

LPT-095

## **USER'S MANUAL**

### **Kewaunee County Surface Water Classification Models**

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# CHAPTER 1

## INTRODUCTION

Without a specific management or implementation goal in mind at the outset, surface water classification can be an academic exercise. However, with careful selection of classification criteria and integration of these criteria on an ecosystem scale, classification of the surface waters within Kewaunee County can provide the information necessary to justify and focus resource protection and land use planning efforts.

The surface water classification schemes presented herein will address both the lacustrine and riverine resources of the County. The surface water classification models represent an adaptation of an ecosystem risk assessment methodology based upon fuzzy set models (Wenger et al. 1990; Wenger and Rong 1987).

Fuzzy set models are appropriate for surface water classification because they incorporate and diffuse the uncertainty inherent in classifying items as problematic as sources of water quality impairment over large areas. Output from the classification models can be used to prioritize future resource protection needs such that the limited financial resources available for abatement can be most effectively appropriated.

## CHAPTER 2

### GETTING STARTED

#### SOFTWARE REQUIREMENTS

The classification models were designed using **Microsoft Excel** software. As a result, the models cannot be used without obtaining a licensed copy of Microsoft Excel. In addition, the models have the capability to interface with **ArcView** Geographic Information System (GIS) software. The ArcView interface allows display of a Kewaunee County map showing the various watershed or subwatershed boundaries and their relative risk rankings. The models can be operated in Microsoft Excel, however, without the use of ArcView. The only disadvantage of operating the models without ArcView is the loss of mapping functions. A licensed copy of ArcView is required for the mapping of risk ranking.





labor-intensive classification systems that require collection of large amounts of field data.

To develop a feasible model that would facilitate countywide application, the stream classification system for Kewaunee County was developed with the following requirements: 1) be user friendly, 2) use readily available information, 3) have the ability to be easily updated as land use and stream conditions change over time, and 4) provide practical information directly related to planning and/or resource protection activities.

### **WATERSHED AND SUBWATERSHED DEFINITION**

Application of a stream classification procedure requires development of a standardized definition of watershed and subwatershed boundaries in the County. Watershed boundaries were determined by reviewing information contained in *The Kewaunee River Priority Watershed Management Plan* (WDNR 1984) and *Twin-Door-Kewaunee Water Quality Management Plan* (WDNR 1995), and by reviewing existing Land Conservation Department watershed mapping. In addition, the watershed boundaries were verified through interpretation of United States Geologic Survey 7.5 Minute Series topographic maps. The watersheds existing within Kewaunee County are listed below with their assigned abbreviations (in parentheses) and are shown in Figure 3-1.

➤ Ahnapee River (AR)	➤ Red River and Little Sturgeon Bay (RR)
➤ East Twin River (ET)	➤ Stony Creek (SC)
➤ Kewaunee River (KR)	➤ West Twin River (WT)

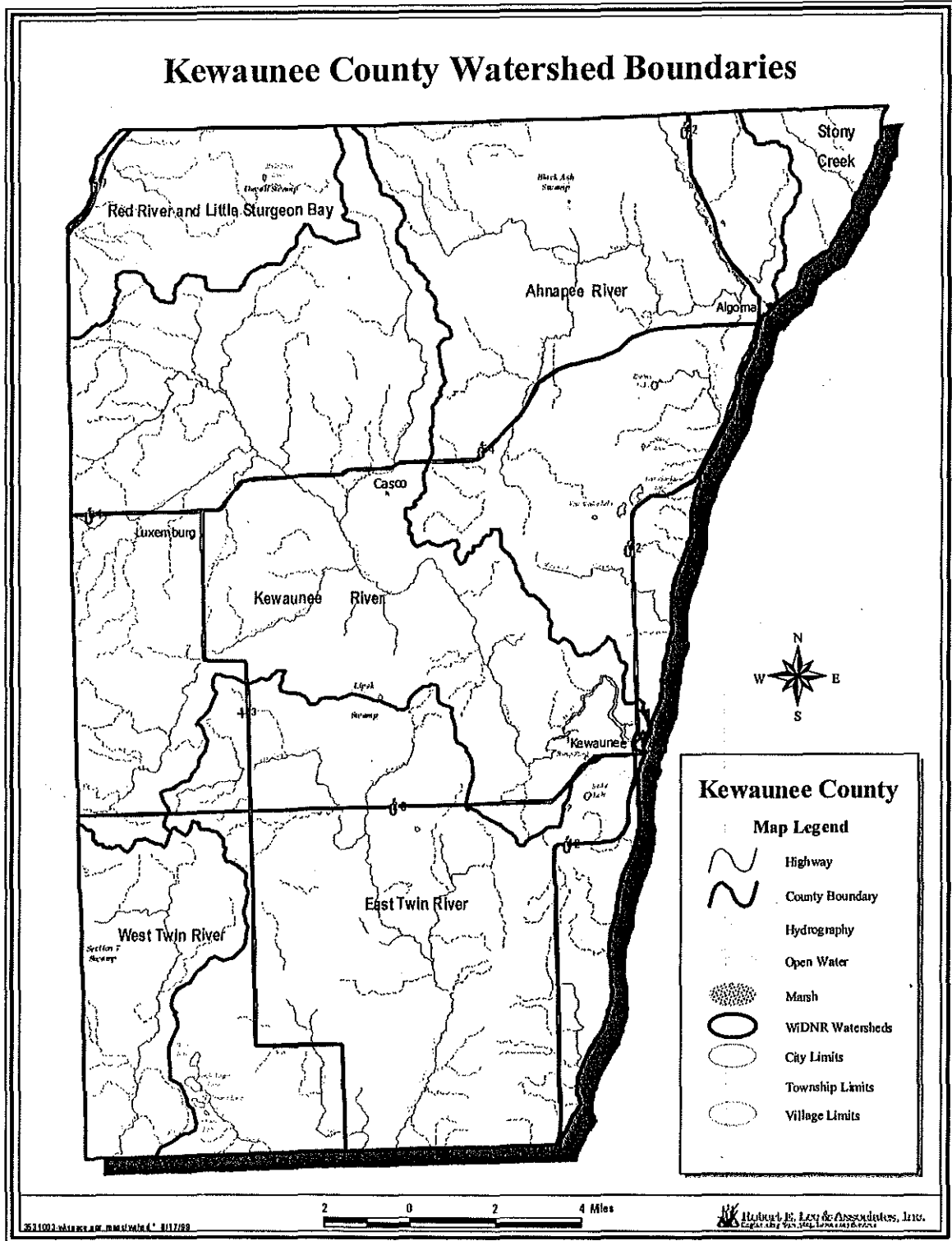


Figure 3-1 Kewaunee County Watersheds

As with the watersheds, delineation of the subwatershed boundaries utilized information contained in *The Kewaunee River Priority Watershed Management Plan* and *Twin-Door-Kewaunee Water Quality Management Plan* and existing Land Conservation Department subwatershed mapping. The scale at which the subwatershed analysis was conducted was largely based upon the current practical level of analysis given existing constraints. As a result, the majority of the County's named streams were delineated as subwatersheds, however many of the unnamed streams and first or second order streams were not delineated. If necessary, the model could be adjusted to further refine the level of analysis (e.g., analysis of all the first or second order streams) in the future. The subwatersheds by watershed are listed below and shown in Figure 3-2.

<p><b><u>Ahnapee River</u></b></p> <ul style="list-style-type: none"> <li>➤ Ahnapee River (AR)</li> <li>➤ Bruemmer Creek (BR)</li> <li>➤ Mashek Creek (MK)</li> <li>➤ Rio Creek (RI)</li> <li>➤ Silver Creek (SV)</li> <li>➤ Three Mile Creek (TM)</li> <li>➤ Unnamed AR1 (AR1)</li> <li>➤ Unnamed AR2 (AR2)</li> </ul>	<p><b><u>Kewaunee River</u></b></p> <ul style="list-style-type: none"> <li>➤ Casco Creek (CO)</li> <li>➤ Lower Kewaunee River (LK)</li> <li>➤ Luxemburg Creek (LC)</li> <li>➤ Martinville School and Champion Tributaries (MSCT)</li> <li>➤ Scarboro Creek (SO)</li> <li>➤ School Creek (SL)</li> <li>➤ Upper Kewaunee River (UK)</li> </ul>
<p><b><u>East Twin River</u></b></p> <ul style="list-style-type: none"> <li>➤ East Twin River (ETR)</li> <li>➤ Jambo Creek (JC)</li> <li>➤ Unnamed ET1 (ET1)</li> </ul>	<p><b><u>Red River and Little Sturgeon Bay</u></b></p> <ul style="list-style-type: none"> <li>➤ Red River (RR)</li> </ul>
<p><b><u>Stony Creek</u></b></p> <ul style="list-style-type: none"> <li>➤ Silver Creek (SI)</li> <li>➤ Unnamed SC1 (SC1)</li> </ul>	<p><b><u>West Twin River</u></b></p> <ul style="list-style-type: none"> <li>➤ Black Creek (BC)</li> <li>➤ Neshota River (NR)</li> </ul>

# Kewaunee County Sub-Watershed Boundaries

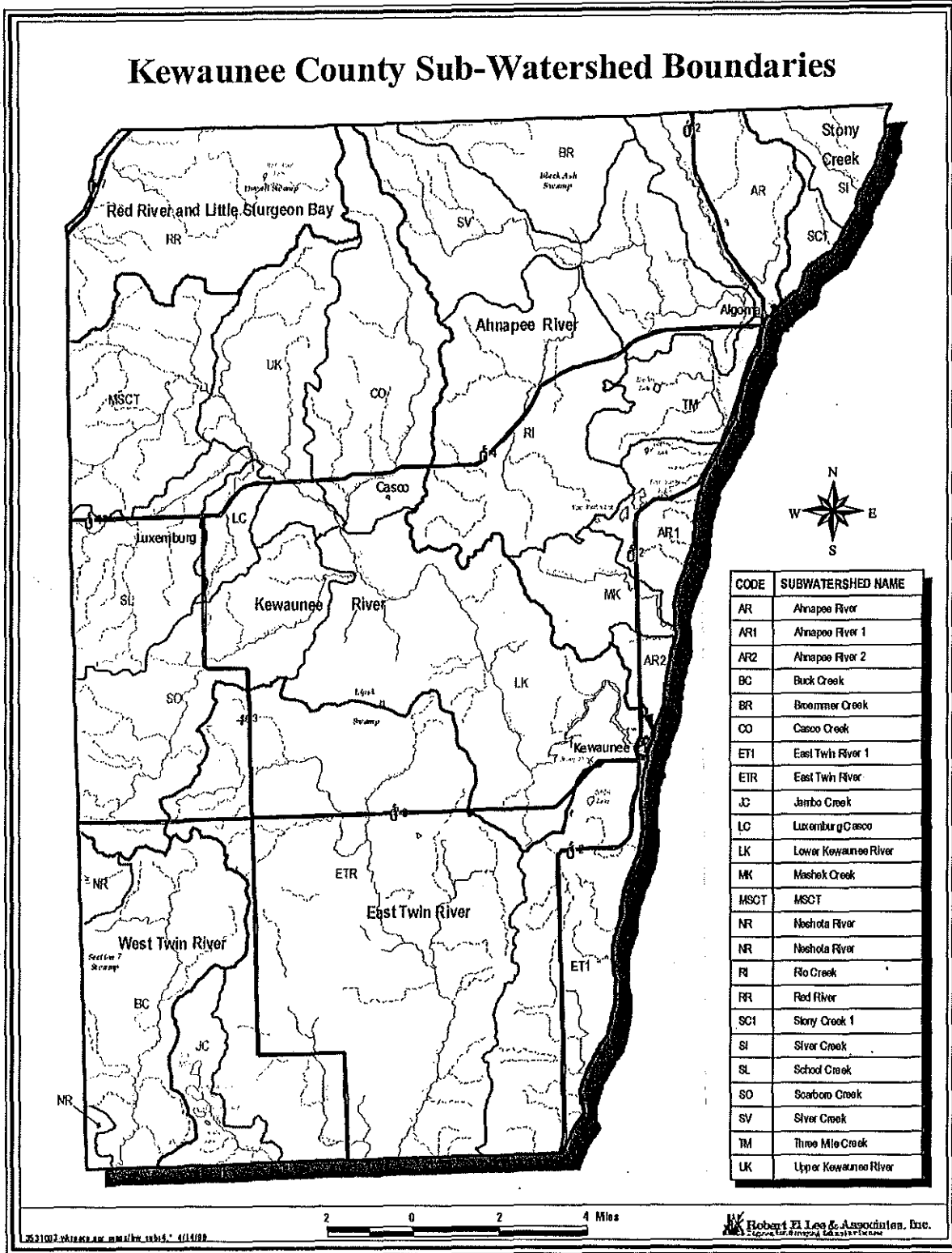


Figure 3-2 Kewaunee County Sub-Watersheds

## CLASSIFICATION MODEL DESIGN

As mentioned, the classification models were developed to operate in Microsoft Excel. Microsoft Excel, like most personal computer based software applications, operates using data files. The stream watershed and subwatershed models were each designed as separate data files. The following files were created in Microsoft Excel:

- Watershed Model.xls
- Complete Subwatershed Model.xls
- Ahnapee River Subwatershed Model.xls
- East Twin River Subwatershed Model.xls
- Kewaunee River Subwatershed Model.xls
- Red River Subwatershed Model.xls
- Stony Creek Subwatershed Model.xls
- East Twin River Subwatershed Model.xls

The file "Watershed Model" is used to classify watersheds, the file "Complete Subwatershed Model" classifies all of the County's subwatersheds relative to each other, and each of the remaining files classifies the subwatersheds within their respective watersheds.

Each file is structurally and functionally similar. Microsoft Excel stores and manipulates data using worksheets. Two worksheets entitled "Data Input" and "Rankings" are present in each file. The "Data Input" worksheet is used to input the information required for the model. The "Rankings" worksheet provides a graphic display of the relative ranking for each watershed or subwatershed.

Macro buttons are used to move within or between the "Data Input" and "Rankings" worksheets. The macro buttons are labeled and provide an easy method for both

inputting data and analyzing how new data affects the relative rankings displayed in the "Rankings" worksheet.

## DATA INPUT WORKSHEET

An example Watershed Data Input Sheet is shown in Figure 3-3. Areas in which the user needs to input values contain red text. The remainder of the "Data Input" worksheet has been protected and cannot be edited or changed unless the worksheet is converted to an unprotected worksheet. (Please see the *Phosphorus Loading* section in this Chapter for a description of the method for editing protected cells.) The macro buttons are labeled in Figure 3-3 and can be used to move between management units or worksheets. In addition, the "Print Sheet" macro button can be used to print the Watershed Data Input Sheet or Subwatershed Data Input Sheet for each management unit.

The "Data Input" worksheet is divided into Risk Variables and Value Weights. The Risk Variables are considered indicators of increased risk for water quality impairment and include Areal Phosphorus Loading Based on Land Use, Areal Sediment Loading Based on Land Use, Animal Units per Cropland Acre, Number of Point Source Discharges, Number of Hazardous Waste Sites, Mean Slope, Percent of Highly Erodible Soils, and Percent of Slopes Greater than 6%. The watersheds or subwatersheds are ranked according to relative risk for water quality impairment based upon the factors listed above. The relative rankings produced by the model are then graphically displayed in the "Rankings" worksheet.

The Value Weights used in the model include the WDNR Potential Biological Use Classifications, Designated Outstanding or Exceptional Resource Waters, and Presence of Water Dependent Threatened and Endangered Species. In addition to the ranking based upon risk for water quality impairment, the model is able to weight the risk ranking in relation to the value of the resource based upon these three factors.

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	
1	<b>WATERSHED DATA INPUT SHEET</b>				Watershed: <b>Annapee River</b>											
2	<b>Variables</b>															
3	<b>Type of Land Use</b>				<b>Acres</b>	<b>Phosphorus Loading Coefficient</b>			<b>Annual Phosph. Load</b>		<b>Sediment Loading Coefficient</b>			<b>Annual Sediment Load</b>		
4						<b>(Pounds per Acre per Year)</b>			<b>(Pounds per year)</b>		<b>(Pounds per Acre per Year)</b>			<b>(Pounds per year)</b>		
5	<b>Urban/Developed</b>															
6	High Intensity				193	1.16			224		490.00			94570		
7	Low Intesity				431	0.36			155		220.00			94820		
8	Golf Course				0	4.53			0		100.00			0		
9	<b>Agriculture</b>				40281	0.89			35850		4000.00			161124000		
10	<b>Grassland</b>				2237	0.27			604		100.00			223700		
11	<b>Forest</b>				2697	0.08			216		120.00			323640		
12	<b>Wetland</b>				9564	0.09			861		120.00			1147680		
13	<b>TOTAL</b>				55875				37909.64					163008410		
14	Animal Units per Cropland Acre				0.31											
15	Number of Point Source Discharges				6											
16	Number of Hazardous Waste Sites				5											
17	Mean Slope				0.21											
18	Percent of Highly Erodible Soils				0											
19	Percent of Slopes Greater than 6 %				0											
20	Areal Phosphorus Loading Based on Land Use				0.68											
21	Areal Sediment Loading Based on Land Use				2917.38											
22	<b>Value Weights</b>															
23	<b>Value</b>				<b>Stream Miles</b>			<b>Weight</b>								
24	<b>WDNR Potential Biological Use Classification</b>															
25	Cold Water Community				4.5				0.2							
26	Warm Water Sport Fish				14.9				0.6							
27	Warm Water Forage Fish				20.5				0.6							
28	Limited Forage Fish				55.5				1.2							
29	Limited Aquatic Life				0				0.0							
30	<b>SUM</b>				95.4				2.7							
31	<b>Value</b>				<b>Stream Miles</b>			<b>Weight</b>								
32	Designated Outstanding or Exceptional Resource Waters				No											
33	Presence of Water Dependent															
34	Threatened and Endangered Species				No											
35																
36																
37	<b>Print Sheet</b>															
38																

East Twin River	West Twin River
Kewaunee River	Risk Ranking
Red River and Little Sturgeon Bay	Risk Ranking Relative to Value
Stony Creek	

Figure 3-3 Watershed Data Input Sheet

For example, a watershed which ranked low in terms of risk may be in a relatively natural state and have high resource value. The consideration of both of these factors together could alter the risk ranking and rank the relatively pristine watershed higher in terms of management priority. Without considering value, management priority may be given to those severely degraded stream resources at the greatest risk for impairment without considering protecting high value stream resources from future impacts. The model allows a comparison of outcomes for both the risk analysis and the risk relative to value analysis. By comparing the two priority rankings, smarter management strategies that incorporate both remediation and protection can be developed.

A description of each of the Risk Variables and Value Weights included in the "Data Input" sheet is provided below.

## **Risk Variables**

### **Aerial Phosphorus and Sediment Loading Based on Land Use**

#### ***Land Use***

As mentioned previously, a primary goal of the classification models is that they utilize readily available information. With that in mind, existing data sources that could be easily incorporated into the County's GIS digital database were considered desirable.

The Wisconsin Initiative for Statewide Cooperation on Landscape Analysis and Data (WISCLAND) is a consortium of government and private organizations formed in 1993 to acquire funding and resources to develop land cover data for the state. The land cover data was derived from Landsat Thematic Mapper satellite imagery developed from 1991 through 1993. The satellite imagery was used to characterize



land cover into the following primary categories: urban/developed, agriculture, grassland, forest, open water, wetland, barren, and shrubland. A *User's Guide to WISCLAND Land Cover Data* can be found in Appendix A.

The WISCLAND data for Kewaunee County was acquired from the Wisconsin Department of Natural Resources (WDNR) and incorporated into the GIS database for the County. The land cover data was then used to create acreage estimates by land use type for each watershed and subwatershed (see cells A5 through A12 in Figure 3-3). The primary function of the land use analysis was to provide a method for analyzing potential phosphorus and sediment loads within each unit. The shrubland land cover category was combined with the forest category because these two land covers are considered to have similar phosphorus and sediment loading rates. Open water was not included in the model because it was not a relevant land cover type from a nutrient or sediment loading perspective. Likewise, the barren land cover type was not included in the model. Analysis of aerial photography indicated that the land cover in the County characterized as barren primarily consisted of abandoned or operational gravel pits and rock quarries. Gravel pits and rock quarries were considered either hydrologically isolated or too difficult to quantify from a nutrient and sediment loading perspective without a large amount of additional work.

NOTE: Because the open water and barren land cover categories have been omitted from the land use acreage, the total acreage for the watershed or subwatershed will often **not** equal the sum of the acreage by land use type. For this reason, total acreage needs to be input to the model in cell E13 (Figure 3-3).

### ***Phosphorus Loading***

Interest in basin phosphorus loading stems from its role in biological metabolism, and the relatively small amounts of phosphorus available in the hydrosphere. In

comparison to other nutrients required by aquatic biota, phosphorus is least abundant and often limits biological productivity (Wetzel 1983). In Wisconsin, phosphorus appears to be the critical nutrient limiting algal production in all but a very few lakes (Lillie and Mason 1983). Because phosphorus often limits biological production, increased phosphorus loading can result in accelerated eutrophication and water quality impairment.

Phosphorus loading coefficients can be used to provide an estimate of phosphorus loading to receiving waters resulting from differing land uses. Caution must be used in interpreting phosphorus loading calculations, however, because the loading coefficients represent "raw" load and not delivered load. For example, a phosphorus loading coefficient for agricultural land is based upon estimates of nutrient export directly from this land use type. The loading coefficient does not provide an estimate of the load delivered to a receiving water body because it does not account for any mitigative processes (e.g., distance from receiving body, natural vegetative buffers, installed best management practices, etc.) that may occur within the watershed.

Cells F6 through F12 in Figure 3-3 contain phosphorus loading coefficients for each of the land use types used in the classification model. The phosphorus loading coefficients for all of the land use types except "Golf Course" were adapted from coefficients provided in the Wisconsin Department of Natural Resources Wisconsin Lake Model Spreadsheet, Version 2.00 (Panuska et al. 1994) phosphorus loading module. The "most likely" loading scenario from the module was used in the classification model. The Wisconsin Lake Model Spreadsheet did not provide a phosphorus loading coefficient for the golf course land use type. A loading coefficient for golf courses was difficult to ascertain from available literature sources, and, as a result, a coefficient from an unpublished report prepared by Versar, Inc. for a development in Central Florida was used (Versar 1991).

Clearly, the classification model needs to be flexible and allow updates to the "fixed" model parameters as better information becomes available. Although the phosphorus loading coefficient cells are protected, the user is encouraged to alter the coefficients if better data becomes available. Nutrient loading coefficients for a given land use can vary greatly within different geographic regions due to factors such as soil types, topography, etc. Whenever, possible, locally derived loading coefficients obtained by methods such as watershed monitoring data should be used. The phosphorus loading coefficient for a given land use can be changed by:

1. Placing the cursor on the coefficient you wish to change in the model.
2. Clicking **Tools** on the menu bar at the top of the screen in Microsoft Excel.
3. Selecting **Protection ► Unprotect Sheet**.
4. Typing in the new coefficient.
5. Clicking **Tools** on the menu bar.
6. Selecting **Protection ► Protect Sheet**.
7. Clicking **OK** in the Protect Sheet dialog box.

Following the above instructions will allow you to change loading coefficients and still maintain a protected worksheet after the changes have been made.

Annual phosphorus loads are automatically calculated for each land use type using the acreage for each land use and the associated loading coefficient. The annual phosphorus loads are shown in cells I6 through I12 in Figure 3-3. As mentioned previously, the loading coefficients **do not** represent the nutrient load delivered to the receiving water. As a result, the annual phosphorus loading data should not be considered an estimate of the delivered load, but, rather, an estimate of the "raw" load from each land use type.

To provide an appropriate base for comparison between management units, the annual phosphorus load is converted to an areal load by dividing the total phosphorus load (Cell I13) by the total acreage (Cell E13). The areal phosphorus load is automatically calculated and displayed in Cell E20 as shown in Figure 3-3.

## ***Sediment Loading***

Excessive sediment loads can cause serious problems in receiving waterbodies. High-suspended sediment concentrations can contribute to decreased light penetration, which leads to a decline in primary productivity and plant growth. This, in turn, impacts the fish and invertebrate communities that use the plants for food and shelter. As primary productivity declines, the entire food chain can be affected. High sediment concentrations can also cause deposition of suspended materials and damage benthic (river bottom) flora and fauna and fish spawning bed areas (Friedemann and Hand 1989). Excessive sediment loads can even lower dissolved oxygen levels through decreased photosynthesis and warming of water caused by suspended materials absorbing solar radiation.

Sediment loading estimates were included in the classification model to account for water quality impairment issues such as those listed in the preceding paragraph. Cells K6 through K12 in Figure 3-3 contain sediment loading coefficients for each of the land use types used in the classification model. Loading coefficients for urban land uses (i.e., high intensity urban/developed and low intensity urban/developed) were adapted from the Wisconsin Department of Natural Resources Source Loading and Management Model (1997). Coefficients for rural land uses, with the exception of "Agriculture", were adapted from loading estimates based upon watershed monitoring conducted in northern Virginia and contained in an unpublished report prepared by the Northern Virginia Planning District Commission (1979). Data from the Kewaunee County Land Conservation Department countywide soil erosion database was used to predict average sediment erosion rates from agricultural lands within each watershed and subwatershed. The predicted erosion rates from the soil erosion database will be more accurate than literature derived estimates, and they will allow the sediment loading coefficient for agricultural land uses to be tailored to the specific conditions found within each watershed or subwatershed.

If locally derived coefficients or better data is obtained in the future, sediment loading coefficients can be modified by using the methodology outlined in the ***Phosphorus Loading*** section.

Annual sediment loads are shown in cells I6 through I12 in Figure 3-3 and are calculated similarly to annual phosphorus loads. As with the phosphorus loads, the loading data should not be considered an estimate of the delivered load, but, rather, an estimate of the "raw" load from each land use type. The areal sediment load is automatically calculated and displayed in Cell E21.

### **Animal Units Per Cropland Acre**

Domestic livestock can be a significant source of nutrient (e.g., manure) and sediment (e.g., trampling) loading to surface waters. With respect to nutrient loading, waste from a single dairy cow can produce 27 pounds of phosphorus and 151 pounds of nitrogen per year (Hammer 1993).

The risk to stream resources associated with domestic livestock was accounted for by inputting an estimate of animal units per cropland acre for each watershed and subwatershed. In Kewaunee County, domestic livestock waste is generally disposed of by spreading on croplands. The input value of animal units per cropland acre provides an estimate of the per acre concentration of animal waste and, therefore, the risk that can be attributed to each management unit due to nutrient loading from animal waste.

Data regarding the number of animal units and cropland acres in each watershed and subwatershed was obtained from Kewaunee County Land Conservation Department database records. The number of animal units per cropland acre was then input into Cell E14 in Figure 3-3. As with the other input variables, this data can be easily updated in the future to reflect temporal changes in associated risk.



### **Number of Hazardous Waste Sites**

The number of hazardous waste sites present in each management unit was obtained from the WDNR *Wisconsin Remedial Response Site Evaluation Report* (1995). The *Report* contains the "Inventory of Sites or Facilities which May Cause or Threaten to Cause Environmental Pollution", "High Priority Spill Sites", and "High and Medium Priority Leaking Underground Storage Tank Sites". The number of hazardous waste sites in each watershed or subwatershed was input in Cell E16 in Figure 3-3. This input variable will need to be updated periodically in the future as existing hazardous waste sites are remediated and/or new sites occur.

### **Mean Slope**

Mean slope was derived for each watershed and subwatershed using a digital elevation model (DEM) for Kewaunee County derived from United States Geologic Survey 7.5 Minute Series topographic maps. The DEM (Figure 3-4) was incorporated into the GIS database for the County.

Mean slope is used as an indicator of the potential for pollutants carried in surface water runoff to be delivered to the receiving waterbodies. A higher mean slope indicates a greater potential for concentrated surface runoff and a decreased likelihood for infiltration.

The mean slope, unlike many of the other risk variables, is a nearly static variable that should experience minimal change over time. The data for this variable is input to Cell E17 in Figure 3-3.

### **Percent of Highly Erodible Soils**

The percent of highly erodible soils within a given management unit provides information regarding the risk of excessive sediment loading to a stream resource.





While areal sediment loading based on land use also provides information regarding risk of excessive sediment loading, the two variables assign risk due to sediment loading based upon a different source. The former variable is focused on land use and standard loading coefficients due to various activities associated with those land use types. The percent of highly erodible soils is an indicator of the properties of the soil itself irrespective of the land use associated with it. For example, in two management units with identical land use allocations, one can assume that the management unit with the greater percentage of highly erodible soils will be at greater risk for water quality impairment due to sediment loading when all other factors are considered equal.

Kewaunee County has obtained Natural Resource Conservation Service (NRCS) digital soil survey maps and the associated soils attribute database for the entire County. The digital maps and database have been incorporated into the County's GIS base map. The percent of highly erodible soils for each watershed or subwatershed was obtained from the digital maps and attribute database. Cell E18 in Figure 3-3 contains the input data for this Risk Variable.

#### **Percent of Slopes Greater than 6%**

Kewaunee County requires the preparation of Nutrient Management Plans for all agricultural lands with a slope greater than 6%. These lands are considered to represent a potential for water quality impacts due to surface runoff if inappropriate management techniques are used. While similar to *Mean Slope*, this Risk Variable is considered to provide an alternative representation of risk for water quality impairment due to surface runoff.

The data for percent of slopes greater than 6% was obtained from the same NRCS digital maps and soils attribute database described in the **Percent of Highly Erodible Soils section**. The value for this variable is input in Cell E19 in Figure 3-3.

## Value Weights

### Potential Biological Use Classification

The WDNR classifies surface waters into the following fish and other aquatic life subcategories pursuant to Chapter NR 102, Wisconsin Administrative Code. It is important to note that the model requires that the subcategories listed below be interpreted in terms of *potential* biological use and not *existing* use.

- Cold Water Communities. This subcategory includes surface waters capable of supporting a community of cold water fish and other aquatic life, or serving as a spawning area for cold water fish species.
- Warm Water Sport Fish Communities. This subcategory includes surface waters capable of supporting a community of warm water sport fish or serving as a spawning area for warm water sport fish.
- Warm Water Forage Fish Communities. This subcategory includes surface waters capable of supporting an abundant diverse community of forage fish and other aquatic life.
- Limited Forage Fish Communities. This subcategory includes surface waters of limited capacity and naturally poor water quality or habitat. These surface waters are capable of supporting only a limited community of forage fish and other aquatic life.
- Limited Aquatic Life. This subcategory includes surface waters of severely limited capacity and naturally poor water quality or habitat. These surface waters are capable of supporting only a limited community of aquatic life.

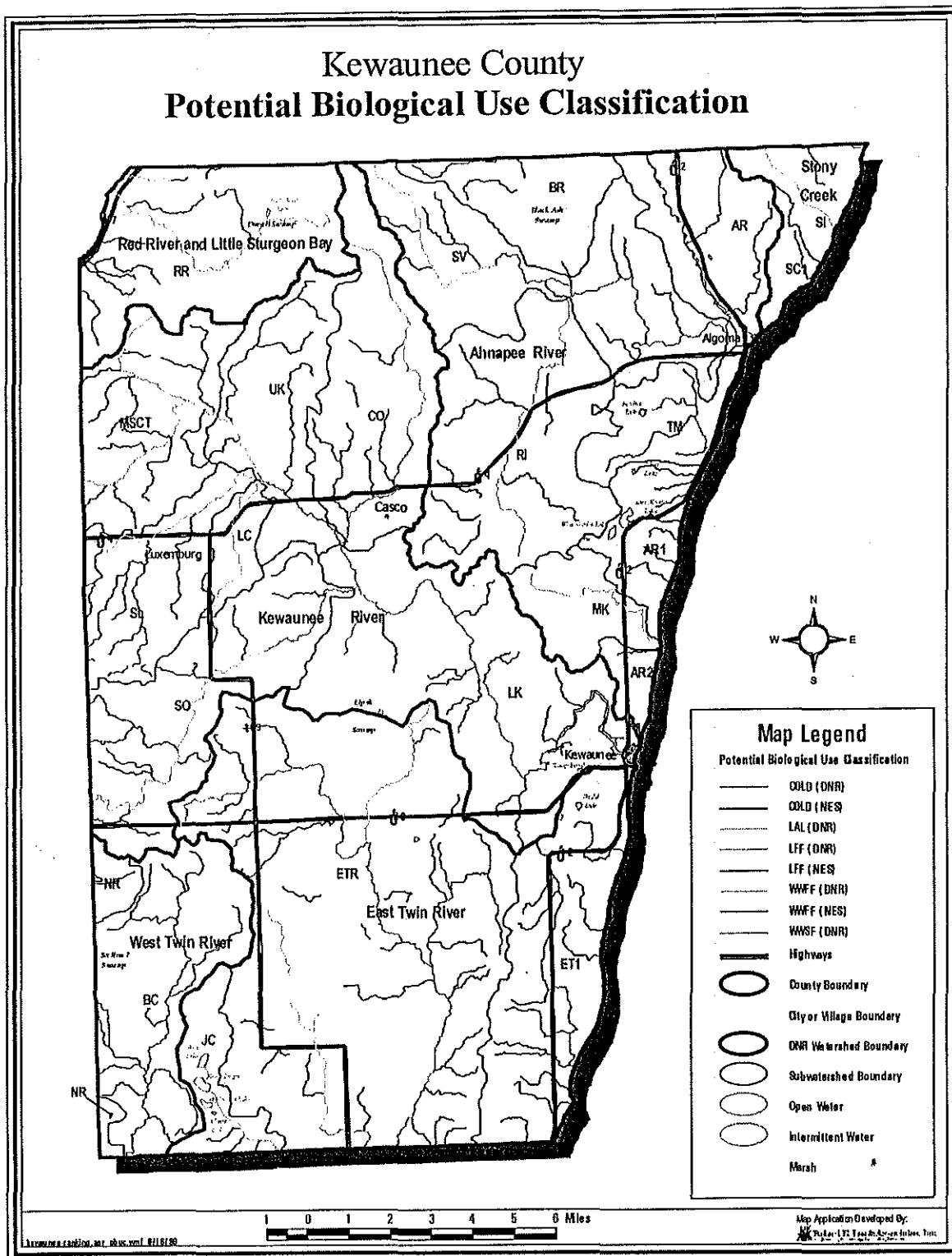
The potential biological use classifications for the streams located in Kewaunee County were obtained from WDNR classifications found in the *Twin-Door-Kewaunee Water Quality Management Plan*. To date, however, all streams in the County have not been assigned a classification by the WDNR. Those streams which were not classified by the WDNR were assigned a classification by NES (Figure 3-5). NES classifications were based upon a review of existing WDNR classifications and methodology found in the *Stream Classification Guidelines for Wisconsin* (Ball 1982). The NES classifications were unable to be field verified due to seasonal constraints. As a result, it is recommended that the potential biological use classification data be field verified in the future and the model updated as appropriate. To aid future verification efforts, the GIS database for the County contains a data layer depicting the potential biological use classifications for all of the County's stream resources and whether the classification was performed by the WDNR or NES.

The number of stream miles within each potential biological use category was calculated using the GIS database for each watershed and subwatershed. The data for this variable was input into Cells E25 through E29 in Figure 3-3.

A weight is assigned to each potential biological use category using the following scale:

<u>Category</u>	<u>Weight</u>
Cold Water Communities	5
Warm Water Sport Fish Communities	4
Warm Water Forage Fish Communities	3
Limited Forage Fish Communities	2
Limited Aquatic Life	1

# Kewaunee County Potential Biological Use Classification



**Figure 3-5 Potential Biological Use Classifications**

A weighted average based upon potential biological use is calculated by the model using the number of stream miles and assigned weight for each category. The weighted average is automatically calculated and shown in Cell G30 (Figure 3-3).

### **Designated Outstanding or Exceptional Resource Waters**

Chapter NR 102, Wisconsin Administrative Code, designates the Outstanding and Exceptional Resource Waters within the state. The presence of either an Outstanding or Exceptional Resource Water within a watershed or subwatershed was considered an indication of increased value in the model.

An answer of "yes" or "no" is input into Cell G32 in Figure 3-3. "Yes" confirms the presence of an Outstanding or Exceptional Resource Water. If "yes" is input, the model weights that management unit as having greater value relative to the other management units.

### **Presence of Water Dependent Threatened and Endangered Species**

Information regarding the presence of water dependent threatened and endangered species in each management unit was obtained from the WDNR, Bureau of Endangered Resources. An answer of "yes" or "no" is input into Cell G34 (Figure 3-3). "Yes" confirms the presence of a threatened or endangered species in that management unit, and, as a result, the model weights the unit as having greater value relative to the other management units.

## **RANKINGS WORKSHEET**

The "Rankings" worksheet provides a graphic display of the relative ranking for each watershed or subwatershed. The "Risk Ranking" macro button will take the user to a graphic display of the ranking based upon risk for water quality impairment. The "Risk Ranking Relative to Value" macro button will take the user to a graphic display of the risk ranking in relation to the value of the resource. In either case, the "Print Graph" macro button can be used to print the chart.

## **HIDDEN WORKSHEETS**

In addition to the "Data Input" and "Rankings" worksheets, each data file contains three hidden worksheets. These hidden worksheets contain information necessary to the operation of the stream classification models, but will rarely require any manipulation. To prevent any accidental altering of these worksheets and also to simplify the classification models, the worksheets were hidden so that they would not normally be displayed. The hidden worksheets include two worksheets labeled "Matrix" and "Macros". Each of these worksheets will be discussed in further detail below. The third hidden worksheet will be further discussed in the **ARCVIEW MAPPING** section.

### **Matrix Worksheet**

As mentioned in **CHAPTER 1**, the surface water classification models represent an adaptation of an ecosystem risk assessment methodology based upon fuzzy set models. The analytical aspects of the classification model are based upon the premise that each watershed or subwatershed basin contains identifiable Risk Variables which act upon the designated management units. The degree of risk attributable to a given Risk Variable for each management unit is used to rank all of the management units relative to each other. A ranking of "one " indicates the highest degree of risk. For example, in Table 3-1 the Kewaunee River Watershed

has the greatest risk attributable to phosphorus loading and the Red River and Little Sturgeon Bay Watershed has the least risk attributable to phosphorus loading. The degree of risk within each of the management units is determined for every risk variable based upon the model input data, and the units are ranked relative to each other in an impact matrix similar to Table 3-1. The fuzzy set difference method described in Harris et al. (1994) is used to evaluate each of the management units with respect to all of the Risk Variables and produce a summary output, or overall risk ranking, relative to the selected risk factors. For the stream classification model, the fuzzy set difference method is also used to evaluate risk variables weighted according to the Value Weights described in the **DATA INPUT WORKSHEET** section. The "Matrix" worksheet contains all of the formulas and commands necessary to apply the fuzzy set difference methodology to the input data.

**Table 3-1. Example Watershed Ranking for Areal Phosphorus Loading Risk Variable**

Watershed	Ranking for Areal Phosphorus Loading Risk Variable
Ahnapee River	4
East Twin River	3
Kewaunee River	1
Red River and Little Sturgeon Bay	6
Stony Creek	5
West Twin River	2

### Macros Worksheet

Some of the functions of the stream classification model, such as printing and moving between worksheets, are controlled by macros. A macro is a recorded file that can be played back to perform simple or complex tasks. The macro must be written and stored in a specified location to be played back. The "Macros" worksheet contains all of the macros needed to operate the stream classification model.

## Revealing Hidden Worksheets

If at any point the user would like to reveal a hidden sheet, the user should:

1. Click **Format** on the menubar at the top of the screen in Microsoft Excel.
2. Select **Sheet ► Unhide** and click the left mouse button or hit enter.
3. Select the sheet you would like to unhide and click the left mouse button or hit enter.

To re-hide the sheet, follow the same procedure as above but select **Hide** rather than **Unhide**.

## ARCVIEW MAPPING

The stream classification models have the ability to interface with ArcView GIS software and utilize the Kewaunee County GIS database to display a map showing the lake, watershed or subwatershed boundaries and their relative risk rankings. The relative risk rankings are displayed as color gradations, and the darkest shade indicates the greatest risk. To activate the mapping function, the user must first make sure that both Microsoft Excel and ArcView are running. Next, the user should click the "Update Map" macro button found on the "Rankings" worksheet. The user will be prompted with the following messages:

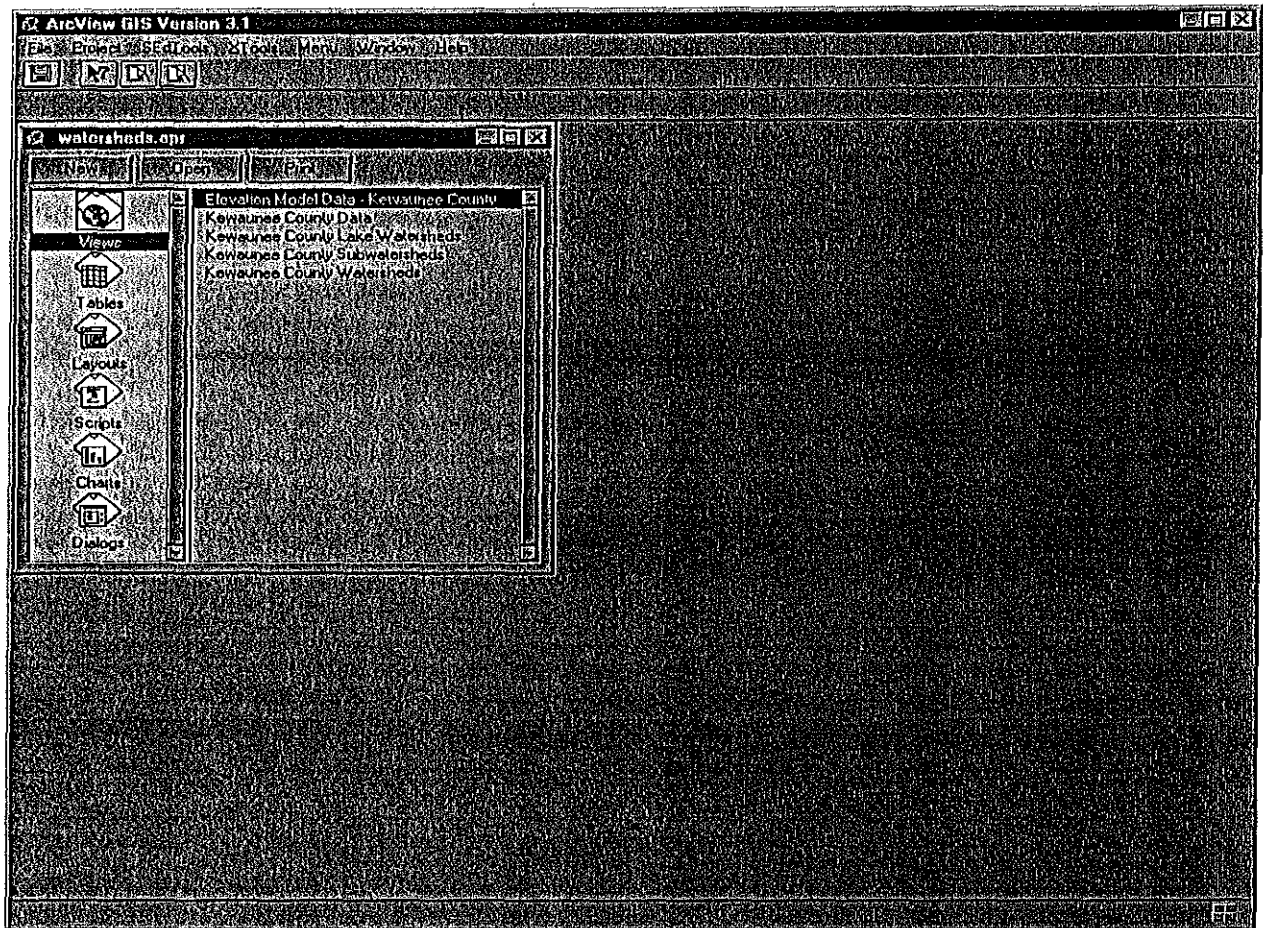
Replace existing 'C:\temp\et.dbf'?

Replace existing 'C:\temp\East Twin River Subwatersheds Model.xls'?

**NOTE:** The expressions "et.dbf" and "East Twin River Subwatersheds Model.xls" are file names and will change based upon the data file you are using.



For both questions, the user should select "Yes". After answering "Yes" to these questions, the user needs to display ArcView on his/her desktop. In ArcView, select



File|Open and navigate to C:\arcview\watersheds.apr. Open this file. Figure 3-6 shows the ArcView startup interface.

**Figure 3-6 The ArcView Environment**

The ArcView application consists of several separate window environments in which the end user can look at and interact with spatial data (Views), view and manipulate tabular records (Tables), create cartographic products (Layouts), customize the ArcView environment to extend its functionality (Scripts), create charts (Charts) and other add-ins designed to help the end user solve a wide variety of spatial problems.

The ArcView environment has been modified to take information produced in Excel and link this tabular data (ranking matrix) to the lake, water and subwatershed boundaries, respectively. The values associated with each watershed's ranking are then mapped in a graduated color scheme to graphically portray the risk ranking in a map format.

There has been some custom programming using Avenue, an object-oriented scripting language unique to ArcView. Using Avenue, the programmer can produce custom menus and dialog windows for end user interaction, combine several routine activities into one process, and simplify the interface for non-GIS professionals using ArcView.

While this customization is valuable to the end user in the support it provides to this model, there are some potential 'glitches' associated with the modifications to the ArcView environment. The scripts and interface have not been exhaustively tested for errors; There may be situations where the custom programming will generate some type of error or error message. We have attempted to address these errors as best we can and we have provided workarounds for any errors we have already encountered. Most of these problems are very minor and can be resolved simply by dismissing the error message window and resuming with the exercise.

To begin, click on "Views" on the left-hand side of the window titled "watersheds.apr". Now click on any of the listed Views on the right-hand side of the same window. Now click on the OPEN button and the appropriate View window should open. Figure 3-7 shows the ArcView interface with a View window, in this case the "Kewaunee County Subwatersheds" View is open.

The View has a list of layers, or "themes", shown on the left-hand side of the screen. When checked ON, these layers are drawn in the area on the right-hand side of the screen. Themes are drawn in the order in which they are listed on the left-hand side of the screen. For example, in Figure 3-7 the theme "roads" is not checked and is therefore not visible. The theme "highways" is checked ON and it is the top-most

checked theme therefore "highways" will be drawn on top of all other themes in the View.

The themes in all the Views have been pre-formatted for cartographic purposes. This formatting is helpful because the cartographic output produced will have a predictable and consistent look and feel. But these colors and line types can be interactively changed by the end user to suit personal taste. The end user has the ability to change the way each theme is drawn; line weight, line type, fill, color and text can all be changed by the end user. By clicking **CTRL+P** or selecting **Window>Show Symbol Window...** from the menu, a small window will appear containing all the various fills, line types, marker or point symbols, fonts and colors available to the end user. For further discussion on these topics, please see "Choosing colors and symbols" in the ArcView online help.



The three options listed in the "Select a Watershed Model" control box represent the views containing the respective watershed boundaries. By clicking on one of these option buttons, two events occur:

1. The View window showing the appropriate watershed boundaries will appear.
2. The classification and ranking buttons for that View will become enabled.

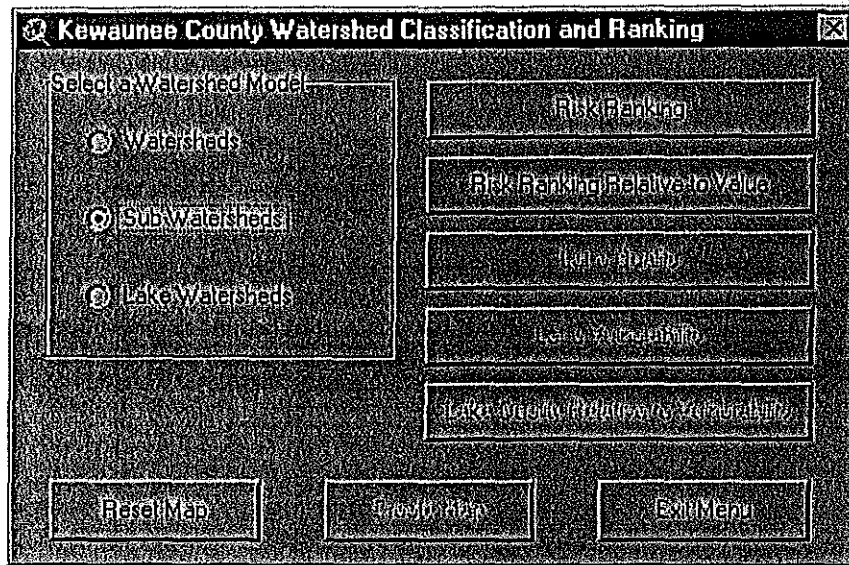


Figure 3-8 The Watershed Classification and Ranking Dialog Box

Assuming the Excel model has been run for the lake watersheds, select **Lake Watersheds** from the control box. The View titled "Kewaunee County Lake Watersheds" should appear. The buttons **Lake Quality**, **Lake Vulnerability** and **Lake Quality Relative to Vulnerability** are now active- the other two buttons above these three have become disabled.

By selecting any of these buttons, ArcView will look for the appropriate table produced from the Excel model and link the result values to the appropriate lake watershed. ArcView will then redraw the view with the lake watersheds colored in red. The red color will become gradually darker as the value increases. This process is similar for all three Watershed models.

The **Reset Map** button allows the end user to erase any ranking and coloring produced by selecting one of the classification buttons. This can be done at any time throughout the course of your ArcView session.

NOTE: When a window's title bar is blue in color, the window is said to be *active* and has the focus of the application. Menus, buttons and tools will change depending upon the currently active window. An error message will generate (Figure 3-9) if the window "watersheds.apr" is currently active and the **Reset Map** button or any other button on the "Kewaunee County Watershed Classification and Ranking" dialog box is selected. This is not a critical error but rather a problem in the code associated with the dialog box. Nothing will happen to the data or the project you are currently working on. If the error message appears, simply dismiss the message by clicking OK and closing any windows the error message may subsequently open.

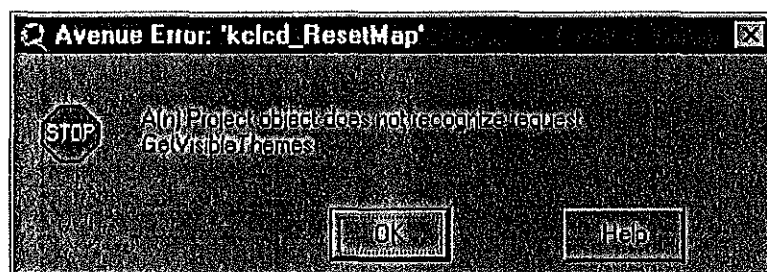


Figure 3-9 Error Message Generated by ArcView

## Mapping the Classification and Ranking Output

Once you have successfully generated a classification and ranking View, the button **Create Map** on the "Kewaunee County Watershed Classification and Ranking" dialog box is enabled. By selecting this button, the View contents are copied and placed into a Layout document. This Layout document is formatted with a title, legend, neatline, scalebar and north arrow (Figure 3-10). This Layout is formatted to be printed on a standard Windows laser printer or any 8.5" by 11" printer you may have connected to your computer or network.

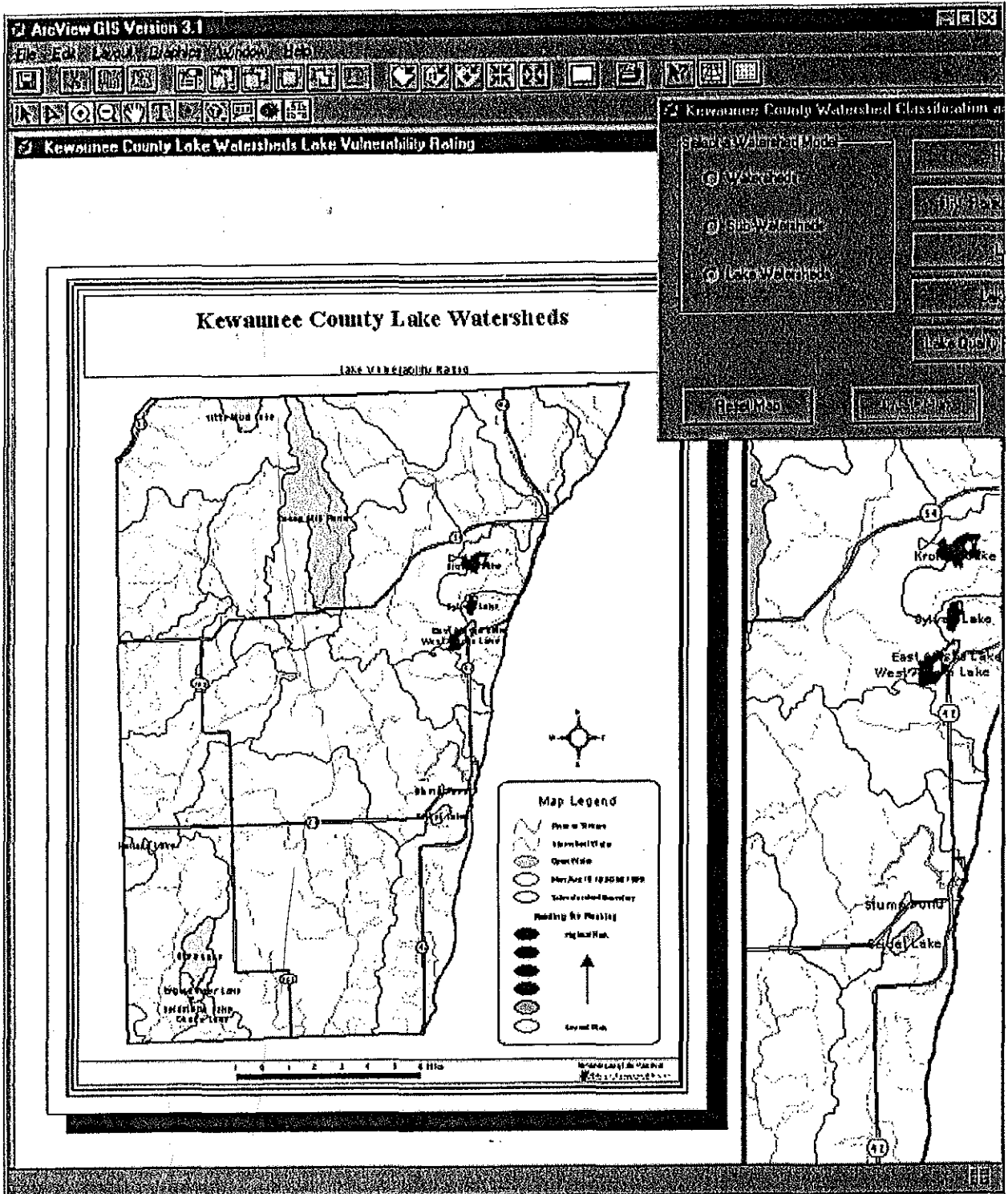


Figure 3-10 The Layout Document Interface

One problem you may notice in the Layout document is the somewhat offset title captions at the top of the layout window. While there is a minor manual adjustment the end user can do to fix this, it poses a rather challenging and abstract programming solution. To manually align the text within the rectangle and the layout window, do the following:

1. Make sure the Layout window is currently the active window by clicking on the title bar. The title bar should now be blue, or a different color than the rest of the windows within ArcView.
2. Select the pointer tool from the toolbar. The pointer tool is the first tool on the left-hand side of the window and resembles a solid black arrowhead.
3. Hold down the left mouse button and draw a box completely around both text labels and the rectangular box surrounding the text. Solid black squares should surround the text and rectangle, respectively.
4. Select **Graphics| Align...** (or click **CTRL+A**) from the menu. A dialog box titled "Align" should appear.
5. Along the top of the grid, click the >|< button and check the "Align with Margins" checkbox near the bottom of the dialog box. Select **OK** to close the dialog box. The graphics should now be centered on the page.

The Layout can be printed directly to a printer by selecting File|Print... from the menu. The Layout can also be saved in several other formats such as JPEG and Bitmap image formats, and PostScript or Windows Metafile formats for document merging. Please see "Laying Out and Printing Maps" in the online help for further discussion on this topic.



## **Closing the ArcView Application**

At any time, you may save your work using the **File|Save** menu option. It is recommended that the original project "watersheds.apr" be kept intact and available to reload should an unexpected problem occur with your project. If some problem prevents you from successfully opening and working with your ArcView project, you can always reload the project "watersheds.apr" from the CD-ROM to the C:\arcview directory and resume your work. If you would like to make changes to anything within the project, it is recommended you use the **File|Save As** menu option and rename the project as something else.

## **ALTERNATIVE DATA ANALYSIS METHODOLOGIES**

### **Analysis of Risk for Water Quality Impairment**

In its simplest form, the stream classification model can be used to prioritize watersheds or subwatersheds based upon risk for water quality impairment. The priority rankings produced by the model can assist in properly appropriating the often limited financial resources available for risk abatement and remediation efforts.

### **Analysis of Risk for Water Quality Impairment Relative to the Value of the Resource**

In addition to the ranking based upon risk for water quality impairment, the model is able to weight the risk ranking in relation to the value of the resource. By considering value of the resource, management priority can be allocated based upon both risk for impairment and resource value. Comparing the outcomes of both the risk analysis and risk relative to value analysis allows the model to support management strategies that incorporate both remediation and protection.

## **Sequential Analysis of Risk Factors**

Often times valuable information can be gained from sequentially analyzing the effect of each Risk Variable on the model output. For example, when analyzing the Kewaunee County Watersheds the user may find that the Kewaunee River Watershed is at the greatest risk. The Risk Variable(s) most responsible for that ranking, however, may not be readily apparent. In an instance like this, the user can enter data into the "Data Input" worksheet one variable at a time and analyze the sequential output (i.e., risk ranking graph) to determine the variable(s) most responsible for producing an effect. Likewise, the user can see how removing a given variable from an analysis alters the risk ranking. Sequential analyses such as these can provide information regarding those risk factors most responsible for an effect and, therefore, those risk factors that should be targeted for remediation efforts.

## **Analysis of Differing Future Conditions**

The stream classification model is primarily designed to allow an analysis of existing conditions, but it can also be used to analyze differing future conditions. For example, if future land use projections suggest that a given subwatershed will have 10,000 acres of agricultural land converted to low intensity developed use, the model could be used to predict the impact on nutrient loads, sediment loads, and overall risk to that watershed. The model can be used in a similar manner to conduct analyses of hypothetical future scenarios for any of the Risk Variables or Value Weights.

## **STREAM CLASSIFICATION MODEL OUTPUTS**

In summary, the following outputs can be generated by the stream classification model:

1. A synopsis report displaying the input data for each management unit.
2. A graphic display of the management unit ranking based upon risk for water quality impairment and/or a graphic display of the risk ranking in relation to the value of the resource.
3. A GIS map of the watershed displaying the management unit ranking based upon risk for water quality impairment and/or the risk ranking in relation to the value of the resource using color gradations.

## CHAPTER 4

### LAKE CLASSIFICATION MODEL

#### BACKGROUND

The lake classification model is based upon two primary factors: the quality of the lakes and their vulnerability to future impacts (e.g., development, nonpoint source pollution, etc.). The model draws on lake classification methods utilized by the Waupaca County Land and Water Conservation Department and procedures outlined in the *Town of Wascott Lakes' Plan* (1981) and Oneida County Lake Classification Model; however, unlike these methods, this lake classification model uses the fuzzy set difference method (Harris et al. 1994) to rank the lakes in terms of quality, vulnerability, and quality relative to vulnerability. All the Kewaunee County lakes listed in the WDNR *Wisconsin Lakes* (1995) publication were included in the model

#### WATERSHED DEFINITION

The watershed for each lake was delineated using a DEM for Kewaunee County derived from United States Geologic Survey 7.5 Minute Series topographic maps. The lakes included in the model are listed below and shown in Figure 4-1.

#### CLASSIFICATION MODEL DESIGN

The lake classification model design is functionally similar to the stream classification model design described in **CHAPTER 3**. Unlike the stream classification models, only one data file, "Lake Model.xls", is used.

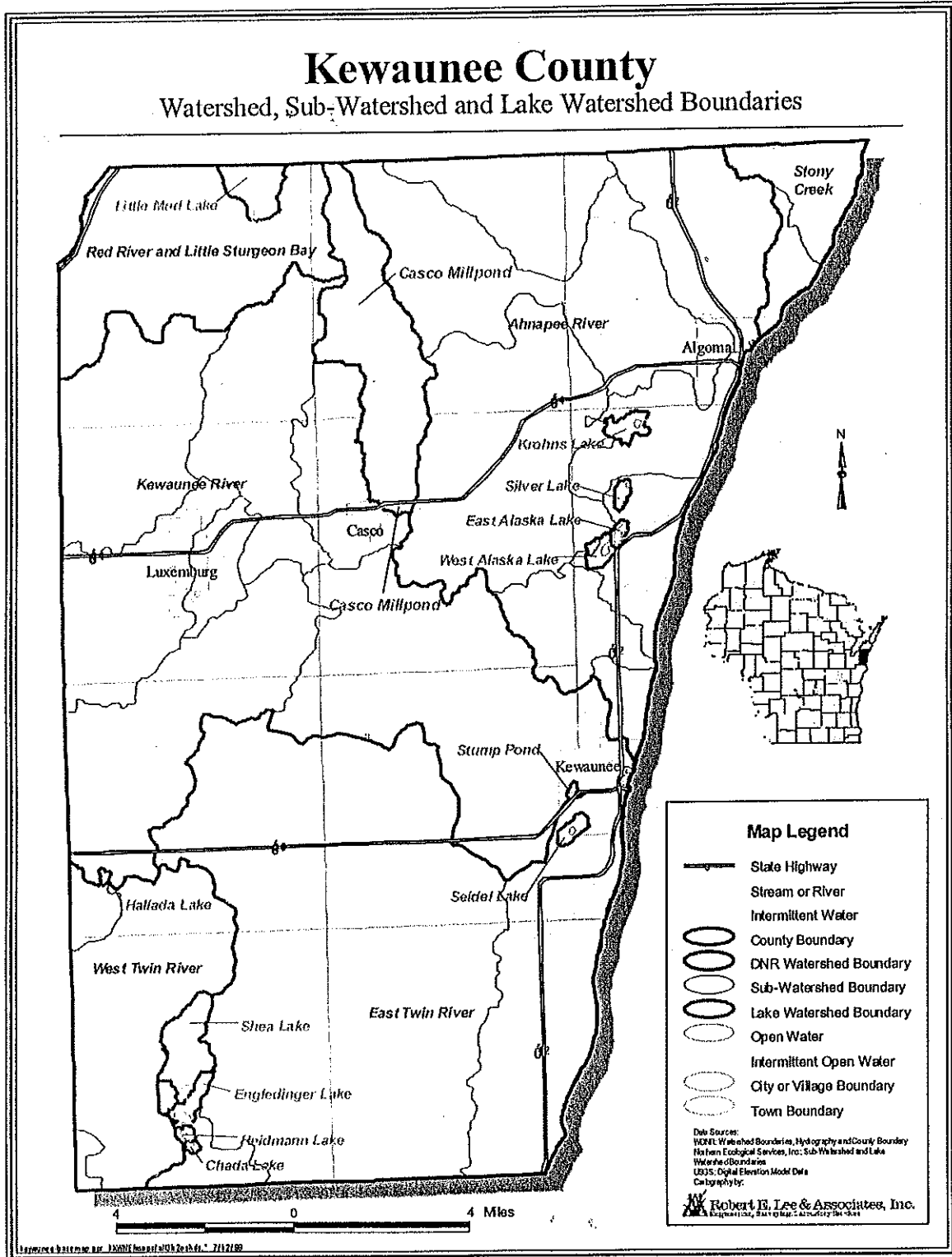


Figure 4-1 Lake Watershed Map



	A	B	C	D	E	F	G	H	I	J	K	L	M
1	<b>LAKE DATA INPUT</b>							Bruemmer Pond			Seidl Lake		
2	Lake:	East Alaska Lake											
3	Lake Quality Criteria				Score								
4	Trophic State				1			Casco Mill Pond			Shea Lake		
5	Existing Fishery Resources				2								
6	Presence of Exotic Species				2								
7	Current Wildlife Use				1			Chada Lake			Stump Pond		
8	Degree of Shoreland Development				3								
9	Existing Drainage Basin Land Uses				1.44								
10	Watershed Land Use				Acres			Engledinger Lake			Sylvan Lake		
11	Golf course, agriculture, high intensity devel.				253								
12	Low intensity developed				0								
13	Grassland, forested, wetland				71			Hallada Lake			West Alaska Lake		
14	<b>SUM</b>				324								
15	Lake Vulnerability Criteria				Score								
16	Lake Surface Area				2			Herdmann Lake			Lake Quality Rating		
17	Maximum Lake Depth				1								
18	Shoreline Topography				1								
19	Drainage Basin Size				2			Krohn's Lake			Lake Vulnerability Rating		
20	Threatened or Endangered Species				1								
21	Special Designations				1								
22	Flushing Rate				3			Little Mud Lake			Lake Quality Rating Relative to		
23	Shoreline Development Factor				2								
24													
25													
26	<a href="#">Print Sheet</a>												
27													

Figure 4-2 Lake Data Input Sheet





### Existing Fishery Resource

The existing fishery resources of the Kewaunee County lakes were primarily characterized based upon review of the WDNR *Wisconsin Lakes* publication. A diverse assemblage of fish was considered indicative of high quality. This criteria could be better defined in the future by conducting in-lake fish surveys and coordinating with WDNR fisheries biologists.

The scoring values shown below are input into cell E5 in Figure 4-2.

<u>Existing Fishery Resources</u>	<u>Scoring</u>
Low quality	3
Medium quality	2
High quality	1

### Presence of Exotic Species

Exotic species such as Eurasian water milfoil (*Myriophyllum spicatum*) and curly-leaf pondweed (*Potamogeton crispus*) can displace native vegetation and degrade aquatic habitats. Field investigations are required to accurately assess this criteria.

The scoring values shown below are input into cell E6 in Figure 4-2.

<u>Presence of Exotic Species</u>	<u>Scoring</u>
Abundant	3
Common	2
Few or None	1

### **Current Wildlife Use**

Current wildlife use in the lakes was estimated through field observations; however, no quantitative data has been collected at this time. This lake quality criteria could be better defined in the future through collection of quantitative data and coordination with WDNR wildlife biologists.

The scoring values shown below are input into cell E7 in Figure 4-2.

<b><u>Current Wildlife Use</u></b>	<b><u>Scoring</u></b>
Low	3
Medium	2
High	1

### **Degree of Shoreland Development**

Increased shoreland development around a waterbody can exacerbate problems due to nutrient, sediment, and chemical loading. For example, sediment loading can increase through loss of the buffering effects of "unmanaged" shoreline vegetation, nutrient loading can increase due to lawn fertilizing, and chemical loading can increase due to use of herbicides and pesticides. Estimating the degree of shoreland development, therefore, can provide an indication of the extent of anthropogenic impacts on a given waterbody. The degree of shoreland development around Kewaunee County lakes was estimated through a review of United States Geologic Survey 7.5 Minute Series topographic maps and 1992 black-and-white digital orthophotography.

The scoring values shown below are input into cell E8 in Figure 4-2.

<u>Degree of Shoreland Development</u>	<u>Scoring</u>
Greater than 3 residences per 100 feet	3
From 1-3 residences per 100 feet	2
Less than 1 residence per 100 feet	1

**Existing Drainage Basin Land Uses**

The WISCLAND land cover data described in the *Land Use* section of CHAPTER 3 was used to characterize existing drainage basin land uses. These land uses were placed into one of three categories based upon their potential for producing high nutrient loads. Phosphorus loading potential for each of the land uses was based upon the loading coefficients described in the *Phosphorus Loading* section in CHAPTER 3. The land uses which posed the greatest risk to lake quality were given a value of three and those that posed the lowest risk were given a value of one. The results are shown below.

<u>Existing Drainage Basin Land Uses</u>	<u>Scoring</u>
Golf course, agriculture, high intensity development	3
Low intensity developed	2
Grassland, forested, wetland	1

Unlike the other lake quality criteria, the user needs to input acreage for the above land use categories into cells E11 through E13. The land cover information can be obtained from the WISCLAND data incorporated into the GIS database for the County. The acreages are used in combination with the above scoring values to develop a weighted score based upon the land use percentages for each category multiplied by its associated scoring value. The weighted value is calculated by the model and shown in cell E9.

## Lake Vulnerability Criteria

### Lake Surface Area

The amount of lake surface area can influence the vulnerability of a given waterbody to environmental degradation. In general terms, smaller lakes are more susceptible to impact from shoreline development and intensive recreational use because their smaller size reduces the lake's ability to buffer the effects of these factors.

The surface area for the Kewaunee County lakes was obtained from the WDNR *Wisconsin Lakes* publication. The scoring values shown below are input into cell E16 in Figure 4-2.

<u>Lake Surface Area</u>	<u>Scoring</u>
100 or more acres	3
25 to 100 acres	2
Less than 25 acres	1

### Maximum Lake Depth

Many shallow lakes do not stratify during the summer and winter months, and lack of stratification creates greater circulation of dissolved nutrients that enter the lakes. Increased nutrient circulation means greater nutrient availability for aquatic plant and algal growth. Because of the above, shallow lakes are particularly susceptible to nutrient loading and resultant turbidity and water quality problems.

The scoring values shown below are input into cell E17 in Figure 4-2.

<u>Maximum Lake Depth</u>	<u>Scoring</u>
40 or more feet	3
20 to 39 feet	2
Less than 20 feet	1

### Shoreline Topography

The topography of a lake's shoreline can influence the delivery rate and quantity of contaminant loads. Given similar soil types, water will travel more quickly down a steep slope than a gentle slope. Water flowing slowly down a gentle slope is more likely to infiltrate and reduce the amount of runoff reaching the lake. Further, rapidly flowing water generally carries a greater suspended solids load than slow flowing water. Because of the above factors, steep shoreline topography makes a lake more vulnerable to contaminant loading.

The scoring values shown below are input into cell E18 in Figure 4-2.

<u>Shoreline Topography</u>	<u>Scoring</u>
0-33% of shoreline moderately to very steep	3
33-66% of shoreline moderately to very steep	2
66-100% of shoreline moderately to very steep	1

### Drainage Basin Size

There are three main types of lakes in Wisconsin: drainage lakes, seepage lakes, and spring lakes. Drainage lakes have both an inlet and an outlet and their main water source is stream drainage. As a result of their connection to streams, these lakes typically have large drainage basins and relatively short retention times.





Flushing rates for the lake classification model were generated using the Wisconsin Department of Natural Resources' Wisconsin Lake Model Spreadsheet, Version 2.00. The scoring values shown below are input into cell E22 in Figure 4-2.

<u>Flushing Rate</u>	<u>Scoring</u>
30+ times/year	3
10.0 - 29.9 times/year	2
0-9.9 times/year	1

### **Shoreline Development Factor**

Shoreline Development Factor (SDF) is a convenient method of estimating the degree of irregularity of the shoreline of a lake compared to the lake surface area. SDF is expressed as the ratio of the length of shoreline versus the circumference of a circle having the same surface area as the lake. For example, a perfectly round lake would have an SDF of 1.00. A high SDF value is indicative of a lake with a relatively large amount of shoreline in relation to surface area. As a result, lakes with high SDF values are generally more vulnerable to shoreline development pressures.

The SDF values for the Kewaunee County lakes were obtained from the Wisconsin Conservation Department (currently WDNR) publication *Surface Water Resources of Kewaunee County*. The scoring values shown below are input into cell E23 in Figure 4-2.

<u>Shoreline Development Factor</u>	<u>Scoring</u>
1.00 to 1.49	3
1.50 to 1.99	2
2.00 or more	1



## RANKINGS WORKSHEET

The "Rankings" worksheet provides a graphic display of the relative rankings for each lake watershed. The "Lake Quality Rating" macro button will take the user to a graphic display of the ranking based upon lake quality; the "Lake Vulnerability Rating" macro button will take the user to a graphic display of the risk ranking in relation to lake vulnerability; and the "Lake Quality Rating Relative to Vulnerability" macro button will take the user to a graphic display of the quality relative to vulnerability ranking. In all cases, the "Print Graph" macro button can be used to print the chart.

## HIDDEN WORKSHEETS

In addition to the "Data Input" and "Rankings" worksheets, each data file contains three hidden worksheets. These hidden worksheets contain information necessary to the operation of the lake classification model, but will rarely require any manipulation. To prevent any accidental altering of these worksheets and also to simplify the classification model, the worksheets were hidden so that they would not normally be displayed. The hidden worksheets include two worksheets labeled "Matrix" and "Macros". As with the stream classification model described in **CHAPTER 3**, the lake classification model is an adaptation of an ecosystem risk assessment methodology based upon the fuzzy set difference method described in Harris et al. (1994). The "Matrix" worksheet contains the mathematical equations used to complete the methodology. The "Macros" worksheet contains all of the macros needed to operate the lake classification model. The third hidden worksheet will be further discussed in the **ARCVIEW MAPPING** section below. Please review the **Revealing Hidden Worksheets** section in **CHAPTER 3** for a description of the method used to reveal hidden worksheets.



## REFERENCES

- Ball, J. 1982. Stream Classification Guidelines for Wisconsin. Wisconsin Department of Natural Resources Technical Bulletin.
- Carlson, R.E. 1977. A trophic state index for lakes. *Limnol. Oceanogr.* 22(2):361-369
- Friedemann, M. and J. Hand. 1989. Typical Water Quality Values for Florida's Lakes, Streams and Estuaries. Florida Department of Environmental Protection, Tallahassee, FL.
- Hammer, D.A. 1993. *Creating Freshwater Wetlands*. Lewis Publishers, Ann Arbor, MI.
- Harris, H.J., R.B. Wenger, V.A. Harris, and D.S. Devault. 1994. A method for assessing environmental risk: a case study of Green Bay, Lake Michigan, USA. *Environmental Management* 18:295-306.
- Kmiotek, S. 1980. Wisconsin Trout Streams. Wisconsin Department of Natural Resources Publication 6-3600(80).
- Lillie, R.A., and J.W. Mason. 1983. Limnological Characteristics of Wisconsin Lakes. Wisconsin Department of Natural Resources Technical Bulletin No. 138.
- MDNR. 1991. Qualitative Biological and Habitat Survey Protocols for Wadable Streams and Rivers. Michigan Department of Natural Resources, Surface Water Quality Division.
- North Virginia Planning District Commission. 1979. Guidebook for Screening Urban Nonpoint Pollution Management Strategies. Unpublished technical report prepared for Metropolitan Washington Council of Governments.
- Panuska, J., N. Booth, and A.D. Wilson. 1994. Wisconsin Lake Model Spreadsheet, Version 2.00, User's Manual. Wisconsin Department of Natural Resources Publication PUBL-WR-363-96 REV.
- Rosgen, D. 1985. A Stream Classification System. In *Riparian Ecosystems and Their Management: Reconciling Conflicting Issues*. First North American Riparian Conference. U.S. Forest Service, Department of Agriculture, Washington, DC. General Technical Report NO. RM-120.
- Town of Wascott. 1981. *Draft Town of Wascott Lakes' Plan*.
- Versar. 1991. Sabal Hammocks Water Quality Assessment. Unpublished technical report prepared for the Lake Poinsett Development Company.

## **Analysis of Differing Future Conditions**

The lake model is primarily designed to allow an analysis of existing conditions, but it can also be used to analyze differing future conditions. For example, if future land use projections suggest that a given watershed will have 100 acres of forested land converted to low intensity developed use, the model could be used to predict the relative impact on lake quality.

## **LAKE CLASSIFICATION MODEL OUTPUTS**

In summary, the following outputs can be generated by the lake classification model:

1. A synopsis report displaying the input data for each lake.
2. A graphic display of the prioritized rankings based upon lake quality, lake vulnerability, and lake quality relative to vulnerability.
3. A GIS map of the lake watersheds displaying the prioritized rankings based upon lake quality, lake vulnerability, and lake quality relative to vulnerability using color gradations.

- WDNR. 1984. The Kewaunee River Priority Watershed Management Plan. Wisconsin Nonpoint Source Water Pollution Abatement Program.
- WDNR. 1995. Twin-Door-Kewaunee Water Quality Management Plan: A Five-Year Plan to Protect and Enhance our Water Resources. Wisconsin Department of Natural Resources Publication PUBL-WR-291-95-REV.
- WDNR. 1995. Wisconsin Remedial Response Site Evaluation Report. Wisconsin Department of Natural Resources Publication PUBLICATION SW-504-95(Rev).
- WDNR. 1995. Wisconsin Lakes. Wisconsin Department of Natural Resources Publication PUB-FM-800 95REV.
- WDNR. 1997. Source Loading and Management Model. Wisconsin Department of Natural Resources, Bureau of Watershed Management.
- Wenger, R.B., and Y. Rong. 1987. Two fuzzy set models for comprehensive environmental decision-making. *Journal of Environmental Management* 25: 167-180.
- Wenger, R.B., H.J. Harris, and Y. Rong. 1990. A framework for incorporating stream use in the determination of priority watersheds. *Journal of Environmental Management* 31:335-350.
- Wetzel, R.G. 1983. *Limnology, Second Edition*. Saunders College Publishing, Orlando, Florida.

# Land Cover of Wisconsin

## User's Guide to WISCLAND Land Cover Data

The Wisconsin Initiative for Statewide Cooperation on Landscape Analysis and Data (WISCLAND) is a consortium of government and private organizations formed in 1993 to promote development of digital geographic data for the state. The initial focus of the consortium was to acquire funding and resources to develop a land cover classification. That effort has now been completed statewide. This document serves as a technical overview and guide to appropriate use of the land cover digital data.

### Source Data

The land cover data product was derived from LANDSAT Thematic Mapper (TM) satellite imagery acquired from fly-overs in August, 1991; May, July, September, and October, 1992; and May, 1993. TM data are organized by rectangular areas referred to as scenes, each 108 miles on a side. Twelve scenes are required to cover Wisconsin. A scene is comprised of roughly 50 million cells, or pixels, each representing a 30-meter square, or an on-the-ground area of 900 square meters.

The TM sensor measures the sun's energy as reflected from elements of the land surface. The spectrum of reflected energy is measured at discrete intervals, referred to as bands, with each band capturing a narrow range of wavelengths. Six bands were used for classification of land cover, including visible (blue, green, red) and non-visible (near infrared, and two mid-infrared) wavelengths. A TM data set includes reflectance values for each pixel for each of the six bands. A unique combination of reflectance values comprises a spectral "signature", and (potentially) allows each element of the landscape to be identified as a particular type of land cover.

Reflectance from vegetative cover can vary significantly over the course of a growing season. Thus, acquisition of multiple dates of coverage, such as early and late in the growing season, often allows a further refinement of spectral signatures, and thus a higher degree of resolution among vegetation types. For example, plant species that have spectrally similar signatures early in the growing season may diverge in this regard later in the season, thus allowing their unique identities to be resolved. Where multiple layers of vegetation exist, such as forest canopy and understory, the measured reflectance is that of the top-most layer. Consequently, a closed forest canopy would not allow understory vegetation to be identified, and an open canopy forest would yield a mix of both tree canopy and understory reflectance.

### Data Preparation

Satellite imagery were processed with Imagine software, v. 8.1 - 8.3, of ERDAS Corporation. Data were initially separated into three general classes that could be readily identified: upland, wetland and urban. This allowed each class to be processed separately using slightly different techniques. Uplands and wetlands were separated by using the vector boundaries of the Wisconsin Wetlands Inventory (WWI) digital data. Urban areas greater than 40 acres were identified using pre-existing vector data sources, then manually delineated and separated. Uplands and wetlands were further

stratified into smaller, more manageable spatial units, as opposed to an entire TM scene. These units were derived by identifying relatively homogenous, contiguous aggregations of pixels based on similar reflectance, and thus represent "Spectrally Consistent Classification Units", or SCCUs. These were delineated manually, using, in addition to the spectral characteristics, a representation of the ecoregions of the state, and a minimum size criterion. From one to five SCCUs per TM scene resulted. Accuracy assessment of the final classification was stratified by SCCU, except for urban areas, which were processed as an entire scene.

The SCCUs are provided as digital vectors with the land cover data. Each SCCU is designated by a 4-digit TM scene number followed by a 1-digit SCCU number (e.g., 2428-2). SCCUs are specific to this project only and should not be interpreted or used as an ecoregion-like data set. A map depicting SCCUs is attached as **Appendix A**.

### **Classification Scheme**

The WISCLAND classification scheme was developed by evaluating several published Landsat TM classification schemes, including those done previously in Wisconsin. It was based on the known capabilities of the TM sensor and a general knowledge of land cover types that exist in Wisconsin.

The classification scheme is hierarchical insofar as possible. There are three levels to the hierarchy, as shown in **Appendix B**. Level one is the eight most general classes, and of necessity included cloud cover. The cloud cover class indicates that certain land surface areas could not be classified due to the obstruction of clouds in all available TM scenes.

Level two includes five level 1 classes that were not subject to further subdivision, and thus carry over to level 2 (Open Water, for example), plus the level 1 class 100 (Agriculture). Although Agriculture usually was further subdivided, in some cases it was not, and thus class 100 is also represented at level 2. This results in a total of six level 1 classes that carry over to level 2. Level 2 also includes 10 more specific classes derived from subdivision of the parent level 1 classes, for 16 classes in total. The level 2 classification was applied uniformly over all SCCUs and is thus considered appropriate for study areas that span more than one SCCU.

As with level 2, level 3 has six level 1 classes that carry over without further subdivision, plus nine level 2 classes that carry over without subdivision, and 23 additional, more specific classes derived from subdivision of the parent level 2 classes. The level 2 class 222 (Forested Wetland) is not represented at level 3 since it is superseded by its more specific level 3 members (223, 229, and 234). This results in a total of 38 classes at level 3.

Unlike level 2, the level 3 classification could not be uniformly applied over all SCCUs, and thus is not exclusively hierarchical. For example, Aspen forest type (level 3) may be identifiable in one SCCU, but not in another (for reasons given below), even if Aspen was present in both. In this case the latter SCCU could have "Mixed/Other Broad-leaved Deciduous" assigned at level 3 for areas of Aspen. Or, alternatively, Aspen could be assigned to the more general "Broad-leaved Deciduous" at level 2, in which case level 3 would be null for that category. As a result, application of the level 3 classes should only proceed given an awareness of their potential variability across SCCUs, and the

implications of this for the application at hand. This spatial variability also can produce visual edge effects along SCCU boundaries, depending on the color scheme chosen for display of the various level 3 classes. For example, if Corn is depicted in yellow and Row Crops in orange, a sharp yellow/orange demarcation along an SCCU boundary will appear where Corn was classified in a particular SCCU but only identified as Row Crops in an adjacent SCCU.

For all vegetation, an attempt was made to classify to level 3 whenever possible. When not possible, as with the Aspen example above, species were grouped into another appropriate class at the same level (often a catch-all "other" category), or aggregated into a more general class at the next higher level. Each pixel in the data set was assigned a 3-digit number representing its class and a 1-digit number representing its level. The WISCLAND land cover classification scheme and definitions for all classes is attached as **Appendix B**.

### **Ground Truth - Uplands**

In order to convert the raw satellite imagery into meaningful data, it was necessary to perform on-site verification of land cover types at selected sites throughout the state. This is known as "ground truth" and is an essential component of any remote sensing project. Ground truth data are used to 1) "train" the computer to recognize and thus differentiate among various land cover types, and 2) to derive estimates of the degree of accuracy of the computed classification. Selection of ground truth sites was based on a stratified random sampling technique using the USGS 1:24,000-scale quadrangle map boundaries as geographic stratification units. For each quadrangle, an area representing one quarter-quarter of the full area, or 1/16<sup>th</sup> of the quadrangle, was chosen at random as a ground truth site. Polygons representing homogenous cover types were then delineated within the chosen area on both aerial photographs (NAPP at 1:40,000 scale) and the satellite imagery. Field work was then conducted to identify cover types in each polygon and to record ancillary information from the ground truth site.

All ground truth polygons were 5 acres or larger in size, and a minimum of 10 per land cover class per SCCU was used as a criterion for determining which land cover types would be included in the classification. For example, if 10 unique sites in one SCCU were verified on the ground for cover type Maple, then five of those sites were allocated to training and five to accuracy assessment of the Maple cover type in that SCCU. For cover type verification, the definition of each class (see **Appendix B**) was used as a benchmark against which the ground truth data were compared. Thus, again for Maple (level 3), its definition requires both a predominance of at least 80% maple tree species and a canopy closure of no less than 70%. So, if 10 ground truth sites met these definition criteria, then classification of the Maple cover type proceeded. If fewer than 10 sites were found, classification of Maple was not attempted, and the classification procedures would place pixels with spectral signatures indicative of Maple into either Mixed/Other Broad-leaved Deciduous (also level 3) or into a more general class such as Broad-leaved Deciduous (level 2). This example also illustrates why Maple may be included in one SCCU, but not in a neighboring one, even if the presence of Maple in the neighbor was verified in some - but less than 10 - ground truth sites. For these reasons, as was stated above, level 3 classes could not be uniformly applied statewide, but rather may vary across SCCUs.



## Ground Truth - Wetlands and Urban

Wetland data were processed similar to upland, except that the Wisconsin Wetland Inventory (WWI) data were used as ground truth for both computer training and accuracy assessment. The final wetland classes were derived from both the WWI attributes and TM classification techniques.

Urban areas were classified and ground-truthed as an entire TM scene, rather than by SCCU. A size threshold of 40 acres was chosen as a minimum for classifying as urban, although smaller areas were included if they occurred near a larger urban complex. Standard automated procedures were used to separate high intensity from low intensity urban, and golf courses were identified and delineated manually. No ground truthing was done in urban areas; rather, aerial photographs provided the source data for accuracy assessments.

In total, 20,235 ground truth sites were inspected. Of that number, 5,799 were allocated to computer training and 5,615 were allocated to accuracy assessment. **Appendix C** depicts the statewide distribution of ground truth polygons relative to SCCU boundaries. Also given is the frequency of land cover categories recorded from the field sites. The area subjected to ground truth in this project represented about 0.3% of the total area of Wisconsin.

## Classification Methodology

"Guided clustering", which is a hybrid supervised/unsupervised classification method, was used to perform the classification. This technique uses a maximum likelihood algorithm which groups "like" pixels together. See Lillesand et al. (1998) under **Additional Documentation** below for more information on this classification method. Upland data were generalized, or "smoothed", by dropping out single pixels and pixel clusters comprised of less than four contiguous pixels. This smoothing procedure is known as a "clump-sieve-and-fill" technique that eliminates the "salt and pepper" effect of scattered, isolated pixels. As a result, the minimum size area of like pixels in upland areas is about one acre, as represented by 2x2 pixel clusters or linear chains of minimally four contiguous pixels in any direction. Even though the smaller clusters may have been correctly classified, they were considered below the minimum resolution for these data and therefore not reliable. Refer to the **Usage Guidelines** section for a discussion of data resolution.

Wetland data also were smoothed by the above procedure, except that individual wetlands less than one acre as identified in the WWI were retained (i.e., not smoothed). These smaller wetlands were considered reliable since the source WWI data were captured at a scale (1:24,000) that accurately depicts areas as small as a fraction of an acre.

Open water data were not smoothed since this class is known to be rendered very accurately in TM classifications. Urban areas also were not smoothed and thus may depict areas as small as one 30-meter pixel, or about 1/4 acre.

## Accuracy Assessment

As stated above, at least 10 ground truth sites per class per SCCU were required to include a class in the final classification for a given SCCU. In addition to the ground-truthed cover types matching the class definitions (as given in **Appendix B**), cover type identities also had to be of a "high confidence" level as judged by the ground-truthing individual. An assessment of accuracy was based on the classified majority within the ground truth polygon. The 5-acre minimum size for these sites represents an area of about 25 pixels. Thus, if 13 or more pixels were classified as red oak and ground truth indicated that 25 pixel equivalents were indeed red oak, then the majority criterion was met and class red oak was considered correct for that entire 5-acre site.

Classification accuracy assessments were performed by a standard technique that produces an error matrix, also referred to as a "confusion" matrix. This procedure detects errors of both omission and commission, i.e., a pixel omitted from its correct class, or a pixel committed to the wrong class. Error matrices were produced separately for uplands (at both level 2 and level 3), wetlands, and urban areas. When data smoothing was done, accuracy assessments were performed on the smoothed data.

An error matrix is included as **Appendix C**, this example representing upland classes at level 3. The matrix compares, for each class, its verified cover type from ground truthing of selected sites (the "Reference" columns) and its classified cover type for those same sites based on computing techniques (the "Classified" rows). These data can be used to determine how well the computing process classified the set of ground truth polygons that were chosen for accuracy assessment. There is one row and one column entry for each class included at level 3 for SCCU #24/29-3. Diagonal entries represent the number of polygons correctly classified. Non-diagonal entries are the number of polygons incorrectly classified, where columns represent errors of omission and row entries are errors of commission. So, for Corn (column 113), 38 polygons were assigned correctly, relative to a total of 40 polygons (the column total) known to be Corn from ground truth. Thus, two polygons were omitted from their correct class - one went to Other Crops and one to Grassland. This yielded 95% correct, and is entered as the "Producer's" entry, referring to the Producer (or Analyst) of the classification desiring a measure of how well the known polygons were classified. In the row entry for Corn, 38 polygons were classed correctly, but two that were classed as Corn were in fact "Other Crops" and thus were committed to Corn erroneously. That yielded 95% correct as the "User's" measure of accuracy, referring to Users of the data needing to know the probability that the classified polygons will actually be that cover type on the ground.

Two other descriptive measures are derived from the matrix. The "overall" percent correct is the number of correctly classed polygons divided by the total number of polygons for all classes; in this case, 196/227, or 86% overall correct for the sites in this SCCU. The other statistic is "KHAT" which is a measure of the degree to which the computed classification was an improvement over a completely random assignment of classes to polygons. The rationale behind the KHAT measure is that even a random assignment of cover types to ground truth polygons will result in a certain number of correct class assignments. KHAT values are reported as percentages between 0 and 100 where higher values indicate a greater improvement from the computing procedure versus random chance. For SCCU #24/29-3, this value was 84%, and indicates that the derived classification was 84% better than that due to chance.

Note in the matrix of **Appendix C** that there was substantial "confusion" among Forage Crops and Grassland in both dimensions, i.e., errors of omission and commission. This is an example of where multiple measures of accuracy may be important. If a user is interested primarily in locating grassland, it is evident from the Producer's accuracy that 83% of known grassland polygons were classified correctly. However, of all ground-truthed polygons classified as grassland, only 15 of 29 (52%) were verified as grassland from ground truth, and 13 were in fact Forage Crops. In this case ground truthing indicates that the user would have only about a 50-50 chance of finding grassland on the ground based on computed classes. Similarly, of 48 polygons known to be Forage Crops, 13 were incorrectly classed as Grassland, for a Producer's accuracy of 73%. But 35 of 39 polygons classified as Forage Crops were correct, for a User's accuracy of 90%. So, again, a User could expect to find Forage Crops in the field for 90% of the polygons classified as such. Lastly for this example, it is noteworthy that Red Pine and Oak classes were highly reliable in this SCCU based on both User's and Producer's measures.

The example above illustrates subtle differences among the accuracy measures, and is an indication of why serious users of the land cover data must become well-versed in use of the accuracy matrices. The importance of this cannot be overstated. The various accuracy measures utilize entries in the matrix slightly differently, each approaches the accuracy issue from a somewhat different perspective, and each has unique application depending on how the classification is to be used. Two points stressed by Lillesand and Kiefer (1994, p. 612 and 617) have relevance here:

"A classification is not complete until its accuracy is assessed." And "...the quality of any accuracy estimate is only as good as the information used to establish the true land cover types present in the test sites."

Accuracy assessments typically are assumed to apply over an entire SCCU, even though the data were derived from ground truth areas only. The validity of extrapolating accuracy results in this way depends on the degree of heterogeneity among cover types in a particular SCCU, and the degree to which ground truth sites are representative of the various classes present across the entire SCCU. Of course, the intent of dividing the state into SCCUs was to ensure that relatively homogenous areas - with respect to spectral characteristics - were classified as a unit.

All error matrices are included with the land cover data. For uplands this includes accuracy measures for Producers, Users, Overall, and KHAT. Matrices for wetlands and urban include only User's and Overall statistics since the method of classifying these categories did not lend itself to construction of complete confusion matrices. Since Cranberry Bogs (148) were delineated manually, they were considered reliable and no accuracy assessments were necessary. The interested user is urged to consult Lillesand and Kiefer (1994), and references cited therein, for a more in-depth discussion of accuracy assessment.

In **Appendix E** is a series of tables and charts that summarize the accuracy assessment results. Accuracy goals for the final data set were 85% minimum correct at level 2 and 75% at the more detailed level 3, as shown. These were considered reasonable and attainable goals given the known capabilities of the TM sensor and reliability of analysis techniques employed in this project. Note that while accuracy goals were met, they represent averages of correct class assignments - averages over all SCCUs and over all species. That is not to say that every location in the state will

exceed 85% correct at level 2. Rather, spatial variation across SCCUs and by species was expected and is thus illustrated in **Appendix E**. Mean KHAT values by SCCU are also given.

In general the highest classification accuracies were in the south-central part of the state - the SCCU centered on Rock County, and also the SCCU covering the Door County peninsula. Lowest accuracies generally were in the far northwest. Open water was usually resolved quite accurately. However, detection of open water when interspersed with wetlands was somewhat less accurate (see User's mean at level 2 in **Appendix E**).

It is noteworthy that the final classification was derived entirely from automated computing techniques. That is, even though extensive ground truth data were gathered, these were used for computer training and accuracy assessment only. Classified pixels that were subsequently shown to be incorrect based upon ground truth data were not re-assigned values to make them correct. The entire data set is thus consistent with respect to how class values were assigned - i.e., by the computer. Of course, all ground truth data were retained as attributed vector polygons and are considered a valuable adjunct to the classified data set (see **Appendix C**).

### **Positional Accuracy**

The source TM data were geometrically corrected by EROS Data Center to fit the USGS 1:24,000-scale quadrangle maps. Accuracy standards were on the order of RMS error no greater than one pixel, or +/- 30 meters. The data were projected using Arc/Info (of Environmental Systems Research Institute, or ESRI) as the map projection software (see **Data Format** below). The chosen spectral resampling algorithm was "nearest neighbor". Positional accuracy of the projected data was evaluated empirically by overlaying vector data that were known to meet National Map Accuracy Standards at 1:24,000 scale (i.e., USGS DLG data). The fit of the overlay was evaluated at 1:40,000 scale, which is the minimum recommended for display of land cover data, and thus would reveal any mis-registrations to the greatest degree. This subjective evaluation proved satisfactory, and although projecting of raster data introduces some degree of spatial error, it is assumed that the stated positional accuracy of the original data was preserved insofar as possible.

### **Data Format**

The Land Cover data are kept in a raster format known as "grid", a format developed by ESRI. The map projection and coordinate system is "Wisconsin" Transverse Mercator (WTM) based on a 1991 adjustment to the North American Datum of 1983 (NAD83/91). WTM differs from Universal Transverse Mercator (UTM) primarily in that the origin has been adjusted to allow the entire state of Wisconsin to reside within the east-west dimensions of a standard UTM zone. WTM coordinate units are meters. Attributes of the land cover grid are kept in an associated "info" file referred to as the Value Attribute Table (VAT). This table encodes for each cell the following:

<u>Field Name</u>	<u>Content</u>
Value	Classification numeric code, 3-digit
Count	Number of cells (per Value) statewide
Levels	Number of classification levels, 1, 2, or 3
Class	Classification name, 47-character
Level1	Classification value at level 1, 3-digit
Level2	Classification value at level 2, 3-digit
Level3	Classification value at level 3, 3-digit or 0 (where not applicable)

Accuracy assessment matrices are provided as Microsoft Excel spreadsheets, and the land cover documentation is in Microsoft Word format.

### **Usage Guidelines**

The TM scenes were primarily from fly-overs in spring and summer of 1992, supplemented with a few scenes from summer 1991 and spring 1993. The data are thus a "snap shot" of land cover conditions at that time. The data's currency for a particular application should be judged accordingly. With a 30-meter pixel size, narrow linear features such as roads and streams are not readily detected. It is recommended that vector data, such as the USGS digital line graph (DLG) data, be used to display those features.

Most applications should use the level 2 classes in order to have a uniform and comprehensive view across all SCCUs. Although level 3 classes are more detailed, they could not be uniformly resolved across SCCUs, and thus comparisons of level 3 classes between SCCUs may not be appropriate. The user should consult the level 3 error matrices to take note of class entries before making comparisons at level 3 between SCCUs. In addition, level 3 is not exclusively hierarchical. Thus, as shown in Appendix B, to get all row crops at level 3, the user must select three classes: Row Crops, Corn, and Other Row Crops. Similarly for oak: Oak, Northern Pin Oak, and Red Oak would need to be aggregated to get all oaks.

Distinguishing among vegetation species with similar spectral signatures can be problematic with TM data. Examples are maple versus aspen, maple versus basswood, and white pine versus red pine. Where these classes are encountered in the data, the user is urged to consult the accuracy assessment matrices for the SCCUs of interest for estimates of reliability.

The land cover data can be appropriately used for a range of display scales from 1:40,000 to 1:500,000. Computer display and query systems typically allow unlimited zoom-in capability. However, a minimum display scale of 1:40,000 is recommended given the known resolution of these data. At that scale, the data can be used to identify cover types and distribution of land cover over a fairly broad area, but not at a specific location. Also, single pixels should not be relied upon to depict a particular class or its distribution. Rather, aggregations of pixels that represent a homogenous area of 5 acres in size (about 25 pixels) is considered a reasonable minimum for these data.

The data can be used to derive areal estimates by cover types for an area of interest. However, resulting areal accuracies will depend on the size of the area of interest. For a

large area, such as a county, the 30-meter cell size would represent a relatively fine-grained spatial array, and errors due to omission and commission of cells along the county boundary would probably be insignificant for most applications. In contrast, for a smaller area, the cell size would be relatively more coarse-grained, and thus edge effects would be more pronounced. This is because raster data usually cannot represent a linear boundary exactly, but rather can only simulate it as a "stair-step" pattern of cells. To illustrate this, land cover types were summed by area for Dane County, one PLSS Township in Dane County, and one PLSS Section in the county. Those areal estimates were then compared to areas derived from vector (or polygon) representations of the same areas. Results are shown below in units of acres.

	<u>Land Cover area</u>	<u>vector area</u>	<u>difference</u>	<u>% difference</u>
Dane Co.	791,870	791,916	-46	<0.01
Township	23,232	23,206	+26	<0.12
Section	633	640	-7	<1.10

### **Metadata**

A metadata document that meets the Federal Geographic Data Committee (FGDC) standards was prepared and is attached as **Appendix F**. This document also is available as a stand-alone, ascii-format file upon request.

### **Documentation and References**

This project followed ground truth procedures, classification schema, and accuracy assessment as presented in:

**Lillesand, T., J. Chipman, D. Nagel, H. Reese, M. Bobo, and R. Goldmann, 1998. Upper Midwest GAP Analysis Image Processing Protocol. U. S. Geological Survey, Environmental Management Technical Center Document # 98-G001, 25 pages.**

The above document is available on the Internet at <http://www.emtc.nbs.gov/umgaphome.html>

**Lillesand, T. M. and R. W. Kiefer, 1994. Remote Sensing and Image Interpretation. 3<sup>rd</sup> edition. John Wiley and Sons.**

**Step-by-step Technical Procedures Used in the WISCLAND Project, April, 1996** gives additional details on procedures employed.

**Accuracy Assessment Matrices** were prepared separately for upland, wetland, and urban classes for each SCCU. They are supplied with the land cover data as Microsoft Excel spreadsheets.

**Lineage Documents** for each SCCU give dates of imagery used, and comments by the analysts regarding source data quality, accuracy assessments, and any caveats or anomalies encountered.

The **Ground Truth Database** includes vector polygons of ground truth sites and an associated database containing information gathered in the field.

**Genesis of the WISCLAND Classification Scheme - January 18 & 19, 1995** details the derivation of the final classification scheme.

**WISCLAND Land Cover Data Project, Final Report, April 1998**

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# Appendix A

## Spectrally Consistent Classification Units (SCCUs) of the WISCLAND Land Cover Project



## Appendix B

### Land Cover Classes Present in the WISCLAND Data Product

Numeric class values assigned to pixels are in parentheses. The three-level hierarchy is indicated by decimal values and indentation. Gaps in the numeric and hierarchical sequence are due to entries in the "extended" classification which were not part of the final classification scheme (see **Metadata** below).

- (100) 1. **URBAN/DEVELOPED**
  - (101) 1.1 **High Intensity**
  - (104) 1.2 **Low Intensity**
  - (105) 1.3 **Golf Course**
  
- (110) 2. **AGRICULTURE**
  - (111) 2.1.1 **Herbaceous/Field Crops**
  - (112) 2.1.2 **Row Crops**
  - (113) 2.1.3 **Corn**
  - (118) 2.1.8 **Other Row Crops**
  - (124) 2.1.9 **Forage Crops (includes hay and hay/mix)**
  - (148) 2.3 **Cranberry Bog**
  
- (150) 3. **GRASSLAND** (includes timothy, rye, pasture, idle, CRP, grass and volunteer)
  
- (160) 4. **FOREST**
  - (161) 4.1 **Coniferous**
    - (162) 4.1.1 **Jack Pine**
    - (163) 4.1.2 **Red Pine**
    - (166) 4.1.5 **White Spruce**
    - (173) 4.1.11 **Mixed/Other Coniferous**
  - (175) 4.2 **Broad-leaved Deciduous**
    - (176) 4.2.1 **Aspen**
    - (177) 4.2.2 **Oak**
    - (179) 4.2.4 **Northern Pin Oak**
    - (180) 4.2.5 **Red Oak**
    - (183) 4.2.8 **Maple**
    - (185) 4.2.10 **Sugar Maple**
    - (187) 4.2.12 **Mixed/Other Broad-leaved Deciduous**
  - (190) 4.3 **Mixed Deciduous/Coniferous**
  
- (200) 5. **OPEN WATER**
  
- (210) 6. **WETLAND**
  - (211) 6.1 **Emergent/Wet Meadow**
    - (212) 6.1.1 **Floating Aquatic Herbaceous Vegetation**
  - (217) 6.2 **Lowland Shrub**
    - (218) 6.2.1 **Broad-leaved Deciduous**
    - (219) 6.2.2 **Broad-leaved Evergreen**
    - (220) 6.2.3 **Needle-leaved**
  - (222) 6.3 **Forested**
    - (223) 6.3.1 **Broad-leaved Deciduous**
    - (229) 6.3.6 **Coniferous**
    - (234) 6.3.10 **Mixed Deciduous/Coniferous**

- (240) 7. BARREN
- (241) 8. SHRUBLAND
- (242) 9. CLOUD COVER

## Appendix B (continued)

### Classification Definitions

The following definitions were used in the classification of the WISCLAND Land Cover data.

I. **Urban/Developed:** Structures and areas associated with intensive human activity and land use.

- a. High Intensity: Greater than 50% solid impervious cover of man-made materials. *Examples: parking lot, shopping mall, or industrial park.*
- b. Low Intensity: Less than 50% solid impervious cover of man-made materials. May have some interspersed vegetation. *Examples: sparse development, single family residence.*
- c. Golf Course

*Note:* Areas meeting the requirements of both Urban/Developed and Forest classes should be classified in the Urban/Developed category. (i.e., residential areas with greater than 10% crown closure of trees would be classified as Urban/Developed, rather than Forest).

II. **Agriculture:** Land under cultivation for food or fiber.

- i. Herbaceous/Field Crops: includes the sub categories of Row, Forage, and Small Grain Crops.
  - ii. Row Crops: includes Corn, Peas, Potatoes, Snap Beans, Soybeans, and Other Row Crops.
  - iii. Forage Crops: includes Alfalfa, Hay and Hay Mix.
- c. Cranberry Bog

III. **Grassland:** Lands covered by non-cultivated herbaceous vegetation predominated by grasses, grass-like plants or forbs. *Examples: cool or warm season grasses, restored prairie, timothy, rye, pasture, idle farmland, CRP land, "volunteer" grasses.*

IV. **Forest:** An upland area of land covered with woody perennial plants, the tree reaching a mature height of at least 6 feet tall with a definite crown.

- a. Coniferous: Upland areas whose canopies have a distinct crown closure of which no less than two-thirds (67%) should be of the coniferous tree group. If the broad-leaved deciduous species group is present, it should not exceed one-third (33%) of the canopy. *Examples: Jack Pine, Red Pine, White Spruce, Hemlock, Tamarack.*
  - i. Jack Pine: No less than 80% of the canopy should be Jack Pine.
  - ii. Red Pine: No less than 80% of the canopy should be Red Pine.

*xiii. Mixed/Other Coniferous:* In the case of Mixed Coniferous, canopy percent must have a distinct crown closure of which no less than 80% is of a single coniferous species, but rather a mix of coniferous species. Other Coniferous is characterized by coniferous species that have a distinct canopy closure, and 80% or greater of that species in the canopy, but that has fewer than the sufficient number of training sets required (at least 5) for classification at the species level.

- b. Broad-leaved Deciduous: Upland areas whose canopies have a distinct crown closure of which no less than two-thirds (67%) should be of the broad-leaved deciduous tree group. If the coniferous species group is present, it should not exceed one-third (33%) of the canopy.

*Examples: Aspen, Oak, Maple, Birch, Balsam Poplar*

- i. Aspen :* No less than 80% of the canopy should be Aspen.
- ii. Oak:* No less than 80% of the canopy should be Oak

vii. Mixed/Other Broad-leaved Deciduous: In the case of mixed broad-leaved deciduous, canopy percent must have a distinct crown closure of which no less than 80% is of a single broad-leaved deciduous species, but rather a mix of broad-leaved deciduous species. Other broad-leaved deciduous is characterized by deciduous species that do have a distinct canopy closure, and 80% or greater of that species in the canopy, but that has fewer than the sufficient number of training sets required (at least 5) for classification at the species level.

- c. Mixed Broad-leaved Deciduous/Coniferous: In the case of mixed broad-leaved deciduous/coniferous forest, canopy percent must have a distinct crown closure, of which no more than two-thirds (67%) should be from either of the species group (coniferous or deciduous).

V. **Open Water:** Areas of water with no vegetation present.

VI. **Wetland:** An area with water at, near or above the land surface long enough to be capable of supporting aquatic or hydrophytic vegetation, and which has soils indicative of wet conditions.

- a. Emergent/Wet Meadow: Persistent and non-persistent herbaceous plants standing above the surface of wet soil. *Examples: Cattails, Marsh Grass, Sedges*
- b. Lowland Shrub: Woody vegetation, less than 20 feet tall, with a tree cover of less than 10%, and occurring in wetland areas.  
*Broad-leaved deciduous examples: Willow, Alder, Buckthorn*  
*Broad-leaved evergreen examples: Labrador-tea, Leather-leaf, Bog Rosemary*

*Coniferous examples: Stunted Black Spruce*

- c. **Forested Wetland:** Wetlands dominated by woody perennial plants, with a canopy cover greater than 10% , and trees reaching a mature height of at least 6 feet.

*Broad-leaved deciduous examples: Black Ash, Red Maple, Swamp White Oak*  
*Coniferous examples: Black Spruce, Northern White Cedar, Tamarack*  
*Mixed Broad-leaved deciduous/Coniferous examples: Mixture of the species above.*

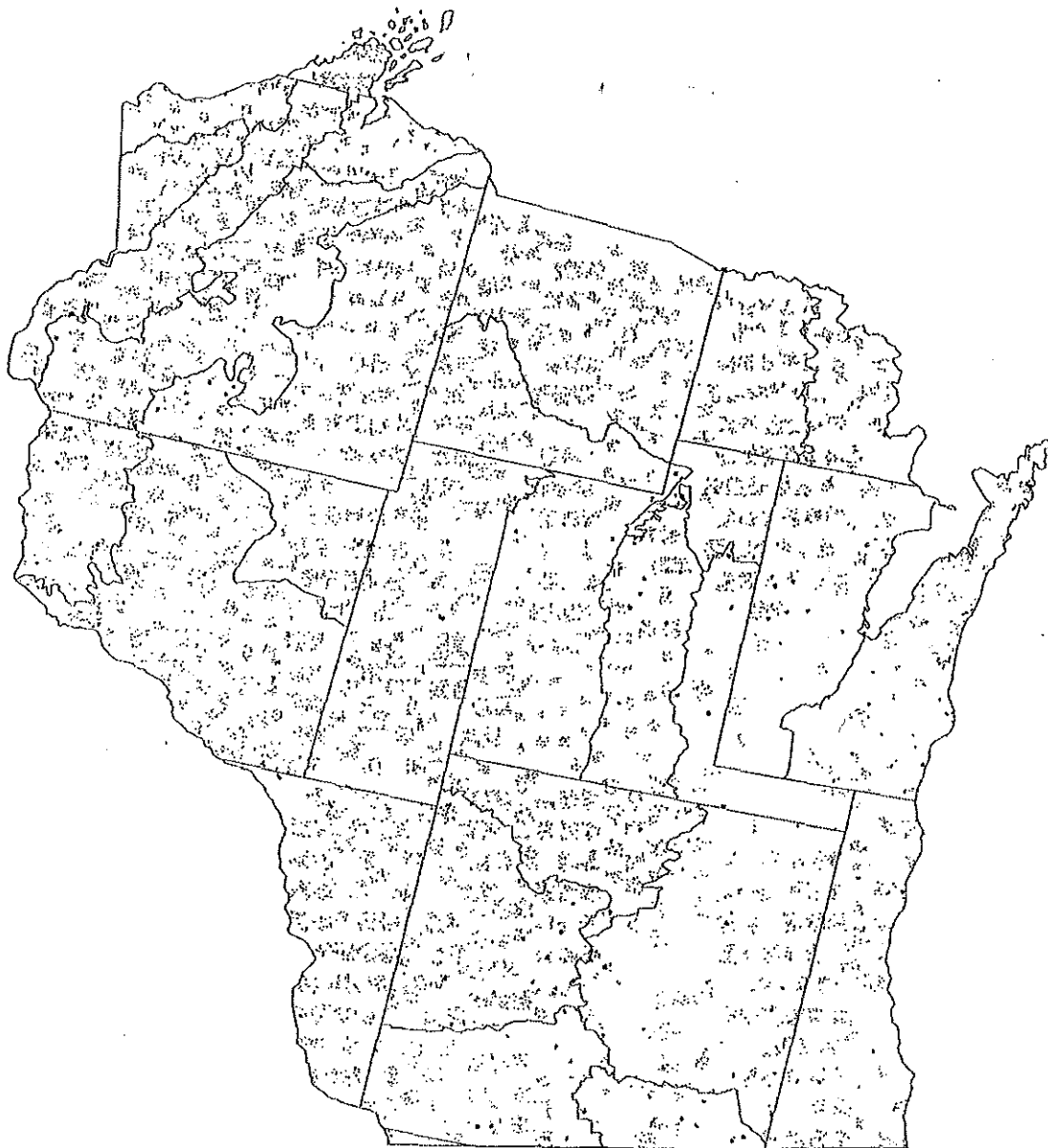
Note: If an area meets the requirements of Forested Wetland, it should take precedence over any other "Forest" Category.

VII. **Barren:** Land of limited ability to support life and in which less than one-third (33%) of the area has vegetation or other cover. If vegetation is present, it is more widely spaced and scrubby than that in Shrubland. *Examples: Sand, Bare Soil, Exposed Rock, Mixed Barren*

VIII. **Shrubland:** Vegetation with a persistent woody stem, generally with several basal shoots, low growth of less than 20 feet, and coverage of at least one-third (33%) of the land area. Less than 10% tree cover interspersed. *Examples: Scrub Oak, Buckthorn, Sumac*

## Appendix C

### Ground Truth Polygons with SCCU boundaries



## Appendix C (cont.)

Frequency of land cover categories recorded from ground truth sites. Frequency is not necessarily indicative of areal coverage. Land cover categories do not match the WISCLAND classification scheme exactly.

Frequency	Category
7,037	Deciduous Forest
2,605	Corn
1,942	Coniferous Forest
1,397	Grassland
1,366	Forage Crops
788	Other Row/Grain Crops
721	Mixed Deciduous Forest
631	Mixed Forest
424	Deciduous Forested Wetland
420	Clearcut/Young Plantation
380	Coniferous Forested Wetland
338	Open Water
303	Lowland Shrub Deciduous
282	Emergent/Wet Meadow
153	Shrubland
152	Mixed Forested Wetland
90	Red/Black Oak
86	Red Pine
83	Low Intensity Urban
57	Other Deciduous Forest
48	Mixed Barren
45	Mixed Coniferous Forest
27	Lowland Shrub Evergreen
26	Lowland Shrub Broad-Leaved Evergreen
24	Cranberry Bog
23	Sugar Maple
22	Other Coniferous Forest
21	Mixed/Other Deciduous
20	Exposed Rock
19	High Intensity Urban
16	Wetland
12	Aspen
12	Sand
11	White Pine
10	Agriculture
10	Bare Soil
8	Barren
3	Green Ash
3	Mixed/Other Coniferous
2	Golf Course
2	Silver Maple
1	Hemlock
1	Mixed Deciduous/Coniferous
1	Upland



# Appendix D

## Accuracy Assessment Error Matrix

### 24/29-3 Upland Level 3 Accuracy Assessment

Classified	Reference												Total	User's	
	113	118	124	150	163	173	177	183	187	190	200	240			
Com (113)	38	2												40	95%
Other Crops (118)	1	14		1										16	88%
Forage Crops (124)		2	35	2										39	90%
Grassland (160)	1		13	16										29	52%
Red Pine (163)					28									28	100%
Mixed/Other Coniferous (173)						4								4	100%
Oak (177)							26		3					29	90%
Maple (183)								5	3					8	83%
Mixed/Other Deciduous (187)							1		11	1				13	85%
Mixed Deciduous/Coniferous (190)							1			6				7	86%
Open Water (200)											10			10	100%
Barren (240)												4		4	100%
<b>Total</b>	<b>40</b>	<b>18</b>	<b>48</b>	<b>18</b>	<b>28</b>	<b>4</b>	<b>28</b>	<b>5</b>	<b>17</b>	<b>7</b>	<b>10</b>	<b>4</b>	<b>227</b>		
Producers	95%	78%	73%	83%	100%	100%	93%	100%	65%	86%	100%	100%			
No. Correct	186														
Overall	86%														
KHAT	84%														

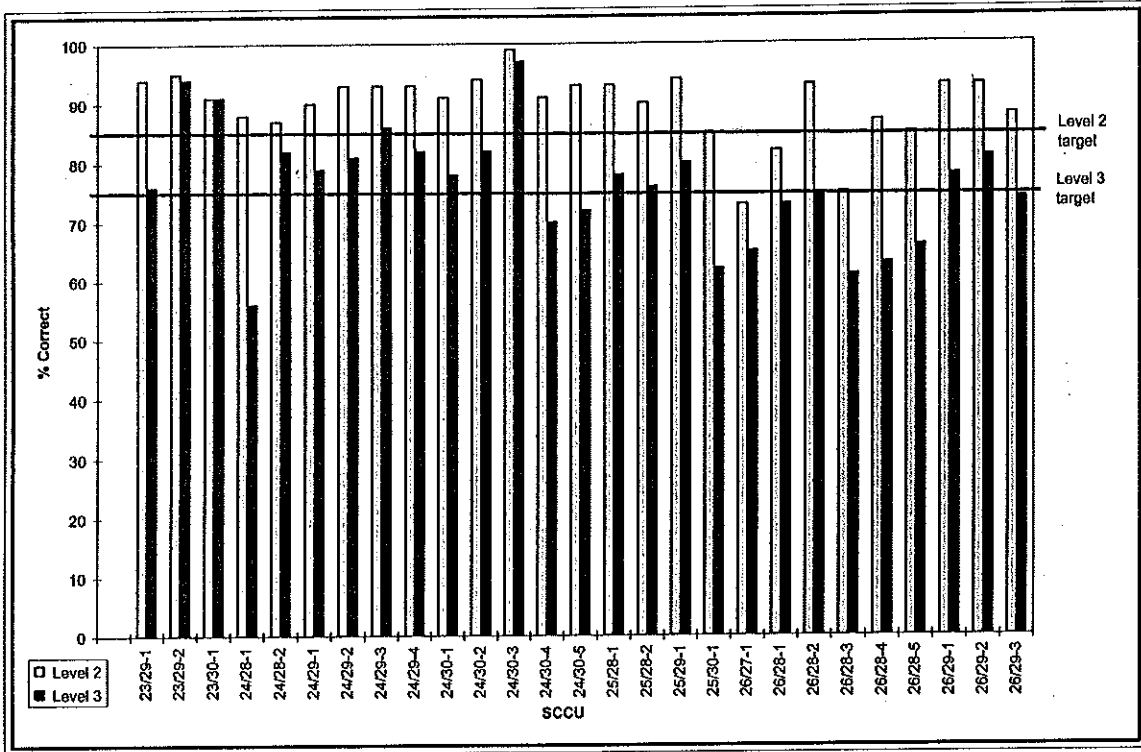
## Appendix E

### Accuracy Assessment Summary - Overall Percent Correct by SCCU or TM Scene (Urban)

SCCU	Level 2	Level 3	Wetland	Urban
23/29-1	94	76	82	100
23/29-2	95	94	82	-
23/30-1	91	91	91	97
24/28-1	88	56	80	97
24/28-2	87	82	86	-
24/29-1	90	79	84	99
24/29-2	93	81	84	-
24/29-3	93	86	83	-
24/29-4	93	82	85	-
24/30-1	91	78	76	97
24/30-2	94	82	80	-
24/30-3	99	97	86	-
24/30-4	91	70	93	-
24/30-5	93	72	85	-
25/28-1	93	78	78	79
25/28-2	90	76	65	-
25/29-1	94	80	78	100
25/30-1	85	62	86	95
26/27-1	73	65	70	98
26/28-1	82	73	86	87
26/28-2	93	75	86	-
26/28-3	75	61	85	-
26/28-4	87	63	79	-
26/28-5	85	66	76	-
26/29-1	93	78	89	99
26/29-2	93	81	76	-
26/29-3	88	74	77	-

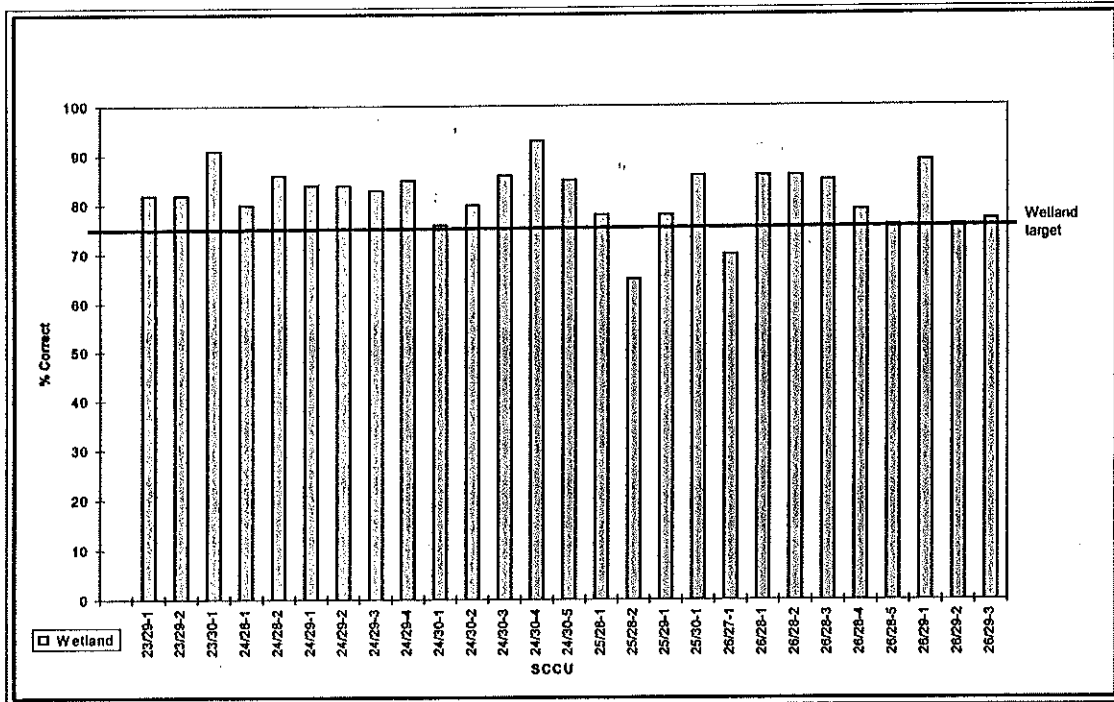
Appendix E (cont.)

Accuracy Assessment Summary - Overall Percent Correct for Uplands by SCCU



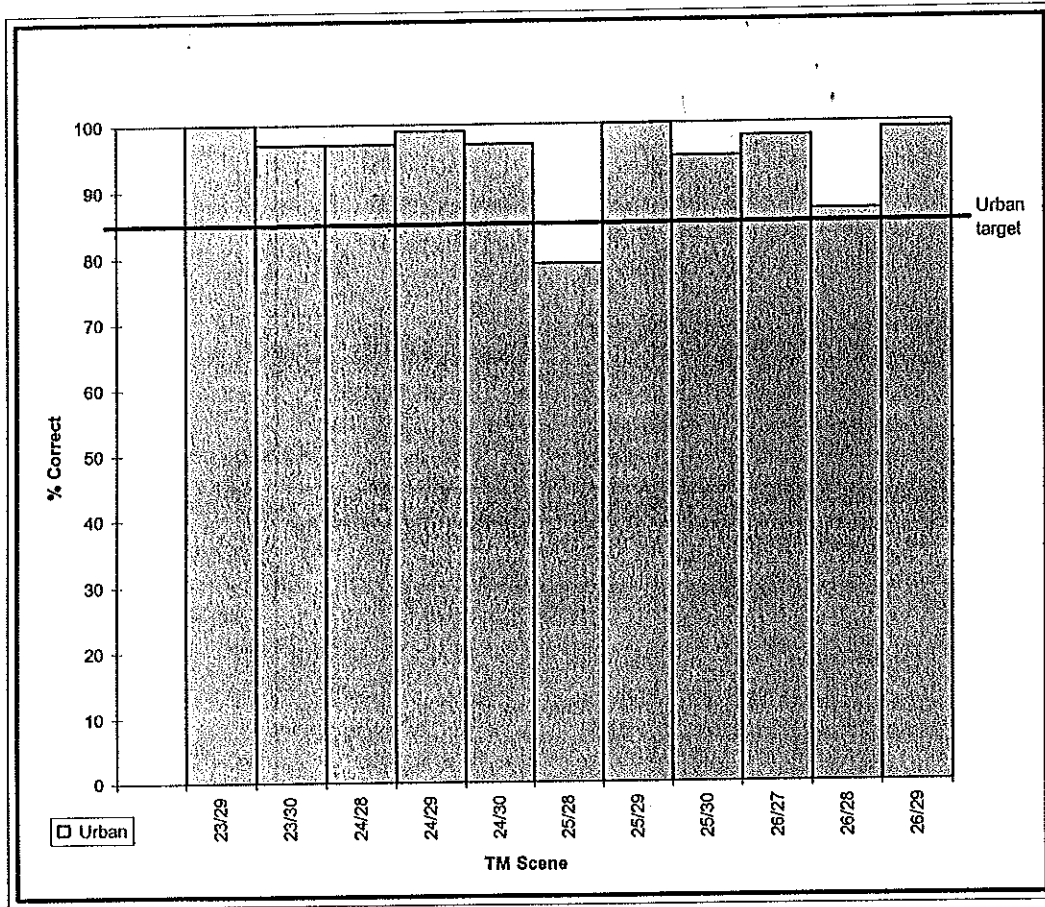
Appendix E (cont.)

Accuracy Assessment Summary - Overall Percent Correct for Wetlands by SCCU



Appendix E (cont.)

Accuracy Assessment Summary - Overall Percent Correct for Urban by TM Scene



**Appendix E (cont.)**

**Accuracy Assessment Summary - User's Mean for Level 2 by SCCU**

SCCU	101	104	105	110	150	161	175	190	200	211	217	240	250	200 (in wetlands)
23/29-1	100	100	100	97	30	100	94	-	100	69	68	100	-	100
23/29-2	-	-	-	96	100	100	100	-	100	78	53	44	-	100
23/30-1	92	100	100	90	88	100	96	-	100	97		93	37	86
24/28-1	100	94	97	100	60	97	96	32	100	75	71	100	-	90
24/28-2	-	-	-	83	55	92	100	75	100	93	68	83	40	100
24/29-1	96	100	100	86	50	87	98	86	100	69	65	-	50	80
24/29-2	-	-	-	94	50	100	90	-	100	83		-	-	100
24/29-3	-	-	-	97	52	100	100	-	100	85		100	-	90
24/29-4	-	-	-	93	76	100	99	70	100	89	73	100	75	86
24/30-1	92	100	100	100	86	91	94	33	100	97		-	-	100
24/30-2	-	-	-	95	66	86	98	-	100	82		100	-	80
24/30-3	-	-	-	100	80	100	100	-	100	91		-	-	100
24/30-4	-	-	-	87	76	-	96	-	100	99		100	-	75
24/30-5	-	-	-	91	76	100	97	-	100	95	75	100	-	71
25/28-1	100	92	44	87	73	100	97	55	100	63		93	58	100
25/28-2	-	-	-	88	73	85	99	33	100	54		0	-	80
25/29-1	100	100	100	96	76	92	97	55	100	81	78	83	-	54
25/30-1	92	92	100	66	93	100	98	-	100	96		83	-	100
26/27-1	90	100	100	-	89	71	78	33	100	89		-	-	
26/28-1	93	79	87	50	89	100	84	47	100	89	86	0	0	
26/28-2	-	-	-	-	91	100	98	67	100	89	84	33	-	
26/28-3	-	-	-	80	69	90	72	0	100	85	100	100	0	91
26/28-4	-	-	-	84	71	89	92	0	100	81		0	-	75
26/28-5	-	-	-	87	50	97	96	35	100	61	85	0	60	75
26/29-1	96	100	100	88	85	100	97	-	100	87		100	-	95
26/29-2	-	-	-	90	75	95	96	67	100	62		-	75	97
26/29-3	-	-	-	86	54	79	94	67	100	73		-	63	75

Appendix E (cont.)

Accuracy Assessment Summary - Producer's Mean for Level 2 by SCCU

SCCU	101	104	105	110	150	161	175	190	200	240	250
23/29-1	100	100	100	92	60	97	100		100	100	
23/29-2				97	55	100	97		100	100	
23/30-1	100	93	100	95	74	100	95		100	100	60
24/28-1	94	97	100	25	100	86	93	55	100	100	
24/28-2				76	61	100	92	50	100	100	67
24/29-1	100	100	96	60	50	100	98	75	100		75
24/29-2				96	33	100	90		100		
24/29-3				87	83	100	100		100	100	
24/29-4				94	72	92	95	94	100	100	100
24/30-1	100	100	93	93	100	94	97	23	100		
24/30-2				94	70	75	99		100	100	
24/30-3				98	100	100	100		100		
24/30-4				96	50		98		100	100	
24/30-5				94	73	67	100		100	100	
25/28-1	93	64	92	62	69	92	98	85	100	100	88
25/28-2				78	85	85	97	25	100		
25/29-1	100	100	100	95	81	94	95	60	100	100	
25/30-1	100	92	93	97	47	50	95		100	100	
26/27-1	100	97	100		94	57	65	75	100		
26/28-1	78	65	100	29	89	67	83	67	100	50	0
26/28-2					77	100	98	100	100	100	
26/28-3				25	52	89	92	0	78		0
26/28-4				68	79	89	96	0	100		
26/28-5				88	67	83	94	30	100	0	50
26/29-1	100	96	100	97	79	84	94		100	100	
26/29-2				90	77	90	98	20	100		100
26/29-3				94	44	93	93	15	100		71

## Appendix E (cont.)

### Accuracy Assessment Summary - User's Mean for Level 3 by SCCU

SCCU	111	112	113	118	124	162	163	166	173	176	177	179	180	183	185	187	212	218	219	220	223	229	
23/29-1	-	-	89	74	82	-	78	-	90	36	50	-	-	-	-	81	-	76	-	-	93	100	
23/29-2	-	94	-	-	93	-	-	-	100	-	-	-	-	-	-	100	-	-	-	-	91	86	
23/30-1	-	95	-	-	93	-	-	-	100	-	-	-	-	-	-	95	-	86	-	-	92	86	
24/28-1	-	-	-	-	100	-	65	80	67	76	-	-	100	-	71	48	-	60	54	40	75	99	
24/28-2	83	-	-	-	-	71	92	-	-	85	-	-	-	-	-	89	-	-	-	-	78	96	
24/29-1	86	-	-	-	-	-	100	-	33	82	80	-	-	100	-	62	-	-	-	-	89	84	
24/29-2	-	-	81	100	74	-	-	-	100	-	-	-	-	-	-	90	-	-	61	-	-	95	100
24/29-3	-	-	95	88	90	-	100	-	100	-	90	-	-	63	-	85	-	75	92	100	80	73	
24/29-4	-	-	76	87	70	90	100	-	88	-	86	-	-	58	-	89	-	-	-	-	91	82	
24/30-1	-	-	100	92	70	57	83	-	-	-	78	-	-	-	-	63	-	66	-	-	64	41	
24/30-2	-	-	89	41	92	-	-	-	86	-	71	-	-	-	-	86	-	60	100	50	86	75	
24/30-3	-	-	96	100	100	-	100	-	-	-	-	-	-	-	-	100	-	57	-	-	94	-	
24/30-4	-	-	97	50	59	-	-	-	-	-	46	-	-	-	-	68	-	79	-	-	80	-	
24/30-5	-	-	97	76	62	-	86	-	50	-	45	-	-	-	-	66	-	-	-	-	91	-	
25/28-1	-	-	-	89	67	85	88	-	69	86	-	-	-	-	76	68	-	84	67	-	86	93	
25/28-2	-	-	-	-	88	-	38	-	60	86	-	-	-	-	75	82	-	83	79	38	65	89	
25/29-1	-	-	93	93	83	89	88	-	71	54	71	-	-	-	-	79	-	-	-	-	80	88	
25/30-1	-	-	88	82	40	-	-	-	100	-	61	-	-	-	-	54	-	70	-	-	71	-	
26/27-1	-	-	-	-	-	-	36	-	67	33	-	-	-	-	-	78	-	93	67	-	69	45	
26/28-1	-	-	-	100	33	-	100	-	100	53	67	-	-	-	-	50	-	95	-	-	72	83	
26/28-2	-	-	-	-	-	-	100	-	0	65	-	-	-	75	-	74	-	-	100	-	89	90	
26/28-3	-	-	-	-	-	80	91	-	25	62	0	40	100	-	-	41	-	83	100	100	94	79	
26/28-4	-	-	76	17	60	-	84	-	18	49	-	-	-	48	-	63	-	78	86	100	70	81	
26/28-5	72	-	76	-	-	-	61	-	100	65	-	-	-	66	-	67	-	79	100	100	57	100	
26/29-1	-	-	69	79	67	-	77	-	100	-	0	-	-	-	-	81	-	95	-	-	85	100	
26/29-2	-	-	78	75	77	-	95	-	-	-	67	-	-	100	-	62	85	94	-	-	69	100	
26/29-3	-	-	96	75	84	73	93	-	-	45	26	-	-	-	-	89	-	84	-	-	75	64	



## Appendix E (cont.)

### Accuracy Assessment Summary - Producer's Mean for Level 3 by SCCU

SCCU	111	112	113	118	124	162	163	166	173	176	177	179	180	183	185
23/29-1	-	-	82	83	70	-	95	-	60	80	67	-	-	-	-
23/29-2	-	96	-	-	91	-	-	-	100	-	-	-	-	-	-
23/30-1	-	95	-	-	82	-	-	-	100	-	-	-	-	-	-
24/28-1	-	-	-	-	25	-	88	57	18	38	-	-	20	-	18
24/28-2	76	-	-	-	-	100	92	-	-	81	-	-	-	-	-
24/29-1	60	-	-	-	-	-	100	-	100	82	67	-	-	65	-
24/29-2	-	-	92	42	88	-	-	-	100	-	-	-	-	-	-
24/29-3	-	-	95	78	73	-	100	-	100	-	93	-	-	100	-
24/29-4	-	-	86	65	79	90	97	-	64	-	86	-	-	54	-
24/30-1	-	-	90	85	70	89	97	-	0	-	94	-	-	-	-
24/30-2	-	-	87	60	81	-	-	-	75	-	75	-	-	-	-
24/30-3	-	-	100	92	83	-	100	-	-	-	-	-	-	-	-
24/30-4	-	-	94	44	83	-	-	-	-	-	39	-	-	-	-
24/30-5	-	-	94	68	78	-	92	-	25	-	34	-	-	-	-
25/28-1	-	-	-	73	40	92	88	-	46	70	-	-	-	-	74
25/28-2	-	-	-	-	78	-	60	-	38	76	-	-	-	-	60
25/29-1	-	-	95	65	89	89	96	-	53	52	68	-	-	-	-
25/30-1	-	-	92	50	89	-	-	-	50	-	60	-	-	-	-
26/27-1	-	-	-	-	-	-	80	-	25	60	-	-	-	-	-
26/28-1	-	-	-	33	25	-	71	-	50	59	67	-	-	0	-
26/28-2	-	-	-	-	-	-	88	-	-	76	-	-	-	38	-
26/28-3	-	-	-	-	-	67	91	-	38	38	0	29	27	-	-
26/28-4	-	-	73	11	35	-	80	-	22	40	0	-	-	55	-
26/28-5	-	-	80	-	-	-	88	-	11	79	-	-	-	78	-
26/29-1	-	-	78	55	92	-	91	-	38	0	0	-	-	-	-
26/29-2	-	-	91	50	77	-	90	-	-	-	29	-	-	11	-
26/29-3	-	-	76	90	79	73	75	-	-	90	62	-	-	-	-

## Appendix E (cont.)

### Accuracy Assessment Summary - KHAT values for Uplands by SCCU

SCCU	Level 2	Level 3
23/29-1	90	72
23/29-2	92	91
23/30-1	89	89
24/28-1	77	45
24/28-2	83	79
24/29-1	85	76
24/29-2	86	75
24/29-3	89	84
24/29-4	91	80
24/30-1	87	73
24/30-2	89	78
24/30-3	98	97
24/30-4	85	63
24/30-5	89	65
25/28-1	90	76
25/28-2	83	69
25/29-1	91	77
25/30-1	77	53
26/27-1	65	58
26/28-1	75	64
26/28-2	88	69
26/28-3	63	56
26/28-4	80	56
26/28-5	78	62
26/29-1	90	74
26/29-2	87	72
26/29-3	81	68

**Appendix E (cont.) - Accuracy Assessment Summary - User's Mean by Class (statewide)**

**Level II - Upland Classes**

Agriculture (110)	1,428/1,573 = 91%
Grassland (150)	407/572 = 71%
Coniferous Forest (161)	655/699 = 94%
Deciduous Forest (175)	2,348/2,524 = 93%
Mixed Coniferous/Deciduous Forest (190)	75/139 = 54%
Open Water (200)	230/230 = 100%
Barren (240)	94/130 = 72%
Shrubland (250)	46/71 = 65%
<b>Overall.....</b>	<b>5,283 / 5938 = 89%</b>

**Level III - Upland Classes**

Herbaceous/Field Crops (111)	54/69 = 78%
Primary Row Crops (112)	109/115 = 95%
Corn (113)	520/589 = 86%
Other Row Crops (118)	160/212 = 75%
Forage Crops (124)	423/578 = 73%
Jack Pine (162)	67/85 = 79%
Red Pine (163)	403/459 = 88%
White Spruce (166)	4/5 = 80%
Mixed/Other Coniferous (173)	109/145 = 75%
Aspen (176)	220/335 = 66%
Oak (177)	313/475 = 66%
Northern Pin Oak (179)	2/5 = 40%
Red Oak (180)	4/4 = 100%
Maple (183)	125/190 = 66%
Sugar Maple (185)	40/53 = 75%
Mixed/Other Deciduous (187)	1,091/1,486 = 75%
<b>Overall.....</b>	<b>3,644 / 4805 = 76%</b>

**Urban**

High Intensity (101)	248/258 = 96%
Low Intensity (104)	275/283 = 97%
Golf Course (105)	268/289 = 93%
<b>Overall.....</b>	<b>791 / 830 = 95 %</b>

**Wetland Classes**

Open Water (200)	545/615 = 89%
Emergent/Wet Meadow (211)	1,477/1695 = 87%
Floating Aquatic (212)	22/26 = 85%
Lowland Shrub (217)	362/482 = 75%
Broad-leaved Deciduous Shrub (218)	807/1,103 = 73%
Broad-leaved Evergreen Shrub (219)	180/221 = 81%
Needle-leaved Deciduous Shrub (220)	15/25 = 60%
Broad-leaved Deciduous Forested Wetland (223)	1,289/1593 = 81%
Coniferous Forested Wetland (229)	924/1085 = 85%
Mixed Deciduous/Coniferous Forested Wetland (234)	468/647 = 72%
<b>Overall.....</b>	<b>6,089 / 7,492 = 81%</b>

## Appendix F

### FGDC-compliant Metadata

#### Identification\_Information:

##### Citation:

##### Citation\_Information:

Originator: Wisconsin Department of Natural Resources (WiDNR)

Publication\_Date: 1998

Title: WISCLAND Land Cover (WLCGW930)

Geospatial\_Data\_Presentation\_Form: Map

##### Publication\_Information:

Publication\_Place: Madison, Wisconsin

Publisher: Wisconsin Department of Natural Resources (WiDNR)

##### Online\_Linkage:

<URL:<http://www.dnr.state.wi.us/org/at/et/geo/data/wlc.htm>>

##### Other\_Citation\_Details:

Upper Midwest Gap Analysis Program (UMGAP) Image Processing Protocol (1997), available at:

<URL:<http://www.umesc.usgs.gov/umgap/documents.html>>

#### Description:

##### Abstract:

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 were acquired from the nationwide MRLC (Multi-Resolution Land Characteristics Consortium) acquisition of dual-date Landsat Thematic Mapper (TM) data primarily from 1992. The image processing technique followed was published in the UMGAP Image Processing Protocol (1997). The original pixel size of the source TM data is 30 meters, however the classified WISCLAND Land Cover data (excluding URBAN) 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. The classification scheme was designed to be compatible with existing classification schemes such as UNESCO's and Anderson's.

##### Purpose:

These data can be used for landscape scale analysis in various disciplines such as wildlife ecology, forestry, or land use planning. The data have been developed for inclusion in the Gap Analysis Program. The data should be used at a scale of at least 1:40,000. It is also suggested that the data be used at no less than the five acre MMU.

##### Supplemental\_Information:

The spatial extent of this data layer is the state of Wisconsin.

Extensive additional information about this data set is provided

in the 'Land Cover of Wisconsin, User's Guide to WISCLAND Land Cover Data', 1999, WiDNR, accessible at:  
<URL:<http://www.dnr.state.wi.us/org/at/et/geo/data/wlc.htm>>

Time\_Period\_of\_Content:

Time\_Period\_Information:

Range\_of\_Dates/Times:

Beginning\_Date: 1991

Ending\_Date: 1993

Currentness\_Reference:

Date of the Landsat TM satellite data acquisition for the MRLC Consortium

Status:

Progress: Complete

Maintenance\_and\_Update\_Frequency: Maintenance based on User feedback. No plans currently for update.

Spatial\_Domain:

Bounding\_Coordinates:

West\_Bounding\_Coordinate: -92.75

East\_Bounding\_Coordinate: -87.08

North\_Bounding\_Coordinate: 47.08

South\_Bounding\_Coordinate: 42.50

Keywords:

Theme:

Theme\_Keyword\_Thesaurus: none

Theme\_Keyword: Land Cover

Theme\_Keyword: Vegetation

Theme\_Keyword: Landsat Thematic Mapper

Theme\_Keyword: Gap Analysis

Place:

Place\_Keyword\_Thesaurus:none

Place\_Keyword: Wisconsin

Access\_Constraints: None

Use\_Constraints: None; Recommendations/guidelines documented.

Point\_of\_Contact:

Contact\_Information:

Contact\_Organization\_Primary:

Contact\_Organization:

Wisconsin Department of Natural Resources (WiDNR), Bureau of Enterprise Information Technology and Applications (BEITA), Geographic Services Section (GEO), ET/8

Contact\_Person: Lance Perry

Contact\_Address:

Address\_Type: mailing address

Address:

Mailcode: ET/8

101 South Webster Street  
P.O. Box 7921  
City: Madison  
State\_or\_Province: Wisconsin (WI)  
Postal\_Code: 53707-7921  
Country: United States of America (USA)  
Contact\_Voice\_Telephone: (608) 267-5181  
Contact\_Facsimile\_Telephone: (608) 266-0870  
Contact\_Electronic\_Mail\_Address: perry1@dnr.state.wi.us

**Browse\_Graphic:**

**Browse\_Graphic\_File\_Name:**

<URL:[http://www.dnr.state.wi.us/org/at/et/geo/data/lcov\\_smp.gif](http://www.dnr.state.wi.us/org/at/et/geo/data/lcov_smp.gif)>

**Browse\_Graphic\_File\_Description:**

The graphic includes a map and legend showing a sample subset of WISCLAND Land Cover data for a small area in northwestern Wisconsin, and illustrating a representative set of land cover classes for that part of the state.

**Browse\_Graphic\_File\_Type:** GIF

**Native\_Data\_Set\_Environment:**

ARC/INFO Grid format;

Data Format Version Number - ARC7.1.1;

Resident Computer Operating System -

DEC (Digital Equipment Corporation) Alpha 2100 server running Pathworks and OSF version 4.0a (Digital Unix);

Resident Size of Dataset - 77MB

**Data\_Quality\_Information:**

**Attribute\_Accuracy:**

**Attribute\_Accuracy\_Report:**

Accuracy Assessment matrices have been completed for each classification unit of the dataset, or 'SCCU' (Spectrally Consistent Classification Unit). These matrices should be referred to when using the WISCLAND Land Cover Data, and are included as MS Excel spreadsheets. Accuracy Assessment was calculated separately for wetlands and uplands. With uplands, errors of omission and commission (both at species level, and generalized level) have been tallied for each classification unit or 'SCCU', including an overall percentage of accuracy, and a K-hat statistic. Wetlands accuracy was also based on the classification unit, with percentage User's accuracy for each class and an overall percentage accuracy. Urban accuracy assessment was performed on its unit of classification, the full TM scene. Both User's and an overall accuracy assessment are given.

**Logical\_Consistency\_Report:**

Because of the 8-bit file structure used for the WISCLAND Land Cover data, the ERDAS software prevents the assignment of invalid pixel values outside of a 0-to-256 range. In addition, the data have

undergone visual, on-screen review by members of the WiDNR/GEO Land Cover development team to check for classification errors or other anomalies.

Completeness\_Report:

A stratified random sampling technique was used to identify 'ground truthing' points for the purpose of land cover classification and accuracy assessment, as described in the WISCLAND Land Cover Protocol. A 'Lineage' document (see Supplemental Information above) lists the final land cover classifications, and classes omitted, for each processing SCCU.

Positional\_Accuracy:

Horizontal\_Positional\_Accuracy:

Horizontal\_Positional\_Accuracy\_Report:

The source nationwide MRLC (Multi-Resolution Land Characteristics Consortium) data were geometrically corrected by EROS Data Center to 1:24,000 scale USGS topographic quadrangle maps. Accuracy standards were on the order of RMS error no greater than 1 pixel. The WISCLAND Land Cover data are considered to reflect the stated positional accuracy of the source MRLC data set, with positional error of no more than plus or minus 1 pixel (30 meters).

Lineage:

Source\_Information:

Source\_Citation:

Citation\_Information:

Originator:

US Geological Survey, EROS (Earth Resources Observation Systems) Data Center

Publication\_Date: 1993

Title:

MRLC (Multi-Resolution Land Characteristics Consortium) acquisition of dual-date Landsat Thematic Mapper (TM) data

Edition: None

Geospatial\_Data\_Presentation\_Form: Remote-sensing image

Publication\_Information:

Publication\_Place: Sioux Falls, South Dakota

Publisher: EROS Data Center

Other\_Citation\_Details: None

Source\_Scale\_Denominator: 40,000 (nominal)

Type\_of\_Source\_Media: 8mm magnetic tape

Source\_Time\_Period\_of\_Content:

Time\_Period\_Information:

Range\_of\_Dates/Times:

Beginning\_Date: 1991

Ending\_Date: 1993

Source\_Currentness\_Reference:

Date of the Landsat TM satellite data acquisition for the MRLC Consortium.

Source\_Citation\_Abbreviation: MRLC Landsat TM satellite data.

Source\_Contribution:

Remote-sensing imagery used to derive land cover information.

For more information refer to: Barra, T.J. and D. Shaw, 1994.

Multi-Resolution Land Characteristics Consortium: Documentation Notebook. Contract 68-DO-0106.

Process\_Step:

Process\_Description:

The geo-rectified MRLC data were processed according to the protocol published in the UMGAP Image Processing Protocol (1997), found at <http://www.emtc.nbs.gov/umgaphome.html>.

The classified data (except URBAN) were generalized from their original 30-meter resolution to a one acre area of any four contiguous like pixels using a clump-sieve-fill algorithm devised within Imagine and described in detail within the in-house technical procedures document. Strata were clipped at the SCCU boundary, converted from Imagine v.8.3 files into ARC/INFO Grids, projected into WTM NAD83 with adjustment for 91, and then joined for continuous coverage.

The classified data (except URBAN) were generalized from their original 30-meter resolution to a one acre area of any four contiguous like pixels using a clump-sieve-fill algorithm devised within Imagine and described in detail within the in-house technical procedures document. Strata were clipped at the SCCU boundary, converted from Imagine v.8.3 files into ARC/INFO Grids, projected into WTM NAD83 with adjustment for 91, and then joined for continuous coverage.

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The classified data (except URBAN) were generalized from their original 30-meter resolution to a one acre area of any four contiguous like pixels using a clump-sieve-fill algorithm devised within Imagine and described in detail within the in-house technical procedures document. Strata were clipped at the SCCU boundary, converted from Imagine v.8.3 files into ARC/INFO Grids, projected into WTM NAD83 with adjustment for 91, and then joined for continuous coverage.

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Process\_Date: 1994-1998

Spatial\_Data\_Organization\_Information:

Indirect\_Spatial\_Reference: None

Direct\_Spatial\_Reference\_Method: Raster

Spatial\_Reference\_Information:

Horizontal\_Coordinate\_System\_Definition:

Planar:

Grid\_Coordinate\_System:

Grid\_Coordinate\_System\_Name: Wisconsin Transverse Mercator (WTM)

Other\_Grid\_System's\_Definition:

Name: WTM 83 (Wisconsin Transverse Mercator, NAD83/91)

Projection: Transverse Mercator

Scale\_Factor\_at\_Central\_Meridian 0.9996

Longitude\_of\_Central\_Meridian -90.000

Latitude\_of\_Projection\_Origin 0.0

False\_Easting 520000.0

False\_Northing -4480000.0

Citation

'Wisconsin Coordinate Systems', published by the Wisconsin State Cartographer's Office, 1995, Madison, Wisconsin

Planar\_Coordinate\_Information:

Planar\_Coordinate\_Encoding\_Method: row and column

Coordinate\_Representation:

Abscissa\_Resolution: 30.0

Ordinate\_Resolution: 30.0

Planar\_Distance\_Units: meters

Geodetic\_Model:

Horizontal\_Datum\_Name: NAD83/91



Ellipsoid\_Name: GEODETIC REFERENCE SYSTEM 80 (GRS80)  
Semi-major\_Axis: 6378137  
Denominator\_of\_Flattening\_Ratio: 298.25722210088

Entity\_and\_Attribute\_Information:

Overview\_Description:

Entity\_and\_Attribute\_Overview:

Each pixel within the WISCLAND Land Cover raster dataset has an associated 8-bit value which corresponds to a Land Cover class. The WISCLAND Land Cover classification scheme is a hierarchical scheme which is modeled after Anderson's Classification scheme (USGS, 1976) but adaptable to other existing classification schemes, especially the UNESCO/The Nature Conservancy classification system.

Entity\_and\_Attribute\_Detail\_Citation:

WISCLAND LAND COVER CLASSIFICATION SCHEME -

Numbers in parentheses are the numeric class values assigned to pixels. The 3-level hierarchy is indicated by decimal values and indentation. Gaps in the numeric and hierarchical sequence are due to entries in the 'extended' classification which were not part of the final WISCLAND classification scheme.

(For a complete explanation of the WISCLAND Land Cover classification scheme, refer to the User's Guide cited in the Supplemental Information section.)

- (100) 1. URBAN/DEVELOPED
  - (101) 1.1 High Intensity
  - (104) 1.2 Low Intensity
  - (105) 1.3 Golf Course
  
- (110) 2. AGRICULTURE
  - (111) 2.1.1 Herbaceous/Field Crops
  - (112) 2.1.2 Row Crops
  - (113) 2.1.3 Corn
  - (118) 2.1.8 Other Row Crops
  - (124) 2.1.9 Forage Crops (includes hay and hay/mix)
  - (148) 2.3 Cranberry Bog
  
- (150) 3. GRASSLAND (includes timothy, rye, pasture, idle, CRP, grass and volunteer)
  
- (160) 4. FOREST
  - (161) 4.1 Coniferous
    - (162) 4.1.1 Jack Pine
    - (163) 4.1.2 Red Pine
    - (166) 4.1.5 White Spruce
    - (173) 4.1.11 Mixed/Other Coniferous
  - (175) 4.2 Broad-Leaved Deciduous
    - (176) 4.2.1 Aspen
    - (177) 4.2.2 Oak
    - (179) 4.2.4 Northern Pin Oak

- (180) 4.2.5 Red Oak
- (183) 4.2.8 Maple
- (185) 4.2.10 Sugar Maple
- (187) 4.2.12 Mixed/Other Broad-Leaved Deciduous
- (190) 4.3 Mixed Deciduous/Coniferous

(200) 5. OPEN WATER

(210) 6. WETLAND

- (211) 6.1 Emergent/Wet Meadow
  - (212) 6.1.1 Floating Aquatic Herbaceous Vegetation
- (217) 6.2 Lowland Shrub
  - (218) 6.2.1 Broad-Leaved Deciduous
  - (219) 6.2.2 Broad-Leaved Evergreen
  - (220) 6.2.3 Needle-Leaved
- (222) 6.3 Forested
  - (223) 6.3.1 Broad-Leaved Deciduous
  - (229) 6.3.6 Coniferous
  - (234) 6.3.10 Mixed Deciduous/Coniferous

(240) 7. BARREN

(241) 8. SHRUBLAND

(242) 9. CLOUD COVER

Distribution Information:

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< <http://www.dnr.state.wi.us/org/legal/WebSiteLegalInformation.html>>

**Standard\_Order\_Process:**

**Digital\_Form:**

**Digital\_Transfer\_Information:**

Format\_Name: ARC/INFO Grid format

Format\_Version\_Number: ARC7.1.1

File\_Decompression\_Technique: WINZIP

Transfer\_Size: 80 (approximate megabytes, uncompressed)

**Digital\_Transfer\_Option:**

**Online\_Option:**

**Computer\_Contact\_Information:**

**Network\_Address:**

**Network\_Resource\_Name:**

Data and accompanying documentation can be downloaded by web browser at the following URL:

<<http://www.dnr.state.wi.us/org/at/et/geo/data/wlc.html>>

Or, contact (608) 264-8916 for IP address to obtain data by FTP.

**Offline\_Option:**

Offline\_Media: CD-ROM

Recording\_Capacity:

Recording\_Density: 650

Recording\_Density\_Units: megabytes

Recording\_Format: ISO 9660

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To order data, leave a message at the DNR GIS Data Request Line, at (608) 264-8916. Or, complete a 'DNR Data Request Order Form', available from the distributor or via the internet at:

<[www.dnr.state.wi.us/org/et/at/geo/](http://www.dnr.state.wi.us/org/et/at/geo/)>, and mail to the contact person and address indicated above.

**Metadata\_Reference\_Information:**

Metadata\_Date: 1999421

Metadata\_Contact:

Contact\_Information:

Contact\_Person\_Primary:

Contact\_Person: John Laedlein  
Contact\_Organization:  
Wisconsin Dept. of Natural Resources, Bureau of Enterprise  
Information Technology and Applications, Geographic Services  
Section, ET/8  
Contact\_Address:  
Address\_Type: mailing address  
Address:  
101 South Webster St.,  
P.O. Box 7921,  
City: Madison  
State\_or\_Province: WI  
Postal\_Code: 53707-7921  
Contact\_Voice\_Telephone: (608) 264-8916  
Contact\_Facsimile\_Telephone: (608) 266-0870  
Contact\_Electronic\_Mail\_Address: laedlj@dnr.state.wi.us  
Metadata\_Standard\_Name:  
FGDC Content Standards for Digital Geospatial Metadata  
Metadata\_Standard\_Version: 199704

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