Geologic History of Kayaderosseras Watershed

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Introduction to study

In the spring of 2005 Skidmore College Environmental Studies students began a five year project under the new Water Resources Initiative to study the Kayaderosseras Creek watershed with a highly interdisciplinary approach. In support of that project, and as a general resource for the area, this study attempts to provide a basic GIS database of relevant maps and layers showing general information, such as roads and towns, and also features such as bedrock geology, surficial geology and land use patterns. The purpose of this database is to provide supporting material for other projects, to establish a base of information which can be used to make comparisons and to uncover further avenues of study. With these goals in mind, this project is purposefully wide in scope, it is hoped that the information gathered and organized here can be used in the future to facilitate focused projects which will illuminate specific characteristics of the watershed. The goal of all these Water Resource Initiative projects will be to establish relevant data which can be used in development of responsible plans for the future of the watershed.

Geologic History of Kayaderosseras Watershed

The geology and topography that we see in the present day Kayaderosseras watershed is the result of hundreds of millions of years of geologic activity. In fact, the oldest rocks in New York State are from the Grenville formations and date back to 1.6 billion years before present (Isachsen et al. 1991). Throughout this time New York has been involved in many geologically important events because of its proximity to the edge of the large North American continental plate. This has resulted in a diversity of geological characteristics across the state and the Kayaderosseras basin is no exception. For the most part there has been a historic cycle of expansions and retractions of the Atlantic, or proto-Atlantic Ocean. These cycles have resulted in periods of mountain building, when the oceanic plate was colliding with the continental plate, and erosion, when the plates were moving apart (Van Diver 1985). The Taconian Orogeny, the Acadian Orogeny and the Alleghanian Orogeny were the most recent of these mountain building events and their impacts can still be seen today in the mountains of the east coast (Isachsen et al. 1991). These deformations have left an abundance of north-easterly faults across the state, especially in the Adirondacks. On top of these rocks that have deformed into mountains from continental collisions, there are also some deposits that were formed when New York was a shallow sea. Many of these deposited rocks have eroded away in the mountains to leave exposed bedrock but can still be found in isolated places and in low lying lands (Isachsen et al. 1991).

Although these mountain building events have created the large scale topography of New York, the recent glacial periods have also had a major effect on the local topography. For the last 2 million years and up until about 10,000 years ago glaciers consistently swept down across the state and then retreated. The most recent glacier to cover the state was during the Wisonsinan glaciations which climaxed about 20,000 years ago and began to recede about 10,000 years ago (Van Diver 1985). The weight of the glaciers forced mountains to sink and scoured bedrock and soil in many areas. Deposits of glacial till, including sand, gravel, clay and silt, were strewn across the state. Glacial erratics (boulders ranging from small to large) were also moved to new locations

(Isachsen et al. 1991). The retreat and melting of glaciers created huge lakes that altered sedimentation patterns and often left large deposits of sand and other materials. With the release from glacial weight the Adirondack Mountains began to rise slowly and continue to rise in the present day. Finally, isolated glaciers left behind kettle holes where they melted that can still be found in the state (Van Diver 1985).

The Kayaderosseras watershed itself straddles an interesting geological location. The north and west regions of the basin reach into the lower Adirondacks and are characterized by the bedrock geology of that region. The watershed is also characterized by a distinct north east trending fault which divides it. The eastern side is composed almost entirely of shale. A previous study has divided the watershed into three general regions based on the presence of consolidated and unconsolidated sediments. The first region is the area of steep slopes and irregular terrain with less soil, the second is the region with moderate slopes and small shallow valleys and the final region is characterized by flat, gently sloping areas with valleys or ridges (Aulenbach et al. 1980). These characteristics of bedrock and surficial geology influence the drainage of the basin and alter the course of its streams. The underlying geology and mineral deposits are also the source of the famous mineral springs that draw tourists each summer (Aulenbach et al. 1980). The physical nature of the land has shaped the opportunities for land use in the basin ever since settlement and has also influenced the impact that those land uses have had on the environment. In order to make plans for the future of the watershed it is important to understand this basic framework.

Methodology and rationale of project

Electronic mapping data was gathered from ESRI, USGS and the Census Bureau websites to be used for analysis in ArcMap 9.0 and Excel. All relevant layer files were clipped to the boundaries of the watershed and saved as new layer files to allow easier map creation and to streamline the database. ArcHydroTools were used to delineate the watershed from a Digital Elevation Model (DEM) with the drainage point placed at the entrance to Saratoga Lake. Five sub-watersheds were also defined in this way to allow comparisons between different areas of the drainage basin (Map 1). The largest sub-watershed encompassed two of the smaller ones in addition to other land. This overlap is the cause of percentages which seem to add to more than one-hundred percent in some of the data.

For land use, detailed categories were grouped to allow a general overview of the watershed and to make comparisons between sub-watersheds (Map 5) based on USGS 1992 land use data. This generalized view of land use divided the watershed into six categories (Table 1). Total area of each land use group was calculated in the watershed by exporting data from ArcMap to Excel and summing. These areas were used to create pie charts for each sub-watershed (Figures 1-6) and to generate statistics for land use in the entire watershed (Figure 7, Table 4). Detailed land use was mapped for each individual sub-watershed to allow a more precise examination (Maps 6-10).

Grouped Category	Land Uses Included in Group
Water	Open Water
Developed	Low Intensity Residential High Intensity Residential Commercial/Industrial/Transportation
Barren/Mined	Quarries/Strip Mines/Gravel Pits
Forested	Deciduous Forest Evergreen Forest Mixed Forest
Agriculture	Pasture/Hay Row Crops Urban/Recreational Grasses
Wetlands	Woody Wetlands Emergent Herbaceous Wetlands

Table 1: Land Use Categories

Bedrock geology was examined in detailed form (Map 11) but in order to make general observations it was also grouped into six categories based on physical properties (Map 12, Table 2). Based on these groups pie charts were made to allow comparison between each sub-basin (Figures 8-13) and statistics were calculated for grouped bedrock coverage in the entire watershed (Figure 14, Table 5).

Functional Groups	Bedrock Included
Carbonates	Beekmantown Group Theresa (Galway) Formation
Interbedded Shale	Dolgeville Formation Schenectady Formation
Hard Rock	Biotite/Hornblende Granite Gneiss Quartzite, Quartze-Biotite Schist Charnockite, Granitic and Quartz
Metasedimentary	Interlayered Metasedimentary Undivided Metasedimentary
Shale	Canajoharie Shale Taconic Melange

Table 2: Functional groups used in creating "grouped bedrock" information

Surficial Geology was also examined in detailed form (Map 13). In this case four groups were created based on what we believed to be the infiltration characteristics of the material (Table 3). These groupings allow comparison of permeability in each sub watershed (Figures 15-20) and an overview of the entire watershed (Figure 21, Table 6).

Permeability Group	**Surficial Material Included**
Bedrock	Bedrock
Permeable Sand/Gravel	Dunes Fluvial Sand/Gravel Lacustrine Delta Lacustrine Sand Outwash Sand/Gravel
Swamp Deposits	Swamp Deposits
Variable Permeability (Boulders to Sand)	Kame Deposits Kame Moraine Till

Table 3: Surficial Geology groupings based on permeability

Several related projects are currently examining chemical and biological indicators of water quality within the watershed. In this effort, certain sample sites have been established to be used as repeatable locations at which change can be measured over time (Map 2). Finally, drainage density was calculated using GIS data to determine total length of river and total area in the entire basin and in each sub-watershed (Figure 22, Table 7).

Results

Land use for the entire watershed was almost 70% forested. Agricultural practices made up 15% of the area while developed land contributed 9% and wetlands and water contributed 7% (Figure 6). These percentages varied within the sub-watersheds. The most forest (88%) and least development (1%) were present in the Upper Kayaderosseras sub-watershed (Figure 5) while the least forest (53%) and the most development (27%) were present in the Loughberry Lake sub-watershed (Figure 3). For a detailed comparison of different land use percentages within each sub watershed refer to Maps 5-10, Figures 1-7 and Table 4.

Bedrock geology in the Kayaderosseras watershed was composed largely of shales (48%) and carbonates (30%) with all other categories contributing less than 10% of the whole (Figure 8). Despite the predominance of shale in the watershed, three sub-watersheds (Glowegee, Upper Kayaderosseras and Geyser) contain more carbonate than shale (Figures 8,9,12). Only the Loughberry and Main Stem sub-watersheds, which reach into eastern parts of the basin, are dominated by shale (Figures 10,11). For complete information on bedrock composition and percentages see Maps 11-12, Figures 8-14 and Table 5.

The surficial geology of the watershed was characterized by 52% variable permeability and 45% permeable sand and gravel (Figure 20). The Glowegee sub-watershed had the highest amount of variable permeability material (95%) and the least permeable sand and gravel (5%) (Figure 16). In contrast to this, the Loughberry sub-watershed had the lowest variable permeability material (4%) and the highest amount of permeable sand and gravel (89%) (Figure 17). For complete data on the distribution of surficial bedrock material see Maps 13-14, Figures 15-21 and Table 6.

Drainage density for the entire watershed was 0.68 Km per Km^2 of area (Table 7). The highest drainage density was found in the Upper Kayaderosseras sub-watershed at 0.87 Km per Km^2 and the lowest was found in the Loughberry Lake sub-watershed at 0.44 Km per Km^2. The entire Kayaderosseras watershed drains 490.56 Km^2. The largest sub-watershed (discounting the Main Stem which encompasses two other sub-watersheds) was the Upper Kayaderosseras with a drainage area of 151.29 Km^2. The smallest was the Loughberry sub-watershed which drains only 58.90 Km^2. Figure 22 and Table 7 provide detailed data on drainage density and area calculations.

Discussion

Although no specific questions were addressed in this study, there are several trends that have become clear and observations that can be made based on the organization of this data. Regarding land use it is apparent that there are sharp distinctions between patterns across the sub-watersheds. It is difficult to draw conclusions from this data because the most recent land use information available is from 1992 and is therefore outdated. However, it is probably that relative relationships between the sub-watersheds are similar today. Two facts are striking when examining the land use charts. First, the Upper Kayaderosseras sub-watershed (which is the largest of the sub-watersheds) contains the highest percentage of forest. This is a hopeful sign for the management of the watershed because the Upper Kayaderosseras encompasses the headwaters of the creek and appears to be relatively free of pollutant sources. The second observation is that the Loughberry sub-watershed contains far and away the greatest amount of development. Loughberry Lake is the drinking water source for Saratoga Springs and this development could be a warning sign of water quality impairment in the future.

Perhaps the most interesting variation in bedrock distribution throughout the watershed is the amount of carbonate rocks present in each sub-watershed. We believe that contact with carbonate containing rocks may provide an alkalinity buffer against acid rain. The almost complete lack of carbonate rocks (4%) within the Loughberry sub-watershed could provide an interesting comparison to another area such as Glowegee which contains 55% carbonate bedrock. Understanding this relationship would require further study and field sampling but these comparisons provide a good starting point toward examining the vulnerability to negative effects related to acid rain.

Of all the watershed characteristics that we have considered, surficial geology appears to show the highest degree of variability across the sub-watersheds. Once again this opens the door to a wide range of future studies. It is likely that the properties of water in the Loughberry sub-watershed (89% permeable sand and gravel) will prove to be drastically different from those of the Glowegee sub-watershed (95% variable permeability). Because the amount of permeable sand and gravel ranges so widely across the sub-watersheds (5%, 24%, 31%, 45%, 57%, 89%) it may be possible to see gradations in water properties with an in depth study focused on infiltration characteristics.

The most interesting uses of this database will probably come from comparisons which incorporate several watershed characteristics and try to understand how they relate to each other. For example, during the process of creating this database we noticed that the Glowegee and Geyser sub-watersheds are fairly similar in total area, land use percentages (other than developed) and bedrock composition. However, they diverge rather drastically in development and the permeability of the surficial geology. By using these two sub-watersheds in detailed field studies it may be possible to isolate certain characteristics and determine the influences that those characteristics have on the water. This is only one example of how this might be done but the data compiled here clearly offers the baseline data needed to start many similar projects.

It is also important to note here that this database is by no means complete and will need to be consistently updated in order to remain useful and relevant. Adding more recent land use data would be a major step in this direction. Another major watershed characteristic which was excluded from this study due to time is soil composition. The relevant GIS soil data has been included in the database but no analysis work has been performed with it. As more projects are conducted on the Kayaderosseras, the relevant data and layers should be synthesized with these preliminary maps. Hopefully this database will prove to be a valuable resource in years to come. The organization of this basic data should allow others to build and get more complicated in the future.

References

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USGS web site

Van Diver BB (1985) Roadside Geology of New York. Mountain Press Publishing Company, Missoula, Montana.

Acknowledgements

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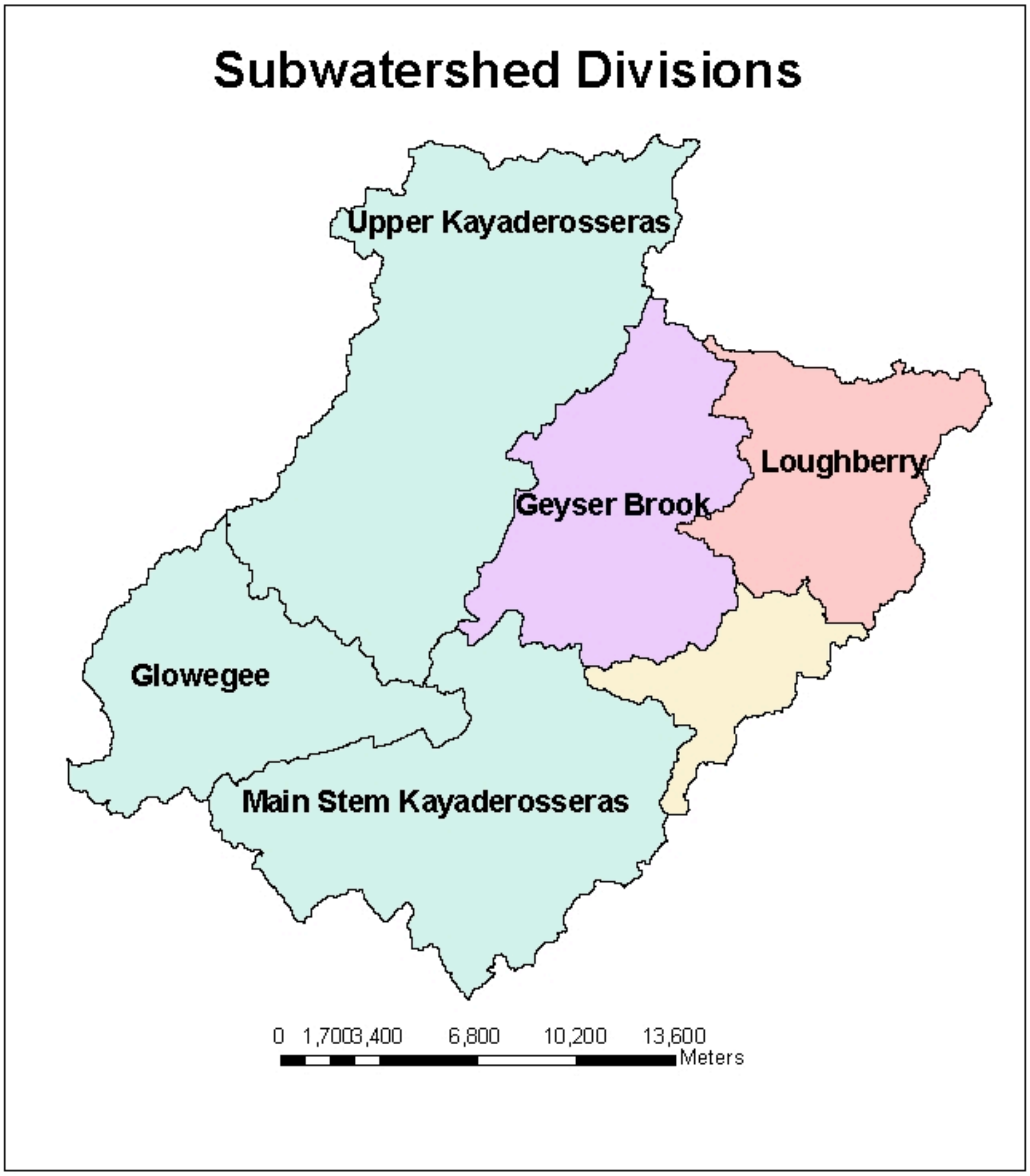
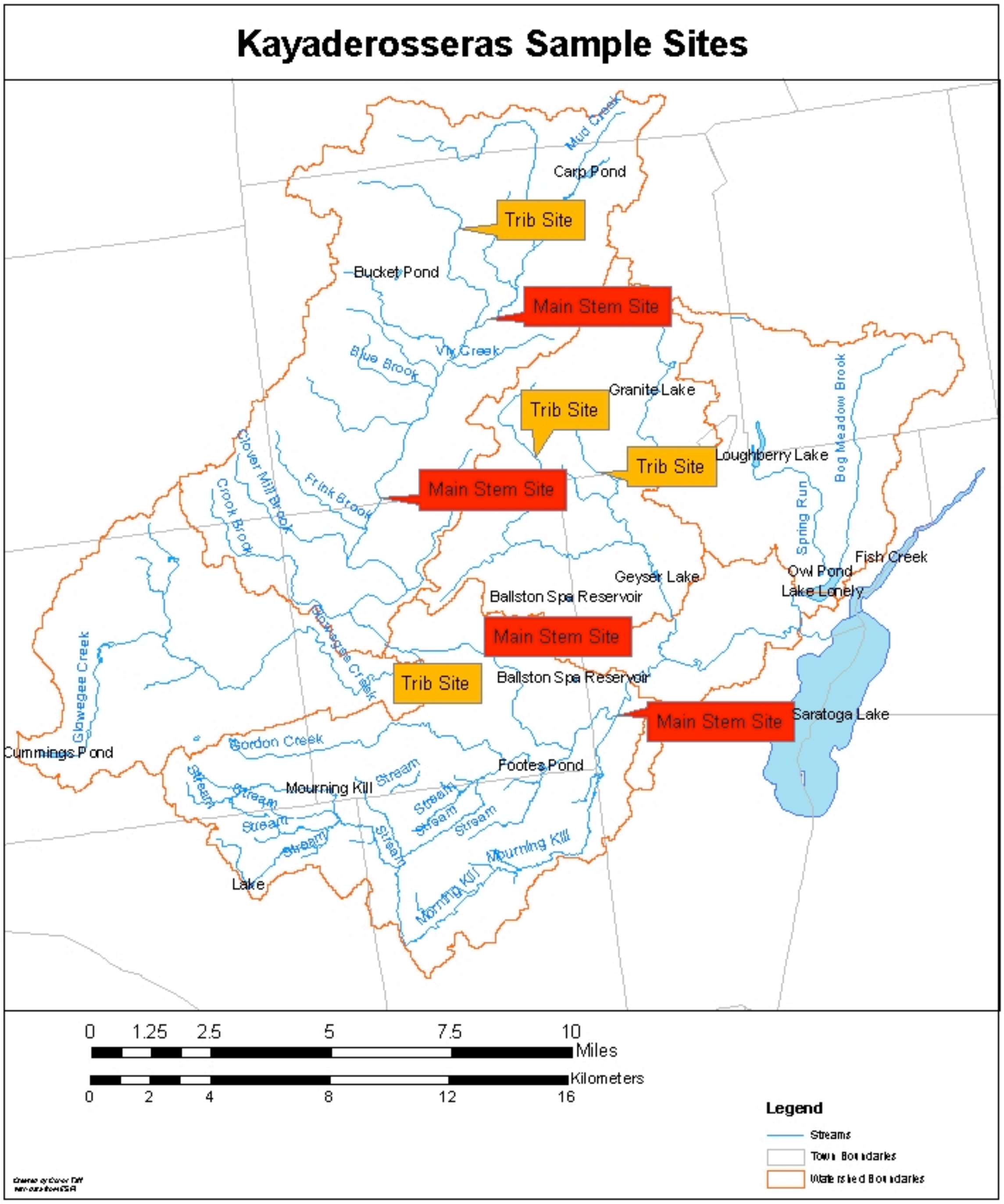
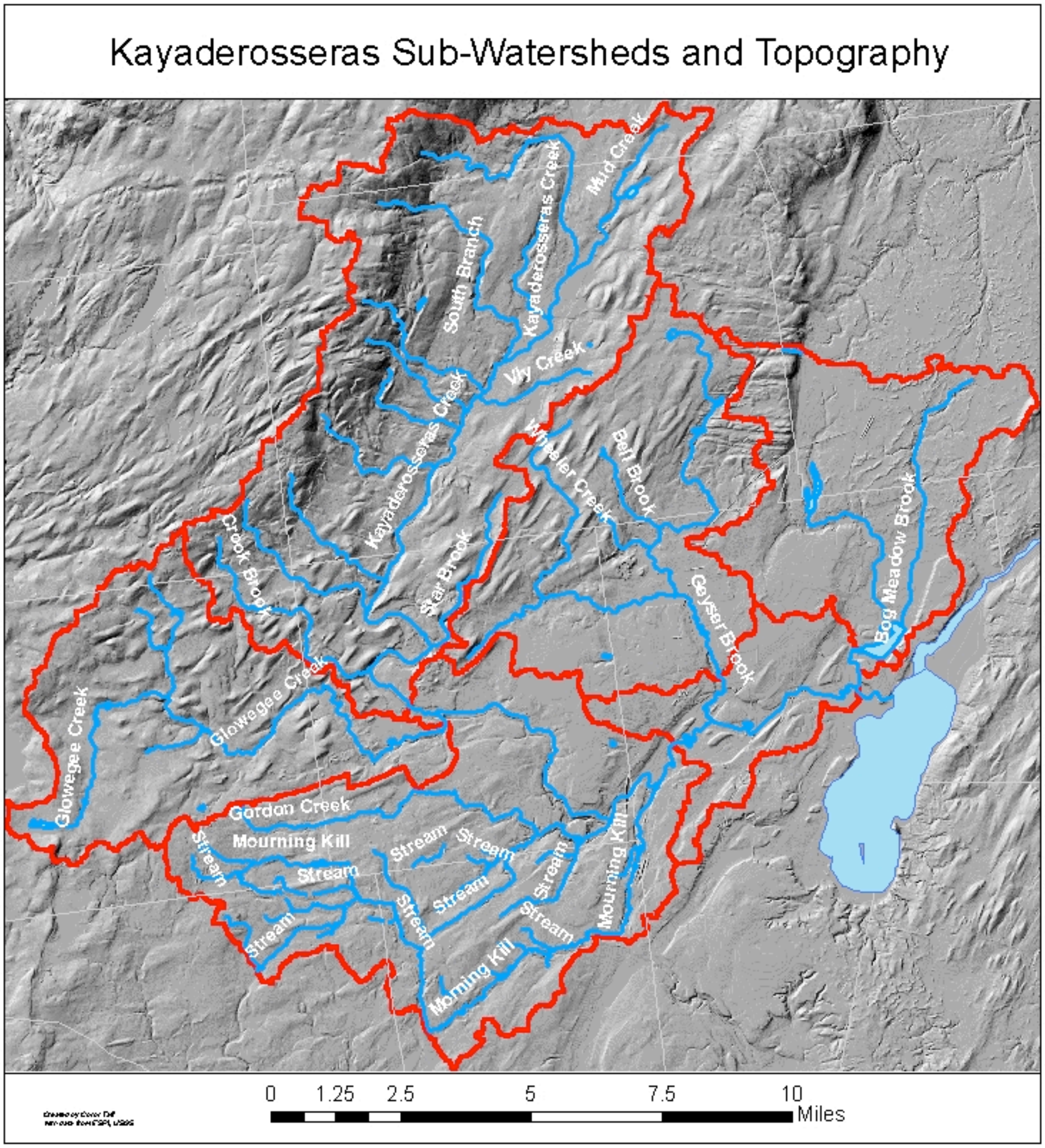
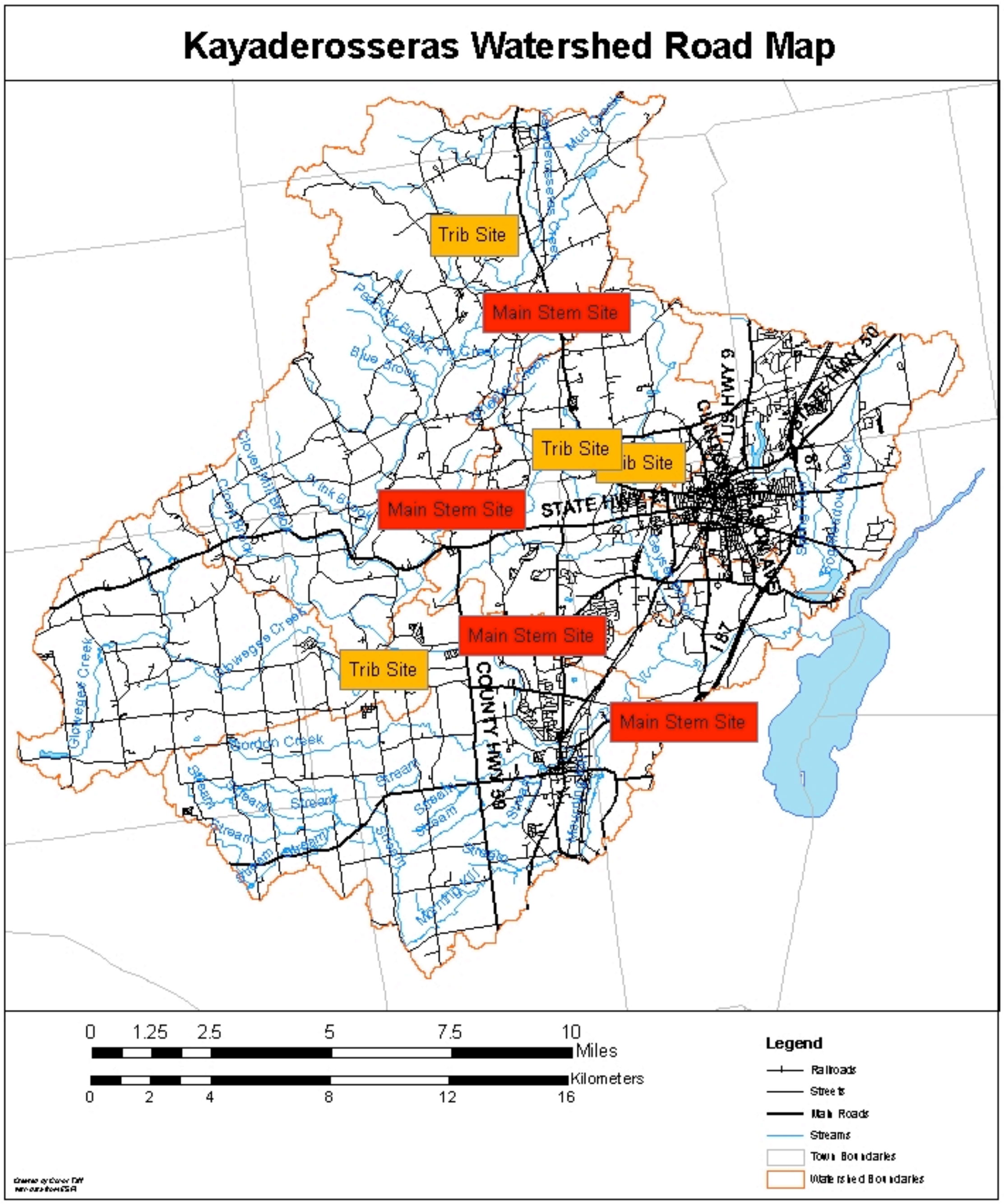

Subwatershed Divisions
Upper Kayaderosseras
Loughberry
Geyser Brook
Glowegee
Main Stem Kayaderosseras
0 1,7003,400 6,800 10,200 13,600
Meters


Kayaderosseras Sample Sites
Mud Creek
Carp Pond
Trib Site
Bucket Pond
Main Stem Site
Vly Creek
Blue Brook
Granite Lake
Trib Site
Trib Site
Loughberry Lake
Bog Meadow Brook
Clover Mill Brook
Frink Brook
Main Stem Site
Crook Brook
Spring Run
Fish Creek
Owl Pond
Geyser Lake
Lake Lonely
Ballston Spa Reservoir
Main Stem Site
Glowegee Creek
Trib Site
Ballston Spa Reservoir
Glowegee Creek
Main Stem Site
Saratoga Lake
Cummings Pond
Gordon Creek
Footes Pond
Mourning Kill
Stream
Mourning Kill
Morning Kill
Lake
0 1.25 2.5 5 7.5 10 Miles
0 2 4 8 12 16 Kilometers
Legend
Streams
Town Boundaries
Watershed Boundaries


Kayaderosseras Sub-Watersheds and Topography
Mud Creek
Kayaderosseras Creek
South Branch
Vly Creek
Kayaderosseras Creek
Kayaderosseras Creek
Wheeler Creek
Bell Brook
Bog Meadow Brook
Star Brook
Crook Brook
Geyser Brook
Glowegee Creek
Glowegee Creek
Gordon Creek
Mourning Kill
Stream
Stream
Stream
Stream
Stream
Stream
Stream
Stream
Stream
Mourning Kill
Morning Kill
0
1.25
2.5
5
7.5
10
Miles


Kayaderosseras Watershed Road Map
Trib Site
Main Stem Site
Trib Site
Main Stem Site
Main Stem Site
Trib Site
Main Stem Site
Gordon Creek
COUNTY HWY 50
0 1.25 2.5 5 7.5 10
Miles
Kilometers
0 2 4 8 12 16
Legend
Railroads
Streets
Main Roads
Streams
Town Boundaries
Watershed Boundaries

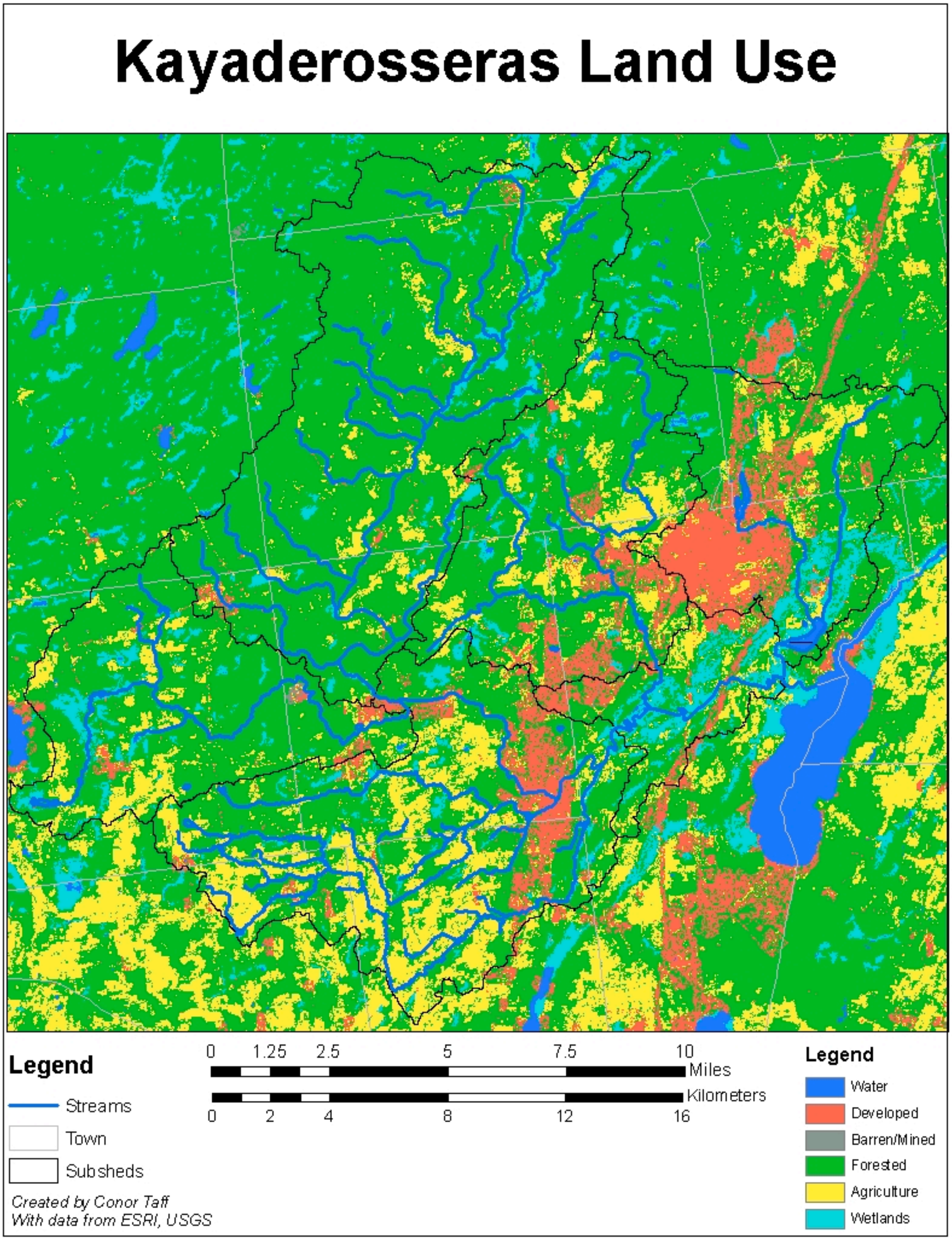
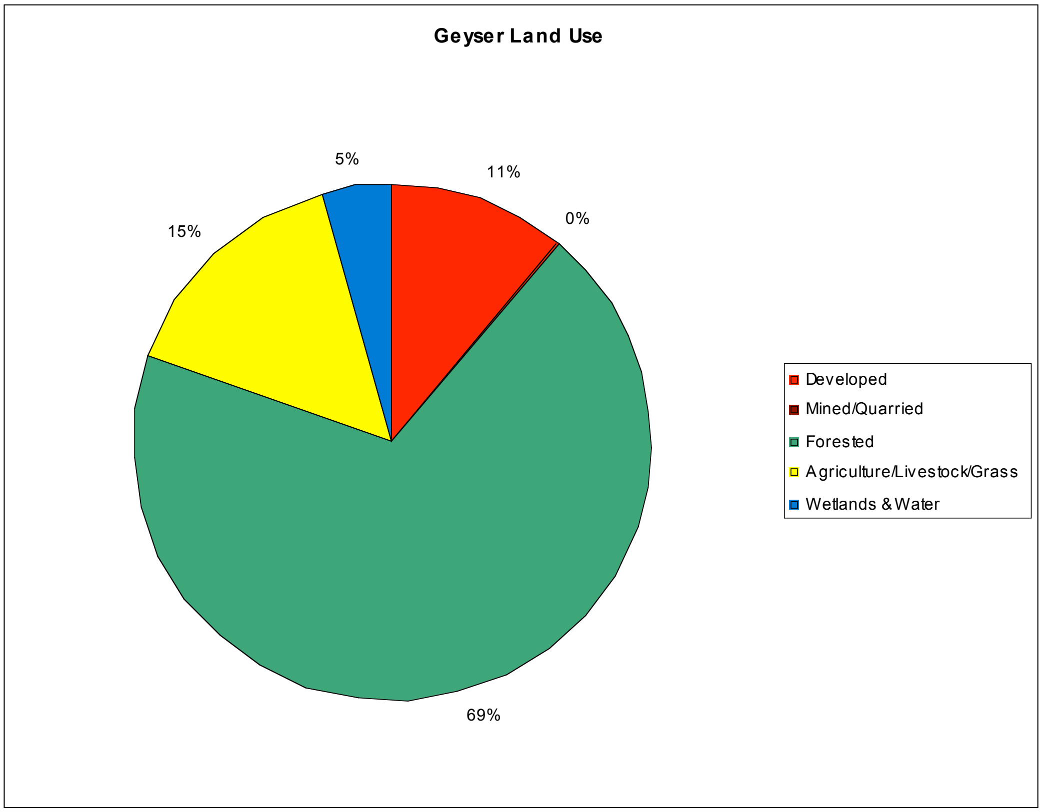
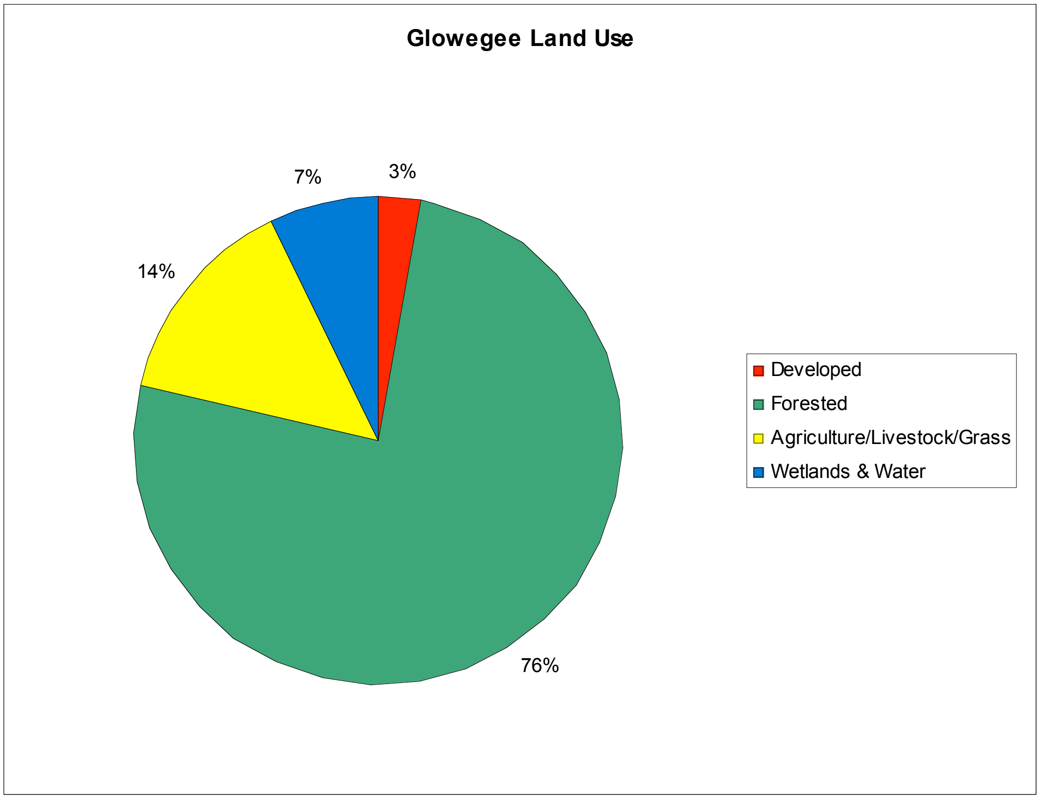

Kayaderosseras Land Use
Legend
Streams
Town
Subsheds
Created by Conor Taff
With data from ESRI, USGS
0 1.25 2.5 5 7.5 10
Miles
Kilometers
0 2 4 8 12 16
Legend
Water
Developed
Barren/Mined
Forested
Agriculture
Wetlands

Figure 1



Geyser Land Use
5%
11%
0%
15%
69%
Developed
Mined/Quarried
Forested
Agriculture/Livestock/Grass
Wetlands & Water

Figure 2



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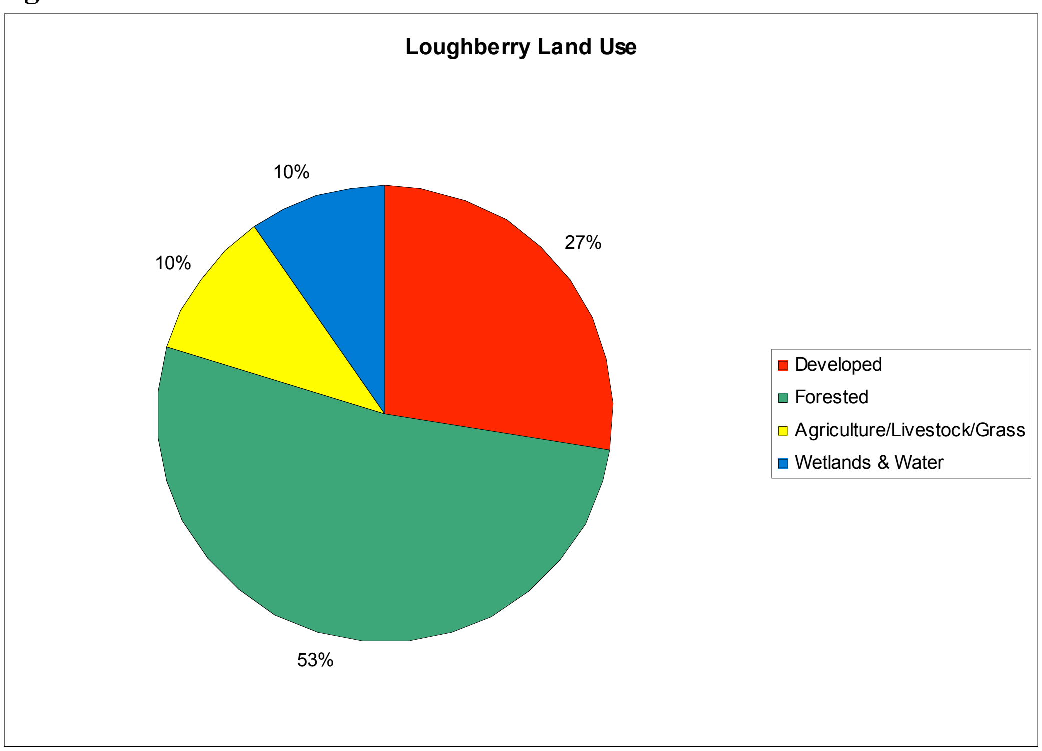


Figure 4

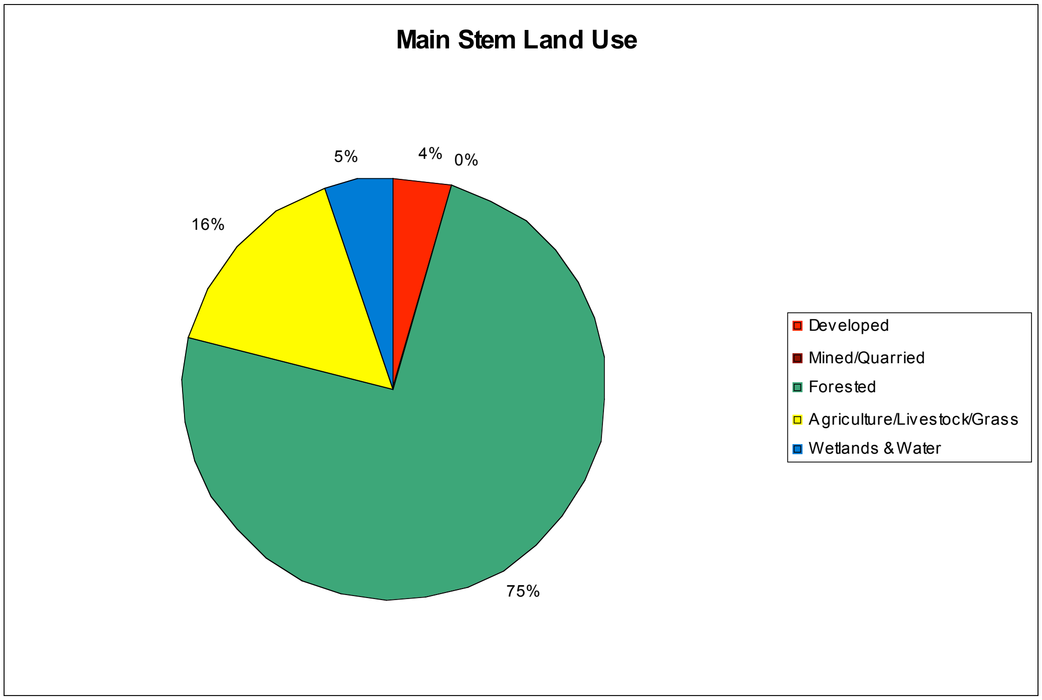
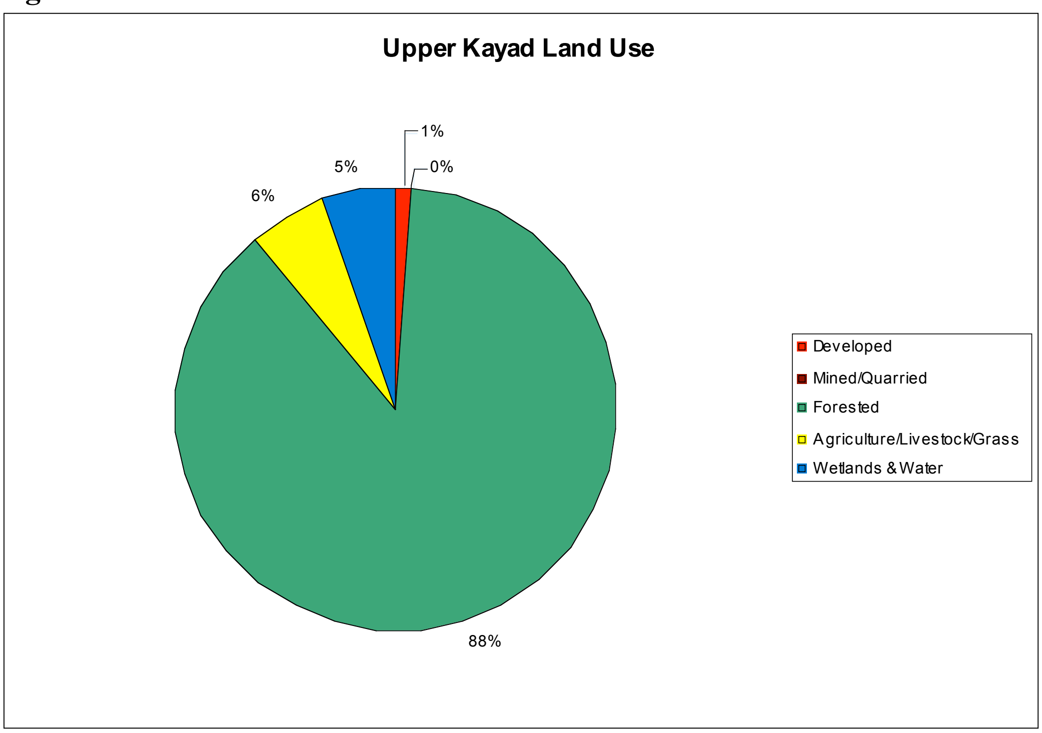


Figure 5



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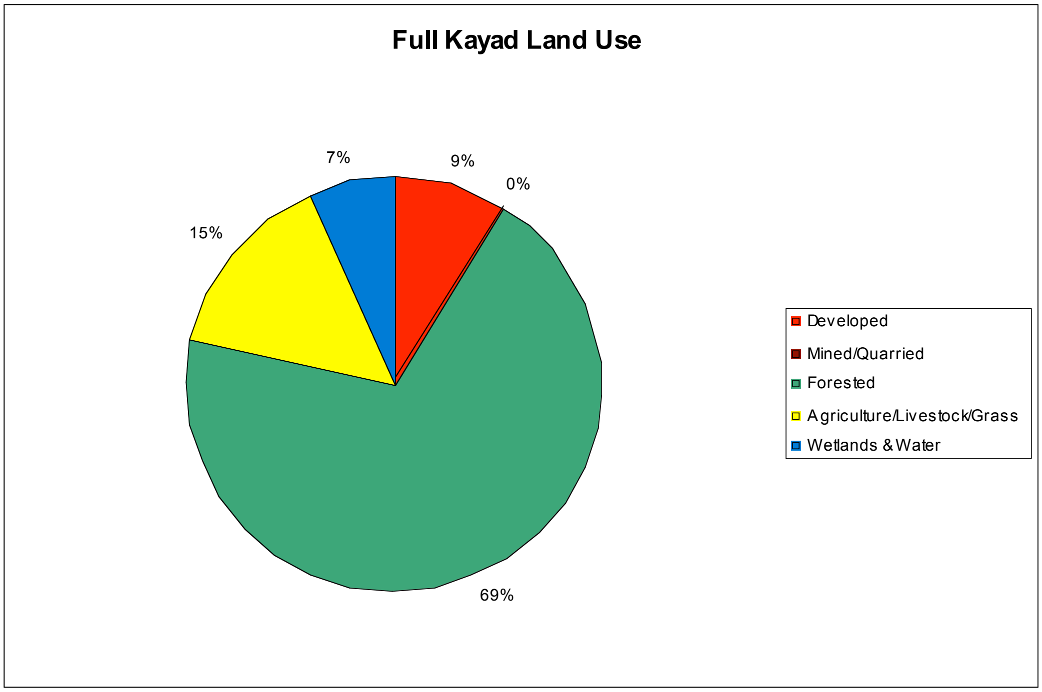

Full Kayad Land Use
7%
9%
0%
15%
69%
Developed
Mined/Quarried
Forested
Agriculture/Livestock/Grass
Wetlands & Water

Figure 7

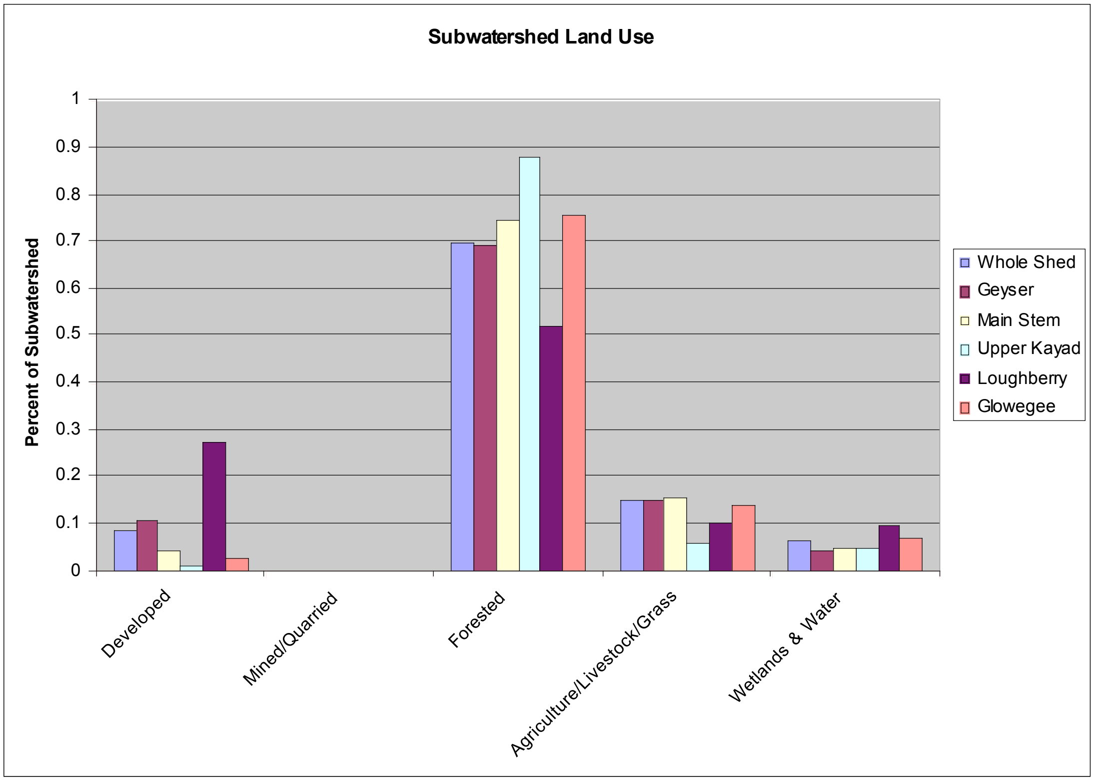
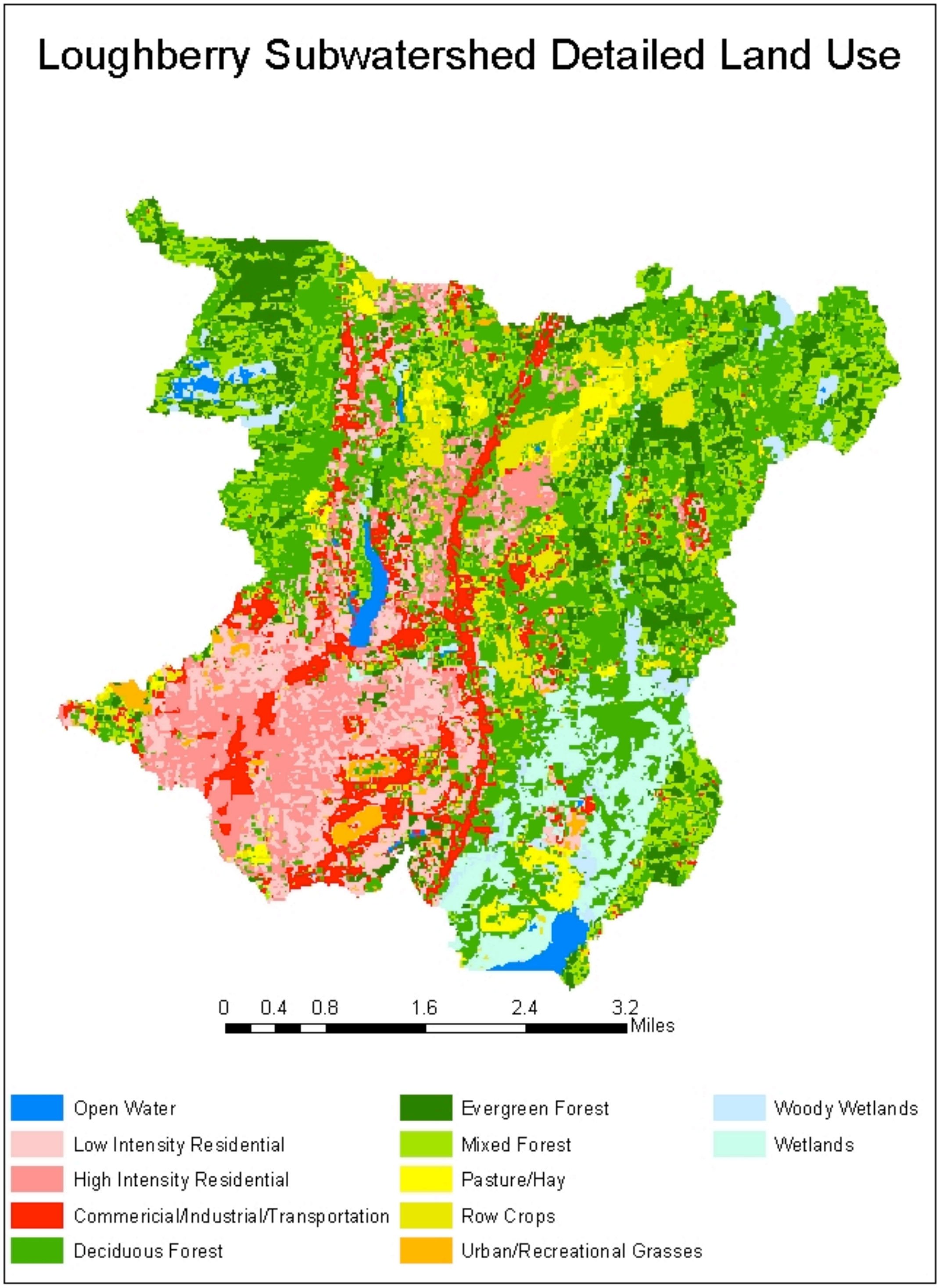
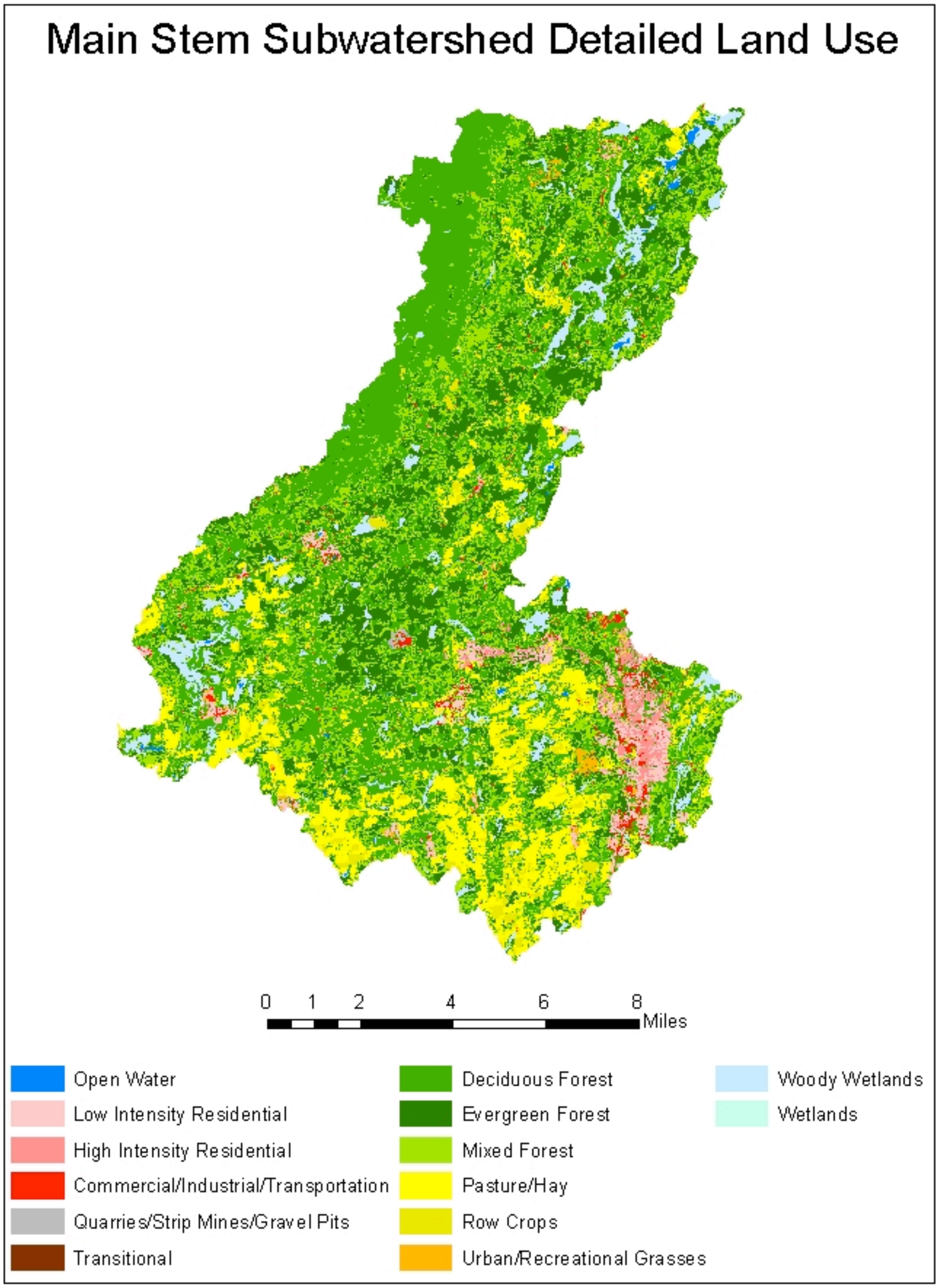
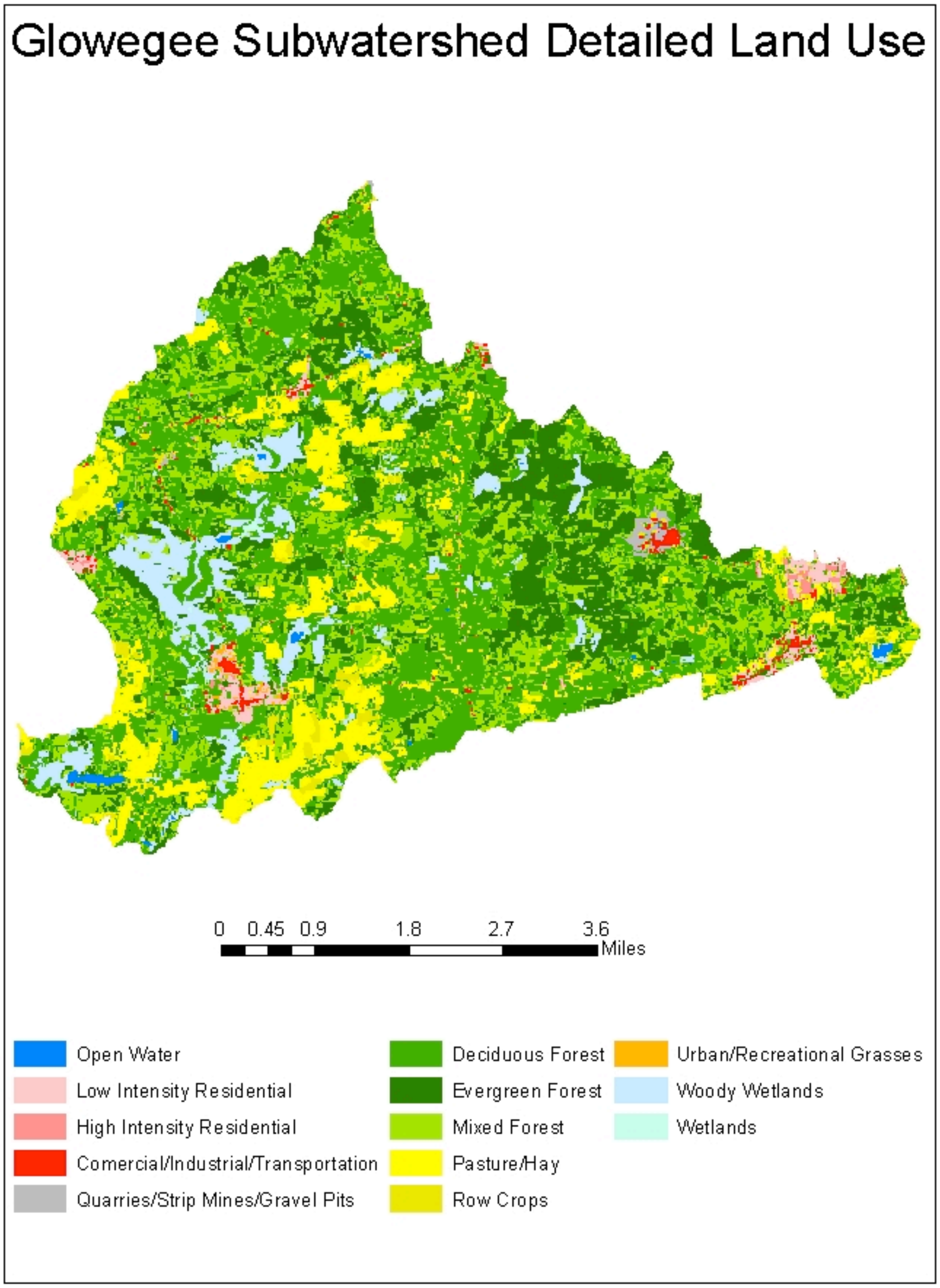


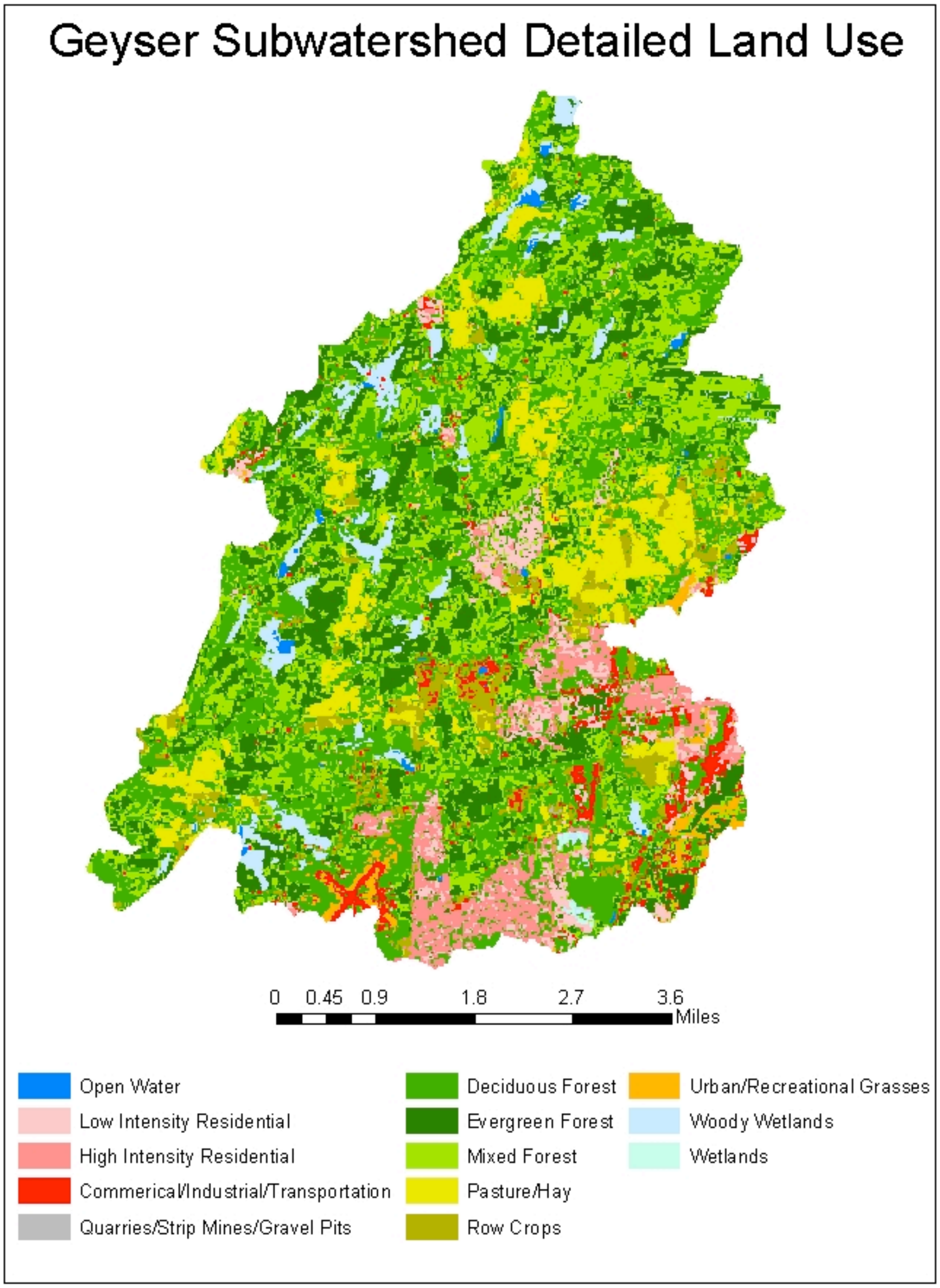
Table 4

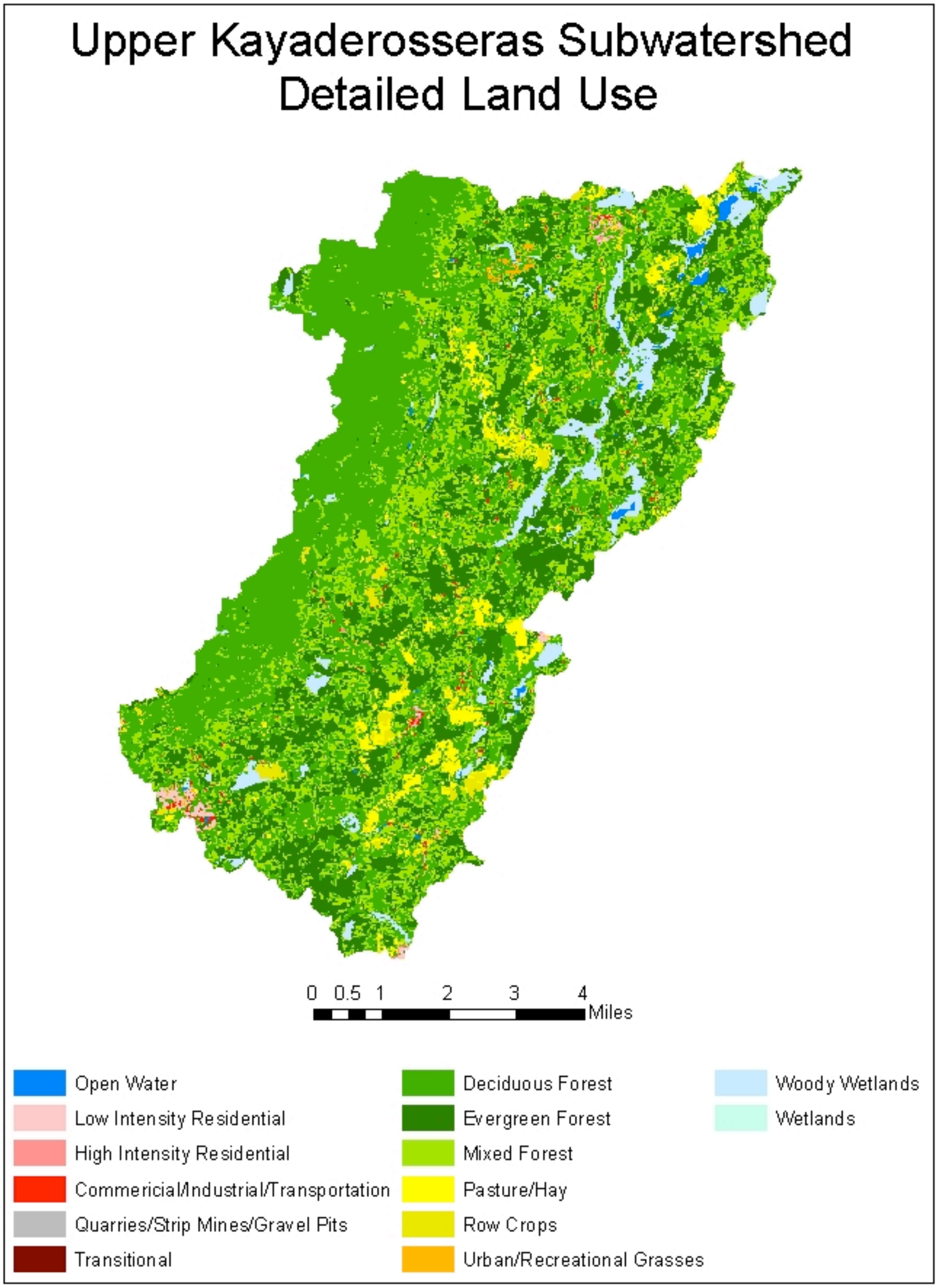
Land Use in Square Km						
Use	**Geyser**	**Glowegee**	**Loughberry**	**Main Stem**	**Upper Kayad**	**Full Kayad**
Developed	8.32	1.84	16.15	14.72	1.58	43.10
Mined/Quarried	0.01	0.00	0.00	0.26	0.01	0.29
Forested	52.37	51.26	30.86	245.58	132.85	341.47
Agriculture/Livestock/Grass	11.37	9.54	6.16	52.19	8.98	73.11
Wetlands & Water	3.45	4.84	5.73	17.01	7.87	32.59
Total Area	75.52	67.73	58.90	329.75	151.29	490.56

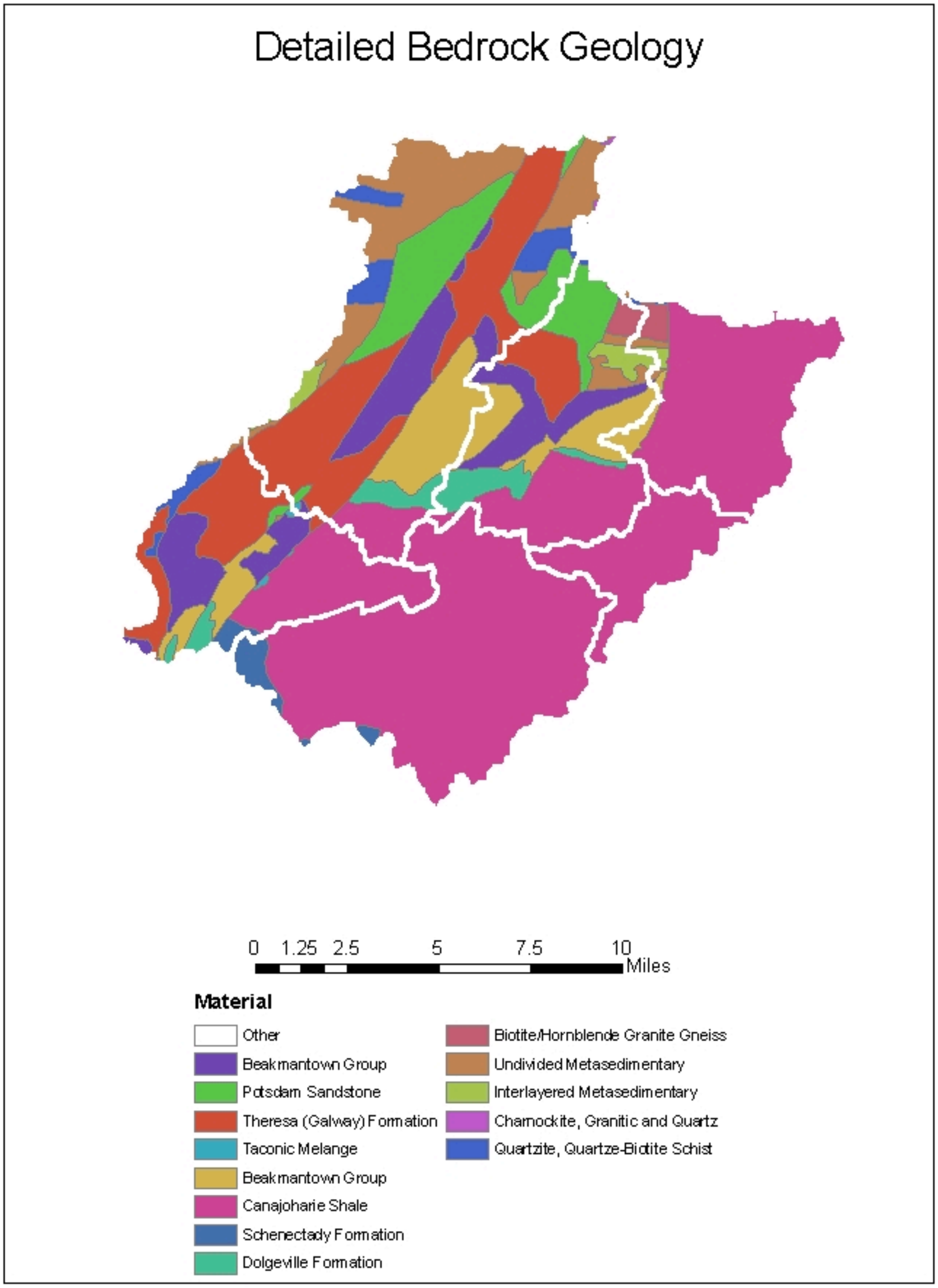

Loughberry Subwatershed Detailed Land Use
0
0.4
0.8
1.6
2.4
3.2
Miles
Open Water
Low Intensity Residential
High Intensity Residential
Commericial/Industrial/Transportation
Deciduous Forest
Evergreen Forest
Mixed Forest
Pasture/Hay
Row Crops
Urban/Recreational Grasses
Woody Wetlands
Wetlands


Main Stem Subwatershed Detailed Land Use
0 1 2 4 6 8
Miles
Open Water
Low Intensity Residential
High Intensity Residential
Commercial/Industrial/Transportation
Quarries/Strip Mines/Gravel Pits
Transitional
Deciduous Forest
Evergreen Forest
Mixed Forest
Pasture/Hay
Row Crops
Urban/Recreational Grasses
Woody Wetlands
Wetlands


Glowegee Subwatershed Detailed Land Use
0 0.45 0.9 1.8 2.7 3.6
Miles
Open Water
Low Intensity Residential
High Intensity Residential
Comercial/Industrial/Transportation
Quarries/Strip Mines/Gravel Pits
Deciduous Forest
Evergreen Forest
Mixed Forest
Pasture/Hay
Row Crops
Urban/Recreational Grasses
Woody Wetlands
Wetlands


Geyser Subwatershed Detailed Land Use
0
0.45
0.9
1.8
2.7
3.6
Miles
Open Water
Low Intensity Residential
High Intensity Residential
Commerical/Industrial/Transportation
Quarries/Strip Mines/Gravel Pits
Deciduous Forest
Evergreen Forest
Mixed Forest
Pasture/Hay
Row Crops
Urban/Recreational Grasses
Woody Wetlands
Wetlands


Upper Kayaderosseras Subwatershed
Detailed Land Use
0 0.5 1 2 3 4
Miles
Open Water
Low Intensity Residential
High Intensity Residential
Commericial/Industrial/Transportation
Quarries/Strip Mines/Gravel Pits
Transitional
Deciduous Forest
Evergreen Forest
Mixed Forest
Pasture/Hay
Row Crops
Urban/Recreational Grasses
Woody Wetlands
Wetlands


Detailed Bedrock Geology
0 1.25 2.5 5 7.5 10
Miles
Material
Other
Beakmantown Group
Potsdam Sandstone
Theresa (Galway) Formation
Taconic Melange
Beakmantown Group
Canajoharie Shale
Schenectady Formation
Dolgeville Formation
Biotite/Hornblende Granite Gneiss
Undivided Metasedimentary
Interlayered Metasedimentary
Charnockite, Granitic and Quartz
Quartzite, Quartze-Biotite Schist

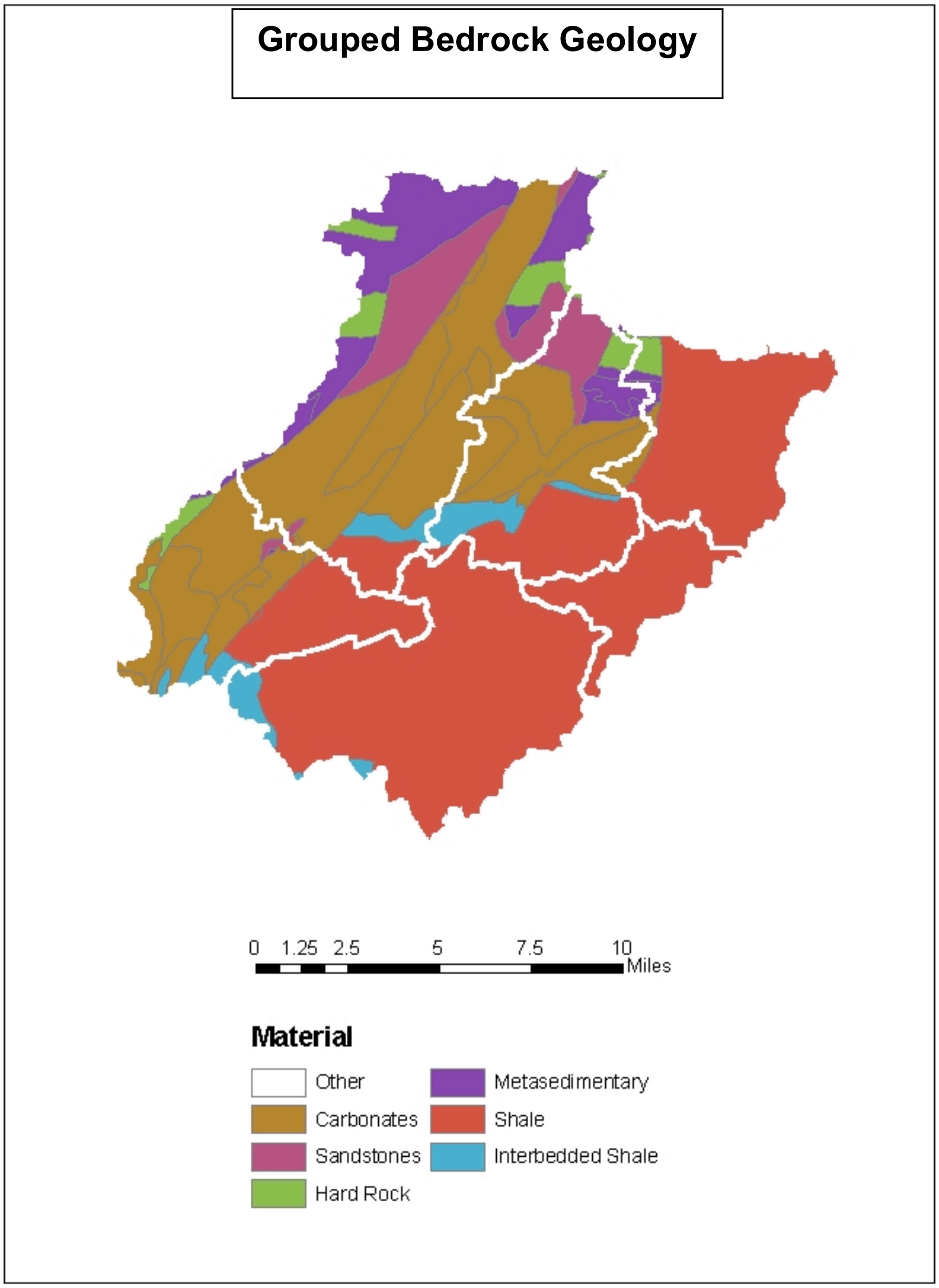

Grouped Bedrock Geology
0
1.25
2.5
5
7.5
10
Miles
Material
Other
Carbonates
Sandstones
Hard Rock
Metasedimentary
Shale
Interbedded Shale

Figure 8

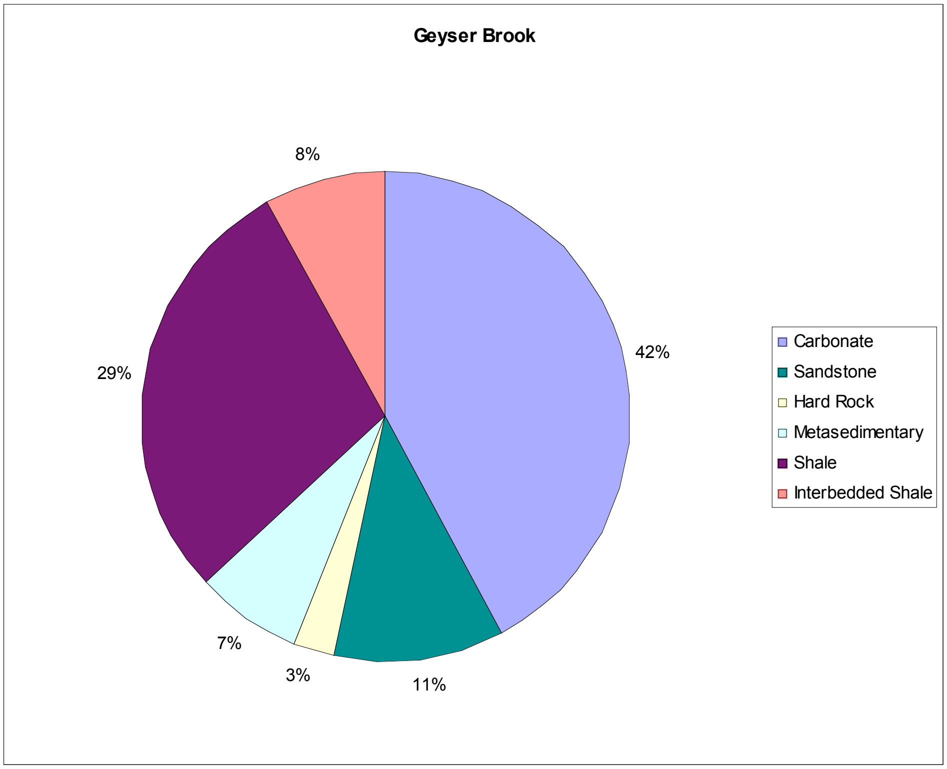


Figure 9

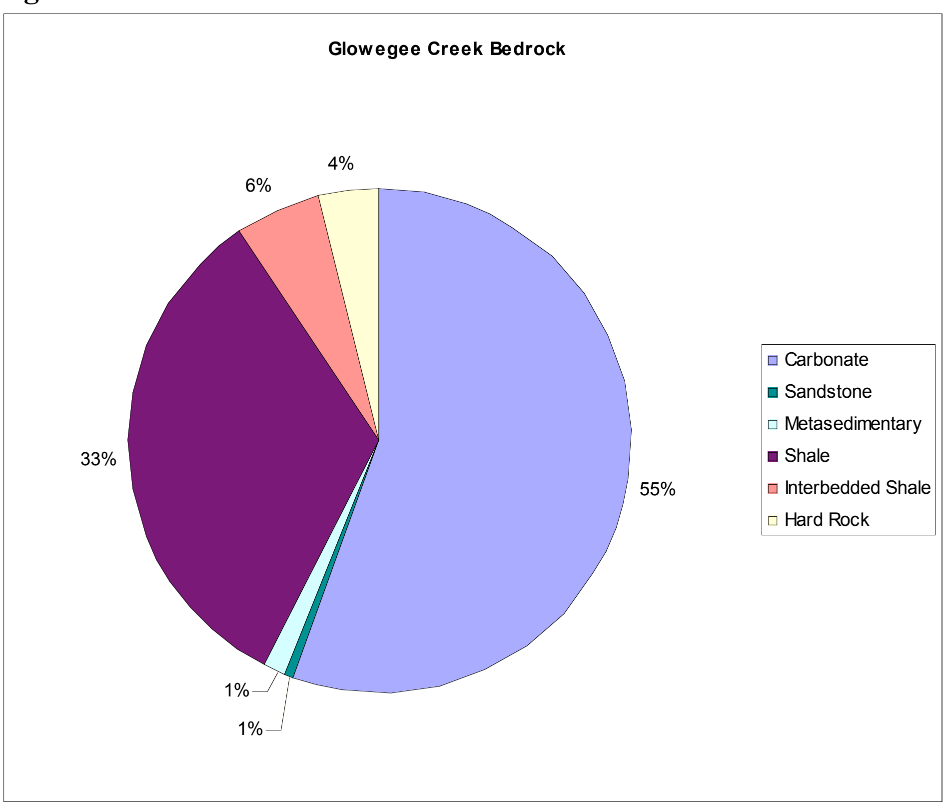


Figure 10

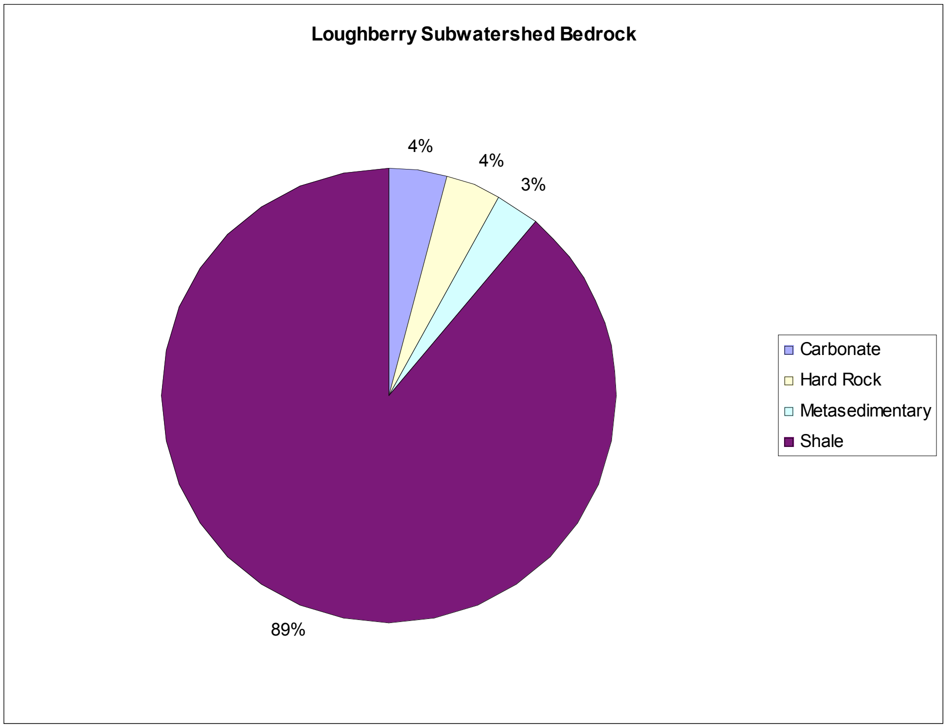


Figure 11

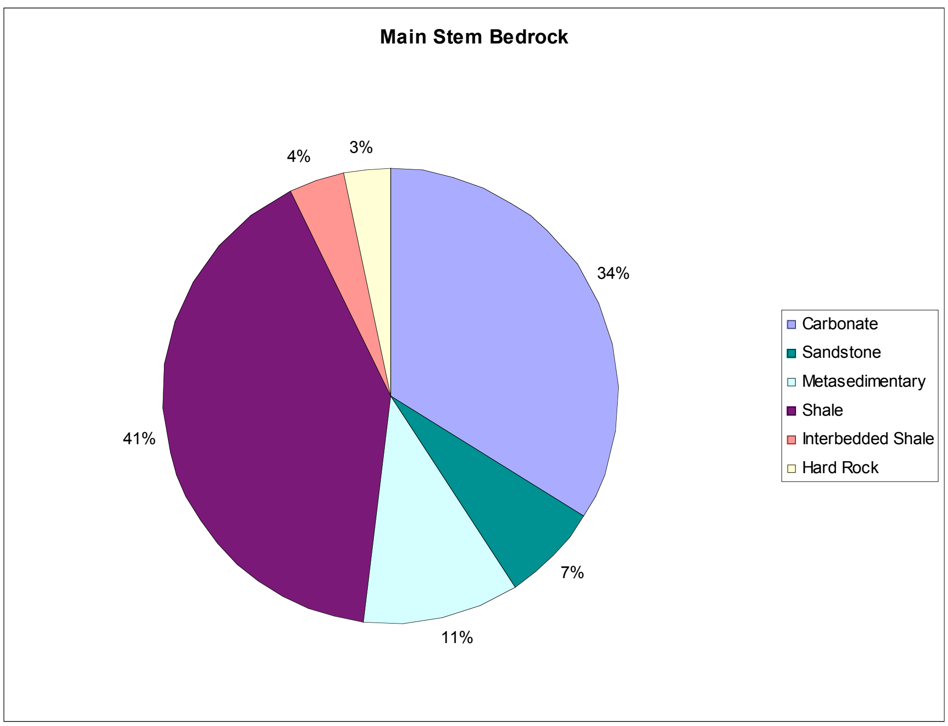


Figure 12

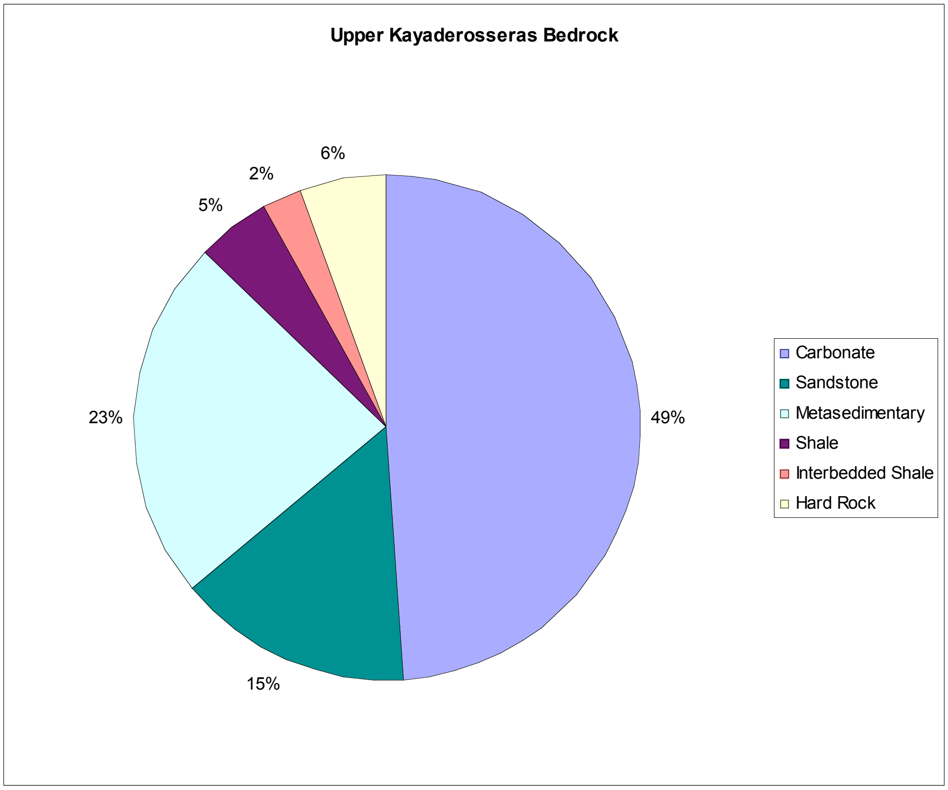


Figure 13

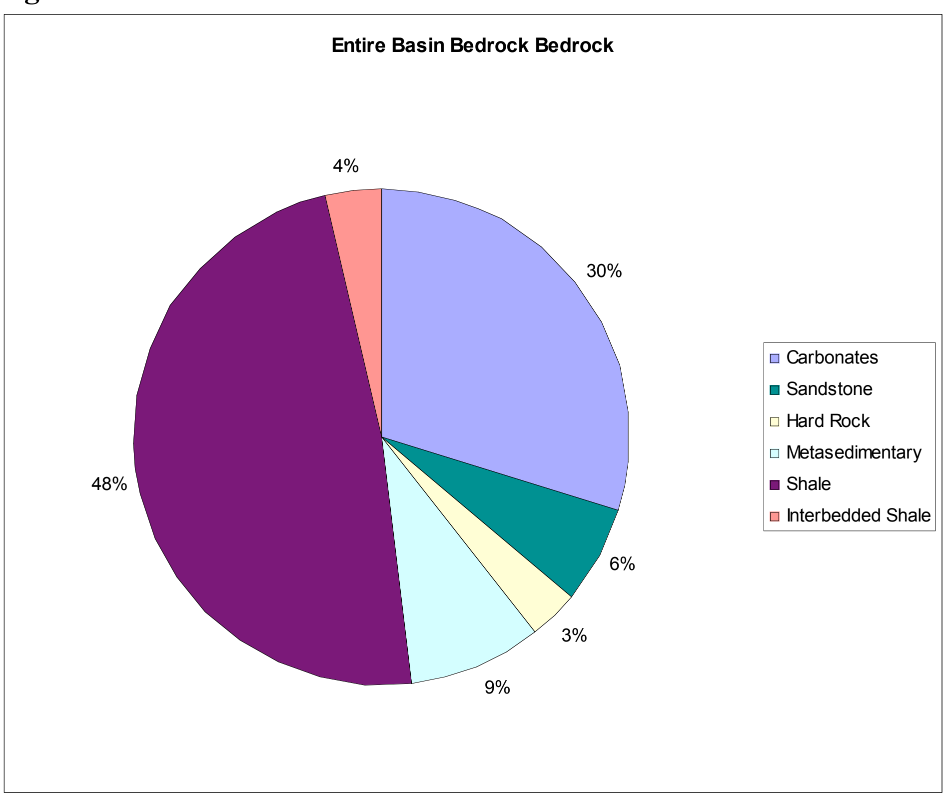


Figure 14

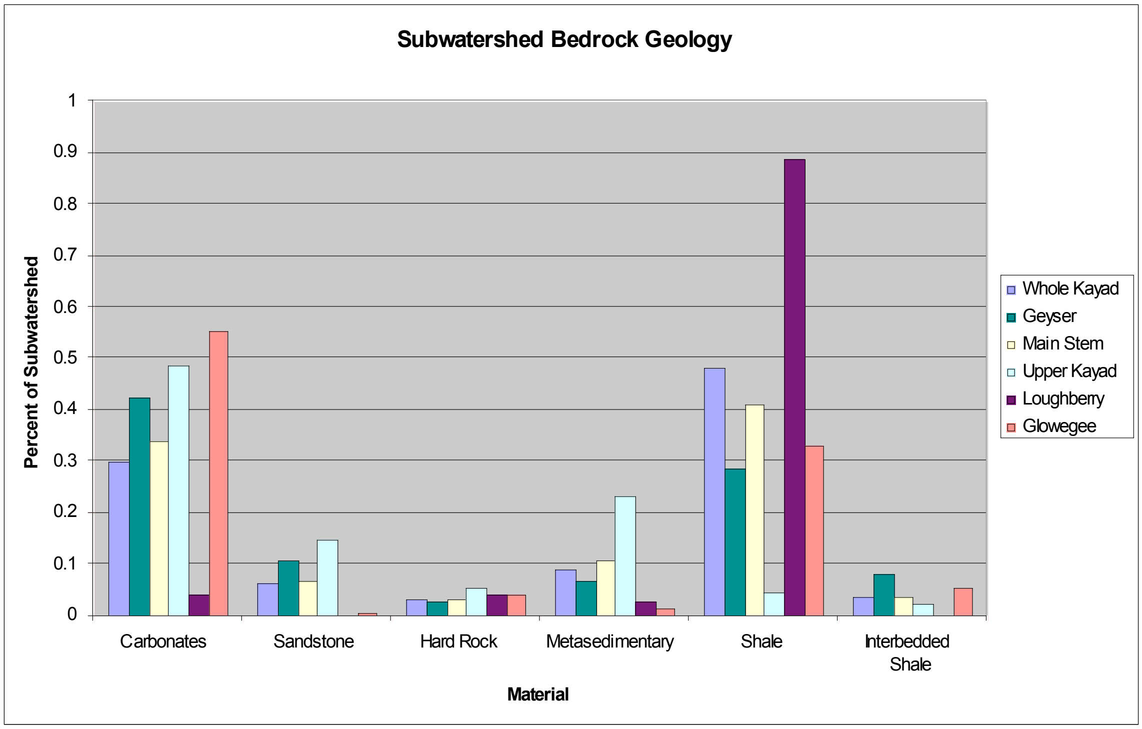
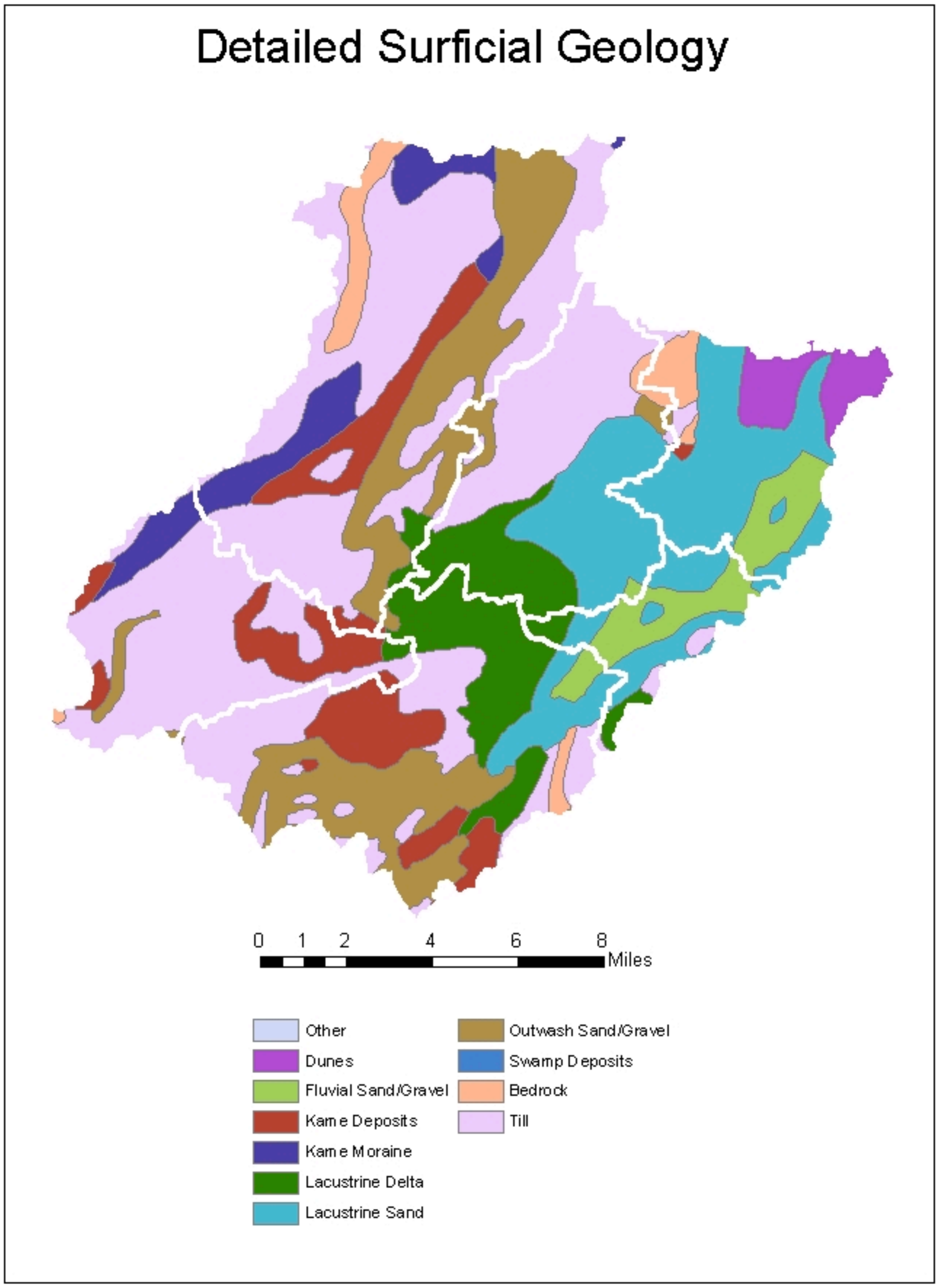


Table 5

Kayaderosseras Watershed Bedrock Coverage in square Km						
Bedrock Categories	**Loughberry**	**Glowegee**	**Geyser**	**Upper Kayad**	**Main Stem**	**Full Kayad**
Carbonate	2.46	37.59	31.98	73.93	111.52	145.96
Sandstone	0.00	0.51	8.28	22.60	23.10	31.39
Metasedimentary	1.73	0.83	5.28	35.49	36.32	15.68
Shale	52.40	22.38	21.71	7.03	135.31	43.34
Interbedded Shale	0.00	3.76	6.11	3.69	12.29	235.81
Hard Rock	2.31	2.66	2.15	8.55	11.21	18.40
Total Area	490.56	75.52	67.73	58.90	329.75	151.29


Detailed Surficial Geology
0 1 2 4 6 8
Miles
Other
Dunes
Fluvial Sand/Gravel
Kame Deposits
Kame Moraine
Lacustrine Delta
Lacustrine Sand
Outwash Sand/Gravel
Swamp Deposits
Bedrock
Till

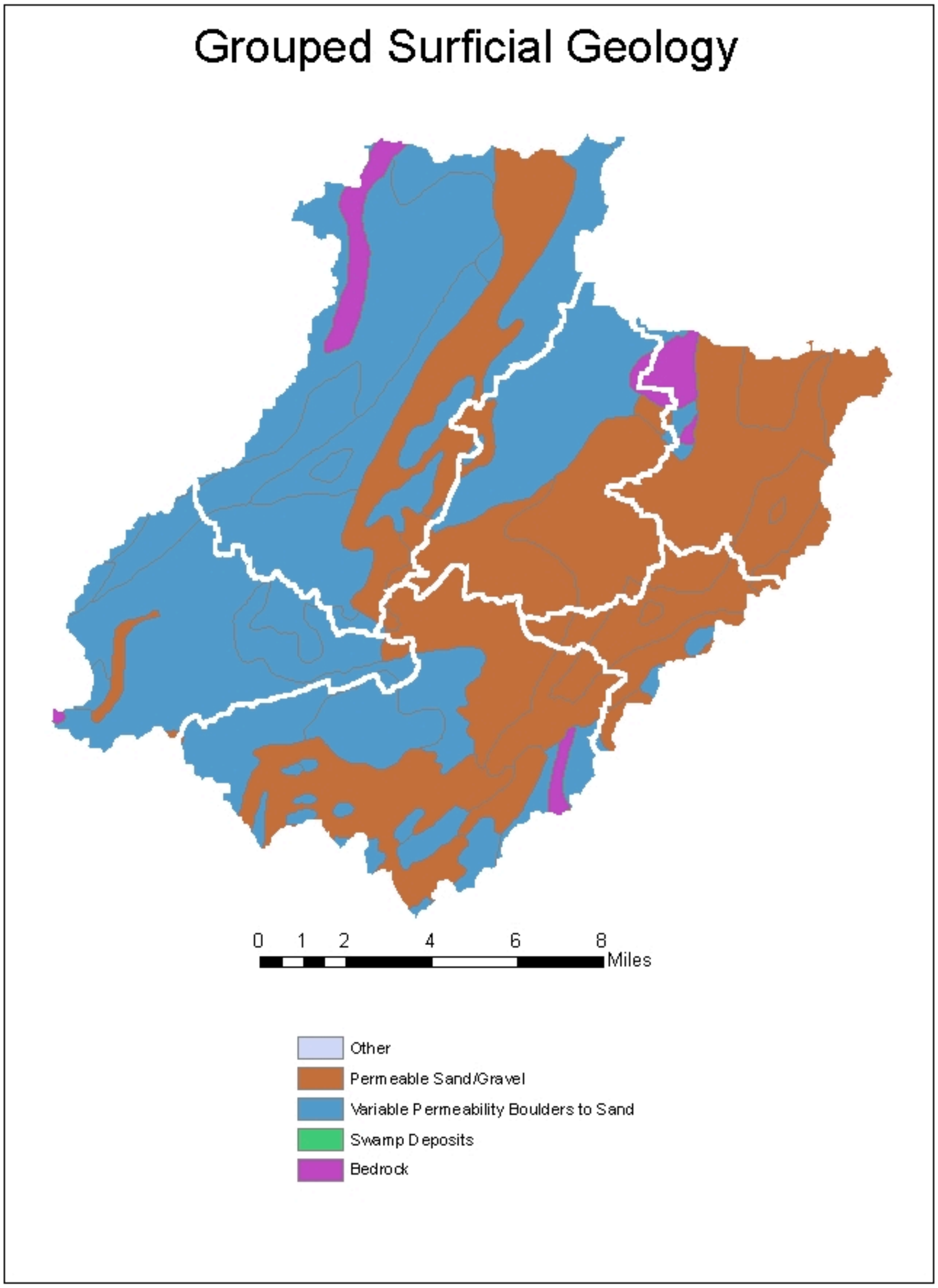

Grouped Surficial Geology
0
1
2
4
6
8
Miles
Other
Permeable Sand/Gravel
Variable Permeability Boulders to Sand
Swamp Deposits
Bedrock

Figure 15

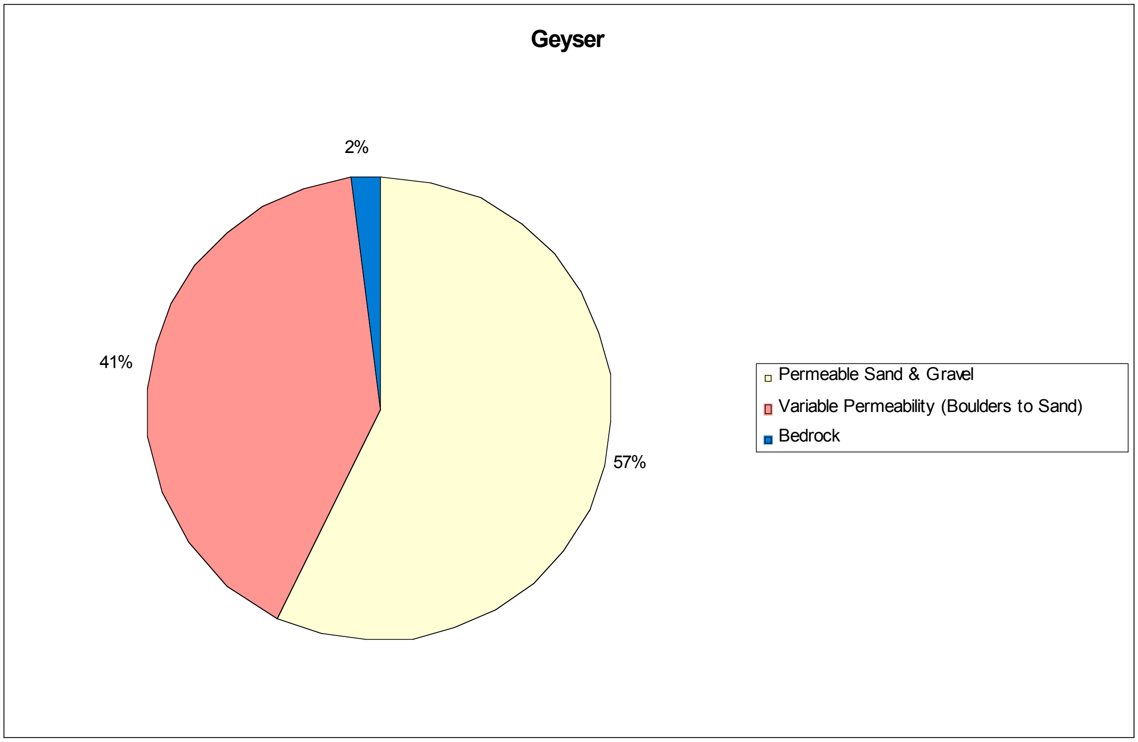


Figure 16

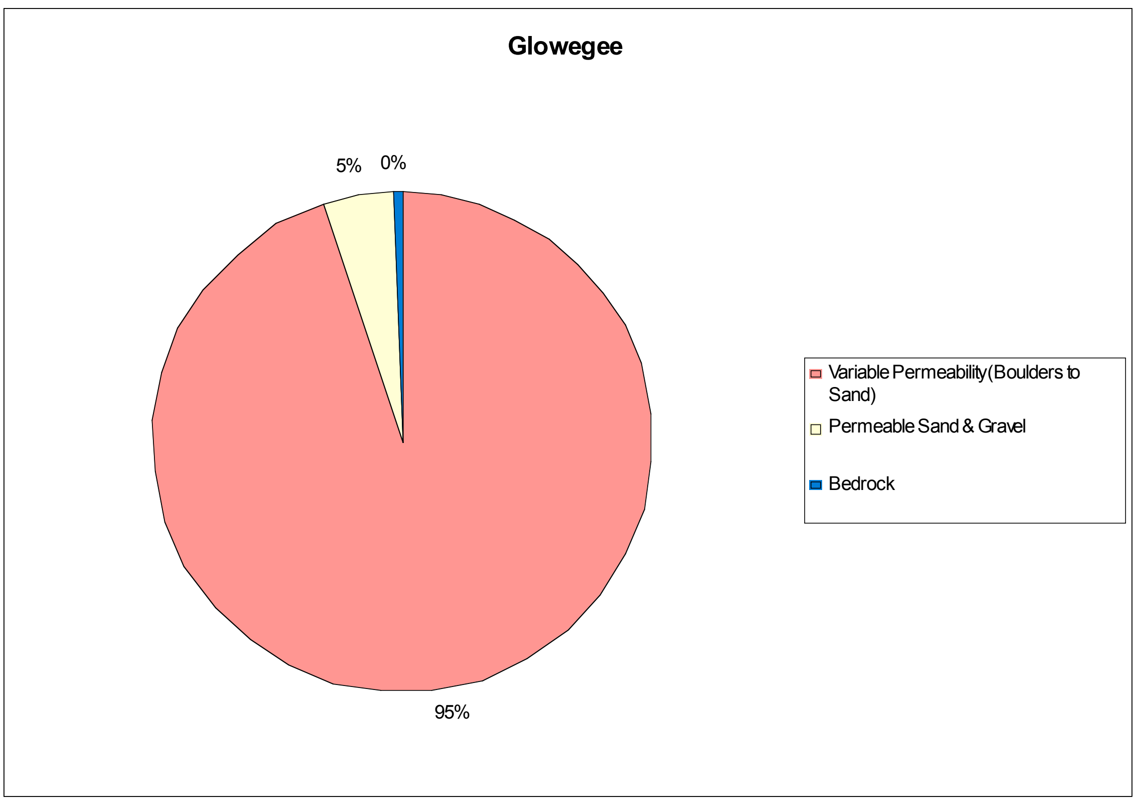


Figure 17

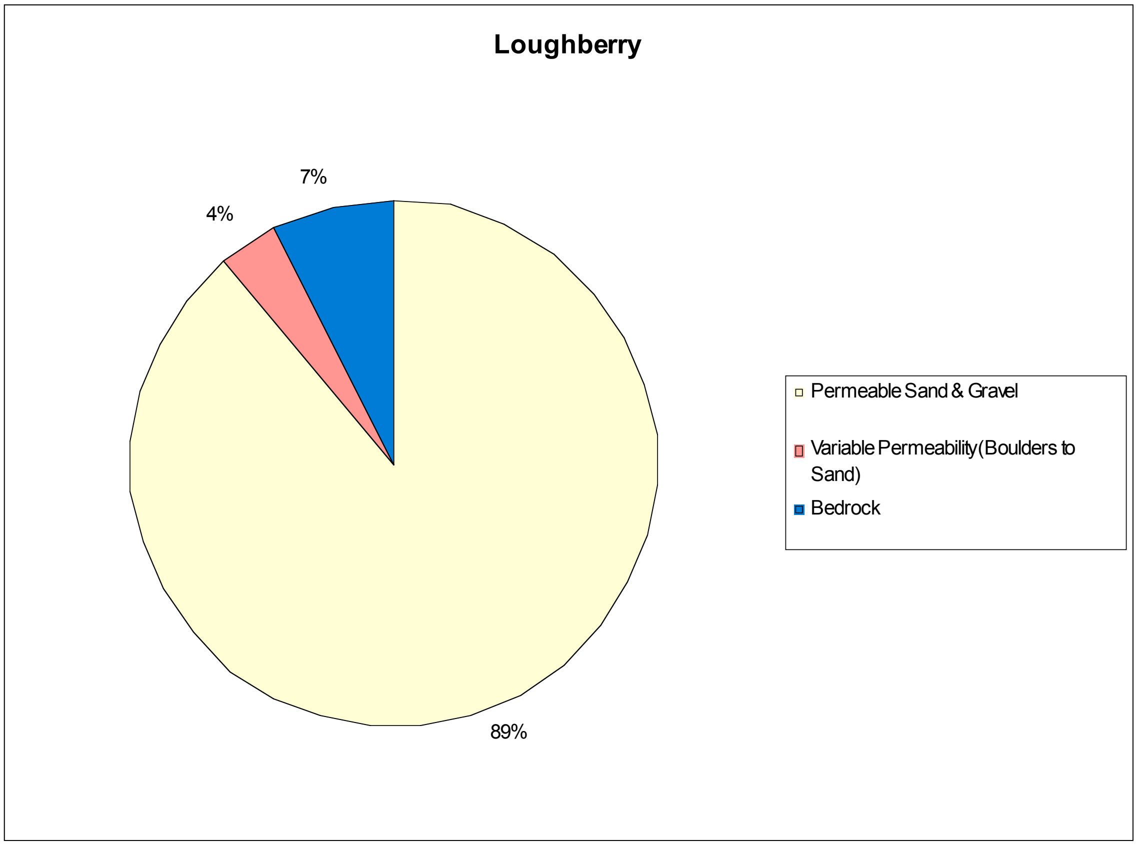


Figure 18

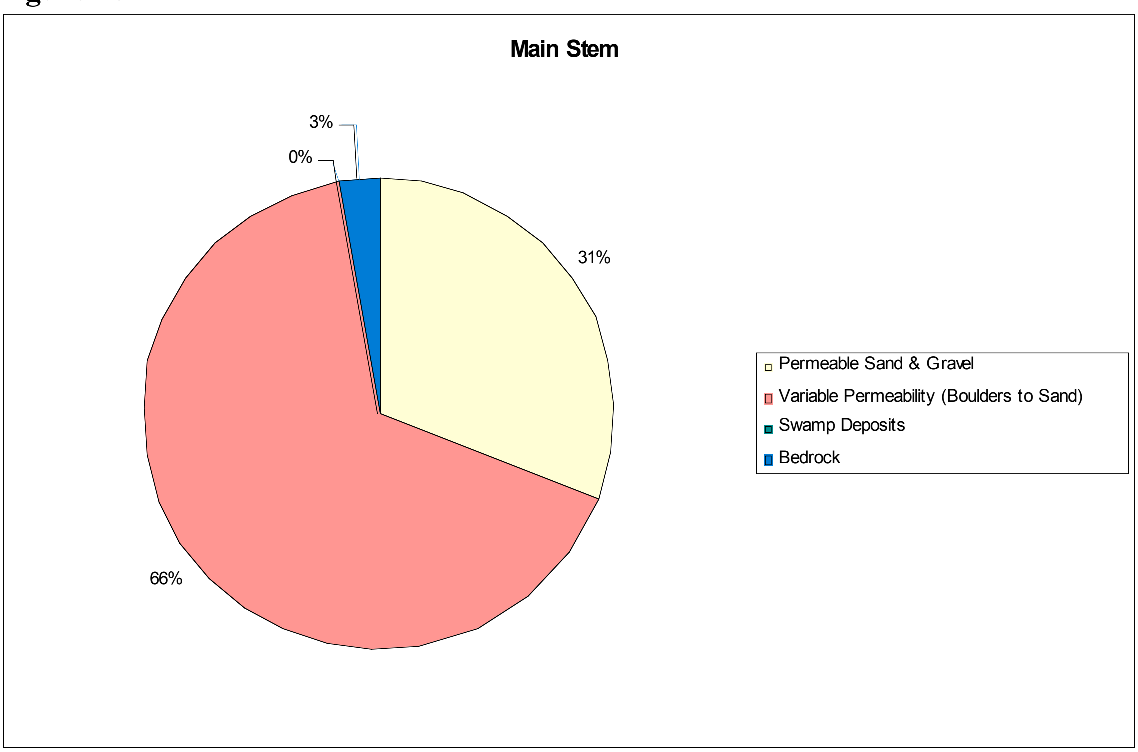


Figure 19

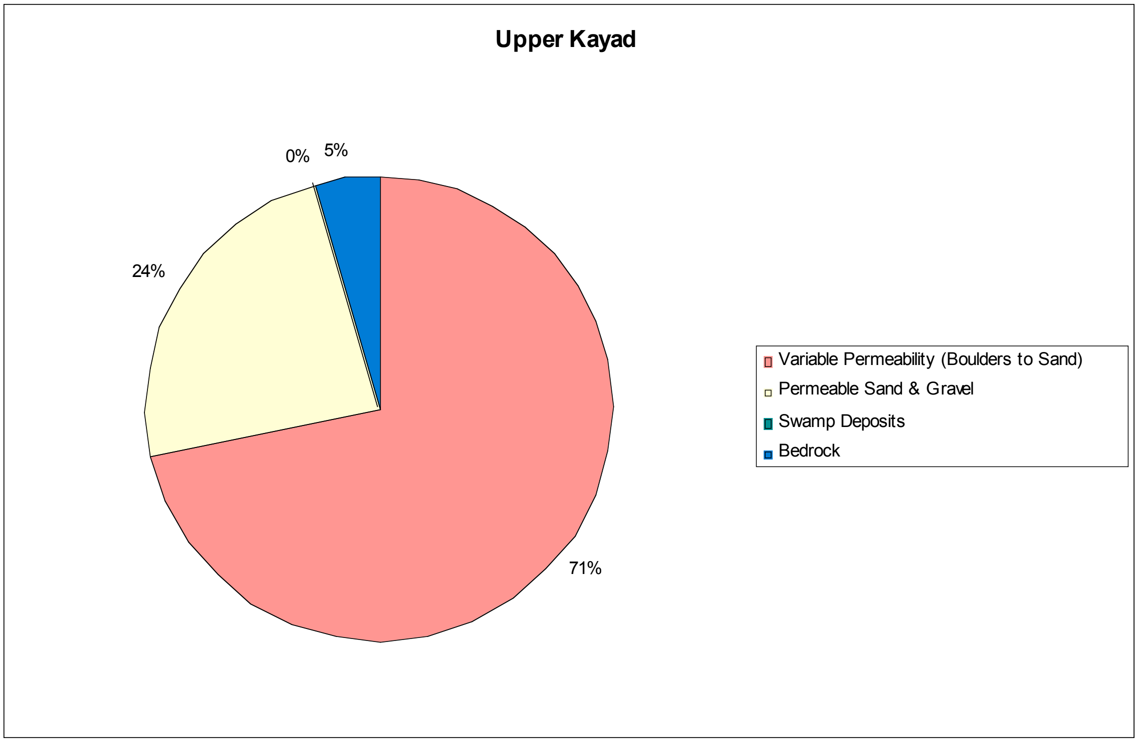


Figure 20

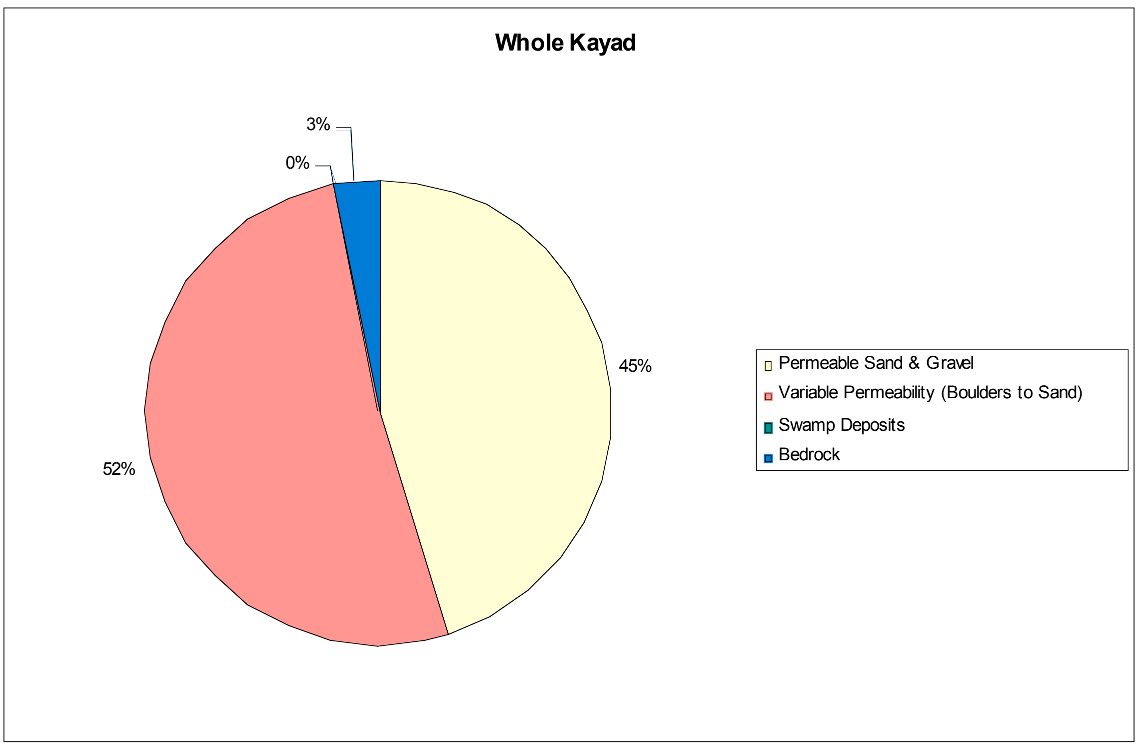


Figure 21

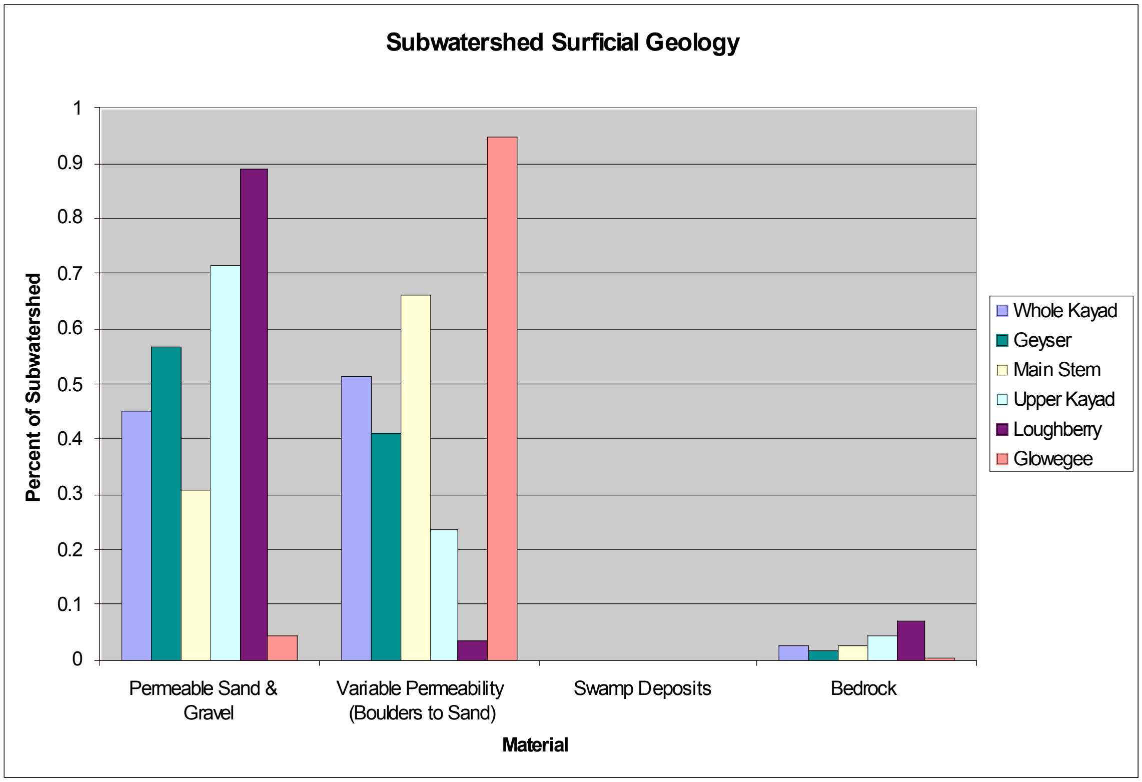


Table 6

Kayaderosseras Surficial Geology in Square Km						
Surficial Category	**Geyser**	**Glowegee**	**Loughberry**	**Main Stem**	**Upper Kayad**	**Full Kayad**
Permeable	43.13	3.07	52.40	101.79	35.88	221.95
Variable Permeability	31.02	64.36	2.10	219.06	108.49	253.94
Swamp Deposits	0.00	0.00	0.00	0.00	0.01	0.01
Bedrock	1.37	0.30	4.40	8.90	6.91	14.67
Total Area	75.52	67.73	58.90	329.75	151.29	490.56

Figure 22

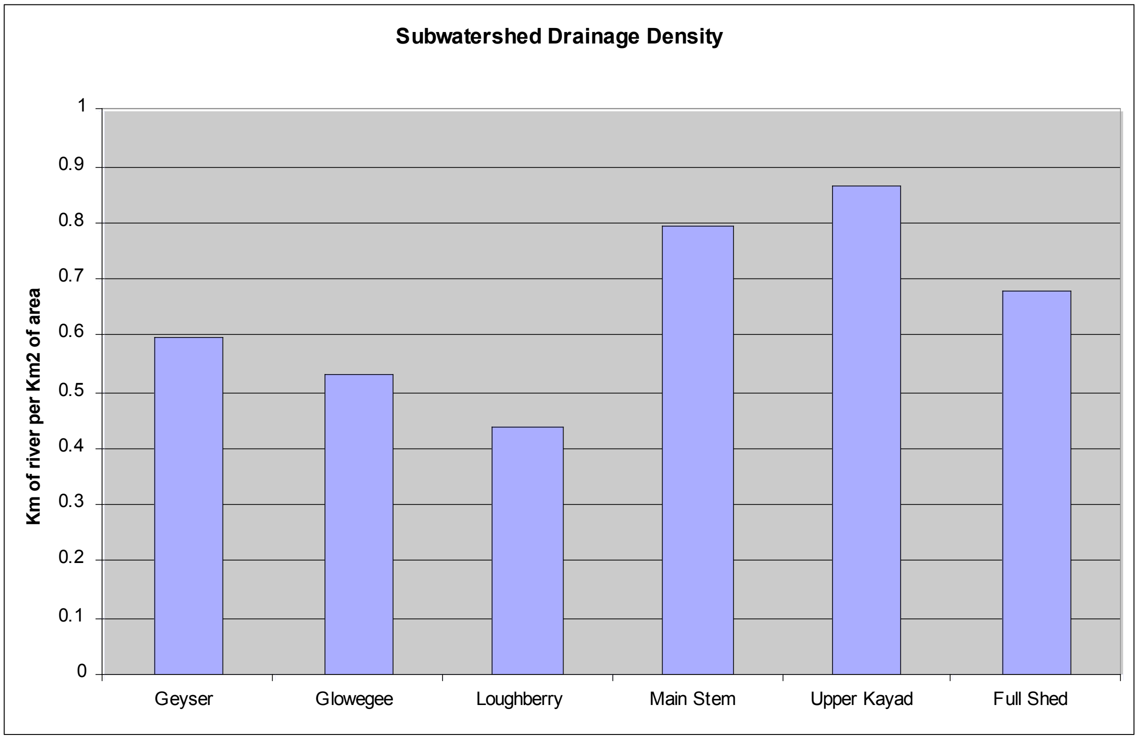


Table 7

Watershed	Geyser	Glowegee	Loughberry	Main Stem	Upper Kayad	Full Shed
River Length (km)	45.22	36.26	25.98	261.85	131.03	333.05
Total Area (km2)	75.52	67.73	58.90	329.75	151.29	490.56
Drainage Density (km/km2)	0.60	0.54	0.44	0.79	0.87	0.68

Appendices

Geologic materials and land use categories

This section provides brief explanations of the geologic categories displayed on the maps. It also includes the groupings used in creating more general land use, bedrock and surficial geology maps.

Land Use Groupings

Water – Open Water
Developed – Low Intensity Residential, High Intensity Residential, Commercial/Industrial/Transportation
Barren/Mined – Quarries/Strip Mines/Gravel Pits
Forested – Deciduous Forest, Evergreen Forest, Mixed Forest
Agriculture – Pasture/Hay, Row Crops, Urban/Recreational Grasses
Wetlands – Woody Wetlands, Emergent Herbaceous Wetlands

Bedrock Geology Categories

Beekmantown Group
Biotite/Hornblende Granite Gneiss
Canajoharie Shale
Charnockite, Granitic and Quartz
Dolgeville Formation
Interlayered Metasedimentary
Potsdam Sandstone
Schenectady Formation
Taconic Melange
Theresa (Galway) Formation
Quartzite, Quartze-Biotite Schist
Undivided Metasedimentary

Grouped Bedrock Geology Categories

Carbonates – Beekmantown Group, Theresa (Galway) Formation
Interbedded Shale – Dolgeville Formation, Schenectady Formation
Hard Rock – Biotite/Hornblende Granite Gneiss, Quartzite, Quartze-Biotite Schist, Charnockite, Granitic and Quartz
Metasedimentary – Interlayered Metasedimentary, Undivided Metasedimentary
Sandstones – Potsdam Sandstone
Shale – Canajoharie Shale, Taconic Melange

Surficial Geology Categories

Bedrock – Exposed or generally within 1 meter of surface, in some areas saprolite is preserved.

Dunes – Fine to medium sands, well sorted, stratified, generally wind-reworked lake sediment, permeable, well drained, thickness variable 1-10 meters.
Fluvial Sand/Gravel – Sand and/or gravel, occasional laterally continuous lenses of silt, deposition farther from glacier than outwash, age and proximity to ice uncertain, permeable, thickness variable (1-20 meters).
Kame Deposits – Coarse to fine gravel and/or sand, includes kames, eskers, kame terraces, kame deltas, ice contact, or ice cored deposition, lateral variability in sorting, texture and permeability, may be firmly cemented with calcareous cement, thickness variable (10-30 meters).
Kame Moraine – Variable texture (size and sorting) from boulders to sand, deposition at an active ice margin during retreat, constructional kame and kettle topography, locally, calcareous cement, thickness variable (10-30 meters).
Lacustrine Delta – Coarse to fine gravel and sand, stratified, generally well sorted, deposited at a lake shoreline, thickness variable (3-15 meters).
Lacustrine Sand – Generally quartz sand, well sorted, stratified, usually deposited in proglacial lakes, but may have been deposited on remnant ice, generally a near-shore deposit or near a sand source, permeable, thickness variable (2-20 meters).
Outwash Sand/Gravel – Coarse to fine gravel with sand, proglacial fluvial deposition.
Swamp Deposits – Peat-muck, organic silt and sand in poorly drained areas, unoxidized, commonly overlies marl and lake silt, potential land instability, thickness 2-20 meters.
Till – Variable texture (size and sorting), generally low permeability, deposition adjacent to ice, thickness variable (10-30 meters).

Grouped Surficial Geology Categories

Bedrock - Bedrock
Permeable Sand/Gravel – Dunes, Fluvial Sand/Gravel, Lacustrine Delta, Lacustrine Sand, Outwash Sand/Gravel
Swamp Deposits – Swamp Deposits
Variable Permeability (Boulders to Sand) – Kame Deposits, Kame Moraine, Till

Database CD and file descriptions

This section provides a pathway map for the organization of the database, where relevant short descriptions of folders or files on the CD are included. Folders are in bold italics, files in normal italics and descriptions in normal font.

1) ***Kayaderosseras***
   a) ***DEM*** – Digital elevation model information for use in topography analysis.
      i) ***Clipped*** – *(Clipped_DEM, demclip_fill)* DEM files clipped to a rectangle around the watershed and prepared for hydro-analysis.
      ii) ***Full*** – *(dem_full)* Larger DEM showing more area around watershed.

b) ***Excel Data*** *(Bedrock, Drainage Density, Land Use, Surficial)* Raw data exported from attribute tables of GIS maps for analysis of areas by each sub-watershed and grouped for the entire watershed. Pre-made pie charts, tables and graphs are in each file.

c) ***Geology***

   i) ***Bedrock***

      (1) ***Clipped*** *(Bedrock_Clip)* Bedrock layer clipped to watershed boundaries.

      (2) ***Full*** *(Bedrock_Full)* Bedrock layer showing larger area.

   ii) ***Surficial***

      (1) ***Clipped*** *(Surficial_Clip)* Surficial geology clipped to watershed boundaries.

      (2) ***Full*** *(Surficial_full_UTM)* Surficial layer showing larger area.

d) ***Land Use***

   i) ***Clipped*** *(landuseclip)* Land Use raster clipped to rectangle around watershed.

   ii) ***Full*** *(land_use_full)* Land Use showing larger area around watershed.

   iii) ***SHP Clip*** *(l_use_clip_poly)* Clipped land use converted to a shape file to analysis of area and different manipulations.

e) ***Maps*** *(Detailed_Bedrock, Detailed_Surficial, Geyser_Detailed_LU, Glowegee_Detailed_LU, Grouped_Bedrock, Grouped_Surficial, Land_Use_General, Lough_Detailed_LU, MStem_Detailed_LU, Road_Map_General, Sample_Sites, Subwatershed_Divisions, Topography_General, UKayad_Detailed_LU)* Pre-made maps stored as JPEG files and ready to print.

f) ***Ortho-imagery*** Aerial photos of the entire watershed divided into five files.

   i) ***U83_2ft*** *(ssa_ne_u83_2ft, ssa_nw_U83_2ft, ssa_se_u83_2ft, ssa_sw_u83_2ft, west_u83_2ft)*

g) ***Projects*** *(Detailed_Bedrock, Detailed_Surficial, Geyser_Detailed_LU, Glowegee_Detailed_LU, Grouped_Bedrock, Grouped_Surficial, Hydro_Sheds, HydroAnalysisClip, Land_Use_General, Lough_Detailed_LU, MStem_Detailed_LU, Road_Map_General, Sample_Sites, Sub-watershed_Divisions, Topography_General, UKayad_Detailed_LU)* ArcMap project files with layers already added and arranged, similar to pre-made map files but these can be manipulated for different purposes.

   i) ***Layers*** Support files needed to open some of the saved projects.

h) ***Roads*** *(Clipped_Main_Roads, Clipped_Railroads, Clipped_Streets, Full_MainRoads_UTM, Full_Railroads-UTM, Full_Streets_U83)* Main roads, streets and railroads clipped to the watershed and showing the larger area.

i) ***Soils***

   i) ***Clipped*** *(Clipped_Soil)* Soil information clipped to the watershed

   ii) ***Full*** *(Full_Soil)* Soil information showing the larger area around watershed.

j) ***Sub-watersheds*** Bedrock, surficial, stream, and land use data clipped to fit within each sub-watershed.

   i) ***Geyser*** *(Geyser_bedrock, Geyser_surficial, Geyser_stream, Geyser_shed, Geyser_landuse)*

   ii) ***Glowegee*** *(Glowegee_bedrock, Glowegee_surficial, Glowegee_stream, Glowegee_shed, Glowegee_landuse)*

iii) ***Loughberry*** *(Loughberry_bedrock, Loughberry_surficial, Loughberry_stream, Loughberry_shed, Loughberry_landuse)*
iv) ***Main Stem*** *(MainStem_bedrock, MainStem_surficial, MainStem_stream, MainStem_shed, MainStem_landuse)*
v) ***Upper Kayad*** *(UpperKayad_bedrock, UpperKayad_surficial, UpperKayad_stream, UpperKayad_shed, UpperKayad_landuse)*

k) ***Towns***
i) ***Clipped*** *(Clipped_towns)* Towns clipped to watershed boundaries.
ii) ***Full*** *(Full_Towns)* Towns of Saratoga County.

l) ***Water*** *(clipped_lakes, clipped_streams)* Lakes and stream layer files clipped to watershed boundaries.

m) ***Watersheds***
i) ***Full Kayad*** *(fullkayadframe, fullkayadoutline)* The frame is a layer file which can be overlain on raster files to make only the area within the watershed visible. The outline is the most general defined outline of the Kayaderosseras watershed.
ii) ***Kayad Subsheds*** *(kayadsubsheds)* Map of the full Kayaderosseras watershed with polygons showing the delineations for each sub-watershed.