APPENDIX A

Erosion Activity Assessment of the D'Olive Creek Watershed

Erosion Activity Assessment of the D'Olive Creek Watershed. Daphne, Alabama.

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Executive Summary

Introduction

As part of the efforts to develop the Comprehensive Watershed Management Plan, Tetra Tech conducted a field investigation of streams within the D'Olive Creek Watershed to define watershed sedimentation and stream stability problems.

The investigation included three components:

- First is an erosion activity assessment. This assessment consisted of locating, through walking the streams and driving through the uplands, the primary sources of sediment within the Watershed. These sources may be due to in-stream channel erosion or upland rainsplash and sheet erosion, erosion of unpaved roads, and gullying of ditches.

- The second component entailed determining the causes of the erosion.

- The third component involved proposing locations to implement potential sediment and stormwater Best Management Practices (BMPs) to help reduce future erosion and sediment loading to the streams, Lake Forest Lake, and D'Olive Bay.

Methodology

The D'Olive Watershed was divided into 9 Watershed Management Units (Table ES-1 and Figure ES-1) based on sediment and water quality sampling locations defined during previous studies of the Watershed by the Geological Survey of Alabama (Cook, 2007; Cook and Moss, 2008). Because sediment load data are available at the most downstream point of each subunit, they become useful for determining the sources of sediment and for future load monitoring.

Table ES-1. Watershed Management Units.

WMU Number*	Streams Within WMU	Tributary Codes
0	Lake Forest Lake and the lowest 1/2 mile of D'Olive and Tiawasee Creeks	L, D (lower), T (lower)
1	Middle and upper tributaries to D'Olive Cr	DA, DAA, DAB, DAC, DACA, DAD
2	Unnamed tributary DB	DB
3	Upper D'Olive Creek and tributaries	D, DD
7	Middle Tiawasee Cr and tributaries below Ridgewood Drive	T, TA, TAA, TB
8	Tiawasee Creek and tributaries above Ridgewood Drive	T, TD, TE, TEA, TF, TG, TGA
9	Tributaries to Tiawasee Creek above Ridgewood Drive	TC, TCA, TCB, TCC
10	Joe's Branch and tributaries	J, JA, JB
11	Unnamed tributary DC	DC

* This numbering is chosen to match that of the GSA studies of 2007 and 2008

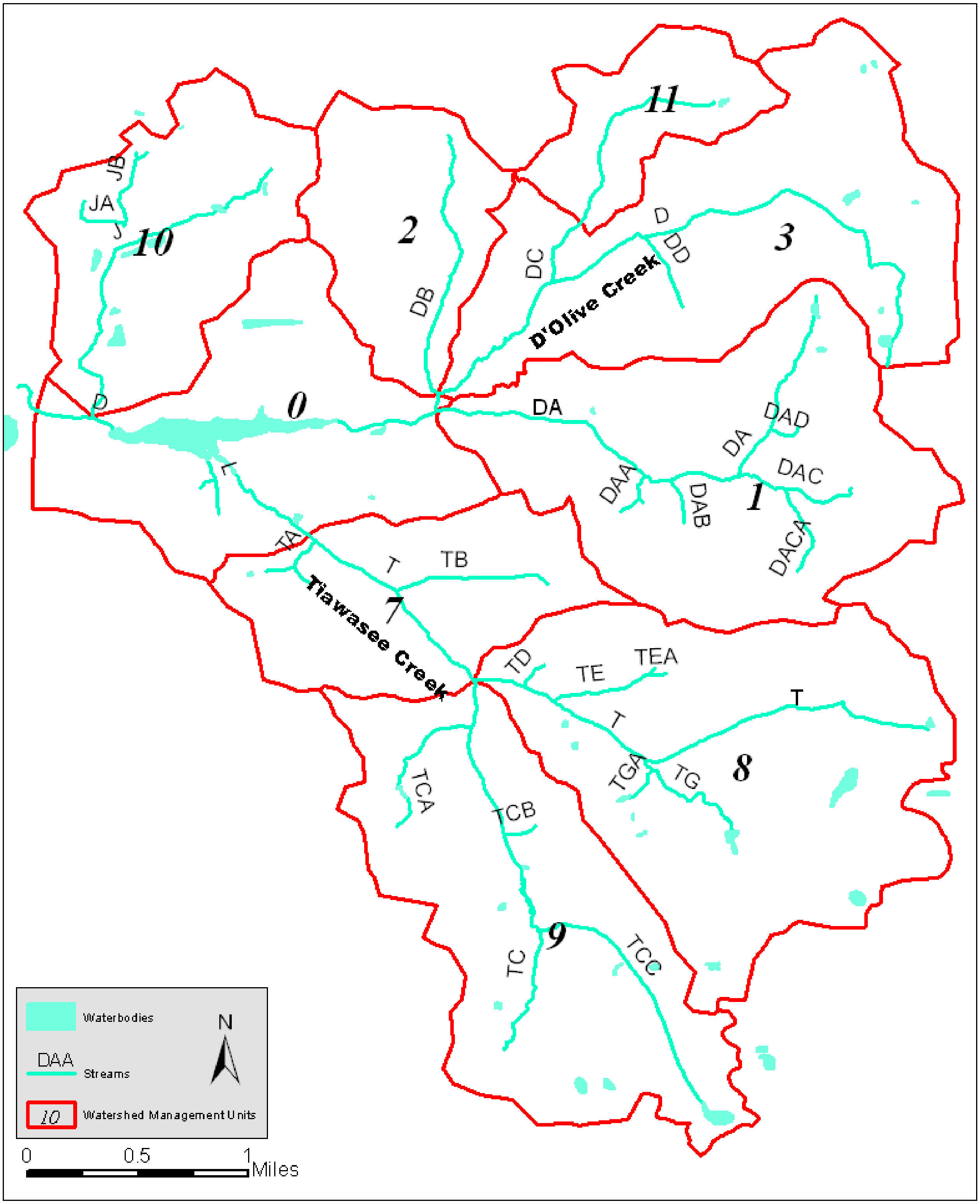

Figure ES-1. Watershed Management Units and Tributary Codes.

The assessment included major portions of the main channel of D'Olive Creek, Tiawasee Creek, Joe's Branch and several of their tributaries (Maps 2 through 8). Additionally, many minor tributaries and as many upland areas as possible were also assessed during the time available. Because many of the tributaries in the Watershed are unnamed, an alphabetical naming convention was employed. The main stems of D'Olive Creek, Joe's Branch, and Tiawasee Creek were all assigned their first letters; D, J, and T respectively (Figure ES-1). Starting at the downstream end and working upstream, each tributary encountered was named alphabetically. Thus, the first tributary on D'Olive Creek was named DA, and the second, DB, and so on. Tributaries to minor tributaries were also named alphabetically, with an example being, DAA would be the first, and DAB would be the second tributaries to tributary DA.

During September 2009, the assessment was carried out by a fluvial geomorphologist walking either on the streambed or along the stream bank while conducting Rapid Geomorphic Assessments (RGAs). The RGA consists of collecting a suite of qualitative and semi-quantitative data that describe the form, stability, and erosion potential of the stream channel at that location. RGAs were conducted at each major change in: channel form, bed and bank materials, and/or riparian vegetation. Data were collected at 274 locations in or near stream channels and in upland areas.

Based on the collected data, stream reaches were rated as having a low, moderate, or high erosion activity. This rating was a semi-quantitative process based on the criteria in Table ES-2.

Table ES-2. Channel assessment criteria per reach.

Erosion Activity	Erosion by Mass Wasting (sum of both banks)		Erosion by Scour (sum of both banks)
Low	Equal to 0%	and	60% or Less
Moderate	Equal to 0%		Greater than 60%
High	Greater than 0%	and	Any percentage

Upland sites of interest encountered outside of streams are described with the prefix "U" on Maps 2 through 8. These sites were rated Low, Moderate, and High for sediment source potential. An example of a High rating is a bare earth construction site with no rainsplash protection on the soil. An example of a Moderate rating is an eroding dirt road that is partially grown over with weeds. An example of a Low rating is a fully grassed lawn. A total of 49 upland sites are included in the data tables in Attachment A.

Other sites documented in the data tables contained in Attachment A include pipeline crossings, detention ponds, and other features not directly related to sediment potential, but may be of interest when designing stormwater and sediment management BMPs.

The field data for the stream sites, upland sites, and other sites are compiled into a series of tables (Data Tables 1 through 4 in Attachment A). Based on the assessment results, each site is highlighted green, yellow, red, or no color to represent low, moderate, or high levels of erosion activity, or Other. The same color scheme is used on Maps 2 through 8 to show levels and locations of erosion activity throughout the Watershed. Photos were taken at most of the assessment points and representative photos of various features are included in the stream reach description (Section 5). All photos taken have been are labeled by assessment point and are compiled into a photo log on one CD included with this report.

Conclusions

In general, streams in the residentially and commercially developed parts of the D'Olive Watershed undergo bed and bank erosion, with the exception of near Lake Forest Lake where lesser amounts of bank erosion are taking place and heavy sediment deposition is occurring. Generally, streams in the undeveloped headwater areas of the Watershed tend to be small, multi-threaded, not undergoing bed and bank erosion, and thus are presently not sediment sources, but potentially are conduits to transport sediment eroded from upland sources.

The highest intensity erosion appears to be located immediately below headcuts and gullied stream reaches immediately below headcuts. Fortunately, because these erosional features are focused in relatively small areas, there are opportunities to mitigate the impact by stabilizing the headcuts and gullied reaches, and by reducing the stormwater runoff from upstream areas.

Locations of headcuts, gullies, and locations of potential high channel instability are identified in the data tables in Attachment A and on Maps 2 through 8. Noteworthy locations include:

- D3 to D5 (Map 3, Watershed Management Unit (WMU) 3): Active mass wasting of incised channel. Large Woody Debris (LWD) jams exacerbate erosion.
- DA9 to DA33 (Map 5, WMU 1): Active mass wasting along reach with highest banks in Watershed. Homes threatened by bank instability.
- DA36 (Map 5, WMU 1): Active mass wasting beneath power line easement.
- DA40 and DAC2 (Map 5, WMU 1): Active large headcuts just above confluence of these two streams.
- TC2 to TC5 (Map 6, WMU 9): Actively advancing headcut resulting in incised channel with mass wasting banks. LWD jams exacerbate erosion.
- JA2 to JA5 (Map 2, WMU 10): Actively advancing headcut resulting in incised channel with mass wasting banks.
- JB5 to JB6 (Map 2, WMU 10): Actively advancing headcut resulting in incised channel with mass wasting banks.
- U38 (Map 7, WMU 7): Actively advancing headcut threatens to undermine Country Club Road.

The remaining erosion hot spots should be prioritized based on the percent of reach undergoing erosion by mass wasting or scour, or proximity to infrastructure.

Areas bordering the streams with steep slope gradients were identified as potential erosion hot spots since it was not possible to discover every problem location during the field assessment. An example from WMU 7 (Map 7) includes at least the following three locations. Each of these locations should be investigated for both high sediment production potential and for potential impacts to roads and residences.

- The apparent gully west of Crestview Circle and South of Buena Vista Drive.
- Tributary TB northwest of Marc Circle and at the headwaters of Tributary TB.
- Apparent gully south of the headwaters of Tributary TAA.

The cause of the gullying and rapid headcut advancement is attributed to increases in runoff (discharge rates and volume) due to past and recent land use changes. Mitigation efforts should include locating areas upstream of the impacted streams where stormwater management BMPs can be installed. This is particularly true to adequately address post-construction conditions.

Tributaries draining areas with unimproved roads and construction sites are heavily impacted by sedimentation. Therefore, rainsplash and sheetwash erosion of soils unprotected by vegetation or other means is a significant contributor of sediment to the streams of the D'Olive Watershed. Although unimproved roads are not as dominant in contributing sediment as when documented in the late 1970s by Carlton and Gail (1979), the freshly eroded surfaces of the few remaining unpaved roads, and large fresh sediment deposits at the base of slopes near these roads indicate unimproved roads are still a factor contributing to the sediment load entering Lake Forest Lake and D'Olive Bay. Headwater tributaries below active construction sites and recently developed areas typically have heavy sediment deposits on their floodplains and in some cases the channels are choked with sediment. Because these tributaries appear to be stable in terms of streambank erosion, the source of the sediments is likely from upland sources. Noteworthy locations of observed upland erosion include:

- U17 and U18: Ineffective erosion control at French Settlement subdivision construction site.
- U45 and DD1: Erosion of unpaved portion of Woodrow Lane.
- U51: Barren residential construction site on Lindsey Circle

The source of the heavy sediment deposits on tributary JB between JB1 and JB5 has not been positively identified. For tributary JB, the gully and headcut at JB6 is a source, but the quantity of sediment deposited along the 500 meters between JB5 and JB1 is so overwhelming that other sources are likely. Possible contributors include the utility crossing at JB3, the power line corridor just south of US 31, the gravel drive leading to the water utility station north of US 31, and possibly other unidentified sources.

Two other small tributaries were impacted by high sediment deposition: DA below US 90, and TG below the French Settlement construction site.

Using the Cook (2007) and Cook and Moss (2008) studies to compare sediment loads (combined suspended and bedload) by WMUs indicates that WMUs 1 and 3 (tributaries DA and D) are the dominant contributors with WMU 3 contributing nearly half the total load and WMU 1 contributing just under one third. WMU 7 (tributary T) contributes the remainder, providing just under one quarter of the total load. During 2007 and 2008, land within the north central part of WMU 0 underwent development as part of the Spanish Fort Town Center complex. The total sediment load draining this area was low. However, because this area was so small, a fourth of a square mile, the normalized sediment loading rate in tons per square mile per year was very high. WMUs 2 and 9 (tributaries TC and the upper T) were essentially insignificant contributors to the total sediment loading of Lake Forest Lake during this time period. Joe's Branch (tributary J), draining WMU 10, doesn't drain into Lake Forest Lake. However it contributes a moderate amount of sediment directly into D'Olive Bay.

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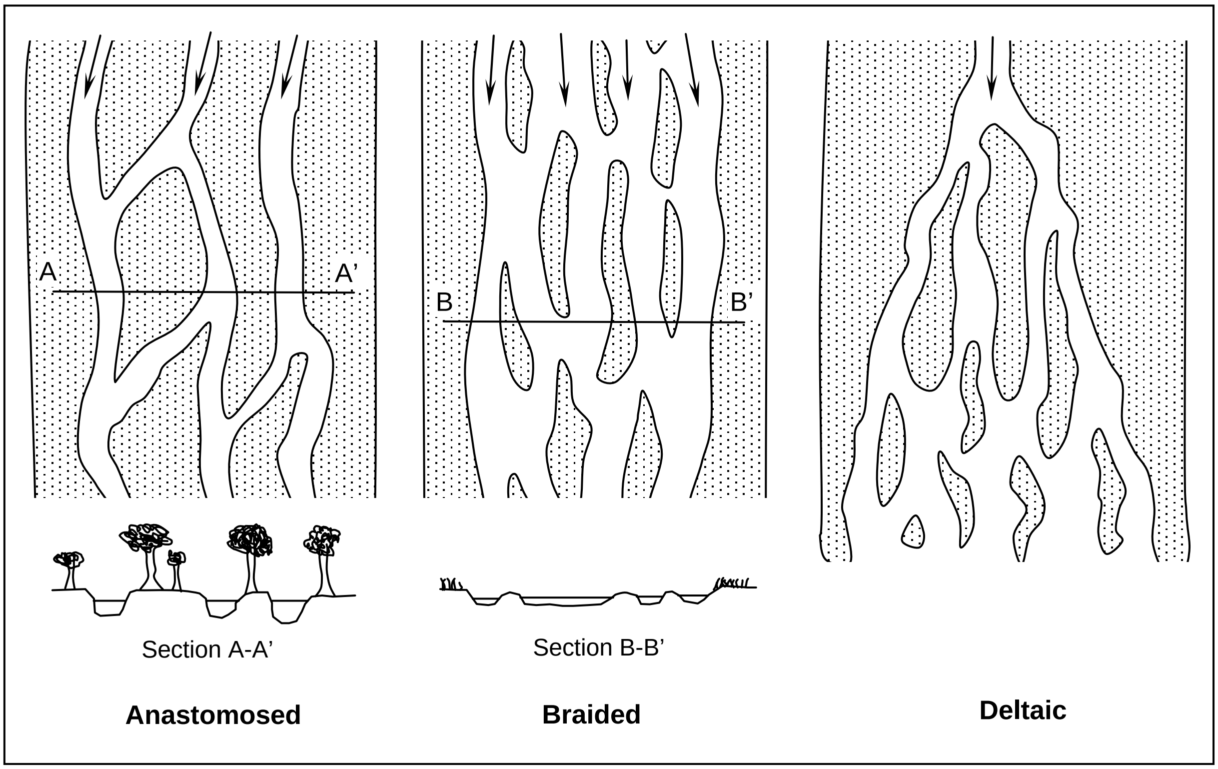
Glossary

Aggradation: Stream bed elevation is becoming higher due to sediment deposition.

Alluvial: Pertains to soils and sediments that were deposited by flowing water. Typically, the floodplain silts and sands deposited during floods.

Anastamosed: Term for multi-threaded channel typically characterized by low-gradient, low-sediment load, stable channels. This is in contrast with braided channels which are typically characterized by moderate-gradient, high-sediment load, unstable channels in which the pattern frequently changes when individual threads become choked with sediment). A third type of multi-threaded channel system, deltaic, is composed of distributary channels which form where a river enters a lake or ocean (See below illustration).



Avulse: The abrupt change in the course of a stream.

Block failure: A mass wasting process in which tension cracks, forming several inches to several feet behind the exposed surface, propagate through the soil mass leading to blocks of material collapsing from the streambank face. Typically occurs in fine-grained cohesive soils.

Colluvial: Pertaining to soils and sediments that are transported by the force of gravity. Typically, residual materials, including partially weathered rock, soils, and rock fragments of all sizes from sand to large boulders. These materials move downslope by creep or mass movement depending on the cohesive strength between the materials and slope steepness.

Creep: Slow downslope movement of earth materials. Typically, a fraction of an inch with each wetting and drying cycle or freezing and thawing cycle.

Headcut (also Knickpoint): An abrupt change in stream gradient where stream flows over an erodible bed, typically of clay, partially weathered rock, or residuum. Active gullies typically have one or more headcuts along their length.

Large Woody Debris (LWD): LWD consists of any woody material that has fallen into the channel and is creating an impact. This could be a single tree that was growing on the banktop and has fallen in, or it could be a bunch of tree limbs that have gotten entangled together on an object in the stream such as a boulder, bridge pier, overhanging tree, or fallen tree.

Incision: Stream bed elevation is becoming lower due the erosion of sediment deposits from the bed and/or erosion of underlying parent materials. Synonymous with degradation

LWD forced riffle: Where LWD constricts the channel or controls gradient in such a way to create a high velocity region that serves the same habitat function as a gravel or cobble riffle.

LWD forced pool: Where LWD blocks the channel and forces flow to scour down into the bed, thus creating a pool habitat.

Mass wasting: General term for the transfer of earth material down hillslopes. It includes four main categories: flow, slide, fall, and creep. Of these, creep is the most important if least spectacular. It is the result of gravity acting on material that has lost cohesion, typically as a result of an increase in water content. A slide (or landslide) is a comparatively rapid displacement of Earth material over one or more failure surfaces which may be curved or planar.

LWD induced bank scour: Where LWD blocks the channel causing moderate to high flows to widen the channel by scouring the banks around the ends of the jam.

Slot canyon: A slot canyon is a narrow canyon, formed by the wear of water rushing through rock or extremely cohesive clay. A slot canyon is significantly deeper than it is wide

Unadjusted Tributary: A tributary, with a bed elevation higher than the main channel at the confluence of the tributary and main channel. The most likely cause is that the tributary is newly formed as a result of an increase in storm runoff. Another possible cause is that the main channel has begun to rapidly incise and the tributary has been unable to keep up. Stream systems that are in equilibrium will have tributaries joining the main channel with their beds adjusted to the same elevation.

Acknowledgements

Wayne Isphording, John Carlton, and Bruce Steiner contributed their experiences and insights on the history of the D'Olive Creek Watershed. Ashley Campbell, Marlon Cook, and Carl Pinyerd contributed their knowledge of ongoing activities that are impacting erosion and hydrology within the Watershed. Nick Jokay, Carl Pinyerd, and Ross Martin conducted the field work. Nick Jokay was primary author of this report.

1.0 Goals

The goals of this investigation included three components:

- First is an erosion activity assessment. This assessment consisted of locating, through walking the streams and driving through the uplands, the primary sources of sediment within the Watershed. These sources may be due to in-stream channel erosion or upland rainsplash and sheet erosion, erosion of unpaved roads, and gullying of ditches.

- The second component entailed determining the causes of the erosion.

- The third component involved proposing locations to implement potential sediment and stormwater Best Management Practices (BMPs) to help reduce future erosion and sediment loading to the streams, Lake Forest Lake, and D'Olive Bay.

2.0 Methods: Stream Channel Assessment

During September 2009, the assessment was carried out by a fluvial geomorphologist walking either on the streambed or along the stream bank while conducting Rapid Geomorphic Assessments (RGAs). The RGA consists of collecting a suite of qualitative and semi-quantitative data that describe the form, stability, and erosion potential of the stream channel at that location. RGAs were conducted at each major change in: channel form, bed and bank materials, and/or riparian vegetation.

Data were collected at 274 locations in or near stream channels and in upland areas. At 66 of these locations, a complete suite of geomorphic parameters was collected. This data included:

GPS coordinates
Bank Top Height
Bank Full Height
Bank Top Width
Surrounding Land Use
Riparian Zone Width
Riparian Zone Cover Type
Bank Face Percent Protection
Bank Face Protection Type (vegetation or constructed)
Percent of Reach Eroding by Mass Wasting
Percent of Reach Eroding by Scour
Bank Face Material
Bed Material Type
Degree of Sediment Deposition
Degree of Wetted Channel Width
Channel Evolution Model Stage
Notes
Photos

Partial data were collected at the remaining 208 locations. The partial data typically consisted of a photograph and note of a feature that was representative of the entire reach, or unique to that specific location. Examples of representative reach features include a typical stable stream bank, typical unstable stream bank, and/or typical bar forms, etc. Examples of unique features include single locations of bank mass wasting, pipeline crossings, tributary confluences, large woody debris, road crossings, and others. Based on the collected data, stream reaches were rated as having a low, moderate, or high erosion activity. This rating was a semi-quantitative process based on the criteria in Table 2-1.

Table 2-1. Channel assessment criteria per reach.

Erosion Activity	Erosion by Mass Wasting (sum of both banks)		Erosion by Scour (sum of both banks)
Low	Equal to 0%	and	60% or Less
Moderate	Equal to 0%		Greater than 60%
High	Greater than 0%	and	Any percentage

In some cases, further adjustments to ratings were made based on professional judgment of additional factors affecting the channel character. These factors include, but are not limited to, bank height, infrastructure, etc.

The assessment included major portions of the main channel of D'Olive Creek, Tiawasee Creek, Joe's Branch and several of their tributaries (Maps 2 through 8). Additionally, many minor tributaries and as many upland areas as possible were also assessed during the time available. Because many of the tributaries in the Watershed are unnamed, an alphabetical naming convention was employed. The main stems of D'Olive Creek, Joe's Branch, and Tiawasee Creek were all assigned their first letters; D, J, and T respectively (Figure 2-1). Starting at the downstream end and working upstream, each tributary encountered was named alphabetically. Thus, the first tributary on D'Olive Creek was named DA, and the second, DB, and so on. Tributaries to minor tributaries were also named alphabetically, with an example being, DAA would be the first, and DAB would be the second tributaries to tributary DA.

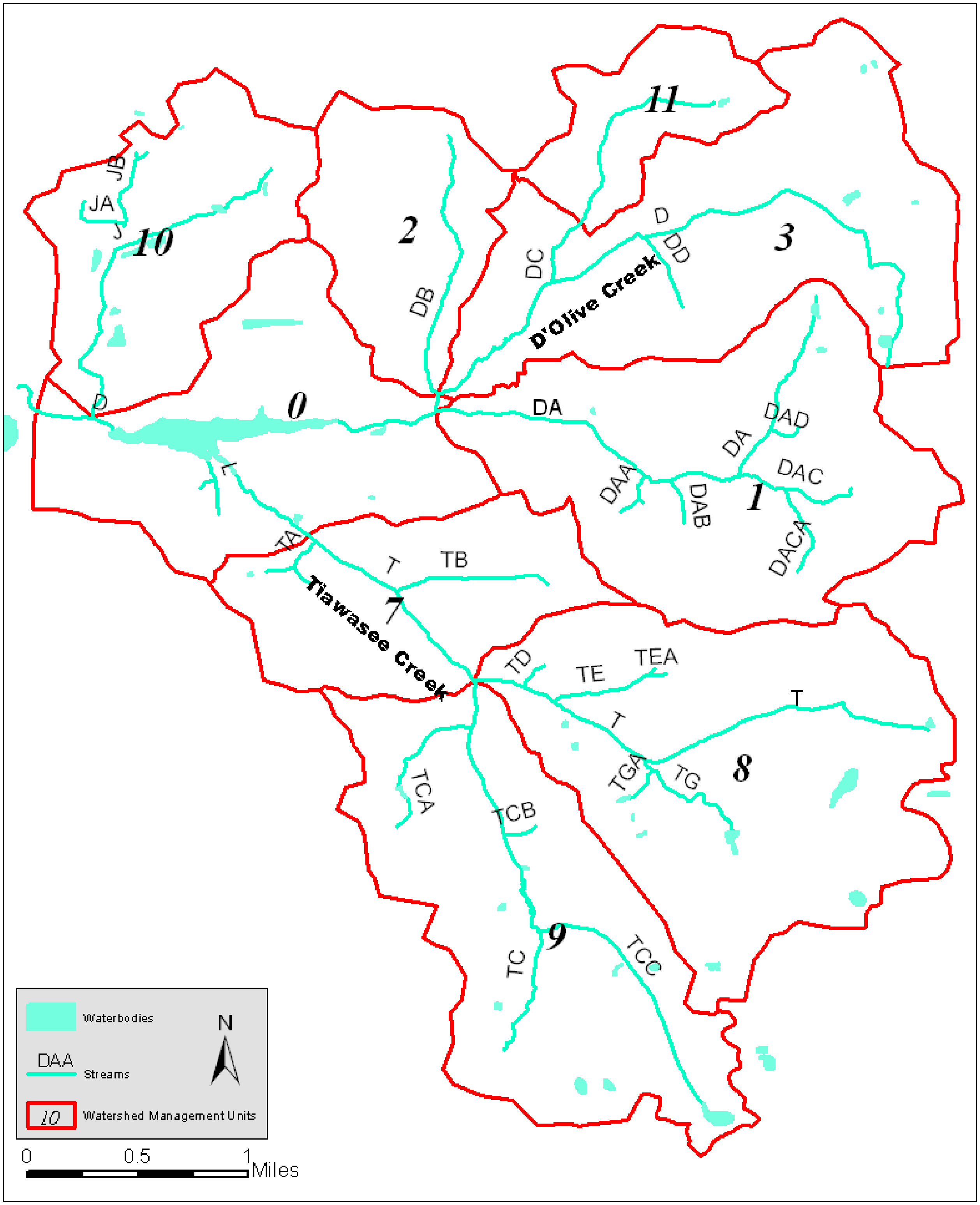


Figure 2-1. Watershed Management Units and Tributary Codes.

Sites of interest encountered outside of streams are described with the prefix "U" for upland. Based on best professional judgment, these sites are rated Low, Moderate, and High for sediment source potential. An example of a High rating is a bare earth construction site with no rainsplash protection on the soil. An example of a Moderate rating is an eroding dirt road that is partially grown over with weeds. An example of a Low rating is a fully grassed lawn. A total of 49 upland sites are included in the data tables.

Sites either in the channel or uplands that are not given Low, Moderate, or High sediment source potential rating are described on the Maps as "Other." These sites document pipeline crossings, detention ponds, and other features not directly related to sediment potential, but may be of interest when designing stormwater and sediment management BMPs.

The field data for the stream sites, upland sites, and other sites are compiled into a series of tables (Data Tables 1 through 4 in Attachment A). Based on the assessment results, each site is highlighted green, yellow, red, or no color to represent low, moderate, or high levels of erosion activity, or Other. The same color scheme is used on Maps 2 through 8 to show levels and locations of erosion activity throughout the Watershed. Photos were taken at most of the assessment points and representative photos of various features are included in the stream reach description (Section 5). All photos taken have been are labeled by assessment point and are compiled into a photo log on one CD included with this report.

3.0 Watershed Management Units

The Watershed is divided into 9 Watershed Management Units (Table 3-1 and Figure 2-1) based on sediment and water quality sampling locations defined during previous studies of the Watershed performed by the Geological Survey of Alabama (Cook, 2007; Cook and Moss, 2008). Because sediment load data are available at the most downstream point of each subunit, they become useful for determining the sources of sediment and for future load monitoring.

Table 3-1. Watershed Management Units.

WMU Number*	Streams Within WMU	Tributary Codes
0	Lake Forest Lake and the lowest 1/2 mile of D'Olive and Tiawasee Creeks	L, D (lower), T (lower)
1	Middle and upper tributaries to D'Olive Cr	DA, DAA, DAB, DAC, DACA, DAD
2	Unnamed tributary DB	DB
3	Upper D'Olive Creek and tributaries	D, DD
7	Middle Tiawasee Cr and tributaries below Ridgewood Drive	T, TA, TAA, TB
8	Tiawasee Creek and tributaries above Ridgewood Drive	T, TD, TE, TEA, TF, TG, TGA
9	Tributaries to Tiawasee Creek above Ridgewood Drive	TC, TCA, TCB, TCC
10	Joe's Branch and tributaries	J, JA, JB
11	Unnamed tributary DC	DC

* This numbering is chosen to match that of the GSA studies of 2007 and 2008.

To help more clearly define present sources of sediment, the Watershed Management Units can be further divided into regions based on the channel condition (erosional vs depositional) and land use observed in the field. In general, streams in the residentially and commercially developed parts of the Watershed undergo bed and bank erosion, with the exception of near Lake Forest Lake where lesser amounts of bank erosion are taking place and heavy sediment deposition is occurring. In general, streams in the undeveloped headwater areas tend to be small, multi-threaded, not undergoing bed and bank erosion, and thus are presently not sediment sources, but potentially are conduits to transport sediment eroded from upland sources.

4.0 Overall State of the Stream Channels of the D'Olive Creek Watershed

4.1 General Geomorphology and Hydrology

The geomorphology of the D'Olive Watershed generally reflects hydrologic and morphologic changes that are typical of urban and agricultural watersheds throughout most of the southeastern United States. However, the unusually high-relief topography, the underlying non-cohesive sandy soils, and the high-intensity rainfall of the region promote a more dramatic response in D'Olive Creek and its tributaries than encountered in other parts of the Southeast where high-relief is due to underlying erosion resistant bedrock and rainfalls are less intense.

By the nature of its high-relief topography, the D'Olive Watershed probably had a historic natural sediment load greater than other small near-coast low-relief watersheds. Prior to settlement, when the Watershed was essentially under 100 percent forest cover, rainsplash erosion, sheet erosion, and gullying of upland surfaces would have been essentially non-existent (Chang, 2006). Due to the high-intensity rainfall climate of the Alabama coast, high flow runoff events would have occurred regularly. However, the greater rainfall infiltration capacity of the porous forest soils would have resulted in subdued flood peaks and corresponding subdued stream bank erosion rates.

With long-term sea level fluctuations (1000 to 100,000 year scale) the stream channels cycle through phases of incision and deposition to match the base level controlled by the prevailing sea level. Stream channels in the incision phase are often marked by one or more "headcuts" which are a natural process (Figure 4-1) but can be initiated, accelerated, and/or slowed by human activities that alter channel gradient (straightening, weirs, etc) or alter runoff (increasing impervious land use, increasing stormwater detention, etc). Headcuts in the D'Olive Watershed streams have likely been propagating upstream for thousands of years. However, the change in hydrology brought on by recent land use change since the 1960s throughout the Watershed has accelerated the rate of headcutting with a corresponding increase in sediment load to Lake Forest Lake and D'Olive Bay. Essentially every tributary in the Watershed has at least one headcut. Some are actively advancing upstream, while the advance of others has been prevented by grade control structures installed at road and pipeline crossings. The nature of specific headcuts will be discussed in the reach descriptions provided in Section 5.0.

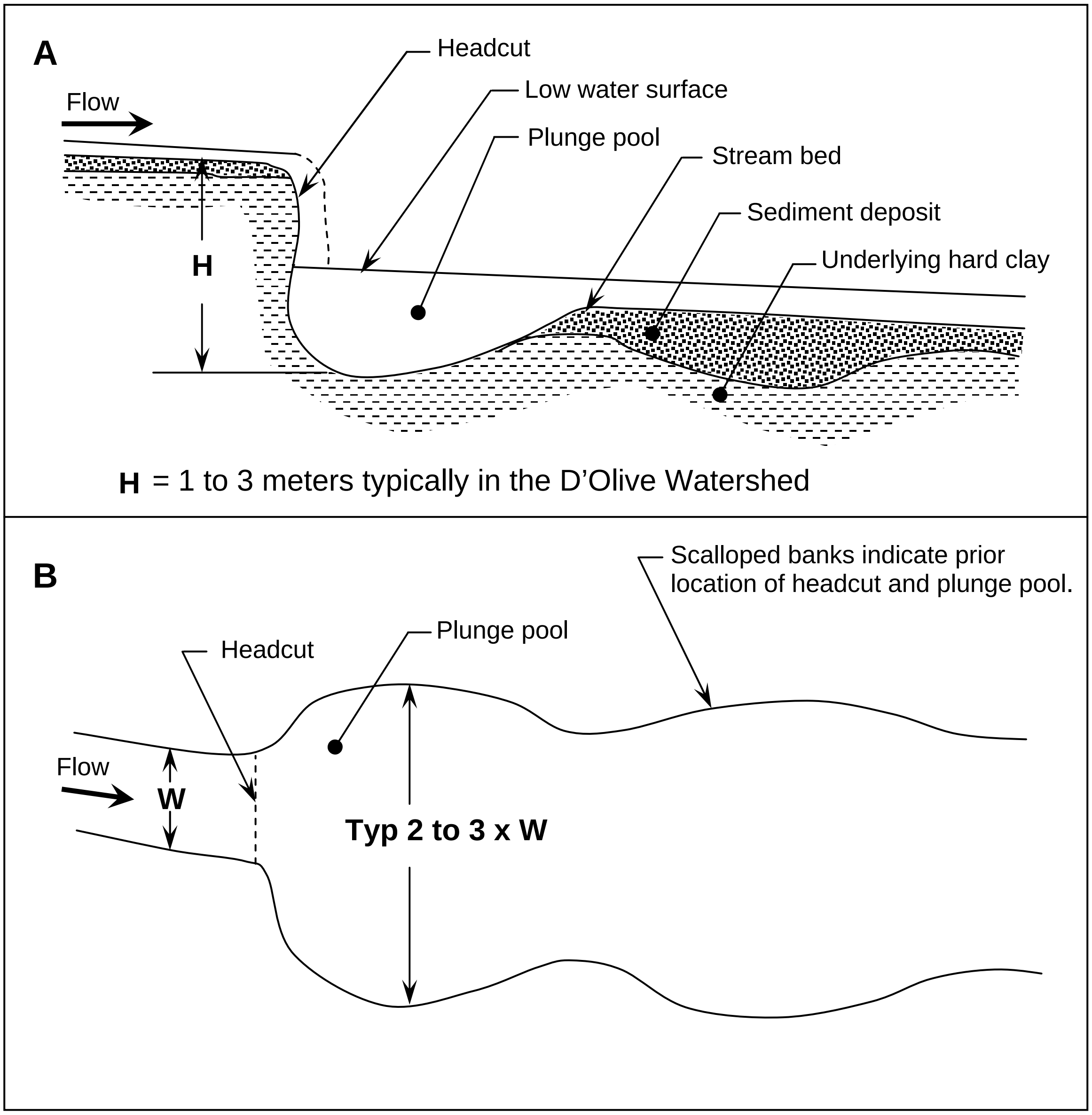


Figure 4-1. (A) Profile and (B) Plan View of a headcut typical to the D'Olive Watershed.

During the streamwalks, many gullied minor tributaries were discovered. The scope of the field portion of the study was limited to only the major tributaries. Thus, it was not practical to explore all tributaries in an effort to locate all gullies. To help better define the potential locations of gullies and headcuts, a slope dataset of the Watershed was created (Maps 2 through 8) This slope data was generated by utilizing the 2005 1-foot topographic contour data to locate slopes greater than 25 degrees. The slope maps are an extremely useful tool because they provide an indication of where severe erosion is taking place that cannot be observed in aerial photos, or be discovered during a typical streamwalk. Many of the high slope areas may be manmade structures, such as retaining walls, and bridge abutments, and therefore need to be accurately identified in the field. Additionally, several headcuts and gullies were discovered in the field which have formed during the four years since the contour data was generated and thus do not show up on the maps. Thus, in all likelihood there may be a number of other unmapped headcuts and gullies within the Watershed.

4.2 Beaver Impacts

Beaver activities can impact stream channels in a variety of ways, both involving soil erosion and sediment deposition. If a beaver dam is high, perhaps one meter or greater, then stream banks adjacent to and immediately below the dam are more susceptible to failure by mass wasting due to being continually saturated. High flows can widen the channel by scouring around the ends of dams. Beaver impoundments often trap large quantities of sediment. Once trapped, this sediment is typically held for long time periods. Even if the dams are washed out during high flows leaving the trapped sediment as a floodplain terrace, it may take many decades for the sediment to be eroded by lateral channel migration through the terrace.

Beaver activity was documented at three locations, two in the upper portions of the Tiawasee Creek Sub-Watershed (WMUs 8 and 9) and a third in WMU 2. A 0.5 meter high beaver dam was observed at site T32 which marks the transition between the non-incised channels of the upper Tiawaseee and the incised channels of the lower Tiawasee (Figure 4-2). Beaver activity, such as gnawings on trees, was observed near sites DB4, DB5, and DB6. Beaver dams do not appear to be contributing to stream channel erosion through bank scour around the dams. In general, beaver dams appear to be promoting the deposition of sediment on the narrow floodplains of Tiawasee Creek and tributary TC.

Figure 4-2. Beaver Dam on Tiawasee Creek. Site T32.

4.3 Channelization Impacts

Channelized streams in urban and agricultural landscapes are common. In-field indicators include channel-side berms of excavated materials, extreme straightness of the channel, and nearby abandoned channels. Further support comes from aerial photos, topographic maps, and from landowners who may have anecdotal information about when work was done on the channel.

Channelization is typically accomplished to make more land available for agricultural or residential use and to help speed flood flows through a watershed by straightening and removing trees and brush from the channel margins. Channelization often changes the equilibrium between sediment, flow, and channel slope. Streams typically respond by naturally adjusting towards their original equilibrium. These adjustments take place through bed incision and bank erosion processes which reduce channel slope and recruit greater sediment loads until a new equilibrium is established. In alluvial channels this adjustment has been characterized via the Channel Evolution Model (CEM) (Figure 4-3). Stages of the CEM include; (I) premodified, (II) constructed (III) incision, (IV) incision and widening through bank mass wasting, (V) aggradation and continued widening, and finally (VI) restabilization.

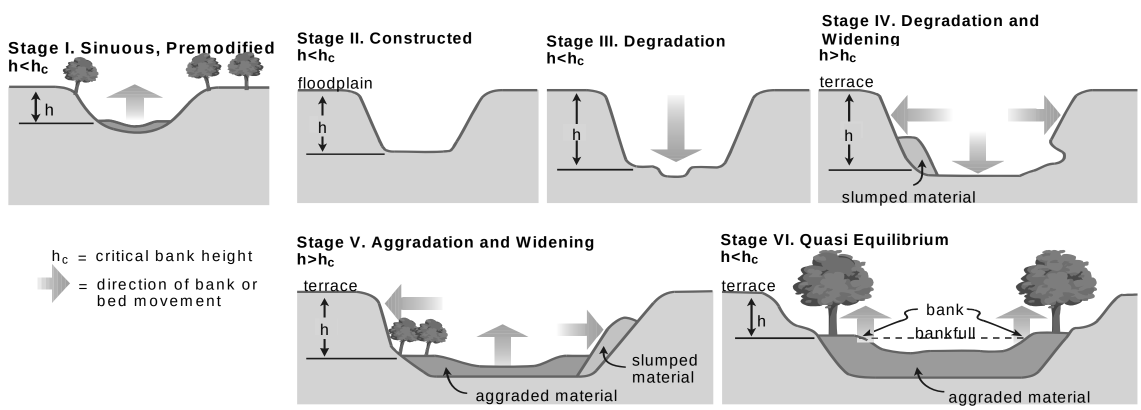


Figure 4-3. Six stages of the Channel Evolution Model (Alonso et al, 2002)

In the D'Olive Watershed, channel dredging and channelization were noted historically (Carlton and Gail, 1979) and observed in the form of soil deposits along Tiawaseee Creek and is implied by the straightness of the lower reach of Tiawaseee Creek between Lake Forest Lake and Bay View Drive (Figure 4-4). However, present and active geomorphic processes related to these historic activities were not obvious during the field assessment. The lower reaches of Tiawasee Creek and D'Olive Creek are choked with sediment and thus have skipped the potential intermediate unstable channel evolution stages of incision (stage III) and incision and widening (stage IV). These lower reaches appear to be either in some indeterminate aggradational stable form, or are approaching stability while aggrading and widening (stage V). This is not to say that the stream channels of the D'Olive Watershed are not actively passing through the various CEM stages. Due to the high relief topography, the streams appear to be naturally progressing through the CEM stages at particular locations along each tributary. A detailed discussion of the channel conditions throughout the Watershed is included in section 5.0.

Figure 4-4. Exceptionally straight reach of Tiawasee Creek choked with sediment. Site T7.

4.4 Large Woody Debris Impacts

Along reaches where banks are actively eroding, soil becomes eroded from underneath trees standing near the bank edge. Without the underlying support from the soil, these trees often end up falling into the channel. During high flows, detritus such as tree limbs, entire saplings, leaves, lumber scraps, and other floating trash are carried downstream until becoming lodged on fallen trees, thereby forming large woody debris (LWD) jams. Once a LWD jam is in place, moderate to high flows are forced around the jam which creates additional bank and bed scour.

In the D'Olive Watershed, LWD jams were noted at several locations. Potential impacts exist where sewage pipelines cross the streams, particularly along Tiawasee Creek. Debris may become snagged on the pipelines and the pipeline support piers, thus causing flow to scour the bed and banks, potentially damaging the pipeline.

The main stem of D'Olive Creek has been severely impacted by LWD between US 90 and I-10. Jams had blocked the channel creating severe scour and bank and bed erosion. Recent efforts during the summer of 2009 to re-stabilize the reach included clearing the jams and stabilizing banks that helped reduce the present erosion impacts and future potential for impacts due to LWD.

LWD jams were found at several locations along tributary DA. These jams did not appear to be causing severe bank erosion impacts. However, due to the incised nature of tributary DA below CR-13, and the history of mass wasting of the hillslopes adjacent to the channel, the potential exists for the recruitment of trees to the stream.

In general, the anastomosed streams flowing through the headwater bottoms had no observed sediment impacts related to LWD. Locations of LWD jams and impacts are noted in the field data Tables included as Attachment A.

4.5 Development Impacts

This discussion will be limited to impacts caused by physical changes to the streams related to developed land uses. Impacts caused by changes in runoff related to development will be discussed in Section 4.6. Stream channels in developed portions of the Watershed may be impacted in several different ways, with the impact severity and frequency being related to the proximity of the stream channel to the developed land and the type of activity. Categories discussed in this section include: infrastructure, trash and yard debris, and landowner practices.

In general, impacts include any rapidly occurring or unforeseen changes to the streams channels or to infrastructure located near the streams. Several documented impact examples include: flooding of homes along Lake View Loop due to a sediment plugged culvert under Gordon Circle; residential structures threatened by mass wasting of streambanks along Donette Loop and Worchester Drive; and the washing out of the US Hwy 90 culvert over tributary DA (east of County Road 13) during an April 2009 rainfall event.

The D'Olive Watershed has been developed into primarily four different types: commercial, low-density residential, agricultural, and undeveloped. (Figure 4-5). Figure 4-5, which is based on the 2001 National Land Cover Database, does not include the following recently commercially developed areas: (1) the Spanish Fort Town Center plaza located northeast of the I-10 and US98 junction; and (2) the Lowe's Plaza and automobile dealerships located southwest of the I-10 and CR27 junction. Recently developed residential areas include the Estates of Tiawasee and the French Settlement, both located west of CR13. Note that there may be other areas that have undergone or are presently undergoing development.

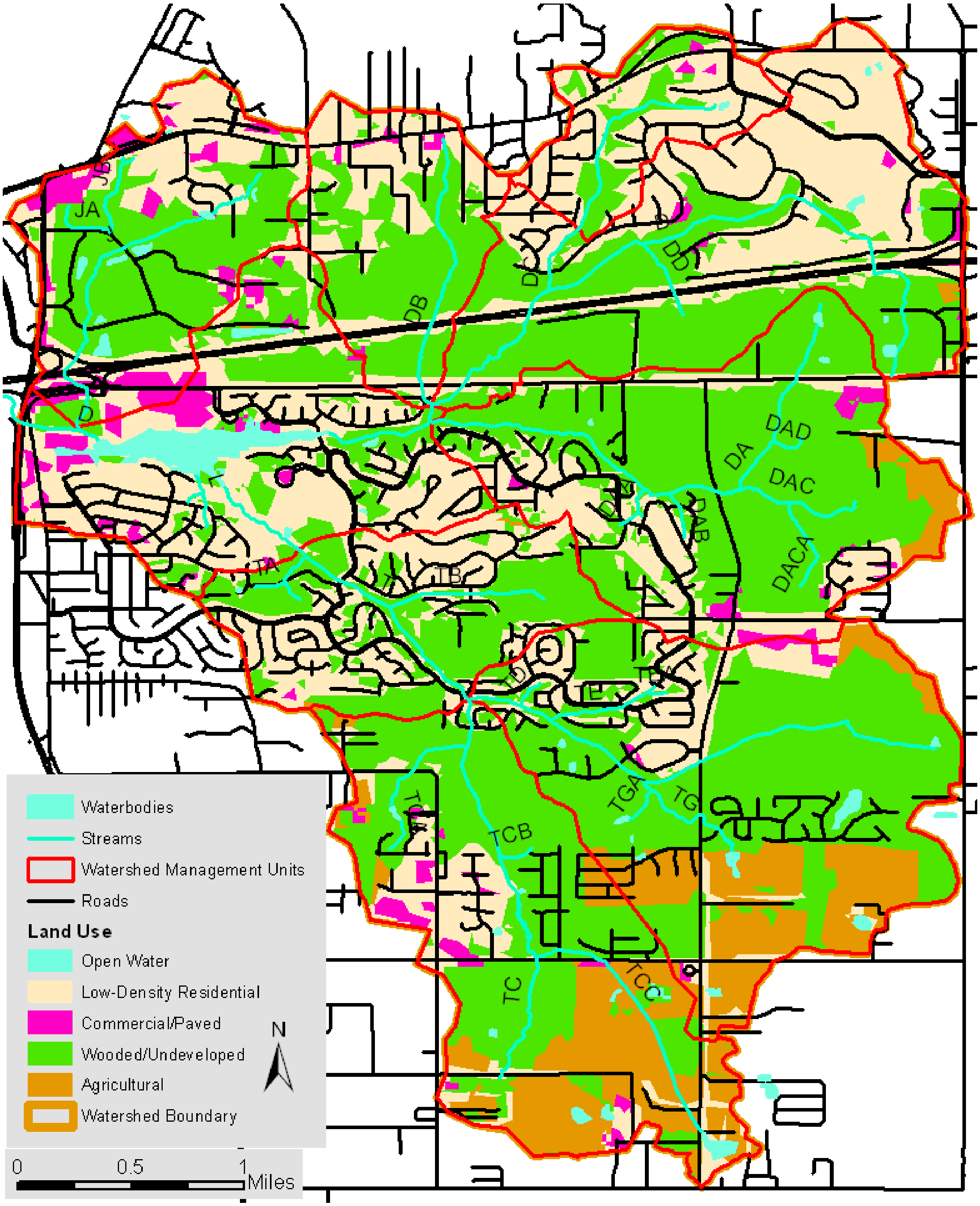


Figure 4-5. Land Use in the D'Olive Creek Watershed (Adapted from the 2001 NLCD).

4.5.1 Infrastructure

Near-stream infrastructure observed in the D'Olive Watershed includes sewage lines parallel to the streams, sewage pipeline crossings, bridges, culverts, stormwater outfalls, residential fences, and residential homes. These infrastructure types may both create erosion impacts to the streams, or be impacted themselves by the streams.

Sewage pipeline crossings have a fairly high potential for woody debris jams forming around the support structures or on the pipelines themselves. During high flows, these jams promote scour of the streambanks and around the support structures as well as create a higher load on the pipeline. Tiawasee Creek has the greatest potential for sewage line crossing impacts with seven locations noted between sites T14 to T29 (Figure 4-6). All the sewage pipelines along Tiawasee Creek had additional rip-rap protection against bank and bed scour.

Figure 4-6. Woody debris jam formed on sewage pipeline crossing. Site T18.

Erosion impacts related to bridges and culverts include chronic scour at the downstream end of the structures punctuated with severe erosion, including being totally washed out, if the structures become blocked or plugged with sediment and woody debris (Figure 4-7). During the field assessment of the D'Olive Watershed, chronic scour was not observed below any road stream crossing. However, the I-10 quadruple box culvert over D'Olive Creek was repaired in August 2009 (Site D7, Figure 4-8) for severe scour that occurred during Tropical Storm Fay and Hurricane Gustav in 2008 (Campbell, 2009). At least two bridges have washed out in the last 13 years: Tiawasee Creek at Greenwood Drive due to record rainfall during Hurricane Danny in 1997 (Map 6, Site TC1), and US-90 over a tributary to D'Olive Creek for unknown reasons during a 5-inch rainfall event in April 2009 (Map 5, Site DA50) (Campbell, 2009). Although the reasons are unknown, the speculated cause is the culvert became plugged, thereby forcing flow to back up to the point of overtopping US-90. This crossing had not failed in at least the previous 30 years (Campbell, 2009). Many of the road/stream crossings act as grade control structures with rip-rap or poured concrete immediately downstream of the bridge or culvert. The hardened surfaces are scour resistant and prevent headcuts from migrating upstream.

Figure 4-7. Culvert blocked by debris. Site TCC1.

Figure 4-8. Scour repair below I-10 crossing of D'Olive Creek. Site D7.

Streambank erosion by mass wasting is not only a significant contributor of sediment to the stream, but man-made structures near the streams can be damaged either directly by the slope failure, or indirectly, if large trees caught in the slope failure happen to fall on a structure. Streams in the D'Olive Watershed, in general, have floodplains that are sufficiently broad so that homes and other buildings are not located where they could be impacted by stream bank failures. Two exceptions noted during the field assessment were along the deeply incised tributaries DA (Sites DA3 to DA32) and TCA at site TCA7. The morphology of the channel from DA3 to DA32 indicates that mass wasting of the banks has been ongoing both historically and at present with one recent major failure occurring during the high rainfall event of late April 2009 (Figure 4-9). Homes atop high and steep banks along these reaches are presently threatened by slope failure. Various types of bank protection have been employed to stabilize slopes adjacent to homes (Figure 4-10). Specific locations will be described in Section 5.2.2.

Figure 4-9. Recent mass wasting of streambank in Lake Forest. Site DA23a.

Figure 4-10. Bank protection along an incised reach of trib DA. Site DA9.

Headcuts serve as an additional source of sediment. Headcouts located below stormwater outfalls have the potential impact to infrastructure. In several locations gullies with advancing headcuts threaten to undermine stormwater outfalls below road crossings. Many of these headcuts are 2 to 4 meters high, and yet are so well obscured by dense surrounding vegetation on the stable land surfaces that the headcut cannot be readily observed from road crossings. One example is at Site U37 (Figure 4-11). The non-vegetated vertical surfaces of this gully are a sediment source, and additionally, this 4 meter deep, 6 meter wide, and 20 meter long feature threatens to undermine Country Club Drive. The specific locations and nature of the gullies found during the field assessment are included in Tables A1 through A4 in Attachment A. Because these gullies are so well hidden from view by dense vegetation not all were discovered. However, the high-slope areas shown on Maps 2 through 8 indicate locations where gullies possibly exist. Example high-slope gullies are presented in Figure 4-12.

Figure 4-11. Four meter deep gully within 5 meters of road is totally obscured by vegetation. Site U37.

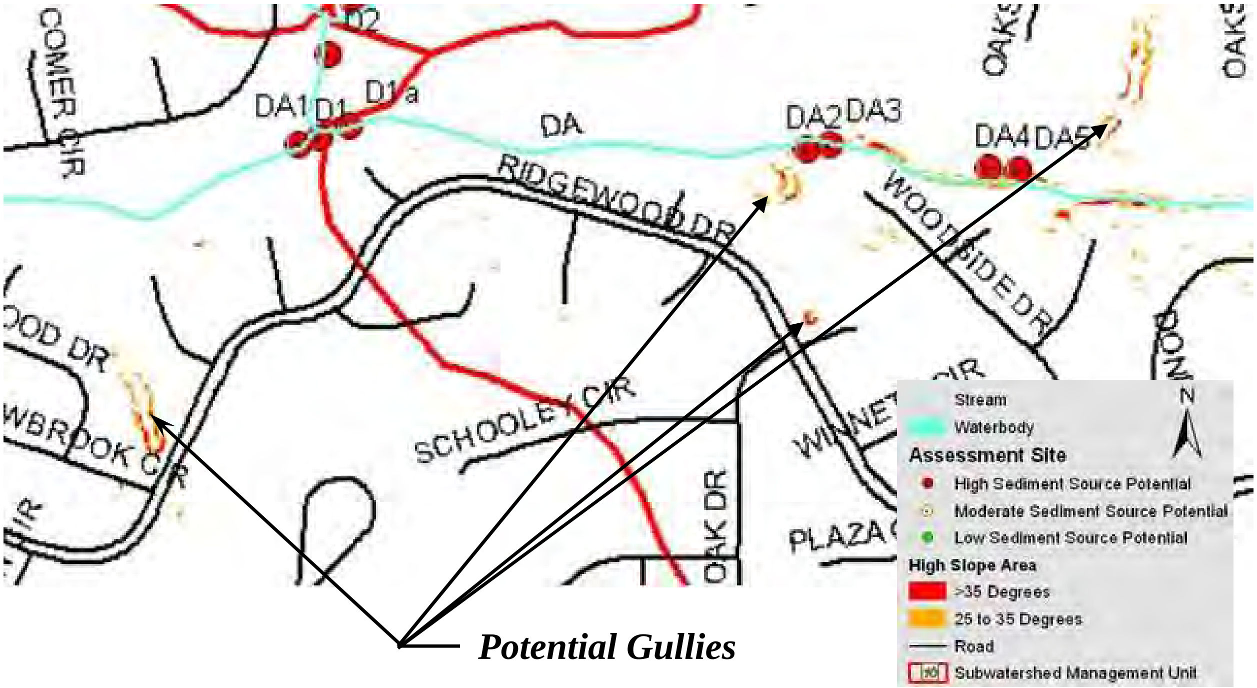


Figure 4-12. Narrow high-slope areas indicate the presence of gullies (Detail from Map 4).

4.5.2 Trash and Yard Debris

In highly developed watersheds, trash and yard debris are not only unsightly in streams, but can serve to exacerbate erosion by clogging the channel and forcing moderate and high flows to scour the banks adjacent to the jam. Erosive trash jams typically are caused when large items, such as shopping carts, bicycles, furniture, appliances, or large quantities of yard debris are dumped into streams. Smaller pieces of debris, both natural and manmade, become caught on the large foundation items, and complete the jam.

The streams in the D'Olive Watershed were relatively trash free. Occasionally debris such as footballs, plastic bottles, and plastic bags were noted, but the low frequency and small size indicated that large quantities of trash are not being thrown into or washed into the streams. An overturned boat in tributary DA between sites DA3 and DA4 was the only large item noted during the study (Figure 4-13). Yard debris was infrequently found in the streams and did not appear to be causing impacts at any location. At sites DC19 and DC24 concrete and tree limbs and/or logs were dumped on eroding stream bank surfaces apparently as an attempt to slow erosion.


Figure 4-13. Boat in tributary DA. Site DA2.

4.5.3 Landowner Practices

Channel stability varies with how landowners choose to maintain their stream frontage. Simply put, stream bank faces that are protected from the scouring impacts during high flows are more stable and undergo less erosion than less protected banks. The forms of protection can be natural or man-made. Natural protection can be provided by either vegetation or by the composition of the bank material. Roots of woody vegetation that penetrate deeply into stream bank soils create a soil binding fabric throughout the soil body. Non-woody vegetation, such as grasses, sedges, wild flowers, and other herbaceous plants, may have very high root densities, but the roots often do not fully penetrate the height of the bank, thus leaving banks susceptible to erosion and mass wasting by undercutting at the bank toe.

Fully vegetated stream bank faces undergo "natural" erosion. This is to say that stream bank erosion is a natural process and the erosion rate in south Alabama for a fully vegetated, forested stream channel would be considered the natural background rate. Natural channels composed of bedrock bed and banks are typically highly erosion resistant. However, the natural bank materials observed in the D'Olive Watershed ranged from highly erodible fine sands to somewhat erosion resistant hard clays. Man-made protection forms include revetments and seawalls. The materials used in constructing these forms include, but are not limited to: concrete, riprap, sheet pilings, gabions (rock baskets), concrete mattresses, and others. The goal when using these hard structures is to reduce the stream bank erosion rate to zero.

The prevalent landowner practices appear to be dictated by the valley form of each stream. The valley forms can be divided into three classes: (1) canyons, (2) floodplains, and (3) bottoms (Figure 4-14).

Canyons are characterized by high terraces from 4 to 6 meters high and higher in close proximity to the channel. Floodplains are characterized by a single threaded channel flowing between moderately high banks, perhaps 1 to 3 meters high, which are accessible by flood waters. Bottoms are characterized by shallow streams, frequently anastomosed (multi-threaded but not impacted by sediment), with banks less than 1 meter high flowing across broad flat valleys.

The canyon reaches include tributary DA from site DA3 to site DA34, tributary JA from JA3 to above JA5, tributary TCA near TCA7 and possibly some of the gullies draining to tributary DA and Tiawasee Creek. Because the bank heights frequently exceed the critical height for a stable slope, stream banks along these reaches have naturally been undergoing mass wasting. Infrastructure, in particular homes, that have been built too close to the high terrace edges are frequently threatened by mass wasting. In some locations, banks have been stabilized though the use of gabions, concrete mattresses, and other means (Figure 4-10).

Streams flowing in the floodplains have the greatest potential to be impacted by landowner activities. Floodplain channels are typically single threaded and deep enough to limit overbank flooding to only moderately severe and greater rainfall events. To create clear views, and to provide easy access to the waterfronts, landowners in many locations have replaced the stabilizing deep-rooted riparian zone forest vegetation with short-rooted lawns. The intermediate bank heights are subject to erosion by scour, and occasionally by mass wasting. Where bank erosion has occurred, landowners have either ignored the erosion or tried to control it through bulkheads and riprap. Tiawasee Creek from Bayview Drive to CR13 (Sites T10 to T45) was the most highly impacted floodplain type stream.

Bottoms throughout the Watershed are frequently inundated during high rainfall events. Thus, these areas are almost without exception undeveloped. Bank erosion is negligible because the bank heights are low, providing a small area available for impact by scouring flows. Because the bottoms are undeveloped, vegetation has not been cleared and provides natural woody vegetative protection along the bank faces.

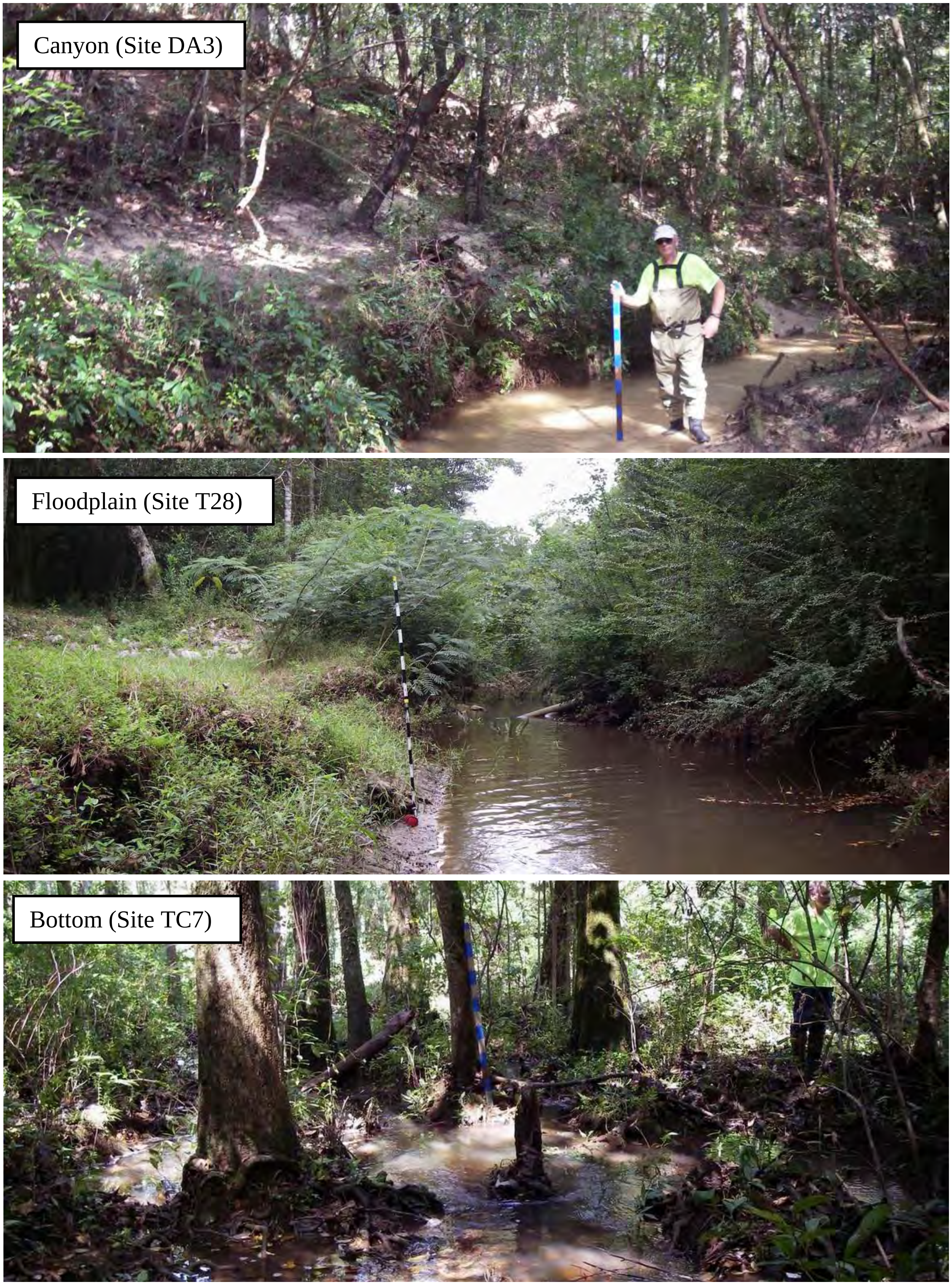


Figure 4-14. Channel forms typical of the “canyon,” “floodplain,” and “bottom” type stream reaches.

4.5.4 Development Impacts to Soil Erosion

Changes in land cover bring about corresponding changes in upland soil erosion rates. The upland soil erosion process begins with raindrops impacting bare soil surfaces. Soil particles can be knocked free of the soil body from the impact of falling raindrops. In sloping topography, these particles will, in general, fall downslope under the influence of gravity. If rainfall is intense enough for overland flow to occur, then the soil particles may become entrained in the overland flow and may be carried from the slope to the nearest stream.

Soil erosion rates are, in general, proportionate to how well the existing land cover shields the soil from direct raindrop impacts. Bare soils, such as construction sites, surface mines, dirt roads, and freshly plowed crop lands undergo the highest soil erosion rates (10 to 100+ tons of soil eroded per acre per year); whereas, developed and vegetated lands, such as fallow fields, lawns, and crop lands when the plants are fully grown have intermediate erosion rates (0.1 to 10 tons of soil eroded per acre per year). Finally, densely forested lands have the lowest soil erosion rates, from about 0.001 to 0.1 tons per acre per year (Dunne and Leopold, 1978). The full range of cover is found in the D'Olive Watershed with examples shown in Figures 4-15 through 4-18.

The range of rainsplash erosion rates is quite broad, approximately five orders of magnitude. Thus, it is likely that change in land cover from forest to suburban and commercial has a high short term impact on soil erosion rates when construction activities are taking place and a moderate long term impact once the soil erosion rate has become adjusted to new land use. It should be noted that the soil erosion rate is not the same as the amount of sediment yielded from a Watershed. Much of the soil eroded in the upland areas becomes trapped at the toes of hillslopes before reaching the streams, becomes redeposited on floodplains after reaching the streams, or settles out in sedimentation ponds and other sediment control BMPs.

The use of modern soil erosion control BMPs has greatly reduced the impacts of land clearing compared to the dramatic impacts of the 1970's (Carlton and Gail, 1979). However, even with properly installed BMP's in place, there still is a significant increase in sediment load above natural background levels during land development, and a slightly increased sediment load generated by the subsequent post-construction land uses that occur on these sites. The modified sediment loads resulting from development have become and will continue to be the new "natural" background sediment load for the developed D'Olive Watershed.

Figure 4-15. Construction site. Note ½ inch of soil loss marked by pedistalled pebble. Site U13.

Figure 4-16. Not fully established grass protection. Note pooling runoff. Site U1.

Figure 4-17. Well established grass vegetative protection. Sites U2 and U22.

Figure 4-18. Leaf litter layer over forest soil. Site U16.

4.5.5 Development Impacts to Stormwater Runoff

In general, the driving force behind impacts to streams from upland sources is land use change. If given enough time, streams adjust their width, depth, and gradient to a stable form capable of transporting the runoff and sediment load contributed from upland sources. Before human actions began modifying the natural vegetative cover of the undeveloped land, the D'Olive Watershed streams would have been naturally adjusted in size and gradient to carry the runoff and natural sediment load delivered from a high-relief forested Watershed in a high-intensity rainfall region. Albeit, the channels would have been, and still are, continuously eroding their beds as they adjust to match their base level, which presently is sea level for Joe's Branch, and Lake Forest Lake for D'Olive and Tiawasee Creeks.

The quantity and timing of when runoff reaches a stream is related to soil perviousness and land use. Coarse grained sandy soils typically are highly pervious and are capable of infiltrating rainfall at a higher rate than fine grained clay rich soils. Typically, soils underlying undeveloped land uses, such as forests, have higher infiltration rates than soils underlying developed land uses. Thick leaf litter layers overlying soils perforated with insect burrows and tunnels left by decayed roots have the highest infiltration rates and often can infiltrate 100% of low to moderate rainfall events. At the other extreme, totally sealed surfaces, such as rooftops, roads, and parking lots provide essentially no infiltration with nearly all rainfall running off (a negligible amount of rainfall does not run off, perhaps 2%, is lost in wetting the impervious surfaces and to evaporation). Land uses with pervious surfaces having intermediate infiltration rates for a given soil texture include cropland, pastures, lawns, and bare soils (Dunne and Leopold, 1978).

The D'Olive Watershed has a split history with regards to stormwater management. Essentially no stormwater management regulations were in place when rapid development began in the 1970s. Impacts of the changing land use on the Watershed were quickly recognized. However, it wasn't until the 1990s when regulations were in place to help mitigate increases in stormflow peaks and sediment loads (Carlton, 2009). Although no pre-development flow data are available for the streams in the D'Olive Watershed, the land use transition from forest to suburban almost certainly resulted in a corresponding increase in storm flow peaks and stream channel erosion rates as the channels began to adjust to the new and changing flow regime. This increase in

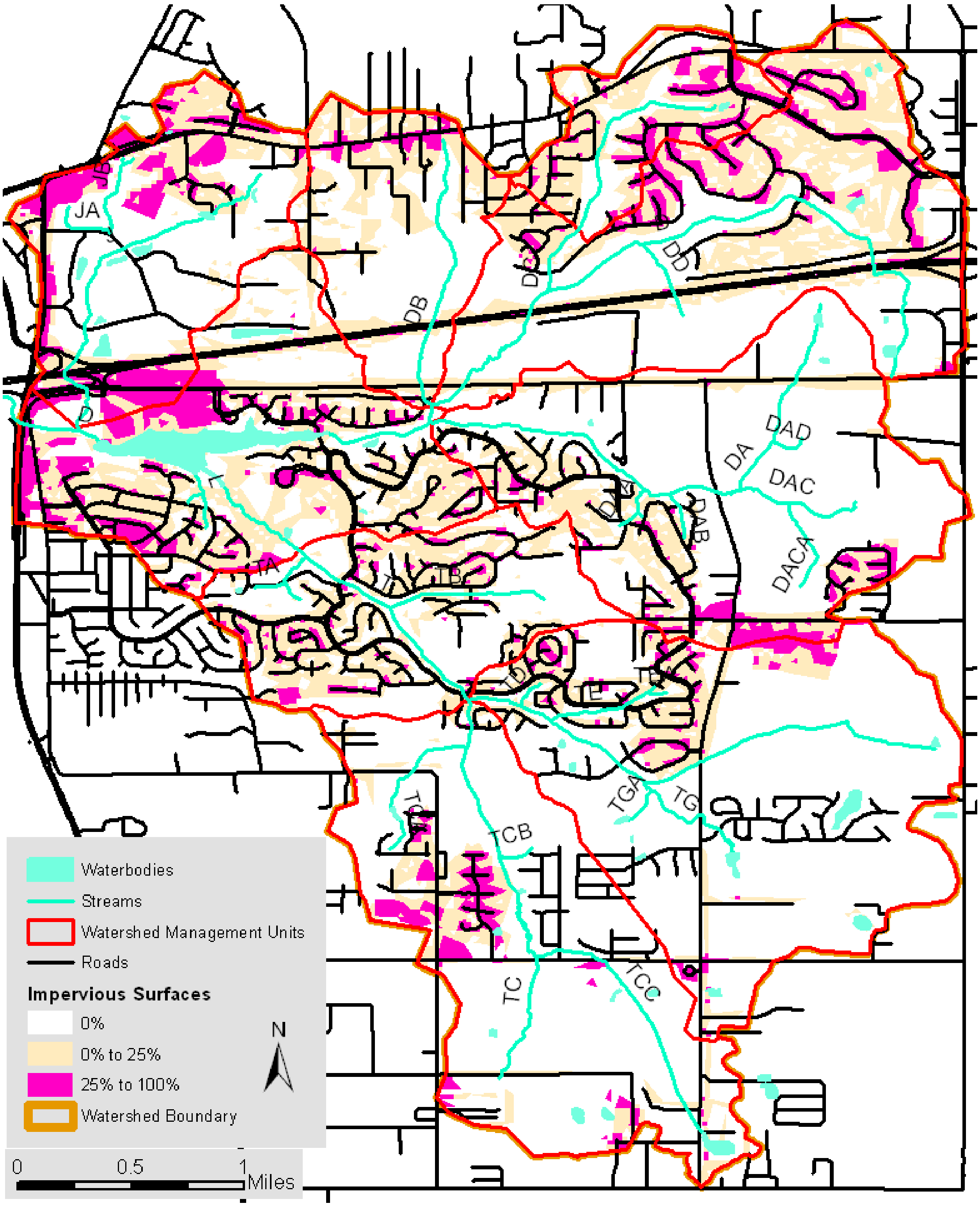


Figure 4-19. Impervious surfaces in the D'Olive Creek Watershed (Adapted from the 2001 NLCD).

channel erosion rates has resulted in a major portion of the observed downstream sediment load and sediment deposition in Lake Forest Lake and in D'Olive Bay. The spatial distribution of impervious surfaces within the Watershed is shown in Figure 4-19. Areas developed since 2001 are not included.

4.6 Waterbodies

Numerous small reservoirs and stormwater detention basins were located throughout the Watershed using aerial photos and then mapped (Maps 2 through 8). Whether by design or by happenstance these small reservoirs and basins serve to reduce stormwater flow peaks and to trap sediments. Most of these structures have been built since the establishment of stormwater and sediment management BMPs in the early 1990s. Therefore, the impact of these structures has only been available for the latter half of the period when rapid development began in the 1970s.

4.6.1 Sediment Loading to Lake Forest Lake

The size, location, and timing of construction of Lake Forest Lake is very fortuitous for helping reduce the sediment impact to D'Olive Bay. The construction of the lake preceded the extensive land clearing during the initial development phase of the Lake Forest subdivision in the early 1970s. The lake is located far enough downstream to capture flow from all tributaries. Joe's Branch is the only exception since it enters D'Olive Creek downstream of the dam. The lake is sufficiently large to trap most of the sediment entering, thus preventing that portion of sediment from reaching D'Olive and Mobile Bays. Isphording (1984) gave an estimate based on lake and bay bathymetry measurements that 72,300 tons of sediment per year were delivered from the Watershed to Lake Forest Lake and D'Olive Bay between 1967 an 1982. Of this sediment, approximately 48,000 tons per year were deposited in Lake Forest Lake, 15,000 tons per year deposited into D'Olive Bay, and the remainder, about 9000 tons per year, were transported into Mobile Bay. The recent sediment loading study conducted by the Alabama Geological Survey (Cook and Moss, 2008) indicates that the total sediment loads into Lake Forest Lake are approximately 7800 tons per year. The sediment loads from the Isphording and Cook studies represent the combined suspended and bedloads.

A comparison between the Isphording and Cook studies indicates that the sediment loading to Lake Forest Lake has dropped significantly since the 1970's. This drop, from 48000 to 7800 tons per year, represents an 84% reduction in sediment loading. Estimating annual sediment loads based on samples and flow data is an inexact science, and thus, any results need to be considered with caution. Errors of +/- one-half order of magnitude are not unreasonable, especially with data collected over short time periods. The great differences between the 1984 and 2008 sediment loading estimates indicate that the load has almost certainly dropped off since the early 1980's, and very likely it has dropped off immensely. However, the loading very likely is still high compared to natural background levels. Cook (2007) indicates that a background "geologic" erosion rate for an undeveloped watershed in the Southeast would be approximately 64 tons per square mile per year. Dividing the 7800 tons per year by the 8.5-square mile drainage of D'Olive and Tiawasee Creeks above Lake Forest Lake yields approximately 920 tons per square mile per year, or around 14 times the erosion rate of an undeveloped watershed.

5.0 Reach-by-Reach Assessment

Tributaries listed in the table of contents have been assessed at one or more sites and have a corresponding paragraph in this section and a listing in the data tables. If a tributary is not listed, it was only assessed at its confluence with D'Olive Creek, Tiawasee Creek, or Joe's Branch and is included as part of the discussion of the main stem streams. Several of the site names are followed by lowercase alphabetical characters. Data at these locations were collected after the data set from the field investigation was prepared. So the lowercase designation was applied to fit the newly collected data into the already prepared data set. An example is sites D2a through D2f represent six sites located between D2 and D3.

5.1 Main Stem of D'Olive Creek

5.1.1 Lake Forest Lake to US 90: D1 to D2f

The main stem of D'Olive Creek from site D1 to site D2f is a depositional reach with heavy sand deposits on the bed. Tree stumps along the channel margin indicate that the stream has been migrating laterally at a relatively fast rate. Bank erosion by scour is common, but mass wasting is uncommon (Figure 5-1). Residential property along this reach does not appear to be impacted by the channel migration/scour erosion. However, flooding at Gordon Circle and Lakeview Loop may have been exacerbated by heavy sediment deposits on the stream bed.

Figure 5-1. Laterally migrating reach of D'Olive Creek with heavy sand deposits. Site D2.

5.1.2 US 90 to I-10: D3 to D7

From D3 to D5 D'Olive Creek flows in an incised channel between banks approximately 3.5 meters high. Channel incision provides a significant sediment source. Mass wasting of the banks is prevalent and many trees growing near the bank top margin are recruited to the channel through mass wasting (Figure 5-2). These trees become the foundations for forming LWD jams which severely exacerbate channel erosion by forcing high flows to scour around the ends of and underneath the jams. Other jams along this reach, that had blocked the entire channel, were partially removed during the stream restabilization effort performed in the summer of 2009 between sites D6 to D7. Historically the reach from US 90 to I-10 was approximately 4 feet deep and 12 feet wide during the 1980's (Carlton, 2009).

Figure 5-2. Trees recruited to channel by bank mass wasting. Site D5.

5.1.3 US 90 to I-10: D6 to D7

High flows in 2008 caused by Tropical Storm Fay and Hurricane Gustav caused severe scour and undercutting of the box culvert under I-10 that threatened the integrity of the interstate over D'Olive Creek (Campbell, 2009). It appears that a headcut had been rapidly migrating up the channel, creating a deeply incised stream with many trees falling into the channel from the unstable banks. During the summer of 2009, the undercut culvert was repaired and the first 500 feet below the culvert from D7 to D6 were restabilized. Banks were laid back to a low angle, riprap was placed at key areas, and crossvanes were placed in the channel to create grade control structures (Figure 5-3). In the restored state, this reach does not appear to be a significant sediment source.


Figure 5-3. Restabilized reach below I-10. Site D6.

5.1.4 Above I-10 in Timber Creek Subdivision: D8 to D11

Within the Timber Creek subdivision, D'Olive Creek is a stable channel that appears to be transporting its sediment load and is not a sediment source. The stream is flowing through a bottom type valley with broad wooded riparian zones on both banks. Banks heights are low and bank faces are well protected by dense roots. Fresh sand was noted on floodplain (Figure 5-4).


Figure 5-4. Stable reach in Timber Creek subdivision. Site D11.

5.2 Tributary DA

5.2.1 From Confluence with D'Olive Creek to County Road 13: DA1 to DA5

Tributary DA from DA1 to DA5 is an aggrading reach presently responding to a high input of sediment from upstream (Figure 5-5). Small amounts of bank erosion are taking place at the downstream end of the reach. Heading upstream from DA3 to DA5, the channel becomes increasingly confined by higher and steeper valley walls until the stream flows through a canyon type valley. Bank forms indicated both historic and recent mass wasting had occurred; however, no residences appeared to be impacted.

Figure 5-5. Reach impacted by both bank erosion and bed sedimentation. Site DA2.

5.2.2 From Confluence with D'Olive Creek to County Road 13: DA5 to DA31

Tributary DA from DA5 to DA31 is a sediment source reach with many areas of raw and unstable stream banks. The channel is confined between very high banks that are susceptible to mass wasting. The topography and hillslope forms along this reach suggest that the mass wasting of hillslopes has been both an ongoing historic problem (probably dating to pre-1960s development) and is also presently active. Homes constructed near or on the top of the banks are presently threatened by mass wasting (Figures 4-9 and 4-10).

5.2.3 From Confluence with D'Olive Creek to County Road 13: DA31 to DA35a

Tributary DA from DA31 to DA35a is a unique reach in that it has formed a slot canyon type channel through a very hard clay substrate (Figure 5-6). Although banks are unprotected, the material appears to be fairly erosion resistant. Above the slot canyon reach the channel is impacted by a small headcut and hard clay banks that are eroding. Chunks of bank material, up to 1 meter in diameter, are wasting from the banks, thus making this portion of the reach a sediment source. This same erosional process is taking place at DA22 (Figure 5-7). A riprap grade control has been installed at DA35 with the apparent purpose of preventing headcuts migrating upstream and undermining County Road 13.

Figure 5-6. Slot canyon channel in hard clay. Site DA32

Figure 5-7. Erosion by block failure observed at DA22 and DA34. Site DA22

5.2.4 From County Road 13 to US 90: DA35b to DA42

Tributary DA immediately from above County Road 13 to the powerline crossing at DA36 is a stable reach. However, beneath the powerline crossing, DA36 and DA37, the channel is a sediment source heavily impacted by the mass wasting of high stream banks and associated LWD recruited to the stream by the mass wasting (Figure 5-8). A rip-rap-lined pipeline crossing (DA37) helps maintain grade control at the upstream end of the reach.

From DA39 to DA42 the tributary crosses a series of headcuts with a total fall of about 3 meters. The headcut and the highly incised reach immediately downstream (and others like it throughout the Watershed) are considered to be the dominant sediment sources.

Figure 5-8. Mass wasting of streambank beneath power line crossing. Site DA36

5.2.5 From County Road 13 to US 90: DA42 to DA51

Tributary DA from DA42 to DA51 is a shallow, low banked stream flowing in a bottom type valley that has been impacted by high sediment loads (Figure 5-9). This reach is not a sediment source. It appears to be responding to high sediment loads. The channel appears to have become choked with sediment resulting in the stream avulsing to other locations on the valley floor. It is possible that much of the sediment was deposited when the US 90 culvert was washed out during the April 28, 2009 event.


Figure 5-9. Typical channel form below US 90 on trib DA. Site DA46

5.2.6 US 90 to headwaters: DA52

Tributary DA immediately above US 90 flows through a wooded wetland. It is not clear if the wetland is the result of the reconstruction of the US 90 crossing, or another cause. In general, the stream is shallow with low banks and flows in a bottom type valley. The stream is not a sediment source. The headwaters themselves contain several detention ponds recently constructed with the development of the Lowe's shopping center and other businesses. These detention ponds very likely are effective at trapping coarse sediments, sand or larger, but will pass much of the silt and clay during high intensity rainfall events. Additionally these ponds should be effective at reducing the flow peaks of stormwater runoff. However, it is not clear what role the detention ponds played, if any, in the April 28, 2009 US 90 culvert failure.

5.3 Tributary DB

Tributary DB is a stable stream flowing across a bottom type valley and does not appear to be a sediment source (Figure 5-10). It appears to be transporting its sediment load. Sediment entering from upstream is transported through the reach without excessive deposition taking place within the channel. Sediment deposits were noted on the floodplains. DB is impacted by beaver dams near sites DB4, 5, and 6. The headwaters near highway 31 are impacted by development with approximately 400 feet of the stream flowing through a culvert from DB15 to DB14.


Figure 5-10. Typical stable reach of tributary DB. Site DB8.

5.4 Tributary DC

Tributary DC is a stable stream flowing across a bottom type valley with low banks that are well protected by roots and subjected to minimal erosion (Figure 5-11). This reach does not appear to be a sediment source and appears to be transporting its sediment load. Sediment deposits were noted on the floodplains. At sites DC12 and DC13 the stream encroaches on the western valley wall causing both erosion and potentially threatening property. The landowner at 139 Sara Street has placed concrete and other debris on the valley slope face in an attempt to slow erosion. This encroachment occurs naturally when a stream, in a meandering pattern across its flooplain, contacts the valley wall. Exceptionally heavy and recent sediment deposits were noted on the east floodplain near DC4 and near DC18 (Figure 5-12). The sediment source was not located with certainty, but is likely related to nearby construction activities at home sites immediately upslope from DC4 and DC18 within the Timber Creek subdivision.

Figure 5-11. Stable reach DC. Site DC7.

Figure 5-12. Fresh heavy floodplain sediment deposit. Site DC4.

5.5 Tributary DD

Tributary DD was assessed where it crossed the unpaved portion of Woodrow Lane. The channel itself does not appear to be a sediment source. However, large quantities of sediment are being eroded from the unpaved road, both east and west of the stream. Eroded material has formed an alluvial fan approximately 30 meters wide near the base of the slope (Figure 5-13). Much of this sediment is being transported to tributary DD, thus contributing to downstream sedimentation impacts.

Figure 5-13. Alluvial fan from dirt road erosion. Site DD1.

5.6 Tributaries DAA and DAAA

Below Ridgewood Drive and Worchester Drive, both tributaries DAA and DAAA are deeply incised and impacted by gullying (sites DAA2 and DAAA1). Mass wasting of the high banks is recruiting woody debris which further impacts channel stability. The instability of these reaches potentially threatens the upstream road crossings. Above Ridgewood Drive, tributary DAA is stable and is not a sediment source.

5.7 Tributary DAB

Tributary DAB was not assessed. However, a tributary between sites U28 and U27 that drains to DAB was assessed. A stable non-incised ephemeral tributary approximately 50 meters long drains from above Edgar Circle (site U28). This tributary passes over a headcut into a gully approximately 50 meters long before joining tributary DAB (site U27). This gully and headcut are presently sediment sources with a potential for impacting the crossing at Edgar Circle if the headcut continues to advance.

5.8 Tributary DAC

Tributary DAC was evaluated only over the lower 200 meters. The channel over this portion is stable, draining a forested sub-watershed through a bottom type valley. The headwaters were not assessed, but the non-impacted channel from DAC1 to DAC3 coupled with the relatively undeveloped upstream land indicates that the headwaters of DAC are probably not contributing much sediment. At DAC2, the stream passes over a headcut. The total fall, approximately 3 meters is similar to that on tributary DA from DA42 to DA40.

5.9 Main Stem of Tiawasee Creek

5.9.1 Golf Course to Bay View Drive: T1 to T8

Tiawasee Creek is a depositional reach between sites T1 and T8 (Figure 5-14). A rod can easily be pushed 0.5 meters into the streambed. Flows have eroded around the north end of the riprap grade control structure at T5, resulting in excessive bank erosion. Some locations of bank scour were observed, but overall the reach is not a sediment source. The stream reach is responding to a high sediment load by aggrading, probably because the stream is within the backwater effect of Lake Forest Lake. Flows approaching the lake begin to slow down along this reach and the sediment drops out. This thick sediment layer is not permanently deposited but is transported downstream at a roughly estimated rate of 100 to 500 meters per year depending on how many high flow events occur. Ultimately, the sediment will be deposited in Lake Forest Lake. A riprap grade control at T8 protects any headcuts from potentially migrating up to the Bay View Drive Bridge.

Figure 5-14. Heavy sand deposits on Tiawasee Creek below Bay View Drive. Site T7.

5.9.2 Bay View Drive to Ridgewood Drive: T9 to T12

The reach from Bay View Drive to Ridgewood Drive was assessed at three locations; downstream (T9 and T10), middle (T11), and upstream (T12). The downstream and middle locations appeared to be impacted by heavy sediment deposits (Figure 5-15). A concrete grade control structure at T9 functions to reduce bank and bed erosion by preventing headcuts from migrating upstream, thus promoting upstream sedimentation. Both conditions help to keep upstream banks below their critical height above which they may fail by mass wasting. The upstream reach is characterized by high slopes adjacent to the channel for approximately 300 meters below Ridgewood Drive (Map 7). Although not directly assessed, these high slopes are indicators of a high potential for bank instability. Bank failure would create a high sediment source reach. At Ridgewood Drive, there is a 1 meter high grade control structure 20 meters downstream of the box culvert under the road.

Figure 5-15. Heavy sand load in the form of dunes on the bed of Tiawasee Creek. Site T11.

5.9.3 Ridgewood Drive to Confluence of Tributary TE: T13 to T30

The reach from Ridgewood Drive to the confluence of Tributary TE is characterized by a series of sewage pipeline crossings protected by riprap grade control structures. These structures prevent headcuts from migrating upstream and thus reduce the potential for channel instability and erosion (Figure 5-16). At two locations, T16, and T22, banks were undergoing erosion by mass wasting. However, overall, the reach is stable although there are specific locations where high amounts of stream bank erosion are taking place.

Figure 5-16. Typical riprap grade control protecting sewage pipeline on Tiawasee Creek. Site T23.

5.9.4 Confluence of Tributary TE to Below County Road 13: T30 to T45

From T30 to T31, Tiawasee Creek is characterized as an extended headcut with approximately 2 meters of fall over 30 meters of length as the stream transitions from a single threaded floodplain valley type to a bottom valley type. The long length of the head cut helps to dissipate energy during high flows and prevents a scour pool from forming. This reach considered to have a moderate sediment potential and not a high one. Upstream of T31, the channel is deep, U-shaped, and stable with low banks (Figure 5-17). A beaver dam at T32 further backs up flow across the valley bottom. This reach is not a sediment source and appears to be transporting the sediment load. From T40 to T45 the channel is undergoing scour, especially where landowners have cleared vegetation to the stream's edge. However, because bank heights are low, 1 meter or less, this upper reach is not considered a significant sediment source.

Figure 5-17. Stable channel characteristic of the upper reaches of Tiawasee Creek. Site T31.

5.10 Tributary TB

Tributary TB was not assessed in the field. An interpretation of the high slope map (Map 7) indicates that the lower third of the tributary, from north of Marc Circle to the confluence with Tiawasee Creek, has high slopes adjacent to the channel, and the headwater reaches have gullies with headcuts. These high slope areas are potentially important sediment sources to Tiawasee Creek.

5.11 Tributary TC

Tributary TC was not walked, but was assessed at several locations from its confluence with Tiawasee Creek upstream to its headwaters. Immediately below Greenwood Drive, the grade is controlled by a concrete drop structure (Figure 5-18) that was installed after the bridge washed out during Hurricane Danny in 1997 (Campbell, 2009).

From TC2 to TC5 the reach is impacted by stream bank mass wasting and headcutting. Many trees have fallen into the stream which further exacerbates stream bank erosion (Figure 5-19). A headcut has migrated upstream from TC4 to TC5 within the past year, and mass wasting of banks near TC4 occurred during the week prior to the field investigation (Campbell, 2009).

Figure 5-18. Concrete drop structure creates grade control below Greenwood Drive. Site TC1.

Figure 5-19. Person standing on rotational failure of high streambank with trees. Site TC2.

Between TC5 and TC6 the character of tributary TC changes from an actively incising and eroding channel to a stable channel flowing across a broad valley bottom. Beaver dams have ponded the stream near TC6. The reach at TC7 is a stable multi-threaded stream that appears to be carrying a low sediment load (Figure 5-20). The reach at TC8 above Whispering Pines Road similarly is stable valley bottom stream.

Figure 5-20. Multi-threaded low sediment load valley bottom type channel. Site TC7.

Tributary TC appears to have a similar stable form near Well Road at site TC10. Well Road is a gravel surfaced road with incised drainage ditches along the south side. Unpaved roads commonly are sediment contributors. The incised ditch at U42 and U43 also are likely to be sediment contributors. However, sediment impacts were not noted downstream at sites TC8, TC7, and TC6.

5.12 Tributary TCA

Tributary TCA was assessed at three points, TCA1, TCA2, and TCA8, and by streamwalk from TCA3 to TCA7. The channel at TCA1 has been re-stabilized with riprap to protect a sewer line and to prevent a headcut from advancing up TCA. The channel at TCA2 is located at a well grassed over unpaved road/stream crossing. The channel is stable; however, it may be an entry point for sediment eroded from the unpaved road. From TCA3 to TCA6 the channel is exceptionally stable valley bottom type channel. No erosion is taking place, nor is sediment being deposited on the streambed or floodplain (Figure 5-21). From TCA7 to TCA8 the channel is deeply incised. At TCA7 a landowner has re-stabilized the eastern stream bank to prevent their residence from falling into the channel. At headcut is advancing towards Eagle Creek Drive at TCA8. This headcut is likely a sediment source (although this is in conflict with the lack of sediment deposits below TCA6) and is potentially threatening the road and adjacent residences. Above Eagle Creek Drive the channel is stable.

Figure 5-21. Stable valley bottom reach. Site TCA4.

5.13 Tributary TCB

Tributary TCB appears to be a stable channel that receives stormwater runoff from Preakness Court. An actively eroding unpaved road north of the stream (site U46) is a potential sediment source (Figure 5-22).

Figure 5-22. Eroding unpaved road north of tributary TCB. Site U46.

5.14 Tributary TCC

Tributary TCC is essentially a straight drainage ditch that was probably dug to help drain the exceptionally flat southeast region of the Watershed (Figure 5-23). This reach does not appear to be a sediment source.

Figure 5-23. Straightened reach of TCC above Jackson Lane. Site TCC1.

5.15 Main Stem of Joe's Branch

The main stem of Joe's branch appears stable with the exception of a headcut at J3. The main stem was visited during high flows (Figure 15-24). The high water prevented field personnel from collecting the full suite of data. Therefore, incomplete data are presented in Data Table 3. The wooded riparian zone and dense roots along the bankfaces appear to offer stability to the channel, even to the extent of slowing the rate of upstream headcut advance. A stormwater detention pond at J1 reduces peak flows. The major sediment contributor to Joe's Branch may be rilling and gullying of the power line easement near the channel (U4).

Figure 5-24. Stable reach of Joe's Branch during bankfull flow. Site J2.

5.16 Tributary JA

The lower half of tributary JA is a stable constructed riprap-lined ditch from its confluence with tributary JB to site JA1 where the stream leaves the forest. JA parallels a high embankment north of Town Center Road. The channel itself is not a sediment source. However, the embankment has a high slope and, although it is well vegetated with grass, the cover shields perhaps only 70% of the soil from rainsplash erosion and sheetwash erosion (Figure 4-16, site U1). Thus, this embankment, and similar embankments, may be a contributor of sediment to downstream.

The upper 50 meters of the constructed reach are buried in sand eroded from upstream (Figure 5-25, site JA1). From JA2 to JA5 the channel is incised between banks up to 7 meters high. Banks are actively mass wasting over nearly the entire reach. This reach is undergoing the most severe channel erosion of all streams visited (Figure 5-26).

Figure 5-25. Essentially 100% of flow is beneath this sand blanked channel. Site JA1.

Figure 5-26. Severely eroding upper reach of tributary JA. Site JA4.

5.17 Tributary JB

The lower half of tributary JB from JB1 to JB5 is heavily impacted by sediment deposits (Figure 5-27). This tributary appears to be the most highly impacted by sedimentation of all streams assessed. This reach is choked with sediment for the entire length with heavy fresh floodplain deposits. Above JB5 to site JB6 the channel is severely incised and is undergoing erosion by mass wasting (Figure 5-28). There are several possible sources of the sediment: the severely eroded reach at JB6, ditch erosion along the south side of hwy 31 (JB7), unpaved road on the north side of US 31 (JB8) or from the power line easement south of US 31 (JB8).


Figure 5-27. Reach of tributary JB choked with sediment. Site JB3.


Figure 5-28. Incised reach of tributary JB undergoing bank mass wasting. Site JB6.

5.18 Tributary L

Tributary L, draining directly to Lake Forest Lake, was assessed above and below Fairway Drive. Upstream of Fairway Drive the stream flows in a concrete lined channel. The stream appears to be stable and is not a sediment source. However, tributary LA, which was not assessed in the field, shows an apparent headcut just below Fairway Drive on the high slope map (Map 4).

6.0 Conclusions

The highest intensity erosion appears to be located immediately below headcuts and gullied stream reaches immediately below headcuts. Fortunately, because these erosional features are focused in relatively small areas, there are opportunities to mitigate the impact by stabilizing the headcuts and gullied reaches, and by reducing the stormwater runoff from upstream areas.

Locations of headcuts, gullies, and locations of potential high channel instability are identified in the data tables in Attachment A and on Maps 2 through 8. Noteworthy locations include:

- D3 to D5 (Map 3, Watershed Management Unit (WMU) 3): Active mass wasting of incised channel. Large Woody Debris (LWD) jams exacerbate erosion.
- DA9 to DA33 (Map 5, WMU 1): Active mass wasting along reach with highest banks in Watershed. Homes threatened by bank instability.
- DA36 (Map 5, WMU 1): Active mass wasting beneath power line easement.
- DA40 and DAC2 (Map 5, WMU 1): Active large headcuts just above confluence of these two streams.
- TC2 to TC5 (Map 6, WMU 9): Actively advancing headcut resulting in incised channel with mass wasting banks. LWD jams exacerbate erosion.
- JA2 to JA5 (Map 2, WMU 10): Actively advancing headcut resulting in incised channel with mass wasting banks.
- JB5 to JB6 (Map 2, WMU 10): Actively advancing headcut resulting in incised channel with mass wasting banks.
- U38 (Map 7, WMU 7): Actively advancing headcut threatens to undermine Country Club Road.

The remaining erosion hot spots should be prioritized based on the percent of reach undergoing erosion by mass wasting or scour, or proximity to infrastructure.

Areas bordering the streams with steep slope gradients were identified as potential erosion hot spots since it was not possible to discover every problem location during the field assessment. An example from WMU 7 (Map 7) includes at least the following three locations. Each of these locations should be investigated for both high sediment production potential and for potential impacts to roads and residences.

- The apparent gully west of Crestview Circle and South of Buena Vista Drive.
- Tributary TB northwest of Marc Circle and at the headwaters of Tributary TB.
- Apparent gully south of the headwaters of Tributary TAA.

The cause of the gullying and rapid headcut advancement is attributed to increases in runoff (discharge rates and volume) due to past and recent land use changes. Mitigation efforts should include locating areas upstream of the impacted streams where stormwater management BMPs can be installed. This is particularly true to adequately address post-construction conditions.

Tributaries draining areas with unimproved roads and construction sites are heavily impacted by sedimentation. Therefore, rainsplash and sheetwash erosion of soils unprotected by vegetation or other means is a significant contributor of sediment to the streams of the D'Olive Watershed. Although unimproved roads are not as dominant in contributing sediment as when documented in the late 1970s by Carlton and Gail (1979), the freshly eroded surfaces of the few remaining unpaved roads, and large fresh sediment deposits at the base of slopes near these roads indicate unimproved roads are still a factor contributing to the sediment load entering Lake Forest Lake and D'Olive Bay. Headwater tributaries below active construction sites and recently developed areas typically have heavy sediment deposits on their floodplains and in some cases the channels are choked with sediment. Because these tributaries appear to be stable in terms of streambank erosion, the source of the sediments is likely from upland sources. Noteworthy locations of observed upland erosion include:

- U17 and U18: Ineffective erosion control at French Settlement subdivision construction site.
- U45 and DD1: Erosion of unpaved portion of Woodrow Lane.
- U51: Barren residential construction site on Lindsey Circle

The source of the heavy sediment deposits on tributary JB between JB1 and JB5 has not been positively identified. For tributary JB, the gully and headcut at JB6 is a source, but the quantity of sediment deposited along the 500 meters between JB5 and JB1 is so overwhelming that other sources are likely. Possible contributors include the utility crossing at JB3, the power line corridor just south of US 31, the gravel drive leading to the water utility station north of US 31, and possibly other unidentified sources.

Two other small tributaries were impacted by high sediment deposition: DA below US 90, and TG below the French Settlement construction site.

Using the Cook (2007) and Cook and Moss (2008) studies to compare sediment loads (combined suspended and bedload) by WMUs indicates that WMUs 1 and 3 (tributaries DA and D) are the dominant contributors with WMU 3 contributing nearly half the total load and WMU 1 contributing just under one third. WMU 7 (tributary T) contributes the remainder, providing just under one quarter of the total load. During 2007 and 2008, land within the north central part of WMU 0 underwent development as part of the Spanish Fort Town Center complex. The total sediment load draining this area was low. However, because this area was so small, a fourth of a square mile, the normalized sediment loading rate in tons per square mile per year was very high. WMUs 2 and 9 (tributaries TC and the upper T) were essentially insignificant contributors to the total sediment loading of Lake Forest Lake during this time period. Joe's Branch (tributary J), draining WMU 10, doesn't drain into Lake Forest Lake. However it contributes a moderate amount of sediment directly into D'Olive Bay.

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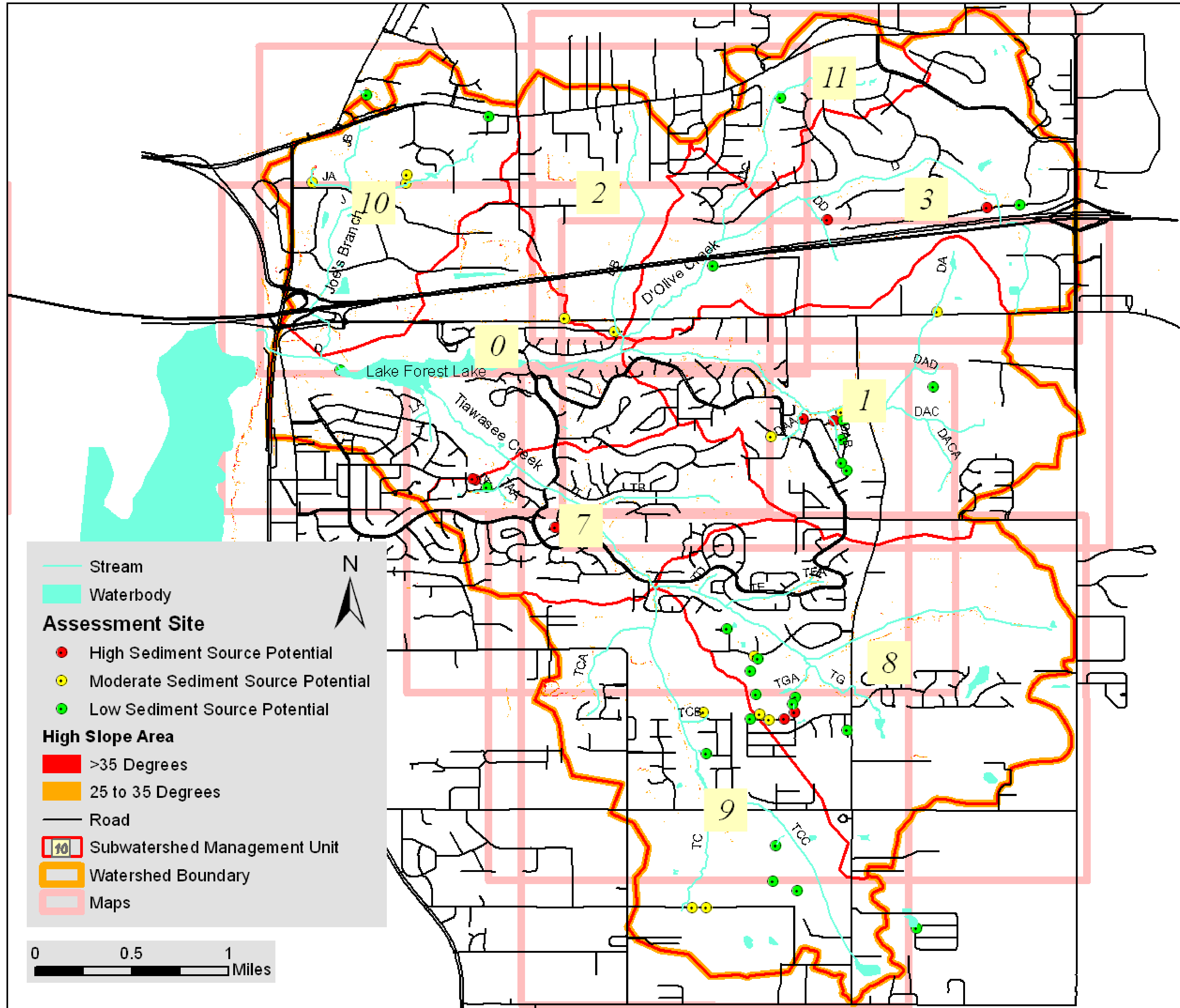
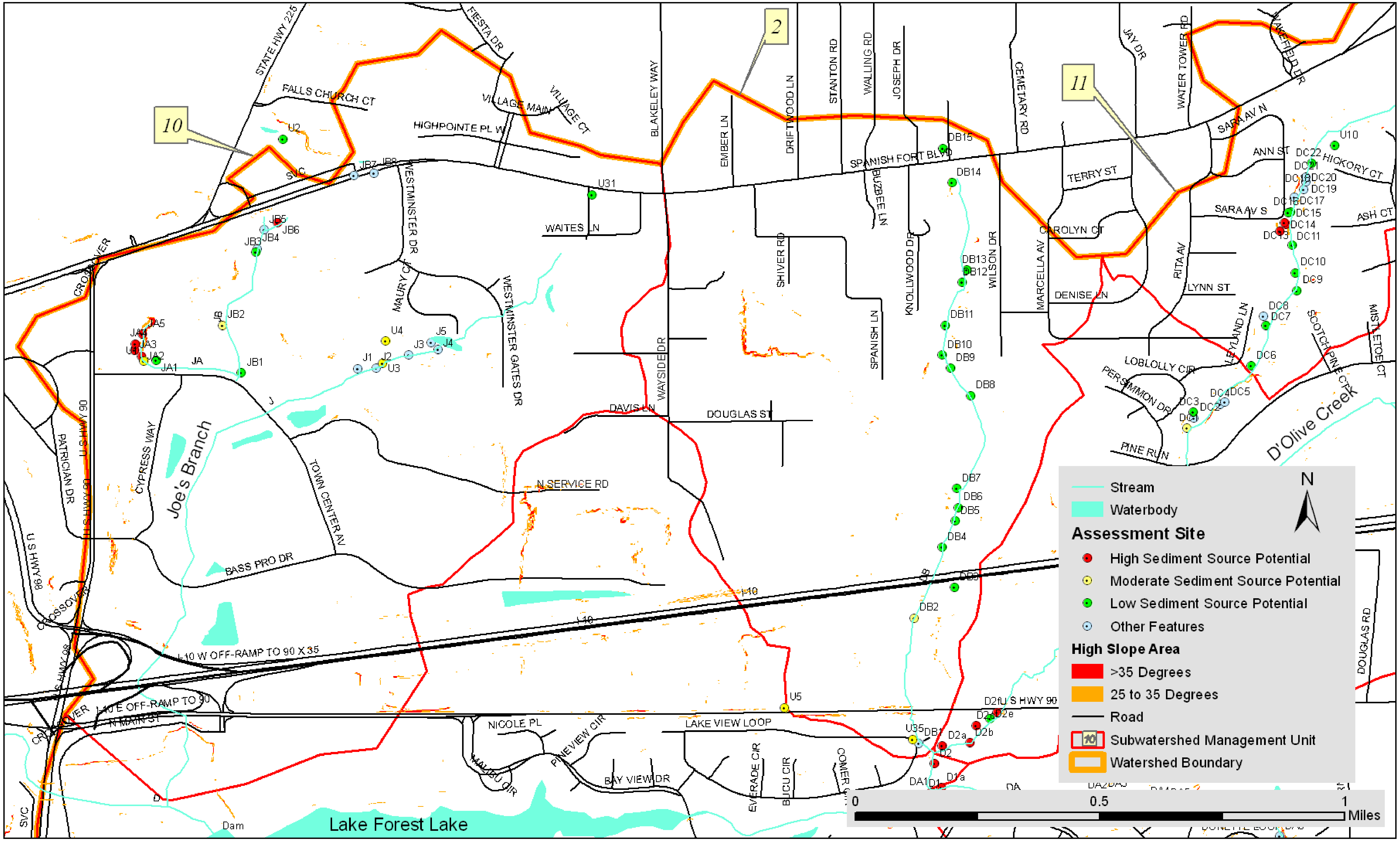
Map	Watershed Management Units
Map 1	Locator Map
Map 2	2 and 10
Map 3	3 and 11
Map 4	0
Map 5	1
Map 6	9
Map 7	7
Map 8	8

Map 1. Locator Map.



Map 2. Watershed Management Units 2 and 10.



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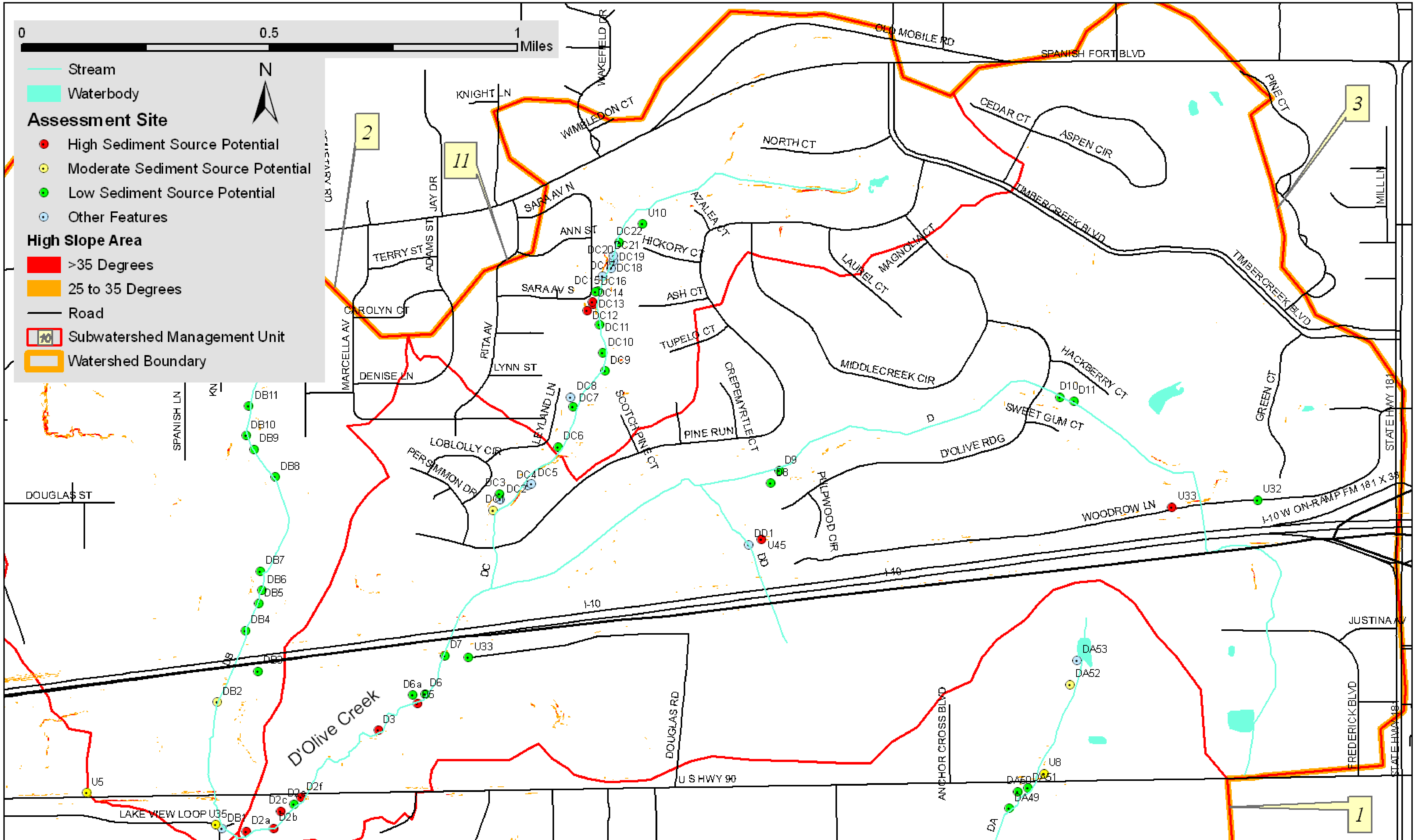
Map 3. Watershed Management Units 3 and 11.



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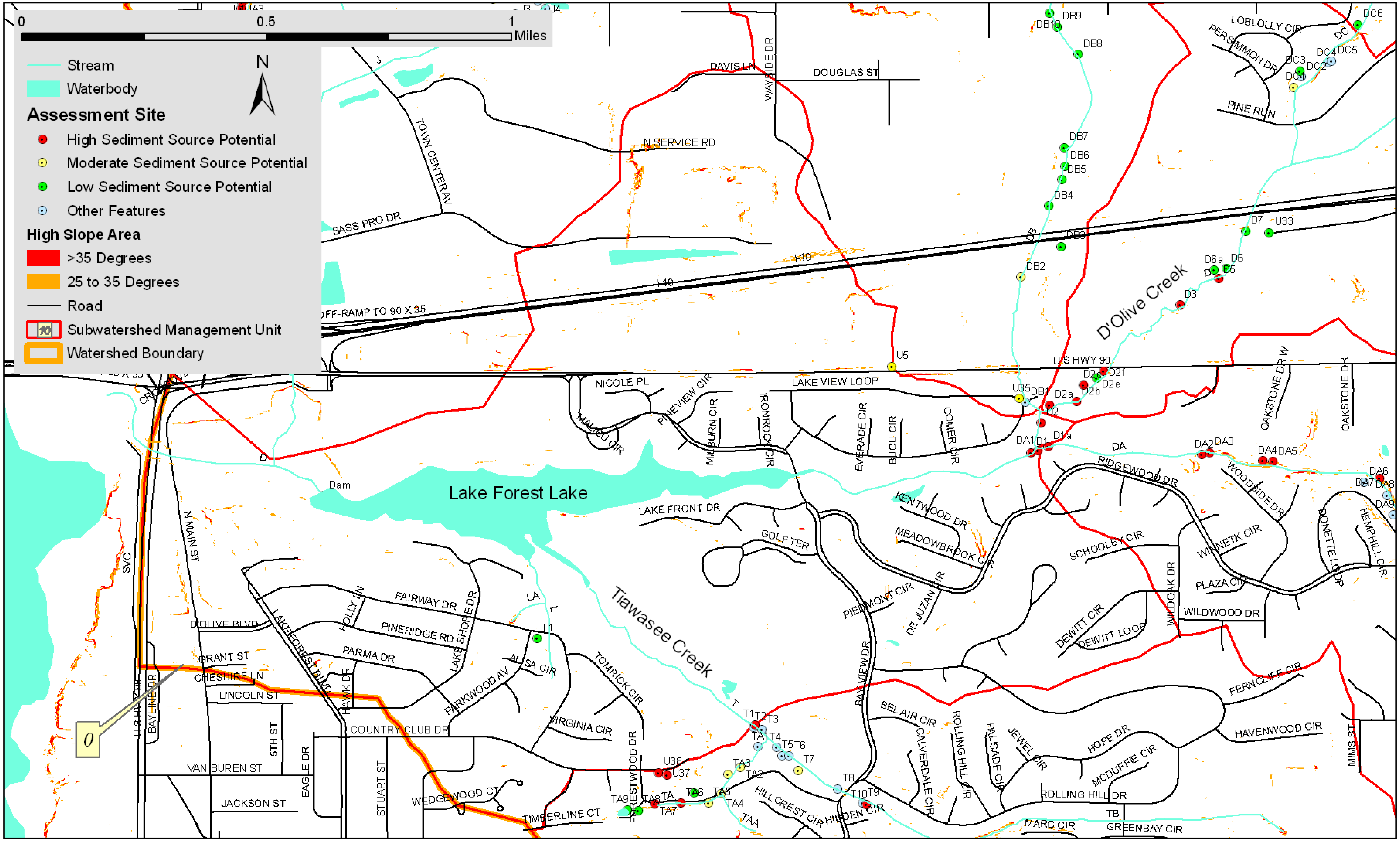
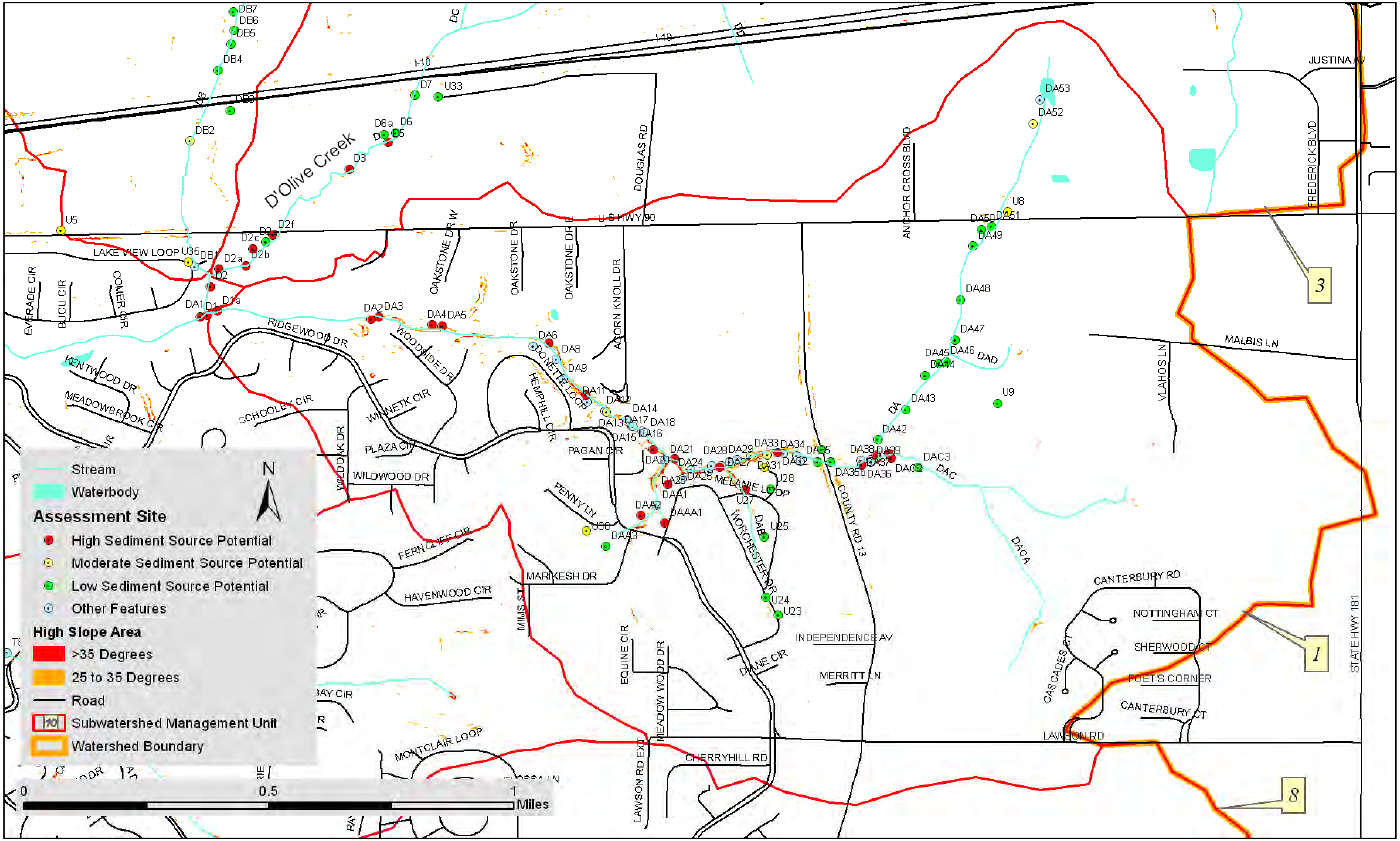
Map 4. Watershed Management Unit 0.



Map 5. Watershed Management Unit 1.



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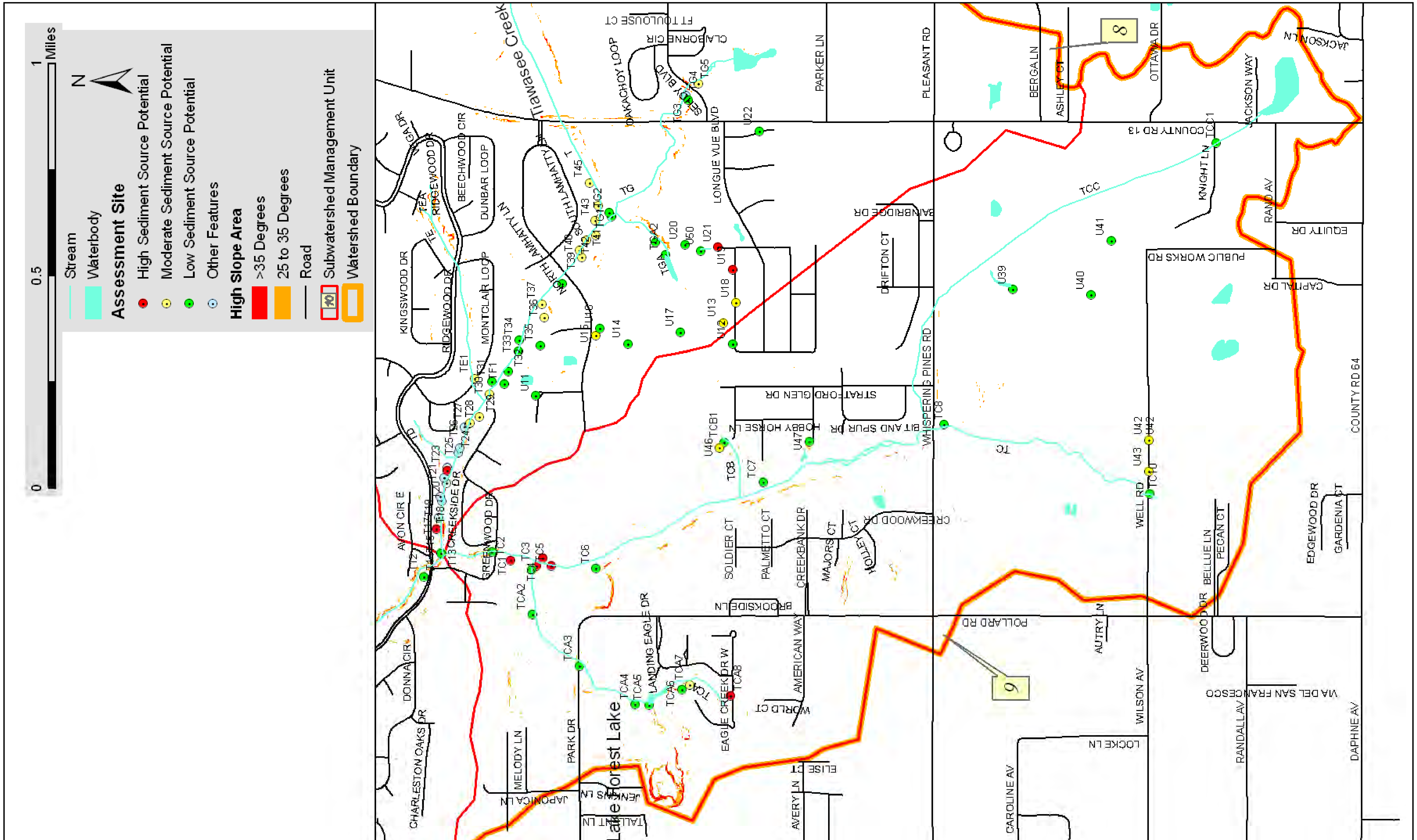
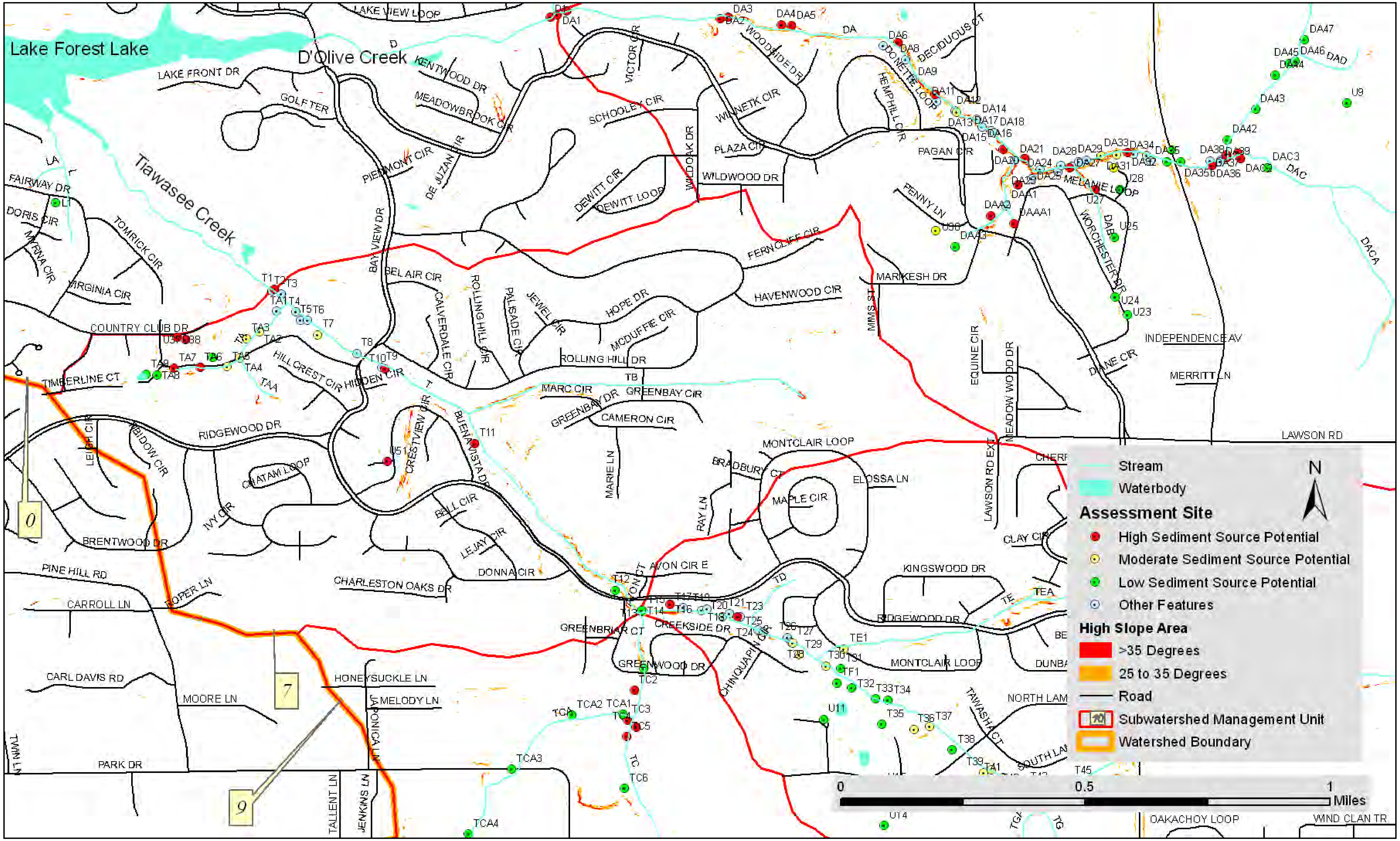
Map 6. Watershed Management Unit 9.



Map 7. Watershed Management Unit 7.



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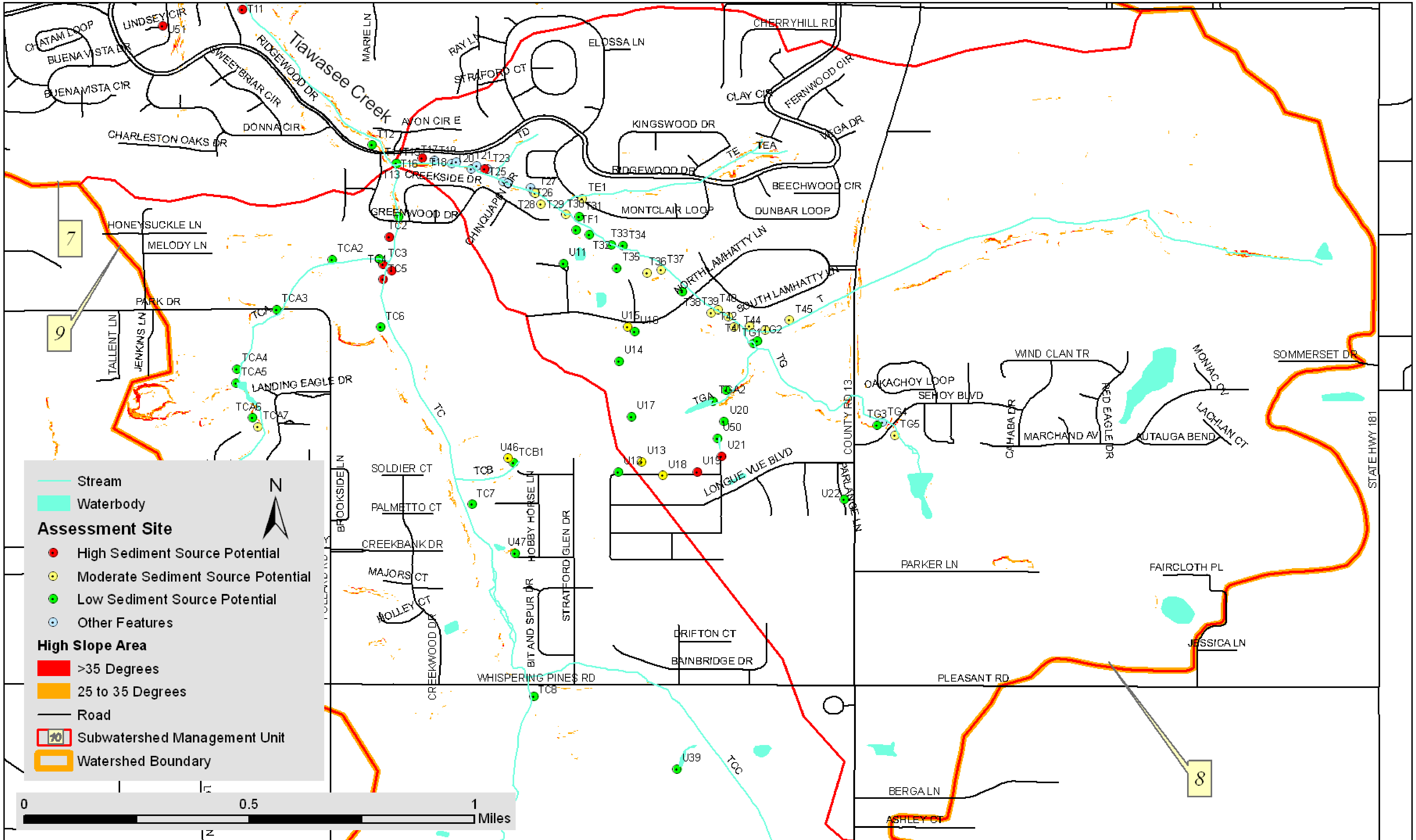
Map 8. Watershed Management Unit 8.



Data Table 1. Field data for the D'Olive Creek main stem and tributaries. **Sheet 1 of 2**

Assessment Site	Latitude	Longitude	Other Location	Bank Top Height (m)		Bankfull Height (m)		Banktop Width (m)	Bed Material (dia in mm)	Surrounding Landuse	Riparian Zone Width (m) and Cover				Bankface Protection % Density and Type				Bank Erosion by Mass Wasting (%)		Bank Erosion by Scour (%)		Dominant Bank Material		Bed Condition	Sediment Deposition	Channel Flow Status	CEM Class	Reach Type	Notes	Assessment Site
				LB	RB	LB	RB				LB	LB Cover	RB	RB Cover	LB	LB Type	RB	RB Type	LB	RB	LB	RB	LB	RB							
D1	30.6528	-87.88634																												Confluence of two main branches of D'Olive Creek.	D-1
D1a	30.653	-87.88584																												Sewage easement in left riparian zone.	D1a
D2	30.6537	-87.88604		1.6	1.6			8	0.5-5	suburban-res	max	forest	5	forest then yard	30	roots	30	roots	10	10	30	30	sand	sand	aggrading loose sand	7	10	V	response	More sinuous than the reach at DA1. Broad point bars. Old woody debris jams. Reach is the same from DA to D2.	D2
D2a	30.6542	-87.8858																												Photo	
D2b	30.6543	-87.885																												Photo	
D2c	30.6548	-87.8848																												Photo	
D2e	30.655	-87.8844																												Power line xing.	
D2f	30.6552	-87.8842																												At Hwy 90	
D3	30.6572	-87.88194		3.5	3.5			15		forest	max	forest	max	forest	20	LWD	20	LWD	50	50	-	-	sand	sand	sand			V	source	Transition from incised reach upstream to braided reach downstream.	D3
D4																														Remnants of chainsawed up LWD jam.	D4
D5	30.658	-87.8808																													D5
D6	30.6582	-87.88057																												End of restored reach.	D6
D6a	30.6582	-87.88092																												Conf with stabilized trib.	D6a
D7	30.6593	-87.87999																												Head of restored reach. I-10 box culvert was undercut 12 feet deep by 25 feet back in when hurricanes faye and gustave came through in 1998. according to Ashley Campbell.	D7
D8	30.6644	-87.87046																												Stormwater outfall at toe of terraced embankment.	D8
D9	30.6648	-87.87021		1.4	1.6	1.4		3	1	suburban-res	max	of light a	max	forest with lots of light and undergrowth	80	roots	80	roots	0	0	10	10	sand	sand	firm sand	18	20	I	transport	Fresh sand on floodplain. Black organic material outcropping on bed. Very sinuous channel.	D9
D10	30.6669	-87.86202		1.2	1.2	1.2	1.2	3	1	suburban-res	max	brush	max	brush	90	roots	90	roots	0	0	20	20	sand	sand	firm sand	20	17	I	transport	Sinuous bottomland stream. Stable reach. Probably influenced by D'Olive Ridge road xing 60m DS.	D10
D11	30.6668	-87.86161																												Root forced riffles. Higher gradient than at D10. Stable reach.	D11
DA1	30.6528	-87.88613		1.9	1.9			7	0.5-5	suburban-res	max	forest	max	forest	40	privet	40	privet	10	0	30	30	sand	sand	aggrading loose sand	7	10	V > VI		Adjusted trib to LB. LWD jam in main stem causing channel widening. High bed load has forced thalweg to LB. LB is undercut.	DA1
DA2	30.6527	-87.8813	North of Woodside Dr.	1.7	2.5			8	1 to 10	suburban-res	max	forest	max	forest	70	roots / saplings	70	roots / saplings	0	10	30	30	sand	sand	aggrading sand	8	10	V>VI	response	Thalweg pushed to channel margin. Moss on bank face indicates stability. Sediment on floodplains. Sinuous with point bars.	DA2
DA3	30.6528	-87.88107																												Old MW location. RB is 5m high.	DA3
DA4	30.6526	-87.8795																												0.5m fall over LWD jam. Sediment backed up behind jam. Unadjusted trib to LB, Exposed roots on LB.	DA4
DA5	30.6525	-87.8792		1.7	2.5	1.7		8	1 to 10	suburban-res	max	forest	max	forest	40	roots	40	roots	10	30	30	30	sand	sand	aggrading sand	8	12	V	response	Example of old MW on RB. Good site for topographic ground truth. Sand on 1.7m high terrace. Scour on outside bends and around LWD jams. Deposition on inside bends. Pool-riffle form with hard clay balls and LWD forming riffles. Iron stone riffles below LWD jams.	DA5
DA6	30.6519	-87.87649																												Trib to LB under boardwalk. With gray turbid water coming out. Trib not adjusted.	DA6
DA7	30.652	-87.87604																												Active MW on RB. Iron stone shelf acts as aquitard at about 1.3m above stream bed. Water dripping from iron stone.	DA7
DA8	30.6515	-87.87582																												Sand bags protect LB at house. Historic MW of RB.	DA8
DA9	30.651	-87.87562																												Upstream end of concrete blanket protecting LB. Blanket ~40m long and 5m high.	DA9
DA10	30.6505	-87.87495		6	1.8		1.8	7	0.2-2	suburban-res	10	brush	max	forest	60	roots	60	roots	50	50	20	20	sand	sand	transporting firm sand	15	14	V	source	Moss on banks.	DA10
DA11	30.6503	-87.8749																												Trib to LB. Recent MW on RB	DA11
DA12	30.65	-87.87437																												Big tree on LB going to fall and mash house at 558 Ridgewood on RB.	DA12
DA13	30.65	-87.87432		2	2			8	22	forest	max	forest	max	forest	50	brush	50	brush	0	0	30	30	clay	clay	clay-ball riffle & sand pool	12	12	V	Transport	LWD jam. Log over top of jam is new since aug 09 according to landowner at 558 Ridgewood. Landowner says the bed was rocky, not sandy when they moved in in 2001.	DA13
DA13a																														30m above DA13, RB scoured to hardpan. Sand deposit on LB toe.	
DA14	30.6498	-87.87371																												Trib on RB, not adjusted, wet, gully, active mass wasting, sed source.	DA14
DA15	30.6495	-87.87357																												Gully on RB, dry, 2m high headcut. Outfall on LB, 1m dia concrete.	DA15
DA16	30.6495	-87.87355																												MW on RB, 4m high x 7m long.	DA16
DA17	30.6494	-87.87329																												Trib on RB, not adjusted, wet.	DA17
DA18	30.6494	-87.87319																												Gully on RB, dry, 1m high headcut.	DA18
DA19	30.6489	-87.87295		2.2	1.5			6	90	forest	Max	forest	max	forest	40	brush	50	brush	10	0	30	30	clay	clay	sand embedded clay-cobbles and iron concretion cobbles	16	16	III	Transport	Broad (10m wide) sand covered terraces at the banktop elevation. Very straight reach.	DA19
DA20	30.6486	-87.87231																												Trib DAA on RB, wet, adjusted, ajax covering bed.	DA20
DA21	30.6486	-87.8726																												MW on LB, 7m x 15m	DA21
DA22	30.6486	-87.87231		4	6			15	128	forest	max	residential / grass	max	forest	50	rip-rap	0		50	50	50	50	hardpan	hardpan	clay-cobble riffle	8	7	IV	Source	Large MW on LB at head of reach 8m high. House threatened by downstream erosion.	DA22
DA23	30.6483	-87.87185																												End of reach. Trib to LB, dry, 1m high headcut.	DA23
DA23a	30.648	-87.8721																												Top-center of landslide scarp.	DA23a
DA24	30.6482	-87.87132																												LWD jam	DA24
DA25	30.6484	-87.87123																												Trib to RB, wet, clay surface of main channel banks are damp from seepage.	DA25
DA26	30.6483	-87.87099		2	3			4	11	forest	15	forest	max	forest	40	brush	40	brush	0	0	40	40	hardpan	hardpan	firm sand	6	9	III	response	Scoured lower banks indicate CEM stage III, but with heavy sand deposits on bed.	DA26
DA27	30.6484	-87.87092																												Conf with trib B to LB. LWD jam on mainstem.	DA27
DA28	30.6485	-87.8707																												Gully to RB with damp bottom. 2m headcut.	DA28
DA29	30.6486	-87.87048																												Trib to RB, stable, not incised on terrace. Main stem scoured to hard clay bank toes.	DA29
DA30	30.6487	-87.87005		2.5	2.5			6	32	forest	max	forest	max	forest	30	brush	50	brush	x	x	30	30	hardpan	hardpan	hardpan ball-gravel pool-riffle	17	16	III	Transport	Hummacky valley face 10 meters high on LB.	DA30
DA31	30.6487	-87.86958																												Natural constriction and scour pool in hardpan.	DA31
DA32	30.6488	-87.86927		2	2			2.3	45	forest	20	forest	max	foest	0	hardpan	0	hardpan	0	10	10	10	hardpan	hardpan	hardpan	17	20	III	Transport	"Keyhole" xsec channel. Boundary between formations?	DA32
DA33	30.6487	-87.86909																												End of reach. Hardpan boulders.	DA33
DA34	30.6487	-87.8687																												Headcut. 0.5m fall	DA34
DA35	30.6485	-87.86859																												Rip-rap wier grade control.	DA35
DA35a	30.6485	-87.8681																												Downstream end of CR 13 culverts	DA35a
DA35b	30.6485	-87.8677																												Upstream end of CR 13 culverts. Rip-Rap grade control 1m high.	DA35b
DA36	30.6484	-87.86678		0.5	0.6			8	22	forest / powerline cut		forest / grass		forest / grass	40	brush	40	brush	40	40	20	20	sand over clay	sand over clay	firm sand	8	7	IV-V	Source	1m or thicker layer of black organic material.	DA36
DA37	30.6485	-87.86681																												Pipeline xing protected by rip-rap.	DA37
DA38	30.6486	-87.86651																												2 tree stumps in bed, 0.4m dia each.	DA38
DA39	30.6485	-87.86652																												Trib on LB, adjusted, wet, 2 more stumps. LB scoured due to LWD jam.	DA39
DA40	30.6486	-87.86634																												Trib to LB, adjusted, wet. Main stem scoured to gray hardpan.	DA40

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Data Table 1. Field data for the D'Olive Creek main stem and tributaries. ***Sheet 2 of 2***

Assessment Site	Latitude	Longitude	Other Location	Bank Top Height (m)		Bankfull Height (m)		Banktop Width (m)	Bed Material (dia in mm)	Surrounding Landuse	Riparian Zone Width (m) and Cover				Bankface Protection % Density and Type				Bank Erosion by Mass Wasting (%)		Bank Erosion by Scour (%)		Dominant Bank Material		Bed Condition	Sediment Deposition	Channel Flow Status	CEM Class	Reach Type	Notes	Assessment Site
				LB	RB	LB	RB				LB	LB Cover	RB	RB Cover	LB	LB Type	RB	RB Type	LB	RB	LB	RB	LB	RB							
DA43	30.6501	-87.86548																												Wrack line 0.55m above floodplain. Headcut over roots into 1.2m deep scour pool.	DA43
DA44	30.6511	-87.86491																												0.2m dia tree in mid-channel. Typ wrack line 0.5m above floodplain.	DA44
DA45	30.6514	-87.8645		0.25	0.25	0.25	0.3	2	0.3	forest	max	forest	max	forest	80	roots	80	roots	0	0	10	10	sand	sand	firm clean tan sand	14	17	1	Transport	Largest trees in woods = 0.35m dia. Some sand on floodplain, although thicker organic soil layer than at DA42.	DA45
DA46	30.6515	-87.86431																												Trib on LB	DA46
DA47	30.6521	-87.86403		0.25	0.25	0.25	0.3	2	0.5	forest	max	forest	max	forest	80	roots	80	roots	0	0	20	20	sand	sand	sand over roots	8	19	1	Transport	Brown sand bed coarser than at DA45. Roots exposed on bed. Avulsion history indicated by old channels on forest floor.	DA47
DA48	30.6533	-87.86386		0.15	0.15			2.5	0.5	forest	max	forest	max	forest	50	roots	50	roots	0	0	10	10	sand	sand	aggrading sand	5	12	V	Response	Reach aggrading. Near avulsion point. Largest pine = 0.6m dia. Largest deciduous = 0.2m dia. Probably pasture in 1970.	DA48
DA49	30.6549	-87.8635																												Trib on RB, wet, adjusted. Same size as main stem.	DA49
DA50	30.6554	-87.86325																												Floodplain impacted by several inches of sand and fine gravel from DA50 to 50m ds.	DA50
DA51	30.6555	-87.86296																												Below US 90	DA51
DA52	30.6585	-87.86171	100m below spillway	0.3	0.3	0.3	0.3	1	1	commercial	20	forest	max	forest	30	roots	30	roots	0	0	30	30	sand	sand	loose sand and silt	10	10	am	ind	Reach has avulsed historically.	DA52
DA53	30.6592	-87.86151																												Outlet from detention pond. Broken Faircloth skimmer.	DA53
DB1	30.6543	-87.8865																												Photo at Gordon Rd crossing	DB1
DB2	30.658	-87.88663		0.5	0.5														0	0	30	30			Bars					Sed on floodplains	DB2
DB3	30.6589	-87.88545	Below I-1	0.6	0.6														0	0	0	0			Bars					Sed on floodplains	DB3
DB4	30.6601	-87.88582	Near lift s	0.5	0.5														0	0	0	0								Multi-threaded channel. Beaver activity.	DB4
DB5	30.6609	-87.88543		0.6	0.6										80	vegetation	80	vegetation	0	0	0	0								Multi-threaded channel. Beaver activity.	DB5
DB6	30.6613	-87.88533		0.6	0.6										80	vegetation	80	vegetation	0	0	0	0								Multi-threaded channel. Beaver activity.	DB6
DB7	30.6618	-87.88538		0.7	0.7										70	vegetation	70	vegetation	0	0	0	0								Erosion at old road/stream xings. Several crossing impact approximately 50 meters of stream. Multi-threaded channel. Historical beaver activity.	DB7
DB8	30.6646	-87.88496		0.3	0.3										80	vegetation	80	vegetation	0	0	0	0								Multi-threaded channel	DB8
DB9	30.6654	-87.88557		0.4	0.4										80	vegetation	80	vegetation	0	0	0	0									DB9
DB10	30.6658	-87.8858		0.4	0.4										80	vegetation	80	vegetation	0	0	0	0									DB10
DB11	30.6666	-87.88572		0.4	0.4										80	vegetation	80	vegetation	0	0	0	0									DB11
DB12	30.6679	-87.8852		0.4	0.4										80	vegetation	80	vegetation	0	0	0	0									DB12
DB13	30.6683	-87.88508		0.4	0.4										80	vegetation	80	vegetation	0	0	0	0									DB13
DB14	30.6719	-87.88578		1	1										80	Rip-Rap	80	Rip-rap	0	0	0	0								Discharge end an approximate 400 foot long culvert from the culvert begaining at the end of the Bible Baptist Church Detention Pond and flowing under US-31.	DB14
DB15	30.6709	-87.88552																												Headwaters at Bible Baptist Church Detention Pond North of US-31. Waters of the area are very turbid due to denudes soils and a 1.15 inch rainfall overnight. Discharge is to detention culvert under US-31	DB15
DC1	30.6636	-87.87858		.75	.75			2.5	0.7	forest	20	forest	max	forest	50	roots	50	roots	0	0	30	30	sand	sand w/roots	braided	8	15	V	response	Hummacky FP. Wrackline 0.5m above FP. Heavy sand deposits on FP. Trees located mid-channel. Largest trees = 0.35m dia deciduous. 20m US stream transition to stable but incised channel 0.7m deep.	DC1
DC2	30.6639	-87.87836																												Iron floc in trib to RB.	DC2
DC3	30.6641	-87.87839																												Trib on RB. Stable. Comes from 0.6m dia culvert in embankment.	DC3
DC4	30.6643	-87.87758																												Fresh orange sand on hillslope. Largest tree = 0.06m dia.	DC4
DC5	30.6644	-87.87745																												50m below house there is sand on slope like at site DC11.	DC5
DC6	30.6654	-87.87668		0.5	0.5			1.8	0.25	forest	max	forest	max	forest	50	roots	50	roots	0	0	20	20	sand	sand	firm sand and roots	15	18	1	response	Hummacky FP. Clean light tan sand. Wrackline 0.5m above FP.	DC6
DC7	30.6666	-87.87624		1	1			2	0.25	forest	Max	forest	20	forest	40	roots	40	roots	0	0	20	20	sand	sand	firm sand	15	19	1	response	Channel is incised compared to site DC-13. Deep pools. Lots of clean sand on FP.	DC7
DC8	30.6669	-87.87631																												On LB 4ft dia culvert w/sand filled silt fence below outlet.	DC8
DC9	30.6677	-87.87532																												10m x 30m pond in clearing. No sign of beaver activity.	DC9
DC10	30.6682	-87.87537																												Braided channel in forest.	DC10
DC11	30.669	-87.87547																												Outfall to RB similar to that at site DC10.	DC11
DC12	30.6694	-87.87583																												Channel has encroached on 5m high R valley wall. Concrete and other trash thrown in for bank protection.	DC12
DC13	30.6696	-87.87565																							gravel					4 inch dia PVC pipe crossing 8 feet above channel. Goes to concrete outfall on L valley wall.	DC13
DC14	30.6697	-87.87568																												30" dia outfall to RB. GMC Jimmy ready fall in stream on LB at 139 Sara St.	DC14
DC15	30.67	-87.87551																												2m dia culvert on main stem.	DC15
DC16	30.67	-87.87558		0.7	0.75			2	8	forest and lawn	max	forest	15	forest	60	roots	60	roots	0	0	20	20	sandy clay	sand	sand/gravel/roots	12	18	am	Transport	Sewage easment along LB. Erosion and rilling in clay on upper left terrace face. Heavy sand deposits on FP.	DC16
DC17	30.6704	-87.87539																												Gully to RB lined with trash and logs.	DC17
DC18	30.6707	-87.87513																												Heavy brown sand on FP.	DC18
DC19	30.6709	-87.87506																													DC19
DC20	30.6709	-87.87506																												Location is toe of valley slope. Heavy sand deposits probably from construction.	DC20
DC21	30.671	-87.87505																													DC21
DC22	30.6714	-87.8749																												0.6m dia concrete outfall w/box on LB. Sewage riser on LB. Silt fence parallell to stream on LB.	DC22
DAA1	30.6472	-87.87286																												Confluence w/gully and trib. Gully carries turbid white flow. Trib carries clear flow.	DAA1
DAA2	30.6469	-87.87332	50 m above golf cart path.	1.2	1.2	1.2	1.2	5	0.5-5	suburban-res	10	forest	10	forest	30	brush / roots	30	brush / roots	20	20	60	60	-	-	aggrading sand	6	8	V	source	Heavy sand deposits. Broad bars. Fresh sand at 1.2 m elevation.	DAA2
DAA3	30.646	-87.87436																												Stable channel. Small amount of sand on trail under powerlines and on the trib bed.	DAA3
DAAA1	30.6467	-87.87262																												Active MW in gully. Many trees fallen in. 2m deep x 6m wide x 50m long. Tan sand deposit on Worchester road above CB draining to gully.	DAAA1
DAC1	30.6488	-87.866																												0.7m fall over LWD jam. Gully to LB with 1.5m headcut. Sed source.	DAC1
DAC2	30.6486	-87.86593																												Anastomosed channel choked with silt/sand flowing over 2m high headcut.	DAC2
DAC3	30.6483	-87.86512		0.4	0.4	0.7	0.7	3	1	forest	max	forest	max	forest	100	forest	100	forest	0	0	0	0	-	-	loose sand	15	20	1	Transport	Single thread. Sed in pools. Fresh sand on floodplain.	DAC3
DD1	30.6626	-87.87111																												Stream xing dirt road. Big alluvial fan due to road erosion on west side. Channel impacted from high sed load from when I-10 headwall failed. All to be fixed when Woodrow is to be extended. Good spot for detention pond.	DD1

Data Table 2. Field data for the Tiawasee Creek main stem and tributaries. ***Sheet 1 of 2***

Assessment Site				Bank Top Height		Bankfull						Riparian Zone Width (m) and				Bankface Protection % Density and Type				Bank Erosion by		Bank Erosion		Dominant Bank Material							Notes	Assessment Site
	Latitude	Longitude	Other Location	LB	RB	LB	RB	Banktop Width (m)	Bed Material (dia in mm)	Surrounding Landuse	LB	LB Cover	RB	RB Cover	LB	LB Type	RB	RB Type	LB	RB	LB	RB	LB	RB	Bed Condition	Sediment Deposition	Channel Flow Status	CEM Class	Reach Type		
T1	30.6447	-87.89449	150m above golf cart bridge	0.8	2			10	1	suburban-res	max	forest	max	herbaceous	-	brush	90	herbaceous	0	10	-	-	sand	sand	aggrading loose sand	6	14	am	response	Heavy sand deposits on floodplain. Adjacent to dredging spoils dumping area on north side.	T1
T2	30.6447	-87.89455																												Pipeline xing 1.6m above bed.	T2
T3	30.6446	-87.89429																												Trib to LB, wet and adjusted.	T3
T4	30.6441	-87.89385																												Outfall to RB. Stable although there is a sand deposit at mouthl	T4
T5	30.6438	-87.89371																												Rip-rap grade control blown out along right bank.	T5
T6	30.6438	-87.8935																												Trib to LB, unadjusted, 0.8m fall.	T6
T7	30.6434	-87.89321	150m below Bay View Drive.	2.5	2.5			10	1	suburban-res	max	forest	max	forest	40	brush	40	brush	0	0	40	40	sand	sand	aggrading loose sand	5	11	V>VI	response		T7
T8	30.6429	-87.89205																												Rip-rap grade control with 1m fall located 10m below Bay View Drive.	T8
T9	30.6424	-87.89132																												Concrete over rip-rap grade control. 1.5 m fall.	T9
T10	30.6424	-87.89121	150m above Bay View Drive	3	3	1.3	1.3	20	1	suburban-res	20	lawn	20	lawn	70	herbaceous	50	brush	0	10	10	20	sand	sand	aggrading sand	10	20	V>VI	response	Grade control 50m downstream. Photos shot in ~1980 from off end of Hidden Circle.	T10
T11	30.6402	-87.88858		3.5	3.5			20	1	suburban-res	20	forest	max	forest					10	10						5	19	V		Heavy sediment on bed. Dunes in bedforms. Dead straight reach. Adjacent to 2009 gully repair off Buena Vista Road.	T11
T12	30.6358	-87.88442																												1m fall over concrete grade control 20m below Ridgewood Dr.	T12
T13	30.6352	-87.88363													80	rip-rap	80	rip-rap	0	0	0	0	rip-rap	rip-rap	stable	-	-	am	transport	Heavy sand on inside point bar.	T13
T14	30.6352	-87.88363																												Confluence. Boulder rip-rap bed and banks grade control 0.7m high.	T14
T14a																														0.5m fall over rip-rap grade control 20m above T14.	T14a
T15	30.6352	-87.8836																												Sewage line xing.	T15
T16	30.6354	-87.88279		1.2	1.2	1.2	1.2	6.5	0.25	forest	15	forest	15	forest	30	brush	30	brush	40	40	20	20	sand	sand	aggrading loose sand	4	7	V	response	Heavy sand deposits on bed at T15 to T16. Long pool behind failed seawall transitions to shallow water w/loose sand. Rip-rap repair of failed seawall.	T16
T17	30.6353	-87.8824																												LWD jam	T17
T18	30.6352	-87.88185																												LWD jam	T18
T19	30.6353	-87.88169																												Pipeline xing. Rip-rap and LWD jam.	T19
T20	30.6351	-87.88123																												Pipeline xing. Rip-rap grade control with 1m fall. Deep scour pool below.	T20
T21	30.6352	-87.88104																												LWD jam	T21
T22	30.635	-87.8808		3	3	3	3	14	0.25	forest	20	forest	20	forest	30	herbaceous	30	herbaceous	20	40	20	20	sand	sand	aggrading loose sand	5	6	V	response	Heavy sand deposits on bank toes. MW on RB. Frequent LWD jams. Deep pools, shallow runs. Vertical banks. Rip-rap grade control at each pipeline xing.	T22
T23	30.635	-87.8807																												Pipeline xing and rip-rap grade control 1m high. Gullied trib on LB. Wet adjusted trib to RB 30m above T23.	T23
T24	30.6347	-87.88019																												Rip-rap grade control with silt fence. 0.6m high fall. Pipeline xing.	T24
T25	30.6346	-87.88003																												Rip-rap grade control. 0.7m high fall. Pipeline xing. 15m dia pool US.	T25
T26	30.6344	-87.87931																												Rip-rap on LB top.	T26
T27	30.6343	-87.8792																												Pipeline xing. Pipe slopes steeply down to LB.	T27
T28	30.6343	-87.87916		1.6	1.6	1.6	1.6	5	0.25	orest and law	max	forest	20	grass	30	brush	40	brush	0	0	50	50	sand	sand	clay balls on sand	10	16	am	ind	Deep pool w/rip-rap grade control at DS end. Rip-rap protecting LB. Stumps in midchannel below T25.	T28
T29	30.6339	-87.87897																												Rip-rap grade control at pipeline xing. 1m fall. Part of fall includes black organic material with stumps.	T29
T30	30.6336	-87.87818		2.5	2.5	2.5	2.5	5	0.25	forest	15	est / la	max	forest	20	roots	20	roots	0	0	40	40	gray to blk c	gray to blk c	loose sand	12	18	am	ind	Rip-rap grade control. Trib to RB cutting thru old stumps. Relict shells on bed of trib TE.	T30
T31	30.6335	-87.87775		0.8	0.8	0.8	0.8	2.8	0.25	lawn	15	ass / bru	15	grass / brush	80	brush	80	brush	0	0	0	0	sand	sand	sand	15	20	1	transport	Deep "U" shaped channel. Not incised. Two threads. Rip-rap grade control at upstream end.	T31
T32	30.633	-87.87742																												Beaver dam. 0.5m fall. Rip-rap along LB creates 1m high levee. Big sediment sink upstream of dam.	T32
T33	30.6326	-87.87672		0.7	0.7			3.5	0.25	forest	max	forest	max	forest	30	brush	30	brush	0	0	0	0	sand	sand	thick sand and limbs	8	18	V	response	Heavy clean light-tan sand deposit on floodplain.	T33
T34	30.6326	-87.87634																												Beaver dam 0.6m fall.	T34
T35	30.6319	-87.87654																												Sand deposit on FP is typical.	T35
T36	30.6317	-87.87557		1.5	1.5	1.5	1.5	2.2	0.25	forest	max	forest	max	forest	50	brush	50	brush	0	0	30	30	sand	sand	thick sand and roots	13	19	I	transport	More incised tha n at T35. Heavy sand on flood plain. Channel is more sinuous above beaver pond.	T36
T37	30.6318	-87.87511																												Headcut created by group of large trees. 0.5m fall.	T37
T38	30.6311	-87.87444																												End of reach. Box culvert. 0.4m fall out of end. No sand on culvert floor. Swampy pool for 60m above T38, then similar to T36.	T38
T39	30.6304	-87.87351		1.2	1.2	1.7	1.7	3.5	0.25	forest	max	forest	10	forest	20	roots	20	roots	0	0	40	40	sand	clayey sand	thick sand layer	12	15	V	response	Similar form to T36 but more sand bars. Tree stumps in channel create headcuts 0.1m high at 2 locations.	T39
T40	30.6305	-87.87328		1	1	0.7	0.7	6	0.5	suburban-res	max	forests	max	brush	50	brush	100	herbaceous	0	0	30	0	-	muck	sand	8	18	am	ind	End of reach T39. Marshy reach with negligible canopy.	T40
T41	30.6303	-87.87294																												End of reach T40	T41
T42	30.63	-87.87277																												Silt fence in stream. 0.5 m fall over silt fence and roots.	T42
T43	30.63	-87.87228																												Sewage riser in channel.	T43
T44	30.6299	-87.87176													60	roots	20	roots	0	0	20	50	-	sand	-	-	18	I	transport	Channel migrating towards yard.	T44
T45	30.6302	-87.87099		0.7	0.7	1	1	2	0.25	forest	max	privet	max	privet	70	roots	70	roots	0	0	10	10	sand	sand	firm sand and roots	16	19	I	transport	Stable channel. Fresh sand on FP with lots of leaf litter over sand. Typical hummacky FP of this valley. Can't tell if it has a series of high flow chutes or has avulsed numerous times. 0.2m high fall over roots.	T45

Data Table 2. Field data for the Tiawasee Creek main stem and tributaries. ***Sheet 2 of 2***

Assessment Site	Latitude	Longitude	Other Location	Bank Top Height		Bankfull		Banktop Width (m)	Bed Material (dia in mm)	Surrounding Landuse	Riparian Zone Width (m) and				Bankface Protection % Density and Type				Bank Erosion by		Bank Erosion		Dominant Bank Material		Bed Condition	Sediment Deposition	Channel Flow Status	CEM Class	Reach Type	Notes	Assessment Site
				LB	RB	LB	RB				LB	LB Cover	RB	RB Cover	LB	LB Type	RB	RB Type	LB	RB	LB	RB	LB	RB							
TA1	30.6441	-87.89442																												Pipeline xing.	TA1
TA2	30.6435	-87.89493		1	1			2.5	0.5-5	forest	max	forest	max	forest	30	privet	30	privet	0	0	30	30	sand	sand	aggrading firm sand	10	10	V	transport	Secondary vegetation growth on FP. Moss on bankfaces implies bank stability.	TA2
TA3	30.6433	-87.8953																												Budweiser can with UPC symbol buried 30cm below floodplain.	TA3
TA4	30.6427	-87.89551																												Culvert under dirt road (platted as Sherwood Drive).	TA4
TA5	30.6424	-87.89588																												8" dia white PVC sewage pipe xing stream 0.8m above bed. Banks 2m high from here to TA4. Negligible MW. Lots of scour.	TA5
TA6	30.6424	-87.89669																												DS end of rip-rap repair. Banks 4m high. Similar forn to gully at site JA3.	TA6
TA7	30.6424	-87.89746																												Gully below point TA8.	TA7
TA8	30.6422	-87.89796																												Dirt road xing detention pond drain.	TA8
TA9	30.6422	-87.89828																												Top of dam of detention pond.	TA9
TC1	30.6335	-87.88356																												Below Greenwood Dr. 3m drop out of box culvert. Constructed after road washed out during hurricane Danny in 1998.	TC1
TC2	30.6329	-87.88385																												4m deep channel with active MW. Large trees fallen in which exacerbate erosion.	TC2
TC3	30.632	-87.88405																												3m high banks undergoing MW.	TC3
TC4	30.6318	-87.88379																												MW within past week says Ashley. "D'Olive Creek below I-10 looked like this in Feb 2008".	TC4
TC5	30.6315	-87.88406																												Headcut advanced from TC4 to TC5 in one year's time. Ashley.	TC5
TC6	30.63	-87.88413																												Beaver pond. Borrow pit on left terrace with recent constructed berm and benches to slow runoff and trap sediment.	TC6
TC7	30.6243	-87.8812																												Anasstomosed stream. Deep channels. Stable channels. Sediment on floodplain. Saw cottonmouth.	TC7
TC8	30.6181	-87.87922																												Broad wet bottom above Whispering Pines Road. Negligible erosion on hillslope from church parkinglot on east side. However, leaf litter in woods has been collected into debris piles by high flows.	TC8
TC10	30.6111	-87.88159																												Potential detention pond location. Existing berm to south creating small pond. Existing flooded woods?	TC10
TCA1	30.6322	-87.88418																												Restabilized tributary at sewer line xing.	TCA1
TCA2	30.6321	-87.88569																												Stable channel. Sewage pipeline xing perp to stream. Slightly incised. Not a sed source.	TCA2
TCA3	30.6305	-87.88747																												From TCA5 to Park Drive no sediment on floodplain.	TCA3
TCA4	30.6286	-87.88876																												Moss covered floodplain below detention structure. No sediment on floodplain. 0.2m deep channel.	TCA4
TCA5	30.6282	-87.88879																												Detention structure.	TCA5
TCA6	30.6271	-87.88825																												Channel full of sediment. Banks 0.8m high. Outfall to LB.	TCA6
TCA7	30.6268	-87.88809																												Channel incised behind lady's house with rip-rap protection on RB.	TCA7
TCA8	30.6254	-87.88847																												Gully head below Eagle Creek Drive. Stable above Drive.	TCA8
TCB1	30.6256	-87.87985																												Flowing trib	TCB1
TCC1	30.6088	-87.86964																												Ditch with debris pliugged culvert. "Rabbit" (city of Daphne employee who lives nearby) said mobile home to the north of Knight Ln has flooded in the past.	TCC1
TE1	30.6341	-87.87764	50 m above Montclair Loop	1.6	1.6	-	-	4	2	suburban-res	10	woods	15	woods	30	roots	30	roots	0	0	50	50	ck organic m	ck organic m	coarse sand over black organic muck	15	-	III	source	Blown out channel with trees and roots mid-channel. Apparent white 8" dia PVC pipe crossing bed 1.5m below bank top. Headcut of 2m fall over 20m long thru black muck and roots.	TE1
TF1	30.6331	-87.87785																												Drainage from pond. Sand embedded channel. Resident said lawsuit brought by Lake Forest against Tiawasse caused pond to be built.	TF1
TG1	30.6294	-87.87214																												Sediment choked confluence with trib to LB.	TG1
TG2	30.6295	-87.87201		1	1	1	1	4	0.25	forest	max	forest	max	est mostly pr	20	herbaceous	20	herbaceous	0	0	0	0	sand	sand	choked with sand	3	5	V	response	Huge sediment load. Possibly dominant source for Tiawasse.	TG2
TG3	30.6268	-87.86817		1	1	1	1	1.9	0.25	forest	max	forest	20	forest	30	roots	30	roots	0	0	20	20	sand	sand	dry sand	10	-	I	transport	Dry bed with sand on floodplain.	TG3
TG4	30.6269	-87.868																												Debris screen on DS side of road xing. 6ft dia culvert. Headcut thru roots is 10m above culvert.	TG4
TG5	30.6265	-87.8676		0.3	0.3	0.3	0.3	2	0.25	20	max	forest	max	forest	30	roots	30	roots	0	0	30	30	sand	sand	sand and roots	-	-	am	response	FP buried in sand. Some moss growing on sand point bar indicates stability. Tangled roots crossing bed.	TG5
TGA1	30.628	-87.87302																												Heavy sand deposit in forest. Braided channel. Roots scoured out by high flows. FP soil consists of 10cm of orange tinged sand overlying brown sand. Not much organic material mixed in.	TGA1
TGA2	30.6276	-87.87345																												Wet detention. Big mosquitos. 6m high outlet structure. Straw on embankment not effective at preventing erosion. 20cm thick sand deposit at top of slope.	TGA2

Data Table 3. Field data for the Joe's Branch main stem and tribs and trib L and Baptizing Branch (outside the Watershed).

Assessment Site				Bank Top Height		Bankfull					Riparian Zone Width (m) and				Bankface Protection % Density and Type				Bank Erosion by		Bank Erosion		Dominant Bank Material							Notes	Assessment Site
	Latitude	Longitude	Other Location	LB	RB	LB	RB	Banktop Width (m)	Bed Material (dia in mm)	Surrounding Landuse	LB	LB Cover	RB	RB Cover	LB	LB Type	RB	RB Type	LB	RB	LB	RB	LB	RB	Bed Condition	Sediment Deposition	Channel Flow Status	CEM Class	Reach Type		
J1	30.6654	-87.90308																												End of reach from J2 to J1. Lots of scour on bankface.	J1
J2	30.6654	-87.90253																												Similar to channel above headcut at J4. Transitions to slightly incised.	J2
J3	30.6658	-87.90158	10m above powerline xing.																											Top of headcut.	J3
J4	30.6659	-87.9007		1	1			2	0.5	forest	max	forest	max	forest	high flow. Probably roots.															Braided system with water flowing in all braids. Banks obscured by high flow.	J4
J5	30.6661	-87.90091																												Top of detention pond dam.	J5
JA1	30.6656	-87.90905		0.3	0.3			8	0.1-1	suburban-res	max	forest	40	tall grass	100	grass	100	grass	0	0	0	0	sand	sand	heavily aggraded	0	0	am	response		JA1
JA2	30.6657	-87.90947																												End of reach. Gully.	JA2
JA3	30.6659	-87.90969		0.3	0.3			7	0.1-1	forest	max	forest	max	forest	10	roots	10	roots	80	80	50	50	silty clay	silty clay	scoured to larger iron concretion cobbles and hardpan.	10	12	IV	source	Trees being recruted to channel by MW. Scour is of MW material.	JA3
JA4	30.6661	-87.90966																												Series of headcuts into hardpan. Banks 4m high and are MW.	JA4
JA5	30.6664	-87.90945																												Same as at JA4 but banks are 7m high. Active slope failure around us in rain.	JA5
JB1	30.6652	-87.90653	100 m above Town Center Ave.	0.4	0.7			4	0.5	commercial	20	forest	20	forest	20	saplings	20	saplings	0	0	0	0	sand	sand	aggrading firm sand	2	2	V	response	Sediment deposits blanket floodplain.	JB1
JB2	30.6666	-87.90708		1.2	1.2			4	0.5	forest	max	forest	max	forest	50	roots	50	roots	10	10	40	40	silty sand	silty sand	aggrading sand	5	5	V	transport	Transports high sand load in incised channel. Several large trees fallen in channel due to mass wasting. 50m US transitions to braided. Remains braided for at least another 150m US.	JB2
JB3	30.6688	-87.90609	200m below US 31	0.3	0.3	0.3	0.3	2	0.5	forest	max	forest	max	forest	20	saplings	20	saplings	0	0	0	0	sand	sand	braided sand	3	3	am	response	Aggrading sand much like at JB1.	JB3
JB4	30.6689	-87.90606																												Heavy deposition across valley under where powerline crosses stream.	JB4
JB5	30.6695	-87.90585																												Confluence. West fork is clear. East fork is turbid.	JB5
JB6	30.6697	-87.90546		3	3			5 to 15	0.2-2	forest	max	forest	max	forest	10	roots	10	roots	70	70	30	30	sandy hardpa	andy hardpa	aggrading sand	5	7	IV	source	Deeply incised and heavy MW taking place.	JB6
JB7	30.6711	-87.90319																												Gullied ditch along south side of US 31.	JB7
JB8	30.6711	-87.9026																												Broad well grassed swale under powerlines. Rip-rap in road side ditch is partially effective grade control. Gravel road from water treatment station. Partly grassed dirt ridge and detention pond next to power substation.	JB8
L1	30.6473	-87.90094																												Above road, concrete lined reach for at least 70m. Rip-rap near road.	L1
Dam	30.6515	-87.90725																												Dam at Lake Forest Lake.	Dam
Stream outside the D'Olive Creek watershed																															
Baptizing	30.757	-87.91348																												Beaver pond on trib to Baptizing Branch.	Baptizing
Baptizing	30.7577	-87.90124																												Headwater trib to Baptizing Branch north of Cloverleaf Landing Rd.	Baptizing

Data Table 4. Field data for the Upland sites.

Assessment Site	Latitude	Longitude	Other Location	Bank Top Height		Bankfull		Banktop Width (m)	Bed Material (dia in mm)	Surrounding Landuse	Riparian Zone Width (m) and				Bankface Protection % Density and Type				Bank Erosion by		Bank Erosion		Dominant Bank Material		Bed Condition	Sediment Deposition	Channel Flow Status	CEM Class	Reach Type	Notes	Assessment Site
				LB	RB	LB	RB				LB	LB Cover	RB	RB Cover	LB	LB Type	RB	RB Type	LB	RB	LB	RB	LB	RB							
U1	30.6656	-87.90942																												Toe of shopping plaza slope. 20m high. 80% cover near toe. 100% cover near top.	U1
U2	30.6722	-87.90529																												Dry detention. No apparent outlet. 2ft dia inlet at west end of basin. Probably outside watershed.	U2
U3	30.6655	-87.90234																												Gullied road under powerline xing. 2m wide x 2m deep.	U3
U4	30.6662	-87.90225																												Photo of rill in powerline easement.	U4
U5	30.6553	-87.89046	Just W of Harley Davidson Shop																												U5
U7	30.6489	-87.86797																												Concrete lined stable ditch on east side of CR 13.	U7
U8	30.6559	-87.86248																												Gully along NE side of US 90. Woody wetland above US 90.	U8
U9	30.6502	-87.86278																												Vegetated dry channel with leaf litter on bottom.	U9
U10	30.672	-87.87421																												Clean white sand on slope behind yard in woods.	U10
U11	30.632	-87.87825																												Detention pond at Tiawasse subdivision.	U11
U12	30.6253	-87.87649																												Catch basin in French Settlement. Soil with 50% grass cover.	U12
U13	30.6256	-87.87575																												2cm high pedistaled pebble represents soil erosion over 10x20m area.	U13
U14	30.6289	-87.87647																												Fork in dirt road. Road has little erosion. Land use is young pine forest on citronelle formation.	U14
U15	30.63	-87.87618																												Dirt road joins Cowles Crossing. Erosion over last 20m of dirt road. Rills in grass hillslope. Sand deposits at slope toe. This type of erosion is pervasive throughout watershed.	U15
U16	30.6298	-87.87596																												Forest floor with dense oak leaf and pine needle duff. Duff is 1-2cm thick plus 1-2 cm of dense roots in sand with white fungus overlying at least 15cm of well sorted tan sand. No black O-horizon. Forest dominated by 3" to 6" dia trees. A few trees to 12" dia.	U16
U17	30.6271	-87.87607																												Forest floor with dense oak leaf and pine needle duff. Duff is 3-5cm thick over well sorted slightly organic-rich brown sand.	U17
U18	30.6252	-87.87507																												Failed silt fence, not properly installed, allows sediment to reach catch basin.	U18
U19	30.6253	-87.87395																												15cm deep rills on area of about 1:10 slope. Estimate of 3cm average eroded over entire area. Most sed deposited behind silt fence. This general area is likely the dominant sed source for TG and T	U19
U20	30.6269	-87.87309																												Exposed hard Citronella Formation.	U20
U21	30.6258	-87.87317																												Gully in Ctronella	U21
U22	30.6244	-87.86922																												98% grass cover on flat ground. 85% grass cover on sloped ground.	U22
U23	30.644	-87.86926																												Catch basin on Worchester Dr.	U23
U24	30.6445	-87.86962																												Catch basin on Worchester Dr.	U24
U25	30.6463	-87.86966																												Catch basin on Melanie Cir.	U25
U26	30.6483	-87.86967																												Escarpment 1.5m high at top of old MW. Largest trees on slope 15" dia.	U26
U27	30.6477	-87.87023																												Actively headcutting gully on RB of trib draining from under Edgar Circle. Lots of sand deposits on forest floor above headcut. Gully ~50m long. Forested channel above headcut is about 50m long.	U27
U28	30.6477	-87.86949																												Catchbasin on Edgar Circle.	U28
U29	30.6478	-87.87252																												Stormwater drain from cul-de-sac outputs high on slope. Multiple sites of MW along trib.	U29
U30	30.6465	-87.87492																												Big sand pile in back of yard.	U30
U31	30.6705	-87.89615																												Ball park. Ashley said there was severe erosion during construction.	U31
U32	30.6639	-87.85624																												Woodrow Lane. Prior to Jan 2009 it was a dirt road west of point U32	U32
U33	30.6637	-87.85874																												Dirt road with upper two feet of soil eroded off to hard Citronelle cap. Gully thru hard surface.	U33
U33	30.6593	-87.8793																												Diviersion channel from D'Olive creek restoration 5 weeks earlier.	U33
U35	30.6544	-87.88668																												Water overtops road at numerous places.	U35
U36	30.6427	-87.89631																												Deposition on Trib. Channels not clearly defined. Apparent multiple sources of flow.	U36
U37	30.6433	-87.89711																												Head of gully, 20m long x 6m wide x 4m deep.	U37
U38	30.6433	-87.89736																												Stormwater catch basin inlet to gully.	U38
U39	30.6158	-87.87462																												Detention pond at ball fields.	U39
U40	30.6131	-87.8748																												Fallow field and parking lot are dead flat. Some rainsplash erosion.	U40
U41	30.6124	-87.87296																												Fallow field and earth mounds.	U41
U42	30.6111	-87.87977	Ditch S. of Well Rd.	1.6	2.2			3	Hardpan	agricultural	1	privet	5	privet	10	privet	10	privet	0	0	80	80	sandy hardpa	andy hardpa	scoured to hardpan	20	16	III	source	Gravel road serves as a sediment source. Headcut 30m US. Bean field to south.	U42
U43	30.6111	-87.88083																												Ditch is 1.2m deep.	U43
U45	30.6627	-87.87073																												Dirt road with upper two feet of soil eroded off to hard Citronelle cap. Gully thru hard surface.	U45
U46	30.6258	-87.88003																												Severely eroded dirt road.	U46
U47	30.6227	-87.87982																												Stressed trees in gentle valley to NW of end of Carosel Ct.	U47
U48	30.6096	-87.86404																												Two detention ponds.	U48
U49																														Detention pond	U49
U50	30.6264	-87.8733																												Apparently effective dry detention.	U50
U51	30.6396	-87.89114																												Barren 0.9 acre lot undergoing severe rainsplash erosion.	U51

APPENDIX B

Wetland Condition Evaluation: D'Olive Creek, Tiawasee Creek, and Joe's Branch Watersheds (Baldwin County, Alabama)

WETLAND CONDITION EVALUATION: D'OLIVE CREEK, TIAWASEE CREEK, AND JOE'S BRANCH WATERSHEDS (BALDWIN COUNTY, ALABAMA)

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INTRODUCTION

The following report provides an overview of current characteristics of, and impacts to, wetlands found within the D'Olive Creek, Tiawasee Creek, and Joe's Branch watersheds in Baldwin County, Alabama. Specifically, the studied wetlands are located in the Daphne and Spanish Fort areas north of County Road 64, west of Mobile Bay, east of Highway 181, and south of Highway 31. D'Olive Creek, Tiawasee Creek, and Joe's Branch are three distinct sub-watersheds within the overall study area. Together they form the D'Olive Bay watershed. A summary of conditions recorded during Vittor & Associates' annual submerged aquatic vegetation (SAV) study within D'Olive Bay itself are also included.

Barry A. Vittor & Associates, Inc. performed a field survey, utilized aerial photography to gather information on the current condition of wetlands within the study area, and created a simple grading system to aid in determining relative impacts. The field survey consisted of pre-selecting sample locations based on accessibility, location within each sub-watershed, and the site's similarity to adjacent wetlands. At each sample location, observations were recorded on canopy species and closure, midstory and understory species and density, degree of apparent sedimentation, exotic species present, impacts to the surrounding upland buffer, and potential methods that could be used to enhance or restore the wetlands. In addition to the initial field survey and examination of aerial photography, detailed photographs taken during Tetra Tech Inc.'s watershed erosion activity assessment were used to determine conditions in areas that were not observed by Vittor & Associates personnel. To foster compatibility between the wetlands assessment and the erosion activity assessment report prepared by Tetra Tech, the sample site location identifiers were labeled using the same nomenclature scheme used by Tetra Tech.

The wetlands referred to in this report are Section 404 jurisdictional wetlands as defined by the U.S. Army Corps of Engineers. Isolated or man-made ponds, ditches, and retention basins were not considered wetlands for the sake of this survey. Three distinct types of jurisdictional wetlands occur within the D'Olive Bay watershed:

(1) Brackish tidal marsh – The brackish tidal marsh is associated with the mouth of D'Olive creek and the vegetated wetland fringe surrounding D'Olive Bay. It is characterized by a thick cover of native marsh species such as southern cattail (*Typha domingensis*), common three square (*Schoenoplectus pungens*), and common reed (*Phragmites australis*).

(2) Bottomland hardwood forested wetlands – The bottomland hardwood forested wetlands are primarily located along the creeks and tributaries and are relatively narrow in the study area watersheds due to the hilly topography of the area. Vegetative characteristics varied widely from location to location, but most wetlands of this type within the watershed are characterized by mature native canopy species such as sweetbay magnolia (*Magnolia virginiana*), swamp tupelo gum (*Nyssa biflora*), and yellow-poplar (*Liriodendron tulipifera*).

(3) Seepage-slope forested pine/hardwood wetlands – Seepage-slope forested pine/hardwood wetlands were very similar to bottomland hardwood wetlands in vegetative composition, but were located on the hillsides surrounding the creek bottoms and contained scattered loblolly pine (*Pinus taeda*) and slash pine (*Pinus elliottii*).

WETLAND IMPACTS

Primary impacts in all wetlands of the listed watersheds are related to sedimentation and/or hydrologic modifications which have altered stream channel characteristics. Much of the watersheds are heavily developed, and much of the development took place on steep slopes that are characteristic of the upland buffers surrounding wetlands in west-central Baldwin County. Unfortunately, Best Management Practices (BMPs) were not always used during the construction process, and large quantities of sediment washed into the wetlands during heavy rain events. BMPs were not required for construction activities until around 1992, and BMPs such as sediment fencing to manage post-construction runoff were not required until recently.

When wetlands become heavily impacted by sedimentation, their native vegetative structure is often altered. Seeds from aggressive exotic species such as Chinese privet (*Ligustrum sinense*) and Chinese tallowtree (*Triadica sebifera*) germinate quickly in freshly deposited sediment where competing native species have either died or become stressed. Exotic species are less desirable than native species for a number of reasons. Because they are growing outside of their normal range and beyond the reach of their established diseases and pests, exotics are often able to out-compete native species that would occupy a similar niche in a native ecosystem. This can lead to the replacement of dozens of diverse native species with one or two exotic species that cannot provide the same natural food source or shelter as the original vegetative community. This process has occurred in most wetlands within the studied watershed to varying degrees.

Severe stream and channel erosion are causing impacts to the wetlands adjacent to the stream channels in many areas. During the survey, it was noted that many large trees growing alongside the streams have recently fallen or are leaning due to their root systems being undercut. When large trees fall, they often crush and shade smaller shrub and herbaceous species which creates openings in both the canopy and understory. As the tree decays, exotic species often become established due to their ability to out-compete native species, as discussed above.

WETLAND CONDITION SURVEY

Sixteen locations within the study area were sampled by Vittor & Associates during a three-day field survey conducted in October, 2009. The 16 sites were chosen based on a number of factors; including their respective positions within each of the three sub-watersheds; accessibility by road (to save man hours in the field by cutting hiking times); representative nature of the impacts and overall condition compared to surrounding wetlands (at least one site was located in each wetland area with unique characteristics in each of the three sub-watersheds); and spatial distribution throughout the study area. Stream reaches and associated wetlands above and below the selected sites were visually inspected on foot and by vehicle to ensure that each site was not located in an area that had unusual characteristics. The sites were treated as individual plots, that is, all observations were made from a single location. This method was used to allow greater consistency between sites. The wetlands and uplands adjacent to each survey location were examined and relevant characteristics were noted. The survey locations were labeled by location within each watershed using the nomenclature approach used in Tetra Tech's Watershed Assessment Report to facilitate comparison between the two studies.

Notes on wetland vegetation (understory, midstory and canopy species composition), health of the vegetation, surrounding buffers, estimated percent cover of exotic species, and apparent impacts were recorded at each location. The results of the field survey were used in conjunction with aerial photography to grade the current condition of wetlands at each sample location, and within each individual sub-watershed. Vittor & Associates created a simple methodology to grade each wetland survey site according to the most important factors affecting the overall watershed: stability of the surrounding upland buffers, current vegetative composition and health, evidence of past impacts, and potential for future impacts. The grading scale is presented in Table 1:

Table 1. *Wetland evaluation methodology (1=most impacts, 5=least impacts)*

SCORE	CHARACTERISTICS
1	Severely impacted/impaired wetland system. Wetlands are severely impacted by sedimentation, upland buffers are unstable and continue to supply sediment during rain events, greater than 50% exotic species composition, canopy trees (natives) are dead or dying, drainage patterns may be altered, and understory vegetation dominated by exotic species.
2	Low-Medium quality wetlands. Canopy trees (native) are stressed and many are dead or dying vegetative strata contain 25-50% exotic species, sedimentation is causing/has caused impacts to drainage patterns, and upland buffers are altered and unstable and may cause further sedimentation in heavy rain events.
3	Medium quality wetlands. Canopy trees are predominately (>75%) native, sedimentation is present but wetlands have stabilized and are functional despite the past sediment, understory vegetation is <25% exotic, upland buffer has been altered but is stable and future sedimentation should be minor.
4	Medium-high quality wetland system. Canopy trees are >95% native, understory vegetation contains <5% exotic species, uplands are stable and have vegetated buffers 50-100 feet wide, past sedimentation has not caused significant reduction in wetland function.
5	Relatively undisturbed/high-quality wetland system. Canopy trees are native and healthy, sedimentation has not caused damage to the original wetland function, understory is free from exotic species, and upland buffers are greater than 100 feet (vegetated) and stable with a low likelihood of future sedimentation.

SURVEY RESULTS

Joe's Branch

Wetlands bordering Joe's Branch, which flows from north to south and empties into D'Olive Creek just west of the Lake Forest Lake Dam, are the most heavily impacted of those found within the three primary drainage ways. Commercial development associated with the recently constructed Spanish Fort Town Center northeast of the intersection of Interstate 10 and Highway 98 surrounds the south half of Joe's Branch. During the site preparation for the new commercial complex, approximately 235 acres of the Joe's Branch watershed were cleared. However, it should also be noted that severe erosion and high sediment source potential has been documented in tributaries to Joe's Branch upstream of drainage from the Spanish Fort Town Center.

Three survey points were examined in the Joe's Branch sub-watershed. Characteristics of the jurisdictional wetlands were very similar at each of the locations. TABLE 2 shows the summary of scores given to the wetland sites surveyed by Vittor & Associates in the Joe's Branch sub-watershed.

***Table 2**. Joe's Branch Summary of scores*

LOCATION	SCORE
Site J1W	1
Site JB1W	2
Site J2W	3

Site J1W (J=Joe's Branch, W=Wetland) was located adjacent to the new Spanish Fort Town Center, in between its southern entrance road (Bass Pro Drive) and the northern entrance road (Town Center Avenue). This section of Joe's Branch has been severely impacted by sedimentation. Approximately 50% of the mature, native canopy trees are dead or dying, the understory is dominated by exotic species. The sediment deposits are over 12 inches deep across much of the wetland, and the upland buffer has been cleared. Site J1W scored a 1 (highest impacts) on our wetland grading scale. While the recently constructed shopping plaza cannot be discounted as a possible source for some of the sediment in this reach of Joe's Branch, it appears that the most significant sources of the sediment have originated from upstream of the site. Tetra Tech's erosion activity assessment has documented actively advancing headcuts, resulting in channel incision and bank erosion, in both tributaries JA and JB. However, it should be noted that it was beyond the scope of this study to comprehensively quantify the relative contributions of sediment sources.

Two locations were sampled north of Site J1W. Sites JB1W and J2W were located approximately 0.5 mile upstream of Site J1W. Site JB1W scored 2 points, and Site J2W scored 3 points using our wetland grading scale. Primary impacts to these two sites were (1) sedimentation due to commercial development and road construction, and (2) exotic species, primarily (*Ligustrum sinense)*, in the under and mid-stories. North of the new commercial development and the surveyed sites, aerial photography was used to examine the main branch of Joe's Branch and tributaries JA and JB. Tributaries JA and JB are clearly impacted by fresh layers of sediment and contain very little understory vegetation. The wetlands adjacent to the main stream channel have experienced less sedimentation for approximately 1500 feet, but sedimentation becomes apparent again south of Maury Court. Maury Court is a residential road in the Westminster Subdivision which contains approximately 21 lots. Homes are currently being built on several of the lots, or have been built within the last few years, and a detention pond was built to slow runoff from the Court.

Tiawasee Creek

The wetlands associated with Tiawasee Creek have been impacted primarily by sedimentation associated with the Lake Forest Subdivision Development, and increased volume and velocity of runoff entering the system during rain events. Approximately 3,700 lots have been developed within the Lake Forest community over the past few decades, but detention ponds were never installed to slow the runoff of water from the residential lots. At the time the Lake Forest subdivision was developed there were no requirements for BMPs during construction or for post-construction stormwater runoff management. Fortunately, the mature hardwood trees that occupy the riparian areas of the watershed were never cleared and most are relatively healthy.

Four sites were surveyed within the Tiawasee Creek sub-watershed. TABLE 3 shows the summary of scores given to the wetland sites surveyed by Vittor & Associates in the Tiawasee Creek sub-watershed.

Table 3. *Tiawasee Creek Summary of scores*

LOCATION	SCORE
Site T2W	4
Site TC1W	3
Site TA1W	4
Site T1W	2

Site T2W, was located near a bridge inside the Tiawasa Subdivision west of Highway 13 and scored a 4 on our wetland grading scale. Although the wetlands have been impacted by sediment, most canopy trees were healthy, and few exotic species have become established along this section of Tiawasee Creek. It should be noted that most of the upland buffer upstream of Site T2W has not been developed for residential housing or commercial purposes. Site TC1W was located southwest of Site T2W just east of Pollard Road, and scored a 3 on the grade scale. It had very similar characteristics to Site T2W, but had a much higher percentage of exotic seedlings in the understory and deeper sediment deposits which might have entered the wetland from an adjacent dirt pit during heavy rain events. Wetlands in the riparian area of Tiawasee Creek east of Tributary TG were relatively undisturbed and the surrounding upland buffer was undeveloped. The only significant impact to wetlands in that section on the Creek was scattered exotics species throughout the understory, resulting in a score of 4 on the grade scale. South of TC1W, wetlands surrounding Tributary TC retain the same characteristics and, therefore, the score of 3 on the grade scale. However, sub-tributary TCC was one of the most heavily impacted wetlands within the study area. TCC flowed through an agricultural field and all native vegetation had been cleared. All wetlands surrounding TCC scored a 1 due to extreme manipulation of the historical wetland system.

Sites TA1W and T1W were approximately 900 feet apart and located near the center of the Lake Forest subdivision. Site TA1W was located near the tennis courts in a seepage-slope type wetland (adjacent to Tributary TA) that drains into the main branch of Tiawasee Creek. The canopy trees at Site TA1W were very healthy and created a closed canopy, which allowed very little light penetration into the understory. The wetland showed evidence of extreme (>12 inches in many locations) sedimentation that likely occurred many years ago, but the system has recovered well in terms of species composition. Site TA1W scored a 4 on our grading scale. Site T1W was located approximately 900 feet east of Site TA1W in the riparian area of Tiawasee Creek. Wetlands around Site T1W were heavily impacted by sedimentation and the removal of much of the native/natural vegetation. The dominant canopy tree species is currently planted loblolly pine, and the midstory was dominated by exotics and green titi (*Cyrilla racemiflora*). Sedimentation has altered the natural hydrology to the point that upland exotics such as cogongrass (*Imperata cylindrica*) and camphortree (*Cinnamomum camphora*) have become established in areas along the creek that were historically bottomland hardwood swamp. Site T1W scored a 2, rather than a 1, on our grade scale because the upland buffer is heavily vegetated in most areas and danger of future sedimentation is minor compared to sites surrounded by new development.

D'Olive Creek

Seven sites were sampled within the D'Olive Creek sub-watershed, and two additional sites, Sites D1W and D2W, were sampled just east of the point where D'Olive Creek empties into D'Olive Bay. Conditions within the D'Olive Creek watershed vary dramatically depending upon location, but the majority of the wetlands have been impacted by sedimentation from commercial and residential developments associated with the Lake Forest and Timber Creek subdivisions. TABLE 4 shows the summary of scores given to the wetland sites surveyed by Vittor & Associates in the D'Olive Creek sub-watershed.

Table 4*. D'Olive Creek Summary of scores*
(Includes confluence of all sub-watersheds near D'Olive Bay)

LOCATION	SCORE
Site D1W	1
Site D2W	4
Site DC1W	2
Site D6W	2
Site D4W	5
Site DA1W	4
Site D3W	2
Site DB1W	4
Site D5W	4

Site D1W was located just southwest of the Interstate 10 and Highway 98 interchange. Nearly all of the wetlands associated with D'Olive Creek in this area have been severely altered or filled, and Site D1W scored a 1 on our grade scale as a result. The narrow wetland fringe that remains on either side of the creek is dominated by young exotic species such as Chinese tallowtree (*Triadica sebifera*) and the native tree species, black willow (*Salix nigra*).

Site D2W was located east of Highway 98 approximately 1200 feet upstream (east) of Site D1W. The Mature forested canopy of Site D2W was healthy, mature, and contained primarily native trees such as Sweetbay (*Magnolia virginiana*), swamp tupelo gum (*Nyssa biflora*), bald cypress (*Taxodium distichum*), and red maple (*Acer rubrum*). Young exotics such as Chinese tallowtree (*Triadica sebifera*) and Chinese privet (*Ligustrum sinense*) were present in the under and mid-stories, but had not become dominant in those strata. Site D2W scored a 4 on the grade scale, and only lost a point due to the presence of scattered exotic species.

Sites DA1W and DB1W were located on separate tributaries of D'Olive Creek, but had very similar characteristics. Site D5W was located on the main drainage way of D'Olive creek, but also had similar characteristics to Sites DA1W and DB1W. Each of the three sites was dominated by a healthy canopy of native hardwood tree species, and sparsely vegetated understories occupied by native species such as wax myrtle (*Myrica cerifera*), giant gallberry (*Ilex coriacea*), and native ferns. Each of the three sites scored a 4 using our numerical evaluation method due to scattered exotics and evidence of previous sedimentation. DA1W was located on the main tributary of D'Olive Creek, tributary DA. Sections of Tributary DA's riparian wetlands are relatively undisturbed and scored 4 on the grade scale. However, areas such as the confluence of DA and sub-tributary DAC have narrow wetland buffers which have been heavily impacted by the erosion of the stream banks. The headwaters of tributary DA have also been heavily impacted by commercial development and the placement of a detention pond in the historical stream channel. Site DB1W was located on Tributary DB, which has relatively few wetland impacts compared to other wetlands within the D'Olive Creek sub-watershed. The entire length of DB scored a 4 on the grade scale due to sparse exotics and minimal siltation due to a primarily undeveloped upland buffer.

Site D4W was the only surveyed wetland point that we scored as a 5 using our grading methodology. It was vegetated with native species in all strata, sediment deposits were not negatively impacting the health of the desirable tree species at the time of the survey, and the upland buffer was stable and contributing little if any additional sediment to the system. Debris deposits were noted on the shrubs and on tree trunks in the wetlands at Site D4W suggesting that, during heavy rain events, the water level rises very rapidly. The high, fast-moving water could be the reason silt deposits had not accumulated in the area surrounding Site D4W. Another factor contributing to Site D4W's score of 5, despite the fact that it is downstream of wetlands that scored 2, 3, or 4, could be the lack of development in the surrounding upland buffer and the buffer's lack of exotic species.

Sites DC1W and D6W, which were located upstream of Site D4W within the Timber Creek subdivision and each scored a 2 on the grade scale, were heavily impacted by sedimentation and exotic species. The native canopy at Site DC1W, had been totally cleared, leaving only small sweetbay (*Magnolia virginiana*), yellow-poplar (*Liriodendron tulipifera*), and Chinese tallowtree (*Triadica sebifera*) in the midstory. Site D6W had numerous large native canopy trees that were dead or dying, most likely due to deep sediment deposits. The wetlands to the east and west of Site D6W had similar characteristics and impacts, and also scored a 2 on the grade scale. The impacts to wetlands north of Site DC1W became less significant towards the headwaters of the tributary, and were graded as a 3, then 4 (see map) as exotic species in the under and mid-stories became less numerous and impacts siltation less severe.

Site D3W was located just east of the eastern tip of the lake in Lake Forest Subdivision. The wetland had been severely altered to the point that it was hard to distinguish what the pre-development conditions might have been. Currently, the wetland is devoid of large canopy trees, is colonized in the midstory by exotic species, and seems to be inundated beyond its natural state due to the impoundment caused by the lake as evidenced by the depth of the creek waters on the surviving trees. The severe hydrologic alteration and exotic species earned Site D3W a score of 2 on the grade scale.

D'Olive Bay

D'Olive Bay receives the runoff from the three sub-watersheds discussed in the previous paragraphs. It is a very shallow body of water bordered to the north and west by brackish tidal marsh, Mobile Bay to the south, and the western shore of the city of Daphne to the east. D'Olive Creek (which carries the water from all three sub-watersheds) flows in to the Bay in its northeast corner.

The brackish tidal marsh that surrounds D'Olive Bay is dominated by cattail (*Typha sp*.) and bulrush (*Schoenoplectus*) species. There are scattered patches of common reed (*Phragmites australis*) in the marsh buffer, but they are confined to the islands of slightly higher ground within the marsh surface. Each of these species is adaptable to fluctuations in water quality and salinity, and plays an important role in filtering the runoff that exits the mouth of D'Olive Creek. There are also several patches of submersed aquatic vegetation (SAV) that occur in the north half of D'Olive Bay. Southern waternymph (*Najas guadalupensis*), grassleaf mudplantain (*Heteranthera dubia*) Eurasian watermilfoil (*Myriophyllum spicatum*) are the dominant SAV species in the bay. It should be noted that Eurasian watermilfoil (*Myriophyllum spicatum*) is an exotic species. In addition to providing habitat and forage for aquatic fauna and birds, the SAV beds perform the valuable function of helping catch sediments that may remain suspended in the discharge from D'Olive creek after heavy rain events.

CONCLUSIONS AND RECOMMENDATIONS

Joe's Branch

Wetlands surrounding Joe's Branch are the most severely impacted of those found within the three sub-watersheds. As Joe's Branch flows from north to south, the impacts increase until the water flows into a series of culverts under Interstate 10. At that point, the original wetland is nonexistent and the primary function of the waterway is to carry runoff to D'Olive Bay.

There are opportunities to enhance or restore segments of wetlands surrounding Joe's Branch, especially the section just north of Bass Pro Drive. Restoration activities could include mechanical removal of the sediment deposits, and supplemental planting of desirable native trees and shrubs. To increase the chance that the restoration activities would be successful, it would be necessary to control stream erosion upstream of the Spanish Fort Town Center. Stream bank and bottom erosion provide the major source of sediment impacting the wetlands. While reducing the sediment bed load transported into the wetlands from stream erosion is considered a priority, it would also be important to better stabilize and maintain the steep upland slopes surrounding the wetlands to protect the wetland from sediments generated by on-site erosion of steep slopes.

Sections of Joe's Branch near survey Sites JB1W and J2W could be enhanced by removal of shallow sediment deposits, and would not require supplemental planting due to the healthy, closed canopy that currently exists in those areas.

Tiawasee Creek

Much of Tiawasee Creek and its tributaries have been heavily impacted by sedimentation over the past few decades. The tributaries and sections of Tiawasee Creek that are located south and east of Lake Forest Subdivision have healthy canopies of mature bottomland hardwood tree species, but exotic species have become established throughout much of the understory and would need to be actively treated and managed to enhance the existing vegetative composition of the wetlands.

Sections of Tiawasee Creek that are surrounded by homes in the Lake Forest Subdivision would be much more difficult to enhance due to the steep topography of the surrounding uplands and the close proximity of the homes, some of which are built on pilings and overhang the jurisdictional wetlands adjacent to the creek. There is a section of the creek just east of the Lake Forest Lake that is not surrounded by development and could be restored or enhanced through a series of steps designed to reduce or eliminate sedimentation during rain events. The first step could be the elimination of runoff from dirt lanes and roads that provide access to the wetland bottom. This could be achieved by limiting traffic with gates, or by placing rock in the tire ruts where most of the sediment originates. The second step would be the removal of existing sediment deposits that have not been washed into the wetlands. The third and final step would be clearing the undesirable planted pines and exotic vegetation in the riparian areas and replanting native species that occupied the wetlands prior to disturbance. It should be noted that enhancement/restoration of the wetlands would be very difficult to execute if steps aren't taken to reduce the quantity and velocity of storm water runoff that flows through the Tiawasee Creek drainage way during heavy rain events.

D'Olive Creek

D'Olive Creek and its associated wetlands have been severely impacted within the majority of the sub-watershed due to dense commercial and residential development. The construction of the Lake Forest Subdivision impacted the western half of the creek, but more recently the Timber Creek Subdivision has contributed to the rapid degradation of habitat quality within the northeastern region of the watershed. Home building within Timber Creek has contributed large quantities of sediment to the upper reaches of D'Olive Creek and its tributaries, and the subdivision's road network, golf course, and driveways/roofs of homes have all contributed greatly to the amount of runoff that the creek must accommodate during storm events. The quantity and velocity of the water has caused severe erosion within the creek bottom and has pushed sediment far downstream, altering the vegetative composition of much of the surrounding wetland acreage. As with the other two watersheds, D'Olive Creek has been impacted primarily by sedimentation.

Wetlands within the D'Olive Creek watershed could be enhanced or restored using the same measures detailed above for the Tiawasee Creek and Joe's Branch wetlands. The first priority in enhancing the wetlands would be to stabilize the sources of runoff and sedimentation that continue to impact the system. For example, there is an old dirt pit just west of Douglas Road that is (or was) frequently used by ATV riders and off-road trucks for recreation. Aerial photography of the area depicts the tire ruts and their paths leading to the wetlands surrounding D'Olive Creek. If these areas could be closed to recreational vehicles, the area could be seeded with appropriate grasses and allowed to re-vegetate and stabilize. Wetlands adjacent to the roads in the Timber Creek subdivision have areas of deep sediment deposits and could be enhanced through removal of the sediment deposits using a conveyor belt system and shovel labor, or through the use of heavy equipment. An exotic species management plan would need to be developed to detail methods of treatment that could be used to rid the wetland's understory of Chinese privet (*Ligustrum sinense*) and Chinese tallowtree (*Triadica sebifera*).

Summary

Restoration or enhancement of any of the wetlands found in the three studied watersheds is possible, but would be labor and time intensive. Establishment of erosion control measures should be first on the list of priorities when examining methods that could be used in the process, followed by development of an aggressive exotic species management plan. Finally, after success has been proven in the efforts to reduce sedimentation and the spread of most exotic species, a vegetative enhancement /restoration plan could be developed that would provide a methodology for returning the wetlands to their pre-development species composition.

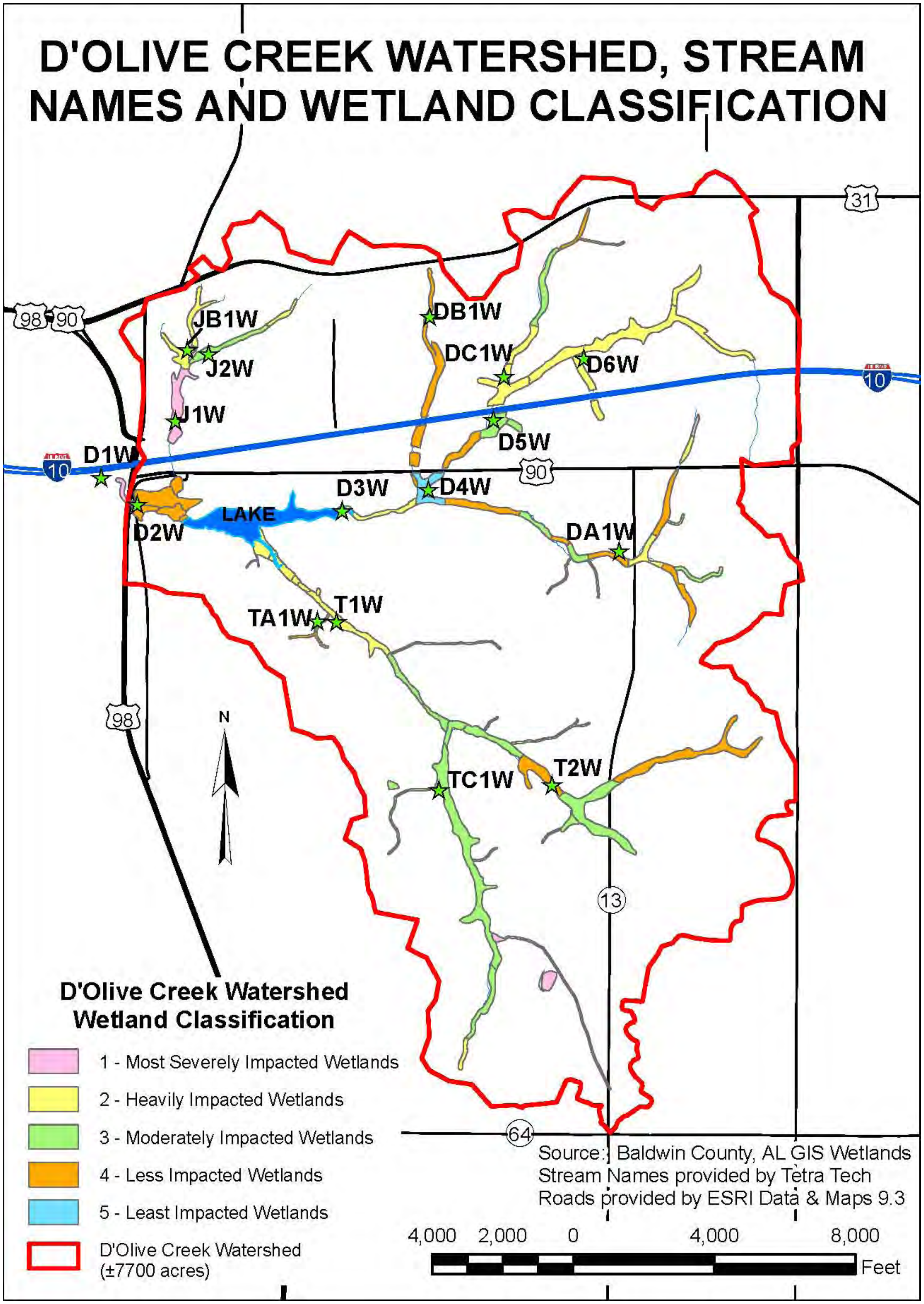
D'OLIVE CREEK WATERSHED, STREAM NAMES AND WETLAND CLASSIFICATION
JB1W
J2W
J1W
D1W
D2W
LAKE
D3W
D4W
DB1W
DC1W
D6W
D5W
DA1W
T1W
TA1W
TC1W
T2W
98
90
10
31
13
64
N
D'Olive Creek Watershed Wetland Classification
1 - Most Severely Impacted Wetlands
2 - Heavily Impacted Wetlands
3 - Moderately Impacted Wetlands
4 - Less Impacted Wetlands
5 - Least Impacted Wetlands
D'Olive Creek Watershed (±7700 acres)
Source: Baldwin County, AL GIS Wetlands
Stream Names provided by Tetra Tech
Roads provided by ESRI Data & Maps 9.3
4,000 2,000 0 4,000 8,000
Feet

PHOTO 1: View of Site D1W looking southwest across D'Olive Creek. Note the exotic vegetative cover in the riparian area and lack of natural canopy.

PHOTO 2: View of Site D2W looking northeast across D'Olive Creek. Note the natural vegetative cover in the riparian area and healthy native canopy.

PHOTO 3: Site J1W understory (Joe's Branch). Note the heavy cover of exotic species and light penetration due to the stressed/open canopy.

PHOTO 4: Taken from the same location as Photo 3, this angle shows the large openings in the canopy caused by tree death and/or defoliation.

PHOTO 5: Site JB 1W looking north. Most significant impact to this area was the heavy sediment deposit and resulting stress in some canopy trees.

PHOTO 6: Site JB 1W looking south. Same situation as seen in Photo 5. Sediment deposits had altered the understory vegetative composition, but were not old/deep enough to kill the canopy trees.

PHOTO 7: Site J2W looking north. Note the re-contouring of the upland buffer to the edge of the wetland line.

PHOTO 8: Site DC1W looking south. Note the extremely dense Chinese tallowtree (Triadica sebifera) in the mid and understories. The canopy had also been cleared of mature trees.

PHOTO 9: Site DC1W looking north. This view shows more clearly the damage done to the canopy of this wetland. The houses in the photo are located in the Timber Creek subdivision.

PHOTO 10: Site D6W looking north. Again, sedimentation has severely stressed the canopy and eliminated much of the native understory vegetation in this section of D'Olive Creek.

PHOTO 11: Site D4W was the only location that received a score of 5 on our grade scale. Note the native canopy, mid and understories. Exotic species are extremely sparse in this area of D'Olive Creek.

PHOTO 12: Site T2W was located on Tiawasee Creek in the Tiawasa Subdivision. Primary impacts to this section of Tiawasee Creek are associated with the establishment of exotic species in the understory.

PHOTO 13: This photo was taken from the upland buffer just west of the Site TC1W wetland (visible as the bottom of the hill). Though the canopy trees at Site TC1W were relatively healthy, the understory was dominated by the exotic shrub Chinese privet (Ligustrum sinense).

PHOTO 14: Site TA1W was located on a seepage slope near stream TA. Though the area had deep sediment deposits, the native vegetation in all strata had adapted and were relatively healthy.

PHOTO 15: Wetlands at Site T1W were heavily impacted in several ways. In this photo, you can see exotic cogongrass (Imperata cylindrica) and Chinese privet (Ligustrum sinense) growing at the waters edge. Also, the nature hardwood canopy had been cleared and loblolly pine (Pinus taeda) planted in the riparian area.

PHOTO 16: Site D3W was located just east of the Lake Forest pond and was dominated by exotic species in all strata. The water level in the wetland also appeared to have been artificially raised due the impoundment of the pond water.