

INDIANA UNIVERSITY

# Indiana University Griffy Lake Watershed

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Sustainability Survey

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## 1.0 Executive Summary

The Indiana University Griffy Lake watershed (IUGLW), along with the Jordan River, is one of two major watersheds draining the IUB campus. The IUGLW refers to that portion of the 5000-acre Griffy Lake watershed (GLW) which falls within the IUB Master Plan boundary. Over the past century The Trustees of Indiana University have amassed roughly 1000 acres of land along the South Fork of Griffy Creek within the GLW which includes the Indiana University Research and Teaching Preserve including University Lake, the IU Championship golf course, and several of IU's operational facilities. Recent reports by the City of Bloomington and the Hoosier Environmental Council indentify the South Fork Griffy Creek watershed as the most heavily impacted in the GLW due to increased development in the area, including current construction by IU. Sediment and E.coli are the two pollutants of concern in the South Fork of Griffy Creek. Indiana University has in place a stormwater quality management plan including Best Management Practices for sediment control. The heavy storms of May 2008 highlighted issues with existing stormwater management approaches and raised questions about sustainable watershed management.

This report is a continuation of Indiana University's commitment to improve the environmental quality and land use efforts of its 2007 sustainability initiative. The broad scope of this report indentifies some of the major issues within the IUGLW related to sustainability. Special attention is given to documenting the current state of the watershed, examining existing management practices, and identifying management priorities within the IUGLW.

Research for this project included the compilation of databases and GIS analyses to inform the future management of the watershed. To compare the health of the IUGLW with the larger GLW, L-THIA modeling was used to predict relative pollutant loads for the respective areas. Field studies confirmed data produced through GIS and provided the opportunity to document the impacts of the May 2008 storms and identify future management hotspots in the watershed.

Present findings suggest that the IUGLW is healthier than the overall watershed. The large amount of forested land, 185 acres of which has been designated a preserve, is an asset to the community providing recreation, education, and a multitude of ecosystem services. University Lake provides valuable nutrient and sediment retention of golf course runoff. The existing stormwater quality management plan (SWQMP) is a marked commitment to improving water quality in the watershed. Although IU faculty and staff are significant contributors of expertise, opportunities exist for IUB to increase its official presence in community-lead initiatives for the sustainable management of the Griffy Lake watershed.

Recommendations are made for the IU Championship golf course to improve its management practices and become the first golf course in the City of Bloomington to receive a certification in golf course sustainability. Existing Best Management Practices for stormwater quality management are critiqued for greater sustainability, and several locations are identified where low impact development principles could readily be implemented.

## **2.0 Introduction**

Griffy Lake is recognized as a significant asset to both the City of Bloomington (COB) and Indiana University Bloomington (IUB) in terms of providing a sizeable natural area just minutes from the heart of the IUB campus and downtown. Access to outdoor recreation is a major consideration in determining citizen quality of life (MCCVB, 2008). In addition to boating and fishing on the reservoir, GLW provides opportunities for research and education, hiking, biking, wildlife viewing, picnics, as well as a host of ecosystem services that contribute to the overall environmental quality of the IUB campus and the city as a whole. The importance of the Griffy Lake watershed has been highlighted by the recent commitment of resources at both the city and state levels to ensure the sustainable management of the watershed. Although IUB faculty/staff were involved in the development of both of these recent initiatives, The Trustees of Indiana University have yet to fully engage in the sustainable management of the GLW. As a major landholder in the GLW, IUB could be a significant driver of more sustainable practices in the GLW.

Given, the extensive research on the Griffy Lake watershed over the past several years, this report attempts to focus on some of the major issues of specific concern to the IUB campus. In particular, this report will provide the following:

- 1) Background information needed to better understand Indiana University's role within the Griffy Lake watershed.
- 2) Identification of management issues within the Indiana University Griffy Lake watershed.
- 3) Consideration of how management of the Griffy Lake watershed fits into IU's overall sustainability initiative.
- 4) GIS analysis of the Indiana University Griffy Lake watershed.
- 5) Specific sustainability goals.
- 6) Recommendations for strengthening IU's contribution to the management of the Griffy Lake watershed.

## **3.0 IUGLW History**

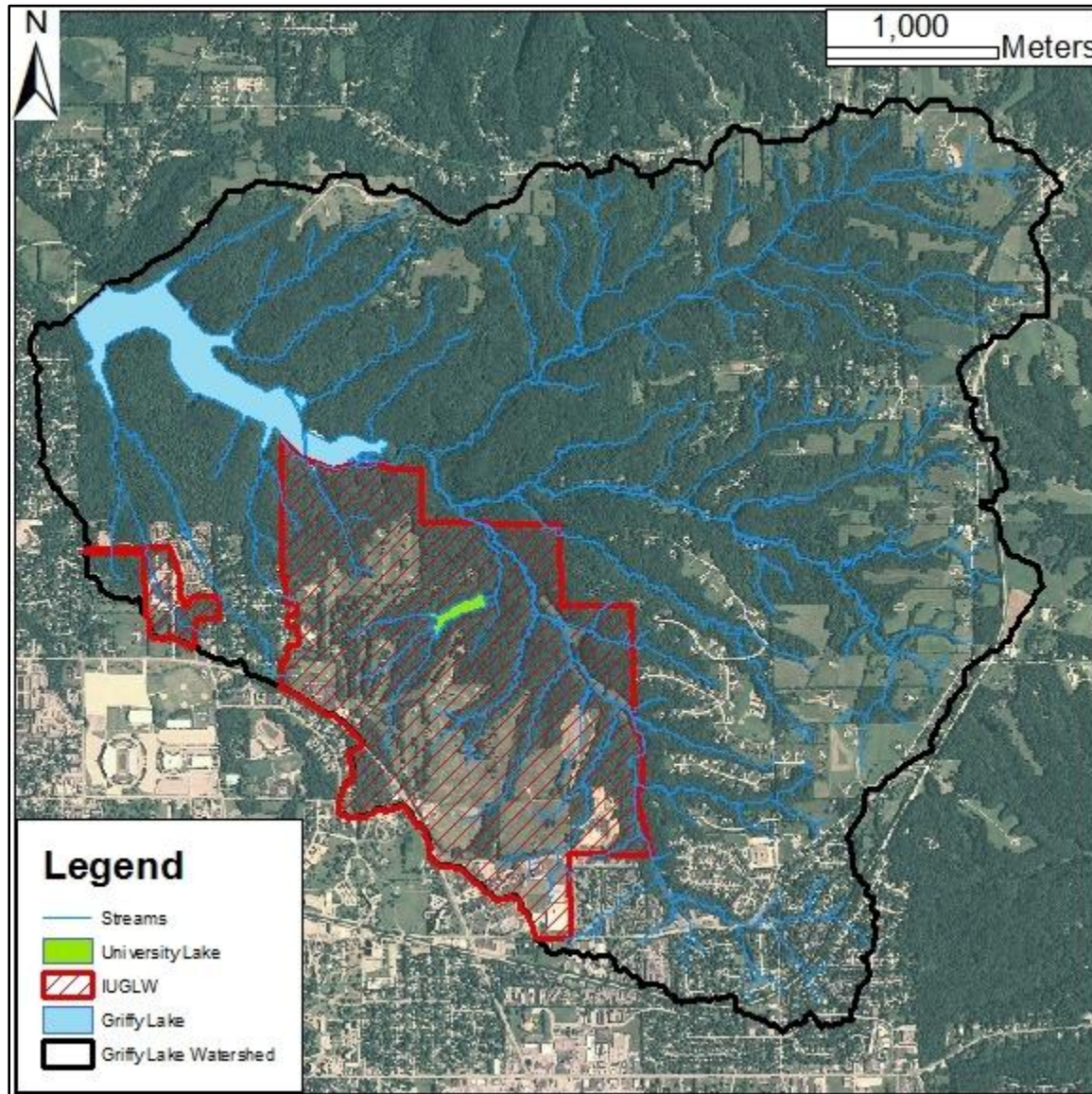
Indiana University's presence in the GLW began in 1911, prior to the construction of Griffy Lake, when The Trustees of Indiana University acquired land comprising the drainage basin of the backup water supply known as University Lake (Sacrett, 1913). In 1924 the Bloomington Water Company constructed a 900 ft wide dam across Griffy Creek. The resulting reservoir and watershed included roughly 900 acres of IUB land with another 100 acres draining into Griffy Creek downstream of the reservoir (JFNew, 2008). After University Lake, the second major development phase within the IUGLW was the construction of the IU Championship golf course which began in 1958, created by clearing forests in the relatively flat, upland portions of Griffy Woods (IU, 2008). Most recently IUB's presence in the watershed has been marked by building developments for many of the campuses operational facilities, primarily along 10<sup>th</sup> street between the by-pass and Range Road.

## **4.0 Physical Characteristics**

Roughly 90% of the IUGLW falls within the South Fork Griffy Creek subwatershed. The other 10% percent is the site of the IU Cyclotron facility which drains into Griffy Lake at the far western end of the reservoir. The main stem of the South Fork Griffy Creek enters the IUGLW from the southeast of the University Architects Office (UAO) and continues roughly along the northeast perimeter of the IUGLW. Indiana University owns approximately one fifth of the 5000-acre GLW (JFNew, 2008). The IUGLW can be roughly divided into three areas by land use. The southeastern extent is under commercial development and includes the IU Warehouse, Physical Plant/University Architects Office, IU Motor Pool, and Auxiliary

Library facilities. The middle section to the northwest of the commercially developed zone is a large area of managed turf/ grasslands which includes the IU Championship golf course and cross country track. The third distinct zone is the forested portion including the IU Research and Teaching Preserve. Contained within the IUGLW are seventeen, mostly first-order, streams, which feed into the South Fork of Griffy Creek/Griffy Lake. The majority of these streams are ephemeral or intermittent drainages (Stringer et al., 2005). All drainage from the IUGLW ends up in Griffy Lake which then flows into Bean Blossom Creek and eventually to the White River (see figure 1).

### Griffy Lake Watershed



Created July 2008

Source: CGDA/UAO

**Figure 1.**

## 4.1 IURTP

The Indiana University Research and Teaching Preserve (IURTP) is a mostly-forested parcel of land at the northern extent of the IU Master Plan boundary. Created in 2001 by the IU Board of Trustees, the IURTP is a 185- acre site dedicated to research and teaching outside the classroom. The IURTP includes 1,500 feet of shoreline on Griffy Lake at the northern extent and entirely contains University Lake to the south. Generally, the topography of the IURTP is characterized by flat-topped ridges along the perimeter, with heavily eroded, steep sloped ravines, draining into a wetland floodplain along the South Fork of Griffy Creek (JFNew, 2008). The IURTP should be monitored for appropriate uses, and existing trails maintained as to minimize erosion potential.

## 4.2 Ecosystem Services

Because the IUGLW remains roughly fifty- percent forested, a key sustainability goal should be the preservation of the current forest cover. The IURTP and surrounding woods are a tremendous asset to both IUB and the City of Bloomington. Although the IURTP is protected, there is actually a larger portion of forested land within the IUGLW that is unprotected and outside the preserve boundaries. This section aims to highlight some of the ecosystem services provided by such areas in an effort to advocate for their preservation. Ecosystem services provided by the forested areas of the IUGLW include:

**Support Services:** Nutrient cycling, soil formation, and primary production.

**Provisioning Services:** Food, fiber, genetic resources, and fresh water.

**Regulating Services:** Air quality, climate regulation, water retention/ purification, erosion control, disease regulation, pest regulation, pollination, and natural hazard regulation.

**Cultural Services:** Aesthetic values, spiritual and religious values, educational values, recreational values, and tourism.

The ecosystem services approach was brought to the fore through the field of urban forestry in an effort to emphasize the connection between healthy ecosystems and healthy human communities. Having significant areas of tree cover has been associated with “energy savings, better air and water quality, reduced stormwater runoff, local climate moderation, increased property values- even reductions in crime and personal stress” (Collins, 2007). All the benefits previously mentioned are well aligned with IU’s overall sustainability goals. Thus, the university should strive to protect and enhance the ecosystem services provided by the IUGLW.

## 4.3 University Lake

University Lake was constructed in the early 1900’s as a backup water supply for IU during periods of drought and contaminated water supply. The reservoir was built by damming a tributary of Griffy Creek that now drains a major portion of the IU Championship golf course. University Lake is no longer used as a water supply and primarily serves as a detention basin for golf course runoff and sediment from the steep surrounding slopes (Burke Engineering, 2004). Although beneficial in its function as a detention basin for nutrients and sediments, the hypereutrophic lake has the potential to contribute large volumes of relatively poor quality water into Griffy Lake. University Lake should be closely monitored as it has been identified as a potential source of aquatic invasives which are actively being managed in Griffy Lake (JFNew, 2008).

## **4.4 Coal Ash Pile**

The Indiana University coal ash pile is a roughly 7.5-acre NPDES-compliant remediation site containing 375,000 cubic yards of coal ash produced by the IU Central Heating Plant. The site/discharge is monitored by the Office of Environmental Health and Safety. The storms of May 2008 have done considerable damage to the riprap-lined drainage ways which are intended to direct water around the coal ash pile. Currently at the outfall of the coal ash pile there is severe gully erosion, which could quickly migrate upstream and potentially compromise the integrity of the remediation (See Appendix E).

## **4.5 Equipment Storage Area**

The IU equipment storage area behind the UAO has been identified as a site of concern by COB for the steep unprotected slopes draining directly into contributing streams to the South Fork Griffy Creek. The roughly 4.5 acre clearing is used as a storage area for various types of small infrastructure, equipment, and landscaping materials needed around campus. Although mostly covered in gravel, inspection reveals significant areas of bare soil and perhaps more significant, what appears to be materials for disposal (Appendix E). “If not addressed, illegal dumps often attract more waste, potentially including hazardous wastes such as asbestos, household chemicals and paints, automotive fluids, and commercial or industrial wastes.” (EPA, 1998). Given the sensitive location and the potential for the problem to be exacerbated, IUB should take immediate measures to ensure that the materials stored at the site are environmentally sound, as well as address the high erosion potential of the site.

## **5.0 Recent Work**

In 2007 alone the City of Bloomington, the Hoosier Environmental Council, the Indiana Department of Environmental Management, and several IUB faculty and staff made significant contributions towards new initiatives aimed at improved management and protection of the GLW. The City of Bloomington issued the Griffy Master Plan Update in June of 2008 with the help of several stakeholders affiliated with but not officially representing IUB (JFNew, 2008). In June of 2008 many of those same stakeholders and several others drafted the Bean Blossom/ Lake Lemon Watershed Management Plan which was partially funded at the state level by IDEM (Schnapp, 2007). It is clear from the significant efforts that have been put forth at both the city and state levels that the watershed protection goals put forth by the IUB Task Force on Sustainability could not be more prescient. With community support for the sustainable management of Griffy Lake at an all-time high, IUB should strive to maximize coordination between its own sustainability initiative and those of the broader community.

### **Summary of Recent Reports**

#### **5.1a. Watershed Management Plan for Restoration and Protection of Bean Blossom Creek and Lake Lemon**

In December 2007 the Hoosier Environmental Council released a watershed management plan for Bean Blossom Creek and Lake Lemon. As a contributing watershed to Bean Blossom Creek, management of the Griffy Creek watershed was identified as a critical success factor. The 2007 report identifies specific management issues for the South Fork of Griffy Creek. The high percentage of impervious cover, high levels of E. coli, erosion from construction and deforestation, and the presence of Polycyclic Aromatic Hydrocarbons, known endocrine disrupters, were identified as major issues in the watershed. The report (Schnapp, 2007) identified several potential areas for greater IU involvement including:

1. Develop projects to showcase Rain Gardens, Green Roofs, Permeable Pavement, etc.
2. Developing pesticide management plans/Alternatives.
3. Restoring wetlands in Trevlac and Aqua Isle areas.
4. Promote pesticide management plans for golf course.
5. Where possible, restore riparian habitat and wetlands.

Link: <http://www.monroe.iaswcd.org/Bean%20Blossom%20Plan/Master%20Page.htm>

### **5.1b. Griffy Lake Master Plan Update 2008**

In June 2008 the City of Bloomington issued the final Griffy Lake Master Plan Update focused primarily on the Griffy Lake Nature Preserve but inclusive of the major management issues facing the GLW. Although The Trustees of Indiana University were not officially represented on the steering committee, several issues were raised in the drafts that are of direct concern to the IUGLW. The Master Plan cited sedimentation of Griffy Lake as the primary management issue. Along with sedimentation, the Master Plan also identified issues relating to invasive species within the IURTP, aquatic health of University Lake, development along range road, increased cooperation between COB and IU, increased connectivity of existing trail systems, potential impact of runoff from the IU Championship golf course, and the lack of appropriate zoning restrictions within the IUGLW. For further information see Griffy Lake Master Plan Update 2008 (JFNew, 2008).

Link: [https://bloomington.in.gov/documents/viewDocument.php?document\\_id=278](https://bloomington.in.gov/documents/viewDocument.php?document_id=278)

## **6.0 Existing Role of Indiana University**

Since first becoming active in management of the GLW during the construction of University Lake in the early 1900's, Indiana University has relaxed its participation in the development of the most recent round of management plans. Representatives of the IURTP are the only official members of the Master Plan Update steering committee listed who have any affiliation with IU. Although part of the University, the IURTP represents the portion of the IUGLW that is arguably having the least negative (and most positive) impact on the GLW. The Bean Blossom steering committee lists only Professor Bill Jones as affiliated with "IU SPEA." Professor Jones however, as an expert in the field played only an advisory role and was not charged with representing the greater interests of Indiana University.

## **7.0 GIS analysis**

As a key part of this sustainability report, Geographic Information Systems (GIS) data were used to facilitate analysis of the IUGLW. GIS used data on land cover, aerial photos, topography, soils, geology, planning, and hydrology, to develop maps which document current land cover/uses within the watershed, as well as to identify areas of interest for watershed management.

The majority of the data were kindly provided by Sally Letsinger of the IUB Center for Geospatial Data Analysis. 2007 NAIP color aerial photographs were acquired from the Indiana University Spatial Data portal. Additionally, Theresa Thompson of Facilities Information Management Services provided the campus master plan layer used to identify the extent of the IU portion of the GLW. The data was provided as is and has yet to be verified. In some cases data have proven to be discordant with other available data sources and as such should be used with caution. However, where known discrepancies have been identified, they were deemed insignificant to the overall findings of the analysis. For example, JFNew, 2008 identifies area of IUGLW as 1100 acres where UAO uses 978.

## 7.1 Summary of Statistics/Data

According to the Geospatial Data provided by the University Architects Office the IUGLW is an area of 978 acres, 90% of which is within the South Fork Griffy Creek subwatershed. The dominant land covers in the IUGLW are deciduous forest (48%), followed by undeveloped grasslands (37.6%). Of the IUGLW, analysis revealed only 5.23% of all the land under any kind of development, the majority of which falls under the commercial/low density residential land cover designations. Impervious surfaces were estimated at 5% however current construction will be increasing that percentage within the next year. Surficial geology of the IUGLW is 64% Terra Rosa and 34% Siltstone and Shale. Bedrock geology is split 74% Mississippian limestone, 26% Mississippian Siltstone and Shale. Within the IUGLW there are approximately 6,561 linear meters or four miles of stream bank characterized by slopes greater than 40%.

## 7.2 Methods

GIS maps were created using 2007 NAIP aerial photographs and existing geo-spatial databases for the GLW and the IUB campus. Appendix C lists the database names, type of data, source, description and projection. Some of the data was used to create reference maps while other sources were used to derive statistics specific to the IUGLW. All of the data used in this analysis is stored on DVD in the IURTP office in Morrison Hall, IUB.

## 7.3 IUGLW Land Cover Database

A major focus of this analysis was the identification of various types of land use and land cover occurring within the IUGLW. Table 1 below shows the NLCD land cover classifications used in the analysis and the statistics associated with each land cover type.

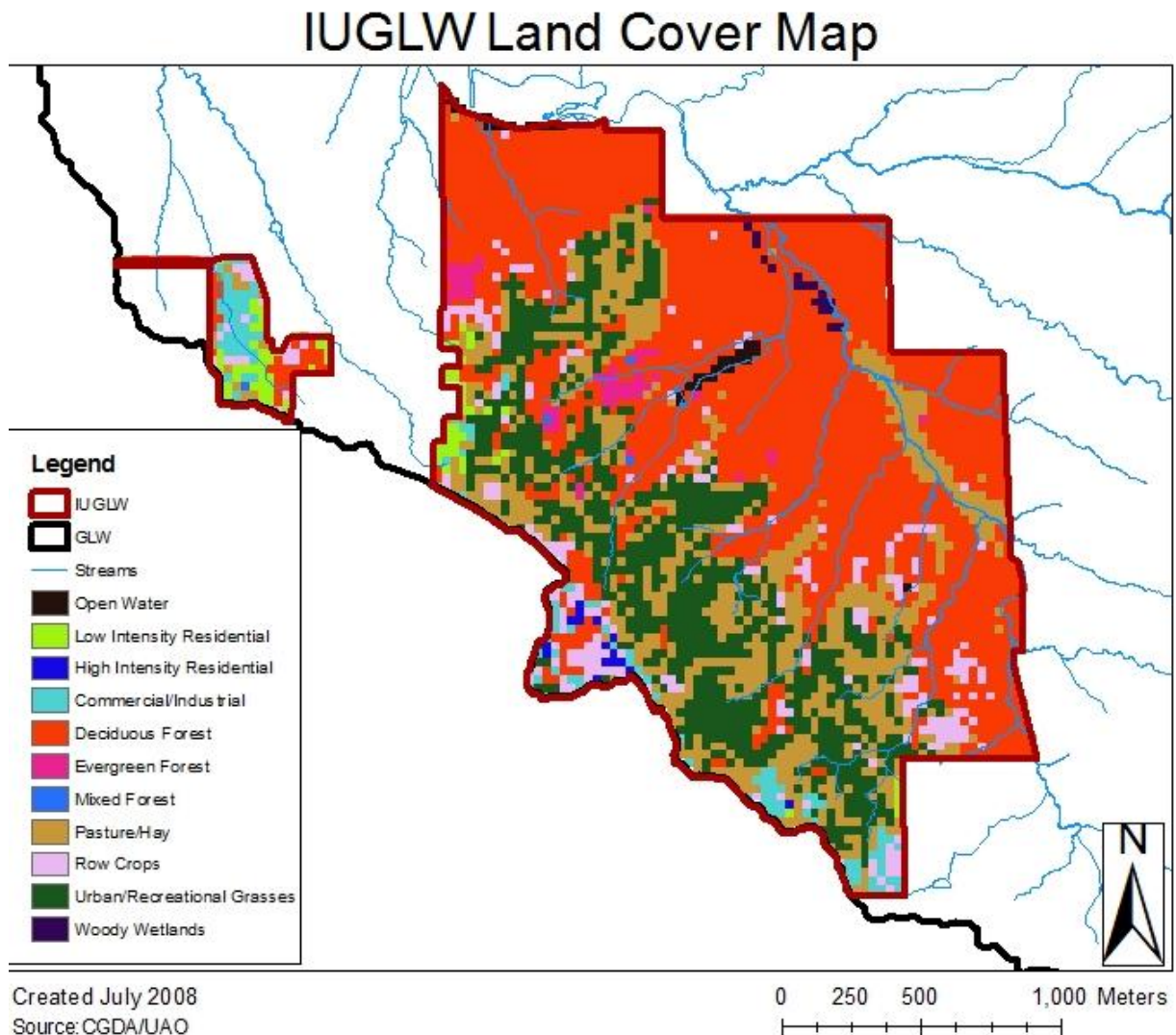
NCLD ID	Land Cover	Cell Count	Acres	Percent
11	Open water	36	7.97	0.81%
21	Low density residential	86	19.04	1.95%
22	High density residential	16	3.54	0.36%
23	Commercial/industrial	129	28.56	2.92%
41	Deciduous forest	2151	476.20	48.69%
42	Evergreen forest	57	12.62	1.29%
43	Mixed forest	4	0.89	0.09%
81	Pasture/hay	844	186.85	19.10%
82	Row crops	257	56.90	5.82%
85	Urban recreational	821	181.76	18.58%
91	Woody wetlands	17	3.76	0.38%
<b>TOTAL</b>		<b>4418</b>	<b>978.07</b>	<b>100%</b>

Table 1.

## 7.4 Procedure for Creating IUGLW Land Use Database

The IU Master Plan layer was joined to the Griffy Watershed Boundary layer using the Clip tool in ArcMap resulting in a new layer (IUGLW) displaying only the portion of the IU Master Plan which falls within the Griffy Watershed Boundary. Beginning with the (mon\_usgs\_lc) database the IUGLW layer was

applied to the raster dataset using the extract by mask feature in ArcMap resulting in a new geo-spatial database containing only the land cover data for the geographic area defined by the IUGLW. Cell counts for each land cover designation were calculated and divided by the total cell count within the IUGLW to determine the percentages of each land cover designation.



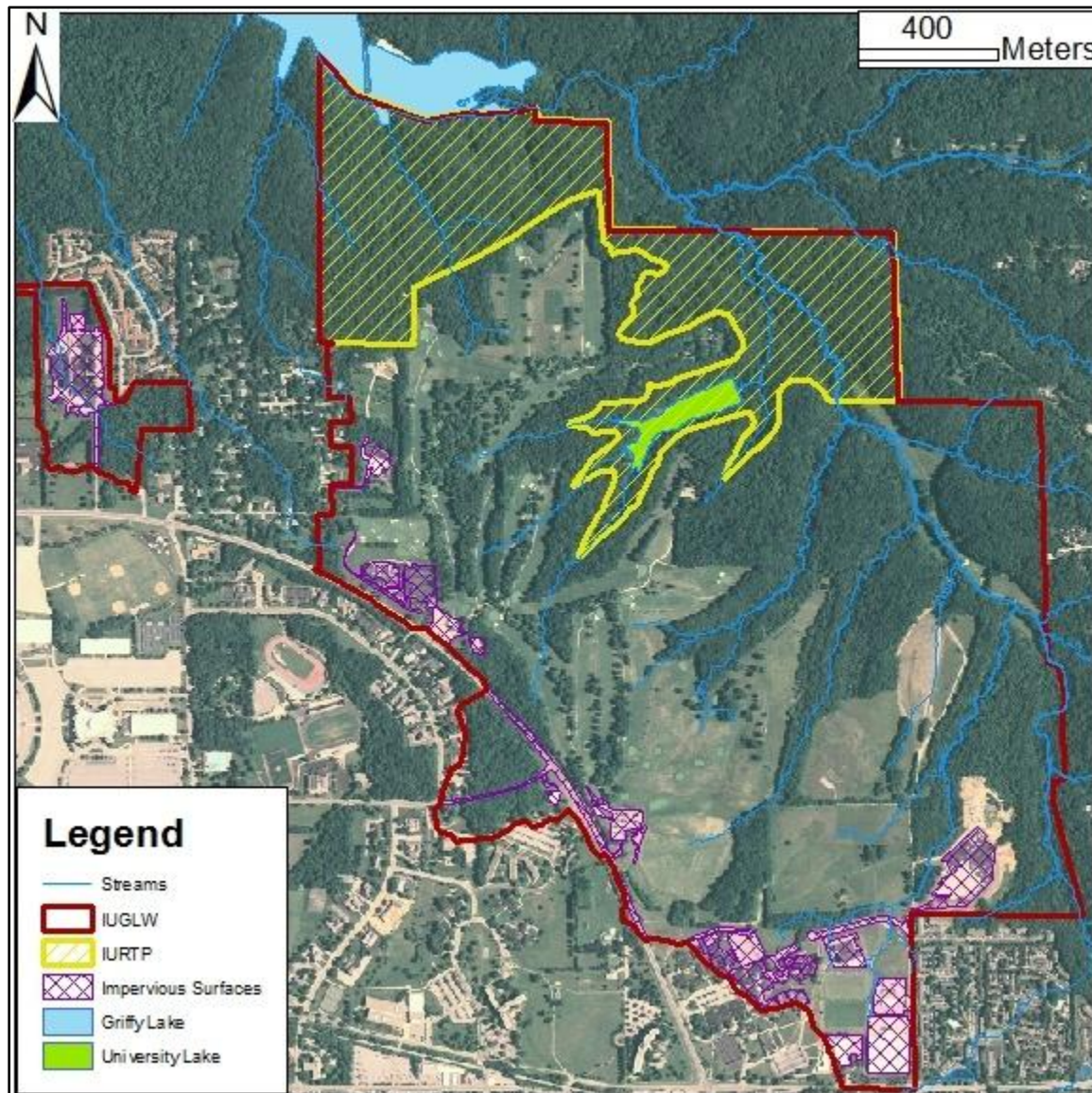
**Figure 2.**

It should be noted that several of the NLCD designations do not accurately portray existing land cover in the IUGLW. Row crops for example do not exist in the IUGLW. Field observation reveals that the areas designated as row crops on the map are areas that do not actually have crop cover but the level of soil disturbance due to development has been similar. Similarly the high percentage of pasture/hay designation refers to areas including the coal ash pile, cross country track, and less frequently mowed portions along golf course fairways.

## 7.5 Impervious Surfaces

Starting with the 2007 aerial photograph (in\_naip2007\_monroe) the digitized image was used to obtain visual estimates of the existing areas of impervious cover. A new shapefile was then created by outlining all of the major building, street, and parking lot surfaces in the image. Field observations were used to verify and obtain the most recent estimates of impervious cover. Measurements were obtained in sq meters and converted to acres. The total area of the new polygons were calculated and divided by the total area of the IUGLW polygon to arrive at the final percentages. Due to the scale of the aerial photograph, golf cart paths within the IUGLW were not calculated in this analysis.

### IUGLW Impervious Cover Map



Created July 2008  
Source: USDA-FSA Aerial Photography Field Office, 2007  
0807\_naip\_1-1\_2in 105. USDA FSA Aerial Photography  
Filed Office, Salt Lake City, Utah.

**Current Impervious Cover = 5%**

**Impervious Cover Acreage = 51 acres**

**Figure 3**

The impervious cover model shown in figure 4 suggests that the current level of impervious cover would predict relatively good water quality. However, the simple model does not take into account the unique topography and highly erodible soils of the IUGLW. Thus, at the present level of impervious surfaces it is likely that water quality in the IUGLW is more characteristic of an “impacted” watershed suggesting poorer instream water quality (Zeilinski, 2002).

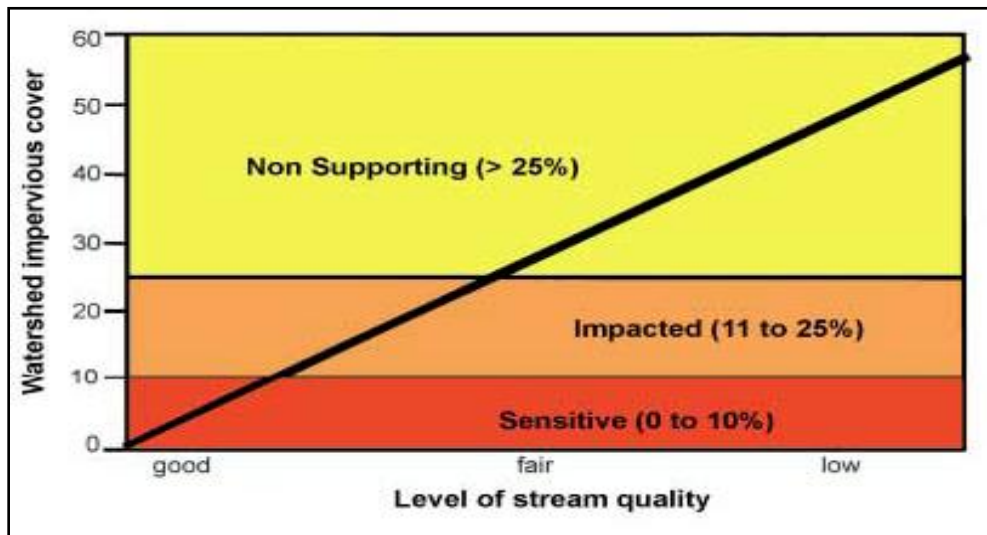


Figure 4. (Zeilinski, 2002)

## 7.6 General Land Uses

Starting with the 2007 aerial photograph (in\_naip2007\_monroe) the measure by polygon tool in ArcMap was used to outline the five major land use areas within the IUGLW. Specifically the analysis was interested in determining the areal split within the IUGLW between land uses of the general designations shown in Table 2.

General Land use Classification	Acres	Percent of Total
Commercial/Residential	106.33	11%
Golf Course	233.56	24%
Forest Outside the IURTP	428.68	44%
Minor Undeveloped Areas	24	2%
IURTP	185	19%
<b>TOTAL</b>	<b>977.57</b>	<b>100%</b>

Table 2.

## 7.7 IUGLW Erosion Hotspots

In February 2000 Commonwealth Biomonitoring, Inc. produced the Griffy Lake Watershed GIS Mapping and Management Plan for COB. The report, which identified several hotspots within the IUGLW, prompted this update which relied mainly upon field inspections. It should be noted that of major significance to the findings of this section are the heavy storms of May 2008 which severely impacted the watershed. Generally speaking, the identified sites (orange markers in Figure 6) are ones where existing “treatment” oriented BMPs have failed or were once installed and not properly maintained. Appendix E includes a table of priory sites and relevant photographs.

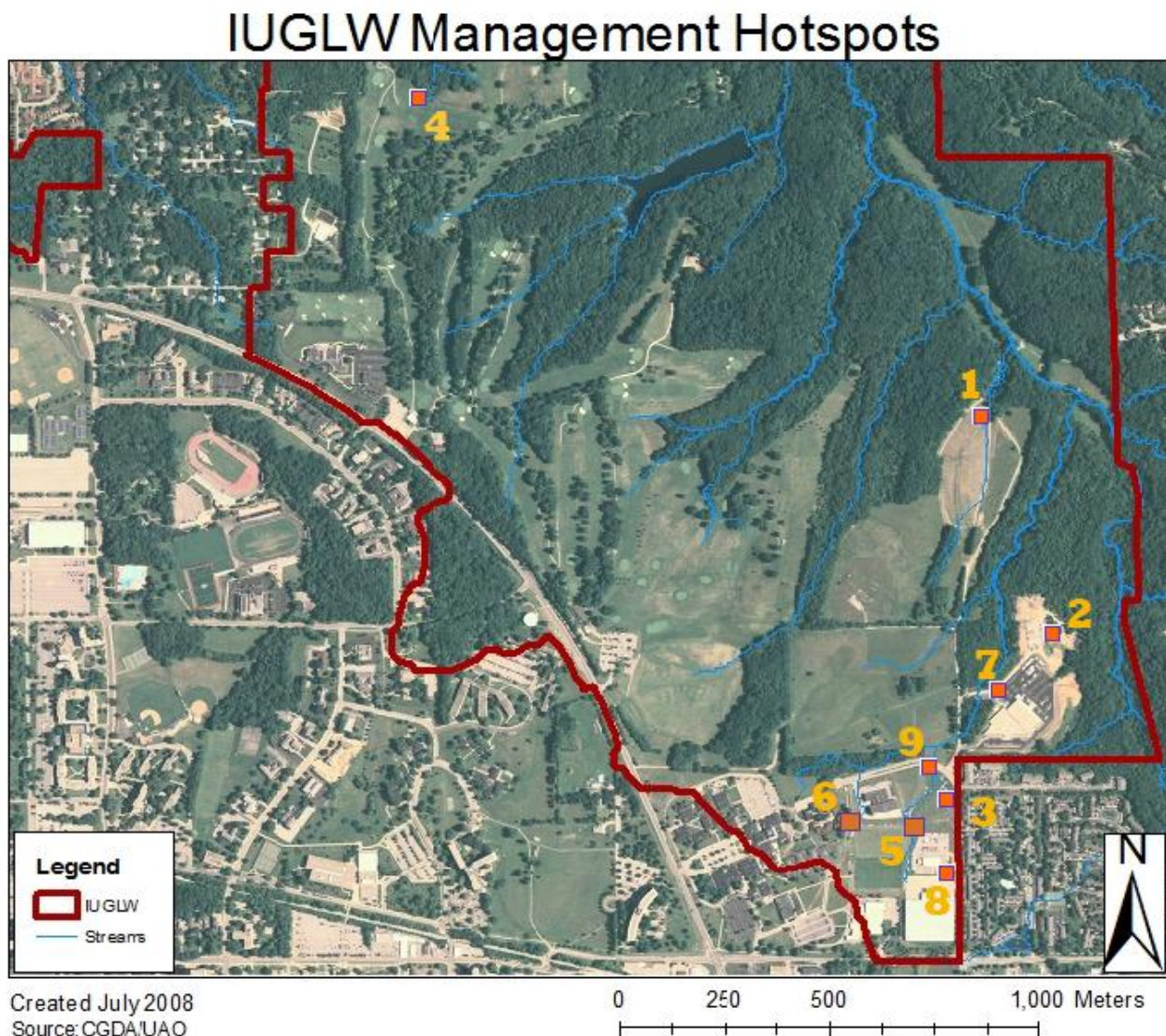


Figure 5.

## 8.0 L-THIA Model

In order to carry out a comparison of the relative status of the IUGLW with the larger Griffy Creek watershed (GCW), we used Purdue University’s Long Term Hydrologic Impact Assessment model (L-THIA) (L-THIA, 2008). Although, several reports have shown that L-THIA may not be the most precise tool for estimating actual water quality values, the fact that it has recently been applied to the larger GCW in previous reports allows for a comparative analysis of the IUGLW. With the required inputs L-THIA uses standard coefficients to compute pollutant loads and concentrations, and runoff from a given land area. In order to carry out the direct comparison with the GCW the specific land cover designations found in the IUGLW had to be grouped into several more general designations. (See Appendix D).

The major interest in running the L-THIA model was to be able to provide a means for IUB to compare the status of the IUGLW with that of the larger GCW. This analysis is less concerned with the actual values produced by the model than with the relative comparison of model outputs.

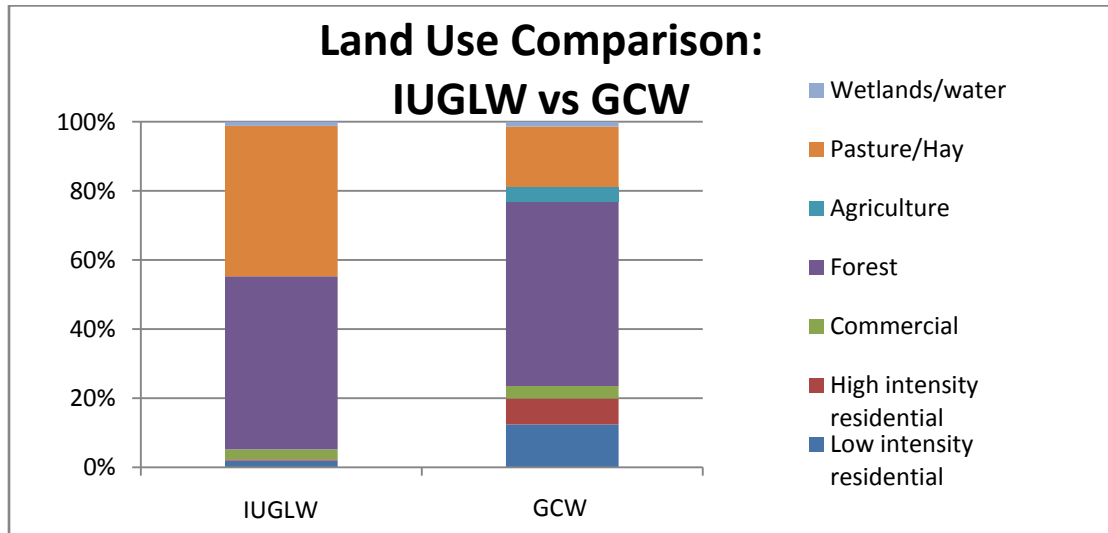


Figure 6 (See Appendix D for sources of land use percentages).

### Results of IUGLW L-THIA Model

Watershed	Area (acres)	Nitrogen	Phosphorous	TSS	BOD	COD	Fecal (millions of Coliform)
<b>GCW</b>							
Avg Annual Concentration (ppm)	8920	1.46	0.34	31.950	13.693	39.319	21663.598
<b>IUGLW</b>							
Avg Annual Concentration (ppm)	978	.980	.135	21.381	40.974	9.465	3615.814

Table 3.

## 8.1 Model Results and Discussion

Comparison of the results from the IUGLW L-THIA model and those for the greater GCW show that generally, the IU portion of the GCW is producing pollutant loads that are less than that of the overall GCW. The one area where IUGLW values exceeded GCW values is Biological Oxygen Demand (BOD). As mentioned before, L-THIA develops estimates based on land use percentages. BOD would be expected to increase with the percent of undeveloped land. The high BOD levels agree with the high levels of detritus we would expect to be produced by large areas of deciduous forests (Shea, 2006).

## 9.0 Golf course sustainability

The Indian University Championship golf course represents roughly 233 acres, or 23%, of the total land area of the IUGLW. Previous reports raised concerns about the potential impact of pesticides and fertilizers from the IU and other golf course within the GLW. A goal of this report was to identify avenues to facilitate the development of a more sustainable golf course. Currently, none of the other golf courses within the GCW are pursuing any type of sustainability certification, allowing for Indiana University to take a leadership role in the field of sustainable golf course management within the GLW.

Some of the major reasons for seeking certification in sustainable golf course management include, but are not limited to (ACSP, 2007):

- Improved quality of golf game and golfer experience
- Reduced costs associated with reduced inputs
- Improved public image
- Improved environmental quality
- Greater workplace safety and environmental health
- Healthier more resilient turf
- Improved efficiency

## 9.1 Audubon Certification Program

The Audubon Cooperative Sanctuary Program for Golf Courses (ACSP) is an extension of the popular certification program for creating environmentally sound developments of any kind. Similarly, The ACSP for Golf Courses offers several different levels of certification. The ACSP, although international in scope, is much more popular within the United States.

” The ACSP is an award winning education and certification program that helps golf courses protect our environment and preserve the natural heritage of the game of golf. By helping people enhance the valuable natural areas and wildlife habitats that golf courses provide, improve efficiency, and minimize potentially harmful impacts of golf operations”(ACSP, 2007).

The ACSP program is strongly focused on developing and managing a golf course to be as unified with the surrounding natural environment as possible. Once a golf course is registered and has paid its annual dues the ACSP will provide print materials for the golf course manager to utilize in evaluating and implementing golf course sustainability. The certification process is achieved

through documentation provided by the course and is granted upon approval. Although the pace of the process is up to the course manager estimated time to certification is one to three years.

**Audubon Strengths:**

- More appropriate for parkland style courses
- Commonly used within the United States
- Strong emphasis on education and awareness
- Proven applications throughout Indiana
- Maximizes overall environmental quality of the golf course
- Multiple levels of certification allowing for incremental improvements

**Audubon Weaknesses:**

- Annual fee required to achieve certification
- Lack of benchmarking services
- Less focused on maximizing the quality of the game

## **10.0 Stormwater Management**

Indiana University currently has in place a comprehensive stormwater quality management plan (SWQMP) in compliance with IDEM’s promulgation of the NPDES Phase II Program. Sediment and E.coli are identified in the SWQMP as the two major pollutant concerns for IUB. Currently, IUB holds a permit for its own municipal separate storm sewer systems (MS4) which is separate and distinct from that of the City of Bloomington. The majority of IUGLW is zoned as “Institutional” and as state owned property is largely exempt from any zoning ordinances at the city/county level such as the City of Bloomington’s environmental constraints overlay. In recognizing the critical “social” component of sustainability IUB should ensure that its MS4 plan at least meets, if not exceeds, the SWQMP standards and practices deemed acceptable by the City of Bloomington community.

## **11.0 Gully Erosion**

Field inspections identified gully erosion along several of the drainages within the IUGLW as a potentially significant source of instream sediment loads. Migrating gullies in this portion of the watershed have been unaffected by the current practice of riprap lining and have the ability to threaten infrastructure as well as compromise the existing drainage network through sedimentation and reduced channel volumes. “Gully initiation is thought to be a response to excessive water in the local environment caused by the removal of perennial vegetation” (DPIW, 2008). Given the surrounding land uses it is likely that the development decisions of IUB are responsible for exacerbating this source of sediment loading within the GLW. IUB should implement the necessary steps, both instream and landscape-based, in order to mitigate this threat to the sustainability of the GLW.

## 12.0 Landscape Based Approaches

IUBs current SWQMP should be highly regarded as a significant step towards the overall sustainability of the GLW. However, existing BMPs and stormwater management strategy has largely focused on treatment rather than prevention of stormwater problems. Landscape based approaches or “low impact development” (LID) is a development philosophy which emphasizes prevention. “In traditional stormwater management, water is typically moved off a site as quickly as possible[LID], however, treats rainfall on-site by attempting to integrate control into site and building design”(Hager, 2003). Riprap lined drainages and downstream silt fences are both BMPs commonly practiced within the IUGLW which are aimed only at the *treatment* of stormwater. IUB should revise its existing SWQMP and architectural guidelines to further emphasize LID principles.

### 12.1 Existing LID Opportunities

The following section highlights some opportunities for IUB to implement LID practices in the short term. Currently IUB mows an extensive area of hill slope which contributes directly to the drainages of the commercially developed IUGLW (see figure 8). Given that these areas serve no immediate practical purpose and are not in a highly visible (main campus area) IUB could designate “all sloped surfaces immediately adjacent to drainages” as no-mow zones and eventually develop a policy of planting a mixture of trees, shrubs, and native grasses in these areas.

The commercially developed area within the IUGLW is assumed to have a negative impact on watershed health for the large area of impervious surfaces which reduce water retention on site and increase downstream velocities. Many of the parking lots in this area are simple flat slabs of cement with no barrier (curb) between the cement and undisturbed land. IUB could utilize these lots to demonstrate biofiltration techniques at the lot/land interface at a minimum cost (see figure 9).

At the confluence of the three major drainages from the commercially developed IUGLW (see figure 10.) there is a depression where the water collects prior to passing under 14<sup>th</sup> st. This collection area is currently mowed and maintained as part of the surrounding lawn. This area should at the very least be a no-mow zone and in the near future should be considered a priority site for constructed wetlands.



**Figure 8.** Mowed hill slopes adjacent to drainages east of auxiliary library facility.



**Figure 9.** Uninterrupted interface of parking lot and landscape at IU Warehouse.



**Figure 10.** Confluence of three major drainages from developed area at Range Rd. and E. 14<sup>th</sup> street.

### 13.0 Sustainability Goals

In the summer of 2007 the Indiana University Task Force on Sustainability developed a general watershed protection goal to maintain the health of “water resources, both within and beyond the boundaries of the IUB campus (Arazan, 2007). Included in the 2007 report was a list of specific goals for the Jordan River watershed. Based on this previous list of recommendations, below is a revised list of specific sustainability goals for the IUGLW.

- i. Expenditure abatement on infrastructure.*  
Reduce silt fence, riprap, and culvert replacement/maintenance costs through preemptive actions to reduce erosional forces caused by unmanaged storm water flow.
- ii. Improve regulations and BMPs associated with construction site runoff.*  
The City of Bloomington currently has in place regulations which are more stringent than that of IU's, from which IU is exempt.
- iii. More efficiently execute grounds keeping/mowing*  
Perform cost benefit analysis using budget information on grounds keeping expenditures to reduce campus greenspace maintenance costs.
- iv. Improve water quality*  
Specifically address pollutant loads of total suspended solids and E.coli bacteria. As described above the IUGLW has many “erosion hotspots” which, once addressed should greatly reduce downstream sedimentation and TSS loads.
- v. Non-point source pollution*  
Runoff associated with non-point source pollutants could be retained before it reaches Griffy Creek and moves downstream through the use of strategically placed wetlands and perennial herbaceous buffer zones along the streambanks. Planting rain gardens around buildings would also decrease the volume of runoff from large roofs and parking lots.

- vi. ***Increase area and improve quality of riparian buffer zone.***  
The addition of low-mow buffer zones, herbaceous perennial plantings of hydrophilic plants and created wetlands. By improving the riparian buffer zone the volume and velocity of water in the IUGLW during storm events will be reduced, thus contributing to better downstream water quality.
- vii. ***Improve golf course sustainability.***  
The unique setting and sensitive location of the IU Championship golf course both demands that sustainability be top priority and provides ample opportunity to implement sustainable management practices.

## 14.0 Recommendations

### Short Term- Within One Year

- **Inspect and repair all existing BMPs for compliance with SWQMP**
- **Install erosion control blankets at coal ash pile outfall**
- **Designate all hill slopes within IUGLW as no-mow zones**
- **Increase participation in ongoing community watershed protection efforts**

### Medium Term – Within Two Years

- **Register IU Championship golf course with ACSP certification program**
- **Revise SWQMP to include more stringent guidelines for sediment control**
- **Construct wetland at confluence of commercial area drainages**
- **Plant bank-stabilizing riparian vegetation along all major drainages**

### Long Term – Ongoing

- **Mandate maximum pervious surfaces practicable in all new construction**
- **Install vegetated biofiltration buffers along all parking lot perimeters**
- **Implement landscape based approaches to stormwater management**
- **Monitor University Lake for aquatic invasives**

## 15.0 Conclusion

The South Fork Griffy Creek is the most heavily impacted subwatershed in the GLW. Although much of the impact to date is attributed to residential development outside the IUGLW, it is development within the IUGLW that has the potential to have the greatest negative impacts in the future. Recent city and state level initiatives highlight the importance of watershed protection in the community and specific concerns within the IUGLW. Sediment is the one pollutant for which IU is both a major source and can feasibly manage. The storms of May 2008 highlighted the major pathways of sediment transport and the existing instream treatments as unsustainable. Given the steep topography and highly erodible soils of the IUGLW, instream erosion is virtually unavoidable. Slowing the flow of water across the landscape should be seen as the only viable option for sustainably managing IUGLW's sediment loads.

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## Appendix A

### List of Acronyms

<b>ACSP</b>	Audubon Cooperative Sanctuary Program
<b>BMP</b>	Best Management Practices
<b>CGDA</b>	Center for Geospatial Data Analysis
<b>COB</b>	City of Bloomington
<b>EPA</b>	Environmental Protection Agency
<b>GCW</b>	Griffy Creek Watershed
<b>GIS</b>	Geographic Information Systems
<b>GLW</b>	Griffy Lake Watershed
<b>IU</b>	Indiana University
<b>IDEM</b>	Indiana Department of Environmental Management
<b>IUB</b>	Indiana University Bloomington
<b>IUGLW</b>	Indiana University Griffy Lake Watershed
<b>IURTP</b>	Indiana University Research and Teaching Preserve
<b>LID</b>	Low Impact Development
<b>L-THIA</b>	Long-Term Hydrologic Impact Assessment
<b>MS4</b>	Municipal storm sewer system
<b>NAIP</b>	National Agriculture Imagery Program
<b>NLCD</b>	National Land Cover Data
<b>NPDES</b>	National Pollution Discharge Elimination System
<b>SWQMP</b>	Stormwater Quality Management Plan
<b>UAO</b>	University Architects Office

## Appendix B

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## Appendix C

### Geo-Spatial Databases for Indiana University Griffy Lake Watershed Project

	<b>Data Layer Name</b>	<b>Type</b>	<b>Description</b>	<b>Source</b>	<b>Projection</b>
1	mon_usgs_lc	ESRI GRID	Land use/land cover grid for Monroe County	USGS	NAD_1983_UTM_Zone_16N
2	bedrock_geology_griffy_mm48.shp	ESRI Shapefile	Bedrock geology of the Griffy IURTP area, from IGS Miscellaneous Map 48	IGS	NAD_1983_UTM_Zone_16N
3	grif_bnd83.shp	ESRI Shapefile	Boundary of the IU Griffy Woods Research and Teaching Preserve	CGD A	NAD_1983_UTM_Zone_16N
4	Griffy_shed83.shp	ESRI Shapefile	Catchment boundary for Griffy Lake, Monroe County, Indiana	CGD A	NAD_1983_UTM_Zone_16N
5	Griffy_subwatersheds83.shp	ESRI Shapefile	Subwatershed boundaries for Griffy Lake, Monroe County, Indiana; derived from synthetic hydrologic (stream) network calculated using ESRI ArcGIS Spatial Analyst hydro tools	CGD A	NAD_1983_UTM_Zone_16N
6	griffyhyd83.shp	ESRI Shapefile	Hydrologic (stream) network. Combination of hydrology mapped by Monroe County and synthetic stream network for unmapped areas (northeastern part of the watershed)	CGD A	NAD_1983_UTM_Zone_16N
7	griflake83.shp	ESRI Shapefile	Boundary of Griffy Lake (reservoir)	CGD A	NAD_1983_UTM_Zone_16N
8	surficial_geology_griffy_mm49.shp	ESRI Shapefile	Surficial geology of the Griffy IURTP area, from IGS Miscellaneous Map 49	IGS	NAD_1983_UTM_Zone_16N
9	univlake83.shp	ESRI Shapefile	Boundary of University Lake (reservoir)	CGD A	NAD_1983_UTM_Zone_16N
10	in_naip2007_monroe	ESRI Pixel	2007 aerial photograph of the IUGLW from National Agriculture Imagery Program	USD A	NAD_1983_UTM_Zone_16N
11	Master_Plan	ESRI Shapefile	Outline of IUB Master Plan boundary from University Architects Office	UAO	NAD_1983_UTM_Zone_16N

## Appendix D

### Specific Land Cover Designations and Simplified Groups Used in L-THIA Model

<b>General L-THIA Categories</b>	<b>Specific NLCD Categories Used</b>
Commercial	Commercial/Industrial
Residential 1/8 acre	Low Density Residential
Residential 1/2 acre	High Density Residential
Forest	Deciduous Forest, Evergreen Forest, Mixed Forest
Grass/Pasture	Pasture/Hay, Urban Recreational Grasses, Row crops
Water/Wetlands	Woody Wetlands, Open Water

### L-THIA Model Inputs

<b>Land Use</b>	<b>Soil Group</b>	<b>Area(acres)</b>
Commercial	B	14.28
Commercial	C	14.28
Residential 1/8 acre	B	1.77
Residential 1/8 acre	C	1.77
Residential 1/2 acre	B	9.52
Residential 1/2 acre	C	9.52
Forest	B	244.85
Forest	C	244.85
Grass/Pasture	B	212.75
Water/Wetlands	B	11.73

## Appendix E

<b>Hotspot in Indiana University Griffy Lake Watershed</b>		
<b>Priority Rank/ID</b>	<b>Site Description</b>	<b>Figure #</b>
<b>1</b>	Outfall at coal ash pile. Riprap lined drainage ways have failed leading to severe eroded gullies, several feet deep and wide. All existing BMPs have failed at this sensitive site.	E.1,E.2,E.3
<b>2</b>	IU equipment storage area behind physical plant. Large areas of exposed soils draining directly into south fork Griffy Creek. Existing silt fence inadequate/failing. Amount and variety of disposal materials increasing, threatening water quality.	E.4,E.5,E.6
<b>3</b>	Major drainages from commercially developed portion of IUGLW. Riprap has been compromised leaving exposed banks highly vulnerable to further erosion.	E.7
<b>4</b>	Gully erosion at edge of IU golf course. Upstream migration of channel jeopardizes fairway along hole #5.	E.8
<b>5</b>	Migrating gully erosion along drainage between IU Warehouse and athletic fields. Bank undercutting behind existing erosion control fabric.	E.9
<b>6</b>	Exposed soils from recent construction on hill slope adjacent to major drainage west of Auxiliary library building.	E.10
<b>7</b>	Culvert outflow to the north of the auxiliary road leading to IU equipment storage area. Failing riprap and filter fabric.	E.11
<b>8</b>	Drainage way between the northeast side of the IU warehouse parking lot and to the southeast of the IU Motor Pool. Bank undercutting behind existing erosion control fabric.	E.12,E.13
<b>9</b>	New channel formation around existing drainage/culvert outflow along E.14 <sup>th</sup> St. and Range road.	E.14



Figure E.1.



Figure E.2.



Figure E.3.



Figure E.4.



Figure E.5.



Figure E.6.



Figure E.7.



Figure E.8.



Figure E.9.



Figure E.10.



Figure E.11.



Figure E.12.



Figure E.13.



Figure E.14.