A GIS Non-point Source Pollution Model of the Onondaga Lake Watershed

by

Elizabeth E. Coyle

A thesis
submitted in partial fulfillment
of the requirements for the
Master of Science Degree
State University of New York
College of Environmental Science and Forestry
Syracuse, New York
April 2002

Approved:
Faculty of Environmental and Resource Engineering

Dr. Paul Hopkins, Major Professor

Dr. Elen Deming, Chairperson,
Examining Committee

Dr. James Hassett, Faculty Chair

Dr. Robert H. Frey, Dean,
Instruction and Graduate Studies

Dr. Robert H. Brock, Director,
Division of Environmental and Resource Engineering

THESIS
C695

Abstract

Coyle, Elizabeth, E. A GIS Non-point Source Pollution Model Of the Onondaga Lake Watershed.....Typed and bound thesis, 156 pages, 21 tables, 14 figures, 2002.

Non-point source (NPS) pollution originates from diffuse sources in a watershed and contaminates the surface waters. Watershed characteristics such as land cover types, soil types, terrain features, and stream proximity strongly influence the kinds and amounts of NPS pollutant inputs to the surface waters. A Geographic Information System (GIS) is an appropriate tool for modeling these watershed attributes due to their geographic nature. This GIS model developed for the Onondaga Lake watershed compiles and analyzes some of these watershed attributes and calculates in-stream concentrations of three NPS pollution indicators at various points within the watershed. A comparison of sample data taken from the watershed tributaries is made with the results calculated by the GIS model and it is shown that reasonable estimates of in-stream concentrations of NPS pollutant indicators can be generated. The ability to reasonably calculate NPS pollutant loadings will become very useful. Ultimately, areas that yield high NPS loadings can be identified and appropriate water quality improvement projects can be implemented based on the characteristics of these areas.

Author's name in full: Elizabeth E. Coyle
Candidate for the degree of Master of Science May, 2002
Major Professor: Paul Hopkins

Division of Environmental and Resource Engineering

State University of New York College of Environmental Science and Forestry, Syracuse, New York

Signature of Major Professor Paul F. Hopkins
Dr. Paul Hopkins

Acknowledgments

First and foremost, I'd like to acknowledge Dr. Paul Hopkins, my major professor and friend, for his encouragement but even more for his patience with me throughout my education and the process of developing this thesis. In addition, I'd like to recognize Dr. James Hassett for his guidance on the hydrological analysis and both Dr. Lee Herrington and James Halligan for their assistance in the preparation and analysis of my data. Each of them saved me from many hours of frustration. I would also like to acknowledge the people at the Onondaga County Department of Drainage and Sanitation, as well as those at the New York State Department of Environmental Conservation who shared their data and information with me. In addition, I would like to recognize my boss, Steven Eidt, for his support, encouragement and flexibility, as well as his understanding. Finally, I would like to mention my parents who not only encouraged me when I felt disheartened and overloaded, but also helped ease the domestic responsibilities of parenting so that I could come this far. Without all of these people I could not have accomplished the work that lies herein. Thanks to all.

List of Tables

1 Runoff Potential and Physical Characteristics of Hydrologic Soil Groups..... 19

2. Onondaga Lake Watershed Sub-basin Areas and Sub-basin Designations..... 30

3. OCDDS Sample Data - Calculated Average and FWA In-stream Concentrations..... .. 33

4. Onondaga County Land Cover Type Classifications..... 35

5. Curve Numbers for the Land Cover Classification System used by N. R. Harshadeep..... 37

6. Curve Numbers for the NLCD Land Cover Type Classification System..... 38

7. Grid Cell Values for Land Cover Type – HSG Combinations..... 39

8. Curve Numbers and Associated Grid Cell Values..... 40

9. USEPA Estimated Mean Concentrations..... 45

10. NLCD Estimated Mean Concentrations..... 45

11. User's and Producer's Accuracy of Land Cover Type Classification..... 51

12. OCDDS Sample Data and Model Results, Storm 1..... 58

13. OCDDS Sample Data and Model Results, Storm 2..... 59

14. OCDDS Sample Data and Model Results, Storm 3..... 60

15. Estimated Percent of In-stream Concentration due to NPS Loadings based on Model Results and OCDDS Sample Data..... 61

List of Tables

16. Land Cover Type Classification Accuracy and Model Results, Storm 1 62

17. Land Cover Type Classification Accuracy and Model Results, Storm 2 63

18. Land Cover Type Classification Accuracy and Model Results, Storm 3 64

19. Model Results at the Mouth of Lake Tributaries 65

20. Suspended Solids Concentrations in Surface Discharges to Onondaga Lake 69

21. Characteristics of the Six Natural Sub-basins in the Onondaga Lake Watershed 73

List of Figures

1. The Onondaga Lake Watershed..... 5

2. Onondaga County Land Cover..... 6

3. Spatial Model for Data Preparation..... 13

4. Soil Associations of Onondaga County..... 17

5. Aspect generated from digital elevation model of Onondaga County..... 22

6. Percent slope generated from digital elevation model of Onondaga County..... .. 23

7. Six Natural Sub-basins of Onondaga Lake Watershed and OCDDS Sample Sites..... 28

8. Watershed Attributes Encoded in Grid Cell Values..... 41

9. Decoding the Value of Parameter A from Encoded Grid Cell Values..... 44

10. Decoding the Value of Parameter R from Encoded Grid Cell Values..... 46

11. Decoding the Value of Parameter S from Encoded Grid Cell Values..... 47

12. Decoding the Values of Parameter D from Encoded Grid Cell Values..... 48

13. Calculation of Model Results based on User's Accuracy..... 53

14. Calculation of Model Results based on Producer's Accuracy..... 53

List of Acronyms

AMC –	Antecedent Moisture Condition
AML –	Arc Macro Language
AMP –	Ambient Monitoring Program
DEM –	Digital Elevation Model
DLG –	Digital Line Graph
EMC –	Estimated Mean Concentration
FWA –	Flow Weighted Average
GIS –	Geographic Information System
HSG –	Hydrologic Soil Group
METRO –	Syracuse Metropolitan Wastewater Treatment Plant
MSL –	Mapping Science Laboratory
NAD27 –	North American Datum of 1927
NAD83 –	North American Datum of 1983
NLCD –	National Land Cover Data
NPS –	Non-point Source
NRCS –	National Resource Conservation Service
NYSDEC –	New York State Department of Environmental Conservation
NYSDOT –	New York State Department of Transportation
OCDDS –	Onondaga County Department of Drainage and Sanitation
RMSE –	Root Mean Square Error
SPDES –	State Pollution Discharge Elimination System
SUNY-ESF –	State University of New York – College of Environmental Science and Forestry
TKN –	Total Kjeldahl Nitrogen
TP –	Total Phosphorous
TSS –	Total Suspended Solids
USDA –	United States Department of Agriculture
USEPA –	United States Environmental Protection Agency
USGS –	United States Geological Survey
UTM –	Universal Transverse Mercator

Table of Contents

Abstract ii

Acknowledgements iii

List of Tables iv

List of Figures vi

List of Acronyms vii

Chapter I: Introduction 1

Chapter II: Background 3

Description of Study Area..... 3
Pollution Problems..... 4
Non-point Source Pollution Indicators..... 7
Hydrodynamics of Non-point Source Pollution..... 9
Geographic Information Systems and Non-point Source Pollution..... 10

Chapter III: Methods and Materials 12

Model Inputs..... 12
Soil Associations..... 14
Hydrologic Soil Groups..... 18
Digital Elevation Model..... 21
Land Cover Type..... 24
Hydrography..... 24
Watersheds..... 25
OCDDS 1999 AMP Storm Event Sample Data..... 26
USGS Gaging Station and Estimated Flow Data 30
Precipitation Data..... 34
Data Integration..... 34
Land Cover Type..... 35
Hydrologic Soil Groups..... 35
Curve Numbers..... 36
Slope..... 39
Distance..... 40
Combining Watershed Attributes..... 41
Model Output..... 42
Basic Model Algorithm..... 43

Table of Contents

Algorithm Parameter A: Based upon percent area..... 43
Non-point Source Pollution Indicator EMCs..... 43
Algorithm Parameter R: Based upon curve number..... 46
Algorithm parameter S: Based upon percent slope..... 47
Algorithm Parameter D: Based upon distance from stream... 48
Algorithm Parameter SI: Storm Index..... 49
Influence of Land Cover Type on Model Results..... 49

Chapter IV: Results 54

Chapter V: Discussion 66

Comparison of Model Output to OCDDS Sample Data..... 66
Erroneous Results..... 66
Trend Observations..... 67
Use of Model Results with Sample Data..... 68
Comparison of Model Output to Research by Dr. Steven Effler. 68
Comparison of Model and Historical Information..... 70
Influence of Model Inputs on Model Results..... 71
Land Cover Type..... 71
Soil Associations..... 75
Digital Elevation Model..... 76
Hydrography..... 77
Watersheds..... 78
Model Confidence..... 78
Potential Improvements..... 79
Possible Follow Up Studies..... 81

Chapter VI: Conclusions 83

References 88

Appendix A: AMLs used in the Digitization of the Onondaga County Soil Associations Data Coverage 90

Appendix B: Onondaga County Soil Series, Soil Associations and Respective Hydrologic Soil Groups 93

Appendix C: Metadata for Data Sets 99

Table of Contents

Appendix D: ArcView Script used to Merge Digital Elevation Models 133

Appendix E: Example Sample Data 135

Appendix F: Example USGS and Estimated Flow Data 142

Appendix G: Precipitation Data 151

Vita 156

Chapter I
Introduction

Pollutant inputs have deteriorated the water quality of urban lakes, planet-wide, through the centuries. Some of these inputs are direct discharges to either the lakes or their tributaries and some are diffuse, indirect inputs coming from the surrounding watersheds. Onondaga Lake, located in Syracuse, NY is no exception. The water quality of this urban lake has also deteriorated due to both point source and non-point source (NPS) pollution. The more h that is reported herein, models three indicator parameters of NPS pollution in the Onondaga Lake watershed, ely two nutrients, total kjeldahl nitrogen (TKN) and total phosphorous (TP), and total suspended solids (TSS).

NPS pollution occurs during runoff events due to precipitation in the watershed. This type of pollution is directly related to watershed characteristics such as terrain, soil type and proximity to surface waters. Areas of steep terrain will have higher rates of surface runoff after torms, carrying nutrients and ent in the runoff to surface waters. Soils that erode easily will contribute more ded solids loadings and clayey soils will have higher runoff rates. Areas that are closer in proximity to surface waters will contribute more than areas further away. The most influential watershed factor however, is how and for what, the land is being used. Each land cover type and use, contributes nutrient and sediment loadings to surface waters,

raising the concentrations of pollutants in these surface waters and deteriorating the water quality.

A geographic information system (GIS) is perhaps one of the most appropriate tools for storing information concerning watershed characteristics and for analysis and modeling. "In fact, a GIS is a unique visualization tool that supports an integrated approach to management of land and water resources since it can merge climate, soil, topography, infrastructure, land-use and hydrology data with various management practices" (Hamdy, 2002). Due to the fact that NPS pollution is directly related to the watershed characteristics, information that is geographically related, a GIS is quite appropriate for modeling this type of pollution in a watershed.

The model developed for the Onondaga Lake watershed demonstrates that a GIS can be used to calculate reasonable estimates of in-stream concentrations due to NPS pollutant loadings from the surrounding watershed. The ability to reasonably estimate NPS pollutant loadings will become very useful in decision-making concerning pollution sources and water quality improvements. Areas contributing high NPS loadings can be identified and the appropriate improvement projects can be implemented based on the characteristics of the high concern areas.

Chapter II
Background

Description of Study Area

Onondaga Lake is located at the northwestern corner of the City of Syracuse in Onondaga County, New York. This small lake covers an area of 12 square kilometers and is approximately 7.6 kilometers long by 1.6 kilometers wide. The lake has an average depth of approximately 10.7 meters with two distinct basins, referred to as the North Deep and the South Deep, that are between 18 and 21 meters in depth. The outlet of Onondaga Lake flows into the Seneca River which joins the Oneida River to form the Oswego River, which ultimately discharges into Lake Ontario.

Virtually the entire drainage basin of the lake, consisting of approximately 712 square kilometers, lies within Onondaga County. The most significant inputs to the lake are the two main tributaries, Onondaga Creek and Nine Mile Creek, and the Syracuse Metropolitan Sewage Treatment Plant (METRO) (Effler, 1996). Harbor Brook, Ley Creek, Bloody Brook and Saw Mill Creek are four other tributaries with Tributary 5a and the East Flume contributing minor hydrologic inputs to the lake. The lake watershed can be sub-divided into six natural sub-basins: Nine Mile Creek, Harbor Brook, Onondaga Creek, Ley Creek, Bloody Brook and Saw Mill Creek (OCDDS, 2001). Figure 1 presents these six natural sub-basins, which were used to define the extent of the Onondaga Lake watershed and thus, the study area for this project. The

and cover in the watershed is diverse and consists of significant areas of both urban nd rural cover types. Figure 2 illustrates the land cover of Onondaga County.

Pollution Problems

Like many other urban lakes, Onondaga Lake is extremely polluted. Water quality degradation, contaminated lake sediments and contaminated soils in surrounding areas, are due to over a century of domestic and industrial waste inputs to the lake (Effler, 1993). These inputs consist of past and current, point and NPS pollution. The point sources have well-defined discharge points and many discharge to the tributaries. These types of discharges are commonly referred to as "end-of-pipe" discharges. NPS pollution is more diffuse in nature and is associated with ground water movement and runoff events. Pollutants can infiltrate into the soils and pollute the ground water or be transported via runoff directly into the lake tributaries, thus contaminating surface waters. The most significant portion of NPS pollution is transported to the lake tributaries during and following storm events via surface runoff.

NPS pollution is the primary threat to water quality in New York State and statewide assessments have shown that this type of pollution causes the majority of the current water quality problems in the state (NYSDEC, 1995). Point sources are now less important because they have been identified and are being addressed through the

Figure 1: The Onondaga Lake Watershed. This illustration shows the hydrography of Onondaga County generated from NYS DOT data. The six natural tributaries to Onondaga Lake are highlighted in blue. In addition, the lake watershed's six natural sub-basins, digitized by the City of Syracuse, are shown. (NYSDOT, 1999) (Monostory, 2001).

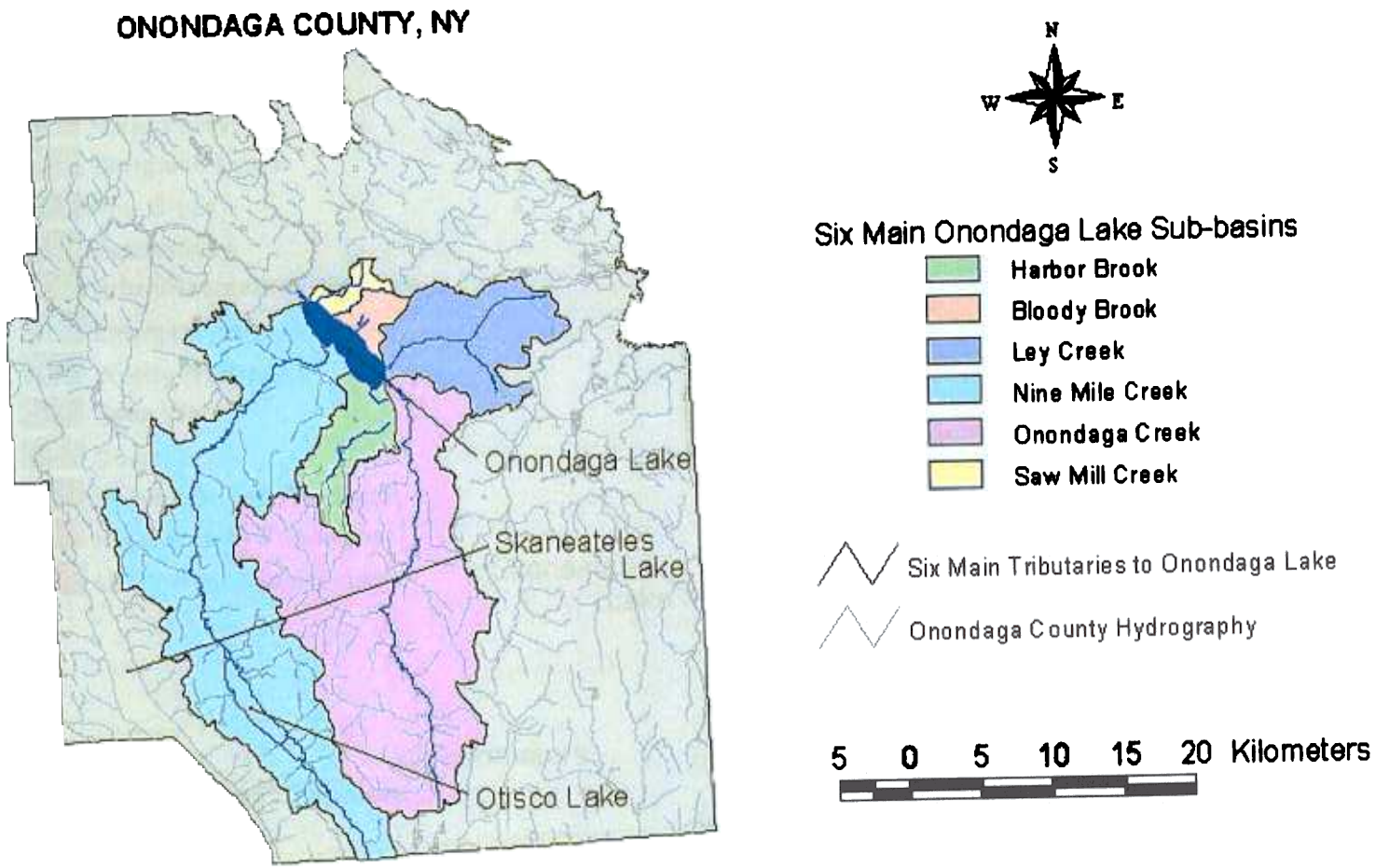
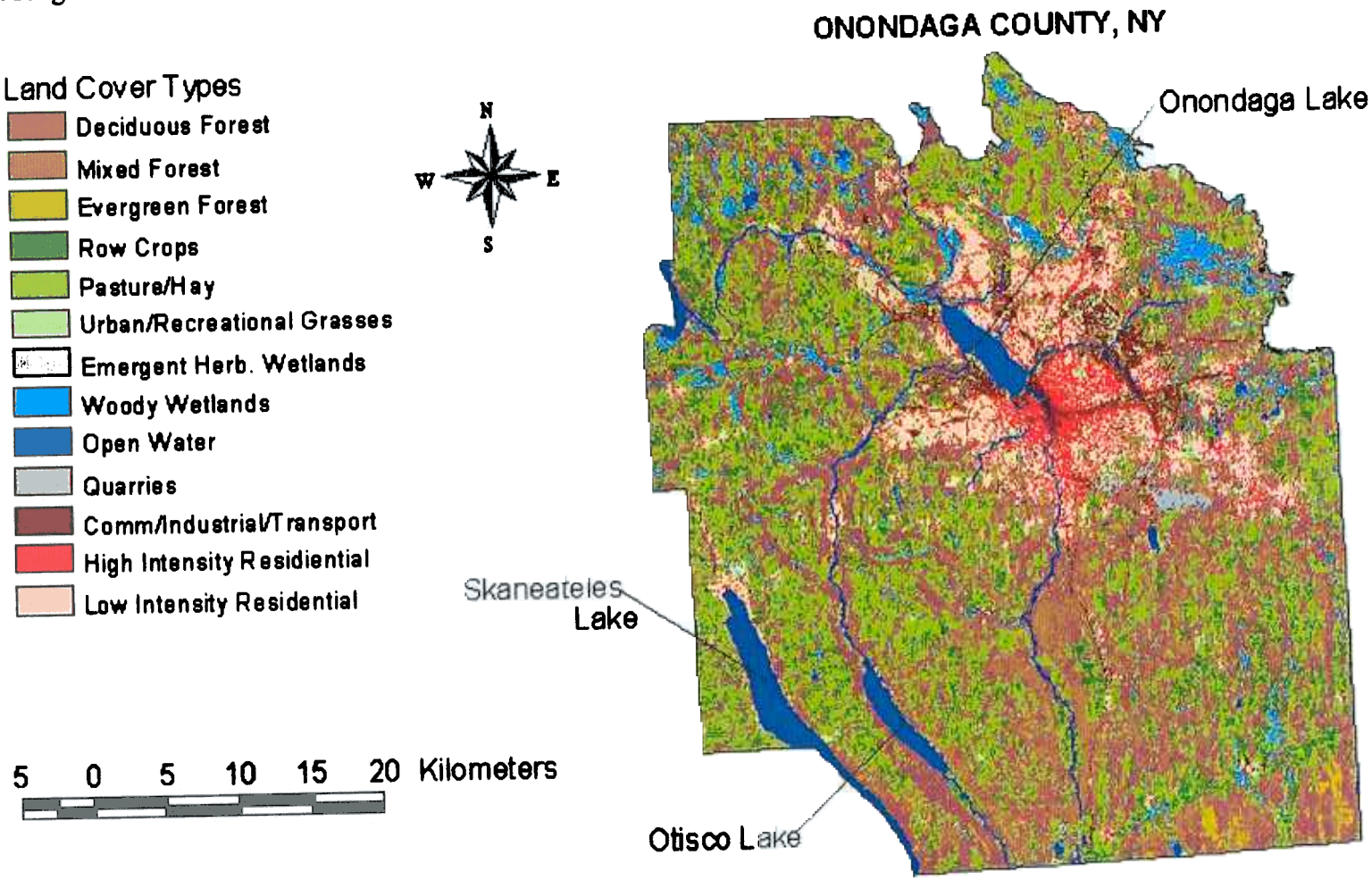


Figure 2: Onondaga County Land Cover. This illustration shows the 25 m x 25 m grid of the Onondaga County land cover data set generated from the National Land Cover Data (USGS, 1997).



State Pollution Discharge Elimination System (SPDES) program. These point sources include contributions from combined sewer overflows, commercial plants, industrial facilities, hazardous waste sites and municipal wastewater treatment plants. However, to ultimately improve the water quality of New York's waters, including Onondaga Lake, it is now becoming extremely important that NPS pollution be addressed.

The New York State Department of Environmental Conservation (NYSDEC) has identified over 40 different sources of NPS pollution, most of which are directly related to land use and land cover type (NYSDEC, 1995). Some of these sources include agricultural, silvicultural or construction activities, diffuse urban runoff, resource extraction and exploration, development of underground plumes originating from land disposal, hydrologic and habitat modification and other sources such as atmospheric deposition. Regardless of the land cover type and/or use, all areas contribute, whether significantly or not, to NPS pollution.

Non-point Source Pollution Indicators

Typically, water quality degradation due to NPS pollution is caused by high concentrations of nutrients and sediment in the water. For the purposes of this project, the water quality parameters explored have been limited to three strong indicators of NPS pollution. Two of these parameters are chemical nutrients, TKN and TP, and the third is a physical parameter, TSS.

Nitrogen exists in the environment in many forms and changes forms as it moves through the nitrogen cycle. The parameter TKN represents the combination of organic nitrogen, which is highly bio-available to plants, and ammonia, which is toxic in high concentrations. Nitrogen is very water-soluble and is transported through groundwater and in surface runoff to the surface waters. The parameter TP represents the total phosphorous in the system. Phosphorous is much less water-soluble than nitrogen and is primarily transported to surface waters via surface runoff. This is due to the tendency of phosphorous to adhere to particulate matter that is physically carried away by surface runoff. TSS represents this particulate matter, providing surfaces for the cycling of many nutrients. In addition to carrying nutrients to surface waters, TSS also impacts the clarity of receiving waters, which in turn impacts aquatic plant life and optical aesthetics.

High levels of nitrogen, phosphorous and suspended solids in surface waters cause a phenomenon referred to as eutrophication. In the process of eutrophication, the nutrients promote the growth of algae and plant life. When the plants die they decompose causing higher levels of oxygen demand. When the dissolved oxygen in the water becomes too low, fish and other aquatic animals die. Death of aquatic life adds to the material that is decomposing and thus, advances the eutrophication process, further depleting the dissolved oxygen. In addition, high concentrations of nutrients in surface drinking water sources can cause human health problems and

reach toxic levels. Suspended solids are also an important component of water quality because they transport adsorbed toxic substances, limit light availability for photosynthesis, and are deposited at the mouth of the tributaries in the lake causing areas of higher contamination in the lake bottom sediments.

Hydrodynamics of Non-point Source Pollution

NPS pollution is transported to surface water from the contributing watershed through the movement of ground water and runoff. The transport of NPS pollution via ground water movement takes much longer to reach receiving waters than does transport by way of runoff. In addition, the amount of NPS pollution contributed by groundwater is typically relatively small compared to the contribution due to runoff. Therefore, the majority of NPS pollution is transported to surface waters during and following precipitations events, such as rainstorms, and during spring thaws when the most runoff occurs. The more intense the precipitation event, the more runoff and the more NPS pollution transported to the surface waters.

The quantity and rate of runoff from the surrounding watershed to the receiving waters is also dependent upon watershed characteristics such as land cover type, soil type, stream proximity and slope. Virtually all of the precipitation from storm events and water from thawing ice and snow will runoff steep terrain, especially if the soils have low infiltration rates. Land cover type also affects the rate of infiltration and

runoff, or the lack thereof. Finally, the closer in proximity to the surface water the more likely runoff is to contribute NPS pollution in the receiving surface water.

Geographic Information Systems and Non-point Source Pollution

According to the AGI GIS Dictionary, GIS is a " computer system for capturing, storing, checking, integrating, manipulating, analyzing and displaying data related to positions on the Earth's surface" (AGI, 1996). A GIS differs from other forms of nformation systems because it deals with spatial information and not just information contained in databases and spreadsheets. Different databases for the same geographic area can be combined, analyzed and the results of the analyses can be mapped and illustrated graphically.

The strongest factors influencing the movement of groundwater and runoff are watershed characteristics such as land cover type, soil type, stream proximity and slope. These characteristics are geographic in nature and have associated information Information concerning hydrologic characteristics of soils can be associated with soil types. Information regarding runoff potential of an area can be associated with the land cover type and so on. Thus, a GIS lends itself to the analysis of those watershed characteristics that influence NPS pollutant loadings. Typically, GIS data are stored in more than one data set, in order to overcome the technical problems caused by large memory and storage requirements. In addition, it is easier to work with complex spatial problems one layer at a time. The data can be revised

and maintained by updating one data set when needed rather then to update the entire information system. The ability to work with layers is a fundamental aspect of GIS and is commonly referred to as data integration.

Geographic data may be represented in GIS in one (or both) of two formats: vector or raster. Data in vector format uses points, lines and polygons to represent geographic features. Raster data sets are composed of grid cells known as pixels. Each data format has particular strengths and weaknesses, and the type of format used is determined by the nature of the work being undertaken and the data available. Regardless of the format, GIS data contain information concerning location of features and attributes associated with the features. These attributes are associated characteristics or properties that are usually kept in tables, containing information such as land cover type, soil association, slope and aspect. Thus, a GIS allows for spatial queries, as well as, traditional data base analyses.

Chapter III
Methods and Materials

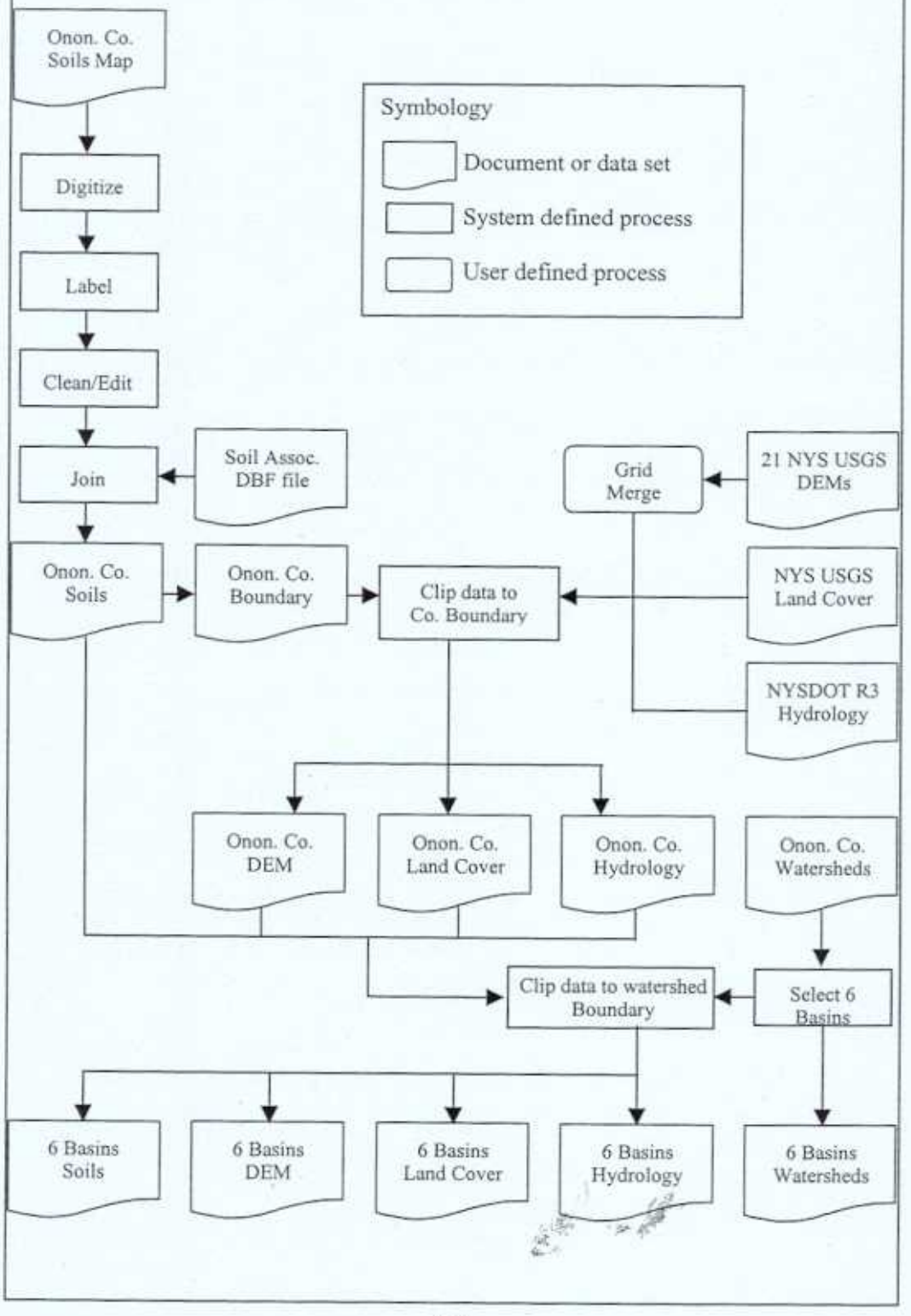
Model Inputs

The largest portion of the work to create this model involved the acquisition and preparation of data. To assess diffuse NPS pollution a GIS consisting of ESRI ArcInfo, ArcEdit, ArcGrid and ArcView software, as well as various vector and raster data sets were used to develop a NPS pollution model. Figure 3 is a graphical representation detailing the steps taken to prepare the GIS data for this model. The **necessary GIS data for this study included:**

- Layer 1: Land Cover Type (raster – grid data)
- Layer 2: Soil Associations (vector – polygon)
- Layer 3: Digital Elevation Model (raster – grid)
- Layer 4: Hydrography (vector – line)
- Layer 5: Watersheds (vector – polygon)
- Layer 6: Water Monitoring Sites (vector – point)

Generally a coordinate system is used to reference the location of spatial information and multiple data sets must all have a common coordinate system. The most common coordinate systems used are latitude and longitude, or grid coordinate systems such as the Universal Transverse Mercator (UTM) system. For this study, the UTM coordinate system was chosen and the reference datum was the North American Datum of 1927 (NAD27). To assist in the ease of analysis all vector data sets were converted to a common UTM/NAD27 grid format. This allowed for the processing

Figure 3: GIS data preparation process.



and integration of all data sets simultaneously. The data sets that needed conversion to grid format were the soil associations, hydrography, watersheds and water monitoring sites. The land cover data set provided by the State University of New York - College of Environmental Science and Forestry (SUNY-ESF) Mapping Science Laboratory (MSL) was in UTM/NAD27 grid format, and the slope calculations generated from the digital elevation model corresponded to the land cover grid.

In addition to the GIS data, sample data, flow data and precipitation data were needed for calculation and comparison purposes. The following discussion provides the specific details concerning the acquisition and preparation for all required data.

Soil Associations

The first data acquired for this project was the soil association map for the Onondaga Lake watershed. "Such a map is a useful general guide in managing a watershed…" (USDA, 1977) and is appropriate for use with a GIS and watershed analysis. The source map, the General Soil Map of Onondaga County, was provided in the Onondaga County soil survey produced by United States Department of Agriculture (USDA) and Soil Conservation Service (USDA, 1977). A soil association data set previously digitized for the Onondaga Creek watershed was available at the SUNY-ESF MSL. However, the rest of the Onondaga Lake watershed had not been completed. The original map used to digitize the Onondaga Creek watershed was not

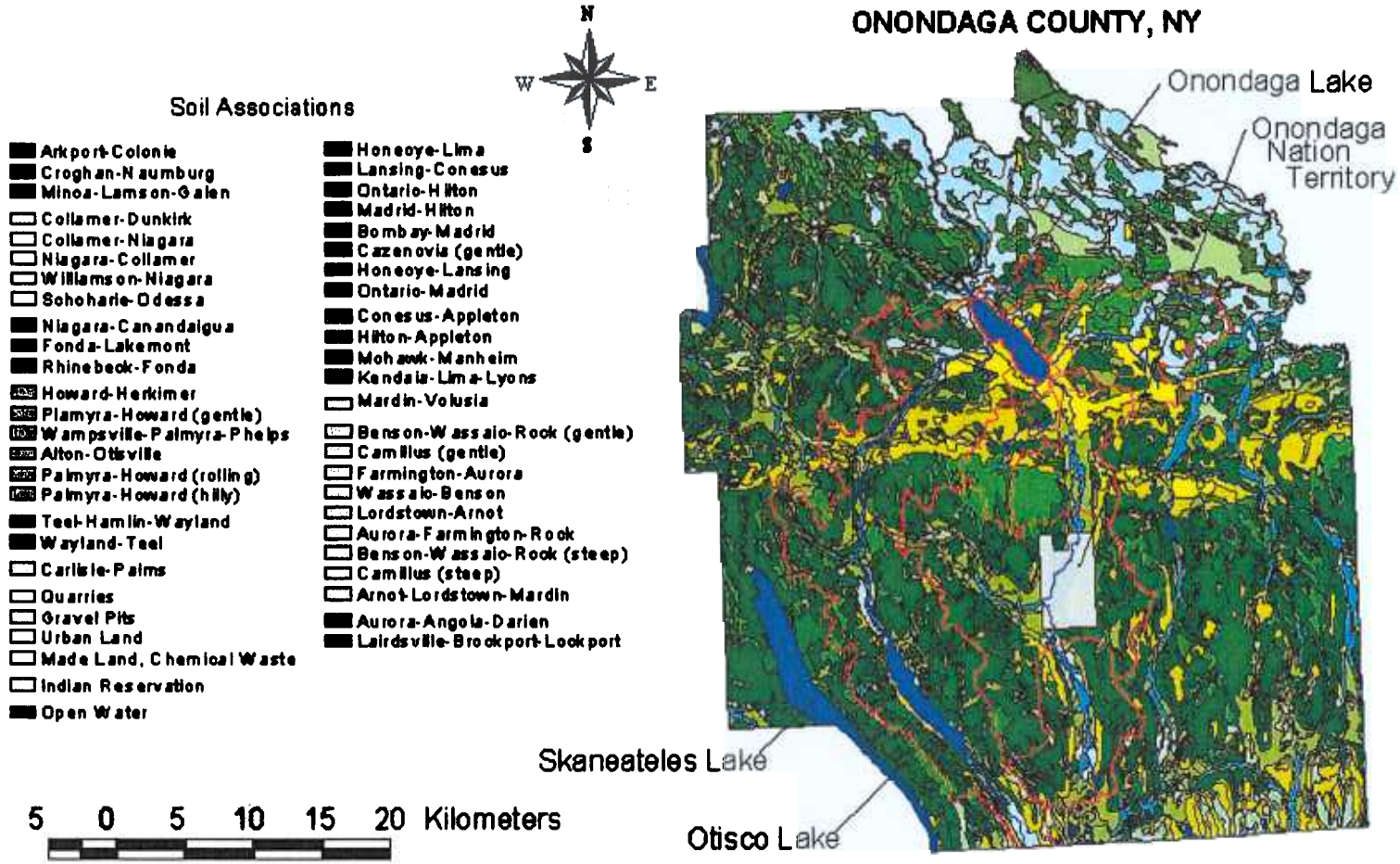
available, so a duplicate map was obtained and used to digitize the remainder of the county. The Onondaga Nation occupies a significant portion of the watershed. Unfortunately, there is no soil data available for the area occupied by the Onondaga Nation. Therefore, the boundaries of the Onondaga Nation territory were digitized, but no soil association was directly assigned to the territory. Although this project needed only data within the Onondaga Lake watershed boundaries, it was felt worthwhile to digitize the County in its entirety, making it available for use with the other County GIS data sets and additional research.

Three Arc Macro Language (AML) programs were written to expedite the process of digitizing the soil data. Two of these programs ensured that the parameters used in the startup of ArcInfo and ArcEdit were consistent each time and aided in the reduction of time spent on the process. The third AML program was used to automate some of the required editing in ArcEdit. Appendix A contains the three AML programs used in ArcInfo and ArcEdit.

Attempts to reduce error as much as possible were made. However, throughout the digitizing process the dimensions of the original map varied slightly. These variations were due to temperature changes, as well as changes in humidity and thus the water content in the paper. In addition, the new lines digitized were adjusted slightly to match the previously digitized data at the border between the older, existing data coverage and the new data coverage created.

Once the remaining areas of the county were digitized, labeled with the corresponding soil association numbers, checked for errors and edited, this coverage was joined with the existing coverage of the Onondaga Creek watershed to create a soil association data coverage for the entire county. The file was then plotted and compared to the original map on a light table to check the quality of digitization and the correctness of the soil association labels. When overlaid onto the original map, no light could be seen between the original map boundaries and the digitized map boundaries. It can thus be concluded that the boundaries were only off the equivalent of a line width (1/60 in) on the ground, which is approximately 26.5 m. This was considered a minor error because the magnitude of error was just above one pixel of the 25 m x 25 m grid data. The error was also considered acceptable since the delineation of soils is not an exact science. Each soil tends to merge gradually with another. Therefore the soil boundaries can lie anywhere within the gradual change between soils. Finally, the boundary adjustments were random and any errors introduced would tend to balance out over the entire watershed canceling the overall effects of the individual errors. The county boundary of the Onondaga County Soil Association data set was used as the boundary for all remaining data sets to be processed. Figure 4 illustrates the digitized soil association map of Onondaga County and Appendix C contains the metadata for the soil association data set.

Figure 4: Soil Associations of Onondaga County. This illustration shows the data set that was digitized at the State University of New York – College of Environmental Science and Forestry (SUNY-ESF) Mapping Science Laboratory (MSL), from the 36" x 46", 1:62,500 scale, generalized soil map included in the Onondaga County Soil Survey (USDA, 1977).



Hydrologic Soil Groups

Each soil association consists of a combination of more specific soils with similar physical characteristics. Similarly, hydrologic soils groups (HSGs) are assigned to soils based on various soil properties related to water absorption and runoff. According to the National Soil Survey Handbook a "Hydrologic group is a group of soils having similar runoff potential under similar storm and cover conditions. Soil properties that influence runoff potential are those that influence the minimum rate of infiltration for a bare soil after prolonged wetting and when not frozen. These properties are (1) depth to seasonally high water table, (2) intake rate and permeability after prolonged wetting, and (3) depth to a very slow permeable layer. The influence of ground cover is treated independently" (USDA, 2001). Since the associations consisted of soils with common physical properties, assignment of HSGs was reasonable way to categorize the physical properties of the soils that influence runoff, and thus the transport of the NPS pollutants.

The New York State division of the National Resource Conservation Service (NRCS) provided a list of the individual soil series and their respective HSGs for the entire state of New York (NRCS, 2000). This list was then reduced to those soil series contained within Onondaga County. Since the soil associations are generalized and contain from one to three of the individual soil types, a determination of the assignment of HSGs to these associations was necessary. Table 1 lists and describes the four HSGs.

Soil Group	Description
A	Lowest Runoff Potential. Inlcudes deep sands with very little silt and clay, also deep, rapidly permeable loess.
B	Moderately Low Runoff Potential. Mostly sandy soils less deep than A, and loess less deep or less aggregated than A, but the group as a whole has above-average infiltration after thorough wetting.
C	Moderately High Runoff Potential. Comprises shallow soils and soils containing considerable clay and colloids, though less than those of group D. The group has below-average infiltration after presaturation.
D	Highest Runoff Potential. Includes mostly clays of high swelling percent, but the group also includes some shallow soils with nearly impermeable subhorizons near the surface.

Group A soils have a low runoff potential because they typically have high

more moderate infiltration and drainage rate and are moderately deep. The texture of these soils varies from fine to moderately coarse grains. Group C soils typically have a slow infiltration rate and may be composed of fine-grained material or have a confining layer that impedes downward flow of the water. Finally, Group D soils have the highest runoff potential. These soils typically consist of clayey materials and have

potential and/or permanently high water tables.

There are also

drained condition (if possible or feasible) and the second to the undrained condition

(USDA, 2001). Only soils that are rated D in their natural condition are assigned to dual groups. Since this model was developed using sample data that was secured during storm events, it was assumed that all soils have been thoroughly wetted by the time sampling had begun and thus the groups with dual assignments were classified as Group D soils. In addition, the Onondaga Indian reservation on the soil map was assumed to be soil Group B because the soil types bordering the reservation are predominantly Group B.

The percentage of each individual soil type in the soil association is included in the Onondaga County Soil Survey and a weighted estimate was calculated using Microsoft Excel to determine the respective HSG for each association. The numbers 1-4 were assigned to soil types with corresponding to HSGs A-D, respectively. The number for each soil type was then multiplied by the percentage of that soil type in the soil association. The weighted soil numbers were then summed and divided by the overall percentage of the soil types included in the soil association (sometimes less than 100% if a minor soil is not included in the association) and then rounded to the nearest integer. These integers ranged from 1-4 and were assigned a HSG A-D, respectively. Appendix B contains the data provided by NRCS, the calculations done to determine HSGs for the soil associations and the resulting HSG assigned to each association. The data was exported in database file format from Excel, imported into ArcView and then joined to the attribute table of the soil association data set.

Precipitation Data

Precipitation input to the model was the 1999 precipitation data from Syracuse's Hancock Field, for each of the storms sampled (NOAA, 1999). Although 1999 was a relatively dry year, it was possible to secure all the necessary storm event sample data, flow records and precipitation data needed to develop and assess the model. **Appendix G contains the detailed precipitation data.**

Data Integration

One technique used to combine raster data sets is to use digit placeholders to encode attribute information from a number of data sets and generate a final coverage that contains all the combined information. For example 13 land cover types could be coded using the 1s and 10s placeholders such that the user knows what the 13 land cover types are. Thus, the cell values in the data set could be 01, 02, 03, … ,11, 12, 13 for encoding purposes. Another data set may use only the 100s placeholder. Both data sets could then be added together to form one data set that contains the information from both coverages. This technique was used to encode all the attributes taken into consideration for this project as described in the paragraphs that follow. The ArcView and ArcGrid software limited the number and size of the available digits to 999,999. In other words, the encoding of attribute information had to be kept in numerical values under 1,000,000 and only place holders up to the **100,000s place could be used.**

Land cover type

The land cover type data set already contained a two-digit numerical value for each type. Therefore, the 1s and 10s placeholders were used to encode land cover. Figure 2 shows the 13 land cover types encoded with the default values used in the NLCD land cover classification system shown in Table 4.

Table 4: Onondaga County Land Cover Type Classifications. These land cover type classifications were generated from the NLCD land cover classification system (USGS, 1997).

Value	Land Cover Type
11	Open Water
21	Low Intensity Residential
22	High Intensity Residential
23	Comm/Industrial/Transport
32	Quarries
41	Deciduous Forest
42	Evergreen Forest
43	Mixed Forest
81	Pasture/Hay
82	Row Crops
85	Urban/Recreational Grasses
91	Woody Wetlands

Hydrologic Soil Groups

The 100s digit was designated to the four hydrologic soil groups. The hydrologic soil groups were defined in the raster data set of soil associations as 1 – 4 representing hydrologic soil groups A – D respectively. This data set was reclassified such that cell values of 100, 200, 300 and 400 corresponded to A, B, C and D respectively.

Curve Numbers

The curve number is an index developed by the Soil Conservation Service (SCS) to numerically represent the potential for storm water runoff within a drainage area. The curve number is estimated for an area based on the combination of land use or cover type, HSG and soil antecedent moisture condition (AMC) (Warren, 1977). All three factors affect the amount of runoff from a particular area and thus affect the curve number assigned to the area. The land cover types and HSGs are contained in the data sets for the lake watershed but a determination of the AMC had to be done.

There are three AMCs for soil: Condition I is the dry soil condition, Condition II represents the average soil condition, and Condition III represents a saturated soil condition due to heavy rainfall (Halley et al., 2001). 1999 was a dry year, but there was rainfall prior to the sampling events and thus, the soils were neither dry nor saturated. Therefore, the assumption of AMC Condition II was considered appropriate. Table 5 indicates the curve numbers used by Nagaraja Rao Harshadeep in his thesis, "Geographic Information Systems as a Tool for Hydrologic Modeling: Application to the Onondaga Creek Watershed" (Harshadeep, 1990). The curve numbers used by Harshadeep were based on a variety of sources and AMC Condition II was assumed. In addition, the curve numbers used by Harshadeep were generated specifically for the local area. Unfortunately, the land cover classifications differed between Harshadeep's project and the NLCD classifications used in this model. As a result, the curve numbers used by Harshadeep were adapted to correspond with the

Table 6: Curve Numbers for the NLCD Land Cover Type Classification System. This table summarizes the Harshadeep land cover type classifications and corresponding NLCD classifications with the associated curve numbers.

NLCD Land Cover Type	Hershadeep Land Cover Type	Hydrologic Soil Group			
		A	B	C	D
Open Water	Water	99	99	99	99
Low Intensity Residential	Low Intensity Residential	51	68	79	84
High Intensity Residential	High Intensity Residential	77	85	90	92
Comm/Industrial/Transport	Highly Developed	89	92	94	95
Quarries	Barren	77	86	91	94
Deciduous Forest	Forest	25	55	70	77
Evergreen Forest	Forest	25	55	70	77
Mixed Forest	Forest	25	55	70	77
[illegible]	[illegible]	67	78	85	89
[illegible]	Agriculture	67	78	85	89
Urban/Recreational Grasses	Lawn/Trees	39	61	74	80
Woody Wetlands	Transition Vegetation	68	79	86	89
Emergent Herb. Wetlands	Transition Vegetation	68	79	86	89

There were a total of 52 possible land cover type – hydrologic soil group combinations based on the land cover type and soil data sets for the lake watershed. Therefore, only two digit placeholders were needed to preserve the attributes for both hydrologic soil group and land cover type. This was done by first adding the cell values from the grids for land cover type (see Table 7) and hydrologic soils group (100, 200, 300 and 400) together. The result was a grid file in which 52 combinations were generated. Each of these 52 unique combinations was then reclassified from 1 – 52 such that only two digit placeholders were used. Table 7 shows the original grid cell values resulting from the addition of the land cover type data and the HSG data, as well as, the reclassification into categories 1 – 52. Table 8 shows the associated curve numbers based on the land cover type - hydrologic soil group combination.

Slope

The percent slope originally ranged from 0% to 197% but was reclassified into 65 ranges, based on 3% increments to reduce the amount of data storage and processing requirements. With the 1s and 10s placeholders dedicated to soil and land cover type (1-52), the 100s and 1,000s placeholders were dedicated to the 65 ranges for percent slope. These ranges were reclassified from - 65 such that the lowest range 0-3% had a value of 100, the range 3 – 6% had a value of 200 and so on to the highest slope range in the data set of 195-197%, which had a value of 6500. Thus, the slope coverage had grid cell values ranging from 100 – 6500.

Table 7: Grid Cell Values for Land Cover Type – HSG Combinations. The original grid cell values (old) used three digits to retain combination information. However, only two digits were needed for the 52 combinations. Therefore, the original cell values were converted into (new) categories, 1 – 52.

	Hydrologic Soil Group							
Land Cover Type	A		B		C		D	
	old	new	old	new	old	new	old	new
Open Water	111	1	211	14	311	27	411	40
Low Intensity Residential	121	2	221	15	321	28	421	41
High intensity Residential	122	3	222	16	322	29	422	42
Comm/Industrial/Transportation	123	4	223	17	323	30	423	43
Quarries	132	5	232	18	332	31	432	44
Deciduous Forest	141	6	241	19	341	32	441	45
Evergreen Forest	142	7	242	20	342	33	442	46
Mixed Forest	143	8	243	21	343	34	443	47
Pasture/Hay	181	9	281	22	381	35	481	48
Row Crops	182	10	282	23	382	36	482	49
Urban/Recreational Grass	185	11	285	24	385	37	485	50
Woody Wetlands	191	12	291	25	391	38	491	51
Emergent Herb. Wetlands	192	13	292	26	392	39	492	52

Table 8: Curve Numbers and Associated Grid Cell Values. Curve numbers (CN) associated with the 52 combinations (combo) of land cover type and hydrologic soil group (HSG).

	HSG - A		HSG - B		HSG - C		HSG - D	
Land Cover Type	CN	combo	CN	combo	CN	combo	CN	combo
Open Water	99	1	99	14	99	27	99	40
Low Intensity Residential	51	2	68	15	79	28	84	41
High Intensity Residential	77	3	85	16	90	29	92	42
Comm/Industrial/Transportation	89	4	92	17	94	30	95	43
Quarries	77	5	86	18	91	31	94	44
Deciduous Forest	25	6	55	19	70	32	77	45
Evergreen Forest	25	7	55	20	70	33	77	46
Mixed Forest	25	8	55	21	70	34	77	47
Pasture/Hay	67	9	78	22	85	35	89	48
Row Crops	67	10	78	23	85	36	89	49
Urban/Recreational Grass	39	11	61	24	74	37	80	50
Woody Wetlands	68	12	79	25	86	38	89	51
Emergent Herb. Wetlands	68	13	79	26	86	39	89	52

Distance

The final set of data needed was information concerning distance to the tributaries. Using the ArcView Spatial Analyst Extension, and the hydrography and sub-basin raster data sets, a distance grid was generated for each sub-basin. The distance grid contained a value for each cell within each natural sub-basin indicating the distance that cell was from the stream. The watershed with the furthest sub-basin boundary was the division of Onondaga Creek designated OC4 (see Figure 7). The most remote point in this division was 12 km from the creek. With the knowledge that the greatest watershed distance ranged from 0 to 12 km, and using a .2 km increment to classify ranges of distance, the distance data set was reclassified into 60 categories. Using the 10,000s and 100,000s placeholders the distance from 1m - .2 km was coded

as 10,000. The next range of distance from .2 km - .4 km was coded 20,000 and so on up to 600,000 which was 11.8 km – 12 km from the stream.

Combining Watershed Attributes

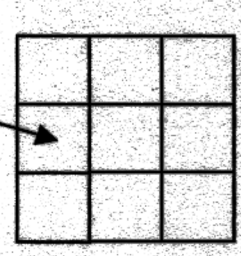
All data sets were added together for each sub-basin. The coverage containing the 52 combinations of land cover type – hydrologic soil groups was first added to the coverage containing the encoded slope information. This result was then added to the coverage containing the encoded distance information. Figure 8 shows an example of one possible final combination and the decoding of the cell value. The ArcView

Figure 8: Watershed Attributes Encoded in Grid Cell Values. This figure shows an example of a final grid cell value based on the combination of watershed attributes. Decoding the information is also illustrated.

Encoded Information:

combination of land cover type & hydrologic soil group:	1 – 52
slope:	100 – 6,500
distance:	10,000 – 600,000

Grid Cell Value = 242,246



Decoded Information:

240,000 = distance from stream:	4.6 km – 4.8 km
2,200 = percent slope:	64 – 67%
46 = land cover type:	evergreen forest
hydrologic soil group:	D
curve number:	77

NLCD land cover classification scheme used in this project. Table 6 contains the curve numbers associated with the NLCD classifications, based upon Harshadeep's curve numbers.

"Water", "low intensity residential" and "high intensity residential" land cover categories were the only common categories between the two classification schemes. Where common categories existed Harshadeep's curve numbers were used for the NLCD curve numbers. "Medium intensity residential" did not have a similar classification under the NLCD scheme and was not used. Finally, the remaining NLCD classifications were associated with the most similar Harshadeep classifications. For example, curve numbers corresponding to "forest" under Harshadeep's classification scheme were used for all forest types in the NLCD classification scheme.

Table 5: Curve Numbers for the Land Cover Classification System used by N. R. Harshadeep. These curve numbers, based on HSGs and land cover types, were used in N. R. Harshadeep's thesis, "Geographic Information Systems as a Tool for Hydrologic Modeling: Application to the Onondaga Creek Watershed" (Harshadeep, 1990).

	Hydrologic Soil Group			
Land Cover Type	**A**	**B**	**C**	**D**
Highly Developed	89	92	94	95
High Intensity Residential	77	85	90	92
Medium Intensity Residential	57	72	81	86
Low Intensity Residential	51	68	79	84
Water	99	99	99	99
Agriculture	67	78	85	89
Lawn/Trees	39	61	74	80
Transition Vegetation	68	79	86	89
Forest	25	55	70	77
Barren	77	86	91	94

software did not have the capability to do the final arithmetic operation in which the last data set was added to all the previously added data sets. Therefore, ArcGrid was used. There were a total of 15,123 unique combinations of land cover, soil type, slope and distance generated in the final data set.

Model Output

The algorithm used for this model was empirical, with the individual terms of the algorithm being based upon observed characteristics of the watershed. Each of the six natural sub-basins was isolated. Every unique combination in the sub-basin was generated with the corresponding number of grid cells containing that unique combination. This information was then imported to Microsoft Excel to perform the calculations. Many of the tables used to determine the unique combinations of watershed parameters in the GIS originated from Excel files and it was therefore, quite easy to perform calculations using table look up commands. The results from these calculations were in-stream concentrations of TKN, TP and TSS due to NPS pollutant loadings from the surrounding watershed. These in-stream concentrations were calculated for locations corresponding to the sample site locations and at the mouths of the six natural tributaries.

Basic Model Algorithm

The Model Algorithm was designed with the assistance of Dr. James Hassett of SUNY – ESF and is as follows:

$$\text{NPS Indicator Concentration} = A * \text{Indicator EMC} * R * S * D * SI.$$

The NPS indicator concentration, the model output, is the in-stream concentration of either TKN, TP or TSS due to the NPS loadings from the surrounding watershed during a storm event. This model is empirical, with each of the algorithm parameters being based on the numerical value of the observed properties of the watershed. The Algorithm input parameters are described below.

Algorithm Parameter A: Based upon percent area

The percent area of the sub-basin or sub-basin division was determined for each unique combination of land cover, soil type, slope and distance. The possible range of values for the percent area was from 0 to 100. The percent area was converted to decimal format, parameter A, for calculation purposes. Figure 9 illustrates the determination of parameter A.

Non-point Source Pollution Indicator EMCs

Pollutant concentrations in runoff are directly related to land cover type. The Terrene Institute in cooperation with the USEPA developed national average concentrations

(mg/l), based upon land cover type, of various pollutants in surface runoff (Terrene Institute, 1996). These national average concentrations are referred to as Estimated

Figure 9: Decoding the Value of Parameter A from Encoded Grid Cell Values. This is an example illustrating the determination of parameter A by decoding information from encoded grid cell values.

The encoded grid cell value of 242,246, representing one unique combination of watershed characteristics, is assigned to 200 grid cells in a sub-basin. There are a total of 1000 grid cells in the sub-basin.

Decoded Information:

240,000 = distance from stream:	4.6 km – 4.8 km
2,200 = percent slope:	64 – 67%
46 = land cover type:	evergreen forest
hydrologic soil group:	D
curve number:	77

Therefore, 20% (A = 0.2) of the sub basin is covered by evergreen forest
& soil of hydrologic soil group D
& has a slope of 64 – 67%
& is 4.6 – 4.8 km from the stream

Mean Concentrations (EMCs). EMCs provide base line concentrations and are estimated for the one-year return frequency storm event. In other words, the EMCs are the estimated average concentrations that would runoff the land cover types due to a storm that occurs, on the average, once a year. A storm event that is more rare, higher in intensity or of longer duration, would cause higher runoff concentrations. A

storm that was less severe but occurred more frequently would cause lower runoff concentrations. The EMCs developed by the USEPA were adapted to correspond with the NLCD land cover classification scheme used in this project. Table 9 shows

Table 9: USEPA Estimated Mean Concentrations. This table summarizes the United States Environmental Protection Agency land cover classification scheme and Estimated Mean Concentrations (USEPA EMCs) of total phosphorous (TP), total kjeldahl nitrogen (TKN) and total suspended solids (TSS) associated with those classifications (Terrene Institute, 1996).

	USEPA EMCs (mg/l)		
Land Cover Type	**TP**	**TKN**	**TSS**
Forest/Rural Open	0.11	0.94	51
Urban	0.11	0.94	51
Agriculture/Pasture	0.37	1.92	145
Low Density Residential	0.52	3.32	70
Medium Density Residential	0.52	3.32	70
High Density Residential	0.24	1.17	97
Commercial	0.33	1.74	77
Industrial	0.32	2.08	149
Highways	0.43	1.82	141
	0.08	0.79	6

Table 10: NLCD Estimated Mean Concentrations. USEPA land cover type classifications and corresponding NLCD classifications and associated estimated mean concentrations (NLCD EMCs).

USEPA Classification	NLCD Classification	NLCD EMCs (mg/l)		
Land Cover Type	Land Cover Type	TP	TKN	TSS
Water/Wetlands	Open Water	0.08	0.79	6
Low Density Residential	Low Intensity Residential	0.52	3.32	70
High Density Residential	High Intensity Residential	0.24	1.17	97
Ave. Commercial & Industrial	Comm/Industrial/Transport	0.325	1.91	113
Highway	Quarries	0.43	1.82	141
Forest/Rural Open	Deciduous Forest	0.11	0.94	51
Forest/Rural Open	Evergreen Forest	0.11	0.94	51
Forest/Rural Open	Mixed Forest	0.11	0.94	51
Agriculture/Pasture	Pasture/Hay	0.37	1.92	145
Agriculture/Pasture	Row Crops	0.37	1.92	145
Urban	Urban/Recreational Grasses	0.11	0.94	51
Water/Wetlands	Woody Wetlands	0.08	0.79	6
Water/Wetlands	Emergent Herb. Wetlands	0.08	0.79	6

the EMCs for TKN, TP and TSS, based upon the USEPA classification scheme. Table 10 shows EMCs associated with the NLCD land cover classifications based upon the USEPA land cover classifications.

Algorithm Parameter R: Based upon curve number

The curve number, which estimates the percent runoff in an area, can be determined based on the type of land cover and the hydrologic soil group as discussed earlier. Thus, the curve number is determined after decoding the integrated data and converted to a decimal value (representative of percent runoff) for use in the calculations. Figure 10 illustrates how the value for the parameter R is determined.

Figure 10: Decoding the Value of Parameter R from Encoded Grid Cell Values. This is an example illustrating the determination of parameter R by decoding information from encoded grid cell values.

The percent area of the sub-basin with the encoded value of 242,246 is:

A = 0.20

Decoded Information

240,000 = distance from stream:	4.6 km – 4.8 km
2,200 = percent slope:	64 – 67%
46 = land cover type:	evergreen forest
hydrologic soil group:	D
curve number:	77

Therefore, the estimated percent runoff in this 20% of the sub-basin is 77% (R = 0.77).

Algorithm parameter S Based upon percent slope

As indicated previously a range of 3 percent was used to classify percent slope. 'or this term in the model algorithm, the higher percent slope of each 3 percent classification range was converted to decimal form and used in the equation. By doing so a minute contribution is always calculated for those areas with a slope from 0 3% Figure llustrates how the value for the parameter S is determined.

Figure 11: Decoding the Value of Parameter S from Encoded Grid Cell Values. This is an example illustrating the determination of parameter S by decoding information from encoded grid cell values.

The percent area of the sub basin with the encoded value of 242,246 is

A = 0.20

Decoded Information

240,000	= distance from stream:	4.6 km – 4.8 km
2,200	= percent slope:	64 – 67%
46	= land cover type:	evergreen forest
	hydrologic soil group:	D
	curve number:	77

Therefore, the estimated percent slope for this area is 67% (S 0.67).

Algorithm Parameter D: Based upon distance from stream

The distance information was categorized into 0.2 km (200 m) increments and possible values range from 0 – 12 km. The D term in the model algorithm was calculated as the inverse square of the highest distance in each range. Figure 12 illustrates how the value for the parameter D is determined.

Figure 12: Decoding the Value of Parameter D from Encoded Grid Cell Values. This is an example illustrating the determination of parameter D by decoding information from encoded grid cell values.

The percent area of the sub basin with the encoded value of 242,246 is

A = 0.20

Decoded Information

240,000 = distance from stream:	4.6 km – 4.8 km
2,200 = percent slope:	64 – 67%
46 = land cover type:	evergreen forest
hydrologic soil group:	D
curve number:	77

Therefore, the value of term to account for distance from the stream is $1/4.8^2$ (D = 0.0434).

Algorithm Parameter SI: Storm Index

The last term of the model algorithm was developed to account for the various storm intensities during sampling events. Storms of low intensity will yield lower runoff concentrations and storms of higher intensity will yield higher runoff concentrations from the various land cover types. For use in the model algorithm, this term was calculated as the ratio of the total precipitation of each of the three individual storms to the total precipitation due to the average 2 year, 2 hour storm for this area. Since the EMCs were average runoff concentrations due to a storm with an intensity that occurs approximately once a year, the 2 year, 2 hour storm was chosen because the return frequency is approximately 1.1 years. There were three storm events for which data had been collected under the AMP, and therefore, three indexes generated as follows:

- 2 year/ 2 hour storm = total precipitation 1.33 inches
- Storm 1 = total precipitation 0.27 inches; SI = 0.27/1.33; SI = 0.203
- Storm 2 = total precipitation 0.42 inches; SI = 0.42/1.33; SI = 0.316
- Storm 3 = total precipitation 0.96 inches; SI = 0.96/1.33; SI = 0.721

Influence of Land Cover Type on Model Results

The land cover type classifications of the grid cells in the land cover data set directly influence the value of three parameters in the model algorithm. The parameter A

represents the percent area of each unique combination of all watershed attributes considered: land cover type, HSG, slope, stream proximity. If the land cover type changes then the value of parameter A changes. Likewise, the parameter R based on curve number and the indicator EMC would change. Therefore, land cover type influences half of the model parameters. As a result, land cover type is considered the driving factor in this model and classification accuracy becomes an important consideration in the model results.

Table 11 presents the user's and producer's accuracies for the classification of land cover types. "A commision error occurs when an area is included in an incorrect categroy" (Congalton, 1999). These errors are represented by user's accuracy. "An ommission error occurs when an area is excluded form the category to which it belongs" (Congalton, 1999). Ommission errors are represented by producer's accuracy. Thus, producer's accuracy is the probability that a grid cell is correctly classified and user's accuracy is the probability that a grid cell actually represents that category on the ground. For this project, both of these types of errors were considered.

It should be noted that not all land cover type confusions cause a change in the curve numbers and EMCs and would therefore not affect loading calculations. For instance, all forest types contribute the same concentrations of TKN, TP and TSS (see Table 10) and have the same curve numbers (see Table 6). Therefore, confusion among

them will not affect the loading calculations. In addition, if the accuracy was 100%, the land cover type was always correctly classified and did not change the loading calculations. Table 11 highlights those land cover types for which confusion does cause a change in the curve numbers and EMCs and thus, a change in model calculations.

Table 11: User's and Producers Accuracy of Land Cover Type Classification. This table presents the user's and producer's accuracy for the most commonly confused land cover classifications. Those land cover types that cause changes in the model calculations when confused, are highlighted. Those land cover types that are not highlighted do not affect the model results when confused (USGS, 2000).

Class Name	Most commonly confused	User's Accuracy	Producer's Accuracy
Open water		**1.00**	**1.00**
Low int. residential	High int. residential	0.83	0.99
High int. residential	Comm/Industrial/Transport	0.61	0.62
Comm/Industrial/Transport	Low int. residential	1.00	0.40
Quarry/strip mine	Comm/Industrial/Transport	0.53	0.22
Deciduous forest	**Mixed forest**	**0.71**	**0.97**
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
Hay/pasture	**Row crops**	[illegible]	[illegible]
Row crops	Hay/pasture	[illegible]	[illegible]
Other grass	Low int. residential	1.00	0.55
Woody wetlands	Evergreen forest	0.11	0.25
Emergent wetland	Woody wetlands	**0.71**	**0.65**

To determine the impact on model calculations due to the misclassification of land cover type, three runs of the model were done. During the first run of the model all classifications were assumed to be correct. The second and third runs were done assuming that all instances of confusion were between the misclassified land cover

type and that land cover type with which it was most commonly confused. The second run was based on the user's accuracy and the third was based on the producer's accuracy.

The calculation to determine the concentration based upon the user's and producer's accuracy used, but expanded upon, the basic model algorithm. The percent accuracy indicates the percentage of area for which the land cover is classified correctly. Therefore, 100 minus the percent accuracy indicates the percentage of area for which the land cover is classified incorrectly. These values were converted to decimal form for calculation purposes. The original parameters were multiplied by the percent classified correctly. The Indicator EMC and R parameters were then changed to correspond to the land cover type most commonly confused and multiplied by the percent classified incorrectly. The results were then added together to determine the NPS Indicator Concentration. In addition the percent difference between Runs 1 and 2 and Runs 1 and 3 were calculated. Figure 13 illustrates the calculation of NPS concentrations based on user's accuracy. Additionally, the calculation of percent difference between model results (assuming all classifications are correct) and those calculations based on user's accuracy are shown. Figure 14 illustrates the same for producer's accuracy.

Figure 13: Calculation of model results based on user's accuracy. The model was originally run assuming all land cover classifications were correct, Run 1. The second run of the model was done using user's accuracy to calculate NPS in-stream concentrations.

Run 2 based on User's Accuracy:

$$\text{NPS Indicator Concentration}_{\text{User's}} = [(A * \text{Indicator EMC}_{\text{original}} * R_{\text{original}} * S * D * SI) * (\text{User's Accuracy}/100)] + [(A * \text{Indicator EMC}_{\text{confused}} * R_{\text{confused}} * S * D * SI) * (\{100 - \text{User's Accuracy}\}/100)]$$

$$\text{User's Percent Difference} = \frac{(\text{Run 2 Results} - \text{Run 1 Results})}{\text{Run 1 Results}}$$

Figure 14: Calculation of model results based on producer's accuracy. The model was originally run assuming all land cover classifications were correct, Run 1. The third run of the model was done using producer's accuracy to calculate NPS in-stream concentrations.

Run 3 based on Producer's Accuracy:

$$\text{NPS Indicator Concentration}_{\text{Producer's}} = [(A * \text{Indicator EMC}_{\text{original}} * R_{\text{original}} * S * D * SI) * (\text{Producer's Accuracy}/100)] + [(A * \text{Indicator EMC}_{\text{confused}} * R_{\text{confused}} * S * D * SI) * (\{100 - \text{Producer's Accuracy}\}/100)]$$

$$\text{Producer's Percent Difference} = \frac{(\text{Run 3 Results} - \text{Run 1 Results})}{\text{Run 1 Results}}$$

Chapter V
Results

Data acquisition and preparation was done in conjunction with the development of a model algorithm to generate results from the GIS model developed. Parameters for the algorithm were determined based on model input from the various data sets collected. The model results are estimates of in-stream concentrations for three parameters TKN, TP and TSS at various points in the lake watershed.

The first run of the model was done under the assumption that all grid cells were associated with the correct land cover type classification. Run 1 results are shown in tables 12, 13 and 14, where they are compared to the OCDDS 1999 AMP sample data from the same locations. For further comparison, the percent difference between the model results and sample data was also determined as follows:

$$\text{Percent Difference FWA} = \frac{(\text{Run 1 Results} - \text{Sample FWA})}{\text{Sample FWA}}$$

The concentration calculated by the model is the in-stream concentration at a point in the stream, due to NPS loadings from the surrounding watershed. The in-stream sample concentration, at the same location, is due to point source and NPS loadings, as well as, any background loadings from ground water inflow and precipitation that

is directly within the confines of the stream channel. These components cannot be separated in the sample data.

Since the NPS component contributes only a portion of the in-stream loading it must be less than the in-stream concentration. The model calculated a total of 72 in-stream concentrations for three parameters, during three storm events, at eight sample locations. Out of the 72 concentrations calculated, nine resulted in model concentrations that were greater than the sample in-stream concentrations and seven occurred during storm three. These nine spurious results produced positive percent differences and are highlighted in tables 13 and 14.

The two erroneous results calculated based on storm two were both for TSS on Onondaga Creek. One of the invalid results was calculated at the Inner Harbor and the other was at Spencer St. The remaining seven unreasonable results were calculated based on storm three and different parameters were affected at different locations. The calculation of TKN and TSS at Hiawatha Blvd. on Harbor Brook was erroneous as was the calculation of TP on Harbor Brook at Velasko. Both TP and TSS calculations yielded illogical results on Onondaga Creek at both Dorwin Ave. and Route 20.

If the assumption is made that the model is accurately calculating concentrations due to NPS loadings then the model concentration can be assumed equal to the NPS

portion of the sample concentration. Again, the percent difference is calculated according to the following:

$$\text{Percent Difference} = \frac{(\text{Model Concentration} - \text{Sample Concentration})}{\text{Sample Concentration}}$$

This can be re-written:

$$\text{Percent Difference} = \frac{(\text{Model NPS} - (\text{Sample NPS} + \text{Sample PS} + \text{Sample BG})}{\text{Sample NPS} + \text{Sample PS} + \text{Sample BG}}$$

Where:

Model NPS = model concentration

Sample NPS = portion of in-stream concentration due to NPS

Sample PS = portion of in-stream concentration due to point source

Sample BG = portion of in-stream concentration due to background

The model is assumed to be calculating in-stream concentrations due to NPS loadings correctly therefore, Model NPS = Sample NPS and the equation can be rewritten again.

$$\text{Percent Difference} = \frac{(\text{Sample NPS} - (\text{Sample NPS} + \text{Sample PS} + \text{Sample BG})}{\text{Sample NPS} + \text{Sample PS} + \text{Sample BG}}$$

Simplifying:

$$\text{Percent Difference} = -\frac{(\text{Sample PS} + \text{Sample BG})}{\text{Sample NPS} + \text{Sample PS} + \text{Sample BG}}$$

Therefore, the percent difference according to the above equation is the percent of the total in-stream concentration that is due to point source loadings and background loadings. If this value is subtracted from 100 percent the result is that percent of the total in-stream concentration that is due to NPS loadings. The results of these calculations can be seen in Table 15.

The affect that land cover type classification had on model results was also explored. The first run generated model results corresponding to drainage basins for sample sites assuming correct classification of land cover types (Run 1). The model was then run two more times with the second run being based on user's accuracy (Run 2) and the third run being based on producer's accuracy (Run 3). In addition, the percent difference between correct classification and misclassification based on user's and producer's accuracy was calculated. Tables 16, 17 and 18 present the results of the three model runs for storms 1, 2 and 3 respectively.

Finally, the model calculations to determine in-stream concentrations at the mouths of the tributaries, entering Onondaga Lake, were done and these results are shown in Table 19.

Table 12: OCDDS Sample Data and Model Results, Storm 1, (mg/l). This table summarizes the model results and OCDDS 1999 AMP sample data flow weighted average (FWA) in-stream concentrations at sample sites during storm 1.

Storm 1 - Storm Index 0.203	Contributing	Model	Sample	Percent
Tributary & Location		Results	FWA	Difference
TKN				
Harbor Brook - Hiawatha Blvd.	HB2+HB3	0.228	0.313	-27.2
Harbor Brook - Velasko Road	HB3	0.094	0.215	-56.3
Onondaga Creek - Inner Harbor	OC2+OC3+OC4+OC5	0.156	0.503	-69.0
Onondaga Creek - Spencer St.	OC3+OC4+OC5	0.114	0.346	-67.1
Onondaga Creek - Dorwin Ave.	OC4+OC5	0.067	0.244	-72.5
Onondaga Creek - Route 20	OC5	0.047	0.214	-78.0
Ley Creek - Park St.	LC2+LC3	0.123	0.886	-86.1
Ley Creek - 7th North St.	LC3	0.042	0.680	-93.8
TP				
Harbor Brook - Hiawatha Blvd.	HB2+HB3	0.022	0.042	-47.6
Harbor Brook - Velasko Road	HB3	0.015	0.019	-21.1
Onondaga Creek - Inner Harbor	OC2+OC3+OC4+OC5	0.025	0.042	-40.5
Onondaga Creek - Spencer St.	OC3+OC4+OC5	0.018	0.040	-55.0
Onondaga Creek - Dorwin Ave.	OC4+OC5	0.010	0.017	-41.2
Onondaga Creek - Route 20	OC5	0.007	0.014	-50.0
Ley Creek - Park St.	LC2+LC3	0.019	0.090	-78.9
Ley Creek - 7th North St.	LC3	0.007	0.081	-91.4
TSS				
Harbor Brook - Hiawatha Blvd.	HB2+HB3	10.053	12.608	-20.3
Harbor Brook - Velasko Road	HB3	3.544	4.960	-28.5
Onondaga Creek - Inner Harbor	OC2+OC3+OC4+OC5	8.504	9.073	-6.3
Onondaga Creek - Spencer St.	OC3+OC4+OC5	6.223	17.808	-65.1
Onondaga Creek - Dorwin Ave.	OC4+OC5	4.208	12.087	-65.2
Onondaga Creek - Route 20	OC5	2.992	5.391	-44.5
Ley Creek - Park St.	LC2+LC3	6.366	25.584	-75.1
Ley Creek - 7th North St.	LC3	2.187	38.128	-94.3

*See Figure 7 for sub-basin identification.

Table 13: OCDDS Sample Data and Model Results, Storm 2, (mg/l). This table summarizes the model results and OCDDS 1999 AMP sample data flow weighted average (FWA) in-stream concentrations at sample sites during storm 2.

Storm 2 - Storm Index 0.316	Contributing	Model	Sample	Percent
Tributary & Location	Sub-basins*	Results	FWA	Difference
TKN				
Harbor Brook - Hiawatha Blvd.	HB2+HB3	0.355	0.821	-56.8
Harbor Brook - Velasko Road	HB3	0.147	0.341	-56.9
Onondaga Creek - Inner Harbor	OC2+OC3+OC4+OC5	0.242	2.150	-88.7
Onondaga Creek - Spencer St.	OC3+OC4+OC5	0.177	0.573	-69.1
Onondaga Creek - Dorwin Ave.	OC4+OC5	0.104	0.368	-71.7
Onondaga Creek - Route 20	OC5	0.074	0.464	-84.1
Ley Creek - Park St.	LC2+LC3	0.192	0.980	-80.4
Ley Creek - 7th North St.	LC3	0.065	0.852	-92.4
TP				
Harbor Brook - Hiawatha Blvd.	HB2+HB3	0.034	0.143	-76.2
Harbor Brook - Velasko Road	HB3	0.023	0.045	-48.9
Onondaga Creek - Inner Harbor	OC2+OC3+OC4+OC5	0.039	0.154	-74.7
Onondaga Creek - Spencer St.	OC3+OC4+OC5	0.028	0.070	-60.0
Onondaga Creek - Dorwin Ave.	OC4+OC5	0.016	0.029	-44.8
Onondaga Creek - Route 20	OC5	0.011	0.049	-77.6
Ley Creek - Park St.	LC2+LC3	0.030	0.142	-78.9
Ley Creek - 7th North St.	LC3	0.011	0.146	-92.5
TSS				
Harbor Brook - Hiawatha Blvd.	HB2+HB3	15.649	50.186	-68.8
Harbor Brook - Velasko Road	HB3	5.516	14.605	-62.2
Onondaga Creek - Inner Harbor	OC2+OC3+OC4+OC5	13.238	11.870	11.5
Onondaga Creek - Spencer St.	OC3+OC4+OC5	9.686	9.103	6.4
Onondaga Creek - Dorwin Ave.	OC4+OC5	6.551	9.345	-29.9
Onondaga Creek - Route 20	OC5	4.658	18.334	-74.6
Ley Creek - Park St.	LC2+LC3	9.909	26.219	-62.2
Ley Creek - 7th North St.	LC3	3.404	29.157	-88.3

*See Figure 7 for sub-basin identification

Table 14: OCDDS Sample Data and Model Results, Storm 3, (mg/l). This table summarizes the model results and OCDDS 1999 AMP sample data flow weighted average (FWA) in-stream concentrations at sample sites during storm 3.

Storm 3 - Storm Index 0.721	Contributing	Model	Sample	Percent
Tributary & Location	Sub-basins*	Results	FWA	Difference
TKN				
Harbor Brook - Hiawatha Blvd.	HB2+HB3	0.809	0.596	35.7
Harbor Brook - Velasko Road	HB3	0.335	0.390	-14.1
Onondaga Creek - Inner Harbor	OC2+OC3+OC4+OC5	0.553	0.949	-41.7
Onondaga Creek - Spencer St.	OC3+OC4+OC5	0.405	0.726	-44.2
Onondaga Creek - Dorwin Ave.	OC4+OC5	0.238	0.307	-22.5
Onondaga Creek - Route 20	OC5	0.168	0.313	-46.3
Ley Creek - Park St.	LC2+LC3	0.438	0.744	-41.1
Ley Creek - 7th North St.	LC3	0.149	0.731	-79.6
TP				
Harbor Brook - Hiawatha Blvd.	HB2+HB3	0.079	0.148	-46.6
Harbor Brook - Velasko Road	HB3	0.053	0.040	32.5
Onondaga Creek - Inner Harbor	OC2+OC3+OC4+OC5	0.089	0.132	
Onondaga Creek - Spencer St.	OC3+OC4+OC5	0.063	0.130	
Onondaga Creek - Dorwin Ave.	OC4+OC5	0.036	0.027	33.3
Onondaga Creek - Route 20	OC5	0.025	0.021	19.0
Ley Creek - Park St.	LC2+LC3	0.068	0.197	-65.5
Ley Creek - 7th North St.	LC3	0.024	0.185	-87.0
TSS				
Harbor Brook - Hiawatha Blvd.	HB2+HB3	35.705	13.506	164.4
Harbor Brook - Velasko Road	HB3	12.586	16.299	-22.8
Onondaga Creek - Inner Harbor	OC2+OC3+OC4+OC5	30.204	33.762	-10.5
Onondaga Creek - Spencer St.	OC3+OC4+OC5	22.101	88.431	-75.0
Onondaga Creek - Dorwin Ave.	OC4+OC5	14.964	9.807	52.6
Onondaga Creek - Route 20	OC5	10.628	8.112	31.0
Ley Creek - Park St.	LC2+LC3	22.609	75.848	-70.2
Ley Creek - 7th North St.	LC3	7.767	72.986	-89.4

*See Figure 7 for sub-basin identification.

Table 15: Estimated Percent of In-stream Concentration due to NPS Loadings based on Model Results and OCDDS Sample Data. Based upon the percent difference between in-stream sample data and model results, the estimated percent of the in-stream concentration due to NPS loadings from the surrounding watershed can be determined.

TKN Percent Difference	Storm 1	Storm 2	Storm 3
Harbor Brook			
Hiawatha Blvd.	72.763	43.182	135.722
Velasko Road	43.824	43.012	85.807
Onondaga Creek			
Inner Harbor	30.949	11.274	58.279
Spencer St.	32.935	30.958	55.749
Dorwin Ave.	27.416	28.297	77.391
Route 20	22.066	15.842	53.584
Ley Creek			
Park St.	13.912	19.579	58.843
7th North St.	6.164	7.658	20.364

TP Percent Difference	Storm 1	Storm 2	Storm 3
Harbor Brook			
Hiawatha Blvd.	52.707	24.097	53.124
Velasko Road	78.554	51.630	132.526
Onondaga Creek			
Inner Harbor	59.910	25.183	67.297
Spencer St.	44.680	39.744	48.859
Dorwin Ave.	59.340	54.149	133.124
Route 20	50.661	22.532	119.956
Ley Creek			
Park St.	21.128	20.845	34.283
7th North St.	8.404	7.243	13.011

TSS Percent Difference	Storm 1	Storm 2	Storm 3
Harbor Brook			
Hiawatha Blvd.	79.733	31.181	264.361
Velasko Road	71.442	37.768	77.217
Onondaga Creek			
Inner Harbor	93.732	111.525	89.462
Spencer St.	34.943	106.409	24.992
Dorwin Ave.	34.816	70.098	152.408
Route 20	55.507	25.407	131.018
Ley Creek			
Park St.	24.881	37.793	29.808
7th North St.	5.736	11.676	10.642

Table 16: Land Cover Type Classification Accuracy and Model Results, Storm 1. This table shows the model results corresponding to drainage basins for sample sites: Assuming Correct Classification of Land Cover Types (Run 1), Classification based on User's Accuracy (Run 2) and Classification based on Producer's Accuracy (Run 3). In addition, the percent difference between correct classification and misclassification based on user's and producer's accuracy is shown.

Storm 1 - Storm Index 0.203		Model Results (mg/L)			Percent Difference	
Tributary & Location	Contributing Sub-basins*	Run 1 Correctly Classified	Run 2 User's Accuracy	Run 3 Producer's Accuracy	User's Accuracy	Producer's Accuracy
TKN						
Harbor Brook - Hiawatha Blvd.	HB2+HB3	0.228	0.227	0.260	-0.439	14.035
Harbor Brook - Velasko Road	HB3	0.094	0.090	0.098	-4.255	4.255
Onondaga Creek - Inner Harbor	OC2+OC3+OC4+OC5	0.156	0.156	0.171	0.000	9.615
Onondaga Creek - Spencer St.	OC3+OC4+OC5	0.114	0.114	0.120	0.000	5.263
Onondaga Creek - Dorwin Ave.	OC4+OC5	0.067	0.067	0.067	0.000	0.000
Onondaga Creek - Route 20	OC5	0.047	0.047	0.047	0.000	0.000
Ley Creek - Park St.	LC2+LC3	0.123	0.122	0.155	-0.813	26.016
Ley Creek - 7th North St.	LC3	0.042	0.042	0.049	0.000	16.667
TP						
Harbor Brook - Hiawatha Blvd.	HB2+HB3	0.022	0.023	0.026	4.545	18.182
Harbor Brook - Velasko Road	HB3	0.015	0.014	0.015	-6.667	0.000
Onondaga Creek - Inner Harbor	OC2+OC3+OC4+OC5	0.025	0.025	0.027	0.000	8.000
Onondaga Creek - Spencer St.	OC3+OC4+OC5	0.018	0.018	0.019	0.000	5.556
Onondaga Creek - Dorwin Ave.	OC4+OC5	0.010	0.010	0.010	0.000	0.000
Onondaga Creek - Route 20	OC5	0.007	0.007	0.007	0.000	0.000
Ley Creek - Park St.	LC2+LC3	0.019	0.019	0.024	0.000	26.316
Ley Creek - 7th North St.	LC3	0.007	0.007	0.008	0.000	14.286
TSS						
Harbor Brook - Hiawatha Blvd.	HB2+HB3	10.053	10.628	10.097	5.720	0.438
Harbor Brook - Velasko Road	HB3	3.544	3.740	3.563	5.530	0.536
Onondaga Creek - Inner Harbor	OC2+OC3+OC4+OC5	8.504	8.696	8.095	2.258	-4.810
Onondaga Creek - Spencer St.	OC3+OC4+OC5	6.223	6.349	6.118	2.025	-1.687
Onondaga Creek - Dorwin Ave.	OC4+OC5	4.208	4.212	4.197	0.095	-0.261
Onondaga Creek - Route 20	OC5	2.992	2.995	2.991	0.100	-0.033
Ley Creek - Park St.	LC2+LC3	6.366	6.477	5.766	1.744	-9.425
Ley Creek - 7th North St.	LC3	2.187	2.236	1.995	2.241	-8.779

*See Figure 7 for sub-basin identification.

Table 17: Land Cover Type Classification Accuracy and Model Results, Storm 2. This table shows the model results corresponding to drainage basins for sample sites: Assuming Correct Classification of Land Cover Types (Run 1), Classification based on User's Accuracy (Run 2) and Classification based on Producer's Accuracy (Run 3). In addition, the percent difference between correct classification and misclassification based on user's and producer's accuracy is shown.

Storm 2 - Storm Index 0.316		Model Results (mg/L)			Percent Difference	
Tributary & Location	Contributing Sub-basins*	Run 1 Correctly Classified	Run 2 User's Accuracy	Run 3 Producer's Accuracy	User's Accuracy	Producer's Accuracy
TKN						
Harbor Brook - Hiawatha Blvd.	HB2+HB3	0.355	0.354	0.404	-0.282	13.803
Harbor Brook - Velasko Road	HB3	0.147	0.140	0.152	-4.762	3.401
Onondaga Creek - Inner Harbor	OC2+OC3+OC4+OC5	0.242	0.244	0.266	0.826	9.917
Onondaga Creek - Spencer St.	OC3+OC4+OC5	0.177	0.177	0.187	0.000	5.650
Onondaga Creek - Dorwin Ave.	OC4+OC5	0.104	0.104	0.104	0.000	0.000
Onondaga Creek - Route 20	OC5	0.074	0.073	0.074	-1.351	0.000
Ley Creek - Park St.	LC2+LC3	0.192	0.190	0.242	-1.042	26.042
Ley Creek - 7th North St.	LC3	0.065	0.065	0.076	0.000	16.923
TP						
Harbor Brook - Hiawatha Blvd.	HB2+HB3	0.034	0.035	0.041	2.941	20.588
Harbor Brook - Velasko Road	HB3	0.023	0.022	0.024	-4.348	4.348
Onondaga Creek - Inner Harbor	OC2+OC3+OC4+OC5	0.039	0.039	0.042	0.000	7.692
Onondaga Creek - Spencer St.	OC3+OC4+OC5	0.028	0.028	0.029	0.000	3.571
Onondaga Creek - Dorwin Ave.	OC4+OC5	0.016	0.016	0.016	0.000	0.000
Onondaga Creek - Route 20	OC5	0.011	0.011	0.011	0.000	0.000
Ley Creek - Park St.	LC2+LC3	0.030	0.029	0.037	-3.333	23.333
Ley Creek - 7th North St.	LC3	0.011	0.010	0.012	-9.091	9.091
TSS						
Harbor Brook - Hiawatha Blvd.	HB2+HB3	15.649	16.544	15.717	5.719	0.435
Harbor Brook - Velasko Road	HB3	5.516	5.822	5.547	5.547	0.562
Onondaga Creek - Inner Harbor	OC2+OC3+OC4+OC5	13.238	13.536	12.601	2.251	-4.812
Onondaga Creek - Spencer St.	OC3+OC4+OC5	9.686	9.883	9.523	2.034	-1.683
Onondaga Creek - Dorwin Ave.	OC4+OC5	6.551	6.556	6.533	0.076	-0.275
Onondaga Creek - Route 20	OC5	4.658	4.663	4.656	0.107	-0.043
Ley Creek - Park St.	LC2+LC3	9.909	10.083	8.976	1.756	-9.416
Ley Creek - 7th North St.	LC3	3.404	3.480	3.106	2.233	-8.754

*See Figure 7 for sub-basin identification.

Table 18: Land Cover Type Classification Accuracy and Model Results, Storm 3. This table shows the model results corresponding to drainage basins for sample sites: Assuming Correct Classification of Land Cover Types (Run 1), Classification based on User's Accuracy (Run 2) and Classification based on Producer's Accuracy (Run 3). In addition, the percent difference between correct classification and misclassification based on user's and producer's accuracy is shown.

Storm 3 - Storm Index 0.721		Model Results (mg/L)			Percent Difference	
Tributary & Location	Contributing Sub-basins*	Run 1 Correctly Classified	Run 2 User's Accuracy	Run 3 Producer's Accuracy	User's Accuracy	Producer's Accuracy
TKN						
Harbor Brook - Hiawatha Blvd.	HB2+HB3	0.809	0.807	0.922	-0.247	13.968
Harbor Brook - Velasko Road	HB3	0.335	0.319	0.347	-4.776	3.582
Onondaga Creek - Inner Harbor	OC2+OC3+OC4+OC5	0.553	0.556	0.607	0.542	9.765
Onondaga Creek - Spencer St.	OC3+OC4+OC5	0.405	0.404	0.426	-0.247	5.185
Onondaga Creek - Dorwin Ave.	OC4+OC5	0.238	0.237	0.238	-0.420	0.000
Onondaga Creek - Route 20	OC5	0.168	0.168	0.168	0.000	0.000
Ley Creek - Park St.	LC2+LC3	0.438	0.434	0.552	-0.913	26.027
Ley Creek - 7th North St.	LC3	0.149	0.148	0.174	-0.671	16.779
TP						
Harbor Brook - Hiawatha Blvd.	HB2+HB3	0.079	0.080	0.093	1.266	17.722
Harbor Brook - Velasko Road	HB3	0.053	0.051	0.055	-3.774	3.774
Onondaga Creek - Inner Harbor	OC2+OC3+OC4+OC5	0.089	0.089	0.096	0.000	7.865
Onondaga Creek - Spencer St.	OC3+OC4+OC5	0.063	0.063	0.066	0.000	4.762
Onondaga Creek - Dorwin Ave.	OC4+OC5	0.036	0.036	0.036	0.000	0.000
Onondaga Creek - Route 20	OC5	0.025	0.025	0.025	0.000	0.000
Ley Creek - Park St.	LC2+LC3	0.068	0.067	0.085	-1.471	25.000
Ley Creek - 7th North St.	LC3	0.024	0.024	0.028	0.000	16.667
TSS						
Harbor Brook - Hiawatha Blvd.	HB2+HB3	35.705	37.748	35.860	5.722	0.434
Harbor Brook - Velasko Road	HB3	12.586	13.284	12.655	5.546	0.548
Onondaga Creek - Inner Harbor	OC2+OC3+OC4+OC5	30.204	30.885	28.752	2.255	-4.807
Onondaga Creek - Spencer St.	OC3+OC4+OC5	22.101	22.551	21.729	2.036	-1.683
Onondaga Creek - Dorwin Ave.	OC4+OC5	14.964	14.959	14.906	-0.033	-0.388
Onondaga Creek - Route 20	OC5	10.628	10.639	10.623	0.104	-0.047
Ley Creek - Park St.	LC2+LC3	22.609	23.006	20.480	1.756	-9.417
Ley Creek - 7th North St.	LC3	7.767	7.941	7.087	2.240	-8.755

*See Figure 7 for sub-basin identification.

Table 19: Model Results at the Mouth of Lake Tributaries. This table summarizes the in-stream concentrations due to NPS loadings calculated by the watershed model.

At mouth of tributaries	Contributing Sub-basins*	Storm 1 (SI = 0.203) (mg/L)	Storm 2 (SI = 0.316) (mg/L)	Storm 3 (SI = 0.721) (mg/L)
TKN				
Nine Mile Creek	NM1	0.065	0.102	0.233
Harbor Brook	HB1+HB2+HB3	0.292	0.455	1.038
Onondaga Creek	OC1+OC2+OC3+OC4+OC5	0.168	0.261	0.595
Ley Creek	LC1+LC2+LC3	0.316	0.492	1.123
Bloody Brook	BB1	0.056	0.088	0.201
Saw Mill Creek	SM1	0.094	0.146	0.334
TP				
Nine Mile Creek	NM1	0.010	0.015	0.034
Harbor Brook	HB1+HB2+HB3	0.047	0.074	0.168
Onondaga Creek	OC1+OC2+OC3+OC4+OC5	0.027	0.042	0.096
Ley Creek	LC1+LC2+LC3	0.050	0.078	0.177
Bloody Brook	BB1	0.009	0.014	0.032
Saw Mill Creek	SM1	0.015	0.023	0.053
TSS				
Nine Mile Creek	NM1	3.672	5.715	13.041
Harbor Brook	HB1+HB2+HB3	13.401	20.861	47.598
Onondaga Creek	OC1+OC2+OC3+OC4+OC5	9.187	14.301	32.631
Ley Creek	LC1+LC2+LC3	14.902	23.197	52.926
Bloody Brook	BB1	1.986	3.091	7.053
Saw Mill Creek	SM1	4.794	7.463	17.028

*See Figure 7 for sub-basin identification.

Chapter V
Discussion

Comparison of Model and OCDDS Sample Data

Tables 12, 13 and 14 compare model results with in-stream sample data FWA concentrations. The in-stream concentrations represent contributions from point sources, non-point sources and background loadings due to ground water and in-stream precipitation. It is impossible to separate the NPS contribution from the other sample components. Thus, a direct comparison cannot be done between the NPS concentrations calculated by the model and the in-stream sample concentrations. However, some observations can be made based upon comparisons between the sample data and the in-stream concentrations calculated by the model.

Erroneous Results

Nine of the 72 results generated were erroneous. Two of the nine erroneous results were generated based on storm two and the remaining seven were based on storm three. Storm three was intense enough that the two USGS gauging stations on Onondaga Creek were washed out, at separate times, during the storm. As a result, flow data was not recorded during large periods of the storm. Four of the questionable results generated for storm three were at Dorwin Ave and Route 20. Since the FWA sample concentrations corresponding to these two sites were calculated based on flow data secured at the Dorwin Ave. gaging station, the FWA concentrations are not accurate. The FWA concentrations of the in-stream sample

Ellipsoid_Name:
Semi-major_Axis:
Denominator_of_Flattening_Ratio:

Distribution_Information:
Distributor:
Contact_Information:
Contact_Organization_Primary:
Contact_Organization: State Universtiy of New York College of Environmental Science and Forestry
Contact_Position: Mapping Science Laboratory
Con tact_Address:
Address_Type: Mailing and physical address
Address: Bray Hall, 1 Forestry Drive
City: Syracuse
State_or_Province: New York
Postal_Code: 13210
Country: USA
Contact_Voice_Telephone:
Contact_Facsimile_Telephone:
Contact_Electronic_Mail_Address:
Resource_Description: ononsoil
Distribution_Liability: None
Standard_Order_Process:
Digital_Form:
Digital_Transfer_Information:
Format_Name: ARCE
Digital_Transfer_Option:
Online_Option:
Computer_Contact_Information:
Network_Address:
Network_Resource_Name:
Fees.
Available for free

Metadata_Reference_Information:
Metadata_Date: 200105
Metadata_Contact:
Contact_Information:
Contact_Organization_Primary:
Contact_Organization: Mapping Science Laboratory
Contact_Address:
Address_Type: Mailing and physical address
Address: Bray Hall, 1 Forestry Drive
City: Syracuse
State_or_Province: New York
Postal_Code: 13210
Country: USA
Contact_Voice_Telephone:
Contact_Facsimile_Telephone:

Contact_Electronic_Mail_Address:
Metadata_Standard_Name: FGDC Content Standards for Digital Geospatial Metadata
Metadata_Standard_Version: FGDC-STD-001-1998

Land Cover

Identification_Information:
Citation:
Citation_Information:
Originator: U.S. Geological Survey (USGS)
Publication_Date: 19970101
Title: New York Land Cover Data Set
Edition: 1
Geospatial_Data_Presentation_Form: raster digital data
Publication_Information:
Publication_Place: Sioux Falls, SD USA
Publisher: U.S. Geological Survey
Online_Linkage: http://edcwww.cr.usgs.gov/programs/lccp/nationallandcover.html
Description:
Abstract:

These data can be used in a geographic information system (GIS) for any number of purposes such as assessing wildlife habitat, water quality, pesticide runoff, land use change, etc. The State data sets are provided with a 300 meter buffer beyond the State border to faciliate combining the State files into larger regions.

The user must have a firm understanding of how the datasets were compiled and the resulting limitations of these data. The National Land Cover Dataset was compiled from Landsat satellite TM imagery (circa 1992) with a spatial resolution of 30 meters and supplemented by various ancillary data (where available). The analysis and interpretation of the satellite imagery was conducted using very large, sometimes multi-state image mosaics (i.e. up to 18 Landsat scenes). Using a relatively small number of aerial photographs for 'ground truth', the thematic interpretations were necessarily conducted from a spatially-broad perspective. Furthermore, the accuracy assessments (see below) correspond to 'federal regions' which are groupings of contiguous States. Thus, the reliability of the data is greatest at the State or multi-State level. The statistical accuracy of the data is known only for the region.

Important Caution Advisory

With this in mind, users are cautioned to carefully scrutinize the data to see if they are of sufficient reliability before attempting to use the dataset for larger-scale or local analyses. This evaluation must be made remembering that the NLCD represents conditions in the early 1990s. The New York portion of the NLCD was created as part of land cover mapping activities for Federal Region II that includes the states of New York and New Jersey. The NLCD classification contains 21 different land cover categories with a

spatial resolution of 30 meters. The NLCD was produced as a cooperative effort between the U.S. Geological Survey (USGS) and the U.S. Environmental Protection Agency (US EPA) to produce a consistent, land cover data layer for the conterminous U.S. using early 1990s Landsat thematic mapper (TM) data purchased by the Multi-resolution Land Characterization (MRLC) Consortium. The MRLC Consortium is a partnership of federal agencies that produce or use land cover data. Partners include the USGS (National Mapping, Biological Resources, and Water Resources Divisions), US EPA, the U.S. Forest Service, and the National Oceanic and Atmospheric Administration.

Purpose:

The main objective of this project was to generate a generalized and nationally consistent land cover data layer for the entire conterminous United States. These data can be used as a layer in a geographic information system (GIS) for any number of purposes such assessing wildlife habitat, water quality and pesticide runoff, land use change, etc.

Supplemental_Information:

The land cover data files are provided as a 'Geo-TIFF'(on CDROM) or 8 bit binary files (from FTP site). The land cover data sets are single band raster images. The X/Y corner coordinates for New York are 1317210/2663820 (projection meters, center of Upper Left pixel).

Time_Period_of_Content:

Time_Period_Information:

Range_of_Dates/Times:

Beginning_Date: 1988

Ending_Date: 1993

Currentness_Reference: ground condition

Status:

Progress: Complete

Maintenance_and_Update_Frequency: As needed

Spatial_Domain:

Bounding_Coordinates:

West_Bounding_Coordinate: -78.955

East_Bounding_Coordinate: -72.029

North_Bounding_Coordinate: 45.897

South_Bounding_Coordinate: 39.989

Keywords:

Theme:

Theme_Keyword_Thesaurus: None

Theme_Keyword: Land Use/Land Cover, Land Management, Land Resources, EDC, EPA, EROS, Imagery, Land Characterization, Land Cover, Landsat, MRLC, Remote Sensing, Satellite, Space Imaging, USGS

Place:

Place_Keyword_Thesaurus: U.S. Department of Commerce, 1977, Countries, dependencies, areas of special sovereignty, and their principal administrative divisions (Federal Information Processing Standard 10-3):Washington, D.C., National Institute of Standards and Technology.

Place_Keyword: North America, United States of America

Place:

Place_Keyword_Thesaurus: U.S. Department of Commerce, 1987, Codes for the identification of the States, the District of Columbia, and the outlying areas of the United States and associated areas Federal Information Processing Standard 5-20; Washington, D.C., National Institute of Standards and Technology.

Place_Keyword: New York, NY

Access_Constraints: None.

Use_Constraints: None. Acknowledgement of the U.S. Geological Survey would be appreciated in products derived from these data.
Point_of_Contact:
Contact_Information:
Contact_Organization_Primary:
Contact_Organization: U.S. Geological Survey EROS Data Center
Contact_Position: Customer Services Representative
Contact_Address:
Address_Type: mailing and physical address
Address: U.S. Geological Survey, EROS Data Center
City: Sioux Falls
State_or_Province: SD
Postal_Code: 57198
Country: USA
Contact_Voice_Telephone: (605) 594-6151
Contact_TDD/TTY_Telephone: (605) 594-6933
Contact_Facsimile_Telephone: (605) 594-6589
Contact_Electronic_Mail_Address:
CUSTSERV@EDCMAIL.CR.USGS.GOV
Data_Set_Credit: This work was performed by the Raytheon STX Corporation under U.S. Geological Survey Contract 1434-92-C-40004.

Data_Quality_Information:
Attribute_Accuracy:
Attribute_Accuracy_Report:
An accuracy assessment is done on all NLCD on a Federal Region basis following a revision cycle that incorporates feedback from MRLC Consortium partners and affiliated users. The accuracy assessments are conducted by private sector vendors under contract to the USEPA. A protocol has been established by the USGS and USEPA that incorporates a two-stage, geographically stratified cluster sampling plan (Zhu et al., 1999) utilizing National Aerial Photography Program (NAPP) photographs as the sampling frame and the basic sampling unit. In this design a NAPP photograph is defined as a 1st stage or primary sampling unit (PSU), and a sampled pixel within each PSU is treated as a 2nd stage or secondary sampling unit (SSU).

PSU's are selected from a sampling grid based on NAPP flight-lines and photo centers, each grid cell measures 15' X 15' (minutes of latitude/longitude) and consists of 32 NHAP photographs. A geographically stratified random sampling is performed with 1 NAPP photo being randomly selected from each cell (geographic strata), if a sampled photo falls outside of the regional boundary it is not used. Second stage sampling is accomplished by selecting SSU's (pixels) within each PSU (NAPP photo) to provide the actual locations for the reference land cover classification.

The SSU's are manually interpreted and misclassification errors are estimated and described using a traditional error matrix as well as a number of other important measures including the overall proportion of pixels correctly classified, user's and producer's accuracy's, and omission and commission error probabilities. At the time of CD release (Summer 2000), the accuracy assessment was not complete. For the Region III accuracy assessment, please check the NLCD Website: http://edcwww.usgs.gov/programs/lccp/nationallandcover.html. The accuracy assessment numbers will be posted there around September, 2000.

While we believe that the approach taken has yielded a very good general land cover classification product for Region II, it is important to indicate to the user where there might be some potential problems. The biggest concerns for Region II are listed below:

1) Accurate definition of the transitional barren class was extremely difficult. The majority of pixels in this class correspond to clear-cut forests in various stages of regrowth. Spectrally, fresh clear-cuts are very similar to row-crops in the leaves-off data. Manual correction of coding errors was performed to improve differentiation between row-crops and clear-cuts, but some errors may still be found. As regrowth occurs in a clear-cut region, the definition of transitional barren versus a forested class becomes problematic. An attempt was made to classify only fresh clear-cuts or those in the earliest stages of regrowth, but there are likely forested regions classed as transitional barren and vice versa.

2) Due to the confusion between clear-cuts, regrowth in clear-cuts, Forested areas, and shrublands, no attempts were made to populate the shrubland classes. Any shrubland areas that exist in this area are classed in their like forest class, i.e. deciduous shrubland is classed as deciduous forest, etc.

Logical_Consistency_Report:

An unsupervised classification algorithm was used to classify the mosaicked multiple leaf-off TM scenes. Aerial photographs were used to interpret and label classes into land cover categories and ancillary data sources resolved the class confusion. Further land cover information from leaf-on TM data, NWI data, and other sources were incorporated to refine and augment the "basic" classification.

Completeness_Report: All photo-interpretable data are mapped.

Positional_Accuracy:

Horizontal_Positional_Accuracy:

Horizontal_Positional_Accuracy_Report:

Each Landsat Thematic Mapper image used to create the NLCD was precision terrain-corrected using 3-arc-second digital terrain elevation data (DTED), and georegistered using ground control points. This resulted in a root mean square registration error of less than 1 pixel (30 meters).

Lineage:

Source_Information:

Source_Citation:

Citation_Information:

Originator: U.S. Geological Survey EROS Data Center

Publication_Date: unknown

Title: Landsat TM scene

Geospatial_Data_Presentation_Form: remote sensing images

Publication_Information:

Publication_Place: Sioux Falls, SD 57198 USA

Publisher: EROS Data Center

Process_Step:

Process_Description:

Land Cover Characterization:

The project is being carried out on the basis of 10 Federal Regions that make up the conterminous United States; each region is comprised of multiple states; each region is processed in subregional units that are limited to the area covered by no more than 18 Landsat TM scenes. The general NLCD procedure is to: (1) mosaic subregional TM scenes and classify them using an unsupervised clustering algorithm, (2) interpret and label the clusters/classes using aerial photographs as reference data, (3)

resolve the labeling of confused clusters/classes using the appropriate ancillary data source(s), and (4) incorporate land cover information from other data sets and perform manual edits to augment and refine the "basic" classification developed above.

Two seasonally distinct TM mosaics are produced, a leaves-on version (summer) and a leaves-off (spring/fall) version. TM bands 3, 4, 5, and 7 are mosaicked for both the leaves-on and leaves-off versions. For mosaick purposes, a base scene is selected for each mosaic and the other scenes are adjusted to mimic spectral properties of the base scene using histogram matching in regions of spatial overlap. Following mosaicking, either the leaves-off version or leaves-on version Is selected to be the "base" for the land cover mapping process. The 4 TM bands of the "base" mosaic are clustered to produce a single 100-class image using an unsupervised clustering algorithm. Each of the spectrally distinct clusters/classes is then assigned to one or more Anderson level 1 and 2 land cover classes using National High Altitude Photography program (NHAP)and National Aerial Photography program (NAPP) aerial photographs as a reference. Almost invariably, individual spectral clusters/classes are confused between two or more land cover classes.

Separation of the confused spectral clusters/classes into appropriate NLCD class is accomplished using ancillary data layers. Standard ancillary data layers include: the "non-base" mosaic TM bands and 100-class cluster image; derived TM normalized vegetation index (NDVI), various TM band ratios, TM date bands; 3-arc second Digital Terrain Elevation Data (DTED) and derived slope, aspect and shaded relief; population and housing density data; USGS land use and land cover (LUDA); and National Wetlands Inventory(NWI) data if available. Other ancillary data sources may include soils data, unique state or regional land cover data sets, or data from other federal programs such as the National Gap Analysis Program (GAP) of the USGS Biological Resources Division (BRD). For a given confused spectral cluster/class, digital values of the various ancillary data layers are compared to determine:
(1) which data layers are the most effective for splitting the confused cluster/class into the appropriate NLCD class, and (2) the appropriate layer thresholds for making the split(s). Models are then developed using one to several ancillary data layers to split the confused cluster/class into the NLCD class. For example, a population density threshold is used to separate high-intensity residential areas from commercial/industrial/transportation. Or a cluster/class might be confused between row crop and grasslands. To split this particular cluster/class, a TM NDVI threshold might be identified and used with an elevation threshold in a class-splitting model to make the appropriate NLCD class assignments. A purely spectral example is using the temporally opposite TM layers to discriminate confused cluster/classes such as hay pasture vs. row crops and deciduous forests vs. evergreen forests; simple thresholds that contrast the seasonal differences in vegetation between leaves-on vs. leaves-off.

Not all cluster/class confusion can be successfully modeled out. Certain classes such as urban/recreational grasses or quarries/strip mines/gravel pits that are not spectrally unique require manual editing. These class features are typically visually identified and then reclassified using on-screen digitizing and recoding. Other classes such as wetlands require the use of specific data sets such as NWI to provide the most accurate classification. Areas lacking NWI data are typically subset out and modeling is used to estimate wetlands in these localized areas. The final NLCD

product results from the classification (interpretation and labeling) of the 100-class "base" cluster mosaic using both automated and manual processes, incorporating both spectral and conditional data layers. For a more detailed explanation please see Vogelmann et al. 1998 and Vogelmann et al. 1998.

Discussion:

While we believe that the approach taken has yielded a very good general land cover classification product for the nation, it is important to indicate to the user where there might be some potential problems. The biggest concerns are listed below:

1) Some of the TM data sets are not temporally ideal. Leaves-off data sets are heavily relied upon for discriminating between hay/pasture and row crop, and also for discriminating between forest classes. The success of discriminating between these classes using leaves-off data sets hinges on the time of data acquisition. When hay/pasture areas are non-green, they are not easily distinguishable from other agricultural areas using remotely sensed data. However, there is a temporal window during which hay and pasture areas green up before most other vegetation (excluding evergreens, which have different spectral properties); during this window these areas are easily distinguishable from other crop areas. The discrimination between hay/pasture and deciduous forest is likewise optimized by selecting data in a temporal window where deciduous vegetation has yet to leaf out. It is difficult to acquire a single-date of imagery (leaves-on or leaves-off) that adequately differentiates between both deciduous/hay and pasture and hay pasture/row crop.

2) The data sets used cover a range of years (see data sources), and changes that have taken place across the landscape over the time period may not have been captured. While this is not viewed as a major problem for most classes, it is possible that some land cover features change more rapidly than might be expected (e.g. hay one year, row crop the next).

3) Wetlands classes are extremely difficult to extract from Landsat TM spectral information alone. The use of ancillary information such as National Wetlands Inventory (NWI) data is highly desirable. We relied on GAP, LUDA, or proximity to streams and rivers as well as spectral data to delineate wetlands in areas without NWI data.

4) Separation of natural grass and shrub is problematic. Areas observed on the ground to be shrub or grass are not always distinguishable spectrally. Likewise, there was often disagreement between LUDA and GAP on these classes.

Acknowledgments

This work was performed under contract the U.S. Geological Survey (Contract 1434-CR-97-CN-40274).
Source_Used_Citation_Abbreviation: Landsat thematic mapper (TM)
Process_Date: 19991001
Process_Contact:
Contact_Information:
Contact_Organization_Primary:
Contact_Organization: U.S. Geological Survey EROS Data Center

Contact_Position: Customer Services Representative
Contact_Address:
Address_Type: mailing and physical address
Address: U.S. Geological Survey EROS Data Center
City: Sioux Falls
State_or_Province: SD
Postal_Code: 57198
Country: USA
Contact_Voice_Telephone: (605) 594 - 6551
Contact_TDD/TTY_Telephone: (605) 594 - 6933
Contact_Facsimile_Telephone: (605) 594 - 6589
Contact_Electronic_Mail_Address:
CUSTSERV@EDCMAIL.CR.USGS.GOV

Spatial_Data_Organization_Information:
Direct_Spatial_Reference_Method: raster
Raster_Object_Information:
Raster_Object_Type: Grid Cell
Row_Count: 17455
Column_Count: 23005
Vertical_Count: 1

Spatial_Reference_Information:
Horizontal_Coordinate_System_Definition.
Planar:
Map_Projection:
Map_Projection_Name: Albers Conical Equal Area
Albers_Conical_Equal_Area:
Standard_Parallel: 29.5
Standard_Parallel: 45.5
Longitude_of_Central_Meridian: -96.0
Latitude_of_Projection_Origin: 23.0
False_Easting: 0
False_Northing: 0
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: North American Datum 1983
Ellipsoid_Name: Geographic Reference System 80
Semi-major_Axis: 6378137
Denominator_of_Flattening_Ratio: 298.257
Entity_and_Attribute_Information:
Overview_Description:

Entity_and_Attribute_Overview:
NOTE - All classes may NOT be represented in a specific state data set. The class number represents the digital value of the class in the data set.

Water
11 Open Water
12 Perennial Ice/Snow

Developed
21 Low Intensity Residential
22 High Intensity Residential
23 Commercial/Industrial/Transportation

Barren
31 Bare Rock/Sand/Clay
32 Quarries/Strip Mines/Gravel Pits
33 Transitional

Vegetated; Natural Forested Upland
41 Deciduous Forest
42 Evergreen Forest
43 Mixed Forest

Shrubland
51 Shrubland

Non-natural Woody
61 Orchards/Vineyards/Other

Herbaceous Upland
71 Grasslands/Herbaceous

Herbaceous Planted/Cultivated
81 Pasture/Hay
82 Row Crops
83 Small Grains
84 Fallow
85 Urban/Recreational Grasses

Wetlands
91 Woody Wetlands
92 Emergent Herbaceous Wetlands

NLCD Land Cover Classification System Land Cover Class Definitions:

Water - All areas of open water or permanent ice/snow cover.

11. Open Water - areas of open water, generally with less than 25 percent or greater cover of water (per pixel).

12. Perennial Ice/Snow - All areas characterized by year-long cover of ice and/or snow.

Developed - areas characterized by high percentage (approximately 30% or greater) of constructed materials (e.g. asphalt, concrete, buildings, etc).

21. Low Intensity Residential - Includes areas with a mixture of constructed materials and vegetation. Constructed materials account for 30-80 percent of the cover. Vegetation may account for 20 to 70 percent of the cover. These areas most commonly include single-family housing units. Population densities will be lower than in high intensity residential areas.

22. High Intensity Residential - Includes heavily built up urban centers where people reside in high numbers. Examples include apartment complexes and row houses. Vegetation accounts for less than 20 percent of the cover. Constructed materials account for 80-100 percent of the cover.

23. Commercial/Industrial/Transportation - Includes infrastructure (e.g. roads, railroads, etc.) and all highways and all developed areas not classified as High Intensity Residential.

Barren - Areas characterized by bare rock, gravel, sad, silt, clay, or other earthen material, with little or no "green" vegetation present regardless of its inherent ability to support life. Vegetation, if present, is more widely spaced and scrubby than that in the "green" vegetated categories; lichen cover may be extensive.

31. Bare Rock/Sand/Clay - Perennially barren areas of bedrock, desert, pavement, scarps, talus, slides, volcanic material, glacial debris, and other accumulations of earthen material.

32. Quarries/Strip Mines/Gravel Pits - Areas of extractive mining activities with significant surface expression.

33. Transitional - Areas of sparse vegetative cover (less than 25 percent that are dynamically changing from one land cover to another, often because of land use activities. Examples include forest clearcuts, a transition phase between forest and agricultural land, the temporary clearing of vegetation, and changes due to natural causes (e.g. fire, flood, etc.)

Forested Upland - Areas characterized by tree cover (natural or semi-natural woody vegetation, generally greater than 6 meters tall); Tree canopy accounts for 25-100 percent of the cover.

41. Deciduous Forest - Areas dominated by trees where 75 percent or more of the tree species shed foliage simultaneously in response to seasonal change.

42. Evergreen Forest - Areas characterized by trees where 75 percent or more of the tree species maintain their leaves all year. Canopy is

never without green foliage.

43. Mixed Forest - Areas dominated by trees where neither deciduous nor evergreen species represent more than 75 percent of the cover present.

Shrubland - Areas characterized by natural or semi-natural woody vegetation with aerial stems, generally less than 6 meters tall with individuals or clumps not touching to interlocking. Both evergreen and diciduous species of true shrubs, young trees, and trees or shrubs that are small or stunted because of environmental conditions are included.

51. Shrubland - Areas dominated by shrubs; shrub canopy accounts for 25-100 percent of the cover. Shrub cover is generally greater than 25 percent when tree cover is less than 25 percent. Shrub cover may be less than 25 percent in cases when the cover of other life forms (e.g. herbaceous or tree) is less than 25 percent and shrubs cover exceeds the cover of the other life forms.

Non-natural Woody - Areas dominated by non-natural woody vegetation; non-natural woody vegetative canopy accounts for 25-100 percent of the cover. The non-natural woody classification is subject to the availability of sufficient ancillary data to differentiate non-natural woody vegetation from natural woody vegetation.

61. Orchards/Vineyards/Other - Orchards, vineyards, and other areas planted or maintained for the production of fruits, nuts, berries, or ornamentals.

Herbaceous Upland - Upland areas characterized by natural or semi- natural herbaceous vegetation; herbaceous vegetation accounts for 75-100 percent of the cover.

71. Grasslands/Herbaceous - Areas dominated by upland grasses and forbs. In rare cases, herbaceous cover is less than 25 percent, but exceeds the combined cover of the woody species present. These areas are not subject to intensive management, but they are often utilized for grazing.

Planted/Cultivated - Areas characterized by herbaceous vegetation That has been planted or is intensively managed for the production of food, feed, or fiber; or is maintained in developed settings for specific purposes. Herbaceous vegetation accounts for 75-100 percent of the cover.

81. Pasture/Hay - Areas of grasses, legumes, or grass-legume mixtures planted for livestock grazing or the production of seed or hay crops.

82. Row Crops - Areas used for the production of crops, such as corn, soybeans, vegetables, tobacco, and cotton.

83. Small Grains - Areas used for the production of graminoid crops such as wheat, barley, oats, and rice

84. Fallow - Areas used for the production of crops that are temporarily barren or with sparse vegetative cover as a result of being tilled in a management practice that incorporates prescribed alternation between cropping and tillage.

85. Urban/Recreational Grasses - Vegetation (primarily grasses) planted in developed settings for recreation, erosion control, or aesthetic purposes. Examples include parks, lawns, golf courses, airport grasses, and industrial site grasses.

Wetlands - Areas where the soil or substrate is periodically saturated with or covered with water as defined by Cowardin et al.

91. Woody Wetlands - Areas where forest or shrubland vegetation accounts for 25-100 percent of the cover and the soil or substrate is periodically saturated with or covered with water.

92. Emergent Herbaceous Wetlands - Areas where perennial herbaceous vegetation accounts for 75-100 percent of the cover and the soil or substrate is periodically saturated with or covered with water.

Entity_and_Attribute_Detail_Citation:
NLCD Regional Land Cover Classification System Key Rev. 07/99

Distribution_Information:
Distributor:
Contact_Information:
Contact_Organization_Primary:
Contact_Organization: U.S. Geological Survey, EROS Data Center
Contact_Position: Customer Services Representative
Contact_Address:
Address_Type: mailing and physical address
Address: Sioux Falls
City: SD
State_or_Province: SD
Postal_Code: 57198
Country: USA
Contact_Voice_Telephone: 605-594-6551
Contact_TDD/TTY_Telephone: 605-594-6933
Contact_Facsimile_Telephone: 605-594-6589
Contact_Electronic_Mail_Address: custserv@edcmail.cr.usgs.gov

Resource_Description: New York Land Cover
Distribution_Liability:

TSS from tributary loadings to the lake in an average year. These concentrations are based on the water years 1988 – 1990 and are based on the discrete measurements and daily average flow rates (Effler, 1996). The model values generated at the mouths of the tributaries should fall between the minimum and maximum. Table 19 presents total loadings of TKN, TP and TSS at the mouth of the six natural tributaries entering the lake as calculated by the lake watershed model.

Table 20: Suspended Solids Concentrations in Surface Discharges to Onondaga Lake (Effler, 1996).

Source	Suspended Solids Concentrations (mg/L)				
	Average	Median	Maximum	Minimum	n
Onondaga Creek	47.9	29	356	6	48
Ninemile Creek	24.7	22	74	2	49
METRO	13.8	12	86	5	49
Ley Creek	25.1	20	103	3	49
Harbor Brook	20.1	9	157	1	49

A comparison of TSS concentrations between Tables 19 and 20 can be done for Onondaga Creek, Nine Mile Creek, Harbor Brook and Ley Creek. The model concentrations of TSS for all four tributaries are between the minimum and maximum concentrations for all three storms. In addition, TSS concentrations estimated for Onondaga Creek and Nine Mile Creek were below average concentrations. This was expected since all three storm events were more frequent, and less intense than the average annual storm. The averages presented in Table 20 may include storms that

exceed the one-year storm in both duration and intensity, which would likely raise the average TSS concentrations.

Model results for Ley Creek and Harbor Brook due to storm three, exceeded the average concentrations in Table 20. Additionally, during storm two the model concentration of TSS for Harbor Brook was approximately the same as the average concentration. Although the cause is not known it can be seen in Table 21 that both Harbor Brook and Ley Creek are predominantly urban drainage basins. This may indicate that model is overestimating TSS for urban areas.

Comparison of Model and Historical Information

Another note to make concerning Table 19 is the overall concentrations of parameters relative to each stream. For instance, historically, concentrations of TKN and TP in Ley Creek have been consistently higher than any of the monitored sites on Onondaga Creek. The model results for TKN and TP show this relationship between Onondaga Creek and Ley Creek. However, the model results also indicate this trend for TSS, which is not accurate. TSS is historically higher in Onondaga Creek and is likely due to the Tully mud boils, which are not considered in the model. As a result Storms 1 and 2 had sample concentrations of TSS which were much higher than those calculated by the model at the Route 20 sample location down stream of the mud boils.

Influence of Model Inputs on Model Results

Each model input parameter has a limited accuracy and some amount of error. The amount of error introduced by each parameter influences the model results. When these parameters are combined the errors of each are compounded in the results. In other words, the errors are propagated. "The propagation of variances and covariances is commonly known in practice as propagation of errors" (Mikhail, 1976). It would have been ideal to study the effects of the accuracy of each parameter on the model results and then to study the effect of the compounded errors on the model results. However, this additional study was outside the scope of this project.

Since the land cover type classifications of the grid cells in the land cover data set directly influence the value of three parameters in the model algorithm, this model input was considered the driving factor of the model. As a result three model runs to assess the effects of land cover classification were done. These were the only three runs done with the model developed. It is understood, however, that other factors, sources of errors and assumptions could affect model results and these are discussed below.

Land Cover Type Classification

Tables 16, 17 and 18 summarize the results of the three model runs done to determine the effect, on model results, of misclassifying land cover type. The first observation

is that confusion based upon the producer's accuracy has a larger impact on the model results than based upon user's accuracy.

Another observation is that in most instances there is less than a five percent difference between Run 1 (assumed correct classification) and Runs 2 (results based on users' accuracy) and 3 (results based on producer's accuracy). However, those watersheds with more than a five percent difference are predominantly small, urban drainage basins such as Ley Creek, and the lower portions of Harbor Brook and Onondaga Creek. These urban drainage basins are more affected by misclassification and in two instances show percent differences as high as 26%. Table 21 presents the characteristics of the six natural sub-basins and it can be seen that the majority of Harbor Brook and Ley Creek watersheds are comprised of urban land cover types. In addition, although the entire Onondaga Creek basin is only about 15% urban, this 15% is almost entirely in sub basins OC2 and OC3. It is only when loadings from OC2 and OC3 are added in that an impact on the results is seen in Tables 16, 17 and 18. In general, the percent difference is zero until contributions from drainage basins OC2 and OC3 are added in. It is therefore concluded that urban sub-basins are more sensitive to land cover misclassification. This may be because the most commonly confused land cover types affecting the model are those that are found in predominantly urban areas such as residential, commercial, industrial, and transportation land cover types.

Table 21: Characteristics of the Six Natural Sub-basins in the Onondaga Lake Watershed.

	Saw Mill % Basin	Bloody Brook % Basin	Ley Creek % Basin	Onondaga % Basin	Harbor % Basin	Nine Mile % Basin
Predominant Land Cover Types						
Open Water	0.06	0.18	0.04	0.07	0.35	3.24
Low Intensity Residential	26.06	45.95	19.71	5.48	25.31	5.17
High Intensity Residential	7.42	15.41	13.85	5.07	13.73	0.89
Comm/Industrial/Transport	12.30	9.81	21.79	2.78	7.37	1.86
Quarries	0.21	0.12	0.06	0.16	0.00	0.14
Deciduous Forest	25.71	10.85	18.64	30.48	20.23	34.89
Evergreen Forest	0.04	0.03	0.11	0.69	0.17	0.41
Mixed Forest	2.16	2.97	5.07	21.82	6.99	9.52
Pasture/Hay	8.57	3.93	7.64	25.05	17.50	33.17
Row Crops	3.54	2.34	3.70	6.78	2.79	7.47
Urban/Recreational Grasses	11.31	8.39	8.75	1.11	5.38	2.18
Woody Wetlands	2.35	0.00	0.48	0.50	0.16	0.99
Emergent Herb. Wetlands	0.27	0.01	0.19	0.02	0.01	0.08
Predominant Hydrologic Soil Groups						
A =	0.61	2.70	1.37	3.00	0.87	0.95
B =	25.55	25.08	31.61	80.23	67.94	60.85
C =	37.32	25.72	32.80	13.89	15.69	26.39
D =	36.52	46.49	34.21	2.88	15.24	8.77
Predominant Slope Ranges						
Level, Nearly Level	66.45	67.39	67.37	19.11	31.71	24.27
Gently Sloping	29.51	28.87	28.76	37.03	45.01	41.40
Strongly Sloping	3.16	2.51	2.75	19.34	13.30	17.17
Moderately Steep	0.84	1.14	1.06	17.98	8.12	12.90
Steep	0.04	0.09	0.06	6.14	1.82	3.72
Very Steep	0.00	0.00	0.00	0.40	0.03	0.53

The percent difference based upon the producer's accuracy is (for the most part) positive for TKN and TP but negative for TSS. In other words, based on producer's accuracy, the Run 3 results are higher for TKN and TP and lower for TSS than Run 1. Therefore, if run under the assumption that all classifications are correct, Run 1, the model may be under estimating TKN and TP but over estimating TSS. The opposite is found when the results based upon the user's accuracy are generated. The percent difference based upon the user's accuracy is (for the most part) negative for TKN and TP but positive for TSS. In other words when calculations are done based on the user's accuracy, the results are low for TKN and TP and higher for TSS. Therefore if run under the assumption that all classifications are correct, Run 1, the model may be over estimating TKN and TP but under estimating TSS. When using model results for decision-making purposes, the impact of land cover type misclassification should be taken into consideration and worst case scenarios should be analyzed. A determination must be made as to whether over estimating a parameter or under estimating it is more of a concern. In addition, the acceptable error should be determined. If the amount of possible error based on user's or producer's accuracy is exceeded, the model accuracy may not be adequate.

Based on the above discussion of land cover type classification, two conclusions can be made. First, land cover type misclassification errors do not significantly affect the model results. The highest percentage of land cover type misclassification based on the user's and producer's accuracy, for the most part, resulted in less than a five

percent difference in model results. However, it should be noted that the results for small, urban watersheds are more sensitive to misclassification than the rural drainage basins. Second, the user's and producer's accuracies are "misclassification extremes", representing the highest possible percentage of misclassification. These accuracies affect the results in opposite ways and the model results fall between the two extremes. In general, these conclusions help to substantiate model confidence.

Soil Associations

There are a number of sources of error in the soil association data set. Some error was introduced during the production of this GIS data set. The source map used to digitize the Onondaga Creek watershed, was not the original source map used to digitize the areas surrounding the Onondaga Creek sub-basin. A duplicate map was used. Additionally, after digitizing the area surrounding the Onondaga Creek watershed, the lines at the border where the two data sets were to be joined, had to be shifted slightly so that they were connected as one continuous line.

In addition to error introduced during production of this GIS data set, some assumptions were made that could affect model results. The HSGs are broad classifications for physical properties of the soils, however, the actual, detailed physical properties of each soil could vary greatly within the HSG classification. It was also assumed that conditions prior to sampling the tributaries were average antecedent moisture conditions, AMC Condition II, and that all soils had been

thoroughly wetted by the time sampling had begun. Thus, the groups with dual assignments were classified as Group D soils. If the soils were not thoroughly wetted it may not have been appropriate to assign Group D to groups with dual assignments. In addition, the Onondaga Indian reservation on the soil map was assumed to be soil Group B because the soil types bordering the reservation were predominantly Group B. Finally, areas that were classified as "chemical/man made" were assumed to be soil Group D, worse case runoff.

If any of the hydrologic soil group classifications or the antecedent moisture conditions were to change, the curve numbers quantifying runoff properties would be affected. This could increase or decrease the amount of runoff accounted for by parameter R in the model algorithm, ultimately affecting the model results. The actual extent to which the model results are affected by these errors is unknown. The error introduced in the digitization process and due to boundary adjustments were random. Therefore, these errors would tend to balance out over the entire watershed canceling the overall effects of the individual errors.

Digital Elevation Model

The vertical Root Mean Square Error (RMSE) statistic is used to describe the vertical accuracy of a DEM and encompasses both random and systematic errors introduced during the production of the data. Since the desired accuracy standard for DEMs is meters it is assumed that the elevations are correct 7 meters. The percent slope

used as a basis for the slope parameter of the model algorithm is calculated as the vertical rise over the horizontal run for each pixel. If the accuracy is off a maximum of 7m in rise over the 25 m horizontal distance of the pixel then as much as a 28% difference in percent slope could be seen. An error of this magnitude might significantly affect the results if this kind of error were extremely common. However, if these errors are random, they would tend to balance out over the entire watershed canceling the overall effects of the individual errors.

Hydrography

When this data set was overlaid on the others data sets used for this project, it was not in alignment. To align the streams and lake boundaries of the NYSDOT hydrography set with the other data sets, the hydrography had to be shifted approximately 15 meters to the west and 15 meters to the south. Although the metadata indicated that the datum and projection were the same as the other data sets it is suspected, though not confirmed, that the problem is related to the projection of the data set. Since the loadings in the streams are based on the surrounding watershed and therefore, the watershed boundaries, the hydrography had little influence on the model results other than to assist in defining the watershed boundaries. In addition, if streams are shifted slightly, the land cover type classification of the pixels may be confused, classified as water instead of land cover type for the shoreline. However, it was shown earlier that the model results are not very sensitive to land cover type misclassifications and

therefore, this slight shift in water features would not have a large impact on the model results.

Watersheds

The watersheds were superimposed over the DEM and it was concluded that the boundaries were within two or three cells of where they should be based on topography. It is therefore assumed that all watershed boundaries are +/- 75 m of where they are supposed to be. It should be noted that upon inspection at various locations, the majority of the boundaries fell within the cell they were supposed to, however not all boundary cells were inspected. Where the boundaries are off two or three pixels, along ridge tops, the land cover and slope are likely to be the same in the general vicinity and thus will not change the loading calculations significantly. Additionally, it did not appear that errors at the boundaries were of the same magnitude nor were they all in the same direction. Therefore it was concluded that these errors are random and their combined effects will cancel out their individual effects. The worst that can happen to the model results, is that a portion of the runoff will be accounted for in one watershed instead of another.

Model Confidence

After exploring the sensitivity of the model results to the driving factor of the model, land cover type, and comparing model results with sample data and data summarized

by Dr. Effler, there is a high level of model confidence. It was determined that land cover type misclassification did not significantly affect the results. When the highest percentage of misclassification was assumed, most times, there was less than a 5% difference in concentrations results. It is noteworthy that the small, urban watersheds were more sensitive to misclassification than the rural drainage basins. Out of the 72 concentrations calculated (8 sites x 3 parameters x 3 storms), 63 resulted in model concentrations that were lower than sample concentrations. That is 87.5 % of the time the model calculated in-stream concentrations due to NPS loadings, which were less than the sample concentrations due to point, NPS and background loadings. In a few instances model results were higher for some of these instances reasonable explanations can be offered. Other factors, sources of errors and assumptions that could possibly affect model results were discussed, but to what extent they affect the model results, is unknown.

Potential Improvements

It was shown that if the model results are assumed correct, they can be used in conjunction with the sample data to estimate that portion of the in-stream concentration due to NPS loadings. Currently, there is no way to separate the point source, and background components of the in-stream sample concentrations from the NPS portion If this could be done through modeling, it would be an extremely useful tool for assisting in decision-making concerning water quality and water quality

improvement projects. Thus, some suggestions for improving the model should be considered.

There are a number of considerations that could give rise to more accurate model results. The EMCs used in this study were based upon national averages and were not specific to the local area. In addition, they were adapted to the NLCD land cover classification system from that used by the USEPA. There are a number of sampling programs currently being conducted by various municipalities in and around the Onondaga Lake watershed, related to NPS pollutant loadings to the lake and its tributaries. In addition, there are a number of private organizations with interests in Onondaga Lake watershed that may have data to contribute. These studies will yield more localized EMCs that better correspond to the NLCD land cover classification system, given enough time and sampling.

Another way in which the model could be improved is to consider more watershed parameters. Rather than grouping the physical characteristics of the soils into broad HSG classifications, specific properties could eventually be associated with each soil association so that more specific hydraulic calculations could be performed. Also the hydraulic characteristics of the tributaries and channel flow could be considered. In addition, as better, more accurate, higher resolution data becomes available it can be incorporated into the model. Finally it would be highly advantageous to design a graphic user interface that makes changing model parameters easier and/or that

allows the user to input locations for which the model calculates in-stream concentrations.

Possible Follow Up Studies

Any of the improvements mentioned above are areas in which possible follow up studies can be done. However, the next appropriate step is to do a statistical sensitivity analysis for the existing model. As discussed, each of the input data sets has an associated amount of error. The error associated with each set is then compounded when the data sets are used together. These errors have not been fully quantified and no statistical analysis has been done. Thus, the effects on the model results are still unknown.

Both a sensitivity analysis and more model runs will provide more information about model validity. The model can be run using more robust data sets as data improves and becomes more available. For example, as more storm event sample data becomes available, the corresponding sample sites and precipitation data can be input to generate additional model results. Likewise, EMCs generated through local studies and higher resolution land cover data can be used as they become available. All of this data can assist in model calibration in addition to model validation.

A final area suggested for follow up study is to perform a trend analysis using the data and model results. For example, loadings from the watersheds (concentration

per unit area) versus watershed characteristics such as land cover type, HSG, and slope could be investigated. Based upon this type of trend analyses and the statistical acceptability of model calculations, prioritization of areas of concern in the watershed can be done.

Chapter VI
Conclusions

Like many other urban lakes, Onondaga Lake is polluted. Pollution to the lake includes past and present, point and non-point source (NPS) pollution.

Today NPS pollution is the primary threat to water quality in New York State. To ultimately improve the water quality of New York's waters, including Onondaga Lake, it is now becoming extremely important that NPS pollution be addressed. As a result, a GIS model was developed for the Onondaga Lake watershed that can reasonably estimate in-stream pollutant concentrations due to NPS pollution loadings from the surrounding watershed.

Typically, water quality degradation due to NPS pollution is caused by the introduction of high concentrations of nutrients and sediment to surface waters. Three NPS pollution indicator parameters that are commonly sampled are two chemical nutrients, total kjeldahl nitrogen (TKN) and total phosphorous (TP), and a third physical parameter, total suspended solids (TSS). These pollutants are transported to surface waters from the contributing watershed through the movement of ground water and runoff. The quantity and rate of runoff from the surrounding watershed to the receiving waters is dependent upon watershed characteristics such as land cover type, soil type, stream proximity and slope.

A GIS lends itself to the analysis of those watershed characteristics that influence NPS pollutant loadings, since the strongest factors influencing the movement of groundwater and runoff are geographic in nature and have associated information. Different databases for the same geographic area can be combined, analyzed and the results of the analyses can be mapped and illustrated graphically. The GIS data used for this study included:

- Land Cover Type
- Soil Associations
- Digital Elevation Model
- Hydrography
- Watersheds
- Water Monitoring Sites

The GIS data sets were combined such that one data set was generated in which all the necessary information was retained from the various data sets. The final data set contained information on land cover type, hydrologic soil group, curve number, percent slope and distance from receiving stream in 25m x 25m grid cells. Using this final GIS data set, USEPA's estimated mean concentrations (EMCs) associated with land cover types and precipitation data, estimated in-stream concentrations due to NPS pollution were calculated. Each time the model was run, these calculations were performed for three parameters, at eight locations, during three storm events. It was determined that land cover was the driving factor of this model so two additional

model runs were performed to explore the impact of land cover type misclassification on model results.

The results of first model run were compared with other sources of information. The storm event sample data collected by OCDDS under the 1999 AMP was one source. A direct comparison cannot be done between the NPS concentrations calculated by the model and the in-stream sample concentrations, however, some observations can be made. 87.5 % of the time the model calculated in-stream concentrations due to NPS pollution, which were less than the sample concentrations. This was considered promising since the in-stream sample concentrations are due to contributions from point sources, non-point sources, and background loadings. In addition, it appears that the model is showing the same trends as the sample data does with concentrations of TKN and TP.

No trend was observed from storm to storm in the TSS sample data. However, model calculations of in-stream concentrations of TSS appear to be reasonable when compared to Dr. Steve Effler's data (Effler, 1996). It should be noted that this comparison also indicated that the model might be over estimating TSS in urban areas.

Finally, there exists a historical trend in which concentrations of TKN and TP in Ley Creek have been consistently higher than any of the monitored sites on Onondaga

Creek. The model results for TKN and TP show this relationship between Onondaga Creek and Ley Creek. However, the model results also indicate this trend for TSS, which is not correct.

The second and third runs of the model were done based on user's and producer's accuracy to determine model sensitivity to land cover type misclassification. When the most common misclassification was assumed, most times, there was less than a 5% difference in concentration results. It is noteworthy that the small, urban watersheds were more sensitive to misclassification than the rural drainage basins.

A high level of model confidence exists for the chemical parameters TKN and TP, however, model results for in-stream concentrations of TSS are questionable. Estimates of TKN and TP seem to be reasonable when compared to the OCDDS sample data in both magnitude and trend and when compared to historical trends. TSS estimates are generally reasonable, however, these estimates may be overestimated in small, urban areas based on Effler's data. In addition small urban areas may be more sensitive to land cover type misclassifications.

Many suggestions have been made to improve the model. Some of them are as follows:

- Acquisition and use of more localized EMCs that better correspond to the NLCD land cover classification system
- Consideration of more watershed parameters in the model
- Consideration of hydraulic characteristics of the tributaries and channel flow
- Development of a graphic user interface that
    - makes changing model parameters easier,
    - allows the user to input locations for which the model calculates in-stream concentrations,
    - and allows the user to update data sets more easily.

Any of these improvements are appropriate areas for follow up studies. However, a statistical sensitivity analysis for the existing model should be done first. The model user should be aware of model input quality and the sensitivity of the model to various parameters. In addition, the acceptable error for the task at hand should be determined. If the amount of maximum tolerated error is exceeded or if the mode data input quality is not high enough, the model accuracy may not be adequate

References

AGI (Association for Geographic Information), 1996, *GIS Dictionary*, University of Edinburg and Association for Geographic Information, URL:http://www.geo.ed.ac.uk/agidict/welcome.html.

Congalton, R.G., and Kass Green, 1999, *Assessing the Accuracy of Remotely Sensed Data: Principles and Practices,* CRC Press Inc., Boca Raton, Florida, pp. 9-10 & 45-46.

Effler, S. W., 1993, *The State of Onondaga Lake*, Onondaga Lake Management Conference, pp. 1-10.

Effler, S. W., 1996, *Limnological and Engineering Analysis of a Polluted Urban Lake*, Springer-Verlag New York Inc., pp. 1-110.

Halley, M. C., White, S. O. and Watkins, E. W., 2001, *ArcView GIS Extension for Estimating Curve Numbers*, URL:/http://www.esri.com/library/userconf/proc00 /professional/papers/PAP657/p657.htm.

Hamdy, A., and Mladen Todorovic, 2002, IT for Sustainable Water Management, *New Generation Water Technology 2002*, World Water Council, Sterling Publications Limited, London, England, pp. 18–20.

Harshadeep, N. R., 1990, *Geographic Information Systems as a Tool for Hydrologic Modeling: Application to the Onondaga Creek watershed*, Thesis, State University of New York, College of Environmental Science and Forestry.

Mikhail, E.M., 1976, *Observations and Least Squares*, University Press of America, Lanham, Maryland, pp. 76-85.

Monostory, L., 2001, *Onondaga County Drainage Basins*, Onondaga County Department of Health, Syracuse, New York.

NOAA (National Oceanic and Atmospheric Administration), 1999, *Local Climatological Data for Syracuse New York*, National Climatic Data Center, Asheville, North Carolina.

NRCS (National Resources Conservation Services), 2000, *Soil Hydrologic Classes for the State of New York*, supplied by F. Gaffney, NRCS – Syracuse, New York.

NYSDEC (New York State Department of Environmental Conservation), 1995, *NewYork State's Nonpoint Source Program*, A Status Report, Albany, NY, pp. 1-14.

NYSDOT (New York State Department of Transportation), 1999, *NYSDOT Region 3 Hydrography*, URL:http://www.nysgis.state.ny.us/gis/inventories/dot.htm.

OCDDS (Onondaga County Department of Drainage and Sanitation), 2001, *Onondaga Lake Ambient Monitoring Program 1999 Annual Report*, Syracuse, New York.

Schwab, G. O., Frevert, R.K., Edminster, T.W., Barnes, K.K., 1981, *Soil and Water Conservation Engineering*, Third Edition, John Wiley & Sons, New York, NY.

Terrene Institute, 1996, *A Watershed Approach to Urban Runoff: Handbook for Decision-makers*, Terrene Institute and USEPA (United States Environmental Protection Agency), Washington, DC.

USDA (United States Department of Agriculture), 1977, *Soil Survey of Onondaga County,* Soil Conservation Service in cooperation with Cornell University Agricultural Experiment Station, Onondaga County, NY.

USDA (United States Department of Agriculture), 2001, *National Soil Survey Handbook*, Hydrologic Group, Natural Resources Conservation Service, URL:http://www.statlab.iastate.edu/soils/ nssh/, Part 618.35.

USGS (United States Geological Survey), 1979, *7.5 minute Digital Elevation Models*, United States Geological Survey, Reston, VA.

USGS (United States Geological Survey), 1997, *New York Land Cover Data Set*, URL:http://edcwww.cr.usgs.gov/programs/lccp/nationallandcover.html.

USGS (United States Geological Survey), 1999, *Water Resources Data, New York, Water Year 1999, Volume 3, Western NY*, Water-Data Report NY-99-3.

USGS (United States Geological Survey), 2000, *Accuracy Assessment of 1992 National Land Cover Data: Methods and Results*, Tables 3 and 6, URL:http:// landcover.usgs.gov/accuracy.

Warren, V. Jr., Knapp, J.W., Lewis, G.L., Harbaugh T.E., 1977, Introduction to Hydrology, Harper and Row publishers, New York, NY, pp. 138-140 & 618-623.

APPENDIX A

AMLs USED IN THE DIGITIZATION OF THE ONONDAGA COUNTY SOIL ASSOCIATIONS DATA COVERAGE

This AML program (arcstart.aml) was used at the beginning of each ArcInfo session to insure that all parameters were consistent during each session and to expedite the process.

```
display 9999
digitizer altek32 com1:9600:8bit:none
&return
```

This AML program (aestart.aml) was used at the beginning of each ArcEdit session to insure that all parameters were consistent during each session and to expedite the process.

```
symbolitem arc 14
symbolitem label 1
setdrawsymbol 7
nodesnap closest 25
arcsnap on 20
intersectarcs all
drawe arc node label ids
draw
&return
```

This AML program (bckgrnd.aml) was in ArcEdit sessions to insure that all background parameters were consistent during each session and to expedite the process. Generally the coverage onctytic was used as the background cover because it contained the existing data and the tics used to geo-reference the additional data being generated.

```
backcov onctytic
backe arc node label ids
draw
&return
```

This AML program (findxy.aml) was used in ArcEdit to aid in the editing of the soil association coverage. When building the coverage, intersections were detected and this program automatically zooms in on the intersection of user provided coordinates. It was provided courtesy of James Halligan, SUNY ESF.

It has three arguments. Get the coordinates of the intersection from build for the x and y values and enter 100 so that the extent of the window opened is 100 units from top to bottom. At the command line enter "&Run Findxy (x value) (y value) 100".

```
&args x y z

&sv size %z%/2

&sv minx %x% - %size%
&sv miny %y% - %size%
&sv maxx %x% + %size%
&sv maxy %y% + %size%

mape %minx% %miny% %maxx% %maxy%

draw

&return
```

APPENDIX B

ONONDAGA COUNTY
SOIL SERIES, SOIL ASSOCIATIONS
AND RESPECTIVE HYDROLOGIC SOIL GROUPS

Onondaga County Soil Series and Respective Hydrologic Soil Groups – Provided courtesy of the New York State Division of the National Resource Conservation Service

SOIL NAME	HYDRO. GROUP	HYDRO. #	SOIL NAME	HYDRO. GROUP	HYDRO. #
ALTON	A	1	LAMSON	D	4
ANGOLA	C	3	LANSING	B	2
APPLETON	C	3	LIMA	B	2
ARKPORT	B	2	LOCKPORT	D	4
ARNOT	C/D	4	LORDSTOWN	C	3
AURORA	C	3	LYONS	D	4
BENSON	D	4	CHEM WASTE		4
BOMBAY	B	2	MADRID	B	2
BROCKPORT	D	4	MANHEIM	C	3
CAMILLUS	B	2	MARDIN	C	3
CANANDAIGUA	D	4	MINOA	C	3
CARLISLE	A/D	4	MOHAWK	B	2
CAZENOVIA	B	2	NAUMBURG	C	3
COLLAMER	C	3	NIAGARA	C	3
COLONIE	A	1	ODESSA	D	4
CONESUS	B	2	ONTARIO	B	2
CROGHAN	B	2	OTISVILLE	A	1
DARIEN	C	3	PALMS	A/D	4
DUNKIRK	B	2	PALMYRA	B	2
FARMINGTON	C	3	PHELPS	B	2
FONDA	D	4	QUARRIES		4
GALEN	B	2	RHINEBECK	D	4
GRAVEL PITS		4	SCHOHARIE	C	3
HAMLIN	B	2	TEEL	B	2
HERKIMER	B	2	URBAN LAND		4
HILTON	B	2	VOLUSIA	C	3
HONEOYE	B	2	WAMPSVILLE	B	2
HOWARD	A	1	WASSAIC	B	2
INDIAN RES.		2	WATER		0
KENDAIA	C	3	WAYLAND	C/D	4
LAIRDSVILLE	D	4	WILLIAMSON	C	3
LAKEMONT	D	4			

This MS Excel spreadsheet used lookup commands to associate the corresponding hydrologic soil group number (1-4) with each soil type. The percentage of each soil type in the soil associations was manually entered from information in the Onondaga County Soil Survey. Once both parameters were entered each hydrologic soil group number was multiplied by the percentage of the corresponding soil. These were then summed for each soil association and then divided by the total percentage of soil in the association to yield a weighted average hydrologic soil group number. This number was rounded and then converted to hydrologic soil groups A-D for each soil association.

ASSOC. #	SOIL 1	% SOIL 1	SOIL 1 HYDRO. #	SOIL 2	% SOIL 2	SOIL 2 HYDRO. #	SOIL 3	% SOIL 3	SOIL 3 HYDRO. #	ASSOC. HYDRO. #	ASSOC. HYDRO. CODE*
1	HONEOYE	70	2	LIMA	15	2				2	B
2	LANSING	70	2	CONESUS	20	2				2	B
3	ONTARIO	60	2	HILTON	15	2				2	B
4	MADRID	70	2	HILTON	15	2				2	B
5	BOMBAY	50	2	MADRID	30	2				2	B
6	CAZENOVIA	75	2							2	B
7	HONEOYE	50	2	LANSING	35	2				2	B
8	ONTARIO	55	2	MADRID	30	2				2	B
9	CONESUS	50	2	APPLETON	35	3				2	B
10	HILTON	55	2	APPLETON	30	3				2	B
11	MOHAWK	65	2	MANHEIM	20	3				2	B
12	KENDAIA	40	3	LIMA	35	2	LYONS	15	4	3	C
13	MARDIN	60	3	VOLUSIA	25	3				3	C
14	BENSON	40	4	WASSAIC	30	2	ROCK OTCRP	15	4	3	C
15	CAMILLUS	80	2							2	B
16	FARMINGTON	50	3	AURORA	30	3				3	C
17	WASSAIC	45	2	BENSON	35	4				3	C
18	LORDSTOWN	60	3	ARNOT	25	4				3	C
19	AURORA	40	3	FARMINGTON	35	3	ROCK OTCRP	15	4	3	C
20	BENSON	35	4	WASSAIC	25	2	ROCK OTCRP	15	4	3	C
21	CAMILLUS	75								2	B
22	ARNOT	40		LORDSTOWN	30		MARDIN	20	3	3	C

ASSOC. #	SOIL 1	% SOIL 1	SOIL 1 HYDRO. #	SOIL 2	% SOIL 2	SOIL 2 HYDRO. #	SOIL 3	% SOIL 3	SOIL 3 HYDRO. #	ASSOC. HYDRO. #	ASSOC. HYDRO. CODE*
23	AURORA	70	3	ANGOLA	10	3	DARIEN	10	3	3	C
24	LAIRDSVILLE	45	4	BROCKPORT	20	4	LOCKPORT	20	4	4	D
25	ARKPORT	40	2	COLONIE	35	1				2	B
26	CROGHAN	40	2	NAUMBURG	30	3				2	B
27	MINOA	45	3	LAMSON	30	4	GALEN	15	2	3	C
28	COLLAMER	60	3	DUNKIRK	25	2				3	C
29	COLLAMER	55	3	NIAGARA	25	3				3	C
30	NIAGARA	70	3	COLLAMER	20	3				3	C
31	WILLIAMSON	65	3	NIAGARA	20	3				3	C
32	SCHOHARIE	50	3	ODESSA	25	4				3	C
33	NIAGARA	55	3	CANANDAGUIA	30	2				3	C
34	FONDA	40	4	LAKEMONT	30	4				4	D
35	RHINEBECK	70	4	FONDA	15	4				4	D
36	HOWARD	55	1	HERKIMER	25	2				1	A
37	PALMYRA	60	2	HOWARD	15	1				2	B
38	WAMPSVILLE	40	2	PALMYRA	25	2	PHELPS	15	2	2	B
39	ALTON	60	1	OTISVILLE	20	1				1	A
40	PALMYRA	50	2	HOWARD	20	1				2	B
41	PALMYRA	60	2	HOWARD	20	1				2	B
42	TEEL	60	2	HAMLIN	15	2	WAYLAND	15	4	2	B
43	WAYLAND	60	4	TEEL	20	2				4	D
44	CARLISLE	50	4	PALMS	30	4				4	D
45	QUARRIES	100	4							4	D
46	GRAVEL PITS	100	4							4	D
47	URBAN LAND	100	4							4	D
48	CHEM. WASTE	100	2							2	B
49	INDIAN RES.	100	2							2	B
50	WATER	100	0							0	W

Soil Number	Soil Association	Hydst
40	PALMYRA-HOWARD	B
41	PALMYRA-HOWARD	B
42	TEEL-HAMLIN-WAYLAND	B
43	WAYLAND-TEEL	D
44	CARLISLE-PALMS	D
45	QUARRIES	D
46	GRAVEL PITS	D
47	URBAN LAND	D
48	CHEM. WASTE	D
49	INDIAN RES.	B
50	WATER	W

APPENDIX C

METADATA FOR DATA SETS

Soils Associations

Identification_Information:
Citation:
Citation_Information:
Originator: State University of New York College of Environmental Science and Forestry
Publication_Date: 200105
Title: Onondaga County, New York Soil Associations
Edition:
Geospatial_Data_Presentation_Form: Map
Publication_Information:
Publication_Place: Syracuse, New York
Publisher: State University of New York College of Environmental Science and Forestry, Mapping Science Laboratory
Description:
Abstract:
Contains soil associations represented by lines and polygons in Onondaga County. New York.
Purpose:
A generalized soil association layer suitable for use in GIS.
Supplemental_Information:
1:62,500 scale. Zone 18 of the UTM grid/projection system (Zone 18 is extended to cover New York State entirely in a single grid zone).
Time_Period_of_Content:
Time_Period_Information:
Range_of_Dates/Times:
Beginning_Date: 1989
Ending_Date: 2001
Currentness_Reference: Publication date
Status:
Progress: Complete
Maintenance_and_Update_Frequency: As needed
Spatial_Domain:
Bounding_Coordinates:
West_Bounding_Coordinate:
East_Bounding_Coordinate:
North_Bounding_Coordinate:
South_Bounding_Coordinate:
Keywords:
Theme:
Theme_Keyword_Thesaurus:
Theme_Keyword: Soil associations, environment
Place:
Place_Keyword_Thesaurus: None
Place_Keyword:
Onondaga County, New York
Native_Data_Set_Environment: ARC/INFO

Data_Quality_Information:
Logical_Consistency_Report: Topologically clean
Completeness_Report:

Linework consists of polygon features representing soil associations and water body outlines.

Positional_Accuracy:

Horizontal_Positional_Accuracy:

Horizontal_Positional_Accuracy_Report:

Digital data is tested by visual comparison with 1:62,500 scale General Soil Map of Onondaga County, New York source mapping.

Quantitative_Horizontal_Positional_Accuracy_Assessment:

Horizontal_Positional_Accuracy_Value:

Horizontal_Positional_Accuracy_Explanation:

Vertical_Positional_Accuracy:

Vertical_Positional_Accuracy_Report:

Quantitative_Vertical_Positional_Accuracy_Assessment:

Vertical_Positional_Accuracy_Value:

Vertical_Positional_Accuracy_Explanation:

Lineage:

Process_Step:

Process_Description:

Created by digitizing the General Soil Map of Onondaga County from the United States Department of Agriculture and Soil Conservation Service soil survey. Digitizing was done from 1989 to 2001 by a number of graduate students at State University of New York College of Environemtnal Science and Forestry using ARC/INFO. The 36" x 46" 1:62,500 scale map covers Onondaga County, New York State. The file was then compared to General Soil Map of Onondaga County 1:62,500 on a light table to insure the quality of digitization and all polygon labels were checked.

Process_Date: 200105

Spatial_Data_Organization_Information:

Direct_Spatial_Reference_Method: Vector

Spatial_Reference_Information:

Horizontal_Coordinate_System_Definition:

Planar:

Grid_Coordinate_System:

Grid_Coordinate_System_Name: Universal Transverse Mercator

Universal_Transverse_Mercator:

UTM_Zone_Number: 18

Transverse_Mercator:

Scale_Factor_at_Central_Meridian:

Longitude_of_Central_Meridian:

Latitude_of_Projection_Origin:

False_Easting:

False_Northing:

Planar_Coordinate_Information:

Planar_Coordinate_Encoding_Method: Coordinate pair

Coordinate_Representation:

Abscissa_Resolution:

Ordinate_Resolution:

Planar_Distance_Units: Meters

Geodetic_Model:

Horizontal_Datum_Name: North American Datum of 1927

Ellipsoid_Name:
Semi-major_Axis:
Denominator_of_Flattening_Ratio:

Distribution_Information:
Distributor:
Contact_Information:
Contact_Organization_Primary:
Contact_Organization: State Universtiy of New York College of Environmental Science and Forestry
Contact_Position: Mapping Science Laboratory
Con tact_Address:
Address_Type: Mailing and physical address
Address: Bray Hall, 1 Forestry Drive
City: Syracuse
State_or_Province: New York
Postal_Code: 13210
Country: USA
Contact_Voice_Telephone:
Contact_Facsimile_Telephone:
Contact_Electronic_Mail_Address:
Resource_Description: ononsoil
Distribution_Liability: None
Standard_Order_Process:
Digital_Form:
Digital_Transfer_Information:
Format_Name: ARCE
Digital_Transfer_Option:
Online_Option:
Computer_Contact_Information:
Network_Address:
Network_Resource_Name:
Fees.
Available for free

Metadata_Reference_Information:
Metadata_Date: 200105
Metadata_Contact:
Contact_Information:
Contact_Organization_Primary:
Contact_Organization: Mapping Science Laboratory
Contact_Address:
Address_Type: Mailing and physical address
Address: Bray Hall, 1 Forestry Drive
City: Syracuse
State_or_Province: New York
Postal_Code: 13210
Country: USA
Contact_Voice_Telephone:
Contact_Facsimile_Telephone:

Contact_Electronic_Mail_Address:
Metadata_Standard_Name: FGDC Content Standards for Digital Geospatial Metadata
Metadata_Standard_Version: FGDC-STD-001-1998

Land Cover

Identification_Information:
Citation:
Citation_Information:
Originator: U.S. Geological Survey (USGS)
Publication_Date: 19970101
Title: New York Land Cover Data Set
Edition: 1
Geospatial_Data_Presentation_Form: raster digital data
Publication_Information:
Publication_Place: Sioux Falls, SD USA
Publisher: U.S. Geological Survey
Online_Linkage: http://edcwww.cr.usgs.gov/programs/lccp/nationallandcover.html
Description:
Abstract:

These data can be used in a geographic information system (GIS) for any number of purposes such as assessing wildlife habitat, water quality, pesticide runoff, land use change, etc. The State data sets are provided with a 300 meter buffer beyond the State border to faciliate combining the State files into larger regions.

The user must have a firm understanding of how the datasets were compiled and the resulting limitations of these data. The National Land Cover Dataset was compiled from Landsat satellite TM imagery (circa 1992) with a spatial resolution of 30 meters and supplemented by various ancillary data (where available). The analysis and interpretation of the satellite imagery was conducted using very large, sometimes multi-state image mosaics (i.e. up to 18 Landsat scenes). Using a relatively small number of aerial photographs for 'ground truth', the thematic interpretations were necessarily conducted from a spatially-broad perspective. Furthermore, the accuracy assessments (see below) correspond to 'federal regions' which are groupings of contiguous States. Thus, the reliability of the data is greatest at the State or multi-State level. The statistical accuracy of the data is known only for the region.

Important Caution Advisory

With this in mind, users are cautioned to carefully scrutinize the data to see if they are of sufficient reliability before attempting to use the dataset for larger-scale or local analyses. This evaluation must be made remembering that the NLCD represents conditions in the early 1990s. The New York portion of the NLCD was created as part of land cover mapping activities for Federal Region II that includes the states of New York and New Jersey. The NLCD classification contains 21 different land cover categories with a

spatial resolution of 30 meters. The NLCD was produced as a cooperative effort between the U.S. Geological Survey (USGS) and the U.S. Environmental Protection Agency (US EPA) to produce a consistent, land cover data layer for the conterminous U.S. using early 1990s Landsat thematic mapper (TM) data purchased by the Multi-resolution Land Characterization (MRLC) Consortium. The MRLC Consortium is a partnership of federal agencies that produce or use land cover data. Partners include the USGS (National Mapping, Biological Resources, and Water Resources Divisions), US EPA, the U.S. Forest Service, and the National Oceanic and Atmospheric Administration.

Purpose:

The main objective of this project was to generate a generalized and nationally consistent land cover data layer for the entire conterminous United States. These data can be used as a layer in a geographic information system (GIS) for any number of purposes such assessing wildlife habitat, water quality and pesticide runoff, land use change, etc.

Supplemental_Information:

The land cover data files are provided as a 'Geo-TIFF'(on CDROM) or 8 bit binary files (from FTP site). The land cover data sets are single band raster images. The X/Y corner coordinates for New York are 1317210/2663820 (projection meters, center of Upper Left pixel).

Time_Period_of_Content:

Time_Period_Information:

Range_of_Dates/Times:

Beginning_Date: 1988

Ending_Date: 1993

Currentness_Reference: ground condition

Status:

Progress: Complete

Maintenance_and_Update_Frequency: As needed

Spatial_Domain:

Bounding_Coordinates:

West_Bounding_Coordinate: -78.955

East_Bounding_Coordinate: -72.029

North_Bounding_Coordinate: 45.897

South_Bounding_Coordinate: 39.989

Keywords:

Theme:

Theme_Keyword_Thesaurus: None

Theme_Keyword: Land Use/Land Cover, Land Management, Land Resources, EDC, EPA, EROS, Imagery, Land Characterization, Land Cover, Landsat, MRLC, Remote Sensing, Satellite, Space Imaging, USGS

Place:

Place_Keyword_Thesaurus: U.S. Department of Commerce, 1977, Countries, dependencies, areas of special sovereignty, and their principal administrative divisions (Federal Information Processing Standard 10-3):Washington, D.C., National Institute of Standards and Technology.

Place_Keyword: North America, United States of America

Place:

Place_Keyword_Thesaurus: U.S. Department of Commerce, 1987, Codes for the identification of the States, the District of Columbia, and the outlying areas of the United States and associated areas Federal Information Processing Standard 5-20; Washington, D.C., National Institute of Standards and Technology.

Place_Keyword: New York, NY

Access_Constraints: None.

Use_Constraints: None. Acknowledgement of the U.S. Geological Survey would be appreciated in products derived from these data.
Point_of_Contact:
Contact_Information:
Contact_Organization_Primary:
Contact_Organization: U.S. Geological Survey EROS Data Center
Contact_Position: Customer Services Representative
Contact_Address:
Address_Type: mailing and physical address
Address: U.S. Geological Survey, EROS Data Center
City: Sioux Falls
State_or_Province: SD
Postal_Code: 57198
Country: USA
Contact_Voice_Telephone: (605) 594-6151
Contact_TDD/TTY_Telephone: (605) 594-6933
Contact_Facsimile_Telephone: (605) 594-6589
Contact_Electronic_Mail_Address:
CUSTSERV@EDCMAIL.CR.USGS.GOV
Data_Set_Credit: This work was performed by the Raytheon STX Corporation under U.S. Geological Survey Contract 1434-92-C-40004.

Data_Quality_Information:
Attribute_Accuracy:
Attribute_Accuracy_Report:
An accuracy assessment is done on all NLCD on a Federal Region basis following a revision cycle that incorporates feedback from MRLC Consortium partners and affiliated users. The accuracy assessments are conducted by private sector vendors under contract to the USEPA. A protocol has been established by the USGS and USEPA that incorporates a two-stage, geographically stratified cluster sampling plan (Zhu et al., 1999) utilizing National Aerial Photography Program (NAPP) photographs as the sampling frame and the basic sampling unit. In this design a NAPP photograph is defined as a 1st stage or primary sampling unit (PSU), and a sampled pixel within each PSU is treated as a 2nd stage or secondary sampling unit (SSU).

PSU's are selected from a sampling grid based on NAPP flight-lines and photo centers, each grid cell measures 15' X 15' (minutes of latitude/longitude) and consists of 32 NHAP photographs. A geographically stratified random sampling is performed with 1 NAPP photo being randomly selected from each cell (geographic strata), if a sampled photo falls outside of the regional boundary it is not used. Second stage sampling is accomplished by selecting SSU's (pixels) within each PSU (NAPP photo) to provide the actual locations for the reference land cover classification.

The SSU's are manually interpreted and misclassification errors are estimated and described using a traditional error matrix as well as a number of other important measures including the overall proportion of pixels correctly classified, user's and producer's accuracy's, and omission and commission error probabilities. At the time of CD release (Summer 2000), the accuracy assessment was not complete. For the Region III accuracy assessment, please check the NLCD Website: http://edcwww.usgs.gov/programs/lccp/nationallandcover.html. The accuracy assessment numbers will be posted there around September, 2000.

While we believe that the approach taken has yielded a very good general land cover classification product for Region II, it is important to indicate to the user where there might be some potential problems. The biggest concerns for Region II are listed below:

1) Accurate definition of the transitional barren class was extremely difficult. The majority of pixels in this class correspond to clear-cut forests in various stages of regrowth. Spectrally, fresh clear-cuts are very similar to row-crops in the leaves-off data. Manual correction of coding errors was performed to improve differentiation between row-crops and clear-cuts, but some errors may still be found. As regrowth occurs in a clear-cut region, the definition of transitional barren versus a forested class becomes problematic. An attempt was made to classify only fresh clear-cuts or those in the earliest stages of regrowth, but there are likely forested regions classed as transitional barren and vice versa.

2) Due to the confusion between clear-cuts, regrowth in clear-cuts, Forested areas, and shrublands, no attempts were made to populate the shrubland classes. Any shrubland areas that exist in this area are classed in their like forest class, i.e. deciduous shrubland is classed as deciduous forest, etc.

Logical_Consistency_Report:

An unsupervised classification algorithm was used to classify the mosaicked multiple leaf-off TM scenes. Aerial photographs were used to interpret and label classes into land cover categories and ancillary data sources resolved the class confusion. Further land cover information from leaf-on TM data, NWI data, and other sources were incorporated to refine and augment the "basic" classification.

Completeness_Report: All photo-interpretable data are mapped.

Positional_Accuracy:

Horizontal_Positional_Accuracy:

Horizontal_Positional_Accuracy_Report:

Each Landsat Thematic Mapper image used to create the NLCD was precision terrain-corrected using 3-arc-second digital terrain elevation data (DTED), and georegistered using ground control points. This resulted in a root mean square registration error of less than 1 pixel (30 meters).

Lineage:

Source_Information:

Source_Citation:

Citation_Information:

Originator: U.S. Geological Survey EROS Data Center

Publication_Date: unknown

Title: Landsat TM scene

Geospatial_Data_Presentation_Form: remote sensing images

Publication_Information:

Publication_Place: Sioux Falls, SD 57198 USA

Publisher: EROS Data Center

Process_Step:

Process_Description:

Land Cover Characterization:

The project is being carried out on the basis of 10 Federal Regions that make up the conterminous United States; each region is comprised of multiple states; each region is processed in subregional units that are limited to the area covered by no more than 18 Landsat TM scenes. The general NLCD procedure is to: (1) mosaic subregional TM scenes and classify them using an unsupervised clustering algorithm, (2) interpret and label the clusters/classes using aerial photographs as reference data, (3)

resolve the labeling of confused clusters/classes using the appropriate ancillary data source(s), and (4) incorporate land cover information from other data sets and perform manual edits to augment and refine the "basic" classification developed above.

Two seasonally distinct TM mosaics are produced, a leaves-on version (summer) and a leaves-off (spring/fall) version. TM bands 3, 4, 5, and 7 are mosaicked for both the leaves-on and leaves-off versions. For mosaick purposes, a base scene is selected for each mosaic and the other scenes are adjusted to mimic spectral properties of the base scene using histogram matching in regions of spatial overlap. Following mosaicking, either the leaves-off version or leaves-on version Is selected to be the "base" for the land cover mapping process. The 4 TM bands of the "base" mosaic are clustered to produce a single 100-class image using an unsupervised clustering algorithm. Each of the spectrally distinct clusters/classes is then assigned to one or more Anderson level 1 and 2 land cover classes using National High Altitude Photography program (NHAP)and National Aerial Photography program (NAPP) aerial photographs as a reference. Almost invariably, individual spectral clusters/classes are confused between two or more land cover classes.

Separation of the confused spectral clusters/classes into appropriate NLCD class is accomplished using ancillary data layers. Standard ancillary data layers include: the "non-base" mosaic TM bands and 100-class cluster image; derived TM normalized vegetation index (NDVI), various TM band ratios, TM date bands; 3-arc second Digital Terrain Elevation Data (DTED) and derived slope, aspect and shaded relief; population and housing density data; USGS land use and land cover (LUDA); and National Wetlands Inventory(NWI) data if available. Other ancillary data sources may include soils data, unique state or regional land cover data sets, or data from other federal programs such as the National Gap Analysis Program (GAP) of the USGS Biological Resources Division (BRD). For a given confused spectral cluster/class, digital values of the various ancillary data layers are compared to determine:
(1) which data layers are the most effective for splitting the confused cluster/class into the appropriate NLCD class, and (2) the appropriate layer thresholds for making the split(s). Models are then developed using one to several ancillary data layers to split the confused cluster/class into the NLCD class. For example, a population density threshold is used to separate high-intensity residential areas from commercial/industrial/transportation. Or a cluster/class might be confused between row crop and grasslands. To split this particular cluster/class, a TM NDVI threshold might be identified and used with an elevation threshold in a class-splitting model to make the appropriate NLCD class assignments. A purely spectral example is using the temporally opposite TM layers to discriminate confused cluster/classes such as hay pasture vs. row crops and deciduous forests vs. evergreen forests; simple thresholds that contrast the seasonal differences in vegetation between leaves-on vs. leaves-off.

Not all cluster/class confusion can be successfully modeled out. Certain classes such as urban/recreational grasses or quarries/strip mines/gravel pits that are not spectrally unique require manual editing. These class features are typically visually identified and then reclassified using on-screen digitizing and recoding. Other classes such as wetlands require the use of specific data sets such as NWI to provide the most accurate classification. Areas lacking NWI data are typically subset out and modeling is used to estimate wetlands in these localized areas. The final NLCD

product results from the classification (interpretation and labeling) of the 100-class "base" cluster mosaic using both automated and manual processes, incorporating both spectral and conditional data layers. For a more detailed explanation please see Vogelmann et al. 1998 and Vogelmann et al. 1998.

Discussion:

While we believe that the approach taken has yielded a very good general land cover classification product for the nation, it is important to indicate to the user where there might be some potential problems. The biggest concerns are listed below:

1) Some of the TM data sets are not temporally ideal. Leaves-off data sets are heavily relied upon for discriminating between hay/pasture and row crop, and also for discriminating between forest classes. The success of discriminating between these classes using leaves-off data sets hinges on the time of data acquisition. When hay/pasture areas are non-green, they are not easily distinguishable from other agricultural areas using remotely sensed data. However, there is a temporal window during which hay and pasture areas green up before most other vegetation (excluding evergreens, which have different spectral properties); during this window these areas are easily distinguishable from other crop areas. The discrimination between hay/pasture and deciduous forest is likewise optimized by selecting data in a temporal window where deciduous vegetation has yet to leaf out. It is difficult to acquire a single-date of imagery (leaves-on or leaves-off) that adequately differentiates between both deciduous/hay and pasture and hay pasture/row crop.

2) The data sets used cover a range of years (see data sources), and changes that have taken place across the landscape over the time period may not have been captured. While this is not viewed as a major problem for most classes, it is possible that some land cover features change more rapidly than might be expected (e.g. hay one year, row crop the next).

3) Wetlands classes are extremely difficult to extract from Landsat TM spectral information alone. The use of ancillary information such as National Wetlands Inventory (NWI) data is highly desirable. We relied on GAP, LUDA, or proximity to streams and rivers as well as spectral data to delineate wetlands in areas without NWI data.

4) Separation of natural grass and shrub is problematic. Areas observed on the ground to be shrub or grass are not always distinguishable spectrally. Likewise, there was often disagreement between LUDA and GAP on these classes.

Acknowledgments

This work was performed under contract the U.S. Geological Survey (Contract 1434-CR-97-CN-40274).
Source_Used_Citation_Abbreviation: Landsat thematic mapper (TM)
Process_Date: 19991001
Process_Contact:
Contact_Information:
Contact_Organization_Primary:
Contact_Organization: U.S. Geological Survey EROS Data Center

Contact_Position: Customer Services Representative
Contact_Address:
Address_Type: mailing and physical address
Address: U.S. Geological Survey EROS Data Center
City: Sioux Falls
State_or_Province: SD
Postal_Code: 57198
Country: USA
Contact_Voice_Telephone: (605) 594 - 6551
Contact_TDD/TTY_Telephone: (605) 594 - 6933
Contact_Facsimile_Telephone: (605) 594 - 6589
Contact_Electronic_Mail_Address:
CUSTSERV@EDCMAIL.CR.USGS.GOV

Spatial_Data_Organization_Information:
Direct_Spatial_Reference_Method: raster
Raster_Object_Information:
Raster_Object_Type: Grid Cell
Row_Count: 17455
Column_Count: 23005
Vertical_Count: 1

Spatial_Reference_Information:
Horizontal_Coordinate_System_Definition.
Planar:
Map_Projection:
Map_Projection_Name: Albers Conical Equal Area
Albers_Conical_Equal_Area:
Standard_Parallel: 29.5
Standard_Parallel: 45.5
Longitude_of_Central_Meridian: -96.0
Latitude_of_Projection_Origin: 23.0
False_Easting: 0
False_Northing: 0
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: North American Datum 1983
Ellipsoid_Name: Geographic Reference System 80
Semi-major_Axis: 6378137
Denominator_of_Flattening_Ratio: 298.257
Entity_and_Attribute_Information:
Overview_Description:

Entity_and_Attribute_Overview:
NOTE - All classes may NOT be represented in a specific state data set. The class number represents the digital value of the class in the data set.

Water
11 Open Water
12 Perennial Ice/Snow

Developed
21 Low Intensity Residential
22 High Intensity Residential
23 Commercial/Industrial/Transportation

Barren
31 Bare Rock/Sand/Clay
32 Quarries/Strip Mines/Gravel Pits
33 Transitional

Vegetated; Natural Forested Upland
41 Deciduous Forest
42 Evergreen Forest
43 Mixed Forest

Shrubland
51 Shrubland

Non-natural Woody
61 Orchards/Vineyards/Other

Herbaceous Upland
71 Grasslands/Herbaceous

Herbaceous Planted/Cultivated
81 Pasture/Hay
82 Row Crops
83 Small Grains
84 Fallow
85 Urban/Recreational Grasses

Wetlands
91 Woody Wetlands
92 Emergent Herbaceous Wetlands

NLCD Land Cover Classification System Land Cover Class Definitions:

Water - All areas of open water or permanent ice/snow cover.

11. Open Water - areas of open water, generally with less than 25 percent or greater cover of water (per pixel).

12. Perennial Ice/Snow - All areas characterized by year-long cover of ice and/or snow.

Developed - areas characterized by high percentage (approximately 30% or greater) of constructed materials (e.g. asphalt, concrete, buildings, etc).

21. Low Intensity Residential - Includes areas with a mixture of constructed materials and vegetation. Constructed materials account for 30-80 percent of the cover. Vegetation may account for 20 to 70 percent of the cover. These areas most commonly include single-family housing units. Population densities will be lower than in high intensity residential areas.

22. High Intensity Residential - Includes heavily built up urban centers where people reside in high numbers. Examples include apartment complexes and row houses. Vegetation accounts for less than 20 percent of the cover. Constructed materials account for 80-100 percent of the cover.

23. Commercial/Industrial/Transportation - Includes infrastructure (e.g. roads, railroads, etc.) and all highways and all developed areas not classified as High Intensity Residential.

Barren - Areas characterized by bare rock, gravel, sad, silt, clay, or other earthen material, with little or no "green" vegetation present regardless of its inherent ability to support life. Vegetation, if present, is more widely spaced and scrubby than that in the "green" vegetated categories; lichen cover may be extensive.

31. Bare Rock/Sand/Clay - Perennially barren areas of bedrock, desert, pavement, scarps, talus, slides, volcanic material, glacial debris, and other accumulations of earthen material.

32. Quarries/Strip Mines/Gravel Pits - Areas of extractive mining activities with significant surface expression.

33. Transitional - Areas of sparse vegetative cover (less than 25 percent that are dynamically changing from one land cover to another, often because of land use activities. Examples include forest clearcuts, a transition phase between forest and agricultural land, the temporary clearing of vegetation, and changes due to natural causes (e.g. fire, flood, etc.)

Forested Upland - Areas characterized by tree cover (natural or semi-natural woody vegetation, generally greater than 6 meters tall); Tree canopy accounts for 25-100 percent of the cover.

41. Deciduous Forest - Areas dominated by trees where 75 percent or more of the tree species shed foliage simultaneously in response to seasonal change.

42. Evergreen Forest - Areas characterized by trees where 75 percent or more of the tree species maintain their leaves all year. Canopy is

never without green foliage.

43. Mixed Forest - Areas dominated by trees where neither deciduous nor evergreen species represent more than 75 percent of the cover present.

Shrubland - Areas characterized by natural or semi-natural woody vegetation with aerial stems, generally less than 6 meters tall with individuals or clumps not touching to interlocking. Both evergreen and diciduous species of true shrubs, young trees, and trees or shrubs that are small or stunted because of environmental conditions are included.

51. Shrubland - Areas dominated by shrubs; shrub canopy accounts for 25-100 percent of the cover. Shrub cover is generally greater than 25 percent when tree cover is less than 25 percent. Shrub cover may be less than 25 percent in cases when the cover of other life forms (e.g. herbaceous or tree) is less than 25 percent and shrubs cover exceeds the cover of the other life forms.

Non-natural Woody - Areas dominated by non-natural woody vegetation; non-natural woody vegetative canopy accounts for 25-100 percent of the cover. The non-natural woody classification is subject to the availability of sufficient ancillary data to differentiate non-natural woody vegetation from natural woody vegetation.

61. Orchards/Vineyards/Other - Orchards, vineyards, and other areas planted or maintained for the production of fruits, nuts, berries, or ornamentals.

Herbaceous Upland - Upland areas characterized by natural or semi- natural herbaceous vegetation; herbaceous vegetation accounts for 75-100 percent of the cover.

71. Grasslands/Herbaceous - Areas dominated by upland grasses and forbs. In rare cases, herbaceous cover is less than 25 percent, but exceeds the combined cover of the woody species present. These areas are not subject to intensive management, but they are often utilized for grazing.

Planted/Cultivated - Areas characterized by herbaceous vegetation That has been planted or is intensively managed for the production of food, feed, or fiber; or is maintained in developed settings for specific purposes. Herbaceous vegetation accounts for 75-100 percent of the cover.

81. Pasture/Hay - Areas of grasses, legumes, or grass-legume mixtures planted for livestock grazing or the production of seed or hay crops.

82. Row Crops - Areas used for the production of crops, such as corn, soybeans, vegetables, tobacco, and cotton.

83. Small Grains - Areas used for the production of graminoid crops such as wheat, barley, oats, and rice

84. Fallow - Areas used for the production of crops that are temporarily barren or with sparse vegetative cover as a result of being tilled in a management practice that incorporates prescribed alternation between cropping and tillage.

85. Urban/Recreational Grasses - Vegetation (primarily grasses) planted in developed settings for recreation, erosion control, or aesthetic purposes. Examples include parks, lawns, golf courses, airport grasses, and industrial site grasses.

Wetlands - Areas where the soil or substrate is periodically saturated with or covered with water as defined by Cowardin et al.

91. Woody Wetlands - Areas where forest or shrubland vegetation accounts for 25-100 percent of the cover and the soil or substrate is periodically saturated with or covered with water.

92. Emergent Herbaceous Wetlands - Areas where perennial herbaceous vegetation accounts for 75-100 percent of the cover and the soil or substrate is periodically saturated with or covered with water.

Entity_and_Attribute_Detail_Citation:
NLCD Regional Land Cover Classification System Key Rev. 07/99

Distribution_Information:
Distributor:
Contact_Information:
Contact_Organization_Primary:
Contact_Organization: U.S. Geological Survey, EROS Data Center
Contact_Position: Customer Services Representative
Contact_Address:
Address_Type: mailing and physical address
Address: Sioux Falls
City: SD
State_or_Province: SD
Postal_Code: 57198
Country: USA
Contact_Voice_Telephone: 605-594-6551
Contact_TDD/TTY_Telephone: 605-594-6933
Contact_Facsimile_Telephone: 605-594-6589
Contact_Electronic_Mail_Address: custserv@edcmail.cr.usgs.gov

Resource_Description: New York Land Cover
Distribution_Liability:

Although these data have been processed successfully on a computer system at the USGS, no warranty expressed or implied is made by the USGS regarding the use of the data on any other system, nor does the act of distribution constitute any such warranty.

Standard_Order_Process:

Digital_Form:

Digital_Transfer_Information:

Format_Name: GeoTIFF

Format_Information_Content:

GeoTIFF is a standard for storing georeference and geocoding information in a TIFF 6.0 compliant raster file (uncompressed). *Transfer_Size:* 401.6 MB

Digital_Transfer_Option:

Offline_Option:

Offline_Media: Compact Disc-Read Only Memory (CD-ROM)

Recording_Format: ISO 9660

Fees: Current prices for the GEOTIFF NLCD data sets on CD-ROM are $32.00 + $5.00 for shipping. Fees are subject to change. Call 1-888-ASK-USGS for current prices.

Ordering_Instructions: NLCD data may be obtained in the following ways:

1. Contacting the nearest Digital Cartographic Data Business Partner (GeoTIFF CD-ROM products only). A list of the Business Partners is available at: http://mapping.usgs.gov/www/partners/bpmain.html;
2. Calling 1-888-ASK-USGS
3. Ordering online via the USGS Global Land Information System at: http://edcwww.cr.usgs.gov/Webglis/
Users of the Global Land Information System should search under the Land Cover category.
4. Visiting and ordering online through the NLCD availability page at: http://edcwww.cr.usgs.gov/programs/lccp/mrlcreg.html

Technical_Prerequisites:

Geo-TIFF viewing software. Some examples are ESRI's ARC/EXPLORER and USGS's DLGV32. The DLGV32 viewer is available free for download at the MidContinent Mapping Center web site (http://mcmcweb.er.usgs.gov/). Digital image processing software or geographic information system software is required to analyze or otherwise manipulate the data.

Metadata_Reference_Information:

Metadata_Date: 19991001

Metadata_Contact:

Contact_Information:

Contact_Organization_Primary:

Contact_Organization: U.S. Geological Survey, EROS Data Center

Contact_Position: Customer Services Representative

Contact_Address:

Address_Type: mailing and physical address

Address: U.S. Geological Survey EROS Data Center

City: Sioux Falls

State_or_Province: SD

Postal_Code: 57198

Country: USA
Contact_Voice_Telephone: 605-594-6551
Contact_TDD/TTY_Telephone: 605-594-6933
Contact_Facsimile_Telephone: 605-594-6589
Contact_Electronic_Mail_Address: custserv@edcmail.cr.usgs.gov
Metadata_Standard_Name:
Federal Geographic Data Committee. Content standard for digital geospatial metadata (revised June 1998). Federal Geographic Data Committee. Washington, D.C.
Metadata_Standard_Version: FGDC-STD-001-1998

Digital Elevation Model

Identification_Information.
Citation:
Citation_Information:
Originator: U.S. Geological Survey
Publication_Date: 19790701
Title: 7.5 minute Digital Elevation Models
Geospatial_Data_Presentation_Form: map
Publication_Information:
Publication_Place: Reston, VA
Publisher: U. S. Geological Survey
Description:
Abstract:
Digital Elevation Model (DEM) is the terminology adopted by the USGS to describe terrain elevation data sets in a digital raster form. The standard DEM consists of a regular array of elevations cast on a designated coordinate projection system. The DEM data are stored as a series of profiles in which the spacing of the elevations along and between each profile is in regular whole number intervals. The normal orientation of data is by columns and rows. Each column contains a series of elevations ordered from south to north with the order of the columns from west to east. The DEM is formatted as one ASCII header record (A- record), followed by a series of profile records (B- records) each of which include a short B-record header followed by a series of ASCII integer elevations per each profile. The last physical record of the DEM is an accuracy record (C-record).

7.5-minute DEM (30- by 30-m data spacing, cast on Universal Transverse Mercator (UTM) projection). Provides coverage in 7.5- by 7.5-minute blocks. Each product provides the same coverage as a standard USGS 7.5-minute quadrangle without over edge. Coverage is for the Contiguous United States, Hawaii, and Puerto Rico.
Purpose:
DEM's can be used as source data for digital orthophotos, and, as layers in geographic information systems, for earth science analysis. DEM's can also serve as tools for volumetric analysis, for site location of towers, or for drainage basin delineation. These data were collected as part of the National Mapping Program.
Supplemental_Information:
7.5-minute DEMs have rows and columns which vary in length and are staggered. The UTM bounding coordinates form a quadrilateral (no two sides are parallel to each other), rather than a rectangle. The user will need to pad out the uneven rows and columns with blanks or flagged data values, if a rectangle is required for the user's application. Some software vendors have incorporated this function into their software for input of standard formatted USGS DEMs.
Time_Period_of_Content:
Time_Period_Information:
Range_of_Dates/Times:
Beginning_Date: 19790701
Ending_Date: Present
Currentness_Reference: ground condition
Status:
Progress: In work

Maintenance_and_Update_Frequency: Irregular

Spatial_Domain:

Bounding_Coordinates:

West_Bounding_Coordinate: -124.7333

East_Bounding_Coordinate: -067.9500

North_Bounding_Coordinate: 49.3833

South_Bounding_Coordinate: 24.5333

Keywords:

Theme:

Theme_Keyword_Thesaurus: none

Theme_Keyword: DEM, digital elevation model, digital terrain model, hypsography, altitude, height, contour line, digital contours

Place:

Place_Keyword_Thesaurus:

U.S. Department of Commerce, 1977, Countries, dependencies, areas of special sovereignty, and their principal administrative divisions (Federal Information Processing Standard 10-3):Washington, D.C., National Institute of Standards and Technology.

Place_Keyword: US, CA, MX,

Place_Keyword_Thesaurus:

U.S. Department of Commerce, 1987, Codes for the identification of the States, the District of Columbia and the outlying areas of The United States, and associated areas (Federal Information Processing Standard 5-2): Washington, D. C., National Institute of Standards and Technology.

Place_Keyword: FIPS code of State or Province

Place_Keyword_Thesaurus:

U.S. Department of Commerce,1990, Counties and equivalent entities of The United States, its possessions, and associated areas (Federal Information Processing Standard 6-4): Washington, D.C. National Institute of Standards and Technology.

Place_Keyword: FIPS code for county or counties.

Access_Constraints: None

Use_Constraints: None. Acknowledgement of the U.S. Geological Survey would be appreciated in products derived from these data.

Data_Quality_Information:

Attribute_Accuracy:

Attribute_Accuracy_Report:

The accuracy of a DEM is dependent upon the level of detail of the source and the grid spacing used to sample that source. The primary limiting factor for the level of detail of the source is the scale of the source materials. The proper selection of grid spacing determines the level of content thatmay be extracted from a given source during digitization.

Logical_Consistency_Report:

The fidelity of the relationships encoded in the data structure of the DEM are automatically verified using a USGS software program upon completion of the data production cycle. The test verifies full compliance to the DEM specification.

Completeness_Report:

The DEM is visually inspected for completeness on a DEM view and edit system for the purpose of performing a final quality control and if necessary edit of the DEM. The physical format of each digital elevation model is validated for content completeness and logical consistency during production quality control and prior to archiving in the National Digital Cartographic Data Base. Due to the variable orientation of the quadrilateral in relation to the

Universal Transverse Mercator (UTM) projection grid, profiles that pass within the bounds of the DEM quadrilateral, may be void of elevation grid points, and are not represented in the DEM. This condition occurs infrequently and is always the first or last profile of the dataset.

Level 2 DEM: Level 2 DEM's may contain void areas due to interruptions to contours in the source graphic or DLG. Void area elevation grid posts are assigned the value of -32,767. In addition, suspect elevation areas may exist in the DEM but are not specifically identified. Suspect areas can be located on the source graphic as a "disturbed surface, " symbolized by contours overprinted with photorevised or other surface patterns.

Positional_Accuracy:

Horizontal_Positional_Accuracy:

Horizontal_Positional_Accuracy_Report:

The horizontal accuracy of the DEM is expressed as an estimated root mean square error (RMSE). The estimate of the RMSE is based upon horizontal accuracy tests of the DEM source materials which are selected as equal to or less than intended horizontal RMSE error of the DEM. The testing of horizontal accuracy of the source materials isaccomplished by comparing the planimetric (X and Y) coordinates of well-defined ground points with the coordinates of the same points as determined from a source of higher accuracy.

Vertical_Positional_Accuracy:

Vertical_Positional_Accuracy_Report:

The vertical RMSE statistic is used to describe the vertical accuracy of a DEM, encompassing both random and systematic errors introduced during production of the data. The RMSE is encoded in element number 5 of record C of the DEM. Accuracy is computed by a comparison of linear interpolated elevations in the DEM with corresponding known elevations. Test points are well distributed, representative of the terrain, and have true elevations with accuracies well within the DEM accuracy criteria. Acceptable test points include, in order of preference: field control, aerotriangulated test points, spot elevations, or points on contours from existing source maps with appropriate contour interval. A minimum of 28 test points per DEM is required to compute the RMSE, which is composed of a single test using 20 interior points and 8 edge points. Edge points are those which are located along, at, or near the quadrangle neatlines and are deemed by the editor to be useful to evaluating the accuracy of the edge of the DEM. Collection of test point data and comparison of the DEM with the quadrangle hypsography are conducted by the quality control units within the USGS.

There are three types of DEM vertical errors; blunder, systematic and random. These errors are reduced in magnitude by editing but cannot be completely eliminated. Blunder errors are those errors of major proportions and are easily identified and removed during interactive editing. Systematic errors are those errors that follow some fixed pattern and are introduced by data collection procedures and systems. These error artifacts include: vertical elevation shifts, misinterpretation of terrain surface due to trees, buildings and shadows, and fictitious ridges, tops, benches or striations. Random errors result from unknown or accidental causes.

DEM's are edited to correctly depict elevation surfaces that correspond to water bodies of specified size.

Level 1 DEM: A RMSE of 7-meters or less is the desired accuracy standard. A RMSE of 15-meters is the maximum permitted. A 7.5-minute DEM at this level has an absolute elevation error tolerance of 50 meters (approximately three times the 15-

meter RMSE) for blunder errors for any grid node when compared to the true elevation. Any array of points in the DEM can not encompass more than 49 contiguous elevations in error by more than 21 meters (three times the 7-meter RMSE). Systematic errors that are within stated accuracy standards are tolerated

Level 2 DEM: A vertical RMSE of one-half of the contour interval, determined by the source map, is the maximum permitted. Systematic errors may not exceed one contour interval, determined by the source map, is the maximum permitted. Systematic errors may not exceed one contour interval specified by the source graphic. Level 2 DEMs have been processed or smoothed for consistency and edited to remove identifiable systematic errors.

Lineage:
Source_Information:
Source_Citation.
Citation_Information:
Originator: U.S. Geological Survey
Publication_Date: Unknown
Title: digital contour lines
Geospatial_Data_Presentation_Form: map
Publication_Information:
Publication_Place: Reston, VA
Publisher: U.S. Geological Survey
Type_of_Source_Media: magnetic tape
Source_Time_Period_of_Content:
Time_Period_Information:
Range_of_Dates/Times:
Beginning_Date: 19790701
Ending_Date: Present
Source_Currentness_Reference: ground condition
Source_Citation_Abbreviation: CONTOUR1
Source_Contribution:
hypsographic vector information which is interpolated to regular grid posts to form DEM grids in 30- by 30- meter UTM data spacing within the 7.5 minute DEM bounds.

Source_Information.
Source_Citation
Citation_Information:
Originator: U.S. Geological Survey
Publication_Date: Unknown
Title: photo ID number
Geospatial_Data_Presentation_Form: remote-sensing image
Publication_Information:
Publication_Place: Reston, VA
Publisher: U.S. Geological Survey
Type_of_Source_Media: transparency
Source_Time_Period_of_Content:
Time_Period_Information:
Range_of_Dates/Times:
Beginning_Date: Unknown
Ending_Date: Present
Source_Currentness_Reference: ground condition
Source_Citation_Abbreviation: PHOTO1

Source_Contribution: elevation values

Source_Information:
Source_Citation:
Citation_Information:
Originator: U.S. Geological Survey
Publication_Date: Unknown
Title: project control
Geospatial_Data_Presentation_Form: map
Publication_Information:
Publication_Place: Reston, VA
Publisher: U.S. Geological Survey
Type_of_Source_Media: magnetic tape
Source_Time_Period_of_Content:
Time_Period_Information:
Range_of_Dates/Times:
Beginning_Date: Unknown
Ending_Date: Present
Source_Currentness_Reference: ground condition
Source_Citation_Abbreviation: CONTROL1
Source_Contribution: ground control points

Process_Step:
Process_Description:
The production procedures, instrumentation, hardware and software used in the collection of standard U. S. Geological Survey (USGS) Digital Elevation Models (DEM's) vary depending on systems used at the contractor, cooperator or National Mapping Division (NMD) production sites. This process step describes, in general, the process used in the production of standard USGS DEM datasets.

Level 1 DEM: Level 1 DEM's are acquired photogrammetrically by manual profiling or image correlation techniques from National Aerial Photography Program (NAPP) or equivalent source photographs. Level 1 30-minute DEM's may be derived or resampled from level 1 7.5-minute DEM's.

Level 2 DEM: Level 2 DEM's are produced by converting 1:24,000-scale and 1:100,000-scale hypsography digital line graph (DLG) data to DEM format or the DEM's are generated from vector data derived from scanned raster files of USGS 1:24.000-scale or 1:100,000-scale map series contour separates.

Level 3 DEM: Level 3 DEM's are created from DLG data that has been vertically integrated with all categories of hypsography, hydrography, ridge line, break line, drain files and all vertical and horizontal control networks. The production of level 3 DEMs requires a system of logic incorporated into the software interpolation algorithms that clearly differentiates and correctly interpolates between the various types of terrain, data densities and data distribution.

Water body editing: DEM surface areas corresponding to water bodies are flattened and assigned map specified or estimated surface elevations. Water body areas are defined as ponds, lakes, and reservoirs that exceed 0.5 inches at map scale and double line drainage that exceeds 0.25 inches at map scale. Water body shorelines are derived either from a

hypsographic DLG or by interactive delineation from 1:24,000-scale or 1:100,000-scale USGS map series.

Edge matching: DEM datasets within a project area (consisting of a number of adjacent files) are edge matched to assure terrain surface continuity between files. Edge matching is the process of correcting adjacent elevation values along common edges. The objective of edge matching is to create more accurate terrain representations by correcting the alignment of ridges and drains, and overall topographic shaping within an approximately 25-30 row or column grid post zone on both edges.

Quality control: DEM's are viewed on interactive editing systems to identify and correct blunder and systematic errors. DEM's are verified for physical format and logical consistency at the production centers and before archiving in the National Digital Cartographic Data Base (NDCDB) utilizing the Digital Elevation Model Verification System (DVS) software.

Source_Used_Citation_Abbreviation: CONTOUR1, PHOTO1, CONTROL1

Process_Date: Unknown

Spatial_Data_Organization_Information:

Direct_Spatial_Reference_Method: raster

Raster_Object_Information:

Raster_Object_Type: grid cell

Spatial_Reference_Information:

Horizontal_Coordinate_System_Definition:

Planar:

Grid_Coordinate_System:

Grid_Coordinate_System_Name: Universal Transverse Mercator

Universal_Transverse_Mercator:

UTM_Zone_Number: 10-19

Transverse_Mercator:

Scale_Factor_at_Central_Meridian: .9996

Longitude_of_Central_Meridian: -123 00 00

Latitude_of_Projection_Origin: 0.0

False_Easting: 500000

False_Northing: 0.0

Planar_Coordinate_Information:

Planar_Coordinate_Encoding_Method: row and column

Coordinate_Representation:

Abscissa_Resolution: 30

Ordinate_Resolution: 30

Planar_Distance_Units: meters

Geodetic_Model:

Horizontal_Datum_Name: North American Datum 1927

Ellipsoid_Name: Clark 1866

Semi-major_Axis: 6378206.4

Denominator_of_Flattening_Ratio: 294.9787

Vertical_Coordinate_System_Definition:

Altitude_System_Definition:

Altitude_Datum_Name: National Geodetic Vertical Datum of 1929
Altitude_Resolution: 1
Altitude_Distance_Units: feet or meters
Altitude_Encoding_Method: explicit elevation coordinate included with horizontal coordinates

---

Distribution_Information:
Distributor:
Contact_Information:
Contact_Organization_Primary:
Contact_Organization: Earth Science Information Center, U.S. Geological Survey
Contact_Address:
Address_Type: mailing address
Address: 507 National Center
City: Reston
State_or_Province: Virginia
Postal_Code: 20192
Contact_Voice_Telephone: 1-888-ASK-USGS
Hours_of_Service: 0800-1600
Contact_Instructions:
In addition to the address above there are other ESIC offices throughout the country. A full list of these offices is at http://mapping.usgs.gov/esic/esic_index.html

Resource_Description: 7.5-minute digital elevation models
Distribution_Liability:
Although these data have been processed successfully on a computer system at the U.S. Geological Survey, no warranty expressed or implied is made by the Geological Survey regarding the utility of the data on any other system, nor shall the act of distribution constitute any such warranty. USGS will warrant the delivery of this product in computer-readable format. and will offer appropriate adjustment of credit when the product is determined unreadable by correctly adjusted computer input peripherals, or when the physical medium is delivered in damaged condition. Requests for adjustments of credit must be made within 90 days from the date of this shipment from the ordering site.

Standard_Order_Process:
Digital_Form:
Digital_Transfer_Information:
Format_Name: DEM
Format_Information_Content:
USGS standard DEM:
The standard USGS DEM can be described as an ASCII formatted elevation file preceded by a metadata header file which consists of one 1024 byte ACSII record.

Transfer_Size: 1
Digital_Transfer_Option:
Offline_Option:
Offline_Media: CD-ROM
Recording_Capacity:
Recording_Density: 680000
Recording_Density_Units: megabytes
Recording_Format: ISO 9660
Compatibility_Information:
This CD-ROM can be used with all computer operating systems that support CD-ROM as a logical storage device. All text files on the disc are in ASCII format. Data files are inASCII or binary format.
Offline_Option:
Offline_Media: Cartridge
Recording_Capacity:
Recording_Density: 3480
Recording_Density_Units: megabytes
Recording_Format:
ASCII; available unlabelled or with ANSI-standard labels; available block sizes are multiples of 1024 characters. To ensure compatibility, a maximum blocking factor of 31744 isrecommended. For efficiency, blocking factors less than 16,000 are discouraged.
Offline_Option:
Offline_Media: Cassette
Recording_Capacity:
Recording_Density: 8-mm High (4.5Gb)
Recording_Density_Units: gigabytes
Recording_Format:
ASCII; available unlabelled or with ANSI-standard labels; available block sizes are multiples of 1024 characters. To ensure compatibility, a maximum blocking factor of 31744 is recommended. For efficiency, blocking factors less than 16,000 are discouraged.
Offline_Option:
Offline_Media: Cassette
Recording_Capacity:
Recording_Density: 8-mm Low (2.3Gb)
Recording_Density_Units: gigabytes
Recording_Format:
ASCII; available unlabelled or with ANSI-standard labels; available block sizes are multiples of 1024 characters. To ensure compatibility, a maximum blocking factor of 31744 is recommended. For efficiency, blocking factors less than 16,000 are discouraged.

Fees:

The online copy of the data set (when available electronically) may be accessed without charge. For cartridge, cassette, and CD-ROM the costs are available at http://edc.usgs.gov/glis/hyper/order_info/prices#7_MIN_DEM

Ordering_Instructions:
Dataset searching and ordering capabilities are available through the Global Land Information System (GLIS) at http://edc.usgs.gov/webglis

---

Metadata_Reference_Information:
Metadata_Date: 199501
Metadata_Contact:
Contact_Information:
Contact_Organization_Primary:
Contact_Organization: U.S. Geological Survey
Contact_Address:
Address_Type: mailing address
Address: 508 National Center
City: Reston
State_or_Province: VA
Postal_Code: 20192
Contact_Voice_Telephone: 703 648 4543
Metadata_Standard_Name: Content Standards for Digital Geospatial Metadata
Metadata_Standard_Version: 19940608
Metadata_Security_Information:
Metadata_Security_Classification_System: None
Metadata_Security_Classification: Unclassified
Metadata_Security_Handling_Description: None

Hydrography

Identification_Information:
Citation:
Citation_Information:
Originator: New York State Department of Transportation
Publication_Date: 199906
Title: NYSDOT Region 3 Hydrography
Edition:
Geospatial_Data_Presentation_Form: Map
Publication_Information:
Publication_Place: Albany, New York
Publisher: New York State Department of Transportation, Mapping and GIS
Online_Linkage: <http://www.nysgis.state.ny.us/gis/inventories/dot.htm>
Description:
Abstract:
Contains hydrographic features represented by lines and polygons in NYSDOT Region 3.
Purpose:
A detailed hydrography layer suitable for use in GIS as well as the published NYSDOT County Base Maps.
Supplemental_Information:
1:100,000 scale. Zone 18 of the UTM grid/projection system (Zone 18 is extended to cover New York State entirely in a single grid zone).
Time_Period_of_Content:
Time_Period_Information:
Range_of_Dates/Times:
Beginning_Date: 1994
Ending_Date: present
Currentness_Reference: Publication date
Status:
Progress: Complete
Maintenance_and_Update_Frequency: As needed
Spatial_Domain:
Bounding_Coordinates:
West_Bounding_Coordinate: -76.98
East_Bounding_Coordinate: -75.75
North_Bounding_Coordinate: 43.82
South_Bounding_Coordinate: 42.26
Keywords:
Theme:
Theme_Keyword_Thesaurus: NYS GIS Clearinghouse categories
Theme_Keyword: Hydrography, environment
Theme:
Theme_Keyword_Thesaurus:
Theme_Keyword:
Cayuga Lake, Erie Canal, North Pond, Lake Ontario, Oneida Lake, Oneida River, Onondaga Lake, Oswego River, Otisco Lake, Owasco Lake, Salmon River Reservoir, Seneca Lake, Seneca River, Skaneateles Lake, bay, brook, canal, coastline, creek, dam, island, lake, pond, rapids, reservoir, river, stream, swamp, waterfall
Place:
Place_Keyword_Thesaurus: None
Place_Keyword:

NYSDOT Region 3, Cayuga County, Cortland County, Onondaga County, Oswego County, Seneca County, Tompkins County.

Access_Constraints:

Data is copyright protected, a signed license is required or access through the New York State GIS Data Sharing Cooperative.

Use_Constraints:

May not be redistributed, commercial use is prohibited with out special license arrangements

Browse_Graphic:

Browse_Graphic_File_Name: Not applicable

Browse_Graphic_File_Description: Not applicable

Browse_Graphic_File_Type: Not applicable

Native_Data_Set_Environment: ARC/INFO

Data_Quality_Information:

Logical_Consistency_Report: Topologically clean

Completeness_Report:

Linework consists of linear hydrography features and water body outlines. All streams or rivers at least one mile in length are shown. Streams or rivers greater than 200 feet wide for at least 0.5 miles are shown with double lines representing the shorelines. All open water bodies greater than 500 feet in the shortest dimension are shown. Various other hydrographic features such as rapids, waterfalls, dams, locks, canals, and aqueducts are identified and shown. Swamps greater than 2,000 feet in the shortest dimension are represented by polygons (no swamp symbology is shown). Islands must have dimensions greater than 100 feet by 300 feet to be shown. All hydrography features labeled on either the NYSDOT 1:75,000 scale County Base Maps (where available) or the NYSDOT 1:250,000 scale 4 sheet State Base Map are attributed in the file with the proper name. Linework is attributed with the following: identifying level, general category of feature, type of feature, proper name of hydrography feature (if available), source, grade separation and date of last feature modification. Polygons and their associated label points are attributed with: identifying level, general category of feature, type of feature, and proper name of hydrography feature (if available). ARC/INFO region subclasses (collections of polygons) are included for all water features (REGION.WATER), islands and incidental polygons (REGION.LAND) and swamps and land subject to inundation (REGION.WETLAND) classifications. The region subclasses are attributed with: identifying level, general category of feature, type of feature, and proper name of hydrography feature (if available).

Positional_Accuracy:

Horizontal_Positional_Accuracy:

Horizontal_Positional_Accuracy_Report:

Digital data is tested by visual comparison with NYSDOT 1:24,000 scale Quadrangle source mapping and/or aerial photography.

Quantitative_Horizontal_Positional_Accuracy_Assessment:

Horizontal_Positional_Accuracy_Value: 50.80

Horizontal_Positional_Accuracy_Explanation: No quantitative tests

Vertical_Positional_Accuracy:

Vertical_Positional_Accuracy_Report: Not applicable

Quantitative_Vertical_Positional_Accuracy_Assessment:

Vertical_Positional_Accuracy_Value: 0

Vertical_Positional_Accuracy_Explanation: Not applicable

Lineage:

Process_Step:

Process_Description.

Created by merging the USGS 30' x 60' 1:100,000 scale Digital Line Graphs (DLG) that cover New York State. The merged files were then reformatted and reclassified to the same standards as the existing County Base Map (CBM) hydrography files. Where CBM hydrography files exist, the DLG alignments were clipped out and replaced with the more up-to-date CBM files (also originally derived from 1:100,000 scale DLG files). The file was then compared to NYSDOT 1:24,000 scale quadrangles, and missing hydrography features were 'heads up'digitized from the raster quadrangle backdrops. Hydography alignments that follow civil boundaries have been clipped out and replaced with 1:24,000 scale boundary alignments to ensure clean vertical integration with the boundary layer.The file was also edge matched at the 7.5' x 7.5' quadrangle edges and along county boundaries where CBM Hydrography files replaced the DLG alignments. The file was converted from a CADD format to a GIS coverage as of the Process Date. Polygon topology was created on the GIS coverage and all polygons and linework were attributed with category and feature. All hydrography features labeled on either the published NYSDOT 1:75,000 scale County Base Maps (where available) or the 1:250,000 scale 4 sheet State Base Map were attributed in the file with their proper name. Three separate ARC/INFO region subclasses were created based on polygon attributes to easily differentiate between land, water, and wetland polygons.

Process_Date: 199805

Spatial_Data_Organization_Information:
Direct_Spatial_Reference_Method: Vector

Spatial_Reference_Information:
Horizontal_Coordinate_System_Definition:
Planar:
Grid_Coordinate_System:
Grid_Coordinate_System_Name: Universal Transverse Mercator
Universal_Transverse_Mercator:
UTM_Zone_Number: 18
Transverse_Mercator:
Scale_Factor_at_Central_Meridian: 0.99
Longitude_of_Central_Meridian: -75.00
Latitude_of_Projection_Origin: 0.00
False_Easting: 500000.0
False_Northing: 0.00
Planar_Coordinate_Information:
Planar_Coordinate_Encoding_Method: Coordinate pair
Coordinate_Representation:
Abscissa_Resolution: 0.61
Ordinate_Resolution: 0.61
Planar_Distance_Units: Meters
Geodetic_Model:
Horizontal_Datum_Name: North American Datum of 1927
Ellipsoid_Name: Clarke Ellipsoid of 1866
Semi-major_Axis: 6378206.40
Denominator_of_Flattening_Ratio: 294.98

Distribution_Information:
Distributor:
Contact_Information:
Contact_Organization_Primary:
Contact_Organization: New York State Department of Transportation, Mapping and GIS
Contact_Position: Map Information Unit
Con tact_Address:
Address_Type: Mailing and physical address
Address: State Office Campus, 4-105
City: Albany
State_or_Province: New York
Postal_Code: 12232-0415
Country: USA
Contact_Voice_Telephone: (518) 485-1428
Contact_Facsimile_Telephone: (518) 485-1820
Contact_Electronic_Mail_Address: mapinfo@gw.dot.state.ny.us
Resource_Description: r3hyd
Distribution_Liability: None
Standard_Order_Process:
Digital_Form:
Digital_Transfer_Information:
Format_Name: ARCE
Digital_Transfer_Option:
Online_Option:
Computer_Contact_Information:
Network_Address:
Network_Resource_Name:
<http://www.nysgis.state.ny.us/gis/inventories/dot.htm>
Fees:
Available for free electronic download to members of the NYS GIS Data Sharing Cooperative through the NYS GIS Clearinghouse <http://www.nysgis.state.ny.us/gis>: Others see <http://dot.state.ny.us/magis/magis.html>.

Metadata_Reference_Information:
Metadata_Date: 199906
Metadata_Contact:
Contact_Information:
Contact_Organization_Primary:
Contact_Organization: Map Information Unit
Contact_Address:
Address_Type: Mailing and physical address
Address: State Office Campus, 4-105
City: Albany
State_or_Province: New York
Postal_Code: 12232-0415
Country: USA
Contact_Voice_Telephone: (518) 485-1428
Contact_Facsimile_Telephone: (518) 485-1820
Contact_Electronic_Mail_Address: mapinfo@gw.dot.state.ny.us

Metadata_Standard_Name: FGDC Content Standards for Digital Geospatial Metadata
Metadata_Standard_Version: FGDC-STD-001-1998

Watersheds

Identification_Information:
Citation:
Citation_Information:
Originator: Les Monostory, Onondaga County Department of Health, Isaac Walton League
Publication_Date:
Title: Onondaga County Drainage Basins
Edition:
Geospatial_Data_Presentation_Form: Map
Publication_Information:
Publication_Place: Syracuse, New York
Publisher:
Description:
Abstract:
Contains drainage basins for major water bodies in Onondaga County
Purpose:
A draiange basin layer suitable for use in GIS.
Supplemental_Information:
Time_Period_of_Content:
Time_Period_Information:
Range_of_Dates/Times:
Beginning_Date:
Ending_Date: 2001
Currentness_Reference:
Status:
Progress: Complete
Maintenance_and_Update_Frequency: As needed
Spatial_Domain:
Bounding_Coordinates: ,
West_Bounding_Coordinate:
East_Bounding_Coordinate:
North_Bounding_Coordinate:
South_Bounding_Coordinate:
Keywords:
Theme:
Theme_Keyword_Thesaurus:
Theme_Keyword: drainage basin, water, environment
Place:
Place_Keyword_Thesaurus: None
Place_Keyword:
Onondaga County, New York
Native_Data_Set_Environment: ARC/INFO

Data_Quality_Information:
Logical_Consistency_Report: Topologically clean
Completeness_Report:
Linework consists of polygon features representing draiange basins of major water bodies.
Positional_Accuracy:
Horizontal_Positional_Accuracy:

Horizontal_Positional_Accuracy_Report:
Drainage basins tested by visual comparison with Digital Elevation Model and Hydrography for Onondaga County.
Quantitative_Horizontal_Positional_Accuracy_Assessment:
Horizontal_Positional_Accuracy_Value:
Horizontal_Positional_Accuracy_Explanation:
Vertical_Positional_Accuracy:
Vertical_Positional_Accuracy_Report:
Quantitative_Vertical_Positional_Accuracy_Assessment:
Vertical_Positional_Accuracy_Value:
Vertical_Positional_Accuracy_Explanation:

Lineage:
Process_Step:
Process_Description:
Hand delineated by Les Monostory of Onondaga County Health Department and founding member of the Isaac Walton League. Digitized by the City of Syracuse in ArcInfo.
Process_Date: 200105

Spatial_Data_Organization_Information:
Direct_Spatial_Reference_Method: Vector

Spatial_Reference_Information:
Horizontal_Coordinate_System_Definition.
Planar:
Grid_Coordinate_System:
Grid_Coordinate_System_Name: Universal Transverse Mercator
Universal_Transverse_Mercator:
UTM_Zone_Number: 18
Transverse_Mercator:
Scale_Factor_at_Central_Meridian:
Longitude_of_Central_Meridian:
Latitude_of_Projection_Origin:
False_Easting:
False_Northing:
Planar_Coordinate_Information:
Planar_Coordinate_Encoding_Method: Coordinate pair
Coordinate_Representation:
Abscissa_Resolution:
Ordinate_Resolution:
Planar_Distance_Units: Meters
Geodetic_Model:
Horizontal_Datum_Name: North American Datum of 1927
Ellipsoid_Name:
Semi-major_Axis:
Denominator_of_Flattening_Ratio:

Distribution_Information:
Distributor:
Contact_Information:

Contact_Organization_Primary:
Contact_Organization: New York State Universtiy College of Environmental Science and Forestry
Contact_Position: Map Science Laboratory
Con tact_Address:
Address_Type: Mailing and physical address
Address: Bray Hall, 1 Forestry Drive
City: Syracuse
State_or_Province: New York
Postal_Code: 13210
Country: USA
Contact_Voice_Telephone:
Contact_Facsimile_Telephone:
Contact_Electronic_Mail_Address:
Resource_Description: ononsoil
Distribution_Liability: None
Standard_Order_Process:
Digital_Form:
Digital_Transfer_Information:
Format_Name: ARCE
Digital_Transfer_Option:
Online_Option:
Computer_Contact_Information:
Network_Address:
Network_Resource_Name:
Fees.
Available for free

Metadata_Reference_Information:
Metadata_Date: 200105
Metadata_Contact:
Contact_Information:
Contact_Organization_Primary:
Contact_Organization: Mapping Science Laboratory
Contact_Address:
Address_Type: Mailing and physical address
Address: Bray Hall, 1 Forestry Drive
City: Syracuse
State_or_Province: New York
Postal_Code: 13210
Country: USA
Contact_Voice_Telephone:
Contact_Facsimile_Telephone:
Contact_Electronic_Mail_Address:
Metadata_Standard_Name: FGDC Content Standards for Digital Geospatial Metadata
Metadata_Standard_Version: FGDC-STD-001-1998

APPENDIX D

ARCVIEW SCRIPT USED TO MERGE DIGITAL ELEVATION MODELS

This program was written to be used in ArcView to merge the grid files of 21 digital elevation models. It was written and provided by Dr. Lee Herrington, SUNY ESF.

```
'Grid merge
'Use
'-compile the script
'-in view make the grid themes to be merged all active
'-click on the script window to run the script on the active view
'Get the active view
theView=av.GetActiveDoc
'Get the list of active themes
theGridThemeList=theView.GetActiveThemes
'create a gridlist and populate it from the grid theme list
gridList={}
for each themen in theGridThemeList
        gridList.Add(themen.GetGrid)
end
'extract the first grid (0) and then remove it from the list
aGrid=gridList.get(0)
gridList.remove(0)
msgBox.Info(gridList.Count.AsString,"")
'merge the extracted grid with the grids still in the list
outGrid=aGrid.Merge(gridList)
'make a Gtheme out of the new grid
newGTheme-Gtheme.Make(outGrid)
'add it to the view
theView.AddTheme(newGTheme)
'and draw it
theView.Invalidate
```

Digital Elevation Models merged:

Central Square, Lysander, Baldwinsville, Brewerton, Cicero, Cleveland, Jordan, Camillus, Syracuse West, Syracuse East, Manlius, Skaneateles, Marcellus, South Onondaga, Jamesville, Oran, Owasco, Spafford, Otisco Valley, Tully, Deruyter

APPENDIX E

EXAMPLE OCDDS 1999 AMP STORM EVENT SAMPLE DATA (OCDDS, 2001)

An example of the OCDDS 1999 AMP Storm Event Sample Data is included in the following pages for the Ley Creek sample site at Park St. For the full data set contact OCDDS.

Sample Data for Ley Creek at Park St – TKN

Date	Location	Time	Conc.	Units	USGS Flow	Loading
Storm 1						
11-Apr-99	Trib-Ley Crk @ Park	20:05:00	1.04	mg/l	47.10	48.99
11-Apr-99	Trib-Ley Crk @ Park	21:20:00	1.84	mg/l	75.58	139.06
11-Apr-99	Trib-Ley Crk @ Park	22:40:00	0.81	mg/l	86.62	70.16
12-Apr-99	Trib-Ley Crk @ Park	00:20:00	0.85	mg/l	72.86	61.93
12-Apr-99	Trib-Ley Crk @ Park	02:20:00	0.96	mg/l	55.64	53.41
12-Apr-99	Trib-Ley Crk @ Park	04:20:00	1.02	mg/l	46.50	47.43
12-Apr-99	Trib-Ley Crk @ Park	06:15:00	0.89	mg/l	41.65	37.07
12-Apr-99	Trib-Ley Crk @ Park	08:25:00	1.04	mg/l	39.19	40.75
12-Apr-99	Trib-Ley Crk @ Park	10:43:00	0.96	mg/l	37.28	35.79
12-Apr-99	Trib-Ley Crk @ Park	12:20:00	0.92	mg/l	34.83	32.05
12-Apr-99	Trib-Ley Crk @ Park	14:35:00	0.81	mg/l	34.53	27.97
12-Apr-99	Trib-Ley Crk @ Park	16:40:00	0.71	mg/l	33.06	23.48
12-Apr-99	Trib-Ley Crk @ Park	19:30:00	1.01	mg/l	31.06	31.37
12-Apr-99	Trib-Ley Crk @ Park	22:15:00	0.13	mg/l	29.82	3.88
13-Apr-99	Trib-Ley Crk @ Park	02:15:00	0.20	mg/l	28.60	5.72
13-Apr-99	Trib-Ley Crk @ Park	06:25:00	0.14	mg/l	27.27	3.82
13-Apr-99	Trib-Ley Crk @ Park	10:55:00	1.04	mg/l	27.75	28.86
13-Apr-99	Trib-Ley Crk @ Park	14:45:00	0.93	mg/l	27.15	25.25
13-Apr-99	Trib-Ley Crk @ Park	18:55:00	1.00	mg/l	26.44	26.44
13-Apr-99	Trib-Ley Crk @ Park	22:15:00	0.48	mg/l	25.75	12.36
14-Apr-99	Trib-Ley Crk @ Park	02:15:00	0.67	mg/l	25.06	16.79
14-Apr-99	Trib-Ley Crk @ Park	06:30:00	0.10	mg/l	25.06	2.51
14-Apr-99	Trib-Ley Crk @ Park	10:50:00	0.94	mg/l	25.06	23.56
14-Apr-99	Trib-Ley Crk @ Park	14:35:00	0.98	mg/l	24.38	23.90
	Totals =				928.25	822.53
	Average Concentration =		0.811			
	Flow Weighted Average Concentration =		0.886			
Storm 2						
29-Jun-99	Trib-Ley Crk @ Park	18:00:00	0.74	mg/l	37.54	27.78
29-Jun-99	Trib-Ley Crk @ Park	20:10:00	0.79	mg/l	55.65	43.96
29-Jun-99	Trib-Ley Crk @ Park	21:40:00	0.92	mg/l	31.01	28.53
29-Jun-99	Trib-Ley Crk @ Park	23:30:00	0.98	mg/l	27.25	26.70
30-Jun-99	Trib-Ley Crk @ Park	01:30:00	0.98	mg/l	17.67	17.31
30-Jun-99	Trib-Ley Crk @ Park	03:25:00	0.96	mg/l	19.88	19.09
30-Jun-99	Trib-Ley Crk @ Park	05:30:00	0.94	mg/l	15.53	14.60
30-Jun-99	Trib-Ley Crk @ Park	07:30:00	1.05	mg/l	16.53	17.36
30-Jun-99	Trib-Ley Crk @ Park	10:10:00	1.42	mg/l	13.90	19.74
30-Jun-99	Trib-Ley Crk @ Park	12:25:00	1.09	mg/l	14.65	15.96
30-Jun-99	Trib-Ley Crk @ Park	14:05:00	0.98	mg/l	12.56	12.31
30-Jun-99	Trib-Ley Crk @ Park	16:15:00	0.85	mg/l	13.11	11.14

30-Jun-99	Trib-Ley Crk @ Park	20:00:00	0.87	mg/l	12.08	10.51
30-Jun-99	Trib-Ley Crk @ Park	23:30:00	0.68	mg/l	11.25	7.65
01-Jul-99	Trib-Ley Crk @ Park	03:30:00	1.07	mg/l	10.11	10.82
01-Jul-99	Trib-Ley Crk @ Park	07:35:00	1.05	mg/l	9.38	9.85
01-Jul-99	Trib-Ley Crk @ Park	12:10:00	1.24	mg/l	8.89	11.03
01-Jul-99	Trib-Ley Crk @ Park	16:00:00	0.64	mg/l	8.68	5.55
01-Jul-99	Trib-Ley Crk @ Park	19:30:00	1.02	mg/l	8.66	8.83
01-Jul-99	Trib-Ley Crk @ Park	23:30:00	1.40	mg/l	8.36	11.71
02-Jul-99	Trib-Ley Crk @ Park	03:30:00	1.05	mg/l	10.84	11.38
02-Jul-99	Trib-Ley Crk @ Park	07:30:00	1.04	mg/l	13.28	13.81
02-Jul-99	Trib-Ley Crk @ Park	11:45:00	0.93	mg/l	15.27	14.20
02-Jul-99	Trib-Ley Crk @ Park	15:45:00	1.79	mg/l	17.97	32.16
	Totals =				410.05	402.00
	Average Concentration =		1.020			
	Flow Weighted Average Concentration =		0.980			
Storm 3						
13-Oct-99	Trib-Ley Crk @ Park	23:15:00	0.99	mg/l	86.16	85.30
14-Oct-99	Trib-Ley Crk @ Park	01:15:00	0.50	mg/l	196.21	98.10
14-Oct-99	Trib-Ley Crk @ Park	03:15:00	1.09	mg/l	213.61	232.84
14-Oct-99	Trib-Ley Crk @ Park	05:15:00	0.83	mg/l	164.25	136.33
14-Oct-99	Trib-Ley Crk @ Park	07:15:00	0.75	mg/l	130.30	97.72
14-Oct-99	Trib-Ley Crk @ Park	10:00:00	0.71	mg/l	119.58	84.90
14-Oct-99	Trib-Ley Crk @ Park	11:45:00	0.63	mg/l	107.47	67.71
14-Oct-99	Trib-Ley Crk @ Park	13:45:00	0.55	mg/l	87.28	48.00
14-Oct-99	Trib-Ley Crk @ Park	15:50:00	0.65	mg/l	69.66	45.28
14-Oct-99	Trib-Ley Crk @ Park	17:45:00	0.62	mg/l	60.01	37.21
14-Oct-99	Trib-Ley Crk @ Park	19:40:00	0.61	mg/l	51.89	31.65
14-Oct-99	Trib-Ley Crk @ Park	21:15:00	0.20	mg/l	46.07	9.21
15-Oct-99	Trib-Ley Crk @ Park	01:15:00	0.77	mg/l	35.78	27.55
15-Oct-99	Trib-Ley Crk @ Park	05:30:00	0.75	mg/l	28.55	21.41
15-Oct-99	Trib-Ley Crk @ Park	10:00:00	0.91	mg/l	23.02	20.95
15-Oct-99	Trib-Ley Crk @ Park	14:15:00	0.79	mg/l	20.55	16.23
15-Oct-99	Trib-Ley Crk @ Park	18:05:00	0.54	mg/l	18.76	10.13
15-Oct-99	Trib-Ley Crk @ Park	21:15:00	0.70	mg/l	18.19	12.73
16-Oct-99	Trib-Ley Crk @ Park	02:15:00	0.90	mg/l	17.08	15.37
16-Oct-99	Trib-Ley Crk @ Park	05:15:00	0.89	mg/l	15.53	13.82
16-Oct-99	Trib-Ley Crk @ Park	09:30:00	0.90	mg/l	14.59	13.13
16-Oct-99	Trib-Ley Crk @ Park	13:45:00	0.89	mg/l	13.72	12.21
16-Oct-99	Trib-Ley Crk @ Park	17:55:00	0.99	mg/l	12.82	12.69
16-Oct-99	Trib-Ley Crk @ Park	21:35:00	0.97	mg/l	12.46	12.09
	Totals =				1563.55	1162.59
	Average Concentration =		0.755			
	Flow Weighted Average Concentration =		0.744			

Sample Data for Ley Creek at Park St – TP

Date	Location	Time	Conc.	Units	USGS Flow	Loading
Storm 1						
11-Apr-99	Trib-Ley Crk @ Park	20:05:00	0.105	mg/l	47.10	4.95
11-Apr-99	Trib-Ley Crk @ Park	21:20:00	0.068	mg/l	[illegible]	5.14
11-Apr-99	Trib-Ley Crk @ Park	22:40:00	0.101	mg/l	[illegible]	8.75
12-Apr-99	Trib-Ley Crk @ Park	00:20:00	0.098	mg/l	72.86	7.14
12-Apr-99	Trib-Ley Crk @ Park	02:20:00	0.129	mg/l	55.64	7.18
12-Apr-99	Trib-Ley Crk @ Park	04:20:00	0.139	mg/l	46.50	6.46
12-Apr-99	Trib-Ley Crk @ Park	06:15:00	0.105	mg/l	41.65	4.37
12-Apr-99	Trib-Ley Crk @ Park	08:25:00	0.090	mg/l	[illegible]	3.53
12-Apr-99	Trib-Ley Crk @ Park	10:43:00	0.078	mg/l	[illegible]	2.91
12-Apr-99	Trib-Ley Crk @ Park	12:20:00	0.078	mg/l	[illegible]	2.72
12-Apr-99	Trib-Ley Crk @ Park	14:35:00	0.041	mg/l	[illegible]	1.42
12-Apr-99	Trib-Ley Crk @ Park	16:40:00	0.065	mg/l	[illegible]	2.15
12-Apr-99	Trib-Ley Crk @ Park	19:30:00	0.093	mg/l	31.06	2.89
12-Apr-99	Trib-Ley Crk @ Park	22:15:00	0.080	mg/l	29.82	2.39
13-Apr-99	Trib-Ley Crk @ Park	02:15:00	0.091	mg/l	28.60	2.60
13-Apr-99	Trib-Ley Crk @ Park	06:25:00	0.083	mg/l	27.27	2.26
13-Apr-99	Trib-Ley Crk @ Park	10:55:00	0.068	mg/l	[illegible]	1.89
13-Apr-99	Trib-Ley Crk @ Park	14:45:00	0.070	mg/l	[illegible]	1.90
		18:55:00	0.078	mg/l	[illegible]	2.06
13-Apr-99	Trib-Ley Crk @ Park	22:15:00	0.133	mg/l	[illegible]	3.42
14-Apr-99	Trib-Ley Crk @ Park	02:15:00	0.083	mg/l	[illegible]	2.08
14-Apr-99	Trib-Ley Crk @ Park	06:30:00	0.093	mg/l	[illegible]	2.33
14-Apr-99	Trib-Ley Crk @ Park	10:50:00	0.067	mg/l	25.06	1.68
14-Apr-99	[illegible]	14:35:00	0.064	mg/l	24.38	1.56
	Totals =				928.25	83.77
	Average Concentration =		0.088			
	Flow Weighted Average Concentration =		0.090			
Storm 2						
29-Jun-99	Trib-Ley Crk @ Park	18:00:00	0.097	mg/l	37.54	3.64
29-Jun-99	Trib-Ley Crk @ Park	20:10:00	0.186	mg/l	55.65	10.35
29-Jun-99	Trib-Ley Crk @ Park	21:40:00	0.190	mg/l	31.01	5.89
29-Jun-99	Trib-Ley Crk @ Park	23:30:00	0.082	mg/l	27.25	2.23
30-Jun-99	Trib-Ley Crk @ Park	01:30:00	0.179	mg/l	17.67	3.16
30-Jun-99	Trib-Ley Crk @ Park	03:25:00	0.117	mg/l	[illegible]	2.33
30-Jun-99	Trib-Ley Crk @ Park	05:30:00	0.178	mg/l	15.53	2.76
30-Jun-99	Trib-Ley Crk @ Park	07:30:00	0.164	mg/l	16.53	2.71
30-Jun-99	Trib-Ley Crk @ Park	10:10:00	0.148	mg/l	13.90	2.06
30-Jun-99	Trib-Ley Crk @ Park	12:25:00	0.128	mg/l	14.65	1.87
30-Jun-99	Trib-Ley Crk @ Park	14:05:00	0.137	mg/l	12.56	1.72
30-Jun-99	Trib-Ley Crk @ Park	16:15:00	0.125	mg/l	13.11	1.64

30-Jun-99	Trib-Ley Crk @ Park	20:00:00	0.129	mg/l	12.08	1.56
30-Jun-99	Trib-Ley Crk @ Park	23:30:00	0.138	mg/l	11.25	1.55
01-Jul-99	Trib-Ley Crk @ Park	03:30:00	0.145	mg/l	10.11	1.47
01-Jul-99	Trib-Ley Crk @ Park	07:35:00	0.128	mg/l	9.38	1.20
01-Jul-99	Trib-Ley Crk @ Park	12:10:00	0.143	mg/l	8.89	1.27
01-Jul-99	Trib-Ley Crk @ Park	16:00:00	0.091	mg/l	8.68	0.79
01-Jul-99	Trib-Ley Crk @ Park	19:30:00	0.130	mg/l	8.66	1.13
01-Jul-99	Trib-Ley Crk @ Park	23:30:00	0.141	mg/l	8.36	1.18
02-Jul-99	Trib-Ley Crk @ Park	03:30:00	0.160	mg/l	10.84	1.73
02-Jul-99	Trib-Ley Crk @ Park	07:30:00	0.136	mg/l	13.28	1.81
02-Jul-99	Trib-Ley Crk @ Park	11:45:00	0.130	mg/l	15.27	1.99
02-Jul-99	Trib-Ley Crk @ Park	15:45:00	0.114	mg/l	17.97	2.05
	Totals =				410.05	58.09
	Average Concentration =		0.138			
	Flow Weighted Average Concentration =		0.142			
Storm 3						
13-Oct-99	Trib-Ley Crk @ Park	23:15:00	0.150	mg/l	86.16	12.92
14-Oct-99	Trib-Ley Crk @ Park	01:15:00	0.306	mg/l	196.21	60.04
14-Oct-99	Trib-Ley Crk @ Park	03:15:00	0.360	mg/l	213.61	76.90
14-Oct-99	Trib-Ley Crk @ Park	05:15:00	0.213	mg/l	164.25	34.99
14-Oct-99	Trib-Ley Crk @ Park	07:15:00	0.159	mg/l	130.30	20.72
14-Oct-99	Trib-Ley Crk @ Park	10:00:00	0.137	mg/l	119.58	16.38
14-Oct-99	Trib-Ley Crk @ Park	11:45:00	0.119	mg/l	107.47	12.79
14-Oct-99	Trib-Ley Crk @ Park	13:45:00	0.128	mg/l	87.28	11.17
14-Oct-99	Trib-Ley Crk @ Park	15:50:00	0.215	mg/l	69.66	14.98
14-Oct-99	Trib-Ley Crk @ Park	17:45:00	0.169	mg/l	60.01	10.14
14-Oct-99	Trib-Ley Crk @ Park	19:40:00	0.115	mg/l	51.89	5.97
14-Oct-99	Trib-Ley Crk @ Park	21:15:00	0.104	mg/l	46.07	4.79
15-Oct-99	Trib-Ley Crk @ Park	01:15:00	0.112	mg/l	35.78	4.01
15-Oct-99	Trib-Ley Crk @ Park	05:30:00	0.183	mg/l	28.55	5.22
15-Oct-99	Trib-Ley Crk @ Park	10:00:00	0.086	mg/l	23.02	1.98
15-Oct-99	Trib-Ley Crk @ Park	14:15:00	0.168	mg/l	20.55	3.45
15-Oct-99	Trib-Ley Crk @ Park	18:05:00	0.095	mg/l	18.76	1.78
15-Oct-99	Trib-Ley Crk @ Park	21:15:00	0.092	mg/l	18.19	1.67
16-Oct-99	Trib-Ley Crk @ Park	02:15:00	0.099	mg/l	17.08	1.69
16-Oct-99	Trib-Ley Crk @ Park	05:15:00	0.099	mg/l	15.53	1.54
16-Oct-99	Trib-Ley Crk @ Park	09:30:00	0.080	mg/l	14.59	1.17
16-Oct-99	Trib-Ley Crk @ Park	13:45:00	0.072	mg/l	13.72	0.99
16-Oct-99	Trib-Ley Crk @ Park	17:55:00	0.081	mg/l	12.82	1.04
16-Oct-99	Trib-Ley Crk @ Park	21:35:00	0.075	mg/l	12.46	0.93
	Totals =				1563.55	307.27
	Average Concentration =		0.142			
	Flow Weighted Average Concentration =		0.197			

Sample Data for Ley Creek at Park St – TSS

Date	Location	Time	Conc.	Units	USGS Flow	Loading
Storm 1						
11-Apr-99	Trib-Ley Crk @ Park		22	mg/l	47.10	1036.30
11-Apr-99	Trib-Ley Crk @ Park		24	mg/l	75.58	1813.81
11-Apr-99	Trib-Ley Crk @ Park		38	mg/l	86.62	3291.49
12-Apr-99	Trib-Ley Crk @ Park		33	mg/l	72.86	2404.27
12-Apr-99	Trib-Ley Crk @ Park		40	mg/l	55.64	2225.61
12-Apr-99	Trib-Ley Crk @ Park		37	mg/l	46.50	1720.49
12-Apr-99	Trib-Ley Crk @ Park		33	mg/l	41.65	1374.43
12-Apr-99	Trib-Ley Crk @ Park		29	mg/l	39.19	1136.39
12-Apr-99	Trib-Ley Crk @ Park		22	mg/l	37.28	820.19
12-Apr-99	Trib-Ley Crk @ Park		18	mg/l	34.83	626.98
12-Apr-99	Trib-Ley Crk @ Park		11	mg/l	34.53	379.84
12-Apr-99	Trib-Ley Crk @ Park		8	mg/l	33.06	264.51
12-Apr-99	Trib-Ley Crk @ Park		22	mg/l	31.06	683.31
12-Apr-99	Trib-Ley Crk @ Park		19	mg/l	29.82	566.51
13-Apr-99	Trib-Ley Crk @ Park		13	mg/l	28.60	371.80
13-Apr-99	Trib-Ley Crk @ Park		23	mg/l	27.27	627.26
13-Apr-99	Trib-Ley Crk @ Park		16	mg/l	27.75	444.02
13-Apr-99	Trib-Ley Crk @ Park		18	mg/l	27.15	488.75
13-Apr-99	Trib-Ley Crk @ Park		23	mg/l	26.44	608.23
13-Apr-99	Trib-Ley Crk @ Park		23	mg/l	25.75	592.19
14-Apr-99	Trib-Ley Crk @ Park		31	mg/l	25.06	776.89
14-Apr-99	Trib-Ley Crk @ Park		29	mg/l	25.06	726.76
14-Apr-99	Trib-Ley Crk @ Park		18	mg/l	25.06	451.10
14-Apr-99	Trib-Ley Crk @ Park		13	mg/l	24.38	317.00
	Totals =				928.25	23748.11
	Average Concentration =		23.458			
	Flow Weighted Average Concentration =		25.584			
Storm 2						
29-Jun-99	Trib-Ley Crk @ Park	18:00:00	19	mg/l	37.54	713.24
29-Jun-99	Trib-Ley Crk @ Park	20:10:00	36	mg/l	55.65	2003.26
29-Jun-99	Trib-Ley Crk @ Park	21:40:00	38	mg/l	31.01	1178.57
29-Jun-99	Trib-Ley Crk @ Park	23:30:00	41	mg/l	27.25	1117.21
30-Jun-99	Trib-Ley Crk @ Park	01:30:00	40	mg/l	17.67	706.68
30-Jun-99	Trib-Ley Crk @ Park	03:25:00	35	mg/l	19.88	695.94
30-Jun-99	Trib-Ley Crk @ Park	05:30:00	31	mg/l	15.53	481.53
30-Jun-99	Trib-Ley Crk @ Park	07:30:00	26	mg/l	16.53	429.86
30-Jun-99	Trib-Ley Crk @ Park	10:10:00	21	mg/l	13.90	291.95
30-Jun-99	Trib-Ley Crk @ Park	12:25:00	15	mg/l	14.65	219.69
30-Jun-99	Trib-Ley Crk @ Park	14:05:00	13	mg/l	12.56	163.23
30-Jun-99	Trib-Ley Crk @ Park	16:15:00	18	mg/l	13.11	235.93

30-Jun-99	Trib-Ley Crk @ Park	20:00:00	20	mg/l	12.08	241.61
30-Jun-99	Trib-Ley Crk @ Park	23:30:00	24	mg/l	11.25	270.10
01-Jul-99	Trib-Ley Crk @ Park	03:30:00	22	mg/l	10.11	222.38
01-Jul-99	Trib-Ley Crk @ Park	07:35:00	18	mg/l	9.38	168.89
01-Jul-99	Trib-Ley Crk @ Park	12:10:00	16	mg/l	8.89	142.30
01-Jul-99	Trib-Ley Crk @ Park	16:00:00	11	mg/l	8.68	95.46
01-Jul-99	Trib-Ley Crk @ Park	19:30:00	17	mg/l	8.66	147.14
01-Jul-99	Trib-Ley Crk @ Park	23:30:00	23	mg/l	8.36	192.30
02-Jul-99	Trib-Ley Crk @ Park	03:30:00	26	mg/l	10.84	281.83
02-Jul-99	Trib-Ley Crk @ Park	07:30:00	22	mg/l	13.28	292.09
02-Jul-99	Trib-Ley Crk @ Park	11:45:00	16	mg/l	15.27	244.37
02-Jul-99	Trib-Ley Crk @ Park	15:45:00	12	mg/l	17.97	215.62
	Totals =				410.05	10751.17
	Average Concentration =		23.333			
	Flow Weighted Average Concentration =		26.219			
Storm 3						
13-Oct-99	Trib-Ley Crk @ Park	23:15:00	117	mg/l	86.16	10080.82
14-Oct-99	Trib-Ley Crk @ Park	01:15:00	142	mg/l	196.21	27861.22
14-Oct-99	Trib-Ley Crk @ Park	03:15:00	183	mg/l	213.61	39091.37
14-Oct-99	Trib-Ley Crk @ Park	05:15:00	87	mg/l	164.25	14289.98
14-Oct-99	Trib-Ley Crk @ Park	07:15:00	43	mg/l	130.30	5602.77
14-Oct-99	Trib-Ley Crk @ Park	10:00:00	41	mg/l	119.58	4902.58
14-Oct-99	Trib-Ley Crk @ Park	11:45:00	29	mg/l	107.47	3116.74
14-Oct-99	Trib-Ley Crk @ Park	13:45:00	24	mg/l	87.28	2094.60
14-Oct-99	Trib-Ley Crk @ Park	15:50:00	23	mg/l	69.66	1602.25
14-Oct-99	Trib-Ley Crk @ Park	17:45:00	29	mg/l	60.01	1740.41
14-Oct-99	Trib-Ley Crk @ Park	19:40:00	34	mg/l	51.89	1764.26
14-Oct-99	Trib-Ley Crk @ Park	21:15:00	41	mg/l	46.07	1889.00
15-Oct-99	Trib-Ley Crk @ Park	01:15:00	33	mg/l	35.78	1180.90
15-Oct-99	Trib-Ley Crk @ Park	05:30:00	23	mg/l	28.55	656.68
15-Oct-99	Trib-Ley Crk @ Park	10:00:00	19	mg/l	23.02	437.40
15-Oct-99	Trib-Ley Crk @ Park	14:15:00	16	mg/l	20.55	328.74
15-Oct-99	Trib-Ley Crk @ Park	18:05:00	14	mg/l	18.76	262.63
15-Oct-99	Trib-Ley Crk @ Park	21:15:00	17	mg/l	18.19	309.27
16-Oct-99	Trib-Ley Crk @ Park	02:15:00	20	mg/l	17.06	341.53
16-Oct-99	Trib-Ley Crk @ Park	05:15:00	21	mg/l	15.53	326.20
16-Oct-99	Trib-Ley Crk @ Park	09:30:00	16	mg/l	14.59	233.46
16-Oct-99	Trib-Ley Crk @ Park	13:45:00	12	mg/l	13.72	164.67
16-Oct-99	Trib-Ley Crk @ Park	17:55:00	9	mg/l	12.82	115.34
16-Oct-99	Trib-Ley Crk @ Park	21:35:00	16	mg/l	12.46	199.42
	Totals =				1563.55	118592.24
	Average Concentration =		42.042			
	Flow Weighted Average Concentration =		75.848			

APPENDIX F

EXAMPLE USGS GAGING STATION DATA AND ESTIMATED FLOW DATA (USGS, 1999)

An example of the USGS gaging station data is included in the following pages for Ley Creek at Park St. Also included, is an example of the estimated flow data for Ley Creek at 7th North St. The flow estimates at 7th North St. were calculated based on the flows at Park St. For the full data set contact USGS.

USGS Gaging Station Data for Ley Creek at Park Street

Ley Creek		Park St	Ley Creek		Park St	Ley Creek		Park St
Date	Time	Flow	Date	Time	Flow	Date	Time	Flow
11-Apr-99	0:30:00	22.419	29-Jun-99	0:30:00	14.175	13-Oct-99	0:30:00	8.338
11-Apr-99	1:00:00	23.064	29-Jun-99	1:00:00	13.954	13-Oct-99	1:00:00	8.338
11-Apr-99	1:30:00	22.419	29-Jun-99	1:30:00	10.865	13-Oct-99	1:30:00	8.338
11-Apr-99	2:00:00	22.419	29-Jun-99	2:00:00	10.944	13-Oct-99	2:00:00	8.316
11-Apr-99	2:30:00	22.419	29-Jun-99	2:30:00	12.081	13-Oct-99	2:30:00	8.005
11-Apr-99	3:00:00	22.419	29-Jun-99	3:00:00	12.464	13-Oct-99	3:00:00	8.005
11-Apr-99	3:30:00	22.419	29-Jun-99	3:30:00	12.491	13-Oct-99	3:30:00	8.005
11-Apr-99	4:00:00	22.419	29-Jun-99	4:00:00	12.909	13-Oct-99	4:00:00	8.005
11-Apr-99	4:30:00	22.419	29-Jun-99	4:30:00	13.334	13-Oct-99	4:30:00	8.005
11-Apr-99	5:00:00	22.419	29-Jun-99	5:00:00	13.495	13-Oct-99	5:00:00	8.005
11-Apr-99	5:30:00	22.419	29-Jun-99	5:30:00	10.108	13-Oct-99	5:30:00	7.983
11-Apr-99	6:00:00	22.419	29-Jun-99	6:00:00	10.108	13-Oct-99	6:00:00	7.679
11-Apr-99	6:30:00	22.419	29-Jun-99	6:30:00	10.108	13-Oct-99	6:30:00	7.679
11-Apr-99	7:00:00	22.419	29-Jun-99	7:00:00	10.133	13-Oct-99	7:00:00	7.679
11-Apr-99	7:30:00	22.419	29-Jun-99	7:30:00	10.483	13-Oct-99	7:30:00	7.679
11-Apr-99	8:00:00	22.419	29-Jun-99	8:00:00	10.508	13-Oct-99	8:00:00	7.679
11-Apr-99	8:30:00	22.419	29-Jun-99	8:30:00	10.865	13-Oct-99	8:30:00	7.679
11-Apr-99	9:00:00	22.419	29-Jun-99	9:00:00	14.882	13-Oct-99	9:00:00	7.679
11-Apr-99	9:30:00	22.419	29-Jun-99	9:30:00	70.156	13-Oct-99	9:30:00	7.658
11-Apr-99	10:00:00	22.419	29-Jun-99	10:00:00	55.636	13-Oct-99	10:00:00	7.338
11-Apr-99	10:30:00	23.064	29-Jun-99	10:30:00	39.199	13-Oct-99	10:30:00	7.046
11-Apr-99	11:00:00	23.064	29-Jun-99	11:00:00	25.401	13-Oct-99	11:00:00	7.338
11-Apr-99	11:30:00	23.064	29-Jun-99	11:30:00	20.467	13-Oct-99	11:30:00	7.046
11-Apr-99	12:00:00	23.064	29-Jun-99	12:00:00	19.198	13-Oct-99	12:00:00	7.360
11-Apr-99	12:30:00	23.719	29-Jun-99	12:30:00	16.688	13-Oct-99	12:30:00	7.360
11-Apr-99	13:00:00	23.064	29-Jun-99	13:00:00	15.245	13-Oct-99	13:00:00	7.360
11-Apr-99	13:30:00	23.064	29-Jun-99	13:30:00	71.553	13-Oct-99	13:30:00	7.338
11-Apr-99	14:00:00	23.719	29-Jun-99	14:00:00	78.069	13-Oct-99	14:00:00	7.046
11-Apr-99	14:30:00	23.064	29-Jun-99	14:30:00	83.648	13-Oct-99	14:30:00	7.338
11-Apr-99	15:00:00	22.419	29-Jun-99	15:00:00	89.351	13-Oct-99	15:00:00	7.046
11-Apr-99	15:30:00	22.419	29-Jun-99	15:30:00	93.643	13-Oct-99	15:30:00	7.338
11-Apr-99	16:00:00	22.419	29-Jun-99	16:00:00	94.765	13-Oct-99	16:00:00	7.024
11-Apr-99	16:30:00	22.419	29-Jun-99	16:30:00	90.144	13-Oct-99	16:30:00	7.046
11-Apr-99	17:00:00	22.419	29-Jun-99	17:00:00	81.345	13-Oct-99	17:00:00	7.360
11-Apr-99	17:30:00	23.719	29-Jun-99	17:30:00	34.714	13-Oct-99	17:30:00	7.381
11-Apr-99	18:00:00	25.748	29-Jun-99	18:00:00	37.539	13-Oct-99	18:00:00	7.658
11-Apr-99	18:30:00	30.226	29-Jun-99	18:30:00	41.351	13-Oct-99	18:30:00	7.360
11-Apr-99	19:00:00	34.531	29-Jun-99	19:00:00	44.534	13-Oct-99	19:00:00	7.360
11-Apr-99	19:30:00	38.227	29-Jun-99	19:30:00	49.490	13-Oct-99	19:30:00	7.381
11-Apr-99	20:00:00	45.177	29-Jun-99	20:00:00	53.809	13-Oct-99	20:00:00	7.769
11-Apr-99	20:30:00	56.742	29-Jun-99	20:30:00	59.321	13-Oct-99	20:30:00	9.282
11-Apr-99	21:00:00	68.589	29-Jun-99	21:00:00	61.464	13-Oct-99	21:00:00	13.058
11-Apr-99	21:30:00	79.069	29-Jun-99	21:30:00	30.396	13-Oct-99	21:30:00	15.867
11-Apr-99	22:00:00	84.689	29-Jun-99	22:00:00	32.254	13-Oct-99	22:00:00	21.479
11-Apr-99	22:30:00	87.583	29-Jun-99	22:30:00	25.153	13-Oct-99	22:30:00	36.802
11-Apr-99	23:00:00	84.689	29-Jun-99	23:00:00	26.492	13-Oct-99	23:00:00	70.665
11-Apr-99	23:30:00	81.850	29-Jun-99	23:30:00	27.249	13-Oct-99	23:30:00	101.657
11-Apr-99	0:00:00	76.342	29-Jun-99	0:00:00	28.210	13-Oct-99	0:00:00	130.596
12-Apr-99	0:30:00	71.114	30-Jun-99	0:30:00	22.506	14-Oct-99	0:30:00	161.555
12-Apr-99	1:00:00	66.116	30-Jun-99	1:00:00	23.313	14-Oct-99	1:00:00	187.070

12-Apr-99	1:30:00	62.504	30-Jun-99	1:30:00	17.667	14-Oct-99	1:30:00	205.341
12-Apr-99	2:00:00	57.869	30-Jun-99	2:00:00	18.231	14-Oct-99	2:00:00	217.137
12-Apr-99	2:30:00	54.526	30-Jun-99	2:30:00	18.805	14-Oct-99	2:30:00	221.662
12-Apr-99	3:00:00	52.361	30-Jun-99	3:00:00	19.389	14-Oct-99	3:00:00	218.646
12-Apr-99	3:30:00	49.208	30-Jun-99	3:30:00	19.983	14-Oct-99	3:30:00	208.582
12-Apr-99	4:00:00	47.167	30-Jun-99	4:00:00	20.587	14-Oct-99	4:00:00	196.587
12-Apr-99	4:30:00	46.166	30-Jun-99	4:30:00	21.202	14-Oct-99	4:30:00	184.938
12-Apr-99	5:00:00	44.200	30-Jun-99	5:00:00	21.368	14-Oct-99	5:00:00	171.553
12-Apr-99	5:30:00	43.168	30-Jun-99	5:30:00	15.533	14-Oct-99	5:30:00	156.953
12-Apr-99	6:00:00	42.151	30-Jun-99	6:00:00	15.533	14-Oct-99	6:00:00	145.180
12-Apr-99	6:30:00	41.148	30-Jun-99	6:30:00	15.564	14-Oct-99	6:30:00	137.586
12-Apr-99	7:00:00	40.160	30-Jun-99	7:00:00	16.036	14-Oct-99	7:00:00	132.077
12-Apr-99	7:30:00	40.160	30-Jun-99	7:30:00	16.533	14-Oct-99	7:30:00	128.517
12-Apr-99	8:00:00	39.186	30-Jun-99	8:00:00	16.569	14-Oct-99	8:00:00	126.699
12-Apr-99	8:30:00	39.186	30-Jun-99	8:30:00	17.113	14-Oct-99	8:30:00	124.895
12-Apr-99	9:00:00	38.227	30-Jun-99	9:00:00	17.370	14-Oct-99	9:00:00	123.225
12-Apr-99	9:30:00	38.227	30-Jun-99	9:30:00	13.737	14-Oct-99	9:30:00	122.990
12-Apr-99	10:00:00	38.227	30-Jun-99	10:00:00	13.766	14-Oct-99	10:00:00	119.575
12-Apr-99	10:30:00	37.281	30-Jun-99	10:30:00	14.175	14-Oct-99	10:30:00	117.717
12-Apr-99	11:00:00	37.281	30-Jun-99	11:00:00	14.175	14-Oct-99	11:00:00	114.165
12-Apr-99	11:30:00	36.351	30-Jun-99	11:30:00	14.205	14-Oct-99	11:30:00	109.226
12-Apr-99	12:00:00	35.434	30-Jun-99	12:00:00	14.621	14-Oct-99	12:00:00	105.721
12-Apr-99	12:30:00	34.531	30-Jun-99	12:30:00	14.651	14-Oct-99	12:30:00	99.419
12-Apr-99	13:00:00	35.434	30-Jun-99	13:00:00	14.899	14-Oct-99	13:00:00	94.765
12-Apr-99	13:30:00	35.434	30-Jun-99	13:30:00	12.464	14-Oct-99	13:30:00	90.144
12-Apr-99	14:00:00	34.531	30-Jun-99	14:00:00	12.491	14-Oct-99	14:00:00	84.406
12-Apr-99	14:30:00	34.531	30-Jun-99	14:30:00	12.881	14-Oct-99	14:30:00	80.179
12-Apr-99	15:00:00	34.531	30-Jun-99	15:00:00	12.881	14-Oct-99	15:00:00	76.079
12-Apr-99	15:30:00	33.642	30-Jun-99	15:30:00	12.881	14-Oct-99	15:30:00	72.142
12-Apr-99	16:00:00	32.768	30-Jun-99	16:00:00	12.909	14-Oct-99	16:00:00	68.424
12-Apr-99	16:30:00	33.642	30-Jun-99	16:30:00	13.305	14-Oct-99	16:30:00	65.954
12-Apr-99	17:00:00	31.907	30-Jun-99	17:00:00	13.168	14-Oct-99	17:00:00	63.537
12-Apr-99	17:30:00	31.907	30-Jun-99	17:30:00	11.307	14-Oct-99	17:30:00	61.171
12-Apr-99	18:00:00	31.907	30-Jun-99	18:00:00	12.053	14-Oct-99	18:00:00	58.857
12-Apr-99	18:30:00	31.060	30-Jun-99	18:30:00	12.053	14-Oct-99	18:30:00	56.594
12-Apr-99	19:00:00	31.060	30-Jun-99	19:00:00	12.053	14-Oct-99	19:00:00	54.382
12-Apr-99	19:30:00	31.060	30-Jun-99	19:30:00	12.053	14-Oct-99	19:30:00	52.290
12-Apr-99	20:00:00	30.226	30-Jun-99	20:00:00	12.081	14-Oct-99	20:00:00	51.090
12-Apr-99	20:30:00	30.226	30-Jun-99	20:30:00	12.464	14-Oct-99	20:30:00	48.114
12-Apr-99	21:00:00	30.226	30-Jun-99	21:00:00	12.357	14-Oct-99	21:00:00	47.035
12-Apr-99	21:30:00	30.226	30-Jun-99	21:30:00	10.865	14-Oct-99	21:30:00	45.112
12-Apr-99	22:00:00	30.226	30-Jun-99	22:00:00	10.865	14-Oct-99	22:00:00	44.131
12-Apr-99	22:30:00	29.406	30-Jun-99	22:30:00	10.865	14-Oct-99	22:30:00	43.033
12-Apr-99	23:00:00	29.406	30-Jun-99	23:00:00	10.891	14-Oct-99	23:00:00	41.082
12-Apr-99	23:30:00	29.406	30-Jun-99	23:30:00	11.254	14-Oct-99	23:30:00	40.095
12-Apr-99	0:00:00	28.600	30-Jun-99	0:00:00	11.254	14-Oct-99	0:00:00	39.122
13-Apr-99	0:30:00	28.600	1-Jul-99	0:30:00	11.254	15-Oct-99	0:30:00	38.164
13-Apr-99	1:00:00	28.600	1-Jul-99	1:00:00	11.153	15-Oct-99	1:00:00	37.098
13-Apr-99	1:30:00	28.600	1-Jul-99	1:30:00	9.740	15-Oct-99	1:30:00	34.472
13-Apr-99	2:00:00	28.600	1-Jul-99	2:00:00	9.765	15-Oct-99	2:00:00	33.584
13-Apr-99	2:30:00	28.600	1-Jul-99	2:30:00	10.108	15-Oct-99	2:30:00	32.710
13-Apr-99	3:00:00	27.871	1-Jul-99	3:00:00	10.108	15-Oct-99	3:00:00	31.907
13-Apr-99	3:30:00	27.871	1-Jul-99	3:30:00	10.108	15-Oct-99	3:30:00	31.850

13-Apr-99	4:00:00	27.871	1-Jul-99	4:00:00	10.133	15-Oct-99	4:00:00	31.004
13-Apr-99	4:30:00	27.871	1-Jul-99	4:30:00	10.483	15-Oct-99	4:30:00	30.171
13-Apr-99	5:00:00	27.871	1-Jul-99	5:00:00	10.386	15-Oct-99	5:00:00	29.353
13-Apr-99	5:30:00	27.871	1-Jul-99	5:30:00	9.025	15-Oct-99	5:30:00	28.551
13-Apr-99	6:00:00	27.871	1-Jul-99	6:00:00	9.025	15-Oct-99	6:00:00	27.823
13-Apr-99	6:30:00	27.153	1-Jul-99	6:30:00	9.049	15-Oct-99	6:30:00	27.105
13-Apr-99	7:00:00	27.153	1-Jul-99	7:00:00	9.379	15-Oct-99	7:00:00	26.445
13-Apr-99	7:30:00	27.871	1-Jul-99	7:30:00	9.379	15-Oct-99	7:30:00	26.398
13-Apr-99	8:00:00	27.153	1-Jul-99	8:00:00	9.403	15-Oct-99	8:00:00	25.657
13-Apr-99	8:30:00	27.153	1-Jul-99	8:30:00	9.740	15-Oct-99	8:30:00	24.340
13-Apr-99	9:00:00	27.871	1-Jul-99	9:00:00	9.669	15-Oct-99	9:00:00	23.719
13-Apr-99	9:30:00	27.153	1-Jul-99	9:30:00	8.678	15-Oct-99	9:30:00	23.675
13-Apr-99	10:00:00	27.153	1-Jul-99	10:00:00	8.678	15-Oct-99	10:00:00	23.021
13-Apr-99	10:30:00	27.153	1-Jul-99	10:30:00	8.678	15-Oct-99	10:30:00	22.419
13-Apr-99	11:00:00	27.871	1-Jul-99	11:00:00	8.701	15-Oct-99	11:00:00	22.419
13-Apr-99	11:30:00	26.445	1-Jul-99	11:30:00	9.025	15-Oct-99	11:30:00	22.377
13-Apr-99	12:00:00	26.445	1-Jul-99	12:00:00	9.002	15-Oct-99	12:00:00	21.784
13-Apr-99	12:30:00	26.445	1-Jul-99	12:30:00	8.678	15-Oct-99	12:30:00	21.784
13-Apr-99	13:00:00	27.153	1-Jul-99	13:00:00	8.655	15-Oct-99	13:00:00	21.743
13-Apr-99	13:30:00	27.153	1-Jul-99	13:30:00	8.338	15-Oct-99	13:30:00	21.119
13-Apr-99	14:00:00	27.153	1-Jul-99	14:00:00	8.338	15-Oct-99	14:00:00	20.546
13-Apr-99	14:30:00	27.153	1-Jul-99	14:30:00	8.338	15-Oct-99	14:30:00	20.546
13-Apr-99	15:00:00	27.153	1-Jul-99	15:00:00	8.338	15-Oct-99	15:00:00	20.546
13-Apr-99	15:30:00	26.445	1-Jul-99	15:30:00	8.361	15-Oct-99	15:30:00	20.506
13-Apr-99	16:00:00	25.748	1-Jul-99	16:00:00	8.678	15-Oct-99	16:00:00	19.903
13-Apr-99	16:30:00	25.748	1-Jul-99	16:30:00	8.655	15-Oct-99	16:30:00	19.349
13-Apr-99	17:00:00	26.445	1-Jul-99	17:00:00	8.361	15-Oct-99	17:00:00	19.310
13-Apr-99	17:30:00	25.748	1-Jul-99	17:30:00	8.678	15-Oct-99	17:30:00	18.766
13-Apr-99	18:00:00	26.445	1-Jul-99	18:00:00	8.655	15-Oct-99	18:00:00	18.766
13-Apr-99	18:30:00	26.445	1-Jul-99	18:30:00	8.338	15-Oct-99	18:30:00	18.728
13-Apr-99	19:00:00	26.445	1-Jul-99	19:00:00	8.361	15-Oct-99	19:00:00	18.193
13-Apr-99	19:30:00	25.748	1-Jul-99	19:30:00	8.655	15-Oct-99	19:30:00	18.231
13-Apr-99	20:00:00	26.445	1-Jul-99	20:00:00	8.338	15-Oct-99	20:00:00	18.766
13-Apr-99	20:30:00	25.748	1-Jul-99	20:30:00	8.338	15-Oct-99	20:30:00	18.728
13-Apr-99	21:00:00	25.748	1-Jul-99	21:00:00	8.384	15-Oct-99	21:00:00	18.193
13-Apr-99	21:30:00	25.748	1-Jul-99	21:30:00	9.002	15-Oct-99	21:30:00	18.193
13-Apr-99	22:00:00	25.748	1-Jul-99	22:00:00	8.678	15-Oct-99	22:00:00	18.193
13-Apr-99	22:30:00	25.748	1-Jul-99	22:30:00	8.655	15-Oct-99	22:30:00	18.193
13-Apr-99	23:00:00	25.748	1-Jul-99	23:00:00	8.338	15-Oct-99	23:00:00	18.193
13-Apr-99	23:30:00	25.748	1-Jul-99	23:30:00	8.361	15-Oct-99	23:30:00	18.155
13-Apr-99	0:00:00	25.748	1-Jul-99	0:00:00	8.678	15-Oct-99	0:00:00	17.629
14-Apr-99	0:30:00	25.748	2-Jul-99	0:30:00	8.678	16-Oct-99	0:30:00	17.629
14-Apr-99	1:00:00	25.748	2-Jul-99	1:00:00	8.903	16-Oct-99	1:00:00	17.629
14-Apr-99	1:30:00	25.748	2-Jul-99	1:30:00	12.000	16-Oct-99	1:30:00	17.593
14-Apr-99	2:00:00	25.061	2-Jul-99	2:00:00	11.254	16-Oct-99	2:00:00	17.076
14-Apr-99	2:30:00	25.061	2-Jul-99	2:30:00	11.254	16-Oct-99	2:30:00	17.076
14-Apr-99	3:00:00	25.061	2-Jul-99	3:00:00	11.228	16-Oct-99	3:00:00	17.005
14-Apr-99	3:30:00	25.061	2-Jul-99	3:30:00	10.840	16-Oct-99	3:30:00	16.000
14-Apr-99	4:00:00	25.061	2-Jul-99	4:00:00	10.458	16-Oct-99	4:00:00	16.000
14-Apr-99	4:30:00	25.061	2-Jul-99	4:30:00	10.059	16-Oct-99	4:30:00	15.969
14-Apr-99	5:00:00	25.061	2-Jul-99	5:00:00	9.728	16-Oct-99	5:00:00	15.533
14-Apr-99	5:30:00	25.061	2-Jul-99	5:30:00	14.651	16-Oct-99	5:30:00	15.533
14-Apr-99	6:00:00	25.061	2-Jul-99	6:00:00	15.013	16-Oct-99	6:00:00	15.533

14-Apr-99	6:30:00	25.061	2-Jul-99	6:30:00	14.146	16-Oct-99	6:30:00	15.502
14-Apr-99	7:00:00	25.061	2-Jul-99	7:00:00	13.708	16-Oct-99	7:00:00	15.073
14-Apr-99	7:30:00	25.061	2-Jul-99	7:30:00	13.277	16-Oct-99	7:30:00	15.073
14-Apr-99	8:00:00	24.385	2-Jul-99	8:00:00	12.853	16-Oct-99	8:00:00	15.073
14-Apr-99	8:30:00	25.061	2-Jul-99	8:30:00	12.464	16-Oct-99	8:30:00	15.043
14-Apr-99	9:00:00	25.061	2-Jul-99	9:00:00	12.923	16-Oct-99	9:00:00	14.621
14-Apr-99	9:30:00	24.385	2-Jul-99	9:30:00	19.349	16-Oct-99	9:30:00	14.591
14-Apr-99	10:00:00	25.748	2-Jul-99	10:00:00	19.272	16-Oct-99	10:00:00	14.175
14-Apr-99	10:30:00	25.061	2-Jul-99	10:30:00	18.118	16-Oct-99	10:30:00	14.175
14-Apr-99	11:00:00	25.061	2-Jul-99	11:00:00	16.973	16-Oct-99	11:00:00	14.175
14-Apr-99	11:30:00	25.061	2-Jul-99	11:30:00	15.502	16-Oct-99	11:30:00	14.175
14-Apr-99	12:00:00	25.061	2-Jul-99	12:00:00	15.043	16-Oct-99	12:00:00	14.146
14-Apr-99	12:30:00	25.748	2-Jul-99	12:30:00	14.621	16-Oct-99	12:30:00	13.737
14-Apr-99	13:00:00	24.385	2-Jul-99	13:00:00	14.651	16-Oct-99	13:00:00	13.737
14-Apr-99	13:30:00	25.061	2-Jul-99	13:30:00	15.104	16-Oct-99	13:30:00	13.737
14-Apr-99	14:00:00	25.748	2-Jul-99	14:00:00	15.564	16-Oct-99	14:00:00	13.708
14-Apr-99	14:30:00	24.385	2-Jul-99	14:30:00	16.072	16-Oct-99	14:30:00	13.305
14-Apr-99	15:00:00	24.385	2-Jul-99	15:00:00	17.113	16-Oct-99	15:00:00	13.277
14-Apr-99	15:30:00	23.719	2-Jul-99	15:30:00	17.667	16-Oct-99	15:30:00	12.881
14-Apr-99	16:00:00	24.385	2-Jul-99	16:00:00	18.270	16-Oct-99	16:00:00	12.881
14-Apr-99	16:30:00	24.385	2-Jul-99	16:30:00	19.349	16-Oct-99	16:30:00	12.881
14-Apr-99	17:00:00	24.385	2-Jul-99	17:00:00	18.810	16-Oct-99	17:00:00	12.853
14-Apr-99	17:30:00	24.385	2-Jul-99	17:30:00	11.307	16-Oct-99	17:30:00	12.491
14-Apr-99	18:00:00	24.385	2-Jul-99	18:00:00	12.053	16-Oct-99	18:00:00	12.881
14-Apr-99	18:30:00	23.719	2-Jul-99	18:30:00	12.081	16-Oct-99	18:30:00	12.853
14-Apr-99	19:00:00	24.385	2-Jul-99	19:00:00	12.491	16-Oct-99	19:00:00	12.464
14-Apr-99	19:30:00	23.719	2-Jul-99	19:30:00	12.909	16-Oct-99	19:30:00	12.464
14-Apr-99	20:00:00	24.385	2-Jul-99	20:00:00	13.334	16-Oct-99	20:00:00	12.464
14-Apr-99	20:30:00	23.719	2-Jul-99	20:30:00	13.796	16-Oct-99	20:30:00	12.464
14-Apr-99	21:00:00	23.719	2-Jul-99	21:00:00	14.271	16-Oct-99	21:00:00	12.464
14-Apr-99	21:30:00	23.719	2-Jul-99	21:30:00	9.403	16-Oct-99	21:30:00	12.464
14-Apr-99	22:00:00	23.719	2-Jul-99	22:00:00	9.740	16-Oct-99	22:00:00	12.464
14-Apr-99	22:30:00	23.719	2-Jul-99	22:30:00	9.740	16-Oct-99	22:30:00	12.464
14-Apr-99	23:00:00	23.719	2-Jul-99	23:00:00	9.765	16-Oct-99	23:00:00	12.464
14-Apr-99	23:30:00	23.719	2-Jul-99	23:30:00	10.133	16-Oct-99	23:30:00	12.436
14-Apr-99	0:00:00	23.719	2-Jul-99	0:00:00	10.483	16-Oct-99	0:00:00	12.053

Estimated Flows for Ley Creek at 7th North St.

Ley Creek		7th N St.	Ley Creek		7th N St.	Ley Creek		7th N St.
Date	Time	Flow	Date	Time	Flow	Date	Time	Flow
11-Apr-99	0:30:00	21.301	29-Jun-99	0:30:00	13.468	13-Oct-99	0:30:00	7.922
11-Apr-99	1:00:00	21.914	29-Jun-99	1:00:00	13.259	13-Oct-99	1:00:00	7.922
					10.323	13-Oct-99	1:30:00	7.922
11-Apr-99				2:00:00	10.399	13-Oct-99	2:00:00	7.901
				2:30:00	11.478	13-Oct-99	2:30:00	7.606
11-Apr-99								
					12.669		4:30:00	
	5:00:00	21.301	29-Jun-99	5:00:00	12.822	13-Oct-99	5:00:00	
11-Apr-99	5:30:00	21.301	29-Jun-99	5:30:00	9.604	13-Oct-99	5:30:00	7.585
11-Apr-99	6:00:00	21.301	29-Jun-99	6:00:00	9.604	13-Oct-99	6:00:00	7.296
11-Apr-99	6:30:00	21.301	29-Jun-99	6:30:00	9.604	13-Oct-99	6:30:00	7.296
11-Apr-99	7:00:00	21.301	29-Jun-99	7:00:00	9.628	13-Oct-99	7:00:00	7.296
11-Apr-99	7:30:00	21.301		7:30:00	9.960	13-Oct-99	7:30:00	
		21.301			9.984	13-Oct-99	8:00:00	7.296
	8:30:00	21.301	29-Jun-99	8:30:00	10.323	13-Oct-99	8:30:00	7.296
	9:00:00	21.301	29-Jun-99	9:00:00	14.140	13-Oct-99	9:00:00	7.296
11-Apr-99	9:30:00	21.301	29-Jun-99	9:30:00	66.657	13-Oct-99	9:30:00	7.276
11-Apr-99	10:00:00	21.301	29-Jun-99	10:00:00	52.862	13-Oct-99	10:00:00	6.972
11-Apr-99	10:30:00	21.914		10:30:00	37.244	13-Oct-99	10:30:00	
11-Apr-99	11:00:00	21.914		11:00:00		13-Oct-99		
11-Apr-99	11:30:00	21.914	[illegible]	11:30:00	19.446	13-Oct-99	11:30:00	6.695
[illegible]		21.914	[illegible]	12:00:00	18.240	13-Oct-99	12:00:00	6.993
[illegible]	[illegible]	22.536	29-Jun-99	12:30:00	15.856	13-Oct-99	12:30:00	6.993
11-Apr-99	[illegible]	21.914	29-Jun-99	13:00:00	14.485	13-Oct-99	13:00:00	6.993
11-Apr-99	13:30:00	21.914	29-Jun-99	13:30:00	67.985	13-Oct-99	13:30:00	6.972
11-Apr-99	14:00:00	22.536	29-Jun-99	14:00:00	74.176	13-Oct-99	14:00:00	6.695
11-Apr-99	14:30:00	21.914	29-Jun-99	14:30:00	79.477	13-Oct-99		6.972
11-Apr-99	15:00:00	21.301	29-Jun-99	15:00:00				
11-Apr-99	15:30:00	21.301	29-Jun-99	15:30:00	88.974	13-Oct-99	15:30:00	6.972
[illegible]	[illegible]	[illegible]	29-Jun-99	16:00:00	90.040	13-Oct-99	16:00:00	6.674
[illegible]	[illegible]	[illegible]	29-Jun-99	16:30:00	85.649	13-Oct-99	16:30:00	6.695
11-Apr-99	17:00:00	21.301	29-Jun-99	17:00:00	77.288	13-Oct-99	17:00:00	6.993
11-Apr-99	17:30:00	22.536	29-Jun-99	17:30:00	32.983	13-Oct-99	17:30:00	7.013
11-Apr-99	18:00:00	24.464	29-Jun-99	18:00:00	35.667	13-Oct-99	18:00:00	7.276
11-Apr-99	18:30:00	28.719	29-Jun-99	18:30:00	39.289	13-Oct-99	18:30:00	6.993
11-Apr-99	19:00:00	32.809	29-Jun-99	19:00:00	42.313	13-Oct-99	19:00:00	6.993
[illegible]	19:30:00	36.320	29-Jun-99	19:30:00	47.022	13-Oct-99	19:30:00	7.013
[illegible]	20:00:00	42.924	29-Jun-99	20:00:00	51.126	13-Oct-99	20:00:00	7.381
11-Apr-99	20:30:00	53.912	29-Jun-99	20:30:00	56.363	13-Oct-99	20:30:00	8.819
11-Apr-99	21:00:00	65.168	29-Jun-99	21:00:00	58.399	13-Oct-99	21:00:00	12.407
11-Apr-99	21:30:00	75.126	29-Jun-99	21:30:00	28.880	[illegible]	21:30:00	15.076
11-Apr-99	22:00:00	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
11-Apr-99	22:30:00	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
11-Apr-99	23:00:00	80.466	29-Jun-99	23:00:00	25.171	13-Oct-99	23:00:00	67.141
11-Apr-99	23:30:00	77.769	29-Jun-99	23:30:00	25.890	13-Oct-99	23:30:00	96.588
11-Apr-99	0:00:00	72.535	29-Jun-99	0:00:00	26.803	13-Oct-99	0:00:00	124.083
12-Apr-99	0:30:00	67.568	30-Jun-99	0:30:00	21.383	14-Oct-99	0:30:00	153.499
12-Apr-99	1:00:00	62.819	30-Jun-99	1:00:00	22.151	14-Oct-99	1:00:00	177.742

12-Apr-9		59.387	30-Jun-99	1:30:00	16.786	14-Oct-99	1:30:00	195.102
12-Apr-99	2:00:00	54.983	30-Jun-99	2:00:00	17.322	14-Oct-99	2:00:00	206.309
12-Apr-99	2:30:00	51.807	30-Jun-99	2:30:00	17.867	14-Oct-99	2:30:00	210.609
12-Apr-99	3:00:00	49.750	30-Jun-99	3:00:00	18.422	14-Oct-99	3:00:00	207.743
12-Apr-99	3:30:00	46.754	30-Jun-99	3:30:00	18.986	14-Oct-99	3:30:00	198.181
12-Apr-99	4:00:00	44.815	30-Jun-99	4:00:00	19.561	14-Oct-99	4:00:00	186.784
12-Apr-99	4:30:00	43.864	30-Jun-99	4:30:00	20.145	14-Oct-99	4:30:00	175.716
12-Apr-99	5:00:00	41.996	30-Jun-99	5:00:00	20.302	14-Oct-99	5:00:00	162.998
12-Apr-99	5:30:00	41.015	30-Jun-99	5:30:00	14.759	14-Oct-99	5:30:00	149.126
12-Apr-99	6:00:00	40.049	30-Jun-99	6:00:00	14.759	14-Oct-99	6:00:00	137.940
12-Apr-99	6:30:00	39.096	30-Jun-99	6:30:00	14.788	14-Oct-99	6:30:00	130.725
12-Apr-99	7:00:00	38.157	30-Jun-99	7:00:00	[illegible]	[illegible]		1
				7:30:00				
[illegible]	8:00:00	37.232	30-Jun-99	8:00:00				
12-Apr-99	8:30:00	37.232	30-Jun-99	8:30:00	16.260	14-Oct-99	8:30:00	118.667
12-Apr-99	9:00:00	36.320	30-Jun-99	9:00:00	16.504	14-Oct-99	9:00:00	117.081
12-Apr-99	9:30:00	36.320	30-Jun-99	9:30:00	13.052	14-Oct-99	9:30:00	116.857
12-Apr-99	10:00:00	36.320	30-Jun-99	10:00:00	13.079	14-Oct-99	10:00:00	113.612
12-Apr-99	10:30:00	35.422	30-Jun-99	10:30:00	13.468	14-Oct-99	10:30:00	111.847
12-Apr-99	11:00:00	35.422	30-Jun-99	11:00:00	13.468	14-Oct-99	11:00:00	108.472
12-Apr-99	11:30:00	34.538	30-Jun-99	11:30:00	13.496	14-Oct-99	11:30:00	103.780
12-Apr-99	12:00:00	33.667	30-Jun-99	12:00:00	13.892	14-Oct-99	12:00:00	100.449
12-Apr-99	12:30:00	32.809	30-Jun-99	12:30:00	13.920	14-Oct-99	12:30:00	94.461
12-Apr-99	13:00:00	33.667	30-Jun-99	13:00:00	14.156	14-Oct-99	13:00:00	90.040
12-Apr-99	13:30:00	33.667	30-Jun-99	13:30:00	11.842	14-Oct-99	13:30:00	85.649
12-Apr-99	14:00:00	32.809	30-Jun-99	14:00:00	11.868	14-Oct-99	14:00:00	80.197
12-Apr-99	14:30:00	32.809	30-Jun-99	14:30:00	12.239	14-Oct-99	14:30:00	76.180
12-Apr-99	15:00:00	32.809	30-Jun-99	15:00:00	12.239	14-Oct-99	15:00:00	72.286
12-Apr-99	15:30:00	31.965	30-Jun-99	15:30:00	12.239	14-Oct-99	15:30:00	68.545
12-Apr-99	16:00:00	31.134	30-Jun-99	16:00:00	12.265	14-Oct-99	16:00:00	65.012
12-Apr-99	16:30:00	31.965	30-Jun-99	16:30:00	12.642	14-Oct-99	16:30:00	62.666
12-Apr-99	17:00:00	30.316	30-Jun-99	17:00:00	12.512	14-Oct-99	17:00:00	60.369
12-Apr-99	17:30:00	30.316	30-Jun-99	17:30:00	10.744	14-Oct-99	17:30:00	58.121
12-Apr-99	18:00:00	30.316	30-Jun-99	18:00:00	11.452	14-Oct-99	18:00:00	55.922
12-Apr-99	18:30:00	29.511	30-Jun-99	18:30:00	11.452	14-Oct-99	18:30:00	53.772
12-Apr-99	19:00:00	29.511	30-Jun-99	19:00:00	11.452	14-Oct-99	19:00:00	51.670
12-Apr-99	19:30:00	29.511	30-Jun-99	19:30:00	11.452	14-Oct-99	19:30:00	49.683
12-Apr-99	20:00:00	28.719	30-Jun-99	20:00:00	11.478	14-Oct-99	20:00:00	48.542
12-Apr-99	20:30:00	28.719	30-Jun-99	20:30:00	11.842	14-Oct-99	20:30:00	45.715
12-Apr-99	21:00:00	28.719	30-Jun-99	21:00:00	11.741	14-Oct-99	21:00:00	44.689
			30-Jun-99	[illegible]	[illegible]			
12-Apr-99	22:00:00	28.719	30-Jun-99	22:00:00	10.323	14-Oct-99	22:00:00	41.931
12-Apr-99	22:30:00	27.940	30-Jun-99	22:30:00	10.323	14-Oct-99	22:30:00	40.887
12-Apr-99	23:00:00	27.940	30-Jun-99	23:00:00	10.348	14-Oct-99	23:00:00	39.034
12-Apr-99	23:30:00	27.940	30-Jun-99	23:30:00	10.693	14-Oct-99	23:30:00	38.095
12-Apr-99	0:00:00	27.174	30-Jun-99	0:00:00	10.693	14-Oct-99	0:00:00	37.171
13-Apr-99	0:30:00	27.174	1-Jul-99	0:30:00	10.693	15-Oct-99	0:30:00	36.261
13-Apr-99	1:00:00	27.174	1-Jul-99	1:00:00	10.597	15-Oct-99	1:00:00	35.248
13-Apr-99	1:30:00	27.174	1-Jul-99	1:30:00	9.254	15-Oct-99	1:30:00	32.753
13-Apr-99	2:00:00	27.174	1-Jul-99	2:00:00	9.278	15-Oct-99	2:00:00	31.909
13-Apr-99	2:30:00	27.174	1-Jul-99	2:30:00	9.604	15-Oct-99	2:30:00	31.079
13-Apr-99	3:00:00	26.481	[illegible]	3:00:00	9.604	15-Oct-99	3:00:00	30.316
				3:30:00	9.604	15-Oct-99	3:30:00	30.262

13-Apr-99	4:00:00	26.481	1-Jul-99	4:00:00	9.628	15-Oct-99	4:00:00	29.458
13-Apr-99	4:30:00	26.481	1-Jul-99	4:30:00	9.960	15-Oct-99	4:30:00	28.667
13-Apr-99	5:00:00	26.481	1-Jul-99	5:00:00	9.868	15-Oct-99	5:00:00	27.889
13-Apr-99	5:30:00	26.481	1-Jul-99	5:30:00	8.575	15-Oct-99	5:30:00	27.128
13-Apr-99	6:00:00	26.481	1-Jul-99	6:00:00	8.575	15-Oct-99	6:00:00	26.436
13-Apr-99	6:30:00	25.799	1-Jul-99	6:30:00	8.597	15-Oct-99	6:30:00	25.754
13-Apr-99	7:00:00	25.799	1-Jul-99	7:00:00	8.911	15-Oct-99	7:00:00	25.126
13-Apr-99	7:30:00	26.481	1-Jul-99	7:30:00	8.911	15-Oct-99	7:30:00	25.082
13-Apr-99	8:00:00	25.799	1-Jul-99	8:00:00	8.934	15-Oct-99	8:00:00	24.377
13-Apr-99	8:30:00	25.799	1-Jul-99	8:30:00	9.254	15-Oct-99	8:30:00	23.127
13-Apr-99	9:00:00	26.481	1-Jul-99	9:00:00	9.187	15-Oct-99	9:00:00	22.536
13-Apr-99	9:30:00	25.799	1-Jul-99	9:30:00	8.245	15-Oct-99	9:30:00	22.495
13-Apr-99	10:00:00	25.799	1-Jul-99	10:00:00	8.245	15-Oct-99	10:00:00	21.873
13-Apr-99	10:30:00	25.799	1-Jul-99	10:30:00	8.245	15-Oct-99	10:30:00	21.301
13-Apr-99	11:00:00	26.481	1-Jul-99	11:00:00	8.267	15-Oct-99	11:00:00	21.301
13-Apr-99	11:30:00	25.126	1-Jul-99	11:30:00	8.575	15-Oct-99	11:30:00	21.261
13-Apr-99	12:00:00	25.126	1-Jul-99	12:00:00	8.553	15-Oct-99	12:00:00	20.698
13-Apr-99	12:30:00	25.126	1-Jul-99	12:30:00	8.245	15-Oct-99	12:30:00	20.698
13-Apr-99	13:00:00	25.799	1-Jul-99	13:00:00	8.224	15-Oct-99	13:00:00	20.659
13-Apr-99	13:30:00	25.799	1-Jul-99	13:30:00	7.922	15-Oct-99	13:30:00	20.066
13-Apr-99	14:00:00	25.799	1-Jul-99	14:00:00	7.922	15-Oct-99		
13-Apr-99	14:30:00	25.799	1-Jul-99	14:30:00	7.922	15-Oct-99	14:30:00	19.522
13-Apr-99	15:00:00	25.799	1-Jul-99	15:00:00	7.922	15-Oct-99	15:00:00	19.522
13-Apr-99	15:30:00	25.126	1-Jul-99	15:30:00	7.944	15-Oct-99	15:30:00	19.484
13-Apr-99	16:00:00	24.464	1-Jul-99	16:00:00	8.245	15-Oct-99	16:00:00	18.911
13-Apr-99	16:30:00	24.464	1-Jul-99	16:30:00	8.224	15-Oct-99	16:30:00	18.384
13-Apr-99	17:00:00	25.126	1-Jul-99	17:00:00	7.944	15-Oct-99	17:00:00	18.347
13-Apr-99	17:30:00	24.464	1-Jul-99	17:30:00	8.245	15-Oct-99	17:30:00	17.830
13-Apr-99	18:00:00	25.126	1-Jul-99	18:00:00	8.224	15-Oct-99	18:00:00	17.830
13-Apr-99	18:30:00	25.126	1-Jul-99	18:30:00	7.922	15-Oct-99	18:30:00	17.794
13-Apr-99	19:00:00	25.126	1-Jul-99	19:00:00	7.944	15-Oct-99	19:00:00	17.285
13-Apr-99	19:30:00	24.464	1-Jul-99	19:30:00	8.224	15-Oct-99	19:30:00	17.322
13-Apr-99	20:00:00	25.126	1-Jul-99	20:00:00	7.922	15-Oct-99	20:00:00	17.830
13-Apr-99	20:30:00	24.464	1-Jul-99	20:30:00	7.922	15-Oct-99	20:30:00	17.794
13-Apr-99	21:00:00	24.464	1-Jul-99	21:00:00	7.966	15-Oct-99	21:00:00	17.285
13-Apr-99	21:30:00	24.464	1-Jul-99	21:30:00	8.553	15-Oct-99	21:30:00	17.285
13-Apr-99	22:00:00	24.464	1-Jul-99	22:00:00	8.245	15-Oct-99	22:00:00	17.285
13-Apr-99	22:30:00	24.464	1-Jul-99	22:30:00	8.224	15-Oct-99	22:30:00	17.285
13-Apr-99	23:00:00	24.464	1-Jul-99	23:00:00	7.922	15-Oct-99	23:00:00	17.285
13-Apr-99	23:30:00	24.464	1-Jul-99	23:30:00	7.944	15-Oct-99	23:30:00	17.250
13-Apr-99	0:00:00	24.464	1-Jul-99	0:00:00	8.245	15-Oct-99	0:00:00	16.750
14-Apr-99	0:30:00	24.464	2-Jul-99	0:30:00	8.245	16-Oct-99	0:30:00	16.750
14-Apr-99	1:00:00	24.464	2-Jul-99	1:00:00	8.459	16-Oct-99	1:00:00	16.750
14-Apr-99	1:30:00	24.464	2-Jul-99	1:30:00	11.402	16-Oct-99	1:30:00	16.715
14-Apr-99	2:00:00	23.811	2-Jul-99	2:00:00	10.693	16-Oct-99	2:00:00	16.225
14-Apr-99	2:30:00	23.811	2-Jul-99	2:30:00	10.693	16-Oct-99	2:30:00	16.225
14-Apr-99	3:00:00	23.811	2-Jul-99	3:00:00	10.668	16-Oct-99	3:00:00	16.157
14-Apr-99	3:30:00	23.811	2-Jul-99	3:30:00	10.299	16-Oct-99	3:30:00	
14-Apr-99	4:00:00	23.811	2-Jul-99	4:00:00	9.936	16-Oct-99	4:00:00	15.202
14-Apr-99	4:30:00	23.811	2-Jul-99	4:30:00	9.558	16-Oct-99	4:30:00	15.173
14-Apr-99	5:00:00	23.811	2-Jul-99	5:00:00	9.243	16-Oct-99	5:00:00	14.759
14-Apr-99	5:30:00	23.811	2-Jul-99	5:30:00	13.920	16-Oct-99	5:30:00	14.759
14-Apr-99	6:00:00	23.811	2-Jul-99	6:00:00	14.265	16-Oct-99	6:00:00	14.759

14-Apr-99	6:30:00	23.811	2-Jul-99	6:30:00	13.440	16-Oct-99	6:30:00	14.729
14-Apr-99	7:00:00	23.811	2-Jul-99	7:00:00	13.024	16-Oct-99	7:00:00	14.322
14-Apr-99	7:30:00	23.811	2-Jul-99	7:30:00	12.615	16-Oct-99	7:30:00	14.322
14-Apr-99	8:00:00	23.169	2-Jul-99	8:00:00	12.212	16-Oct-99	8:00:00	14.322
14-Apr-99	8:30:00	23.811	2-Jul-99	8:30:00	11.842	16-Oct-99	8:30:00	14.293
14-Apr-99	9:00:00	23.811	2-Jul-99	9:00:00	12.278	16-Oct-99	9:00:00	13.892
14-Apr-99	9:30:00	23.169	2-Jul-99	9:30:00	18.384	16-Oct-99	9:30:00	13.863
14-Apr-99	10:00:00	24.464	2-Jul-99	10:00:00	18.311	16-Oct-99	10:00:00	13.468
14-Apr-99	10:30:00	23.811	2-Jul-99	10:30:00	17.215	16-Oct-99	10:30:00	13.468
14-Apr-99	11:00:00	23.811	2-Jul-99	11:00:00	16.127	16-Oct-99	11:00:00	13.468
14-Apr-99	11:30:00	23.811	2-Jul-99	11:30:00	14.729	16-Oct-99	11:30:00	13.468
14-Apr-99	12:00:00	23.811	2-Jul-99	12:00:00	14.293	16-Oct-99	12:00:00	13.440
14-Apr-99	12:30:00	24.464	2-Jul-99	12:30:00	13.892	16-Oct-99	12:30:00	13.052
14-Apr-99	13:00:00	23.169	2-Jul-99	13:00:00	13.920	16-Oct-99	13:00:00	13.052
14-Apr-99	13:30:00	23.811	2-Jul-99	13:30:00	14.351	16-Oct-99	13:30:00	13.052
14-Apr-99	14:00:00	24.464	2-Jul-99	14:00:00	14.788	16-Oct-99	14:00:00	13.024
14-Apr-99	14:30:00	23.169	2-Jul-99	14:30:00	15.270	16-Oct-99	14:30:00	12.642
14-Apr-99	15:00:00	23.169	2-Jul-99	15:00:00	16.260	16-Oct-99	15:00:00	12.615
14-Apr-99	15:30:00	22.536	2-Jul-99	15:30:00	16.786	16-Oct-99	15:30:00	12.239
14-Apr-99	16:00:00	23.169	2-Jul-99	16:00:00	17.359	16-Oct-99	16:00:00	12.239
14-Apr-99	16:30:00	23.169	2-Jul-99	16:30:00	18.384	16-Oct-99	16:30:00	12.239
14-Apr-99	17:00:00	23.169	2-Jul-99	17:00:00	17.872	16-Oct-99	17:00:00	12.212
14-Apr-99	17:30:00	23.169	2-Jul-99	17:30:00	10.744	16-Oct-99	17:30:00	11.868
14-Apr-99	18:00:00	23.169	2-Jul-99	18:00:00	11.452	16-Oct-99	18:00:00	12.239
14-Apr-99	18:30:00	22.536	2-Jul-99	18:30:00	11.478	16-Oct-99	18:30:00	12.212
14-Apr-99	19:00:00	23.169	2-Jul-99	19:00:00	11.868	16-Oct-99	19:00:00	11.842
14-Apr-99	19:30:00	22.536	2-Jul-99	19:30:00	12.265	16-Oct-99	19:30:00	11.842
14-Apr-99	20:00:00	23.169	2-Jul-99	20:00:00	12.669	16-Oct-99	20:00:00	11.842
14-Apr-99	20:30:00	22.536	2-Jul-99	20:30:00	13.108	16-Oct-99	20:30:00	11.842
14-Apr-99	21:00:00	22.536	2-Jul-99	21:00:00	13.560	16-Oct-99	21:00:00	11.842
14-Apr-99	21:30:00	22.536	2-Jul-99	21:30:00	8.934	16-Oct-99	21:30:00	11.842
14-Apr-99	22:00:00	22.536	2-Jul-99	22:00:00	9.254	16-Oct-99	22:00:00	11.842
14-Apr-99	22:30:00	22.536	2-Jul-99	22:30:00	9.254	16-Oct-99	22:30:00	11.842
14-Apr-99	23:00:00	22.536	2-Jul-99	23:00:00	9.278	16-Oct-99	23:00:00	11.842
14-Apr-99	23:30:00	22.536	2-Jul-99	23:30:00	9.628	16-Oct-99	23:30:00	11.816
14-Apr-99	0:00:00	22.536	2-Jul-99	0:00:00	9.960	16-Oct-99	0:00:00	11.452

APPENDIX G

PRECIPITATION DATA
(NOAA, 1999)

HOURLY PRECIPITATION

(WATER EQUIVALENT IN INCHES)

SYRACUSE, NY

APRIL 1999 SYR WBAN # 14771

DATE	1	2	3	4	5	6	7	8	9	10	11	12
01							T	0.03	0.01	0.02	0.06	0.04
02												
03												
04	0.03	0.04	0.03	0.03	0.01	T	T	T				
05												
06												
07												
08			T	0.03	T							
09												
10												
11												
12	0.01											
13												
14												
15												
16									T	0.04	0.04	T
17			T	T	0.01	T	T					
18	T	T		T	T	T						T
19							T	T	T	T	T	T
20												
21												
22						T	T	T	0.04	0.05	0.05	T
23	0.02	0.02	0.06	0.03	0.01	0.02	T	T	T	T		T
24												
25												
26							T					
27												
28												
29												
30												

DATE	13	14	15	16	17	18	19	20	21	22	23	24
01	T											
02											T	
03										0.06		
04												
05												
06				0.02	T			T		T	0.04	
07												
08												
09			T									
10												
11				T	0.15	0.08	0.01	T			T	T
12												
13												
14												
15												
16	0.06	0.08	0.06	0.05	0.02	0.05		T	T			
17	T	0.03	0.03	T	T	0.01		0.01	T	0.01	T	0.01
18	T											
19	0.01	0.01	T	T	T	T						
20	T											
21												
22	0.01	T	T	T	0.01	0.01	0.03	0.04	0.02	0.05	0.05	T
23	T											
24												
25												
26												
27												
28												
29												
30												

DATE	Sum if Different (See Note 2)	2400 LST Water Equiv
01		0.16
02		T
03		0.06
04		0.14
05		0.00
06		0.06
07		0.00
08		0.03
09		T
10		0.00
11		0.24
12		0.01
13		0.00
14		0.00
15		0.00
16		0.40
17		0.11
18		T
19		0.02
20		T
21		0.00
22		0.36
23		0.16
24		0.00
25		0.00
26		T
27		0.00
28		0.00
29		0.00
30		0.00

Storm 1

MAXIMUM SHORT DURATION PRECIPITATION (See Note)

Time Period (Minutes)	5	10	15	20	30	45	60	80	100	120	150	180
Precipitation (Inches)												
Ending Date												
Ending Time (Hour/Min)												

Date and time are not entered for TRACE amounts.

Note : The sum of the hourly totals is given when it differs from the daily total. NWS does not edit ASOS hourly values but may edit daily and monthly totals. Hourly, daily, and monthly totals are printed as reported by the ASOS site.

HOURLY PRECIPITATION

(WATER EQUIVALENT IN INCHES)

SYRACUSE, NY

JUNE 1999 SYR **WBAN # 14771**

DATE	FOR HOUR (LST) ENDING AT 1	2	3	4	5	6	7	8	9	10	11	12
01									T			
02	T	0.01	T									
03		T								T	T	T
04												
05												
06												
07												
08												
09												
10												
11												
12												
13												
14												
15						T	T					
16												
17												
18	T	T										
19												
20												
21						T	T					
22												
23												
24												
25							T	0.17	0.20	0.30	0.04	
26												
27												
28	0.01	T	0.01									0.13
29								T	T		T	T
30												

DATE	FOR HOUR (LST) ENDING AT 13	14	15	16	17	18	19	20	21	22	23	24	DATE	Sum if Different (See Note)	2400 LST Water Equiv.
01	T	T	0.01	T		T	T								0.01
02								T	T						0.01
03	T							T	T						T
04															0.00
05															0.00
06															0.00
07			T	T											T
08															0.00
09															0.00
10															0.00
11															0.00
12															0.00
13															0.00
14		T	0.21	0.02	T	T	0.15								0.38
15															T
16															0.00
17		T	0.02	0.02	0.03	0.03	0.04	0.01	T						0.20
18															T
19															0.00
20															0.00
21			T												T
22															0.00
23															0.00
24															0.00
25	T														0.71
26															0.00
27								T	0.02						0.08
28	0.02														0.17
29	0.17	0.06	0.01												0.24
30															0.00

Storm 2

bcg 11/1

MAXIMUM SHORT DURATION PRECIPITATION (See Note)

Time Period (Minutes)	5	10	15	20	30	45	60	80	100	120	150	180
Precipitation (Inches)												
Ending Date												
Ending Time (Hour/Min)												

Date and time are not entered for TRACE amounts.

Note : The sum of the hourly totals is given when it differs from the daily total. NWS does not edit ASOS hourly values but may edit daily and monthly totals. Hourly, daily, and monthly totals are printed as reported by the ASOS site.

HOURLY PRECIPITATION

(WATER EQUIVALENT IN INCHES)

SYRACUSE, NY

JULY 1999 SYR WBAN # 14771

DATE	FOR HOUR (LST) ENDING AT 1	2	3	4	5	6	7	8	9	10	11	12
01												
02	0.01	T	0.04	0.02	0.04	0.01	T	T	T			
03												
04		T	0.27	T	0.15	0.21	0.09					
05												
06												T
07												
08									T			
09				T	T	T	T	0.02	0.07	T	0.03	T
10		0.03									T	T
11												
12												
13												
14												
15												
16												
17												
18												
19					T	T	T	0.08	0.03		0.05	T
20												
21												
22												
23												
24				T		T						
25												
26												
27						T						
28												
29						T	0.01					
30												
31												

DATE	FOR HOUR (LST) ENDING AT 13	14	15	16	17	18	19	20	21	22	23	24
01												
02							T	T			T	T
03												
04							T	0.77	0.07	T		T
05												
06	T	T		0.14								
07												
08										0.03	T	
09	T		T	T					0.02	0.17	T	
10			T								T	
11												
12												
13												
14												
15												
16												
17					0.04	0.01						
18												
19		T	T	T								
20												
21												
22												
23												
24												
25												
26												
27												
28												
29			T	T								
30												
31							0.05	0.09	T	T		

DATE	Sum if Different (See Note)	2400 LST Water Equiv.
01		T
02		0.12
03		0.84
04		0.72
05		0.00
06		0.14
07		0.03
08		T
09		0.31
10		0.03
11		0.00
12		0.00
13		0.00
14		0.00
15		0.00
16		0.00
17		0.05
18		0.00
19		0.16
20		0.00
21		0.00
22		0.00
23		0.00
24		T
25		0.00
26		0.00
27		T
28		0.00
29		0.01
30		0.00
31		0.14

end

MAXIMUM SHORT DURATION PRECIPITATION (See Note)

Time Period (Minutes)	5	10	15	20	30	45	60	80	100	120	150	180
Precipitation (Inches)												
Ending Date												
Ending Time (Hour/Min)												

Date and time are not entered for TRACE amounts.

Note : The sum of the hourly totals is given when it differs from the daily total. NWS does not edit ASOS hourly values but may edit daily and monthly totals. Hourly, daily, and monthly totals are printed as reported by the ASOS site.

HOURLY PRECIPITATION

(WATER EQUIVALENT IN INCHES)

OCTOBER 1999 SYR WBAN # 14771

DATE	1	2	3	4	5	6	7	8	9	10	11	12
01												
02												
03						T	T					
04	0.02	0.17	0.12	0.13	0.29	0.13	T					
05												
06			T	T	T				T	0.02	0.01	T
07												
08												
09	0.02	T										
10					0.02	0.02	0.12	0.08	T	0.01		0.03
11		0.02	T									
12												
13												
14		0.02	0.04	0.09	0.03	0.04	0.02	0.02	T	T	T	
15												
16												
17												
18	0.01	0.01	0.01	T								
19												
20		T	T	0.01	T							
21	T			T	T							
22							T	0.02	0.01			T
23												
24	T	0.02	0.01	0.01	0.01	T	0.01	T				0.01
25	0.01	T										
26												
27					T	0.01	T					
28												
29												
30												
31										T	T	T

DATE	13	14	15	16	17	18	19	20	21	22	23	24
01												
02										T		
03											T	T
04												
05												
06	0.02	T										
07												
08									T	0.05	0.04	T
09												
10	T					T						0.01
11												
12												
13							0.05	0.18	0.17	0.23	0.07	T
14												
15												
16												
17		T						T	T	T	0.01	0.01
18												
19												
20												T
21												
22	0.01	0.02	T		0.05		T		T			
23			0.01	0.01	T			T	0.01	0.11	0.04	0.02
24	T	T	0.01	T	T						T	0.01
25												
26												
27												
28												
29												
30												
31												

Sum #

out of

IUM S

Time

Prec

Ending Date

Ending Time (

entered

E amounts.

NOAA, National Climatic Data Center

Vita

Name
Elizabeth E. Coyle

Date and Place of Birth
June 5, 1965 Lexington, Kentucky

Education

	Name and Location	Dates	Degree
High School:	Thomas J. Corcoran Syracuse, New York	6/82	Regents Diploma
College:	Onondaga Community College Syracuse, New York	5/94	AS
College:	SUNY–ESF Syracuse, New York	5/96	BS
Grad. School:	SUNY–ESF Syracuse, New York	5/02	MS

Employment

Employer	Dates	Job Title
NYSDEC Syracuse, New York	7/98 – 5/02	Env. Engineer 1