add reach length

EXTENSION OF TIME-SERIES DATA

This section describes the procedures used to extend the existing meteorological, point source, and atmospheric deposition time series (1995–2009) through 2012.

Because the BASINS database has not been updated since 2009, additional meteorological data were obtained through a variety of sources to extend those time series. The Automated Surface/Weather Observing System (ASOS/AWOS) and the National Weather Service Cooperative Network (COOP) data were provided by the Midwestern Regional Climate Center (MRCC) and HIDEN data was provided by the MPCA. Selecting the new meteorological data used to extend the existing time series was based on the proximity to an existing station, as well as the completeness and quality of data. All of the extension data were processed before appending or filling the existing time series. In general, the extension sites overlapped with the existing BASINS met locations with an average distance of 1 mile between sites (Figure 9).

Precipitation

The original and existing PREC time series consisted of BASINS and HIDEN stations, with the addition of NEXRAD data for the Chippewa model application. Daily COOP and hourly ASOS/AWOS stations were filled with the nearest like station until no missing values remained. Filled daily precipitation stations were disaggregated in WDMUtil to an hourly time series by using the filled hourly ASOS/AWOS sites and a 90 percent data tolerance. The existing BASINS stations were then appended with the nearest filled/disaggregated extension station. Six of the ASOS/AWOS precipitation records were suspect (less than 5 inches annually when surrounding stations recorded 25 inches) so the next closest station was used to append the BASINS data.

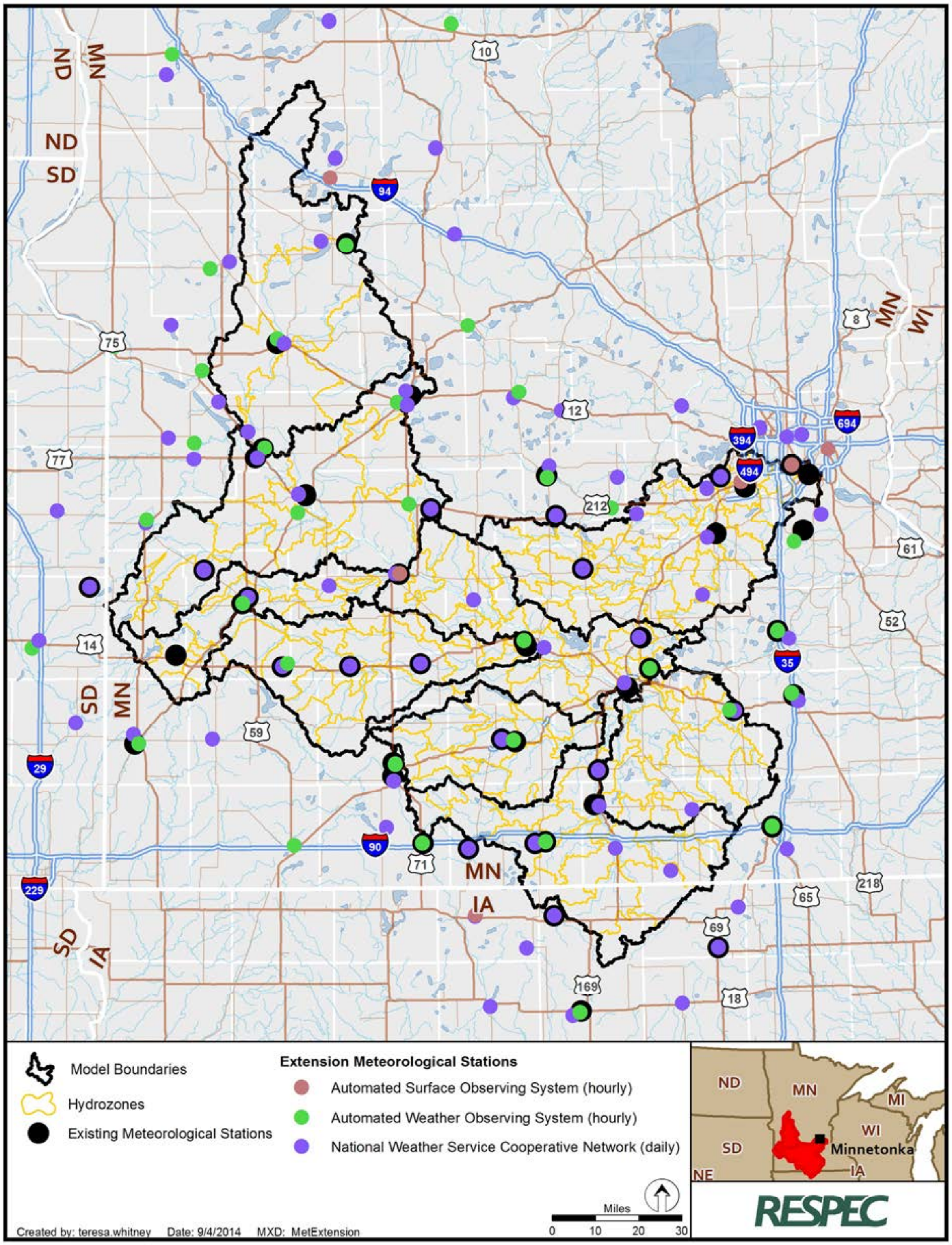

Figure 9. Existing and Extension Meteorological Sites.

For HUC8 07020006–07020012, HIDEN stations were reprocessed for the entire modeling period by filling missing data using the nearest HIDEN station or newly extended and aggregated BASINS sites. Once the missing values were filled, the HIDEN stations were disaggregated to an hourly time series in WDMUtil. The HIDEN stations for the Hawk-Yellow Medicine model application were processed for only the extension period and disaggregated by using the filled ASOS/AWOS hourly stations. Because of the incorporation of NEXRAD data, the Chippewa was extended by using the most complete and centralized HIDEN station within each hydrozone.

Air Temperature

Daily COOP and hourly ASOS/AWOS stations were filled by using ratio of means with the nearest like site until no missing values remained. Filled daily minimum and maximum temperature sites were disaggregated in WDMUtil to an hourly time series using the observation hour. If the nearest extension site was a daily station, a check was performed to determine if there was an hourly site within 4 miles. If an hourly site was within 4 miles of an existing BASINS station, the station was appended using hourly data. All but one BASINS station (MN218429) was within 4 miles of an extension site, which was extended and filled by ratio of means with the nearest extension site (20 miles).

Cloud Cover, Wind Speed, and Dew Point Temperature

Hourly ASOS/AWOS sites were filled (ratio of means for Wind Speed [WIND] and Dew Point Temperature [DEWP]) with the nearest like station until no missing values remained. DEWP was unavailable so it was calculated using a simple temperature and relative humidity (RH) relationship:

$$\mathrm{DEWP}=\mathrm{ATEM}-\frac{9}{25}(100-\mathrm{RH}) \quad (1)$$

Cloud Cover (CLOU) descriptions at the uppermost cloud layer were assigned real numbers based on a 0–10 scale (CLR–0, FEW–1, SCT–4, BKN–7, and OVC–10). Once all hourly extension data were filled, the BASINS stations were appended because all sites were within 4 miles of an existing station.

Potential Evapotranspiration and Solar Radiation

Data for Potential Evapotranspiration (PEVT) and Solar Radiation (SOLR) were largely unavailable or incomplete. Daily SOLR was recalculated from average daily cloud cover for the entire modeling period (1995–2012) in WDMUtil by using latitude and then disaggregated to an hourly time series. Hourly Penman Pan evaporation was estimated by loading hourly time-series data into the WDMUtil and aggregating these data to calculate daily PEVT as a function of minimum and maximum daily Air Temperature (ATEM), mean daily DEWP, total daily WIND, and total daily SOLR. The data were then disaggregated to hourly time series. Penman Pan evaporation is converted to PEVT in the external sources block of the UCI (where model inputs are called and distributed) by using an adjusted pan factor of 0.79, which was initially derived from the National Oceanic and Atmospheric Administration (NOAA) Evaporation Atlas. PEVT and SOLR time series were recalculated for the entire modeling period to ensure consistency in data.

Point Sources

A total of 146 point sources (13 major and 133 minor) are represented in the Minnesota River Watershed, and 125 are explicitly represented (Table 5). Point source locations are shown in Attachment C. All explicitly represented point source flows and loads were recalculated for the entire modeling period to ensure consistency during processing. For the stations not explicitly represented, a unit discharge time series was set up for two time periods (April 1 to June 15 and September 15 to December 15), and a factor was applied in the UCI to estimate daily flow and constituent loads [Tetra Tech, 2011]. The unit discharge time series was extended through 2012 by appending the original data with same unit discharges for the spring and fall periods.

Explicitly represented data were processed into daily time series by distributing the total discharge from each source throughout the month. Mechanical sites were assumed to discharge for the entire month in which it had data. Controlled ponds generally discharge intermittently for variable lengths of time, and data for the sites were provided by the MPCA as a combination of monthly volumes and monthly average flow. If a controlled pond was missing monthly discharge, it was assumed that the pond did not release effluent to the surface water during that month. An estimate of the number of discharge days was supplied by the MPCA and was incorporated by using the following logic supplied by Henningsgaard [2012]:

1. If there are only a few discharge days followed by a month with only a few discharge days or if the first month has only a couple and the next month has up to approximately 10 discharge days, they should be placed at both the end and beginning of the 2 months.
2. If there are over 6 discharge days in a month but fewer than approximately 18 discharge days, they can be placed anywhere consecutively.
3. If there are over approximately 18 discharge days, one-half should be placed in the first half of the month and one-half should be placed in the second half of the month.

For each facility, the period of record and completeness were assessed. Available constituents from point sources applicable for modeling purposes include carbonaceous 5-day biochemical oxygen demand (CBOD5), total suspended solids (TSS), total phosphorus (TP), and dissolved oxygen (DO). Point source water-quality data were filled by using monthly mean values. Where monthly means were unavailable, interpolation was used. The available effluent water-quality parameters vary by site, but in general, most parameters were available from wastewater treatment facilities.

Nitrogen species data and orthophosphate-phosphorus were largely unavailable in the minor point source data. Facility classes for each point source determined loads for nitrogen species and were calculated by using numbers supplied by Weiss [2012]. Methods for estimating other phosphorus species from point sources were derived from methods similar to those used in the earlier version of the Minnesota River model application [Tetra Tech, 2009]. The nutrient portions of the Minnesota River Watershed external sources blocks contain estimates where nutrient data were unavailable. Temperature data were derived from a minor wastewater treatment facility located in the Sauk River Watershed and were adjusted for differences in temperature between the two watersheds (HUC8 07020006–07020012), or a conversion factor was applied to the discharge with an assumed temperature of 55°F (HUC8 07020004–07020005). All available data for model inputs have been uploaded into the project WDM file, and all available data used for comparison to model simulations are in an observed data Microsoft Excel file.

Table 5. Point Source Summary (Major Point Sources Are Indicated in Bold) (Page 1 of 5)

Model Application	Site I.D.	Facility Name	Reach
Hawk-Yellow Medicine	MNG580122	Hanley Falls WWTP[a, b]	101
Hawk-Yellow Medicine	MNG580010	Cottonwood WWTP[a]	103
Hawk-Yellow Medicine	MNG580033	Minneota WWTP[a]	106
Hawk-Yellow Medicine	MNG580090	Taunton WWTP[a]	112
Hawk-Yellow Medicine	MNG580103	Ivanhoe WWTP[a]	113
Hawk-Yellow Medicine	MNG580128	Porter WWTP[a]	118
Hawk-Yellow Medicine	MN0024775	Saint Leo WWTP[a]	123
Hawk-Yellow Medicine	MNG580003	Belview WWTP[a]	130
Hawk-Yellow Medicine	MNG580059	Echo WWTP[a]	140
Hawk-Yellow Medicine	MNG580107	Wood Lake WWTP[a]	152
Hawk-Yellow Medicine	MNG580093	Clarkfield WWTP[a]	161
Hawk-Yellow Medicine	MN0056588	Maynard WWTP	202
Hawk-Yellow Medicine	MN0023035	Clara City WWTP	205
Hawk-Yellow Medicine	MNG580104	Pennock WWTP[a]	207
Hawk-Yellow Medicine	MN0045446	Raymond WWTP[a]	211
Hawk-Yellow Medicine	**MN0025259**	**Willmar WWTP**	**213**
Hawk-Yellow Medicine	MNG580057	Danube WWTP[a]	231
Hawk-Yellow Medicine	MN0022829	Bird Island WWTP[a]	234
Hawk-Yellow Medicine	MN0020907	Olivia WWTP	234
Hawk-Yellow Medicine	MN0020737	Renville WWTP	250
Hawk-Yellow Medicine	**MN0040665**	**Southern Minnesota Beet Sugar–Renville**	**250**
Chippewa	**MN0020133**	**Montevideo WWTP**	**101**
Chippewa	MN0022144	Watson WWTP	102
Chippewa	MN0023582	Hancock WWTP	114
Chippewa	MN0020036	Benson WWTP	115
Chippewa	MNG580119	Danvers WWTP[a]	115
Chippewa	MNG580108	Clontarf WWTP[a]	116
Chippewa	MNG580220	Farwell Kensington Sanitary District WWTP	120
Chippewa	MNG580134	Hoffman WWTP[a]	120
Chippewa	MN0023329	Evansville WWTP	122
Chippewa	MN0021415	Starbuck WWTP	134
Chippewa	MN0024007	Lowry WWTP[a]	135
Chippewa	MNG580125	Sunburg WWTP[a]	145
Chippewa	MNG580086	Murdock WWTP[a]	148
Chippewa	MN0020583	Kerkhoven WWTP	152

Table 5. Point Source Summary (Major Point Sources Are Indicated in Bold) (Page 2 of 5)

Model Application	Site ID	Facility Name	Reach
Redwood	MNG580105	Ruthton WWTP	31
Redwood	MNG580116	Tyler WWTP	119
Redwood	MNG580030	Lynd WWTP	210
Redwood	MNG580062	Russell WWTP	210
Redwood	**MN0057037**	**ADM Corn Processing–Marshall**	**250**
Redwood	**MN0022179**	**Marshall WWTP**	**251**
Redwood	MNG580121	Ghent WWTP	305
Redwood	MNG580043	Vesta WWTP	410
Redwood	MNG580124	Milroy WWTP	437
Middle Minnesota	MN0059331	Northern Con-Agg LLP–Redwood Falls	11
Middle Minnesota	MN0051292	Morton WWTP	50
Middle Minnesota	MN0021083	Franklin WWTP	70
Middle Minnesota	MN0020443	Morgan WWTP	73
Middle Minnesota	MNG580060	Fairfax WWTP	177
Middle Minnesota	MN0062154	Northern Con-Agg LLP–Frohrip Kaolin Mine	191
Middle Minnesota	MN0064785	Saint George District Sewer System	251
Middle Minnesota	MNG255006	Firmenich Inc	310
Middle Minnesota	**MN0030066**	**New Ulm WWTP**	**310**
Middle Minnesota	MN0061638	New Ulm Quartzite Quarry	330
Middle Minnesota	MNG640025	Courtland WTP	350
Middle Minnesota	MN0021687	Comfrey WWTP	361
Middle Minnesota	MNG580080	Searles WWTP	377
Middle Minnesota	MNG580207	Hanska WWTP	381
Middle Minnesota	MNG580037	Nicollet WWTP	415
Middle Minnesota	MN0067172	POET Biorefining–Lake Crystal	471
Middle Minnesota	MN0055981	Lake Crystal WWTP	473
Middle Minnesota	MN0063029	Wis-Pak of Mankato Inc	490
Middle Minnesota	MN0000914	Xcel - Wilmarth Generating Plant	550
Middle Minnesota	**MN0030171**	**Mankato WWTP**	**550**
Middle Minnesota	MN0067237	Hard Rock Quarries Inc	551
Middle Minnesota	MN0064408	Hiniker Co	555
Middle Minnesota	MNG250108	Midwest Electric Products Inc	559
Middle Minnesota	MN0030651	Knollwood Mobile Home Park WWTP	592
Middle Minnesota	**MN0022535**	**Saint Peter WWTP**	**610**
Middle Minnesota	MN0053082	Unimin Corp - Kasota Plant	617
Middle Minnesota	MNG580009	Cleveland WWTP	617

Table 5. Point Source Summary (Major Point Sources Are Indicated in Bold) (Page 3 of 5)

Model Application	Site ID	Facility Name	Reach
Cottonwood	MN0020559	Balaton WWTP	30
Cottonwood	MNG580101	Garvin WWTP	50
Cottonwood	MN0021725	Tracy WWTP	153
Cottonwood	MN0021776	Walnut Grove WWTP	215
Cottonwood	MNG580114	Revere WWTP	215
Cottonwood	MNG580100	Lamberton WWTP	267
Cottonwood	MNG580127	Westbrook WWTP	277
Cottonwood	MNG580106	Storden WWTP	277
Cottonwood	MNG580115	Sanborn WWTP	310
Cottonwood	MN0061646	Acme-Ochs Plant	350
Cottonwood	MN0024953	Springfield WWTP	350
Cottonwood	MNG580112	Lucan WWTP	373
Cottonwood	MNG580126	Wanda WWTP	383
Cottonwood	MN0025151	Wabasso WWTP	385
Cottonwood	MNG580094	Clements WWTP	399
Cottonwood	MNG580041	Sleepy Eye WWTP	410
Cottonwood	MN0001171	Del Monte Foods Inc–Sleepy Eye Plant 114	435
Cottonwood	MN0022284	August Schell Brewing Co	490
Blue Earth	MN0021920	Elmore WWTP	30
Blue Earth	MN0002313	Darling International Inc–Blue Earth	70
Blue Earth	MN0020532	Blue Earth WWTP	90
Blue Earth	MNG580118	Alden WWTP	93
Blue Earth	MNG580097	Kiester WWTP	111
Blue Earth	MNG580129	Bricelyn WWTP	111
Blue Earth	MNG580120	Frost WWTP	115
Blue Earth	MN0001287	Seneca Foods Corp–Blue Earth	133
Blue Earth	MN0000957	Interstate Power–Fox Lake Station	212
Blue Earth	MN0021296	Welcome WWTP	213
Blue Earth	MN0068063	Green Plains Fairmont LLC	234
Blue Earth	**MN0025267**	**Winnebago WWTP**	**235**
Blue Earth	MNG580023	Granada WWTP	243
Blue Earth	**MN0030112**	**Fairmont WWTP**	**250**
Blue Earth	MN0022071	Trimont WWTP	299
Blue Earth	MN0030490	Vernon Center WWTP	370
Blue Earth	MN0001228	CHS Oilseed Processing - Mankato	870
Watonwan	MN0066541	Delft Sanitary District WWTP	10

Table 5. Point Source Summary (Major Point Sources Are Indicated in Bold) (Page 4 of 5)

Model Application	Site ID	Facility Name	Reach
Watonwan	MNG580035	Mountain Lake WWTP	30
Watonwan	MN0066036	Milk Specialties Co (MSC)	35
Watonwan	MN0067458	La Salle WWTP	110
Watonwan	MN0022977	Butterfield WWTP	115
Watonwan	**MN0024759**	**Saint James WWTP**	**131**
Watonwan	MN0063118	POET Biorefining– Ethanol 2000 LLP	174
Watonwan	MNG580113	Neuhof Hutterian Brethren	181
Watonwan	**MN0024040**	**Madelia WWTP**	**210**
Watonwan	MN0021652	Truman WWTP	243
Le Sueur	MN0021032	New Richland WWTP	491
Le Sueur	MNG580102	Hartland WWTP	491
Le Sueur	**MN0020796**	**Waseca WWTP**	**551**
Le Sueur	MNG580025	Janesville WWTP	617
Le Sueur	MN0024716	Saint Clair WWTP	670
Le Sueur	MNG580018	Freeborn WWTP	715
Le Sueur	MN0021172	Mapleton WWTP	729
Le Sueur	MN0021849	Waldorf WWTP	733
Le Sueur	MNG580075	Pemberton WWTP	737
Le Sueur	MN0025224	Wells-Easton-Minnesota Lake WWTP	773
Le Sueur	MNG580109	Delavan WWTP	801
Le Sueur	MN0022624	Amboy WWTP	807
Le Sueur	MNG580206	Good Thunder WWTP	817
Lower Minnesota	MN0001716	Unimin Corp - Ottawa Plant	10
Lower Minnesota	MN0060216	Le Sueur Cheese Co	50
Lower Minnesota	MN0023931	Le Center WWTP	53
Lower Minnesota	MNG255043	Winco Inc	53
Lower Minnesota	MN0003671	Dairy Farmers of America– Winthrop	77
Lower Minnesota	MN0051098	Winthrop WWTP	77
Lower Minnesota	MN0060798	MG Waldbaum Co–Gaylord	85
Lower Minnesota	MN0062561	Heartland Corn Products	85
Lower Minnesota	MNG580204	Gaylord WWTP	85
Lower Minnesota	MNG580020	Gibbon WWTP	111
Lower Minnesota	MN0023876	Lafayette WWTP	127
Lower Minnesota	MN0022152	Le Sueur WWTP	141
Lower Minnesota	MN0000264	Seneca Foods Corp - Arlington	203
Lower Minnesota	MN0020834	Arlington WWTP	203

Table 5. Point Source Summary (Major Point Sources Are Indicated in Bold) (Page 4 of 5)

Model Application	Site ID	Facility Name	Reach
Lower MN	MN0022772	Belle Plaine WWTP	251
Lower MN	MN0025585	Hamburg WWTP	279
Lower MN	MN0024392	Norwood Young America WWTP	283

(a) Station discharge was not explicitly represented.
(b) WWTP = Wastewater Treatment Plant.

Atmospheric Deposition

Atmospheric deposition of nitrate and ammonia was reprocessed for the entire modeling period to ensure consistency of time-series data.

Wet atmospheric deposition data were downloaded from the National Atmospheric Deposition Program (NADP). The NADP site chosen to represent the Minnesota River Watershed wet deposition was MN23. Wet deposition includes the deposition of pollutants from the atmosphere that occur during precipitation events. Thus, nitrate and ammonia wet deposition was applied as concentrations (milligrams per liter [mg/L]) to the precipitation input time series.

Dry deposition is independent of precipitation. Dry atmospheric deposition data were downloaded from the U.S EPA's Clean Air Status and Trends Network (CASTNet). The CASTNet site chosen to represent the Minnesota River Watershed dry deposition was PRK134. The nitrate and ammonia dry deposition data (originally in kg/ha) were converted to a pound/acre flux. Both the wet and dry atmospheric deposition sites are illustrated in Figure 10.

Original dry deposition data were supplied at a weekly time step as kg/ha. To transform the data into daily time series, they were divided by the number of days in the sampling period. Similarly, the wet deposition was obtained at a weekly time step, plus or minus multiple days. Because wet deposition was in units of concentration, it did not need to be divided by the number of days in the sampling period. Instead, the concentration was assigned to each day of the sampling period. Once transformed to daily time-series data, missing dry and wet deposition data were patched by using interpolation between the previous and later dates, when fewer than 7 days occurred between values (rare with this dataset) and by using monthly mean values when more than 7 days occurred between values (likely scenario).

SUMMARY

The Minnesota River Watershed was delineated into subwatersheds, and a reach network was defined to represent drainage properties within the basins. A numbering scheme was developed, and the physical properties of model reaches and subwatersheds were calculated and entered into the UCI. F-tables were developed by using lake and reach properties to allow the model to route water effectively through the system. Fourteen existing subwatersheds were resegmented and all valid UCI inputs were updated. Hydrozones were created to maximize the use of available meteorological time-series data. These data were processed and loaded into

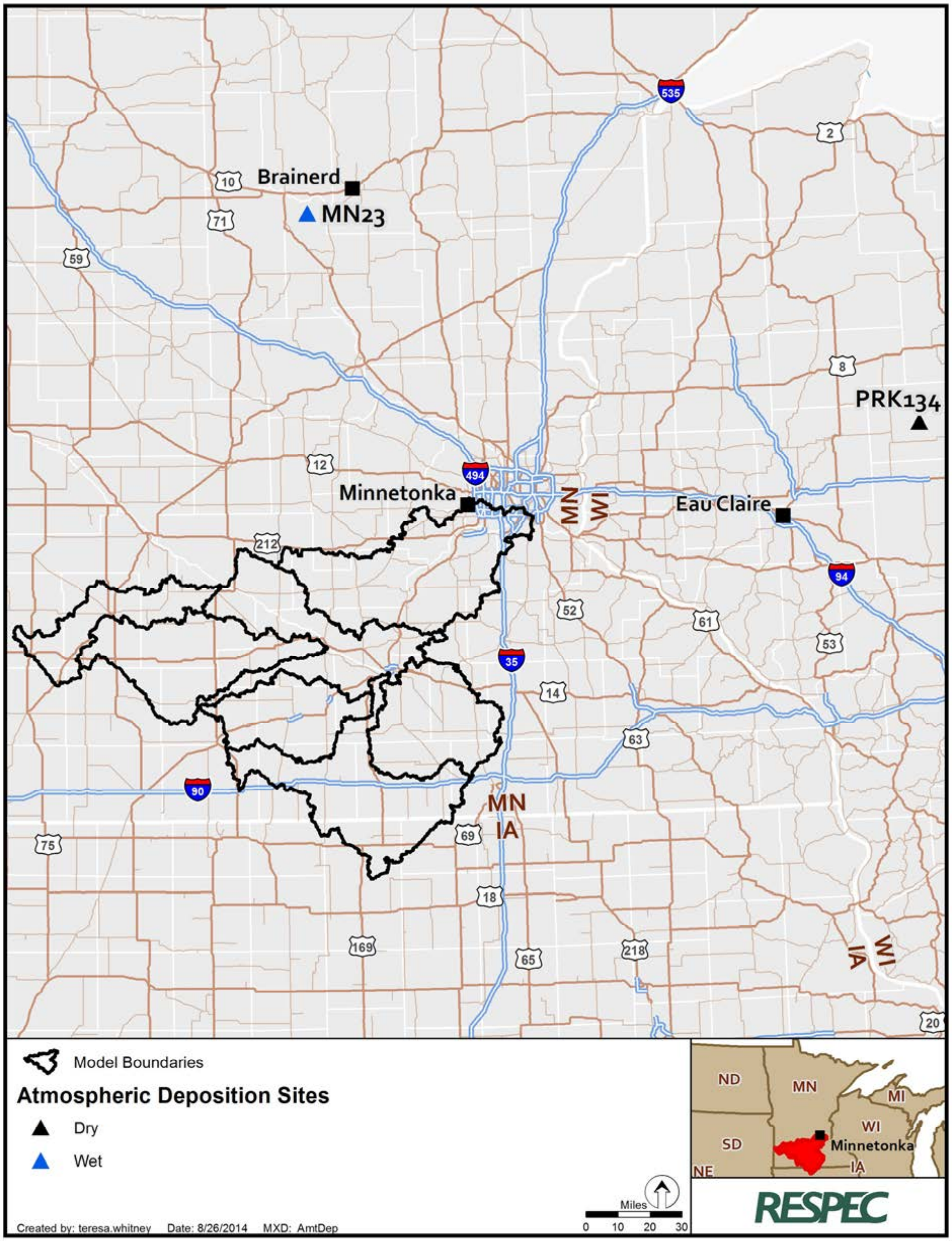

Figure 10. Atmospheric Deposition Sites.

WDM files to supply model inputs including PREC, PEVT, ATEM, CLOU, DEWP, SOLR, as well as point sources. Time-series data was extended either by reprocessing for the entire modeling period or appending existing data. Unique pervious and impervious classifications were developed based on watershed characteristics. Initial parameters were based on existing model applications.

REFERENCES

Barr Engineering, 2007. *Detailed Assessment of Phosphorus Sources to Minnesota Watersheds–Atmospheric Deposition: 2007 Update*, prepared by Barr Engineering, Minneapolis, MN, for Minnesota Pollution Control Agency, St. Paul, MN.

Henningsgaard, B., 2012. Personal communication between C. McCutcheon, RESPEC, Rapid City, SD, and B. Henningsgaard, Minnesota Pollution Control Agency, St. Paul, MN, January 20.

Murphy, P. and J. Harner, 2001. *Lesson 22: Open Lot Runoff Management Options.* Livestock and Poultry Environmental Stewardship Curriculum, Kansas State University, Midwest Plan Service, Iowa State University, Ames, IA.

RESPEC, 2011. *Minnesota River Model Revisions*, RSI(RCO)-2045/5-12/2, external memorandum from M. P. Burke, RESPEC, Rapid City, SD, to C. Regan, Minnesota Pollution Control Agency, St. Paul, MN, April 7.

RESPEC, 2014. *Refinement of the Delineation for the Minnesota River Basin*, RSI(RCO)-1146/6-14/23, external memorandum from S. J. Kenner, RESPEC, Rapid City, SD, to C. Regan, Minnesota Pollution Control Agency, St. Paul, MN, April 7.

Tetra Tech, 2009. *River Basin Turbidity TMDL and Lake Pepin Excessive Nutrient TMDL Model Calibration and Validation Report*, prepared by Tetra Tech, Research Triangle Park, NC, for the Minnesota Pollution Control Agency, St. Paul, MN.

Tetra Tech, 2011. *Hawk Creek/Yellow Medicine River Detailed HSPF Model*, prepared by Tetra Tech, Research Triangle Park, NC, for the Minnesota Pollution Control Agency, St. Paul, MN.

Tetra Tech, 2012. *Chippewa River Detailed HSPF Model*, prepared by Tetra Tech, Research Triangle Park, NC, for the Minnesota Pollution Control Agency, St. Paul, MN.

Weiss, S., 2012. *Point Source Nitrogen Load Estimates for Minnesota*, Minnesota Pollution Control Agency, St. Paul, MN.

Thank you for reviewing the methods for the development, extension, and resegmentation for the Minnesota River Watershed HSPF model application. We are available to discuss the contents of this memorandum with you and appreciate any feedback you may have.

Sincerely,

Seth J. Kenner
Staff Engineer

SJK:amk

Project Central File 2429 — Category A

ATTACHMENT A

MODEL APPLICATION REACHES AND SUBWATERSHEDS

RSI-2279-14-144

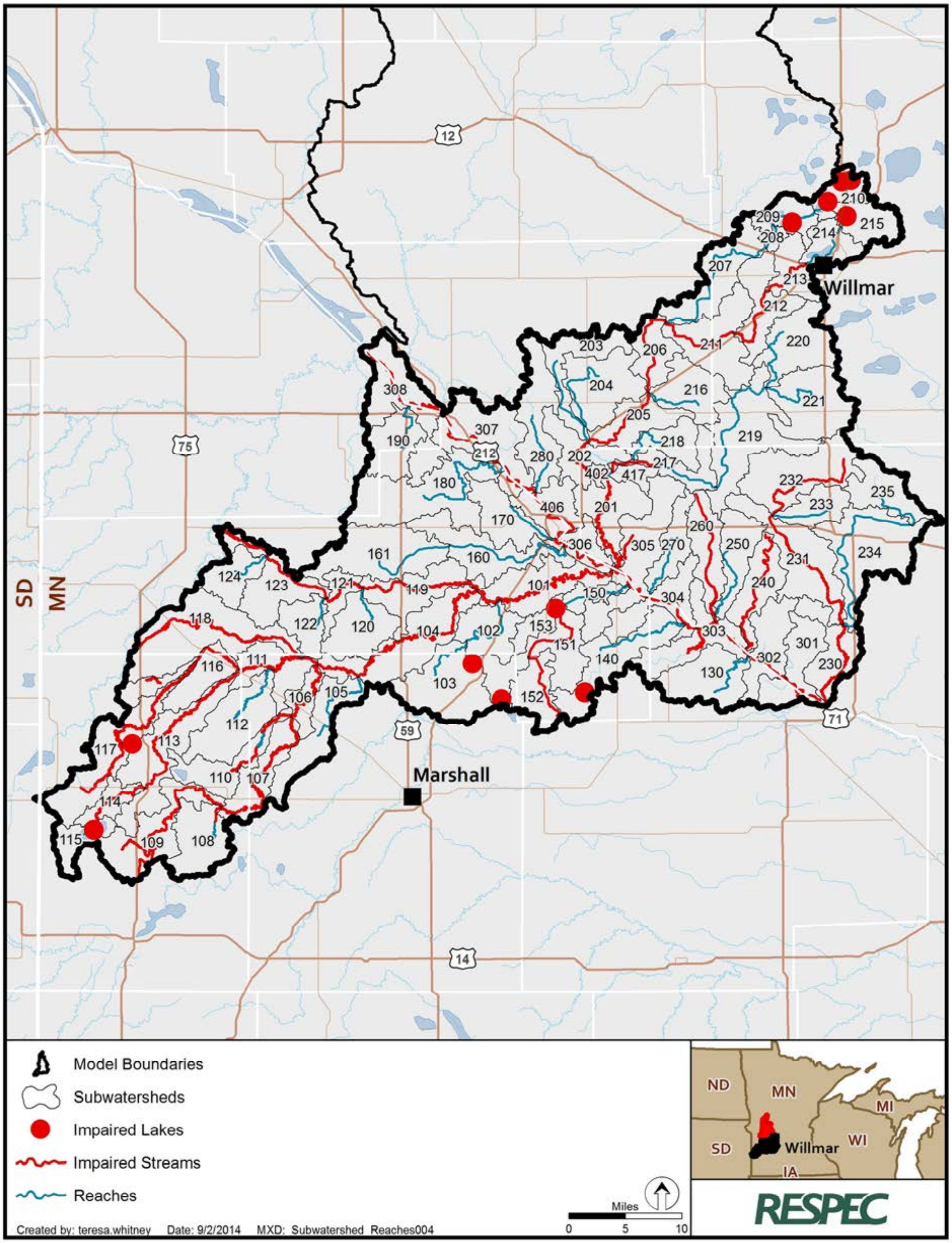

Figure A-1. Hawk-Yellow Medicine Watershed Reach and Subwatershed I.D.s.

RSI-2279-14-145

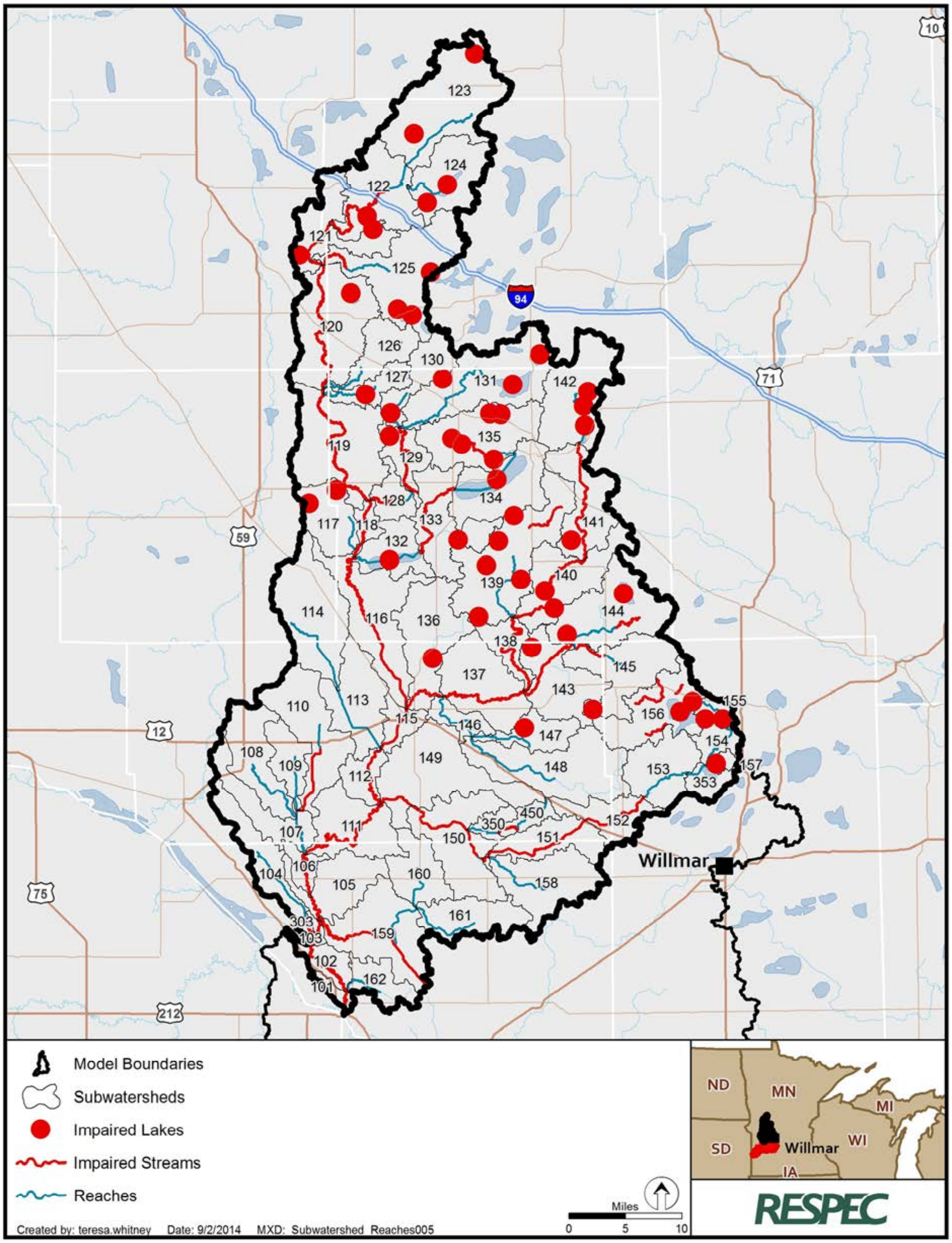

Figure A-2. Chippewa Watershed Reach and Subwatershed I.D.s.

RSI-2279-14-146

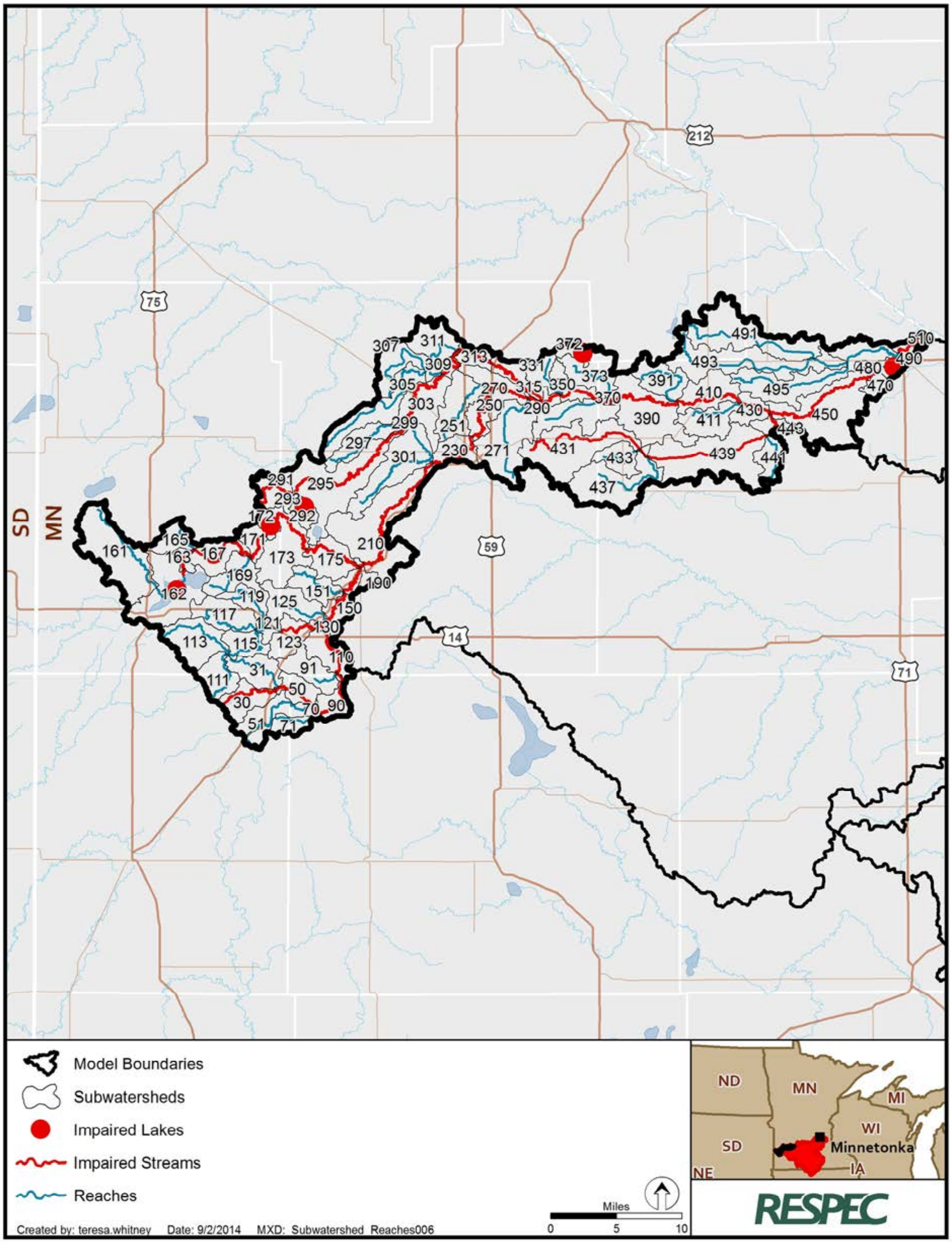

Figure A-3. Redwood Watershed Reach and Subwatershed I.D.s.

RSI-2279-14-147

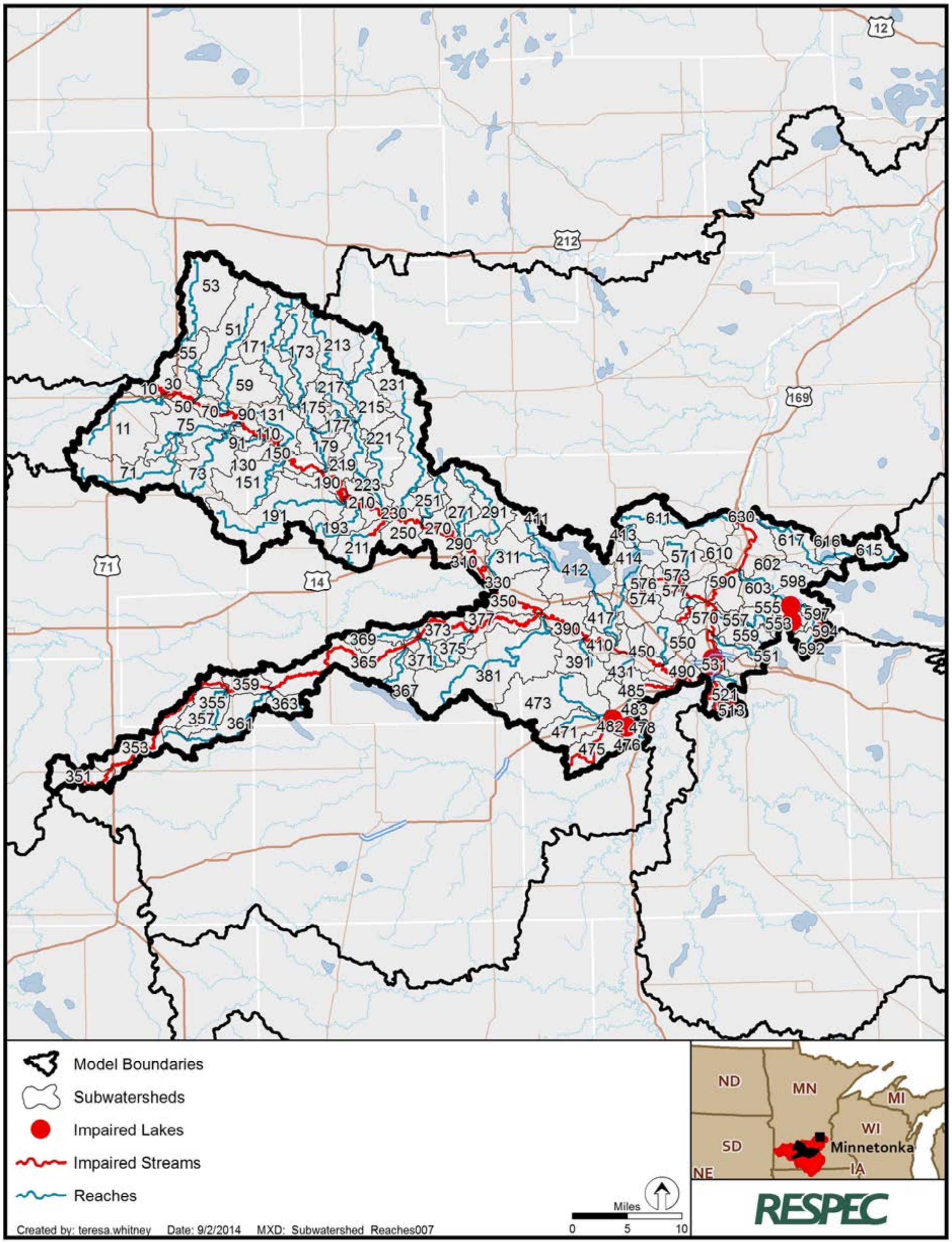

Figure A-4. Middle Minnesota Watershed Reach and Subwatershed I.D.s.

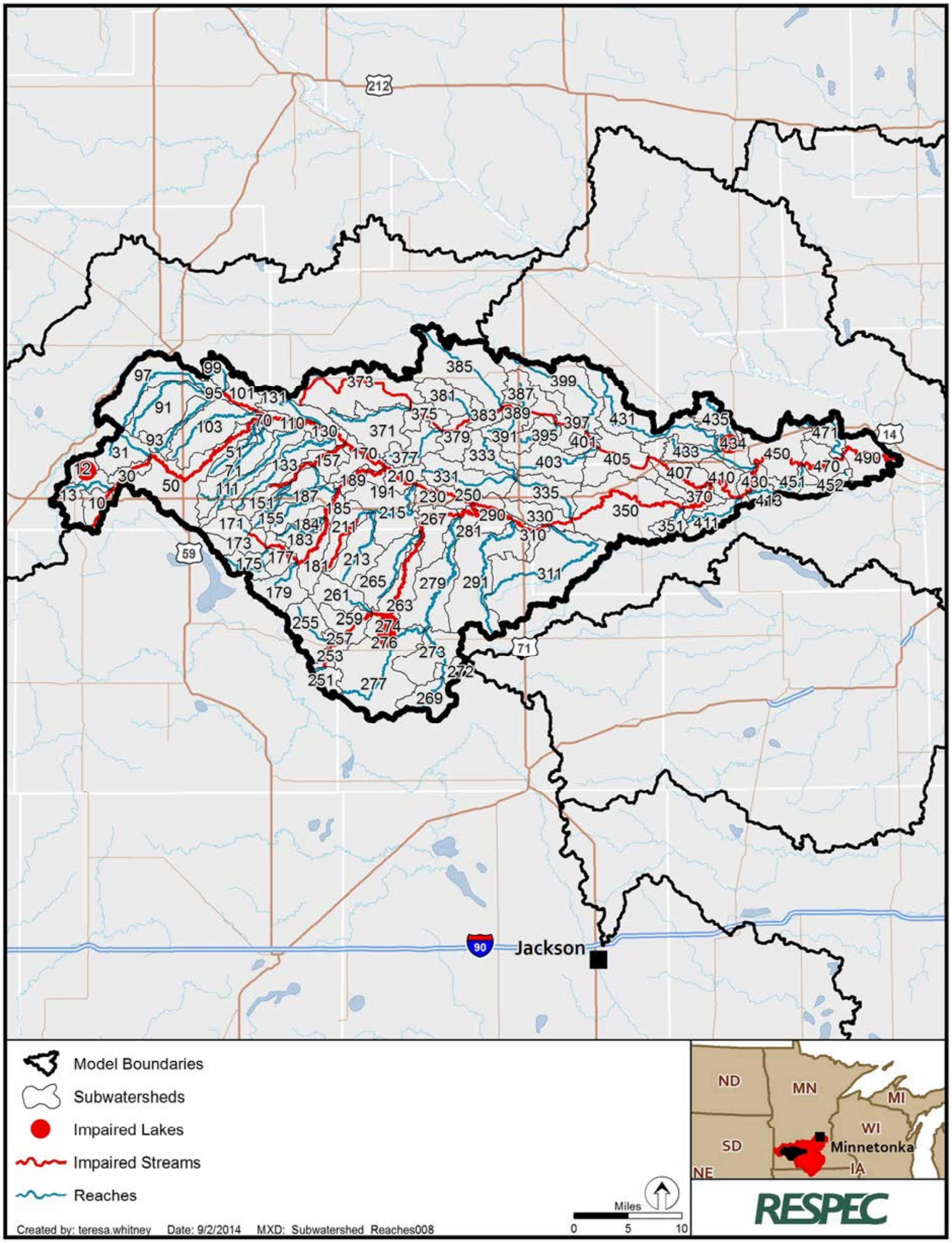

Figure A-5. Cottonwood Watershed Reach and Subwatershed I.D.s.

RSI-2279-14-149

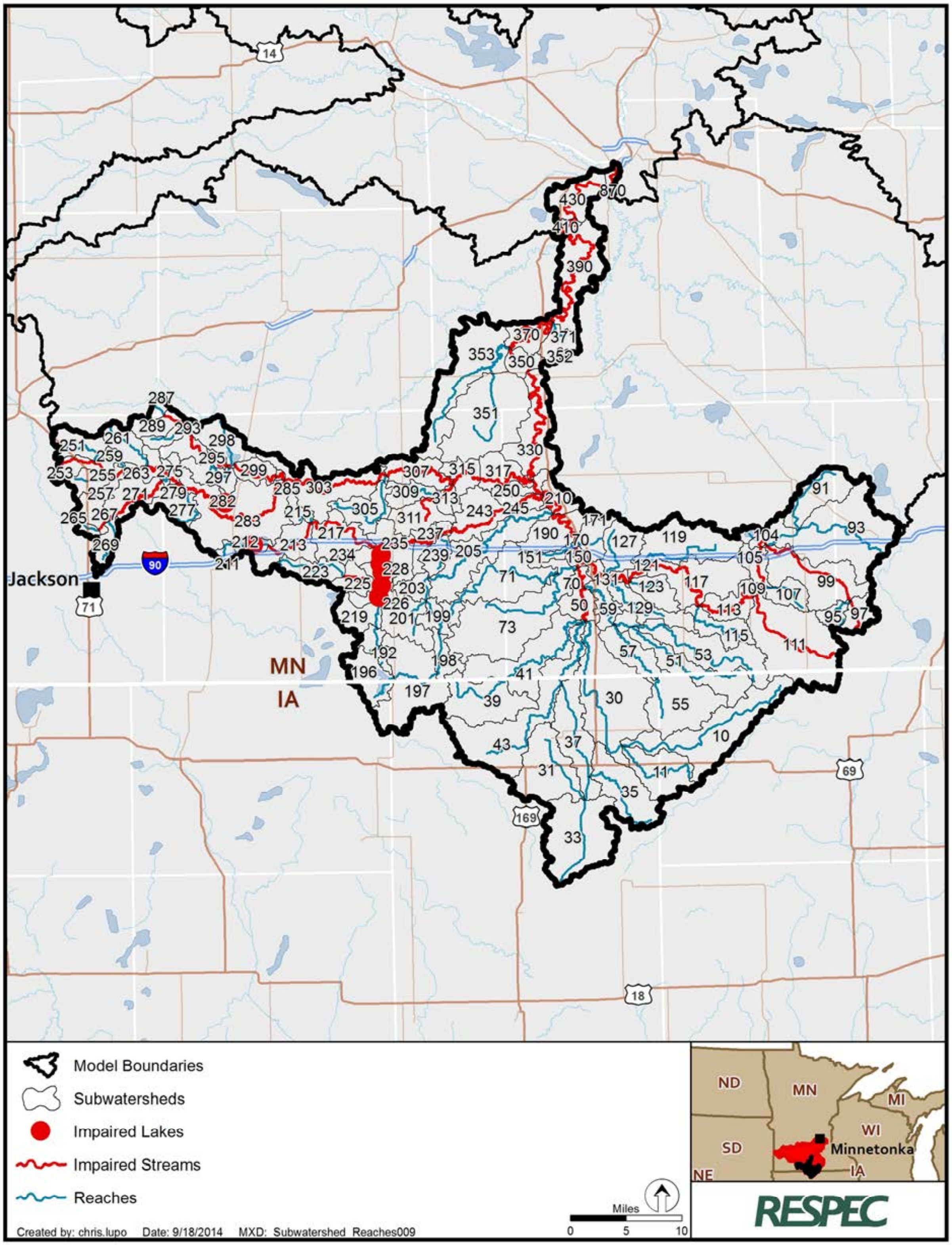

Figure A-6. Blue Earth Watershed Reach and Subwatershed I.D.s.

RSI-2279-14-150

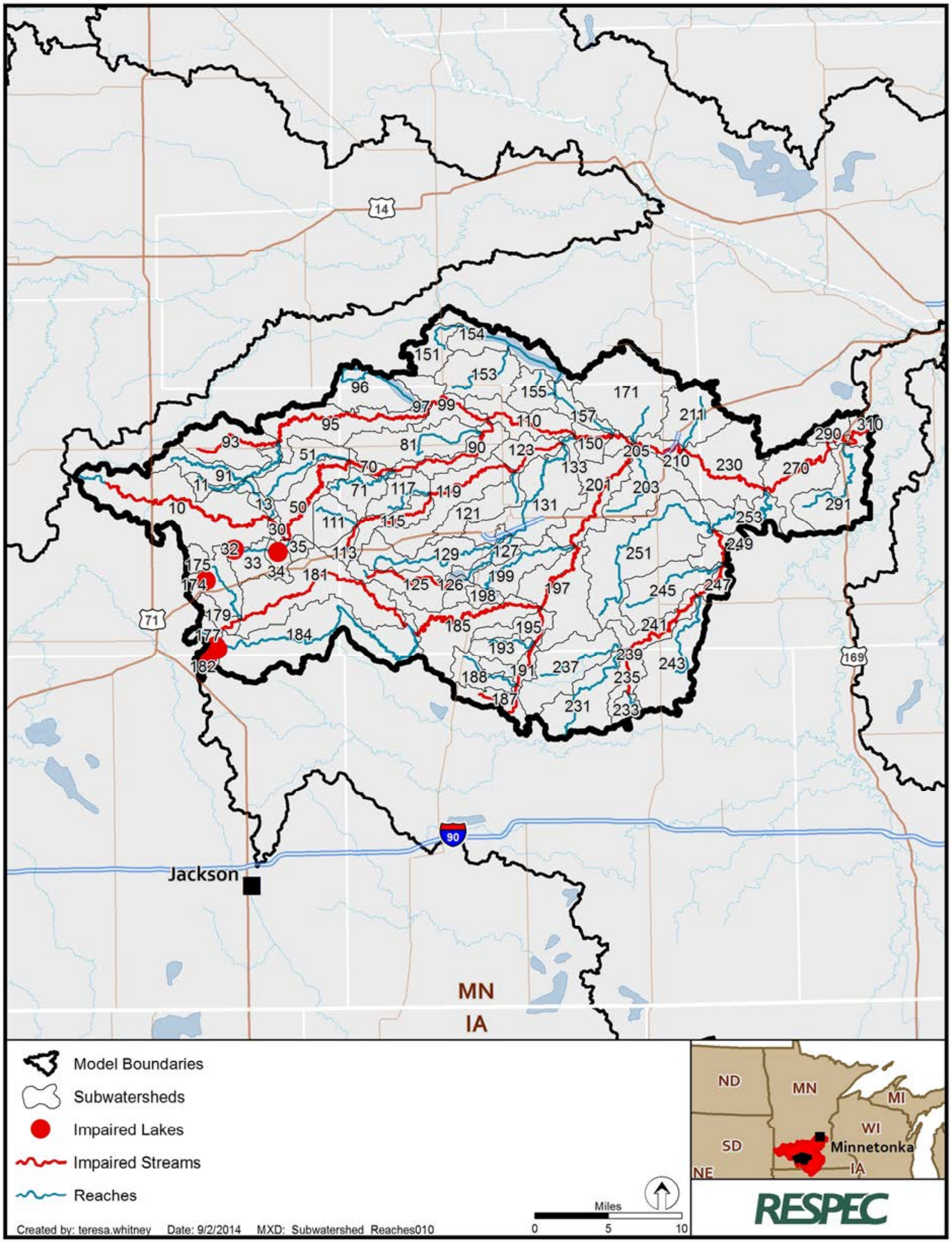

Figure A-7. Watonwan Watershed Reach and Subwatershed I.D.s.

RSI-2279-14-151

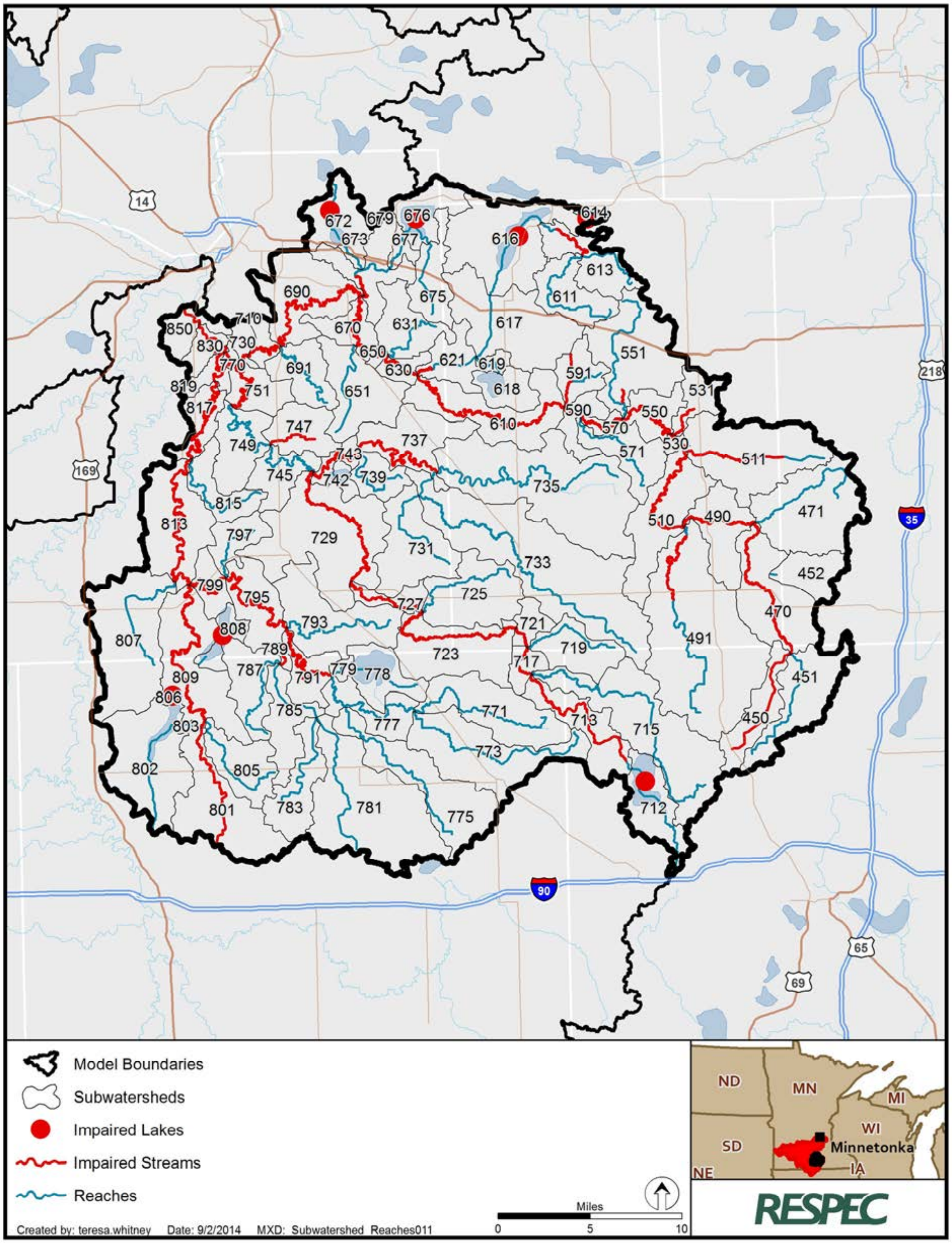

Figure A-8. Le Sueur Watershed Reach and Subwatershed I.D.s.

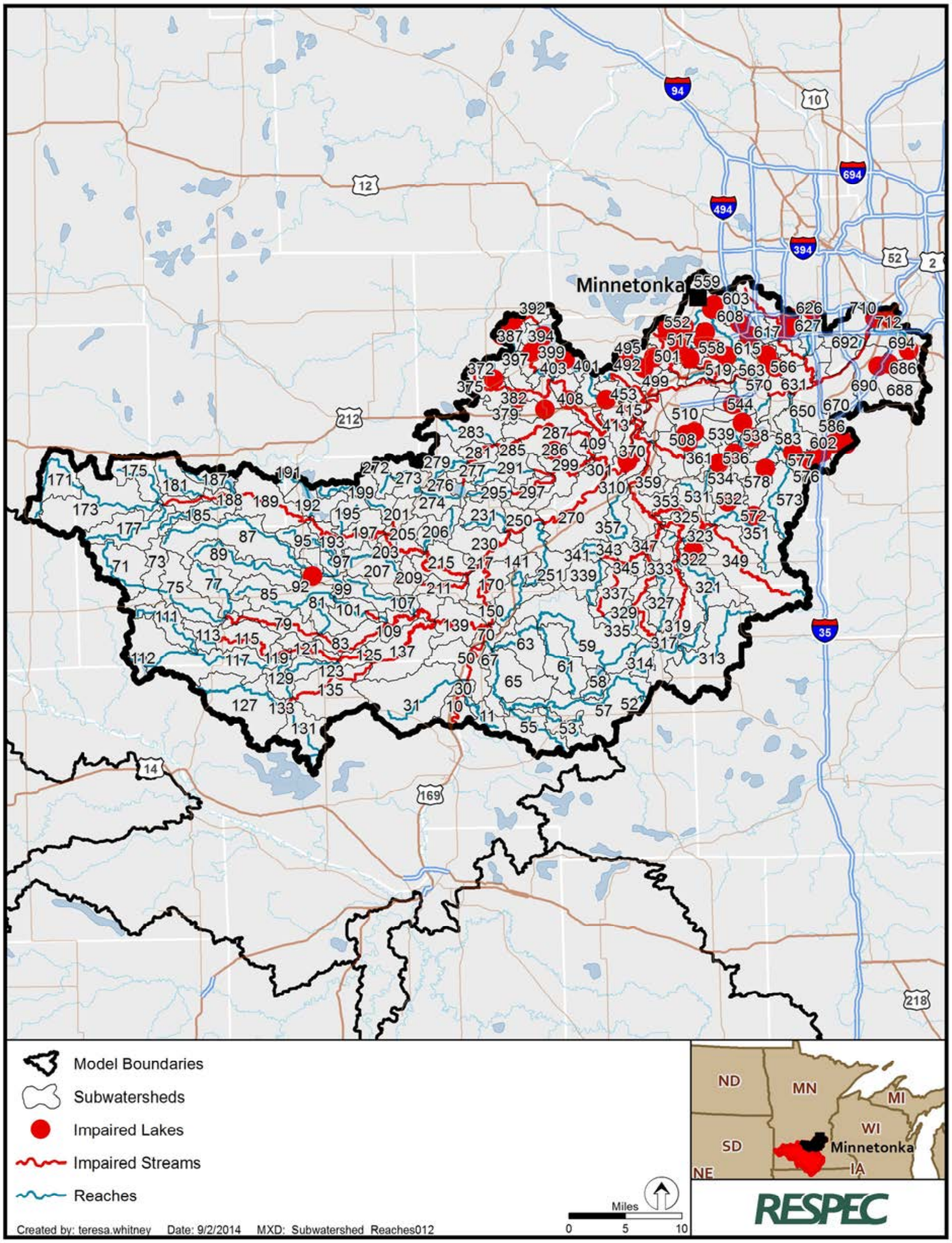

Figure A-9. Lower Minnesota Watershed Reach and Subwatershed I.D.s.

ATTACHMENT B

MODEL APPLICATION HYDROZONES AND PRECIPITATION STATIONS

RSI-2279-14-153

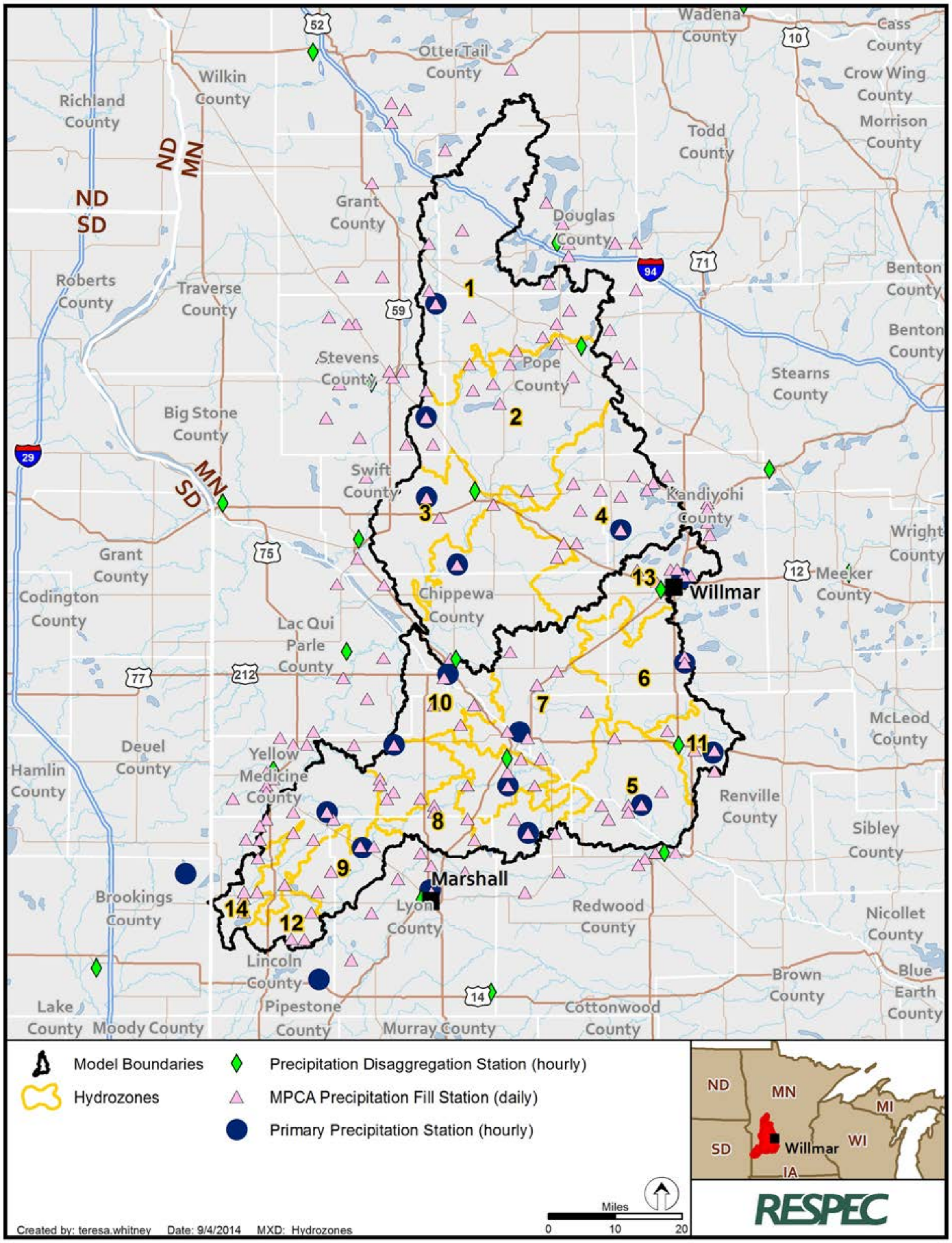

Figure B-1. Hawk-Yellow Medicine and Chippewa Watershed Hydrozones and Precipitation Stations.

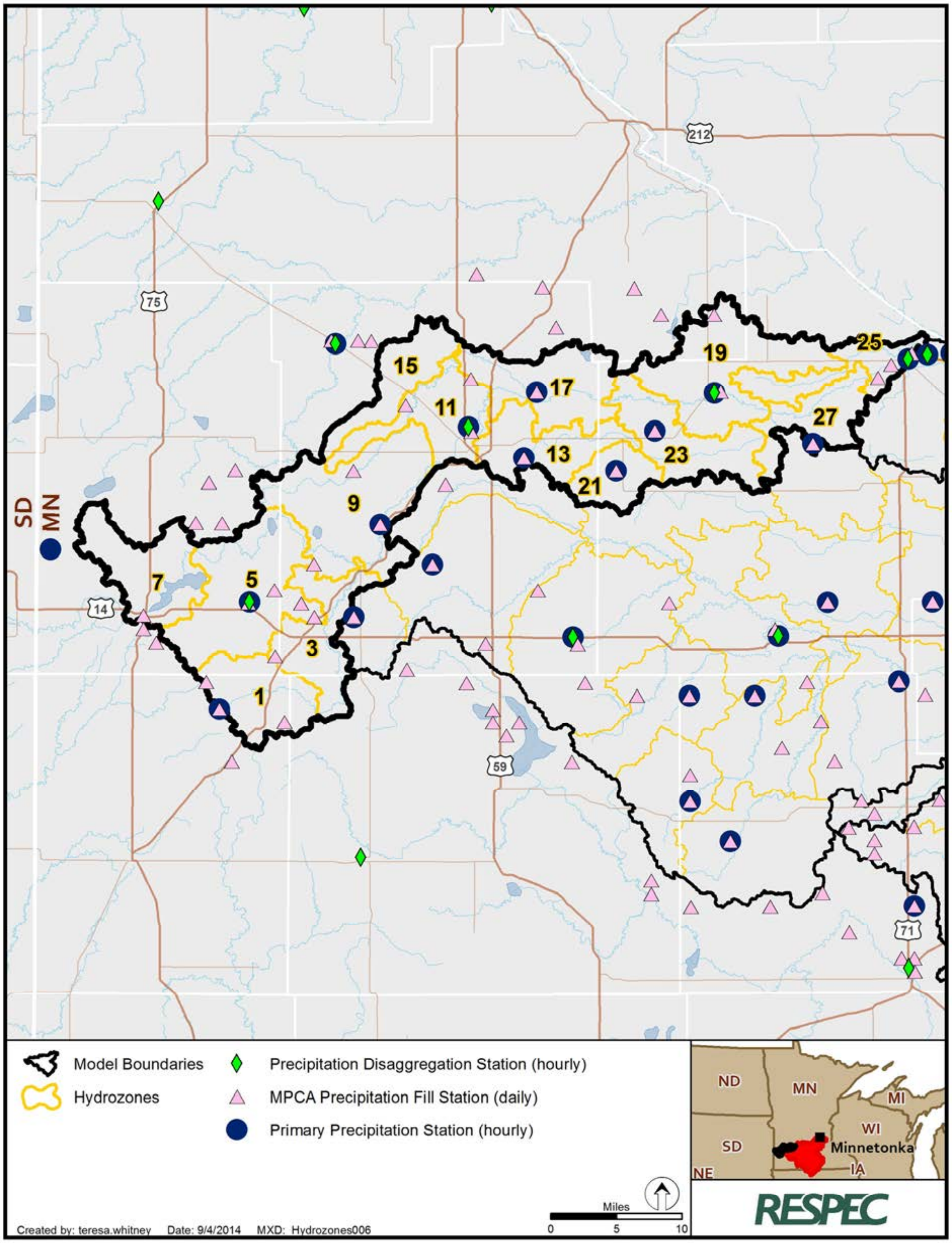

Figure B-2. Redwood Watershed Hydrozones and Precipitation Stations.

RSI-2279-14-155

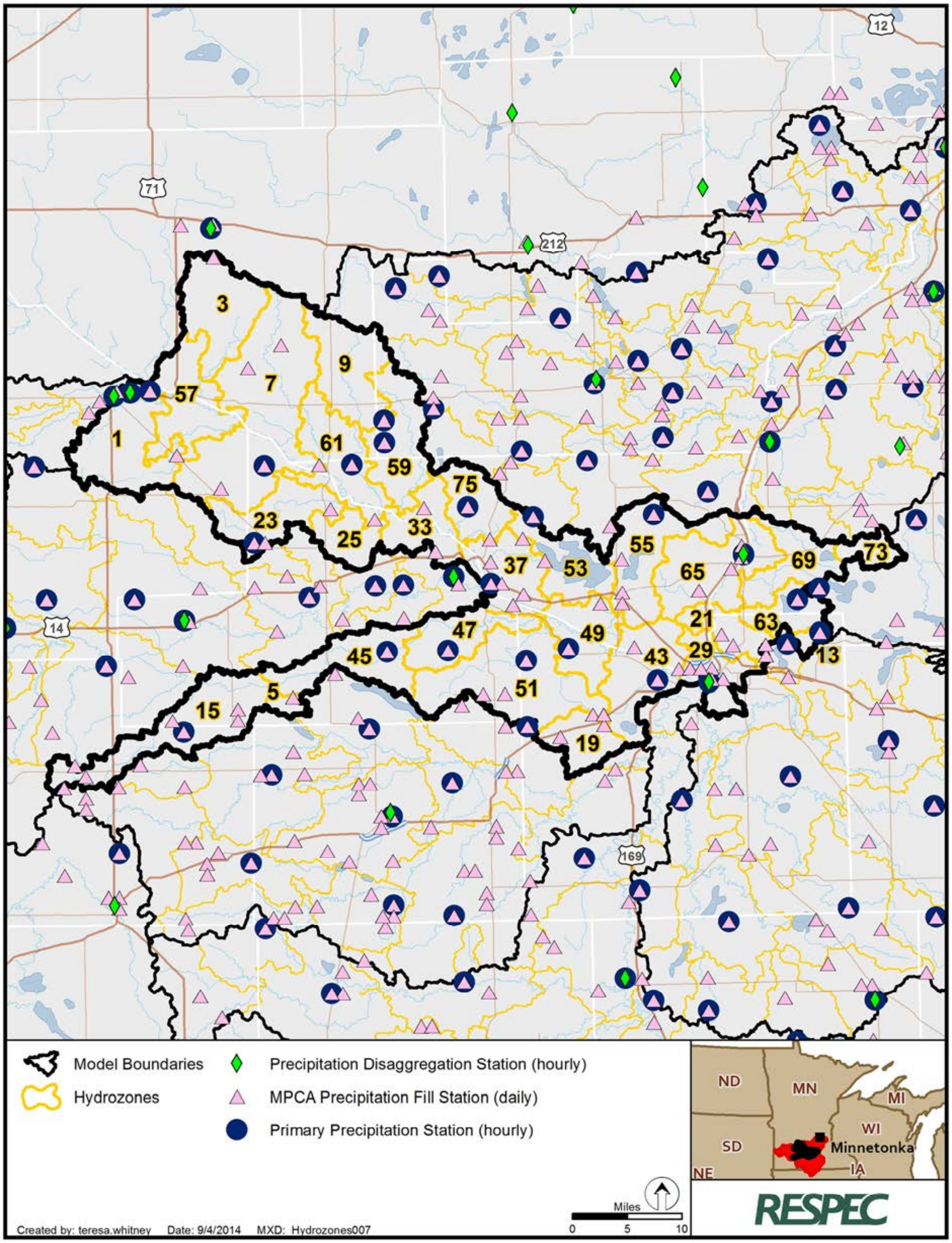

Figure B-3. Middle Minnesota Watershed Hydrozones and Precipitation Stations.

RSI-2279-14-156

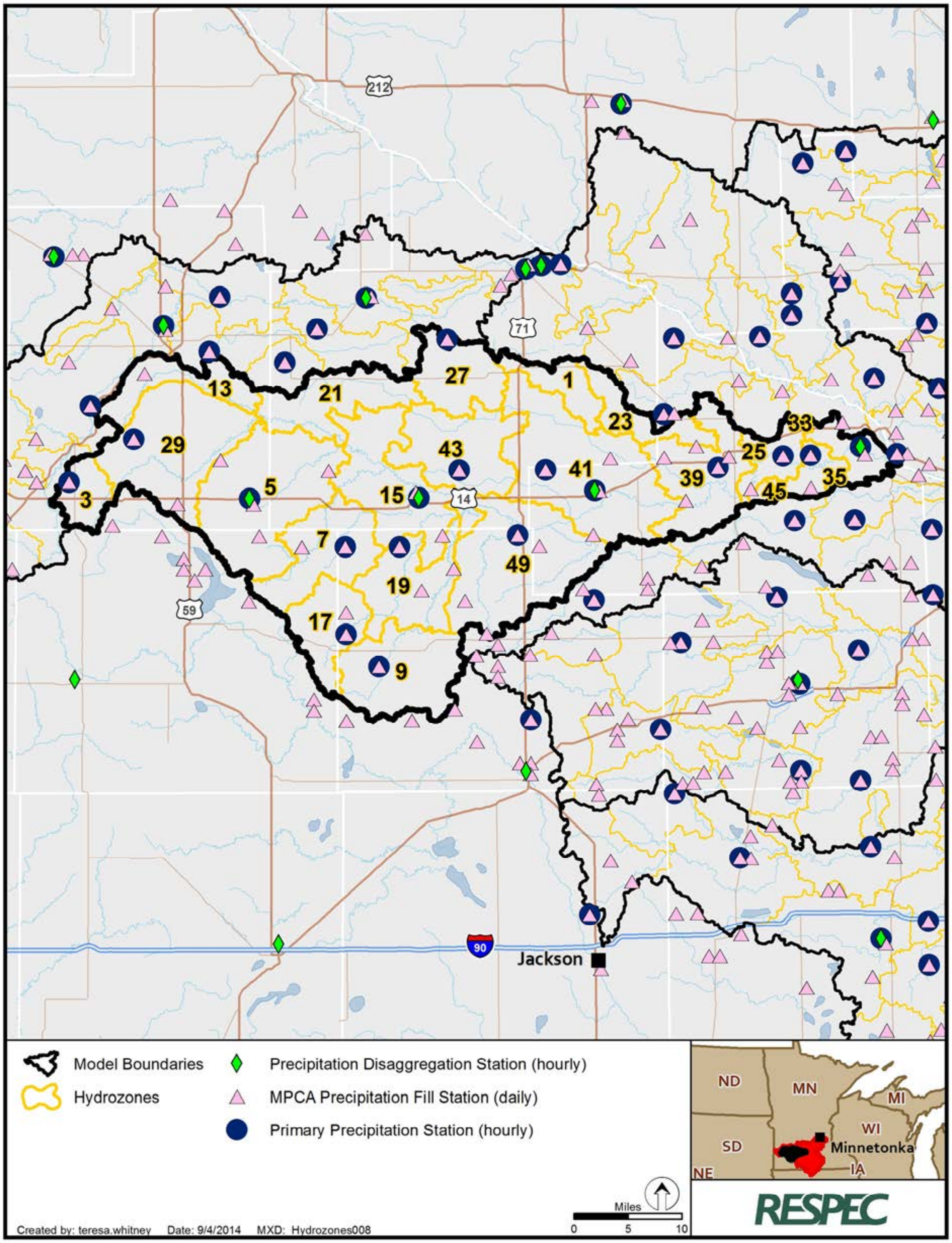

Figure B-4. Cottonwood Watershed Hydrozones and Precipitation Stations.

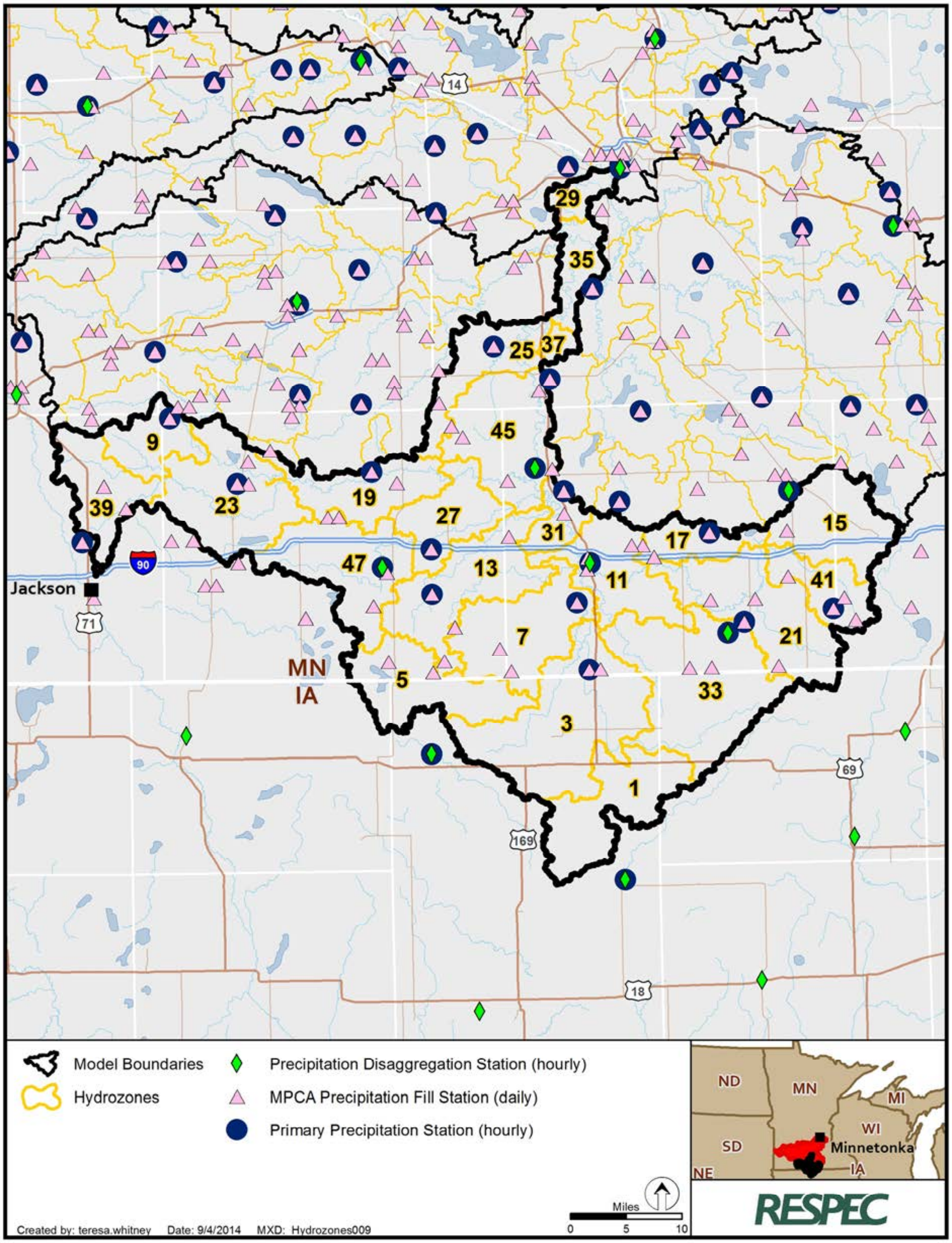

Figure B-5. Blue Earth Watershed Hydrozones and Precipitation Stations.

RSI-2279-14-158

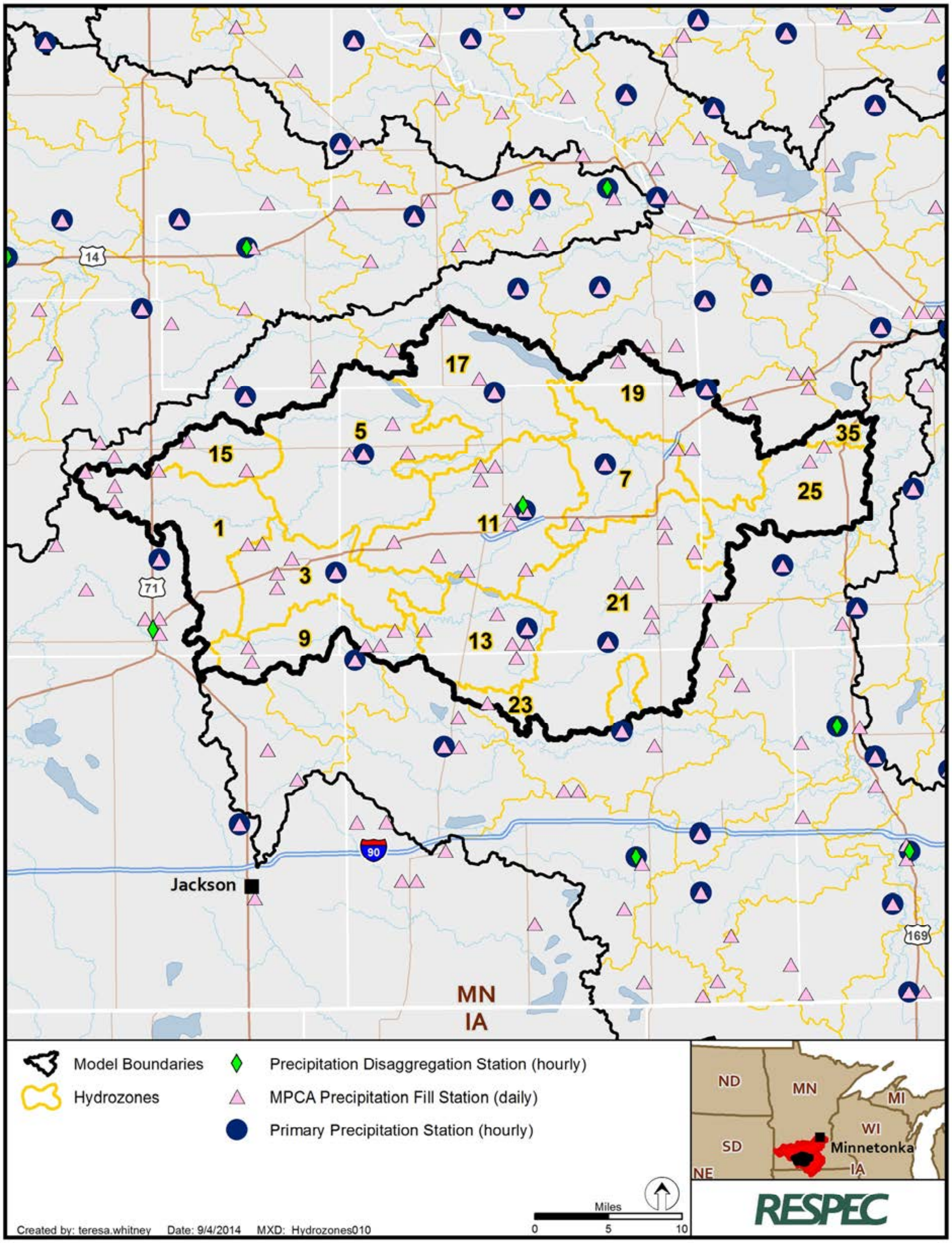

Figure B-6. Watonwan Watershed Hydrozones and Precipitation Stations.

RSI-2279-14-159

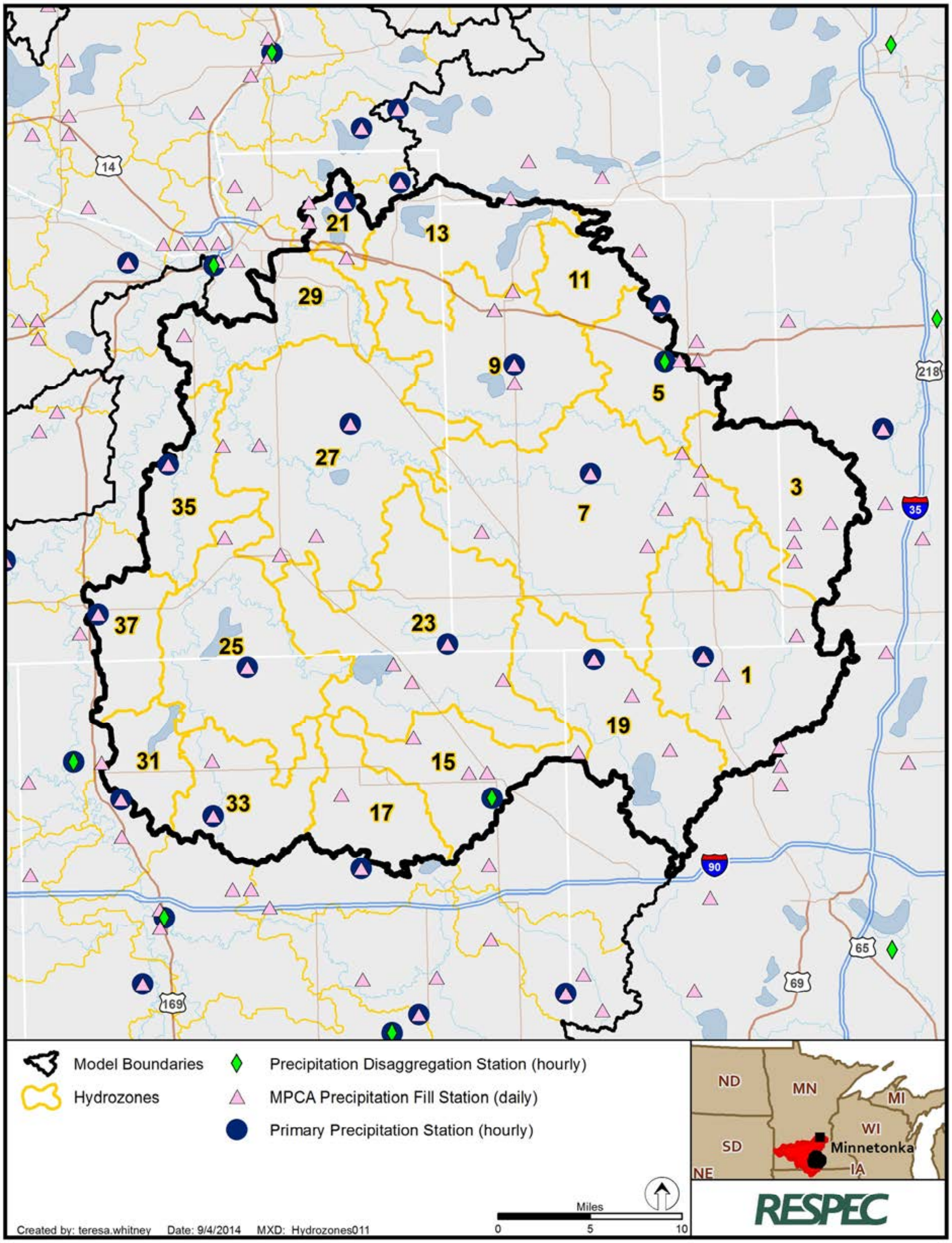

Figure B-7. Le Sueur Watershed Hydrozones and Precipitation Stations.

RSI-2279-14-160

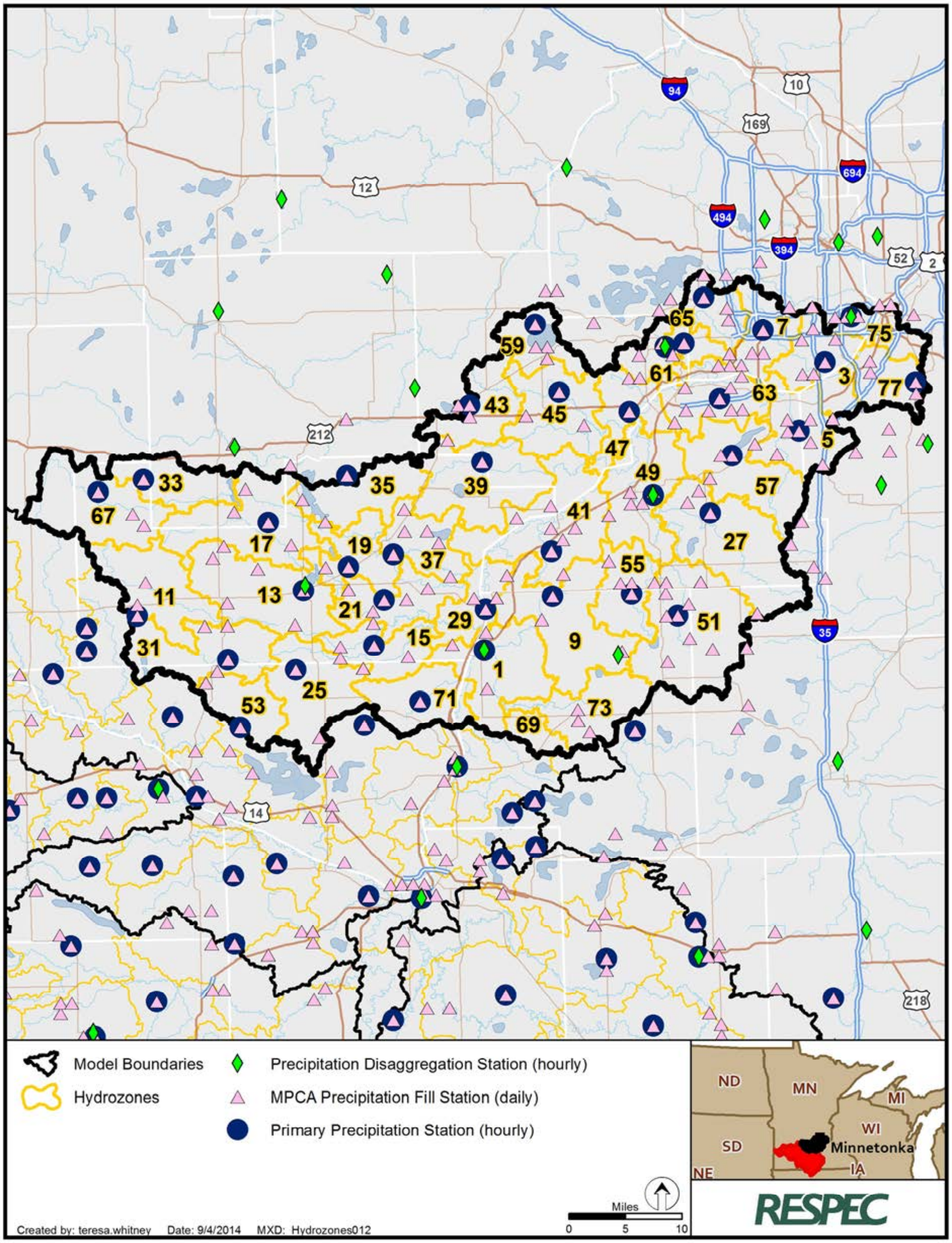

Figure B-8. Lower Minnesota Watershed Hydrozones and Precipitation Stations.

ATTACHMENT C

MODEL APPLICATION POINT SOURCE LOCATIONS

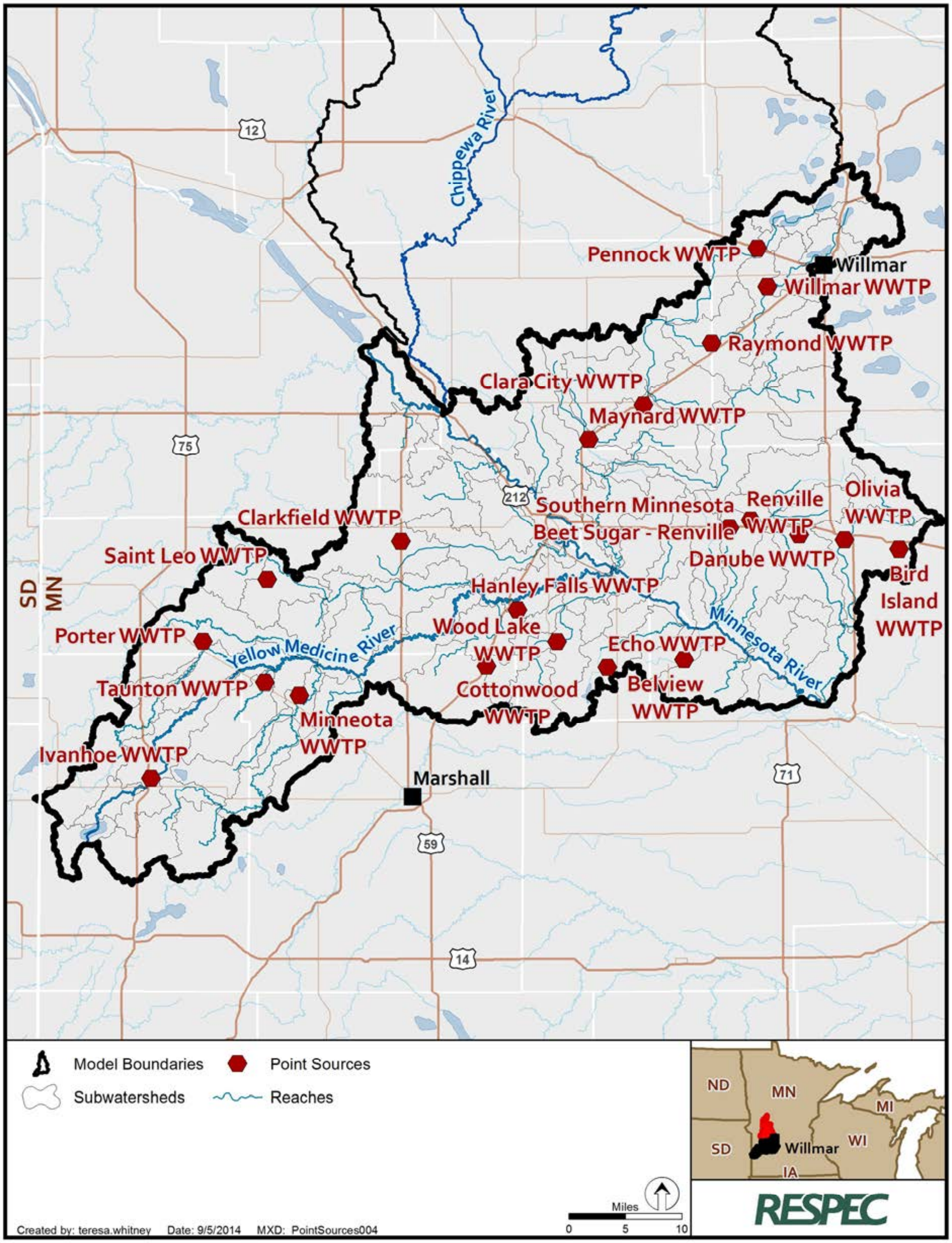

Figure C-1. Hawk-Yellow Medicine Watershed Point-Source Locations.

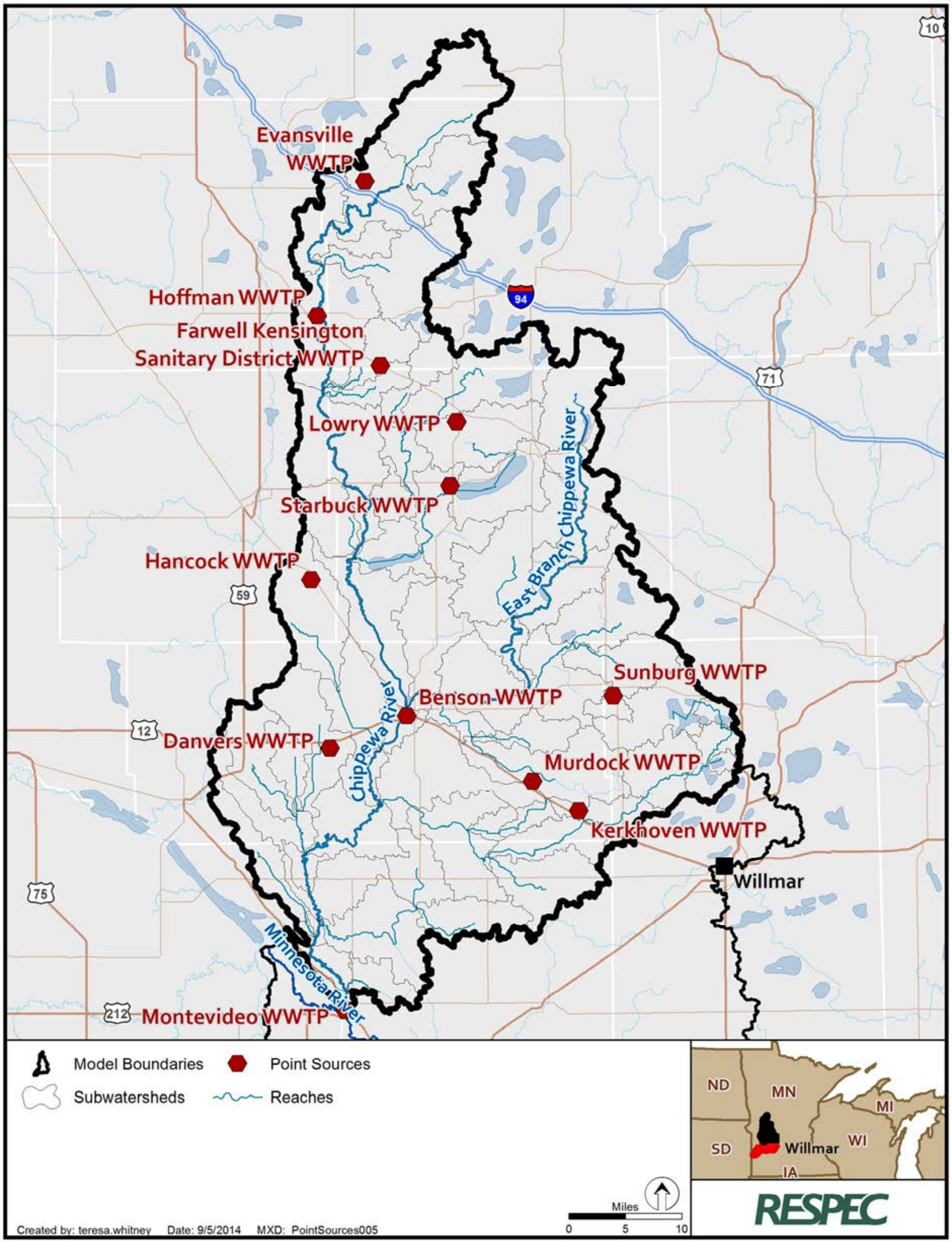

Figure C-2. Chippewa Watershed Point-Source Locations.

RSI-2279-14-163

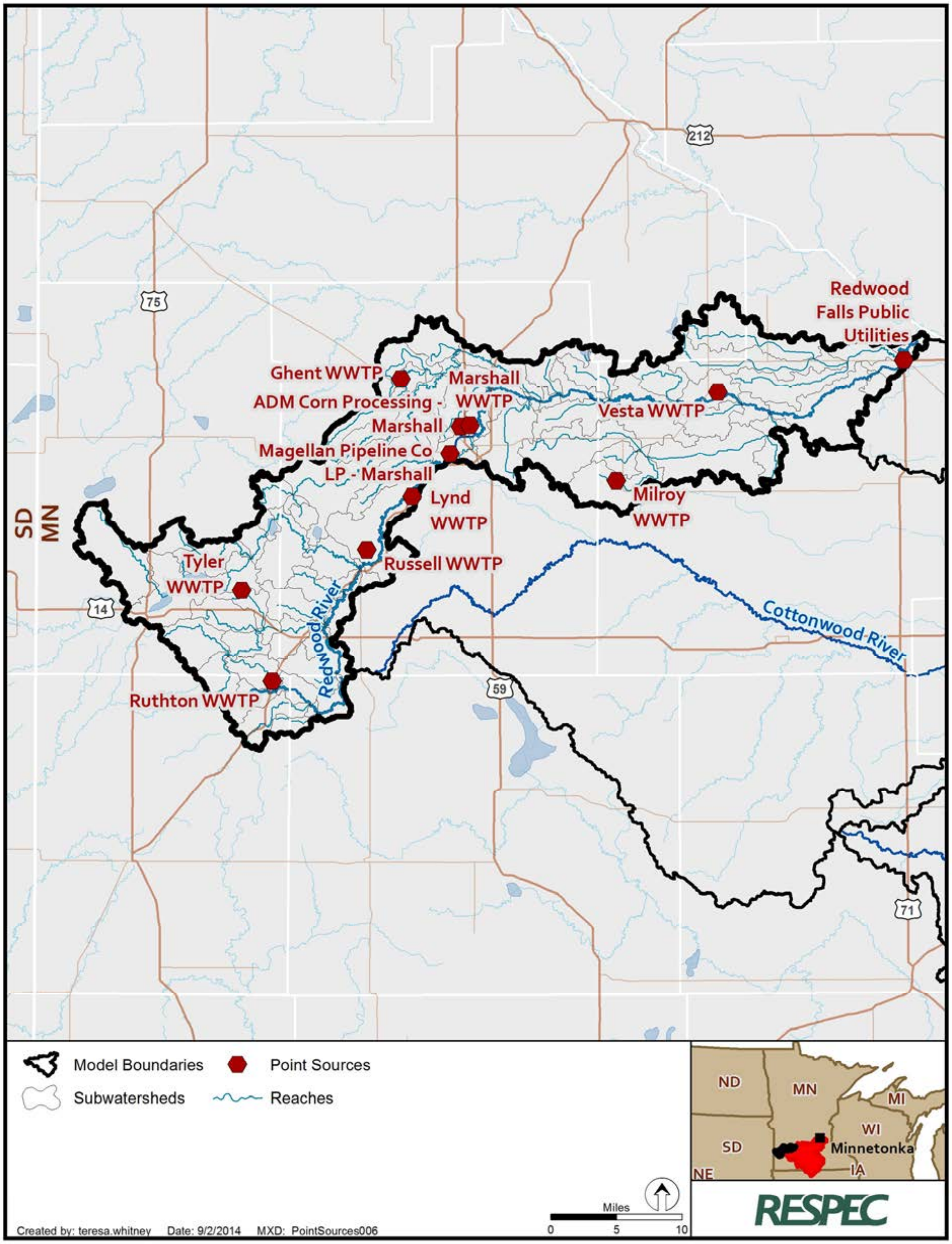

Figure C-3. Redwood Watershed Point-Source Locations.

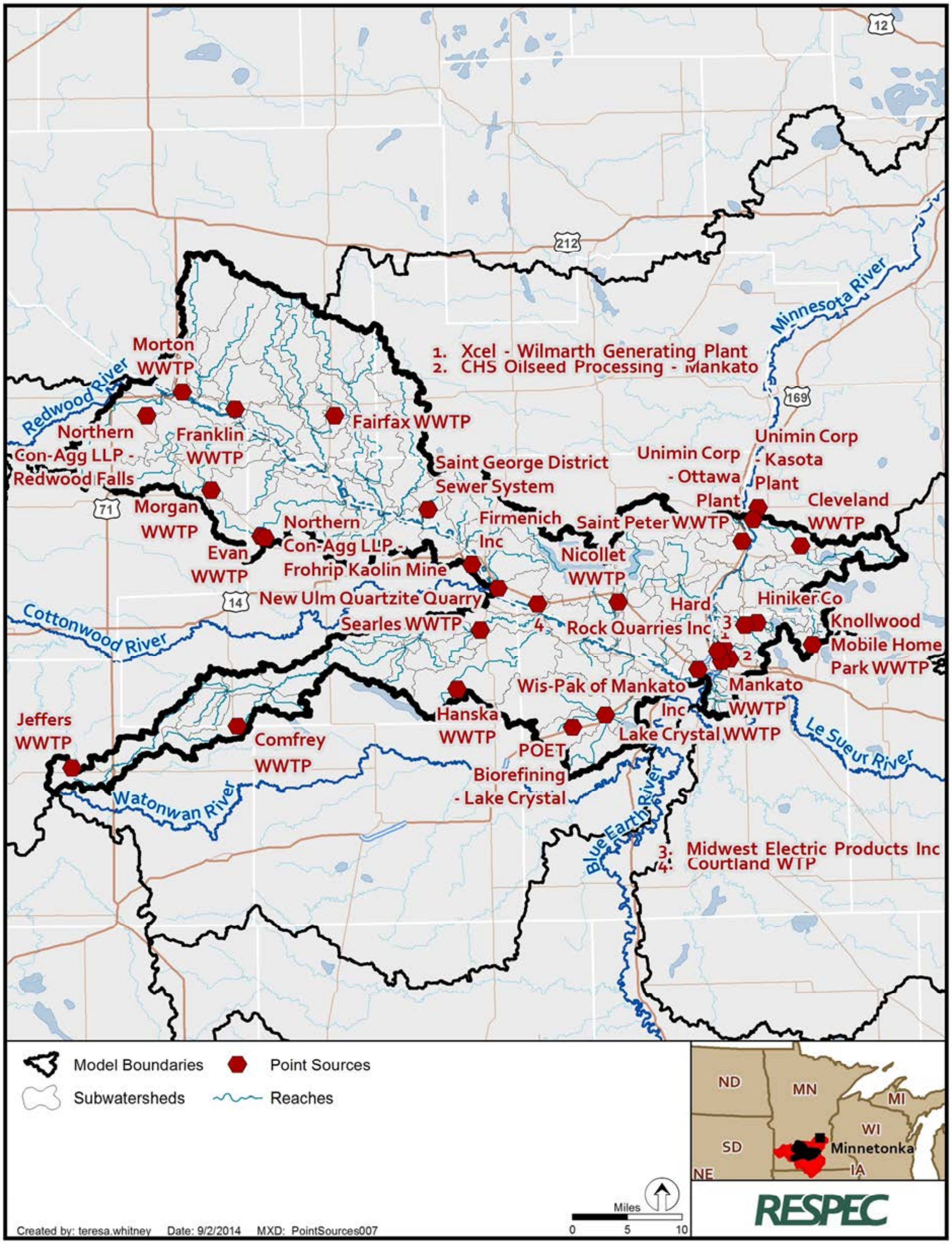

Figure C-4. Middle Minnesota Watershed Point-Source Locations.

RSI-2279-14-165

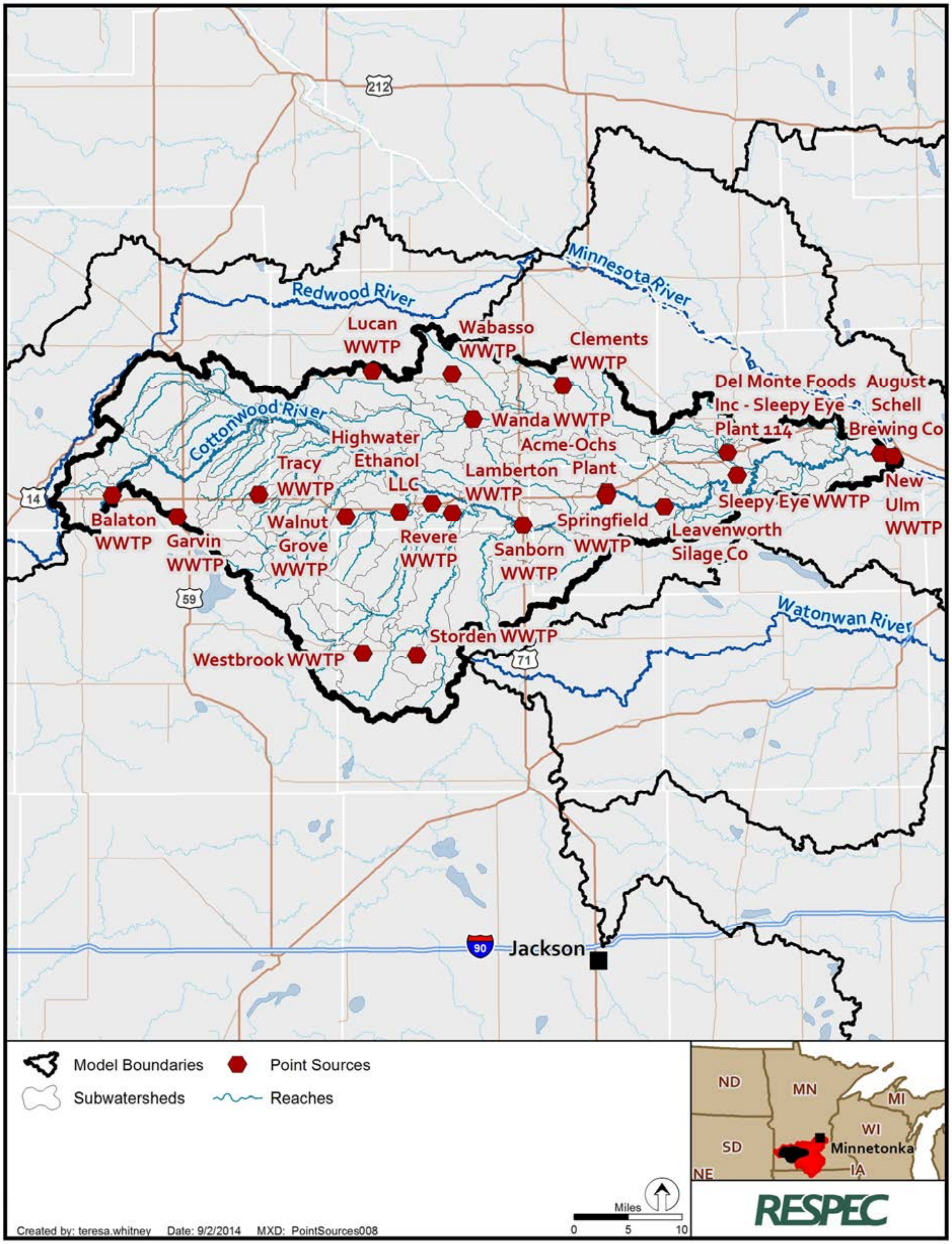

Figure C-5. Cottonwood Watershed Point-Source Locations.

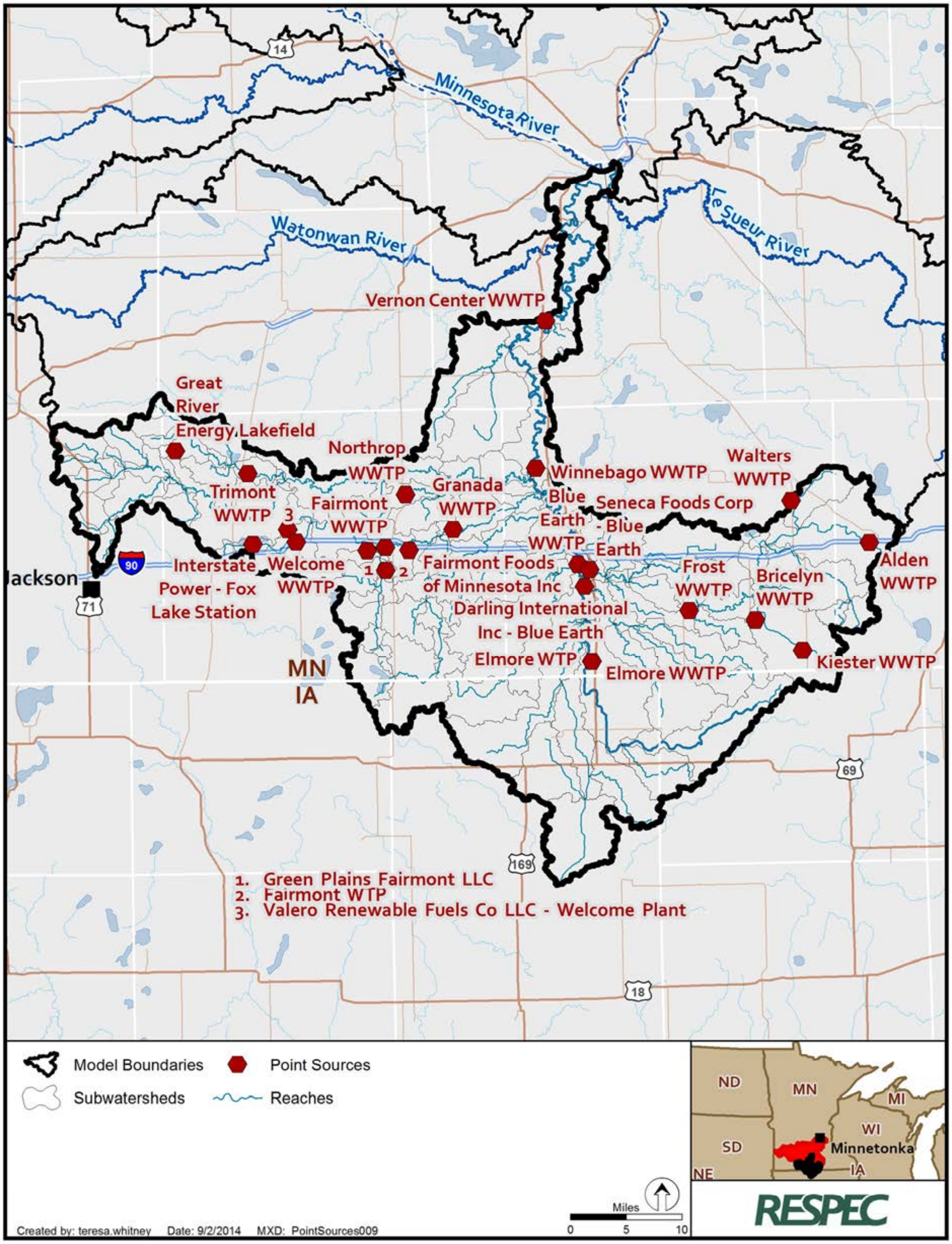

Figure C-6. Blue Earth Watershed Point-Source Locations.

RSI-2279-14-167

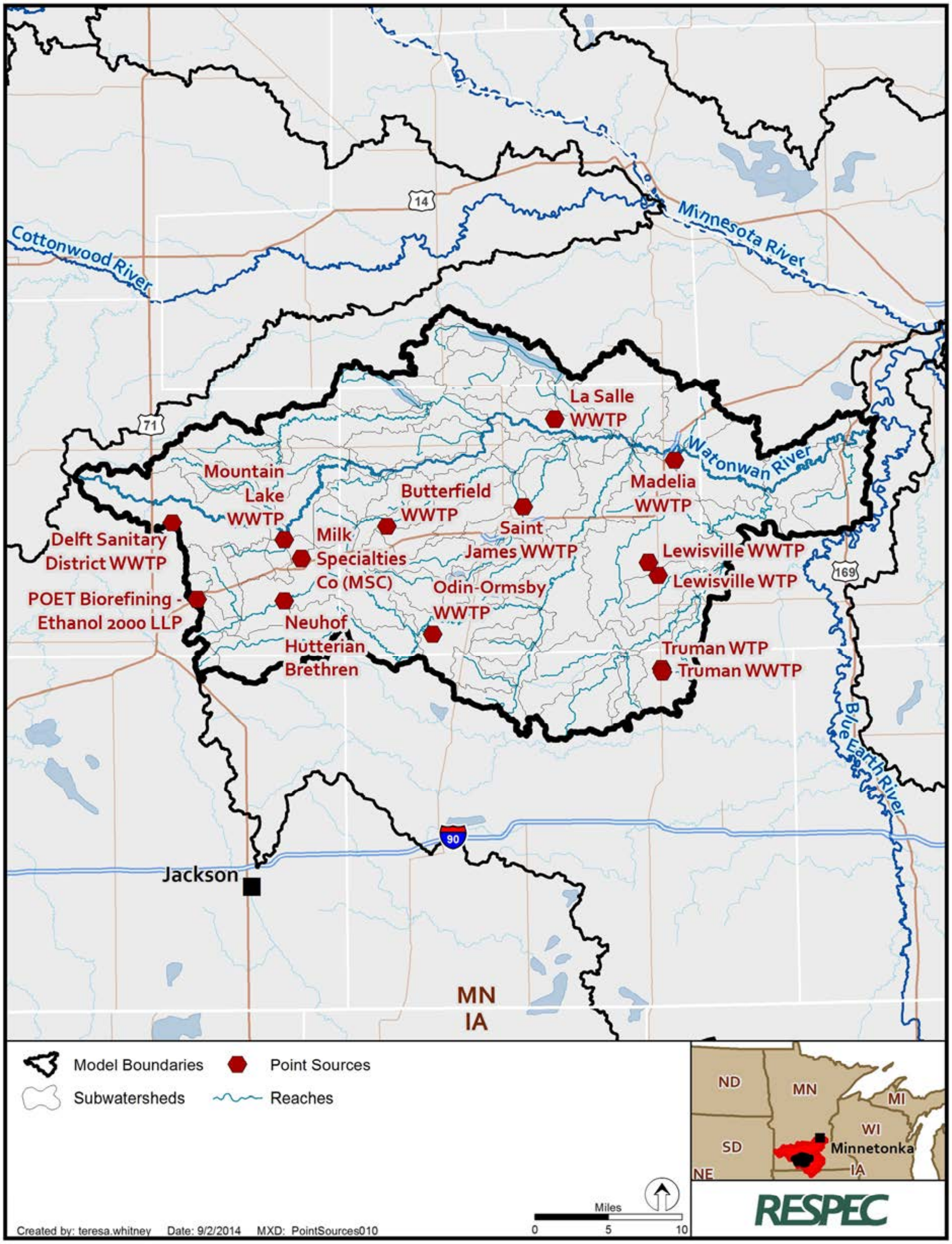

Figure C-7. Watonwan Watershed Point-Source Locations.

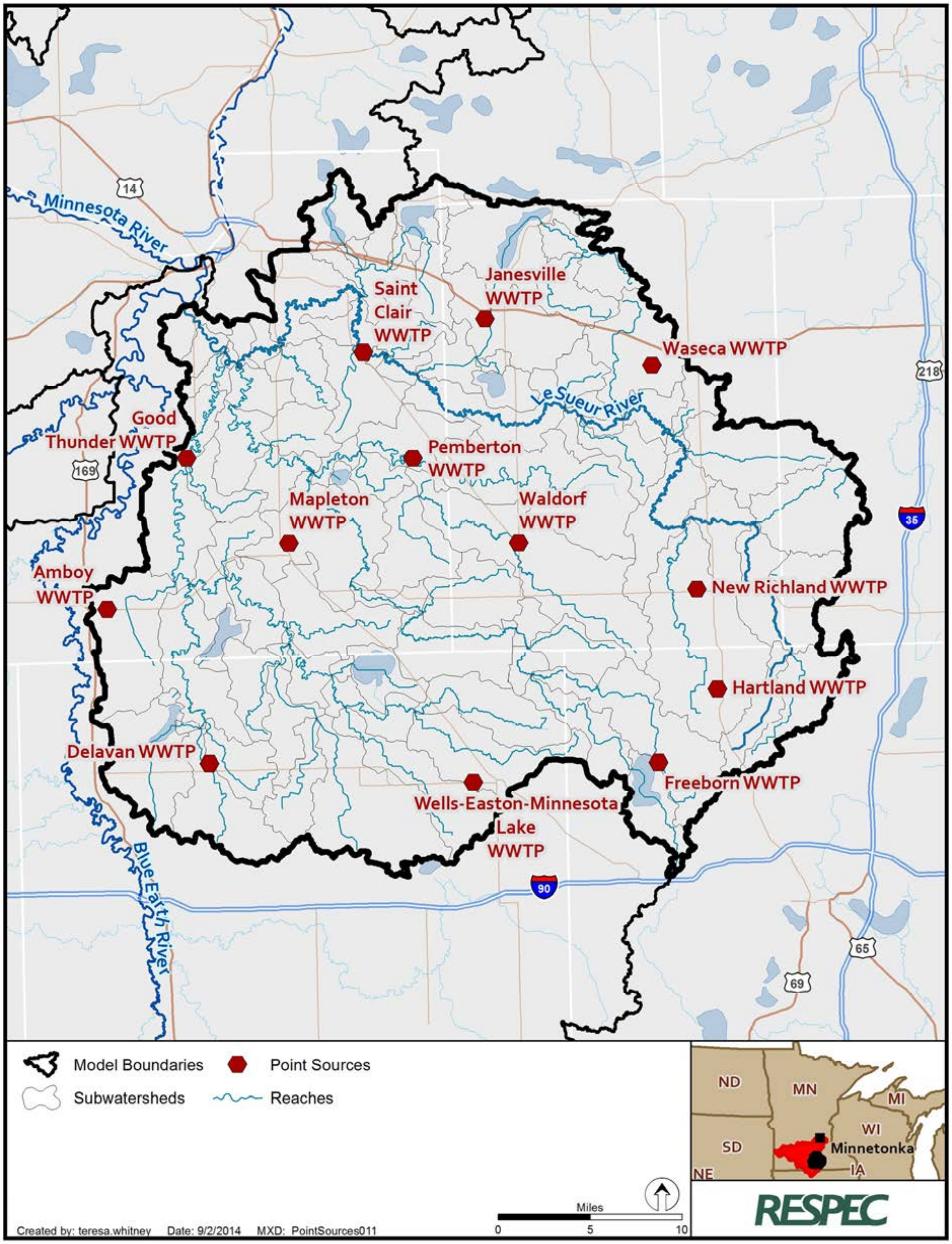

Figure C-8. Le Sueur Watershed Point-Source Locations.

RSI-2279-14-169

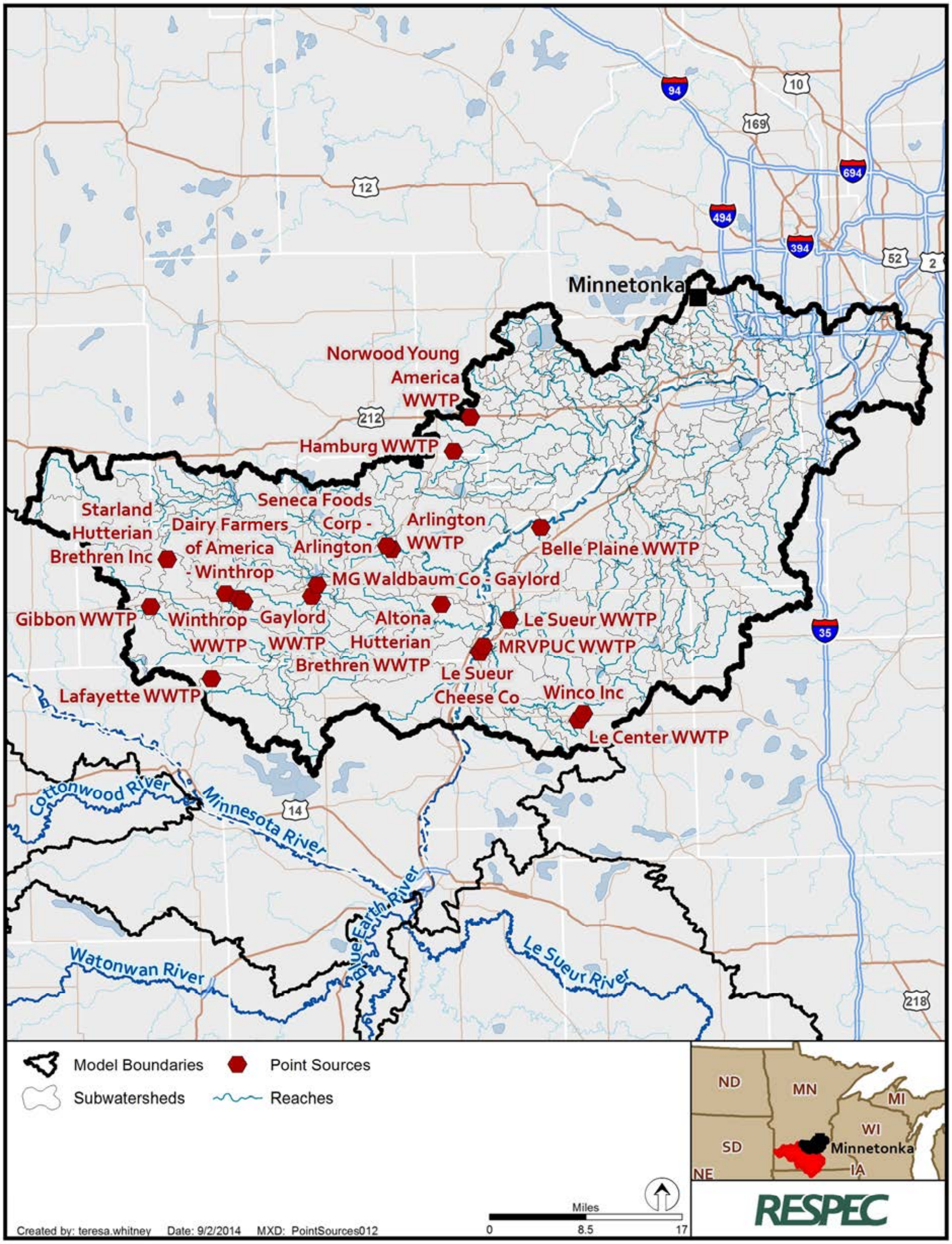

Figure C-9. Lower Minnesota Watershed Point-Source Locations.