CHAPTER 2
DATA COLLECTION

Background

Extensive amounts of data were required to create the input files for the modeling. Data necessary for this study included stream-gaging records, land use information, soils data, hydrologic data, topographic information, climate records, agricultural management data, and discharge records from point sources. This information was obtained from public agencies including the USDA, USGS, WDNR, UW-Extension, UW-Madison Agricultural Engineering Department, Wisconsin Geological Survey, Wisconsin State Climatology Office, and various County Land Conservation Offices. Additional data was received from individual wastewater treatment plants through a survey.

Except for water quality monitoring conducted at the nine RRP sponsored gaging stations (August 1998 – present), this study relied on existing data sources. No new additional data was collected. Multiple sources and types of data were identified based on a review of the input requirement of SWAT. Early in the data acquisition process, it was apparent that digital data would greatly assist in reducing the work needed to process data for input into SWAT. Digital data utilized for this study provided by the WDNR includes:

- 100,000 scale county polygon coverage
- 24,000 scale landnet clipped to basin
- dam point coverage
- 100,000 scale minor civil divisions coverage
- 100,000 hydrography and later 24K hydrography clipped to extent of basin
- 24,000 scale point coverage of monitoring locations
- 100,000 scale state trunk highways line coverage
- 250,000 scale STATSGO soil coverage
- 24,000 scale subwatershed boundary coverage
- 24,000 scale watershed region coverage
- 75 meter DEMs statewide coverage and later 30M DEMs clipped to basin

ARCVIEW and ARCVIEW Spatial Analyst (for grid based analysis) were used to construct, process, and analyze GIS coverages to supply inputs for the SWAT model and construct maps. Environmental Systems Research Institute, Inc. (ERSI), developed both of these software programs.

Climate Data

Climate data, specifically daily precipitation and temperature data, was gathered from monitoring sites located within, or near, the Rock River Basin. Because the spatial variability of precipitation can dominate the water balance of large watersheds (Arnold et. al., 1998), multiple climate stations were selected for this study. Each watershed was assigned the nearest climate monitoring station.

Climate records were obtained from the State Climatologist for 17 monitoring stations located in and around the Rock River Basin. Stations include: Arlington, Beaver Dam, Burlington, Fond Du Lac, Fort Atkinson, Germantown, Hartford, Janesville (Afton), Lake Mills, Lake Geneva, Madison, Milwaukee, Oconomowoc, Stoughton, Watertown, Westbend, and Whitewater. Of these stations, 14 are located within the basin. All of the stations used had time periods where data was missing. The three stations outside of the basin were used to help fill in missing data points. Daily precipitation and daily max/min temperatures were obtained in a digital format for each station for the period 1960 until 1998. Data for 1999 was obtained via hard copy and entered into the digital database.

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Precipitation reported as "trace" (less than 0.01") was replaced with zeros and "missing" data was replaced with a value calculated using the Thiessen polygon method using records from the three closest surrounding stations. The normal-ratio method was used to replace missing temperature records. Data was processed into an ASCII format that was compatible with SWAT. A separate precipitation and temperature file for each station was generated.

Table 2.1 provides a summary of 14 stations located within the Rock River Basin. The location of the stations is shown on Figure 2.1.

TABLE 2.1
SUMMARY OF CLIMATE STATIONS

Station	Type of Station	Days of Missing Data	Average Precipitation (inches) 1961 – 1990
Arlington	Cooperative	933	31.14
Beaver Dam	Cooperative	2	31.73
Beloit	Cooperative	573	33.05
Fond Du Lac	Cooperative	67	29.39
Fort Atkinson	Cooperative	***	32.87
Germantown	Cooperative	26	30.50
Hartford	Cooperative	8	31.74
Lake Geneva	Cooperative	222	36.91
Lake Mills	Cooperative	253	32.78
Madison	National Weather Service	72	30.88
Oconomowoc	Cooperative	161	30.90
Watertown	Cooperative	89	32.71
Westbend	Cooperative	198	31.99
Whitewater	Cooperative	88	32.44

It should be noted that the spatial distribution and number of monitoring sites influences the estimate of areal distribution of precipitation. Figure 2.2 shows the variability of precipitation of three selected stations used to model the Upper Rock River. The figure shows precipitation variability over time and space.

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Insert Figure 2.1 from ARCVIEW of Climate monitoring sites (Figure 2.1)

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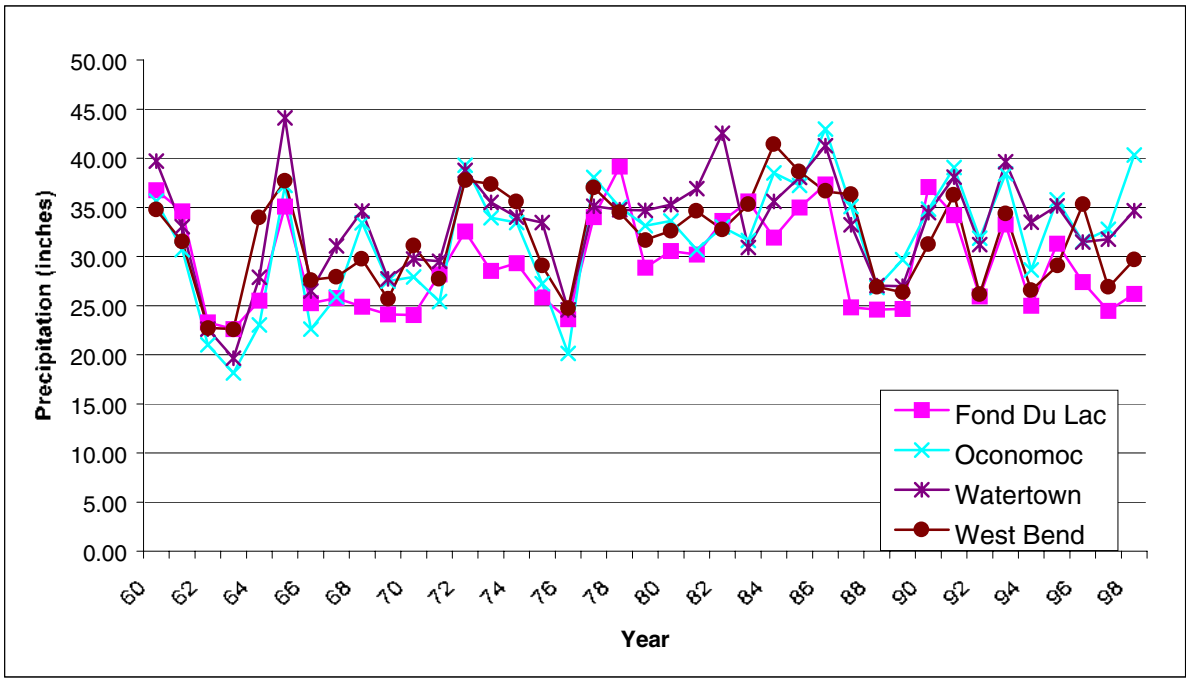
FIGURE 2.2
ANNUAL VARIABILITY OF PRECIPITATION
FOR FOUR STATIONS IN THE
UPPER ROCK RIVER BASIN



There has been a great deal of research conducted on precipitation measurement errors. Studies indicate that wind is the major cause of error in gage measurements (Larson and Peck, 1974). These errors are greater for snowfall then with rain. In a comparison of two National Weather Service stations in a 20 mph wind, a catch efficiency of 70% was observed for snow fall and 20% for rainfall (Larson and Peck, 1974). On average, the expected range of errors in rainfall data range from 0 to 20% for winds between 0 and 20 mph.

Two types of stations exist within the Rock River basin, National Weather Service and cooperative. The cooperative stations tend to be less accurate. Cooperative observers do not always record precipitation using the same event period. These time lags have a "smoothing out" effect on precipitation events reducing the hyetographs (plot of rainfall versus time) by up to a factor of 1/3 or more and thus no longer representing the true nature of the storm event (Baumgart, 1998).

Soils Data

The WDNR provided the STATSGO (State Soil Geographic Database) soil data coverage for the state of Wisconsin. This database contains digital geographic soils data made by generalizing from the more detailed soil survey maps. Where more detailed soil maps were not available for the STATSGO system, data on soils from analogous areas, geology, topography, and vegetation were assembled together with Landsat images. Spatial data consists of digital soil survey maps compiled to agency (USDA National Soil Survey) standards on USGS 1:250,000 scale topographic quadrangle series. Attribute data consists of data on map unit composition, soil properties and interpretations from the National Cooperative Soil

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Survey Database. Individual county soil surveys were used to augment the STATSGO coverage data to determine average values for the various soil-input parameters. The STATSGO database was selected for this project because a complete coverage of county soil surveys was not yet available in a digital format however the STATSGO coverage provides an appropriate level of detail for this modeling effort.

The STATSGO database provides a summary of soils by association. Information for each association is contained in a table that summarizes values for each soil series contained in a particular association. The soil series are ranked by percent composition and include data on each unique soil layer representing the major soil horizons in a particular series. Data for each layer includes: depth of each layer, depth of rooting zone, bulk density, available water capacity, organic carbon, clay content, sand content, albedo, USLE K factor, percent rock fragments, hydraulic conductivity, and percent passing various sieve sizes. Because of the scale data is summarized at, considerable variability is introduced. Adjustments of bulk density or available water capacity by as much as 30 percent are not unreasonable.

One of the important input parameters for SWAT is the initial nutrient concentration in the soil profile. Data on soil nutrient concentrations was obtained from a summary of soil test results provided by UW-Extension. This summary was an excerpt from a report published in 1994 and provides average soil nutrient levels by county.

Land Use Data

Land use information was based on WISCLAND GIS coverage, which was obtained from the WDNR. The WISCLAND (Wisconsin Initiative for Statewide Cooperation on Landscape Analysis and Data) Land Cover data set is a raster representation of vegetation/land cover for the state of Wisconsin. The source data was acquired from the nationwide MRLC (Multi-Resolution Land Characteristics Consortium) acquisition of Landsat Thematic Mapper (TM) data primarily from 1992. The original pixel size of the source TM data is 30 meters on a side, however the classified WISCLAND Land Cover data (excluding urban areas) are generalized or 'smoothed' to an area no smaller than four contiguous pixels (equivalent to approximately one acre). The result of this smoothing is that any feature five acres or larger may be resolved in the data (i.e., Minimum Mapping Unit (MMU) of five acres). The Land Cover data are usable at nominal scales of 1:40,000 to 1:500,000 for a wide variety of resource management and planning applications (WDNR metadata). The data set best describes land conditions during the period 1991 to 1993. The WISCLAND data can be used for landscape scale analysis in various disciplines such as wildlife ecology, forestry, or land use planning. It is suggested that the data be used at no less than the five acre MMU.

Accuracy Assessment matrices have been completed for each land use classification unit of the data set, or 'SCCU' (Spectrally Consistent Classification Unit). A “SCCU” is the finest resolution of landuse in WISCLAND. These matrices should be referred to when using the WISCLAND Land Cover Data. Accuracy Assessment was calculated separately for wetlands and uplands. For the upland land use category, errors of omission and commission (both at species level and generalized level) were tallied for each classification unit (SCCU) including an overall percentage of accuracy, and a K-hat statistic. Wetland accuracy was also based on the SCCU, with percentage accuracy for each class and overall percentage accuracy. Urban accuracy assessment was performed on its unit of classification at the full TM scene. Details on the accuracy are contained in the WISCLAND documentation.

The basic land use categories used for this study included urban, forested, and agricultural. For this study, all urban areas were classified as one land use. Forested areas were also classified as one land use category. Agricultural land was divided by its individual use categories. Agricultural land uses included pasture, barren land, corn, hay, soybeans, or other row crops. Interviews with individual County Land Conservation Agents were used to verify agricultural land use.

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Topographic Data

Topographical data was required for delineation of subwatersheds and generation of model inputs such as slope and slope length. Initially, the WDNR provided complete 75-meter digital elevation models (DEMs) of the Rock River Basin and a partial coverage of the 30-meter DEMs. DEMs are digital records of terrain elevations for ground positions at regularly spaced horizontal intervals which are derived from United States Geological Survey (USGS) maps.

Analysis conducted during the modeling of the pilot scale models revealed that the 75-meter DEM was too coarse for the requirements of this study. Soon after this analysis, the 30-meter coverage was completed and available for the entire project area. When compared to the USGS quad maps, the 30-meter DEMs generated 10-foot contour lines nearly identical to those found on the quad maps. The DEMs were used to delineate watershed and sub-watershed boundaries, identify internally drained areas, and derive average slopes and slope lengths.

Hydrologic Data

Digital hydrography layers in GIS format were obtained from the WDNR. Initially only 1:100,000 scale was available, however, after completion of the pilot areas, a basin wide 1:24,000 scale layer was available. The 24,000 hydrography displayed streams and rivers, lakes and impoundments, and wetlands. Streams and rivers were identified as intermittent or permanent. A digital format of the WDNR watershed boundaries at 1:24,000 scale was used as a starting point for watershed delineation. In addition to the hydrography layer, a second 1:24,000 scale wetland coverage provided by the WDNR was used to augment the wetland data from the hydrography layer. This data not only allowed for locating the wetlands, but also allowed classification of the type of wetland so that it could be better simulated in the model.

GIS coverage showing the location of all the dams within the basin was also obtained from the WDNR. Information contained within the data set included location, official name of the dam, and the river or other waterbody on which the dam is located. Additional information for specific dams such as height, impoundment size, water volume, and outlet structure was obtained from the counties and the Dam Safety/Floodplain Management Section at the WDNR. Once collected, this information was linked back to the original GIS coverage.

USGS Gaging Data

The United States Geological Survey (USGS) maintains records for numerous gaging and monitoring stations throughout Wisconsin. Approximately 80 gaging stations within the Rock River Basin were located and screened for use in this Study. Historical records extending back over a 30-year period were gathered from gaging stations. Stations were ranked based on the dates of records, the length of records, the type of data (flows, sediment data, and nutrient data) and the accuracy or quality of the data. These stations are summarized in Table 2.2.

Data for monitoring sites was downloaded from the USGS Internet web site. Data was available in a space-delimited text format, which was then imported to the *Microsoft Excel*™ format. Records from 1960 to the present were used for model calibration and validation. Missing data was disregarded and thus, not used for calibration purposes.

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Figure 2.3 shows the location of the gaging stations. Note that the stations in green had flow records only, the stations in red had flow, sediment, and phosphorus data, and the stations in yellow represent the nine locations sponsored by the RRP and include flow, sediment, and phosphorus data for 1999 with additional sampling continued in 2000. Additional data was obtained from USGS publications specifically, "Low-Flow Characteristics of Streams in the Rock River Basin, Wisconsin" (USGS, 1978) and "Measurement and Prediction of Sediment Yields in Wisconsin Streams" (USGS, 1976).

TABLE 2.2 SUMMARY OF USGS GAGING STATIONS LOCATED IN ROCK RIVER BASIN

STATION #	NAME	COUNTY	DRAINAGE AREA	RECORD TYPE	PERIOD OF RECORD
5423000	West Branch Rock River	Fond Du Lac	40.70	daily flows and peaks	1971to 1978
5423100	West Branch Rock River @ Cth D	Fond Du Lac	43.90	daily flows	1978 to 1981
5423500	South Branch Rock River @ Waupun	Fond Du Lac	63.60	Est.daily discharges	March 1987 to Current
5424000	East Branch Rock River near Mayville	Dodge	181.00	daily flow and peak flow	1949 to 1970
5424082	Rock River @ Hustisford	Dodge	511.00	daily flows and peak flows	1978 to 1985
5425500	Rock River @ Watertown	Jefferson	969.00	Est. daily discharges	Oct 1976 to Current
5425912	Beaver Dam River	Dodge	157.00	No est. daily discharge	March 1985 to Current
5426000	Crawfish River @ Milford	Jefferson	762.00	Est. daily discharges	June 1931 to Current
5426031	Rock River @ Jefferson	Jefferson	1850.00	daily flows and peak flow	1978 to 1994
5426250	Bark River near Rome	Jeffersoon	122.00	Est. daily discharges	Oct 1983 to Current
5426900	Whitewater Creek @ Millis Rd	Walworth	20.60	daily flow values	1978 to 1981
5427000	Whitewater Creek @ Willis Ray Rd	Walworth	22.80	daily flows and peak flows	1978 to 1981
5427235	Lake Koshkonong near Newville	Jefferson	25.60	No est. daily gage heights	July 1987 to Current
5427570	Rock River @ Indianford	Rock	2630.00	Est. daily discharges	May 1975 to Current
5427718	Yahara River @ Windsor	Dane	73.60	Est. daily discharges	Oct 1989 to Current
5427900	Sixmile Creek near Waunakee	Dane	41.10	Daily flow and peak flow	1976 to 1981
5427948	Pheasant Branch @ Middleton	Dane	18.30	Est. daily discharges	July 1974 to Current
5428000	Lake Mendota @ Madison	Dane	233.00	No est. daily gage heights	Jan 1916 to Current
5429000	Lake Monona @ Madison	Dane	279.00	No est. daily gage heights	Sep 1915 to Current
5430095	Badfish Creek @ Cth A	Dane	41.90	Daily flow and peak flow	1985 to 1988
5430150	Badfish Creek near Cooksville	Rock	82.60	Est. daily discharges	July 1977 to Current
5430175	Yahara River @ St Hwy 59	Rock	518.00	Est. daily discharges	July 1977 to Current
5430500	Rock River @ Afton	Rock	3340.00	Est. daily discharges	Jan 1914 to Current
5431014	Jackson Creek @ Petrie Road	Walworth	8.96	Daily flow and peak flow	1983 to 1995
5431016	Jackson Creek @ Mound Road	Walworth	16.80	Est. daily discharges	Feb 1993 to Current
5431018	Delavan Lake Trib. @ S Shore Dr.	Walworth	9.99	Daily flow and peak flow	1988 to 1991
5431022	Delavan Lake Outlet @ Borg Rd	Walworth	42.10	Est. daily discharges (poor)	Oct 1983 to Current
5431486	Turtle Creek @ Carvers Rock Rd	Rock	199.00	Est. daily discharges (fair)	Sep 1939 to Current
5431500	Turtle Creek near Clinton	Rock	202.00	peak flow	1938 to 1979

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Insert Figure 2.3
Location of USGS Gaging Stations
(Arcview Figure)

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Cropland Management and other Agricultural Data

Cropland management practices were determined from several sources. The WISCLAND coverage was used to estimate the type of crop and approximate land area dedicated to that crop. A transect survey performed in 1997 – 1998 on a county-by county basis was obtained from DATCP to access tillage practices. Results of the transect survey were summarized by WDNR watershed areas, and crop acreage. Interviews with county Land Conservation Department staff were used to gather additional information on crop rotations; types of crops; tillage practices; fertilizer application and manure management; irrigation; and location, size, and number of animal units for large dairy, hog, beef, and poultry operations. USDA Statewide Agricultural Statistics were summarized for each county and used to verify crop yields and estimate animal units.

In addition to NRCS, DATCP, and the Counties, information on typical agricultural practices within the basin was obtained from UW-Madison Department of Agricultural Engineering and UW-Extension.

A summary of the transect survey is included in Appendix A.

Point Source Data

Point source data (flow and effluent phosphorus concentrations) for existing conditions was collected from WDNR permit records where available. Supplemental information was obtained from a survey sent to all municipal and industrial point sources within the Rock River Basin. In most cases flow data was readily available, however phosphorus data was not. If a phosphorus concentration was not available from any of the previously mentioned sources, a discharge concentration of 4 mg/l was assumed based on average literature values for typical POTWs (unpublished correspondence, Strand Associates, 1999). Figure 2.4 shows the location of the point sources within the basin and Table 2.3 and 2.4 summarizes average annual phosphorus loads under existing conditions and the1 mg/l imposed under NR 217 for the Lower and Upper Rock River Basins respectively.

Phosphorus loads under NR 217 compliance conditions were calculated using 1 mg/l except for municipal sources with monthly loads less than 120 pounds per month and industrial sources with loads less than 50 pounds per month. Discharges from point sources meeting these criteria remained the same under existing and NR 217 conditions. Alternative limits above 1 mg/l were not evaluated. Alternative limits are evaluated on a case by case basis by the WDNR after submittal by a point source.

Insert Figure 2.4
Location of Point Source Discharges

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TABLE 2.3
SUMMARY OF POINT SOURCE DISCHARGERS
THAT DISCHARGE TO A SURFACE WATER BODY
LOWER ROCK RIVER BASIN

Permit Number	Facility Name	WDNR Watershed	Ave. Annual P Load (lb/yr) Existing	Proposed
0022608	Sharon WWTP	LR01	2360	590
0022039	Clinton WWTP	LR01	4038	1010
0031461	WalCoMet	LR01	24689	12001
0030350	Janesville	LR02	86010	42391
0031054	Plymouth Town SD No. 1	LR03	168	168
0024023	Footville WWTP	LR03	1473	1473
0026930	Town of Beloit Treatment Facility	LR03	2230	882
0023370	City of Beloit Treatment Facility	LR03	37596	29507
0021059	Consolidated Koshkonong SD	LR04	2157	1137
0060453	Milton	LR04	2872	1245
0020338	Stoughton WWTP	LR06	5904	4142
0020681	Oregon WWTP	LR07	3240	2854
0024597	MMSD	LR07	64347	64347
0021512	Arlington WWTP	LR09	283	283
0060577	Town of Dane WWTP	LR10	610	610
0026352	Rockdale WWTP	LR11	160	160
0020346	Edgerton WWTP	LR11	3965	1511
0026948	Cambridge WWTP	LR11	4774	1239
0002062	Dean Foods Vegetables	LR11	11211	1262
0022489	Fort Atkinson WWTP	LR11	28095	6229
0023744	Deerfield WWTP	LR12	2799	560
0020478	Sun Prairie	LR12	28613	8133
0031844	Sullivan SD No.1	LR13	343	343
0025585	Village of Sullivan	LR13	366	366
0021351	Dousman	LR13	2702	676
0032026	Delafield-Hartland	LR13	14086	4847
0020001	Whitewater WWTP	LR14	14816	5194
0031020	Palmyra	LR15	2905	575

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TABLE 2.4
SUMMARY OF POINT SOURCE DISCHARGERS
THAT DISCHARGE TO A SURFACE WATER BODY
UPPER ROCK RIVER BASIN

Permit	Facility Name	WDNR	Ave. Annual P Load (lb/yr)	
Number		Watershed	Existing	Proposed
0002038	Ladish Malting	UR01	34560	3908
0028541	City of Watertown WWTP	UR01	47207	10541
0021008	City of Columbus WWTP	UR02	928	928
0031194	City of Lake Mills WWTP	UR02	10290	2573
0002003	Alto Dairy Cooperative	UR02	52399	2514
0029271	Village of Lowell WWTP	UR03	268	268
0028509	Village of Reesville WWTP	UR03	895	895
0031160	Village of Randolph WWTP	UR03	3996	999
0023345	City of Beaver Dam WWTP	UR03	62786	10468
0002046	Waterloo Malting Co	UR05	552	552
0030881	City of Waterloo WWTP	UR05	3728	1269
0024627	Village of Marshall WWTP	UR05	3909	978
0029611	Wisconsin Academy	UR06	259	259
0023973	Village of Fall River WWTP	UR06	589	589
0022161	Johnson Creek Treatment Facility	UR07	3673	669
0031364	Lebanon Sanitary District	UR08	65	65
0023051	Hidden Meadows	UR08	410	410
0031038	Ixonia Sanitary District No.1	UR08	665	665
0026077	Max P.E. Radloff & Sons	UR08	1335	11
0020486	Village of Iron Ridge WWTP	UR08	1539	1539
0020702	Village of Clyman WWTP	UR08	1678	1678
0020303	Village of Hustisford WWTP	UR08	1788	1788
0021474	City of Juneau WWTP	UR08	4829	575
0020231	City of Horicon WWTP	UR08	5930	1483
0024333	City of Jefferson WWTP	UR08	27039	5190
0053627	Pabst Farms	UR09	2512	50
0021181	Oconomowoc Treatment Facility	UR09	14087	6945
0031381	Ashippun Sanitary District	UR10	1096	1096
0020290	Slinger Treatment Facility	UR11	928	928
0020192	Hartford Treatment Facility	UR11	3423	3423
0050016	Grande Cheese Co.	UR11	10533	921
0001996	National Rivet and Mfg	UR12	52	52
0031551	Burnett Sanitary District	UR12	310	310
0022772	City of Waupun WWTP	UR12	16743	5097
0035548	Village Kekoskee WWTP	UR13	579	579
0021601	Village of Brownsville WWTP	UR13	725	725
0020532	Village of Lomira WWTP	UR13	809	809
0022322	Village of Theresa WWTP	UR13	1193	1193
0028053	Allenton Treatment Facility	UR13	2156	539
0024643	City of Mayville WWTP	UR13	15135	2235

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