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Watershed Management Plan
for the
D'Olive Creek, Tiawasee Creek, and Joe's Branch Watersheds
Daphne, Spanish Fort, and Baldwin County, Alabama

Final – August 2010

Submitted to:

Mobile Bay National Estuary Program
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Acknowledgements

Excessive erosion and sedimentation have plagued D'Olive Creek Watershed since the 1970s. Increased volume and velocity of stormwater runoff, as well as changes to local drainage patterns resulting from urbanization of the Watershed have exacerbated concerns over erosion and sedimentation within the Watershed streams, Lake Forest Lake, D'Olive Bay, and Mobile Bay.

In recent years, the Mobile Bay National Estuary Program (MBNEP) facilitated efforts to address the D'Olive Watershed problems. This involved establishing the D'Olive Watershed Working Group (DWWG) which is a coalition of federal, state, and local agencies; county and local governments; property owners; developers; and commercial interests. These entities worked together to reach the collective decision that a comprehensive Watershed Management Plan (WMP) was needed for the D'Olive Watershed.

Preparation of this WMP was made possible by collaborative funding provided by the Alabama Department of Environmental Management, U.S. Environmental Protection Agency, Mobile Bay National Estuary Program, Mississippi-Alabama Sea Grant Consortium, Alabama Power Company, Baldwin County, the Cities of Daphne and Spanish Fort, and the Lake Forest Property Owners Association.

Thompson Engineering, Inc. was selected to organize and manage the work of the Consultant Team. Thompson Engineering personnel were responsible for evaluating the Watershed problems and developing conceptual management measures to address them; suggesting modifications to the regulatory framework that guides land use and development activities within the Watershed; and identifying possible funding sources to finance implementation of the management measures contained in the WMP. Other members of the Consultant Team included: (1) Tetra Tech, Inc. which led the stream evaluation work; (2) Barry A. Vittor & Associates, Inc. that conducted the wetland evaluations; (3) Hand Arendall LLC which assisted in the review of the existing regulatory framework and evaluation of funding options; and (4) the Alabama Coastal Foundation which, in conjunction with MBNEP, developed the community relations and public outreach strategy to gain the support of the Watershed stakeholders in implementing the WMP recommendations. Principal personnel from the Consultant Team who contributed to development of this WMP included: Glen Coffee, Emery Baya, Carl Pinyerd, Cindy Roton, John Carlton, Terri Litrell, and Jake Gibbs (all of Thompson Engineering); Nick Jokay (Tetra Tech); Barry P. Vittor (Barry A. Vittor & Associates); Neil Johnston and Preston Bolt (Hand Arendall); and Bethany Kraft (Alabama Coastal Foundation).

The Consultant Team would like to recognize the following individuals, organizations, and agencies that assisted in the conduct of various phases of work on the WMP. Roberta Swann, Sara Shields, and Tom Herder of the Mobile Bay National Estuary Program provided steady and consistent leadership in managing the contract. Ashley Campbell of the City of Daphne shared her intimate knowledge of the D'Olive Watershed, and her sustained energy and genuine passion in seeking long term solutions to the Watershed's many problem areas

played a major role in the development of the WMP. Julie Batchelor of Baldwin County provided valuable information relative to the County's land use planning and zoning activities. The cooperation of Baldwin County's Kenny McIlwain in making available the County's 2005 Geographic Information System database (along with advance distribution of 2009 aerial imagery) was crucial to developing the many graphics contained in the WMP and in the land use/land cover analyses presented in the Plan. The NASA land cover analysis covering the period 1974 through 2008 was used to supplement the Baldwin County land use data and to present historical trend information. Bruce Renkert of the City of Spanish Fort and Patti Hurley of the Alabama Department of Environmental Management responded in a timely manner to a variety of information requests. Marlon Cook of the Geological Survey of Alabama willingly shared his extensive knowledge of the Watershed's discharge and sediment loading data, while Vince Calametti of the Alabama Department of Transportation cooperated in providing information on the State's highway maintenance program and opportunities to modify aspects of that program to reduce stormwater runoff. The Lake Forest Property Owners Association has a great interest in the outcome of the WMP. As a result, John Peterson shared information on concerns related to sedimentation problems reducing the volume of Lake Forest Lake and Ray Sturch devoted his time to assure the relationship of the Lake Forest Golf Course to stormwater runoff issues was fully appreciated. Finally, Henry Lawson of the Lake Forest Improvement Committee and Victoria Phelps of the Daphne Planning Commission also shared their views on the stormwater runoff and sediment transport problems affecting the Lake Forest Subdivision.

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Watershed Description. The D'Olive Creek Watershed is located in Baldwin County, Alabama. Draining a total area of over 7,700 acres, the Watershed consists of three principal tributaries: D'Olive Creek, Tiawasee Creek, and Joe's Branch. The overall Watershed receives its name from D'Olive Creek which is considered to be the drainage's major stream. Governmental control for the Watershed is shared by the Cities of Daphne and Spanish Fort and by Baldwin County.

D'Olive Creek and Tiawasee Creek flow into Lake Forest Lake, with Joe's Branch joining D'Olive Creek downstream of the lake. The entire D'Olive Watershed empties into Mobile Bay by way of a small embayment known D'Olive Bay. Mobile Bay is Alabama's principal estuary, receiving drainage from most of Alabama (all but the extreme northern and southeastern portions of the State) as well as portions of northwestern Georgia and northeastern Mississippi. Mobile Bay is included in the National Estuary Program.

The D'Olive Watershed contains over a total of almost 23 miles of streams. As portrayed in Figure ES-1, a total of 2.2 miles of streams have already been substantially degraded by past head-cutting and sediment accumulations; 3.9 miles of streams are currently being affected by active head-cutting, and an additional 5.9 miles of streams have the potential to experience degradation in the future. Thus, slightly over half of the Watershed's total stream mileage have been, currently are being, and/or have the potential of being adversely affected by conditions created by excessive stormwater runoff.

The Geological Survey of Alabama completed a study of sediment loadings in the D'Olive Watershed during the 2-year period of 2007-2008. The study revealed that the D'Olive Creek drainage supplied approximately 83% of the total sediment load delivered to Lake Forest Lake over this period, with the Tiawasee Creek drainage providing most of the remainder. Thus, it is clear that D'Olive Creek sediment loads are much more significant in terms of the total sediment load received by the lake. The study data indicated that 65% of the D'Olive Creek sediment bedload originated from its unnamed tributary designated as "DA" in this report. Data sources considered in developing the WMP indicate that at least 70% of the lake's total volume has been filled with sediments since it was constructed in 1973.

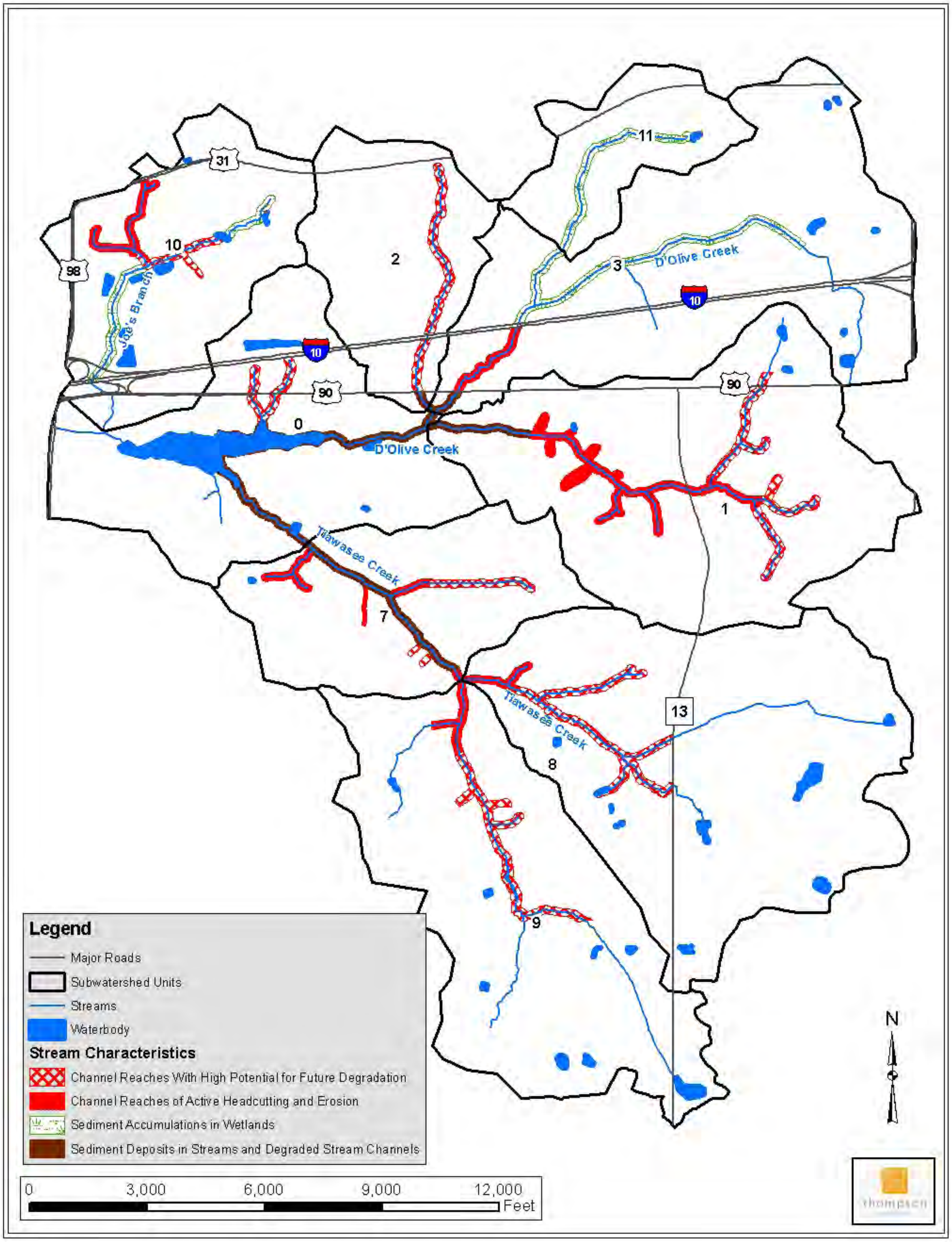

Figure ES-1. Stream and Wetland Degradation Problems in the D'Olive Watershed

Topography, rainfall, soil characteristics, and land cover are the four principal factors that influence stormwater runoff and control overland erosion within the D'Olive Watershed. Of these, land cover is the only factor that man has almost complete control to influence through his land use activities. At the time the WMP was prepared, 47% of the D'Olive Watershed was considered to be in urban land use. Most of the remaining undeveloped land in the Watershed is zoned for residential development, with a small acreage targeted for commercial use.

Watershed Conditions and Critical Areas and Issues. Excessive erosion and sedimentation have plagued the D'Olive Watershed since the 1970s. Population growth and urban development have continued to intensify problems in each of the Watershed's three principal drainages. Increased volume and velocity of stormwater runoff, as well as changes to local drainage patterns, have exacerbated concerns over erosion and sedimentation within the Watershed's stream network, Lake Forest Lake, D'Olive Bay, and Mobile Bay.

To respond to these concerns, the D'Olive Watershed Working Group (DWWG) reached the decision that a comprehensive WMP was needed for the Watershed. The DWWG is a coalition of federal, state, and local agencies; county and local governments; property owners; developers; and commercial interests.

Urban development transforms a portion of the landscape to hard surfaces (i.e. rooftops, driveways, roads, parking lots, patios, compacted soils, etc.) that are collectively referred to as Impervious Cover. The Impervious Cover Model (ICM) developed by the Center for Watershed Protection shows that when the level of imperviousness in a watershed exceeds around 25%, the opportunities to pursue stream restoration become substantially diminished. Data considered in this WMP indicates the Percent Impervious Cover within the overall D'Olive Watershed ranged between 20% and 25% at the time the time the Plan was prepared. Assuming that all remaining undeveloped lands in the D'Olive Watershed could be converted to residential and commercial uses by 2020, the potential Percent Impervious Cover could approach 38%. That level of imperviousness would place streams in the D'Olive Watershed well within the Non-Supporting Streams category of the ICM.

Sediment discharge in the D'Olive Watershed is high because of: (1) the extensive dissection (i.e., deeply eroded stream valleys with relatively steep slopes and numerous tributary segments) that characterizes the Watershed; and (2) the inherent instability of most of the exposed sediments. Excessive stormwater runoff from the urban landscape exacerbates the stream instability problems and contributes to the high sediment loads. Streams within the Watershed are contained on Alabama's 303(d) list of impaired waterbodies due to the excessive sedimentation from urban development.

Wetlands within the D'Olive Watershed are also being adversely affected by the sedimentation and/or hydrologic problems that have altered stream channel characteristics. The principal wetland impacts are associated with Joe's Branch and D'Olive Creek and their respective tributaries. Wetlands along the lower reaches of the main stem Tiawasee Creek channel and along its unnamed tributary designated as "TCC" have also been affected to varying degrees. When wetlands become impacted by excessive sedimentation, opportunities for invasive, exotic plant species to become established are enhanced.

Stormwater issues attributable to urbanization are pervasive throughout the entire D'Olive Watershed. Given the historic development patterns that have occurred to date and the projected future land uses for the Watershed, stormwater runoff reduction measures must be considered for the entire Watershed. Control of stormwater runoff is a Watershed-wide issue of critical importance that must be addressed in a holistic fashion if the stream degradation and sediment transport problems are to be resolved.

Lake Forest Lake receives the drainage from D'Olive Creek and Tiawasee Creek which represents 91% of total area of the D'Olive Watershed. Between 1967 and 1982, it was estimated these two streams delivered approximately 48,000 tons of sediment per year into Lake Forest Lake. An additional 24,000 tons per year was estimated to have passed through the lake to be deposited in D'Olive Bay and Mobile Bay. Recent data indicates the total sediment loads now being delivered to Lake Forest Lake are now approximately 7,800 tons per year. Although sediment loading rates have been reduced, the sediment loads entering Lake Forest Lake are still high, being 14 times the expected erosion rate of an undeveloped watershed.

Despite the reduced sediment discharges into D'Olive Bay, shoaling is still occurring in the Lake Forest Yacht Club entrance channel near the southern end of the bay. However, it is believed those sediments primarily originate from the Blakeley River, with the deposition of those sediments in the vicinity of the yacht club being representative of the natural deltaic processes at work in Upper Mobile Bay and not the direct result of conditions within the D'Olive Watershed.

Watershed Management Goals and Objectives. The four primary objectives that guided development of the conceptual management measures addressed in the WMP were:

- Reduce upstream sediment inputs into the Lake Forest Lake/D'Olive/Tiawasee system.
- Reduce outgoing sediment loads into D'Olive Bay and the Mobile Bay estuary.
- Remediate and restore past effects of these sediment loads, including lake restoration.
- Mitigate future impacts of development in the watersheds, where feasible.

Secondary objectives that influenced the formulation of management measures included: (1) comply with the provisions of Section 319 of the Clean Water Act; (2) develop data and management measures to assist in developing the sediment TMDL scheduled for 2013 to remove the D'Olive Watershed streams from the 303(d) list of impaired streams; (3) contribute to implementation of the Mobile Bay Comprehensive Conservation and Management Plan; (4) maintain Impervious Cover in the Watershed to no more than 25%; (5) restore the natural watershed hydrology, to the extent feasible, by increasing retention of runoff and thereby reducing runoff rate, volume, and duration; (6) mitigate the adverse effects of channel incision, accelerated head-cutting, and streambank erosion caused by development-induced hydrological modifications; (7) remediate and restore waterways, wetlands, and floodplains which have been adversely impacted by sediment deposition and accumulation; and (8) minimize further alteration of hydrology within undeveloped or low-development areas by establishing more effective standards and criteria for runoff retention and erosion control.

Management Measures. Without more effective stormwater management, the projected level of growth will greatly constrain viable stream restoration options. Time is of the essence, given the ongoing channel degradation problems that are being exacerbated with each significant rain event.

This WMP outlines a holistic approach to accomplish the above stated goals and objectives. The WMP identifies a broad range of conceptual measures that can be applied to more effectively manage stormwater and urban development within the D'Olive Watershed. By successfully addressing the co-related problems of excessive stormwater runoff and sediment transport within the D'Olive Watershed, the long-term health of the Watershed's streams and wetlands (and also D'Olive Bay and Mobile Bay) will be enhanced.

The conceptual management measures described in the WMP could be implemented individually or combined to create comprehensive approaches to address both short-term and long-term solutions to the problems being experienced within the D'Olive Watershed over the 10-year life (i.e. through 2020) of this WMP and beyond. The measures include those that can be implemented by individual property owners; neighborhoods and property owner associations; future developers; and/or governmental institutions having jurisdictional responsibility within the Watershed.

The following categories of conceptual management measures are addressed in the WMP:

- Repair immediate problems:
    - Stream restoration
    - Restoration of Lake Forest Lake
    - Wetland restoration/enhancement
- Restore Watershed hydrology
    - Stormwater retrofits for existing developed areas
    - "Smart Growth" concepts for new developments and re-developments
        - Land use planning as the first BMP
        - Low Impact Development/Green Infrastructure (LID/GI) techniques
        - Green Streets concepts
        - Forest preservation
        - Rainwater harvesting
        - Rain gardens

    - Bioretention areas
    - Regional stormwater facilities
    - Preservation of green space
    - Preserve/restore riparian buffers
    - Alternative vegetation management on a variety of land uses
- Strengthen regulatory controls of land development and stormwater runoff

Cost Estimates. Where possible, rough-order-of-magnitude (ROM) cost estimates were developed for each of the management measures presented in the WMP. Preparation of detailed cost estimates were not possible due to the conceptual level of planning that guided development of this WMP. The ROM cost estimates are intended only for preliminary budgetary considerations. However, what is clear is that the costs of correcting the significant hydrological and sediment problems affecting the D'Olive Watershed will be substantial, and are anticipated to range between $22 and $44 million.

What must be acknowledged by D'Olive Watershed interests is that the costs of doing nothing, or at greatly reduced scales, will also result in deferred costs that will eventually have to be paid at some time in the future. The piecemeal actions that have traditionally been undertaken in the Watershed after major storm events to repair road stream crossings, stabilize stream channels, and address eroded streambanks that threaten private property are representative of such deferred costs.

Although governmental entities will out of necessity be required to take a lead role in addressing many of the existing problems, these governmental entities can also pursue regulatory changes to reform future development practices. Such changes could make significant contributions to reducing the likelihood for similar problems to occur in the future as the remaining 2,500 acres of the Watershed zoned for development are converted primarily to residential and commercial uses. That can be accomplished by strengthening regulatory controls and adopting an enhanced land use development philosophy that emphasizes restoration/preservation of the Watershed's hydrology and by requiring developmental interests to design their facilities accordingly and to bear the upfront costs during development to reduce the likelihood of their development projects causing long-term harm to the hydrology of the D'Olive Watershed.

Implementation Strategies. Successful implementation of the management measures presented in the WMP will require that a diverse array of implementation strategies be employed. These strategies will involve all levels of stakeholders within the Watershed: appropriate State agencies (Alabama Department of Environmental Management (ADEM), Department of Transportation, etc.); Baldwin County and the Cities of Daphne and Spanish Fort; other organizations (Mobile Bay National Estuary Program (MBNEP), non-governmental organizations, etc.); property owners associations, and individual property owners. The following implementation strategies should be pursued. They should be initiated as soon as possible and pursued in a concurrent fashion.

- The Baldwin County Commission; the Cities of Spanish Fort and Daphne; the ADEM; and the MBNEP should cooperate to create an intergovernmental "Watershed Restoration Task Force" to focus on implementation of specific measures and actions.
- Repair of the 20,000 feet of stream reaches in the D'Olive Watershed being affected by active head-cutting and channel incision should be pursued immediately after the WMP is approved.
- The Watershed Restoration Task Force could cooperate with the Lake Forest Property Owners Association to develop a "Lake Restoration Plan".
- A Watershed-scale stormwater retrofit program (i.e. involving existing stormwater facilities or new facilities) in existing developed areas should be planned and implemented in a programmatic approach.
- The County and municipalities should collaborate to modify regulatory framework to develop consistent codes and requirements that transcend governmental boundaries to create Watershed-based design, construction, and post-construction stormwater management standards.
- A sustained, targeted public education and community outreach and public education program should be developed and consistently pursued to assure the stakeholders are effectively informed of the Watershed issues and the management needs addressed in the WMP.
- Develop and implement a regular monitoring program to assess and evaluate conditions within the D'Olive Watershed over the 10-year period addressed by this WMP.
- Develop a well-coordinated funding request program that marries the most appropriate funding sources with specific management measures.

Financing Alternatives. A watershed approach to the design, construction, and maintenance of the management measures addressed in the WMP will require a significant and steady stream of funding. Municipalities and other political subdivisions should consider and pursue various funding options for stormwater management, such as the creation of a stormwater utility authority and/or public-private partnerships.

There are a number of different financial structures that could facilitate funding for the management measures identified in this WMP. Fourteen alternatives for funding and financing stormwater improvements in the D'Olive Watershed are discussed in the Plan:

- Water use service fees (i.e., stormwater utility fees)
- Property, sales, or other taxes paid into general funds
- Federal grants, loans, and revenue sharing
- "Green" stimulus funding
- Non-governmental organizations and other private funding
- Mitigation banks
- Impact fees

- Special assessments
- System development charges
- Environmental tax shifting
- Municipal bonds
- Capital improvement cooperative districts
- Alabama improvement districts
- Tax increment financing districts.

Community Outreach and Public Education. The WMP outlines a conceptual Community Outreach and Public Education Plan that should be followed on a consistent basis to address the diverse needs and responsibilities of the affected stakeholders living or doing business within the D'Olive Watershed. Given the varying degrees of knowledge regarding the effects of ongoing urbanization on land use and water quality issues in the Watershed, outreach and education products should be developed that target different messages to different target audiences on issues relating to implementation of the WMP. The activities should be focused on increasing the sensitivity and understanding of the target audiences of the necessity of implementing the management measures outlined in the WMP to: (1) improve environmental quality; (2) enhance the quality of life; and (3) reduce the need to pursue future actions with public funds to correct the consequences of unwise development practices.

Monitoring Program. The WMP outlines the basic requirements of a Monitoring Program that should be pursued to track the efforts and success of efforts related to the implementation of management measures outlined in the Plan. The WMP recommends that Baldwin County, Spanish Fort, Daphne, the Alabama Department of Environmental Management, and the Mobile Bay National Estuary Program establish an intergovernmental "Watershed Restoration Task Force". The Task Force would guide efforts to implement the management measures; monitor and evaluate the effectiveness of the management efforts; seek funding for the management measures; and promote education and outreach activities.

The Task Force should conduct a physical inspection of the Watershed annually. The inspections would focus on monitoring the current condition of the Watershed streams to address the status of the stream and wetland degradation areas. The annual inspections should attempt to (1) determine if the major problem areas are expanding or have been effectively mitigated; (2) assess the effectiveness of management measures implemented to date; (3) assess the overall implementation status of recommended management measures against the Master Implementation Schedule discussed in Section 11.3; and (4) reconsider the implementation priorities to determine if adjustments are in order. The Task Force should document their findings in an annual report.

Two parameters were identified that can be effectively used to "indicate" the overall condition of the D'Olive Watershed: (1) sediment loading; and (2) percent Impervious Cover (IC). Both parameters can be measured by accepted methods and procedures. An annual flow and sediment monitoring program is described. The flow and sediment data would be submitted to the Task Force in an annual data report. Watershed IC should be measured periodically through 2020. IC measurements should be targeted to occur at 2-year intervals, depending upon the availability and quality of adequate remote sensing imagery and the costs to perform the required analyses of that imagery. The IC data should be provided in an electronic, GIS compatible format.

It is believed an adequate Monitoring Program can be established and pursued at a cost ranging between $100,000 and $150,000 each year.

Recommendations. Specific recommendations were offered in the WMP for implementation during the 10-year period addressed by the Plan. Many of these recommendations could be combined for strategic implementation purposes. The recommendations are directed at (1) restoring the Watershed's hydrology to the extent feasible; (2) reducing sediment loads transported downstream to Lake Forest Lake and the D'Olive Bay/Mobile Bay system; (3) removing the D'Olive Watershed streams from ADEM's 303(d) list of impaired streams; (4) contributing to maintaining quality of life issues within the D'Olive Watershed; and (5) reducing the amount of future public funds which could ultimately be required to repair degraded streams in the Watershed.

The recommendations are summarized as follows:

- An intergovernmental "Watershed Restoration Task Force" should be established to guide implementation of the provisions of the WMP.
- Prioritize the D'Olive Watershed's nine subwatersheds to assure that the areas most affected by stormwater runoff and sediment transport are addressed first.
- Implement a programmatic stream restoration approach for a sustained effort to halt the active head-cutting and channel erosion processes currently affecting 20,000 linear feet of streams in the Watershed (see Figure ES-1).
- Develop a comprehensive Watershed hydrologic/hydraulic model (or models) to provide Watershed managers a useful tool(s) to implement the WMP.
- A Green Space Plan should be developed for the Watershed to identify appropriate candidate areas that could be acquired and maintained in an undeveloped condition. The green space areas should be centered along the riparian corridors that border the Watershed streams.
- The Cities of Daphne and Spanish Fort and Baldwin County should evaluate the feasibility of also applying the Baldwin County Horizon 2025 Plan suggestion that greenways/corridors have a minimum width of 400 feet be to stream segments within the two cities as well as in the unincorporated areas of the Watershed.
- Conservation easements should be acquired for the remaining Grady Ponds that exist within the headwater drainage areas of the southeastern portion of the D'Olive Watershed. Opportunities to incorporate these natural features into an overall stormwater management system for the Watershed should be evaluated.
- A wetlands restoration/enhancement program should be implemented, including the removal of accumulated sediments (where feasible), removal of exotic plants, and reestablishment of desirable wetland species.

- The potential to impact groundwater resources should be considered when analyzing stormwater runoff reduction management measures for the D'Olive Watershed.
- The Lake Forest Property Owners Association should mount a sustained campaign to clearly explain that Lake Forest Lake has become a *de facto* sediment deposition basin for 91% of the total D'Olive Watershed. Of the total acreage draining into the lake (7,050 acres), only 1,600 acres originates within the Lake Forest Subdivision, with the remaining 5,450 acres being located in upstream areas. As a result, the lake is capturing a substantial volume of the coarse-grained bedload sediments that would otherwise be delivered to the D'Olive Bay/Mobile Bay system. The loss of the lake's volume represents a loss to the entire Watershed because of the important functions that it serves to protect D'Olive Bay and Mobile Bay from accelerated sedimentation.
- Community stakeholders should evaluate alternative approaches to remove accumulated sediments to restore the volume of Lake Forest Lake.
- All remaining unimproved roads within the Watershed should be stabilized (preferably with pervious material) to minimize erosion and to minimize sediments being transported to area streams.
- Developers should be required to stabilize all roads and parking areas within their project sites as soon as possible after completing clearing, grubbing, shaping, grading, and ditching to retain sediments on-site and to limit the amount stormwater runoff that leaves the site during construction. The stormwater management facilities for each new development should be installed first, and their functionality confirmed.
- Daphne, Spanish Fort and Baldwin County should cooperate in assessing the potential to establish a stream/wetlands mitigation bank or in-lieu fee mitigation program within the D'Olive Watershed.
- Ordinances should be passed and strictly enforced to prevent off-road recreational activities from occurring on power line and other utility right-of-ways to prevent disturbance of soils and erosion. This should be accompanied by the utility companies responsible for maintenance of the right-of-ways being required to pursue remedial actions to repair disturbed areas.
- A "Vegetation Management Plan" should be developed for the Lake Forest Golf Course in close coordination with the golf course stakeholders and the Lake Forest Property Owners Association. That Plan should emphasize reforestation; minimize mowing where play would not be significantly affected; and encourage property owners bordering the course to install protective vegetation barriers separating their property from course fairways to slow stormwater runoff and foster on-site retention.
- The WMP identifies 24 modifications to the existing regulatory environment addressing construction activities to prevent stormwater pollution and reduce stormwater runoff. During the first year following approval of the WMP, the identified entities responsible for each regulatory action should consider the individual recommendations and initiate implementation as appropriate.
- The three governmental entities responsible for the D'Olive Watershed should develop consistent zoning goals and subdivision design guidance that emphasizes minimization

of Impervious Cover; reduces the width of subdivision roads; emphasizes retention of rainfall runoff; applies incentives to encourage Low Impact Development/Green Infrastructure techniques; requires a percentage of the land within project sites be devoted to common green space use; minimizes tree removal and/or requires that replacement trees be planted. Applicable "smart growth" concepts should be employed to the maximum extent possible to guide future subdivision designs.

- For the major roadways in the Watershed, innovative measures should be pursued to reduce the frequency of mowing; allow natural vegetation to reclaim as much of the cleared right-of-ways as possible consistent with safety design standards; promote the use of porous ditch-lining materials; provide energy dissipaters where ditch runoff is discharged into receiving streams; incorporate stormwater retention facilities within the roadway drainage facilities; and landscape/reforest portions the I-10 interchange areas to reduce the overall percentage of Impervious Cover associated with highway corridors.
- A sustained, targeted public education and community outreach program will be critical to assure that the need for action is appreciated. Initiation of that program will begin with the Public Meeting at which the Draft WMP will be introduced for review and comment. After the WMP is completed, regular efforts that utilize a variety of techniques will be required to keep the message fresh and in front of the Watershed stakeholders.
- Monitoring should be performed to assess the effectiveness of the management measures to reduce stormwater runoff and sediment load volumes. The following measures should be included, at a minimum, in the monitoring program:
    - Flow gauges should be established within D'Olive Creek and Tiawasee Creek immediately upstream of their entry into Lake Forest Lake.
    - A periodic sediment loadings assessment program should be performed.
    - A periodic assessment of the 32,000 linear feet of Watershed streams that have the potential to be affected by the continued upstream progression of head-cutting and channel incision (see Figure ES-1) should be performed.
    - The Baldwin County GIS should be expanded to include a new Impervious Cover data layer that should be regularly updated.

In 2015, the effectiveness of the WMP should be formally evaluated to analyze the progress of the stream restoration program; evaluate the current status of stream degradation; assess the effectiveness of the management measures in accomplishing their respective goals and objectives; assess the status of Impervious Cover in the Watershed; and determine if any mid-term corrections in implementing the WMP are needed to address changing conditions. A second evaluation should be accomplished in 2020 at the end of the 10-year period addressed by this WMP.

1.0 Introduction

1.1 Purpose

Excessive erosion and sedimentation have plagued the approximately 7,700-acre D'Olive Watershed since the 1970s. Population growth and urban development have continued to intensify problems in each of the Watershed's three principal drainages (D'Olive Creek, Tiawasee Creek, and Joe's Branch) within the Cities of Daphne and Spanish Fort and associated unincorporated areas of Baldwin County. Increased volume and velocity of stormwater runoff, as well as changes to local drainage patterns, have exacerbated concerns over erosion and sedimentation within the Watershed's stream network, Lake Forest Lake, D'Olive Bay, and Mobile Bay.

To respond to these concerns, the Mobile Bay National Estuary Program facilitated efforts to address the D'Olive Watershed problems. This involved establishing the D'Olive Watershed Working Group (DWWG) which is a coalition of federal, state, and local agencies; county and local governments; property owners; developers; and commercial interests. These entities worked together to reach the collective decision that a comprehensive Watershed Management Plan (WMP) was needed for the D'Olive Watershed.

This WMP outlines a holistic approach to (1) reduce sediment sources; (2) repair degraded stream channels; and (3) restore the Watershed's hydrology to the maximum extent technically feasible. To accomplish these broad goals, this WMP identifies a broad range of measures that can be applied to more efficiently manage urban development within the D'Olive Watershed. This WMP can also serve as a tool to assist in preparing the Total Maximum Daily Load (TMDL) to reduce sediment that is scheduled for 2013. Development of the TMDL should contribute to removing the D'Olive Watershed streams from the State of Alabama's 303(d) list of impaired streams. By successfully addressing the co-related problems of excessive stormwater runoff and sediment transport within the D'Olive Watershed, the long-term health of D'Olive Bay and Mobile Bay will be enhanced.

1.2 Period Addressed by the Plan

Based on the intense growth that the Baldwin County's Eastern Shore has consistently experienced since the 1990s, there is a strong possibility that the D'Olive Watershed could reach a 100% "build out" condition by 2020. At the time the WMP was prepared, approximately 45% of the Watershed was covered in forest and agriculture. Over the 10-year period leading to 2020, it is anticipated that most of the remaining forest and agricultural lands will be converted to urban development, primarily residential uses. Therefore, this WMP was developed to address the 10-year period ending in 2020.

1.3 Document Overview

This WMP is organized in the following manner:

- Section 2 describes the D'Olive Watershed, addressing its pertinent resource characteristics and providing historical context to enable an understanding of the scope of the problems of concern.
- Section 3 evaluates the existing conditions within the Watershed to lay the foundation upon which the management measures were formulated.
- Section 4 identifies the critical areas within the Watershed that have been most affected by excessive stormwater runoff and sediments.
- Section 5 explains the goals and objectives that were used to guide development of the management measures.
- Section 6 describes the conceptual management measures considered to address the stormwater runoff and sediment problems. These measures range from pure engineering solutions to modifications of the regulatory framework controlling development to approaches to better manage future urbanization of the Watershed.
- Section 7 contains a summary of the rough-order-of-magnitude (ROM) cost estimates for the measures.
- Section 8 discusses potential strategies to implement the various features of the WMP.
- Section 9 presents the results of an investigation of potential sources to fund implementation of the management measures.
- Section 10 describes a public education and community outreach program to explain the need to pursue corrective measures and to gain the support of the Watershed stakeholders that is necessary to effectively implement the WMP in a holistic fashion.
- Section 11 outlines a monitoring program to evaluate the success of the management measures over the 10-year planning period to reduce stormwater runoff and sediment sources.
- Section 12 lists the specific recommendations made to implement the WMP.
- Section 13 identifies the extensive literature considered to develop this WMP.

1.4 Watershed Management Team

Preparation of the WMP was accomplished through a collaborative effort that was guided by the DWWG. The members of the DWWG involved representatives of the following entities.

- Mobile Bay National Estuary Program

- Congressman Jo Bonner
- State Representative Randy Davis
- Baldwin County delegation to Alabama Legislature
- City of Daphne
- City of Spanish Fort
- Baldwin County
- Alabama Department of Environmental Management
- Alabama Department of Conservation and Natural Resources-State Lands Division, Coastal Section
- Geological Survey of Alabama
- US Fish and Wildlife Service
- US Army Corps of Engineers
- Natural Resources Conservation Service
- Alabama Department of Transportation
- Lake Forest Property Owners Association
- Lake Forest Improvement Committee
- Tonsmeire Properties
- Malbis Properties
- Cypress/Spanish Fort I LP
- Coastal Alabama Clean Water Partnership
- AT&T

1.5 Public Participation

The Draft WMP was presented to the public at a public meeting on June 29, 2010. The meeting was held at the Alabama Department of Conservation and Natural Resources' Five Rivers Delta Resource Center in Spanish Fort. Following the meeting, the Draft WMP was made available for public review for a 30-day period that ended on July 29, 2010. During that period, hardcopies of the Draft WMP were placed at libraries and other public locations within the Watershed. An electronic copy of the Draft WMP was also linked to the Mobile Bay National Estuary Program's website. In addition to the views and questions expressed at the public meeting, three written comments were received. Appendix E contains the minutes documenting the principal discussions held during the public meeting and the written comments that were received. The comments received did not require any major changes during the preparation of the Final WMP.

2.0 Watershed Description

2.1 Watershed Boundary

The D'Olive Creek Watershed is located in Baldwin County, Alabama (see Figure 2-1). The Watershed is located within the U.S. Geological Survey (USGS) 8-digit Hydrologic Unit Code (HUC) cataloguing unit 03160204 (Mobile-Tensaw). Draining a total area of over 7,700 acres, the Watershed consists of three principal tributaries: D'Olive Creek, Tiawasee Creek, and Joe's Branch. The overall Watershed receives its name from D'Olive Creek, which is considered to be the major stream in the drainage basin.

Tiawasee Creek and D'Olive Creek flow into Lake Forest Lake. Immediately downstream of the Lake Forest Lake Dam, Joe's Branch joins D'Olive Creek. The D'Olive Watershed empties directly into Mobile Bay by way of a small embayment also known D'Olive Bay. Mobile Bay is Alabama's principal estuary, receiving drainage from all but the extreme northern and southeastern portions of the State, as well as portions of northwestern Georgia, and northeastern Mississippi. Mobile Bay is included in the National Estuary Program, one of only 28 officially designated estuaries across the nation that enjoy that status as authorized by the 1987 amendments to the Clean Water Act.

Numerous unnamed first-order and second-order tributaries, many of which are intermittent in nature, flow into the three named streams comprising the D'Olive Watershed. For the purposes of this Watershed Management Plan (WMP), an alphabetical naming convention was employed for these unnamed streams. The main stems of D'Olive Creek, Joe's Branch, and Tiawasee Creek were assigned their first letters; D, J, and T respectively (see Figure 2-2). Starting downstream and working upstream, each unnamed tributary was named alphabetically. Thus, the first unnamed tributary encountered on D'Olive Creek was named DA, and the second, DB, and so on. Tributaries to these tributaries were also named alphabetically, with DAA being an example of the first and DAB being the second tributaries to DA. The same naming convention was employed to identify even the smallest of the unnamed tributaries (i.e., DACA) that were recognized on topographic mapping and in the field.

The D'Olive Watershed is divided into nine subwatersheds (Table 2-1 and Figure 2-2). The subwatersheds were delineated to reflect sampling locations originally defined during previous studies performed by the Geological Survey of Alabama (Cook, 2007; Cook and Moss, 2008). Since sediment load data are available at the most downstream point of each subwatershed, the subwatershed approach is useful for determining the sources of sediments and for future load monitoring.

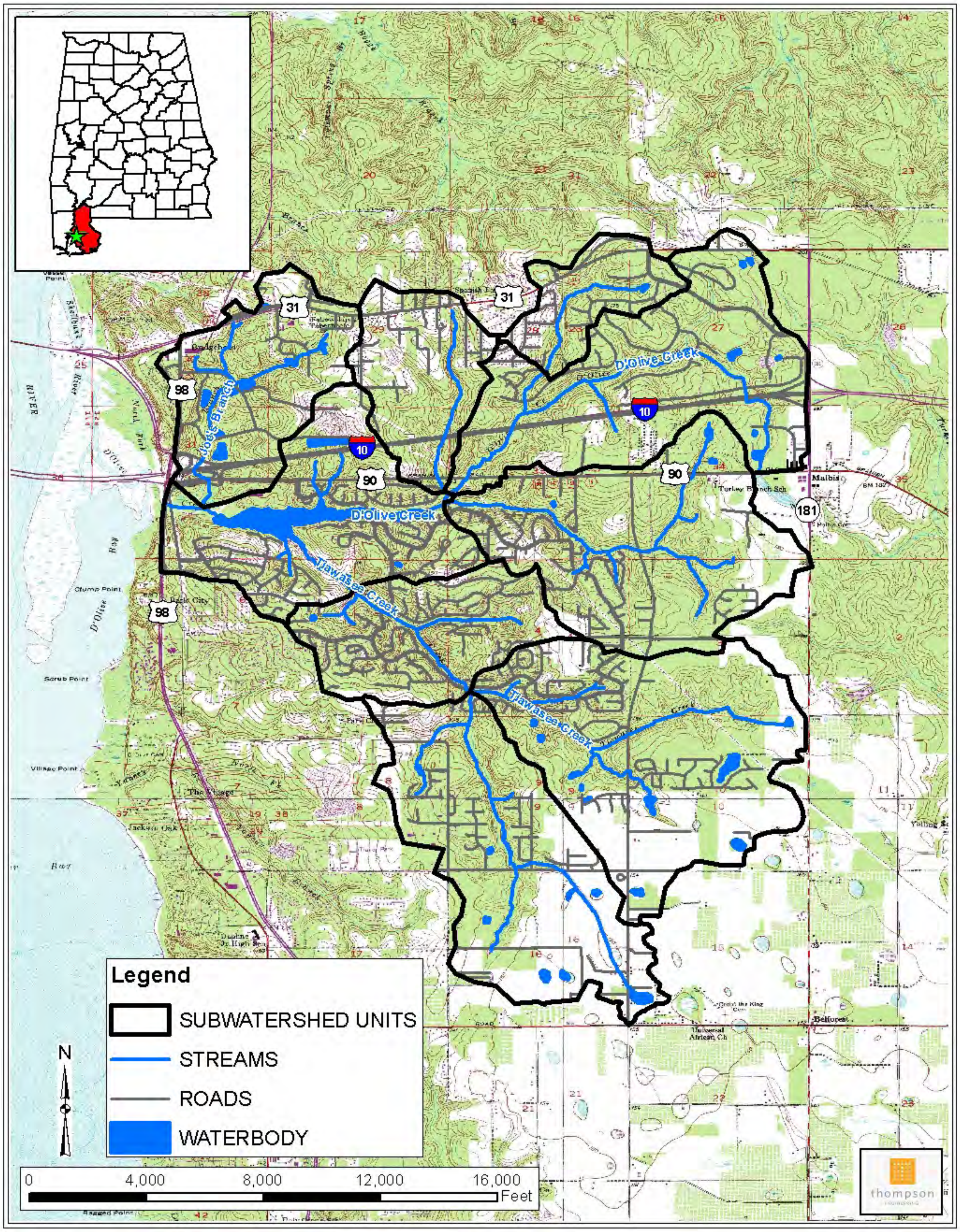

Figure 2-1. D'Olive Watershed

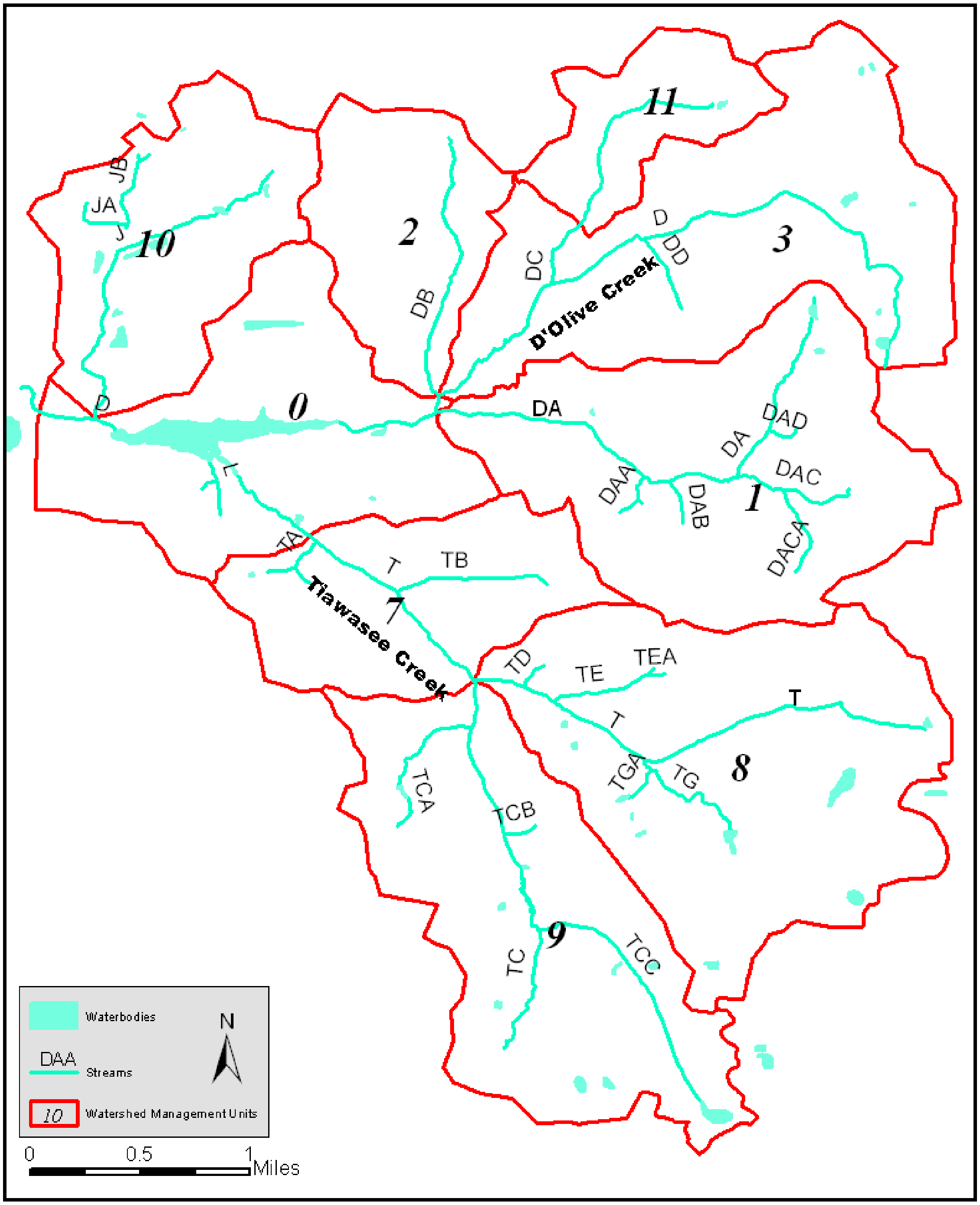

Figure 2-2. D'Olive Watershed, Subwatersheds, and Tributary Designations

Table 2-1. D'Olive Subwatersheds and Tributary Stream Segments

Subwatershed Number [1/]	Streams Within Subwatersheds	Tributary Designations	Total Area (acres)
0	Lake Forest Lake and the lowest 1/2 mile of D'Olive and Tiawasee Creeks	L, D (lower), T (lower)	893
1	Middle and upper tributaries to D'Olive Cr	DA, DAA, DAB, DAC, DACA, DAD	1,161
2	Unnamed tributary DB	DB	466
3	Upper D'Olive Creek and tributaries	D, DD	1,159
7	Middle Tiawasee Cr and tributaries below Ridgewood Drive	T, TA, TAA, TB	601
8	Tiawasee Creek and tributaries above Ridgewood Drive	T, TD, TE, TEA, TF, TG, TGA	1,342
9	Tributaries to Tiawasee Creek above Ridgewood Drive	TC, TCA, TCB, TCC	1,132
10	Joe's Branch and tributaries	J, JA, JB	661
11	Unnamed tributary DC	DC	297
		Total Watershed Acreage	**7,713**

[1/] The subwatershed numbering convention was chosen to match that used in the Geological Survey of Alabama studies of 2007 and 2008.

2.2 Hydrology

2.2.1 Surface Water Resources

The D'Olive Watershed contains almost 23 miles of streams. Table 2-2 lists the streams within the Watershed; providing the stream segment lengths in feet, the beginning and ending elevations for each stream segment, and the slope (i.e. elevation change in feet/feet of stream length) for each stream segment. Figure 2-3 shows the locations of the stream segments listed in Table 2-2.

The largest and only named impoundment in the Watershed is Lake Forest Lake. This approximately 40-acre lake was constructed in 1973 as part of a large residential development of the same name. The lake and its associated concrete dam are managed and maintained by the Lake Forest Property Owners Association. Depths in this lake have been severely reduced by excessive sedimentation.

A number of smaller impoundments also exist within the Watershed. Most of these small impoundments have been constructed as stormwater detention facilities in connection with the many residential and commercial developments that are scattered throughout the watershed.

Several distinctive natural depression wetlands, referred to as Grady Ponds, also occur within the southeastern headwater region of the Watershed. These depressional wetlands have not yet experienced the severe erosion that has shaped the topographic and drainage features of the lower elevation reaches of the Watershed. Section 2.8 addresses the wetland features in more detail.

Table 2-2. Length and Slope Data for D'Olive Watershed Stream Segments

Principal Stream	Tributary	Stream Segment	Subwatershed	Length (feet)	Elevation Change (feet)			Percent Slope
					Downstream	Upstream	Change	
D'Olive Creek	D	D1 (J to Lake Forest Dam)	0	531	1	5	4	0.75
		D2 (Lake Forest Lake to DA)	0	2,521	18	20	2	0.08
		D3 (DA to DB)	0	359	20	23	3	0.84
		D4 (DB to US 90)	3	728	23	27	4	0.55
		D5 (under US 90)	3	123	27	28	1	0.81
		D6 (US 90 to I-10)	3	2,304	28	43	15	0.65
		D7 (under I-10)	3	360	43	47	4	1.11
		D8 (I-10 to DC)	3	450	47	51	4	0.89
		D9 (DC to DD)	3	2,338	51	69	18	0.77
		D10 (DD to I-10)	3	5,677	69	151	82	1.44
		D11 (under I-10)	3	407	151	159	8	1.97
		D12 (I-10 to headwater)	3	3,084	159	188	29	0.94
	DD	DD1 (D to I-10)	3	1,167	69	112	43	3.68
		DD2 (under I-10)	3	319	112	114	2	0.63
		DD3 (I-10 to headwater)	3	404	114	118	4	0.99
	DA	DA1 (D to DAA)	1	5,005	20	44	24	0.48
		DA2 (DAA to DAB)	1	592	44	52	8	1.35
		DA3 (DAB to County Road 13)	1	856	52	66	14	1.64
		DA4 (under County Road 13)	1	272	66	67	1	0.37
		DA5 (County Road 13 to DAC)	1	406	67	75	8	1.97
		DA6 (DAC to DAD)	1	1,355	75	101	26	1.92
		DA7 (DAD to US 90)	1	1,467	101	127	26	1.77
		DA8 (under US 90)	1	167	127	130	3	1.80
		DA9 (US 90 to headwater)	1	1,772	130	160	30	1.69
	DAA	DAA1 (DA to DAAA)	1	561	44	65	21	3.74
		DAA2 (DAAA to headwater)	1	521	65	83	18	3.45
	DAAA	DAAA1	1	145	65	82	17	11.72
	DAB	DAB1 (DA to headwater)	1	1,097	52	94	42	3.83
	DAC	DAC1 (DA to DACA)	1	1,079	75	98	23	2.13
		DAC2 (DACA to headwater)	1	1,689	98	136	38	2.25

Table 2-2 (cont'd). Length and Slope Data for D'Olive Watershed Stream Segments

Principal Stream	Tributary	Stream Segment	Subwatershed	Length (feet)	Elevation Change (feet)			Percent Slope
					Downstream	Upstream	Change	
	DACA	DACA1 (DAC to headwater)	1	2,207	98	150	52	2.36
	DAD	DAD1 (DA to headwater)	1	751	101	123	22	1.46
	DC	DC1 (D to headwater)	11	6,713	51	127	76	1.13
	DB	DB1 (D to US 90)	2	590	23	26	3	0.51
		DB2 (under US 90)	2	109	26	32	6	5.50
		DB3 (US 90 to 1-10)	2	1,219	32	64	32	2.63
		DB4 (under I-10)	2	414	64	65	1	0.24
		DB5 (I-10 to headwater)	2	4,406	65	128	63	1.43
Tiawasee Creek	T	T1 (Lake Forest Lake to TA)	0	2,453	18	22	4	0.16
		T2 (TA to TB)	7	2,085	22	31	8	0.38
		T3 (TB to TC)	7	2,761	31	39	8	0.29
		T4 (TC to TD)	8	1,084	39	51	12	1.11
		T5 (TD to TE)	8	732	51	57	6	0.82
		T6 (TE to TG)	8	2,408	57	81	24	1.00
		T7 (TG to County Road 13)	8	1,140	81	91	10	0.88
		T8 (under County Road 13)	8	198	91	93	2	1.01
		T9 (County Road 13 to headwater)	8	5,125	93	171	78	1.52
	TA	TA1 (T to TAA)	7	773	22	35	13	1.68
		TA2 (TAA to headwater)	7	512	35	57	22	4.30
	TAA	TAA1 (TA to headwater)	7	633	35	66	31	4.90
	TB	TB1 (T to headwater)	7	3,253	31	94	63	1.94
	TC	TC1 (T to TCA)	9	1,152	39	58	19	1.65
		TC2 (TCA to TCB)	9	2,705	58	84	26	0.96
		TC3 (TCB to TCC)	9	2,678	84	99	15	0.56
		TC4 (TCC to Whispering Pines Road)	9	112	99	102	3	2.68
		TC5 (Whispering Pines Road to headwater)	9	3,050	102	134	32	1.05
	TCA	TCA1 (TC to Park Drive)	9	1,307	58	92	34	2.60
		TCA2 (under Park Drive)	9	280	92	103	11	3.93

Table 2-2 (cont'd). Length and Slope Data for D'Olive Watershed Stream Segments

Principal Stream	Tributary	Stream Segment	Subwatershed	Length (feet)	Elevation Change (feet)			Percent Slope
					Downstream	Upstream	Change	
		TCA3 (Park Drive to headwater)	9	852	103	116	13	1.53
	TCB	TCB1 (TC to headwater)	9	730	84	97	13	1.78
	TCC	TCC1 (TC to Whispering Pines Road)	9	1,551	99	144	45	2.90
		TCC2 (Whispering Pines Road to "Grady" pond)	9	4,494	144	151	7	0.16
	TD	TD1 (T to headwater)	8	697	51	72	21	3.01
	TE	TE1 (T to TEA)	8	2,126	57	102	45	2.12
		TE2 (TEA to headwater)	8	195	102	115	13	6.67
	TEA	TEA1 (TE to headwater)	8	378	102	119	17	4.50
	TG	TG1 (T to TGA)	8	333	81	82	1	0.30
		TG2 (TGA to County Road 13)	8	1,349	82	100	18	1.33
		TG3 (under County Road 13)	8	142	100	112	2	1.41
		TG4 (County Road 13 to headwater)	8	1,203	112	126	14	1.16
	TGA	TGA1 (TG to headwater)	8	862	82	106	24	2.78
Joe's Branch	J	J1 (D to I-10)	10	944	1	7	6	0.64
		J2 (under I-10)	10	1,171	7	10	3	0.26
		J3 (I-10 to JB)	10	2,969	10	38	28	0.94
		J4 (JB to detention pond)	10	1,792	38	81	43	2.40
		J5 (detention pond to headwater)	10	1,532	81	140	59	3.85
	JB	JB1 (J to JA)	10	481	38	45	7	1.46
		JB2 (JA to JB3-JB4 split)	10	1,716	45	73	28	1.63
		JB3 (JB3-JB4 split to headwater)	10	156	73	79	6	3.85
		JB4 (JB3-JB4 split to headwater)	10	260	73	87	14	5.38
	JA	JA1 (JB to headwater)	10	1,352	45	80	35	2.59
Lake Forest Lake	TCo	TCo1 (lake to TCoE and TCoW split)	0	144	18	22	4	2.77
		TCoE1 (TCo to US 90)	0	688	22	42	20	2.91
		TCoE2 (US 90 to I-10)	0	1,021	42	90	48	4.70
		TCoW1 (TCo to US 90)	0	622	22	36	14	2.25
		TCoW2 (US 90 to I-10)	0	654	36	41	5	0.76
	UNK	UNK1 (lake to UNKA)	0	495	18	21	3	0.61
		UNK2 (UNKA to headwater)	0	813	21	63	42	5.17
	UNKA	UNKA1 (UNK to headwater)	0	384	21	28	7	1.82

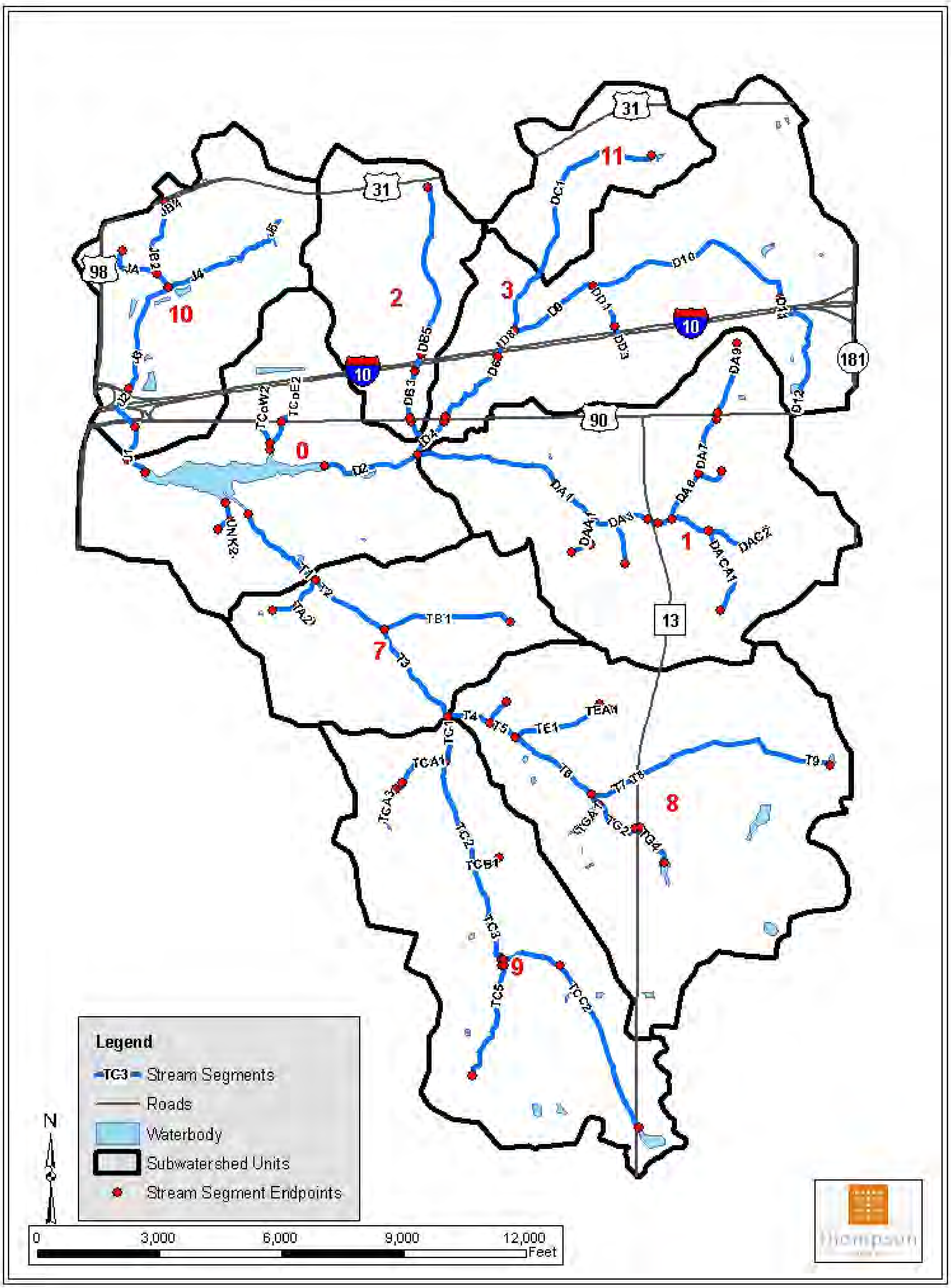

Figure 2-3. Stream Segments for D'Olive Watershed Streams Used to Prepare Table 2-2

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Runoff patterns vary based on factors such as geographic location, local meteorological conditions, vegetative cover, soils, and land use. These will be discussed in subsequent sections of this WMP.

2.2.2 Groundwater Resources

The major aquifer underlying the D'Olive Watershed is the Miocene-Pliocene aquifer. This aquifer consists of the Citronelle Formation and the undifferentiated deposits of the deeper Miocene Series. No continuous confining unit exists between the Citronelle Formation and the shallow part of the Miocene Series undifferentiated. As a result, the two units generally act as a single aquifer.

The recharge area for the aquifer includes all of Mobile and Baldwin Counties and parts of Washington County. In their natural state, the soils throughout most of this area are highly permeable and allow rapid infiltration of surface water. Consequently, the shallow unconfined aquifer is considered to be highly vulnerable to surface water sources of contamination. The aquifer becomes less vulnerable to contamination from the surface with an increasing degree of confinement by clay layers.

Six public water-supply wells identified in by Gillett *et al.* (2000) are located within the D'Olive Watershed. Six additional public water-supply wells occur outside the Watershed boundary, but are within close proximity (i.e. <2,000 feet) to the boundary. These public drinking water wells all derive water from the Miocene-Pliocene aquifer. Below is a list of the wells (identified in Gillet *et al.* (2000)) located within the Watershed boundary:

- Supply well BALCC-6 located south of Waites Lane in Spanish Fort. Operated by Spanish Fort Water System. It was drilled in 1959 to a depth of 378 feet.
- Supply well BALLL-09 located approximately 240 feet west of Timberline Court in Daphne. Operated by Daphne Utilities Board. It was drilled in 1959 to a depth of 315 feet.
- Supply well BALLL-02 located approximately 145 feet west of 507 Ridgewood Drive in Daphne. Operated by Daphne Utilities Board. It was drilled in 1977 to a depth of 155 feet.
- Supply well BALLL-03 located approximately 255 feet west of 130 Kingswood Drive in Daphne. Operated by Daphne Utilities Board. It was drilled in 1982 to a depth of 176 feet.
- Supply well BALLL-011 located approximately 55 feet south of 8194 Well Road in Daphne. Operated by Daphne Utilities Board. It was drilled in 1984 to a depth of 198 feet.
- Supply well BALLL-09 located approximately 300 feet east of Well Road in Daphne. Operated by Daphne Utilities Board. It was drilled in 1992 to a depth of 215 feet.

In addition to the above listed established public water supply wells, there is also a newer well developed by the City of Daphne off County Road 13 behind Daphne High School.

The public utilities operating these wells have conducted source water assessments which define the recharge zones considered vulnerable to contamination. Protection of these groundwater resources should be a consideration when evaluating projects which may introduce potentially contaminated surface waters into groundwater.

2.3 Mobile Bay

The D'Olive Watershed empties directly into Mobile Bay by way of a small embayment known as D'Olive Bay (see Figure 2-1). With a drainage area of 43,000 square miles, Mobile Bay is considered to be the sixth largest river system in the United States. Having an average flow of 100,000 cubic feet per second (cfs), the Mobile Basin is ranked as the fourth largest drainage system in the nation with respect to discharge, second only to the Mississippi, Columbia, and the Yukon River Basins. The Mobile Drainage Basin is comprised of much of Alabama south of the Tennessee River drainage, and includes extreme northwestern Georgia and the northeastern portion of Mississippi as well.

The Mobile Delta is dissected by five major distributaries: the Mobile River, Tensaw River, Spanish River, Apalachee River, and Blakeley River. Of these, the Blakeley River flows past the D'Olive Bay. The Mobile Bay system, including D'Olive Bay, has a diurnal tidal cycle (i.e., one high and one low tide per day).

Mobile Bay provides vital nursery habitat for commercially and recreationally important fish species. In recognition of its importance, Mobile Bay was designated as an estuary of "national significance" in 1996 and was included in the National Estuary Program.

The health of the Mobile Bay estuary is influenced by changing Land Use/Land Cover (LU/LC) patterns within its overall watershed. Increasing urbanization, particularly that occurring within the areas near the shoreline, poses a number of concerns.

Between 2000 and 2006, the populations of Mobile and Baldwin Counties grew by 1.1% and 20.5%, respectively. This population growth was accompanied by increased urban development. Concerns over water quality impacts and aquatic habitat degradation resulting from the land use changes in the D'Olive Watershed and their effects on Mobile Bay contributed to the decision to prepare this WMP.

2.4 D'Olive Bay

D'Olive Bay is a small embayment that is associated with the delta region of the Upper Mobile Bay (see Figure 2-1). D'Olive Bay connects with the Blakeley River, one of the five major distributaries within the Mobile Delta. D'Olive Bay derives its name from a French immigrant, Louis D'Olive, who settled the area in 1803. However, it was not until the Civil War that the bay was first referred to as D'Olive Bay.

D'Olive Bay is oriented in a north-south direction, being just over one mile in length and less than one-third mile in width. Along with upland drainage from the D'Olive Watershed, the Blakeley River and Mobile Bay influence sedimentation patterns within D'Olive Bay.

Marshlands cover the low northern and western sides of D'Olive Bay, while hilly upland areas define the eastern border of D'Olive Bay. D'Olive Bay is separated from the Blakeley River by a prograding narrow peninsula of fluvial origin that is slightly over one mile in length. Historic mapping indicates natural deltaic deposition of sediments may not have formed the western peninsula until around 1820, which would make D'Olive Bay about 150 years old as a distinct geologic feature within the Mobile Delta (Isphording, 1981).

Isphording (1981) reported that D'Olive Bay had an average depth of approximately four feet in the late 1960s. Beginning sometime after 1967, depths within D'Olive Bay began to decrease as a result of the rapid sediment accumulations attributed to the development of the Lake Forest Subdivision. By 1980, the average depth of the upper portions of the bay had decreased to an average of around 2 feet. Shoaling was also reported in the channel in the southwestern portion of the bay, the part of the bay that provided deepwater access from the Lake Forest Yacht Club to the Blakeley River and Mobile Bay. Based on an observed rate of sedimentation of 0.107 to0.166 feet per year between 1967 and 1980, Isphording projected that the depths would continue to shallow to the point that the bay would cease to exist around 1995 to 2000. However, in recent years, the excessive sediment quantities reaching D'Olive Bay appear to have diminished somewhat from the earlier peak volumes.

Flow into and out of D'Olive Bay can occur by way of three openings. The largest is the southern mouth of D'Olive Bay where it empties into Mobile Bay. The second opening is a natural channel that was enlarged by dredging through the fluvial peninsula that separates the bay from the Blakeley River to provide access to the yacht club. The third opening is located in the extreme northwestern portion of the bay and is an extremely narrow channel that connects with the I-10 work canal. Discharges from D'Olive Creek enter the bay through the I-10 canal connection. It is through these access points that discharges and sediments are delivered to D'Olive Bay.

2.5 Lake Forest Lake

Lake Forest Lake was constructed in 1973 as a recreational resource and aesthetic feature within the extensive Lake Forest subdivision. Tiawasee Creek and D'Olive Creek empty into this approximately 40-acre impoundment. Not only does the lake receive the drainage from over 1,600 acres of the Lake Forest subdivision, the runoff from 91% of the total D'Olive Watershed flows through the lake. Joe's Branch and its 661-acres subwatershed drains into D'Olive Creek downstream of the Lake Forest Lake Dam.

Since its completion, Lake Forest Lake has served as a sediment trap for materials originating from the upstream watershed areas. The lake is particularly efficient at trapping larger particles (i.e. sands), with smaller grain size materials (i.e. silts and clays) staying in suspension and being transported through the lake into D'Olive Bay and eventually into Mobile Bay. The coarse sediments settle to form large deltas where D'Olive and Tiawasee

Creeks flow into the lake. Although the photograph contained in Figure 2-4 was taken in 1980 at the point where D'Olive Creek enters the lake, these sedimentation patterns still occur today.

All lakes naturally serve as sediment traps, and are doomed to fill eventually. However, the consequences of poor construction practices during the initial development of the Lake Forest Subdivision accelerated the rate of sedimentation
and greatly reduced the volume of the lake more rapidly than should have normally occurred. In recent years, channel degradation resulting from accelerated stormwater runoff flows and additional sediments derived from sources farther upstream have continued to contribute to the sedimentation problems within Lake Forest Lake.

The total amount of sediment carried into the reservoir between 1967 through 1980 was estimated by Isphording. His calculations indicated that during this 14-year period, almost 718,000 tons of sediment was deposited in Lake Forest Lake, reducing the impoundment's volume by over 345 acre-feet.

Isphording (1981) predicted that the high rates of sedimentation would continue to reduce the trap efficiency of Lake Forest Lake as coarse-grained materials settled in the lake. If the sediment accumulations are not removed and the rate of delivery into the lake is not reduced, the lake will eventually become completely filled. Then, all sediments transported by D'Olive Creek and Tiawasee Creek will pass through the lake and into D'Olive Bay, where the rate of sediment accumulations will destroy this small embayment many years sooner than would be the case through natural deltaic processes.

Figure 2-4. 1980 Deposition of Sediments in D'Olive Creek at Lake Forest Lake (from Isphording, 1981)

2.6 Topographic Relief

Topography is one of the four principal factors influencing overland erosion. The others are rainfall, soil characteristics, and land cover.

The D'Olive Watershed extends roughly four miles inland from Mobile Bay, and has a north-south axis of less than five miles. Over this relatively short distance, elevations rise quickly from sea level to approximately 165 feet along the southern boundary of the Watershed and to around 200 feet along its northern drainage divide. The combination of relatively rugged terrain and high elevations is unique along the entire Gulf Coast of the United States from Florida to Texas. Figure 2-5 shows the 5-foot contours within the D'Olive Watershed.

Topographic relief is a complex function of slope steepness and slope length. The slopes in the D'Olive Watershed from ridge top to the bottom of the Watershed's incised stream valleys can be both steep and long. The steeper the slope, the faster precipitation runs down the slope and the more scouring of the soil surface occurs. The longer the slope, the greater the surface area for collection of precipitation and, therefore, the greater the volume of water carried down the slope. This greater volume carried down the longer slope is both thicker in depth and faster flowing, resulting in greater shear forces for detaching of soil particles from the surface of the soil. Research has shown that reduction of slope length by approximately one-half will reduce the amount of soil lost from the slope by approximately one-third. Practices involving berms and diversions can be used on the long steep slopes to effectively reduce soil loss.

The rapid rise in elevation through the Watershed influences stream slope as summarized by stream segment in Table 2-2. The relatively high stream gradients produce high energy flow conditions during rainfall events.

It is this rapid rise in elevation from sea level over a relatively short distance and the relative steepness and rugged nature of the overall Watershed that contributes to accelerated stormwater runoff and stream channel instability. The streams are engaged in a perpetual struggle to reach an equilibrium condition among runoff volumes, stream gradients, and the erodibility of the streambed materials through which they pass. Changes in either one or all of these variables produce localized channel instabilities, collapses in streambanks, and the erosion of the streambed.

To dissipate the energy of the flows that they convey, streams can either increase their overall length by laterally shifting their channels across their floodplains, or they can reduce their gradients through erosion (i.e. incising) of their streambed. The extreme topography of the D'Olive Watershed and the resulting limited floodplains force the streams to incise downward since there is no room for lateral adjustments in stream length.

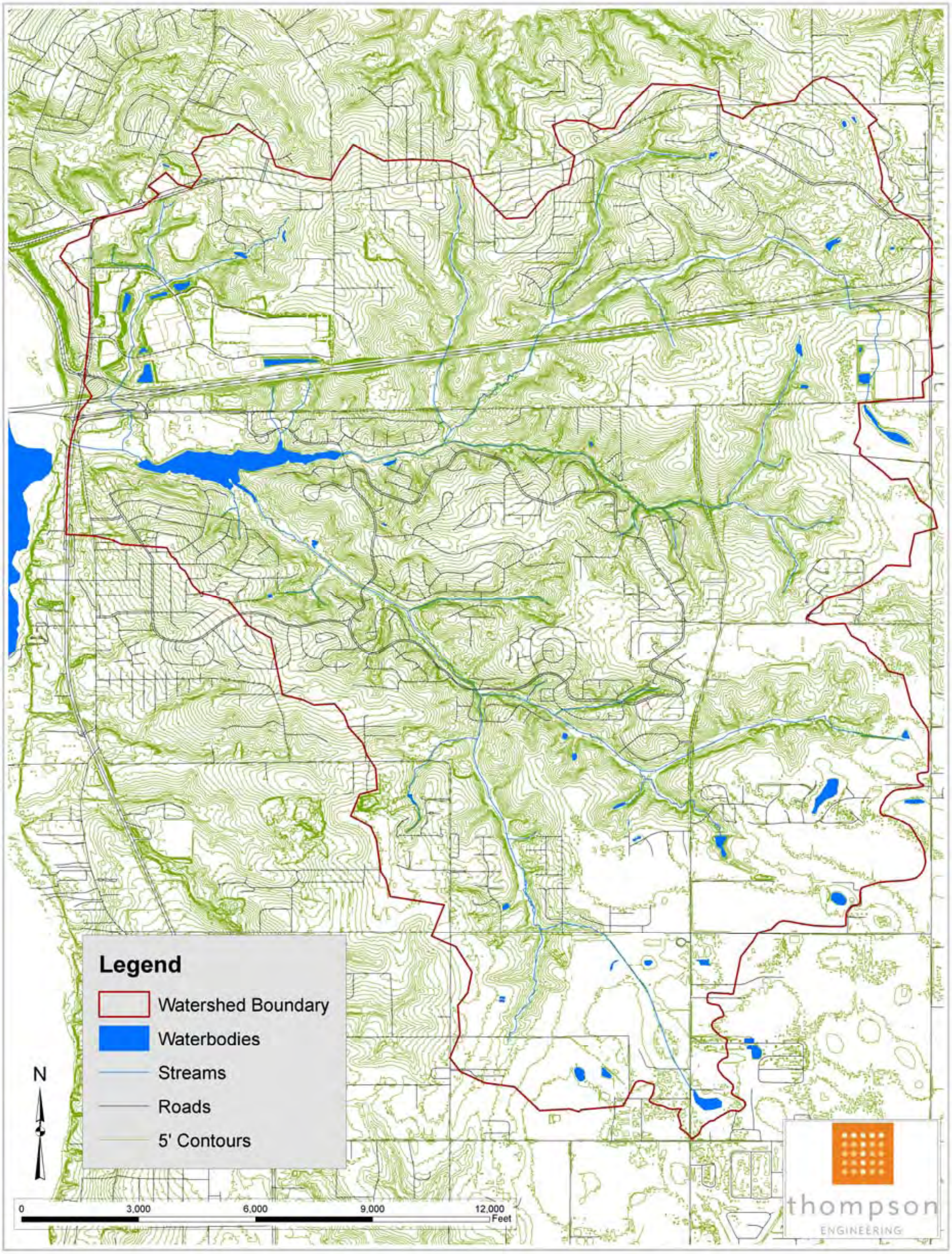

Figure 2-5. Depiction of 5-foot Topographic Contours within the D'Olive Watershed

Head-cutting is the hydrologic phenomenon that occurs as a stream attempts to modify its gradient to reduce the energy level of water as it flows from a higher to a lower elevation. To dissipate the energy, the stream attempts to reduce the gradient of the channel by cutting downward. As the stream cuts downward (i.e., incises), the stream erodes the channel to produce a lower gradient channel. Figure 2-6 illustrates how a head-cut can appear in both plan and longitudinal profile view of a conceptual stream reach. As the stream channels incise, the slopes of the channel banks become steeper.

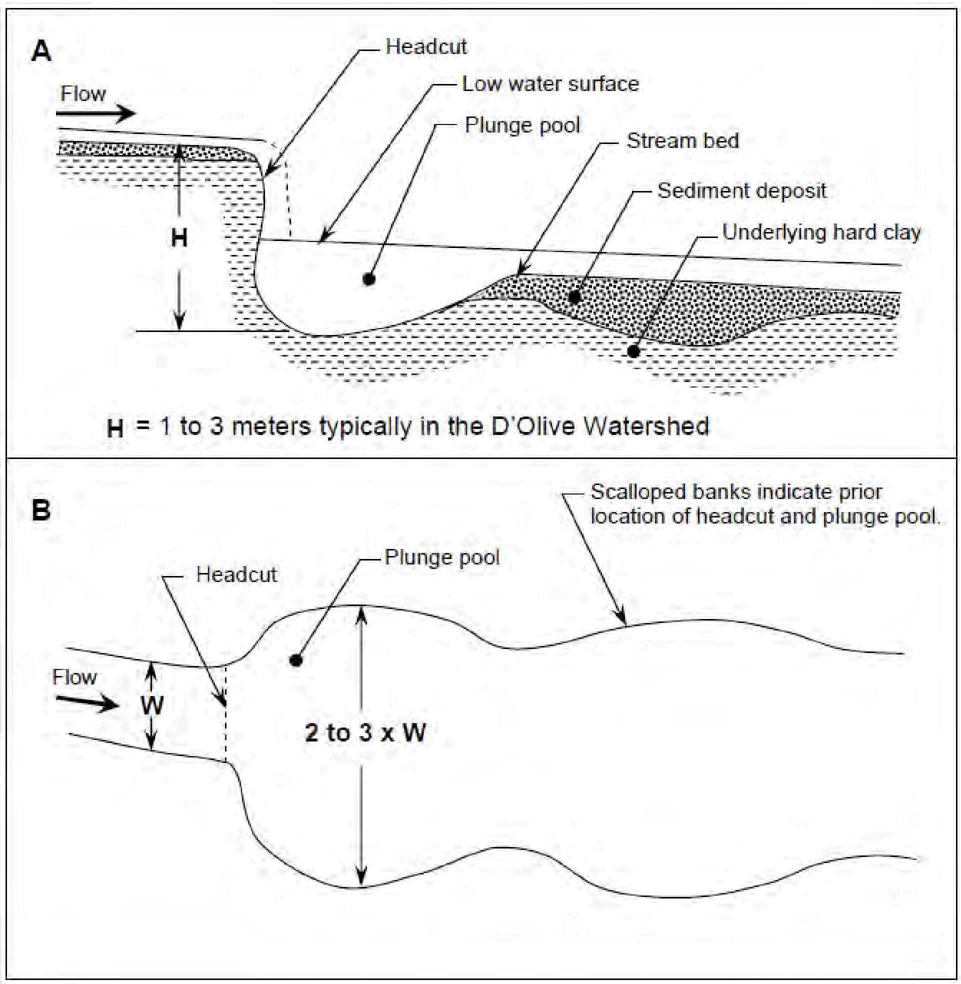

Figure 2-6. (A) Profile, and (B) Plan View of a Typical Head-cut in the D'Olive Watershed

Typically, the location of active head-cutting will produce a distinct change in elevation and channel instability within the reach of stream being affected. Figure 2-7 shows a head-cut affecting a relatively short reach of channel in Tributary DC where the channel streambed is comprised of materials that are resistant to erosion. However, in areas where the stream channel and banks are made up of materials that are less resistant to erosion, the active reach of head-cutting can be extended over a considerable distance, with erosion of the channel occurring rapidly in response to high flow events. Figure 2-8 shows such a head-cut on

Figure 2-7. Head-cut through Erosion Resistant Streambed Materials on Tributary DA

Figure 2-8. Head-cut through Less Erosion Resistant Materials on Tributary TC Showing Effects of Mass-Wasting of Streambanks and Collapse of Trees into Channel

Tributary TC where the channel instability has resulted in mass wasting of the streambank (i.e. bank failure) and the introduction of uprooted trees into the channel.

Head-cutting is a natural process by which streams adjust their gradient to changes in elevation, flow characteristics, runoff velocities, and the materials through which the streams flow. Head-cutting in the D'Olive Watershed has been occurring since the modern sea level became established at its present elevation within Mobile Bay around 15,000 to 18,000 years ago. The extreme elevations through which the Watershed streams flow in pre-historic times and the erodible nature of the soils gradually produced the highly dissected landscape and the numerous steep ravines and rolling hills that characterize the Watershed today. Figure 2-9 illustrates the steep slopes that flank many of the streams within the Watershed. These steep slopes are a direct byproduct of the historical head-cutting processes.

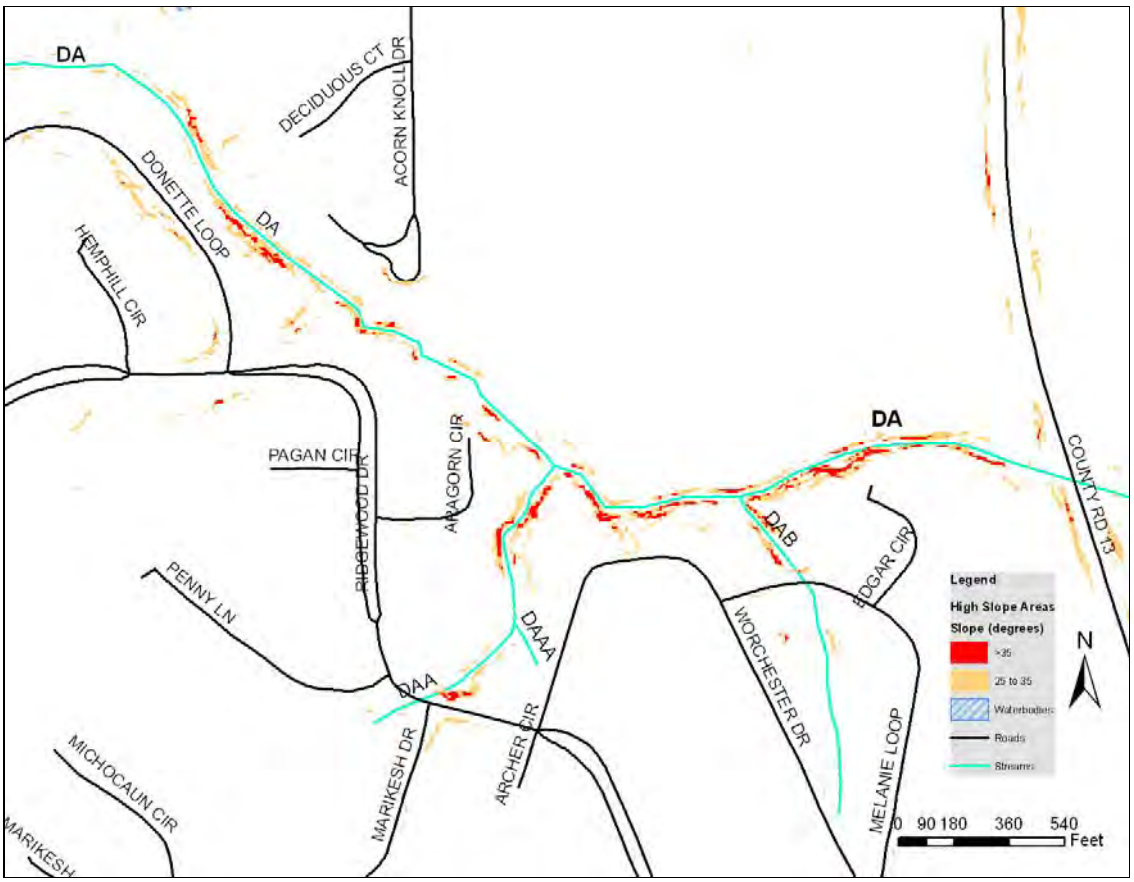

Figure 2-9. Steep Slopes Flanking Tributary DA Downstream from County Road 13

When Europeans began to the settle the Watershed in the early 1800s and initiated the conversion of the land from forest to agriculture, they accelerated the natural head-cutting processes. With increasing population growth and added technical capabilities to transform the landscape, human activity continued to adversely influence the stability of the Watershed

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streams. The explosive urbanization of the Watershed that began in the 1960s has further accelerated stormwater runoff and exacerbated the channel instability problems.

2.7 Floodplains

Figure 2-10 shows the extent of the 100-year floodway which closely reflects the narrow width of floodplains within the D'Olive Watershed. The extent of floodplains is limited by the relatively rugged terrain depicted in Figure 2-5 and as further illustrated in Figure 2-9. The steep slopes that closely flank the Watershed's three major streams and their principal tributaries result in their associated floodplains being very narrow in width. In those cases where specific stream segments have gentle gradients and somewhat wider floodplains, sediments generated by upslope sources have often become deposited to varying depths in the flanking floodplains.

A strip of riparian vegetation is associated with the floodplains. This strip varies in width depending upon the location within the Watershed and the neighboring land uses. An even narrower strip of wetlands occurs at the lowest elevations within the floodplains (see Section 2.8).

When the process of head-cutting causes a specific stream segment to incise deeper into its bed, its contiguous floodplain often remains at its historic elevation. In such situations, the floodplain may no longer experience periodic overbank flows during high rainfall events. This results in most, if not all, of the high flow events and their associated energies being confined within the incised channel. The concentration of hydraulic energy contributes to further channel incision, streambed erosion, and overall increase in channel instability.

2.8 Wetlands

2.8.1 404(b)(1) Jurisdictional Wetlands

The occurrence of wetlands within the D'Olive Watershed is limited by the extreme topographic conditions and the relatively narrow floodplains and limited riparian habitat flanking the streams. Despite these physical habitat limitations, the Watershed supported 477 acres of wetlands in 2005 according to the Baldwin County GIS database (see Table 2-8). It should be noted that the wetland acreage data layer contained in the Baldwin County GIS likely under estimates the actual amount of wetlands in the D'Olive Watershed because of the inherent difficulty involved in mapping seepage slope wetlands. Even with intense urbanization, analysis of remote sensing data indicates that the overall acreage of wetlands within the Watershed has remained relatively consistent since the 1970s.

Three primary wetland types are found within the Watershed:

- 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*

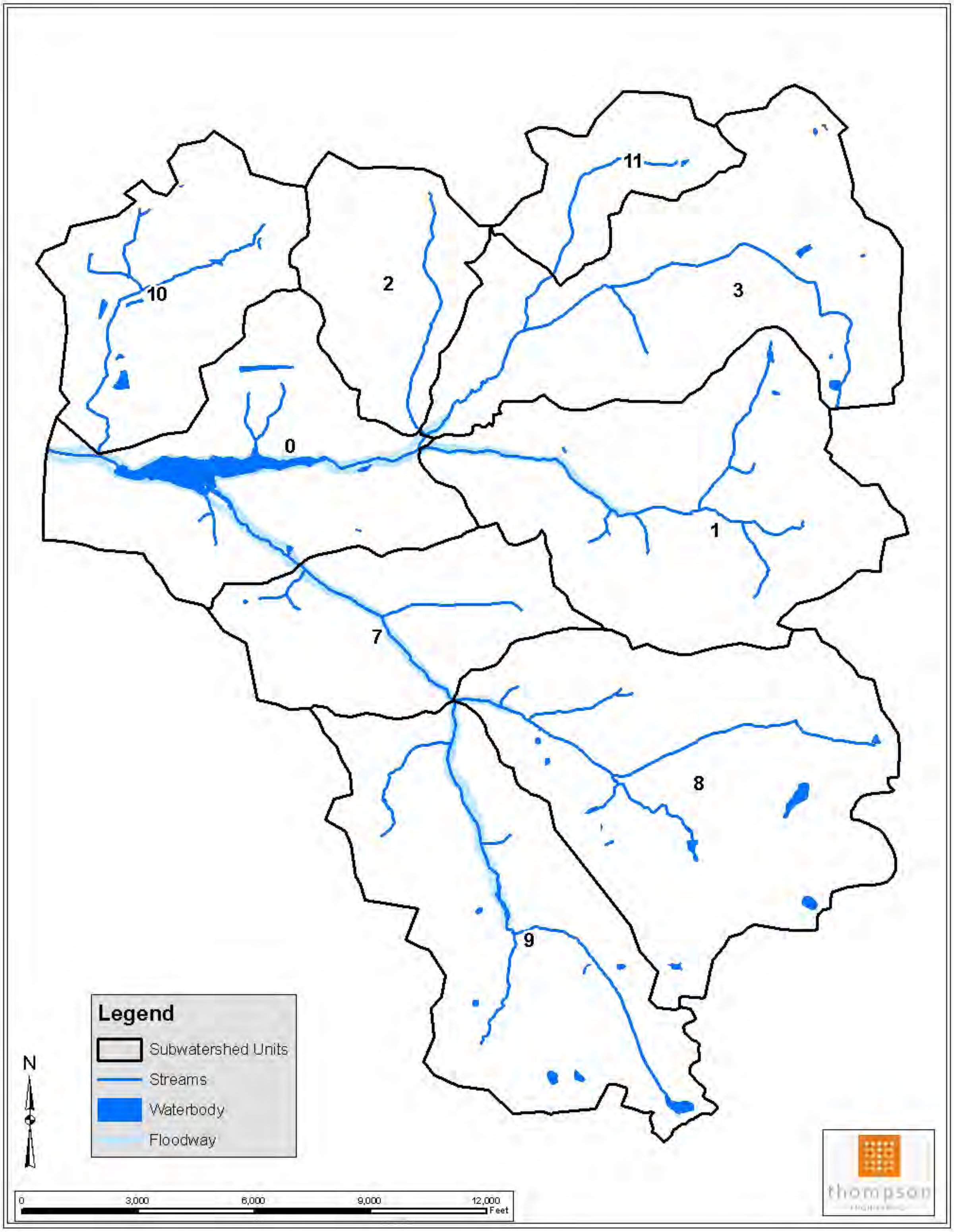

Figure 2-10. Extent of 100-year Floodplain in the D'Olive Watershed

domingensis), common three square (*Schoenoplectus pungens*), and common reed (*Phragmites australis*).

- Bottomland hardwood forested wetlands – The bottomland hardwood forested wetlands are primarily located along the creeks and tributaries. These wetlands occur as a relatively narrow strip along the streams due to the hilly topography of the area. Vegetative characteristics vary 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*).

- Seepage-slope forested pine/hardwood wetlands – Seepage-slope forested pine/hardwood wetlands are very similar to bottomland hardwood wetlands in vegetative composition, but are located on the hillsides flanking the creek bottoms. These areas contain scattered loblolly pine (*Pinus taeda*) and slash pine (*Pinus elliottii*). During periods of high rainfall, small springs can develop and add to the base flow of the Watershed streams.

2.8.2 Grady Ponds or Citronelle Ponds

An additional wetland feature also occurs within the southeastern portion of the D'Olive Watershed. These wetlands, which are associated with geological depressions, are not regulated under Section 404(b)(1) of the Clean Water Act because of their small size and their isolated nature. Nevertheless, these features do support wetland vegetation and serve as catchments for locally generated drainage.

These natural depressions are referred to both as "Citronelle Ponds" because of their association with outcrops of the Citronelle geologic formation, and as "Grady Ponds" because the soils in these depressional features are typically classified as being in the Grady soil series.

Figure 2-11 shows the locations of the five Grady ponds that are located in the Watershed as determined from an examination of aerial photography, topographic mapping, and field work. While still present as obvious geographic features, the physical characteristics of these ponds have been materially altered by local drainage and land use practices. Nevertheless, they still retain their ability to retain water during times of abundant rainfall.

Grady Ponds as geological features have a limited range, occurring within 13 counties of the western Florida Panhandle, southwestern Alabama, and southeastern Mississippi. Baldwin County has the largest number of ponds, having over 3,000 of the region's 7,000 ponds (Folkerts, 1997). Land use changes offer the single greatest threat to these natural wetland depressions. Agricultural and forestry practices and individual drainage projects have destroyed many of these ponds.

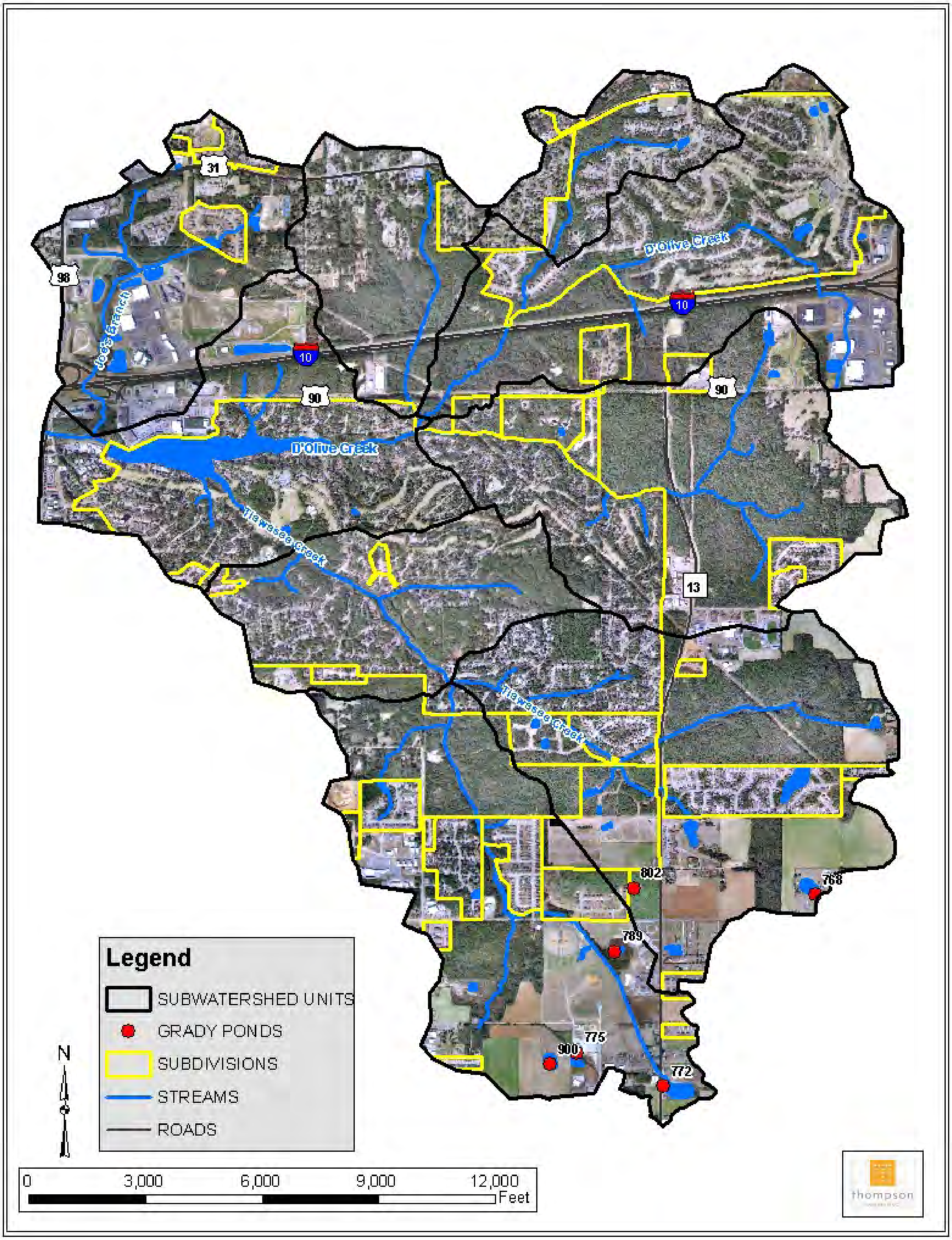

Figure 2-11. Grady (i.e., Citronelle) Ponds in the D'Olive Watershed

Almost all Grady Ponds occur on the undissected gently rolling or flat surfaces of the exposed Citronelle Formation. Many of the depressions are filled with water, especially in the winter and spring. Grady Ponds exist in landscapes without slope, appearing as topographical depressions having a general oval shape and often occur on some of the highest elevations in the area. This is the case in the relatively flat southeastern portion of the D'Olive Watershed that has elevations ranging from 150 to 160 feet and within which it is difficult to determine the flow path of surface runoff.

Grady Ponds tend to be shallow depressions (i.e., 3.9 to 5.9 feet), with flat bottoms that slope very little toward the center. As a result, most of the contour lines are crowded near the edges of the ponds and the ponds generally show little tendency to have a deeper area near their centers. The slope into the flat bottoms begins rather abruptly at the edges of the ponds.

Grady Ponds are believed to be naturally formed by the dissolution of minerals within the underlying Citronelle Formation. However, there is generally little connection with the groundwater table which results in semi-permanent ponding of surface water for much of the year. This is because the ponds generally develop on clay subsoils that inhibit downward percolation of ponded water. As a result, evapotranspiration and surface drainage serve as the principal water level control mechanisms.

Almost all of the unaltered Grady Pond depressions hold water in the winter and early spring. Rains tend to fill the ponds by mid-winter. Water levels tend to remain high until mid-April. A general drying trend occurs from April until October, with smaller ponds drying completely.

All of the water in Grady Ponds is derived from rain, including runoff from the very small catchment basins that typically surround the ponds. Generally, the catchment basins are seldom larger than twice the surface area of the ponds themselves. Topographic maps show little or no slope toward the ponds from adjacent areas. Typically, the ponds are not naturally connected to surface drainage features. Where surface connections do exist, they are the result of erosion forces or anthropogenic actions to drain the depressions. Such connections will create head-cuts that will result in the eventual destruction of the ponds.

In their natural state, nearly all Grady Ponds harbored a community dominated by pond cypress and swamp tupelo. However, the vegetation that exists today in many of the ponds has been altered by a variety of human activities. While these ponds are unique as ecological habitats, they also contribute to the localized detention, retention, and storage of stormwater runoff. The five ponds that occur in the southeastern portion of the D'Olive Watershed (see Figure 2-11) have the potential to aid in managing stormwater runoff.

2.9 Rainfall

Rainfall is the most powerful factor effecting soil loss within the D'Olive Watershed. Rainfall is the only factor that cannot be modified by land development practices since it will occur regardless of the on-the-ground conditions. Thus, adequate measures be in place to adequately manage stormwater runoff.

The main transport mechanism of eroded sediments is rainfall runoff. The amount of sediment discharge generally increases with increases in stormwater runoff. Runoff is based upon the complete array of storm events that affect the Watershed, including those that are small and moderate sized, as well as those that are severe and extreme in nature.

The D'Olive Watershed is approximately 20 miles by air from the Mobile Regional Airport which maintains an active weather station having a period of record dating back to 1900. Climatic conditions, especially rainfall amounts and patterns experienced within the D'Olive Watershed are considered to be similar to those recorded at the Mobile Regional Airport.

Mobile is rated as the wettest city in the United States, having an average annual rainfall of 67 inches with an average of 60 rainy days per year. Rainfall occurs throughout the year and can be associated with winter/spring frontal events, summer and fall tropical cyclonic systems, or summer afternoon convective thunderstorms. Figure 2-12 shows the monthly distribution of rainfall throughout the year.

Rainfall produces the kinetic energy needed to detach soil particles from the soil surface. The climatic conditions that influence the amount of erosive kinetic energy available from rainfall include (1) annual rainfall amount, (2) rainfall intensity and (3) raindrop geometry or the size of rain drops.

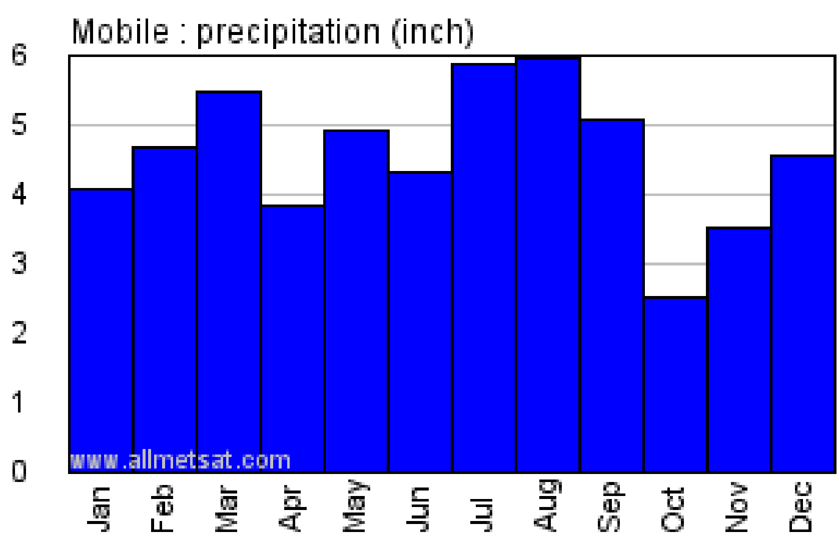

Figure 2-12. Rainfall Distribution by Month at the Mobile Regional Airport

Warm moist air from the Gulf of Mexico allows for the formation of large convectional storms that typically produce intense periods of rainfall over a short period of time and feature large rain drops. The larger the raindrop, the more mass the raindrop has and the higher the terminal velocity of the raindrop when it strikes the surface of the earth. Higher intensity rainfall and larger raindrops provide more kinetic energy for detaching soil particles during precipitation.

The influence of rainfall on erosion is reflected in the Universal Soil Loss Equation:

$$A = \mathbf{R} \times K \times LS \times C \times P$$

where **R** = Rainfall Erosion Index. Rainfall Erosion Index values (i.e. R factors) are determined from raindrop energy, rainfall intensity, rainfall frequency, and storm duration data. Figure 2-13 shows the Rainfall Erosion Index isopleths for the eastern United States. **R** values in Alabama vary from around 250 along the Tennessee State Line to around 650 along the Gulf Coast. **R** values for the North Central Gulf Coast are among the highest in the continental United States (Schwab *et al*, 1971) reflecting the intensity of rainfall events affecting the D'Olive Watershed, both in terms of power and amount of rain.

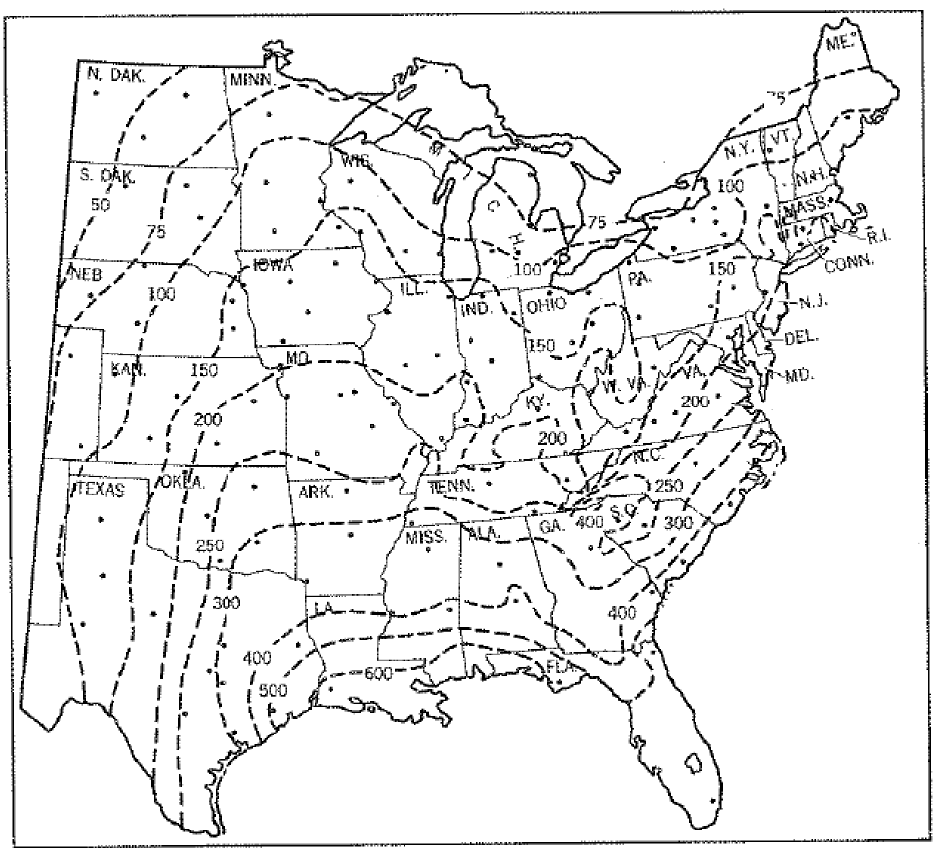

Figure 2-13. Rainfall Index Values for the Eastern United States
(from Schwab *et al*, 1971)

Rainfall events in the D'Olive Watershed are often intense, producing large amounts of rain within a short period of time. Many storms are characterized by large raindrops which contain considerable energy when they strike the earth. The D'Olive Watershed experiences some of the most erosive rainfall in the United States, with only the southern tip of Louisiana in the Mississippi Delta having slightly higher rainfall factors.

Stormwater detention and flood reduction studies are often based on statistically determined storm events that are based on long periods of record for a given geographical. One such statistical storm is the 95th Percentile Rainfall Event, a precipitation amount that 95% of all rainfall events do not exceed[1/]. For the Mobile Regional Airport, the 95th percentile of all rainfall events equals 2.46 inches. Small rainfall events that are 0.1 of an inch or less are excluded from the percentile analysis because such rainfall amounts generally do not result in any measurable runoff due to absorption, interception, and evaporation by permeable, impermeable and vegetated surfaces.

Another metric used to characterize rainfall is the Maximum 24-Hour Rainfall amount. For his sedimentological study of the D'Olive Watershed, Isphording (1981) compiled rainfall data for the period 1967 through 1980 from the Fairhope Weather Station which located a short distance south of the D'Olive Watershed. Isphording's data for the 14 years considered are provided in Table 2-3. Table 2-3 identifies the Maximum 24-Hour Rainfall amounts that occurred each year over the 14-year period considered in his study. While the data contained in Table 2-3 is almost 30 years old, it still serves to illustrate rainfall conditions that are generally representative of today. It is believed that the overall description of the rainfall characteristics measured at the Fairhope Weather Station would not vary significantly from the data presented in Table 2-3.

2.10 Geology and Soils

While topographic conditions and rainfall amounts influence stormwater runoff volumes and velocities, the composition and characteristics of the surface soils and subsoils of a watershed are critical in determining the erodibility of the materials over which the runoff flows. The physical features of the soil materials also play an important role in stream stability.

2.10.1 Geological Materials and Geologic History of Watershed

The geological history and composition of the D'Olive Watershed are important to understanding the stream instability and sedimentation problems being experienced there. The D'Olive Watershed is underlain by sediments that were originally deposited over millions of years when the region was covered by the sea. The different sediment layers are defined by the dominant types, colors, and relative amounts of gravels, sands, silts, and clays that comprise them. Each layer was deposited at a different period of time and is reflective of the major geological forces at work on the earth during their deposition and the proximity to the prehistoric coastline.

[1/] Technically, the 95th Percentile Rainfall Event is defined as the measured precipitation depth accumulated over a 24-hour period for the period of record that ranks as the 95th percentile depth based on the range of all daily event occurrences during the period of record.

Table 2-3. Summary of Rainfall Data for Fairhope, Alabama Weather Station, 1967-1980 (from Isphording, 1981)

Year	Total Annual Rainfall (inches)	Average Annual Rainfall for Reported Days (inches)	Total Days Rainfall Reported	Maximum 24-Hour Rainfall Event (inches)	Frequency of 24-Hour Rainfall (years)
1967	51.88	0.541	96	4.25	1.0
1968	41.17	0.401	103	2.81	1.0
1969	75.91	0.656	116	6.15	2.7
1970	64.62	0.479	135	4.58	1.0
1971	55.98	0.413	136	2.47	1.0
1972	57.10	0.545	105	4.12	1.0
1973	71.12	0.545	132	2.92	1.0
1974	55.34	0.459	121	5.12	1.5
1975	88.12	0.527	168	5.55	2.0
1976	64.90	0.533	122	4.90	1.3
1977	57.90	0.409	136	2.96	1.0
1978	94.06	0.719	131	11.25	44.0
1979	70.16	0.546	129	4.91	1.3
1980	67.75	0.503	131	5.47	1.8

If it was possible to turn the D'Olive Watershed on its side, from a geological standpoint, the underlying sediments would appear as a two-layer cake. The upper layer (i.e., stratum) is referred to as the Citronelle Formation, while the lower stratum is known as the Miocene. For the most part, the upper Citronelle Formation is exposed throughout the Watershed, since the more recent Holocene/Pleistocene deposits that would have appeared as "icing" on this "two-layer cake" is discontinuous, having been largely eroded away.

Figure 2-14 provides a generalized geologic cross-sectional view of the relationship and relative thicknesses of the Citronelle and Miocene deposits throughout the north-south length of Baldwin County. Depending on the location and the magnitude of historic erosion, the Citronelle Formation varies in thickness from 0 to 200 feet, while the underlying Miocene Formation ranges from 100 to 3,400 feet thick.

During the Ice Age that ranged from 2.5 million to 15,000 years ago, the sea level receded in response to thickening of the polar ice caps. As the sea level declined and the coast line extended seaward into the present day Gulf of Mexico, what is today Baldwin County became exposed. Between 15,000 to 18,000 years ago, the Ice Age ended and the present day sea level was established and Mobile Bay was formed as a dominant geological feature that would eventually become a part of Alabama's future coastline.

When the sea began to recede and the Citronelle deposits were initially exposed, the surface of these sediments formed a nearly continuous plain in the region. That exposure brought these materials into their first contact with rainfall which initiated the erosion processes that would eventually form the D'Olive Watershed.

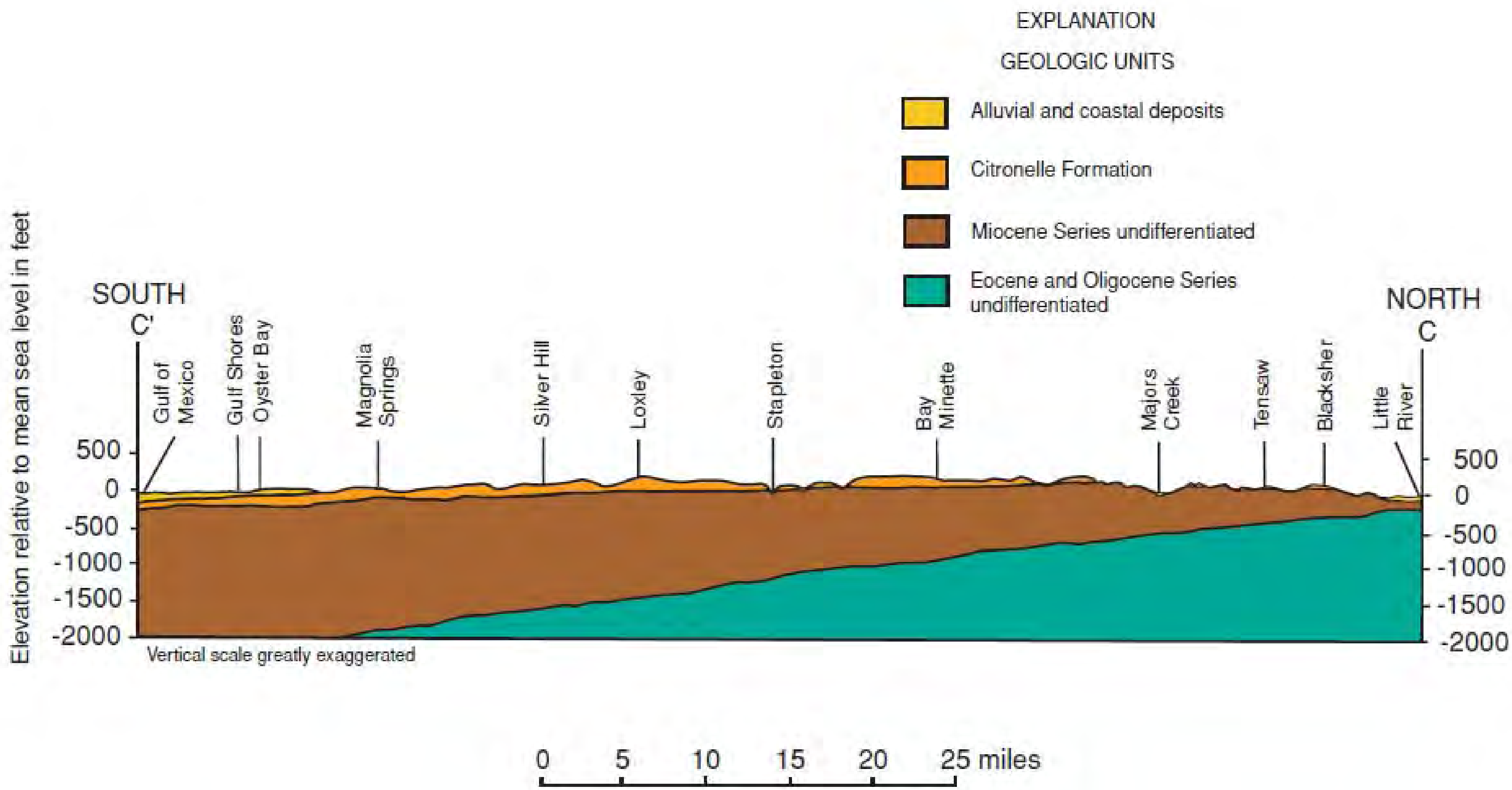

Figure 2-14. Generalized geologic cross section from south to north in Baldwin County, Alabama (from Gillett *et al*, 2000)

As the sea level fell, rudimentary stream channels began to develop over the newly exposed land surface to carry rainfall runoff to the sea. Gradually over time, the initial channels began to dominate drainage patterns as the burgeoning precursor watershed streams sought the shortest and most direct path to the sea. As the sea level continued to fall and watershed elevations increased, the channels began to incise and cut through the surface Citronelle deposits and expose the older materials, including the more erodible underlying Miocene Formation. The rate of erosion was greatest within the stream channels, with the oldest geologic formations being exposed along the banks immediately bordering the channels. Head-cutting, mass-wasting, and streambed erosion continued as the channels sought to keep up with the receding sea. This was accomplished by the corresponding erosion of the overall surface of the lands that flanked the streams. Over this 2.5 million-year period, the erosion and head-cutting processes created the network of steep ravines and valleys that characterize much of the modern Watershed (see Figure 2-5).

The more stable climatic conditions that developed at the end of the Ice Age allowed the Watershed lands to become covered with the native forest that dominated the area at the time of European settlement. While the natural vegetative cover could not eliminate the head-cutting processes, it was sufficient to slow runoff velocities and thereby slow the rate of head-cutting and streambed erosion. The conversion of the natural vegetation to agriculture and then to urban and commercial developments of today significantly accelerated surface runoff and erosion within the Watershed.

2.10.2 Soil Characteristics

Soil characteristics represent one of the four principle factors influencing overland erosion. The other three factors are rainfall, topography, and land cover.

Soils are classified by use of an erodibility factor (i.e., K-Factor) that is related to how much soil is lost due to the kinetic energy displaced during raindrop impact and stormwater runoff. The K-Factor is based primarily on the grain size of soil particles. Soils consisting of fine sand and silt size particles have higher K-factors than cohesive clay particles. Fine sands and silty soils are more easily detached by raindrop impact and stormwater runoff than are cohesive clays and medium to coarse grained sands. The amount of organic matter in soils also influences the K-Factor because organic matter acts as a glue to hold soil particles together into clods into which water can infiltrate and decrease runoff.

Typically subsoils have higher K-factors and are more erodible than topsoils. When land clearing and grading activities expose subsoils, the K-Factor increases. Exposed subsoils can be expected to erode faster because they have less organic matter and plant root mass to hold the soil particles together structurally. The formation of micropores that allow percolation of rainfall is reduced in subsoils, resulting in increased runoff. Increased runoff produces greater sheer forces for detaching soil particles from the surface, and accelerating erosion.

The parent subsoil materials within the D'Olive Watershed are more highly variable with clay, silt and sand strata than are the weathered and more homogenous superficial soils. As such, some of these subsoil strata may contain highly erodible fine sand and silty stratum which are highly erodible when exposed to precipitation and stormwater runoff.

Figure 2-15 displays the distribution of K factors for the native superficial soils of the D'Olive Watershed. The K factors for the soil series occurring within the D'Olive Watershed vary from 0.10 to 0.32. Soils having K factors less than 0.23 are considered to have low erodibility, while soils with K factors from 0.23 to 0.36 are considered to be moderately erodible.

2.10.3 Erosion Hazard Map

As the surface sediments eroded and the streams cut downward through the Citronelle materials, the underlying more erodible Miocene deposits become exposed. The erodible Miocene sediments are exposed in areas where topsoils are thin and fluvial interception has created steep slopes. This is especially the case in the lowermost reaches of Tiawasee Creek which is located near the "valley floor" of the D'Olive Watershed. Miocene materials are also exposed at other locations along the mostly deeply incised portions of other stream segments at the lowest elevations in the Watershed.

Crisler (1981) conducted a study of the D'Olive Watershed for the Soil Conservation Service, producing an "erosion hazard" map which was used to construct Figure 2-16. This map shows that the areas most prone to erosion occur within the areas that have experienced the most extensive fluvial dissection, which exposed the underlying Miocene deposits.

The Erosion Hazard Index (EHI) was developed from the factors used in the Universal Soil Loss Equation (USLE) as shown below. Values in excess of 100 indicate those areas that have the potential to contribute extensive quantities of sediments.

$$\mathbf{EHI = K} \text{ x } \mathbf{L} \text{ x } \mathbf{R} \text{ x } \mathbf{S}$$

Where:
K = Value related to the inherent properties of the soil (particle size, strength, etc.)
L = slope length (measured in feet)
R = rainfall factor (dependent upon amount, pattern and intensity)
S = slope steepness (measured in percent)

Table 2-4 displays the computed EHI values for each of the nine subwatersheds that make up the D'Olive Watershed. This information indicates the lower reaches of Tiawasee Creek and the Joe's Branch subwatershed have the greatest potential to contribute extensive quantities of sediments. Within the lower Tiawasee Creek, elevations on the slopes of exposed Miocene sediments drop approximately 170 feet along an approximate 2000-foot long slope. Although the average slope is around 10 percent, much steeper slopes occur in localized areas. In such a physical environment, Best Management Practices (BMPs) are especially necessary during soil disturbance activities and to reduce post-construction surface runoff. Comparison of the EHI information with Figure 2-15 shows that the K factors in this area are also the highest in the Watershed.

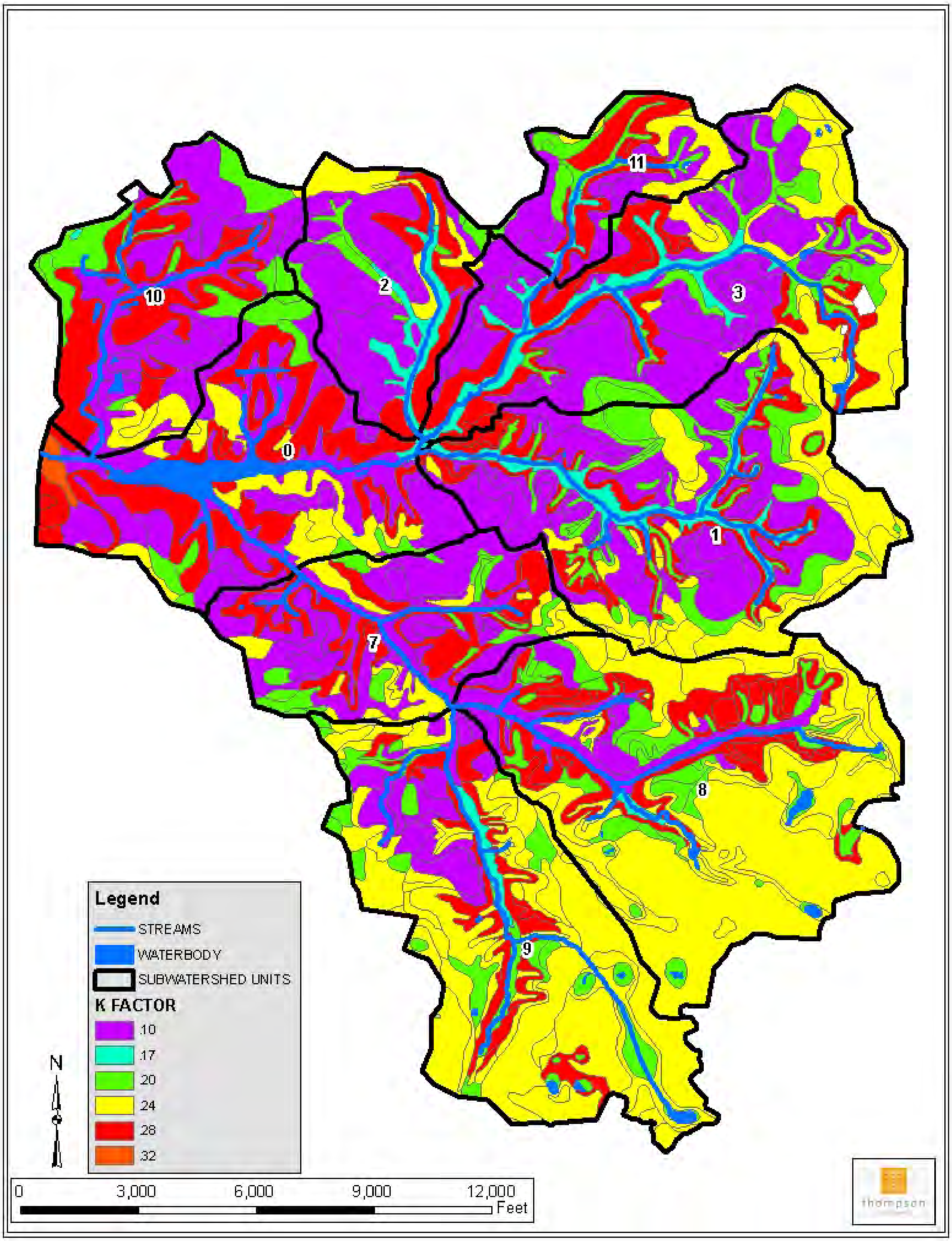

Figure 2-15. Soil K-factors in the D'Olive Watershed
(source: USDA, Natural Resources Conservation Service)

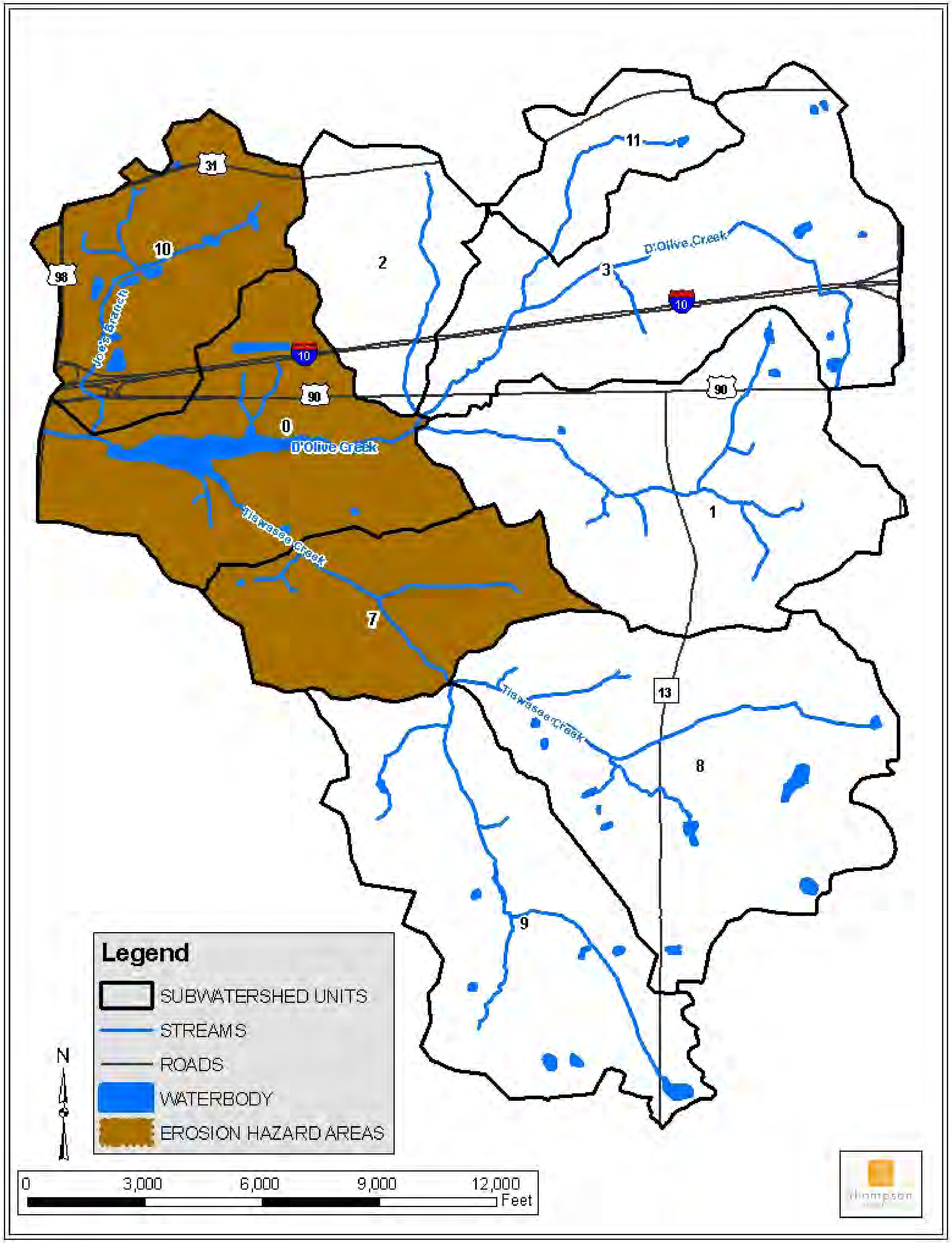

Figure 2-16. Erosion Hazard Map of the D'Olive Watershed (based upon Crisler, 1981)

Table 2-4. Erosion Hazard Index (EHI) for D'Olive Watershed
(based upon Crisler, 1981)

Subwatershed [1/]	Streams Within Subwatersheds	Tributary Designation	EHI Index
1	Middle and upper tributaries to D'Olive Cr	DA, DAA, DAB, DAC, DACA, DAD	58
2	Unnamed tributary DB	DB	74
3 and 11	Upper D'Olive Creek and tributaries	D, DD, DC	54
0 and 7	Lake Forest Lake and the lowest 1/2 mile of D'Olive and Tiawasee Creeks and Middle Tiawasee Creek and tributaries below Ridgewood Drive	L, T (lower), TA, TAA, TB	98, 105, 132
8	Tiawasee Creek and tributaries above Ridgewood Drive	T, TD, TE, TEA, TF, TG, TGA	66
9	Tributaries to Tiawasee Creek above Ridgewood Drive	TC, TCA, TCB, TCC	51
10	Joe's Branch and tributaries	J, JA, JB	98 and 107

[1/] The Subwatershed numbering convention was chosen to match used in the Geological Survey of Alabama studies of 2007 and 2008.

2.10.4 Sediment Transport and Sedimentation in the D'Olive Watershed

Natural erosion of the earth's land surface occurs on a geologic time scale. However, human activities can accelerate erosion rates greatly above natural rates. Construction activities that do not employ effective erosion and sediment control practices can cause excessive soil losses. Conversion of forest and agricultural land to commercial and residential uses can accelerate erosion and sediment transport rates in streams several orders of magnitude above the natural rates (Isphording, *et al*, 1984).

The D'Olive Watershed experienced enormous overland erosion impacts during the initial developments of the Lake Forest subdivision (Carlton and Gail, 1979 and Isphording, 1981). These activities resulted in significant increases in erosion and sediment transport rates. Although improved construction practices and regulatory controls have significantly reduced overland erosion rates in the Watershed, ongoing urbanization has accelerated post-construction surface runoff (i.e., volumes, velocities, and timing). The added runoff is contributing to channel instability and erosion problems.

Lake Forest Lake continues to serve as a trap for bedload sediments originating from upstream sources in the D'Olive Creek and Tiawasee Creek drainages. Sedimentation will continue to shorten the usable life of this lake. Bedload sediment transported by Joe's Branch is discharged directly into D'Olive Bay.

For the 14-year period between 1967 and 1980, Isphording (1981) determined that construction of the Lake Forest subdivision increased the annual sediment transport rate by 61,058 tons/year over natural levels, with approximately 48,000 tons per year being deposited in Lake Forest Lake over that period. More recently, the Alabama Geological Survey (Cook and Moss, 2008) indicated that the total sediment load entering Lake Forest Lake to be approximately 7,800 tons per year. The Isphording and Cook studies both considered combined suspended and bedloads.

Comparison of the Isphording and Cook studies indicates that the annual sediment loading to Lake Forest Lake has dropped significantly since the 1970's. The decline from 48,000 to 7,800 tons per year represents an 84% reduction in sediment loading. Estimating annual sediment loads based only on samples and flow data is an inexact science, and thus, the 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. Although the sediment loads have certainly dropped since the early 1980's, the loads are 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 7,800 tons per year by the 8.5-square mile drainage of D'Olive and Tiawasee Creeks above Lake Forest Lake yields approximately an existing load of 920 tons per square mile per year. This amount is around 14 times the erosion rate of an undeveloped watershed.

2.11 Political Institutions

Responsibility for the management of the D'Olive Watershed is divided between the Cities of Daphne and Spanish Fort and Baldwin County. Figure 2-17 illustrates the areas within the Watershed that fall under the jurisdictional control of each of these three governmental entities. Table 2-5 lists the Watershed acreages controlled by each entity, along with a breakdown of the extent of their control within each of the nine subwatersheds.

With the exception of I-10 and US 31, US 90, US 98, and State Road 181 and their associated rights-of-ways, there are essentially no significant State or Federal land holdings within the Watershed. Again, with the exception of the highways, all publicly owned lands are controlled by Daphne, Spanish Fort, or Baldwin County.

Around 66% of the Watershed is located within Daphne's municipal boundaries. It is important to note that Daphne's portion of the Watershed receives the drainage from the City of Spanish Fort and the incorporated portions of Baldwin County that are located within the higher elevation headwater areas of the Watershed. As a result, Daphne has experienced most of the Watershed's stormwater runoff and sediment related problems over the years.

The planning jurisdictions of the Cities of Daphne and Spanish Fort extend beyond their respective boundaries as allowed by the Extraterritorial Jurisdiction provision of Alabama State Law. The ETJ provision allows cities the authority to review all planned subdivision developments within their ETJ which extends a maximum of five miles outside their corporate limits. Therefore, all developments that occur within the neighboring unincorporated lands of Baldwin County are subject to review by either Daphne or Spanish Fort. Daphne and Spanish Fort share ETJ review responsibilities for the unincorporated County lands located north of I-10 along State Highway 181 and U.S. 31.

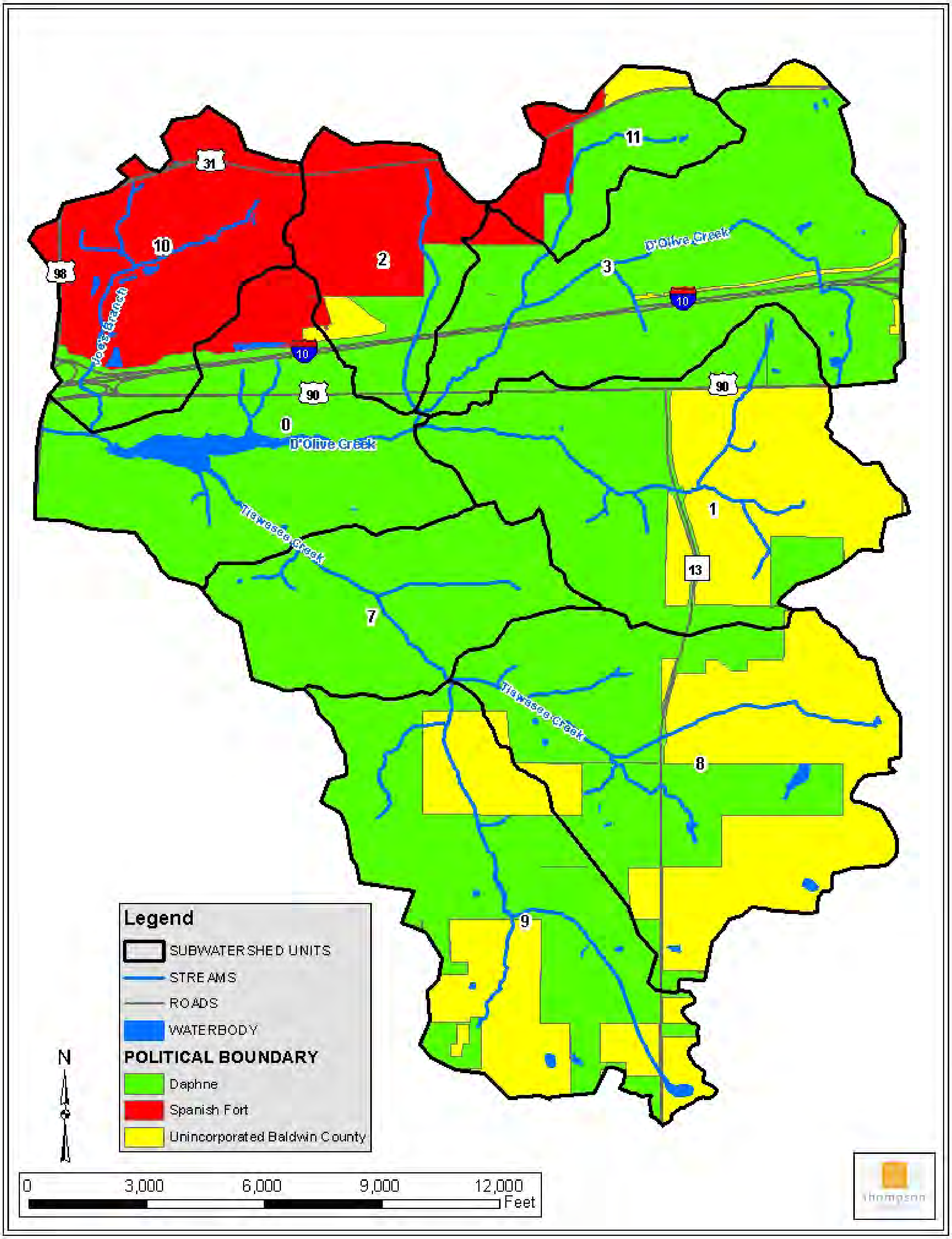

Figure 2-17. Division of Governmental Control of D'Olive Watershed

Table 2-5. Division of D'Olive Watershed Lands between Daphne, Spanish Fort, and Baldwin County [1/]

Political Entity	Subwatershed No. [2/]										
	0	**1**	**2**	**3**	**7**	**8**	**9**	**10**	**11**	**Total**	**Percent**
Daphne	806	698	142	1,100	601	699	719	105	191	**5,061**	**66%**
Spanish Fort	83	0	301	23	0	0	0	556	76	**1,039**	**13%**
Baldwin County	4	464	23	36	0	643	413	0	30	**1,613**	**21%**
Total	**893**	**1,161**	**466**	**1,159**	**601**	**1,342**	**1,132**	**661**	**297**	**7,713**	**100%**

[1/] Excerpted from 2005 Baldwin County GIS database.
[2/] See Figure 2-2 and Table 2-1 for location and descriptive information, respectively, on each of the subwatersheds.

The 1,613 acres of unincorporated Baldwin County lands located within the Watershed are contained with the county's Planning District No. 15. The citizens of Planning District No. 15 elected to develop zoning provisions consistent with the county's planning and zoning authority to control growth within their portion of the county. A zoning plan for these lands has been completed with the assistance of the Baldwin County Planning and Zoning Department. Section 2.13.4.1 provides additional information on the zoning plan for the county lands contained within the Watershed.

Almost every residential subdivision within the Watershed has an established property owners association (POA). The powers of the individual POAs are limited to their respective areas of influence. Further, the aggressiveness of the individual POAs in undertaking specific activities may vary considerably between residential subdivisions. As will be explained later in this WMP, the POAs have the potential to contribute to the implementation of specific Watershed management measures.

2.12 Population

Population data specifically for the D'Olive Watershed are not available. Therefore, historic and projected population data contained in Baldwin County's Comprehensive Horizon 2025 Horizon Plan for the cities of Daphne, Spanish Fort, and the unincorporated portions of the county's Study Area 2 were considered to gain an appreciation of existing and future population characteristics for the Watershed.

2.12.1 Historic Population Trends

Baldwin County has experienced significant and constant growth since 1980. Between 2000 and 2006, population growth in Baldwin County ranked second out of Alabama's 67 counties in terms of both absolute growth (i.e., 140,415 to 169,162) and percentage of growth (i.e. 20%).

The City of Daphne is Baldwin County's largest municipality. Its 2006 population was 18,996, up from 16,581 in 2000. The City of Spanish Fort had a 2006 population of 5,601 compared to 5,423 in 2000. Both municipalities are located in Baldwin County's densely populated Eastern Shore, which includes the neighboring unincorporated portions of the county and the City of Fairhope to the south. Figure 2-18 illustrates the densely populated nature of the Eastern Shore area within which the D'Olive Watershed is located.

2.12.2 Projected Future Population Growth

The results of the 2010 Census were not available at the time this WMP was prepared. Baldwin County's Horizon 2025 Plan contains population projections for the county. The county's total population is projected to increase from 166,725 in 2006 to 190,765 in 2010, 246,546 by 2020, and 279,315 by 2025.

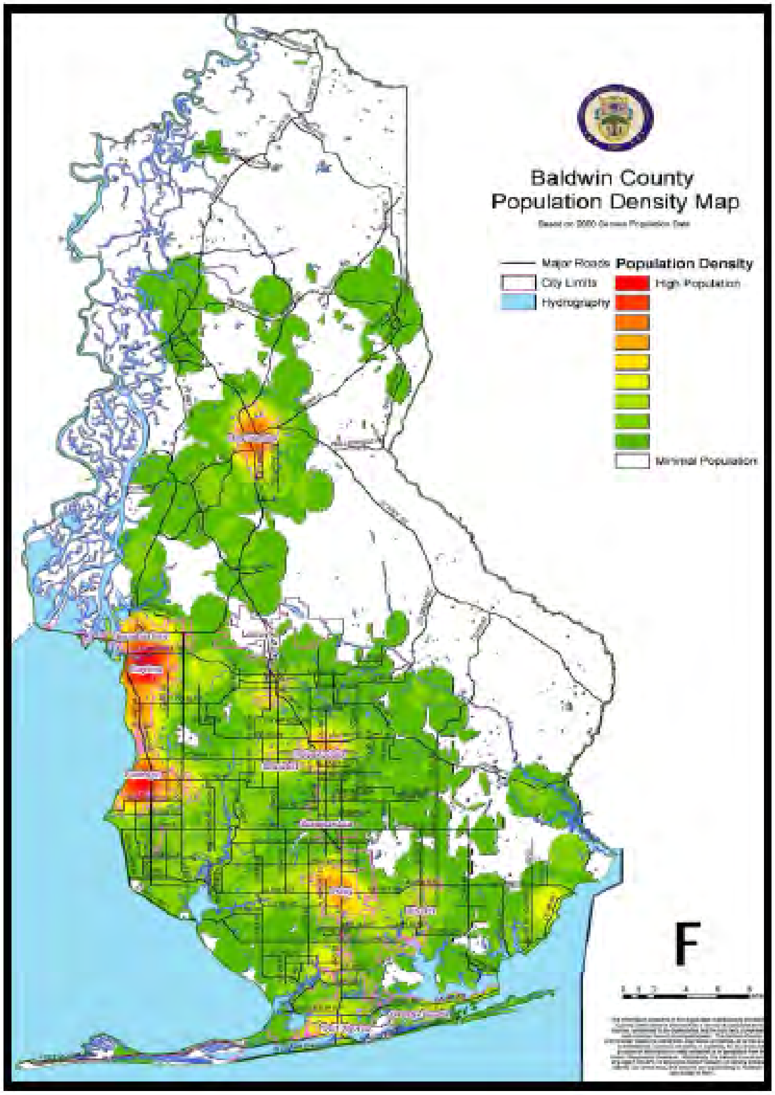

Figure 2-18. Population Density Map for Baldwin County (from Baldwin County Planning and Zoning Department)

Because of the large size of Baldwin County and its differential growth patterns, the Horizon 2025 Plan divided the county into four study areas. The overall population growth is apportioned between the four study areas to reflect the differences in the patterns of growth throughout the County. The D'Olive Watershed is included in Study Area 2 which consists of the 95,638 acres that are collectively referred to as the Eastern Shore. The Eastern Shore stretches from Spanish Fort southward to Fairhope and includes the immediate neighboring unincorporated areas of the County.

It is possible to project population growth that could occur within the D'Olive Watershed by using the existing Horizon 2025 Plan data and developing a set of conservative population growth densities from the projected population growth data. For example, the Horizon 2025 Plan projects the total population in Study Area 2 will increase from the 57,981 individuals residing in the area in 2006 to 94,914 by 2025. This represents a population increase of 36,933. Currently, 30% of Baldwin County's population resides in the unincorporated portions of the county, with the remainder living within the established municipalities. This means that the 25,853 individuals (i.e. 70%) of the 36,933 population increase would be expected to locate within the Eastern Shore's existing cities, while the balance of 11,080 individuals would reside in the unincorporated areas of Study Area 2. Around 19,200 acres of Study Area 2 are included within the existing cities, with 76,428 acres being located in the unincorporated areas. Using these numbers, it is possible to develop projected densities for the future population growth. Thus, the lands occurring within the boundaries of the existing cities would add an average of 1.35 persons per acre. This is compared to the unincorporated portions of the county that would experience a population expansion of 0.15 persons per acre.

Applying these two growth densities to the D'Olive Watershed would result in the 6,100 acres occurring within the Spanish Fort and Daphne gaining 8,235 individuals, while the 1,613 acres of unincorporated County lands would experience a population increase of 197 individuals. This means that the Watershed could experience an overall population increase of 8,432 by 2025. This population increase is considered to be a conservative estimate since it is likely that the actual population growth could be much larger within the D'Olive Watershed given the proximity of the Watershed to the main transportation arteries on the Eastern Shore that (1) lead directly to Mobile; (2) are near the commercial centers now located near the two existing I-10 interchanges; and (3) the planned new County Road 13 interchange at I-10. These considerations could continue to make the D'Olive Watershed especially attractive to individuals locating within the Study Area 2 portion of Baldwin County.

If the overall population growth for the D'Olive Watershed is considered to be 8,432 individuals, it is possible to develop an estimate of the housing needed to accommodate the added individuals. Population data from 2006 indicate that the existing households within the Eastern Shore of Baldwin County are comprised of 2.38 individuals. Dividing this average household size into the population increase of 8,432 indicates 3,543 additional housing units could be needed in the Watershed to accommodate this population growth estimate through 2025.

Since this WMP is directed at addressing D'Olive Watershed conditions and management needs for the 10-year period extending from 2010 to 2020, it is possible to make one additional assumption to develop a housing demand need for the 2020 target year. That assumption is population growth will occur on a straight line basis which would result in an annual housing need of approximately 236 units. Thus, for the 10-year period, a total demand for 2,360 additional housing units could develop for the Watershed. Given the existing pattern for single family residences to dominate the Watershed housing market, an additional 2,360 individual homes would be required to satisfy the housing needs of the projected population growth through 2020.

The actual acreage needed to satisfy the demand for new homes could range from a low of 590 acres if a lot size was one-quarter acre is used to as much as 2,360 acres if each house lot was one acre in size. This does not take into account the possibility that even larger lot sizes may be used for homes constructed in those portions of the Watershed occurring on unincorporated county lands. It must also be recognized that the actual rate of population growth and future housing needs will be significantly influenced by both short term and long term local, regional, and national economic trends. Further, the demand for new homes will depend upon the availability of existing homes.

2.13 Land Use and Land Cover

Land use/land cover (LU/LC) significantly influences stormwater runoff velocities, volumes, and timing within watersheds. The following summarizes existing land use trends and projected land use information for the D'Olive Watershed through 2020.

2.13.1 Roads and their Influence on Development Patterns

Highways greatly influence the location, type, and pattern of land use. This has certainly been the case for the D'Olive Watershed, as well as the overall region of Baldwin County collectively referred to as the Eastern Shore. Six roadways in particular have played a major role in influencing land use change within the Watershed: U.S. 31, U.S. 90, U.S. 98, I-10, State Road 181, and County Road 13. These roads are shown in Figure 2-19.

In the initial third of the 20th Century, US 31, US 90, and US 98 converged north of the Watershed in Spanish Fort, where they crossed the lower Mobile-Tensaw Delta by way of the low elevation, two-lane "Causeway" that was completed in 1927. Before the "Causeway" was built, boats were the only means of travel between Mobile and Baldwin County's Eastern Shore. In February 1941, opening of the two-lane Bankhead Tunnel underneath the Mobile River enhanced the travel corridor between the two counties.

The "Causeway" was subject to periodic flooding. That situation, combined with the general tendency for most people to live near their jobs, discouraged extensive development of the Eastern Shore of Baldwin County prior to the 1960s. The small unincorporated community of Spanish Fort was essentially associated with US 31 that parallels the northern D'Olive Watershed Boundary, while Daphne demonstrated a similar affiliation for U.S. 98 that traversed the area near the Mobile Bay shoreline. Very little of the early Daphne community was actually located within the D'Olive Watershed. The land along U.S. 90, which cuts across the northern portion of the Watershed, was essentially undeveloped.

A combination of events occurred in the 1960s to spur development of the Eastern Shore in general and the D'Olive Watershed in particular. First, I-10 was conceived to create this major east-west transportation artery serving the nation. Initial construction was completed in the late 1960s resulted in the termination of I-10 near the convergence of three existing US highways in Baldwin County. This further congested traffic on the "Causeway". Recognizing that a 4-lane elevated bridge would eventually be constructed to connect the I-10 segments that ended on each side of Mobile Bay, the Diamond Head Corporation acquired the lands for the massive Lake Forest Subdivision, initiating construction around 1971. The Lake Forest Subdivision is principally located within the D'Olive Watershed.

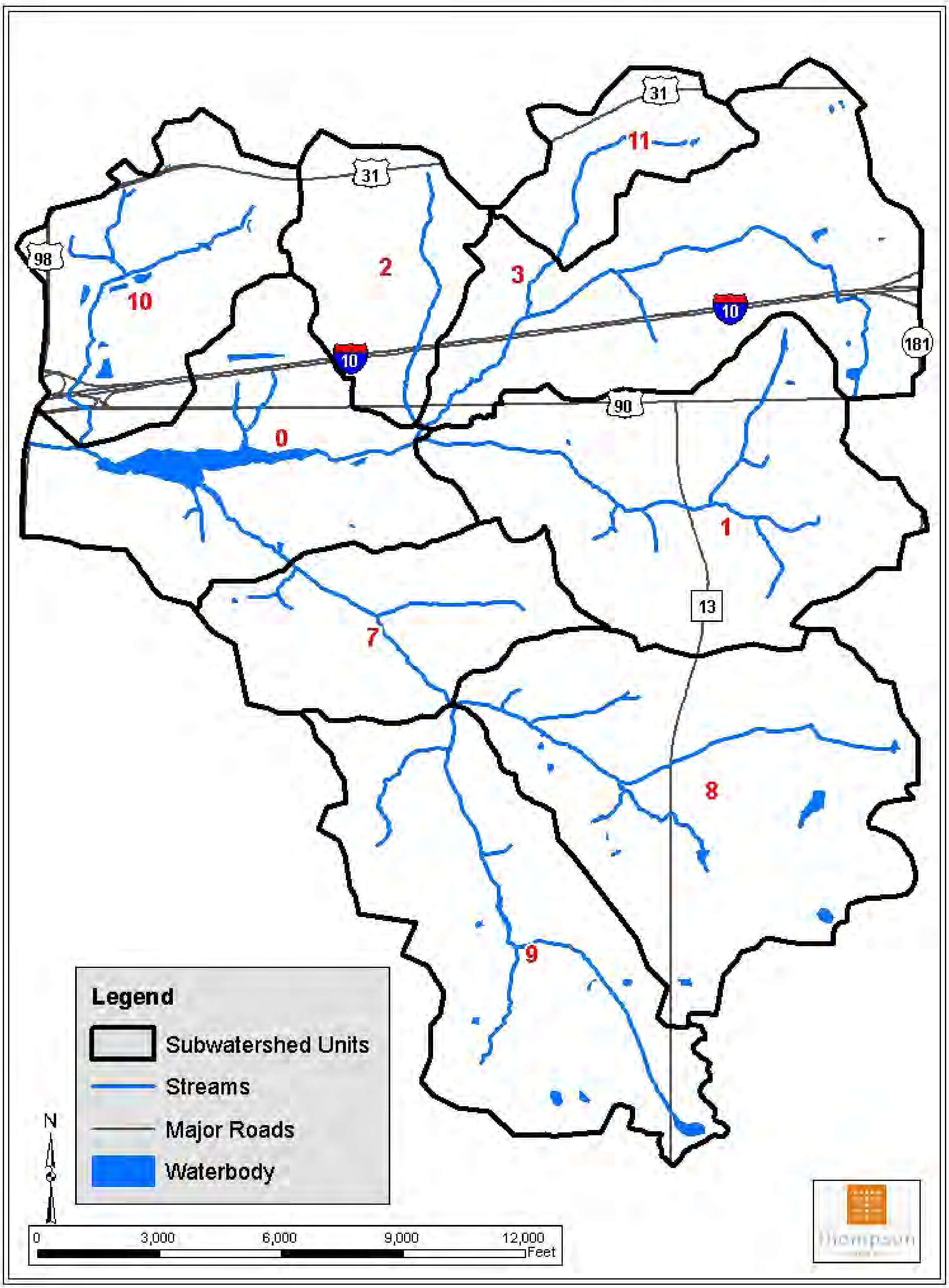

Figure 2-19. Major Highways Serving D'Olive Watershed

In the late 1970s, the I-10 "Bayway" bridge was completed. This was soon thereafter followed by the widening and upgrading of the "Causeway" to make it less susceptible to flooding. These two actions provided more reliable and efficient modes of transportation between Mobile County and the Baldwin County's Eastern Shore.

The improved transportation links made it easier for people to live in Baldwin County and work in Mobile County. Thus, an exodus began in the 1980s as people began to move to the Eastern Shore for quality of life and other reasons. Being the closest Eastern Shore communities to Mobile, Spanish Fort and Daphne began to experience increasing demands for housing to accommodate the needs of their rapidly expanding populations. This resulted in the conversion of land to residential uses and eventually to the incorporation of Spanish Fort. Spanish Fort and Daphne both annexed county lands at various times as their municipal areas grew. These annexations gradually brought larger portions of the D'Olive Watershed under their individual areas of responsibility and control.

What originally began as the development and expansion of a large bedroom community to serve individuals who worked in Mobile has gradually transformed Daphne and Spanish Fort into fully functional cities where many individuals can now work, reside, shop, and recreate within the same area without having to go to Mobile. This was allowed in large part by the development of several commercial ventures over the years that are centered around the principal highways, including the earliest shopping center in Spanish Fort on U.S. 31; development of the Jubilee Square along U.S. 90 and U.S. 98; completion of the Spanish Fort Town Center at the U.S. 98-I-10 interchange; and more recently the large Eastern Shore Park commercial development at the I-10-State Road 181 interchange.

The continued growth of businesses and homes in the Spanish Fort-Daphne region and the unincorporated areas of Baldwin County placed added pressures on the area's existing roadways. The level of service of the principal roadways is often exceeded during workday rush-hour periods in both the mornings and afternoons.

At the time of preparation of this WMP, major improvements were underway on State Road 181 which parallels the approximate eastern boundary of the D'Olive Watershed. State Road 181 is being widened from a two-lane to a four-lane highway as shown in Figure 2-20.

In 1999, County Road 13 was constructed to accommodate the increased traffic demands created by the various residential subdivisions located within the eastern portions of the D'Olive Watershed. This north-south artery cuts across the eastern third of the Watershed, crossing several tributary streams to terminate at U.S. 90. Originally constructed to provide easier access to U.S. 90, plans are in the advanced stages of design to cross U.S. 90 and construct a new interchange with I-10. This highway improvement project is proposed for construction in 2011.

Construction of a new service road paralleling the northern side of I-10 is proposed to connect the large commercial centers located on US 98 and State Road 181. Construction of

Figure 2-20. Widening in Progress of State Road 181

that road could serve as a catalyst to facilitate further economic development along that potential roadway.

As the D'Olive Watershed's population continues to grow, additional traffic flow needs will likely result in the need to widen County Road 13 in the future. No projection is available as to whether that need could develop within the 10-year period addressed by this WMP.

2.13.2 Historic Land Use Trends

Three databases were consulted to evaluate trends in land use/land cover (LU/LC) within the D'Olive Watershed. These data sets, which date back to 1967, provide insight into the type, location, and extent of land use changes within the Watershed over time. In addition, the influence of major developmental events can easily be discerned by examining the changes in LU/LC data.

Because the type and acreage of specific LU/LC types are major determiners of stormwater runoff velocities, one obvious discrepancy was observed when this data was analyzed. The discrepancy relates to differences in the total area reported for the overall D'Olive Watershed in the various studies that have been performed. For example, the acreage used to describe the Watershed has ranged from the 7,713 acres used in preparing this WMP to 8,235 acres reported in the 2008 NASA study. Other intermediate acreages used in other reports prepared over the years have fallen between these two acreages.

The discrepancy in the total Watershed acreage is the result of the various mapping and remote sensing sources used over the years. This WMP relied upon the Baldwin County GIS database that was largely comprised of 2005 data. Although the LU/LC data layer in the Baldwin County GIS database is presently restricted to the interpretation of 2005 aerial photography, that database is still believed to be the most accurate data set available to define land use activities within the Watershed. However, the text of this WMP points out major land use changes that have occurred since 2005 that are not reflected in the Baldwin County GIS database.

One additional factor that is believed to have influenced the discrepancy in the reported D'Olive Watershed acreages reported over the years is the variable quality of topographic mapping that was available at different periods. This is particularly critical for the southeastern portion of the Watershed. Within that area, the drainage divide for D'Olive Watershed is difficult to discern from the neighboring drainages since the divide is located atop a relatively flat plain with elevations that range between 155 feet and 165 feet along the Watershed boundary. Because of the relative "flatness" of this area, a deviation of only a few inches in natural elevations can have a major influence on the runoff pathway that rainwater will follow. This situation has been further confused over the years by numerous ditching projects aimed at enhancing the removal of water from this area. Fortunately, 1-foot contour LIDAR data was available within the Baldwin County GIS database that proved to be useful in establishing the overall boundary for the D'Olive Watershed and in further distinguishing the nine internal subwatersheds (Watershed Management Units) considered in this WMP.

2.13.2.1 1981 Isphording Study

Isphording (1981) first documented land use changes within the D'Olive Watershed as the major cause of the excessive sedimentation that significantly affected D'Olive Bay between 1967 and 1980. As shown in Table 2-6, most all the D'Olive Watershed was covered in forests and agriculture before 1967. By 1980, commercial and residential development had significantly increased, while the acreage in forest declined.

Table 2-6. Land Use Changes in the D'Olive Watershed between 1967 and 1980 [1/]

Land Use	1967	1980	Change
Forest	6,034 (77%)	3,938 (50%)	- 2,096 (-27%)
Agriculture	1,125 (14%)	1,313 (17%)	+188 (+3%)
Urban	640 (8%)	2,146 (27%)	+1,506 (+19%)
Multilane Highways	0 (0%)	290 (4%)	+ 290 (+4%)
Miscellaneous	79 (1%)	191 (2%)	+122 (+1%)

[1/] From Isphording, 1981.

For example, the amount of land classified as urban increased from 8% to 27%, representing a threefold conversion to urban land use between 1967 through 1980. This was accompanied by an increase of 4% in the area covered by multilane highways, which was related to completion of I-10 from the east to its then termination at the Mobile Bay shoreline. At the same time, the acreage in upland forest, the dominant land use/land cover in the Watershed decreased from 77% to 50% over the 14-year period.

The urban development was primarily associated with construction of the massive Lake Forest Subdivision that began around 1967. Isphording's study documented that the conversion of forest to urban uses within the Lake Forest Subdivision was primarily responsible for the adverse sedimentation that affected D'Olive Bay during the 14-year period between 1967 and 1980. Isphording attributed the erosion to:

- The extensive land clearing that was conducted on soils that were strongly prone to slope failure;
- Inadequate protection of the disturbed soils;
- The wet climate;
- A vast network of unpaved roads;
- Apparent inadequate design of drainage channels; and
- Large-scale gullying and erosion.

2.13.2.2 2008 NASA Study

Under the direction of the Mobile Bay Natural Estuary Program, NASA (2008) used remote sensing imagery to investigate historic LU/LC changes in the areas bordering the northern portion of Mobile Bay. This study focused on a regional analysis of urban expansion at the watershed level using Landsat data for the following years: 1974, 1979, 1984, 1988, 1991, 1996, 2001, 2005, and 2008. The LU/LC change analysis considered upland herbaceous, barren, open water, urban, upland forest, woody wetland, and non-woody wetland-dominated land cover types. The analysis was presented for the years 1974, 1984, 1996, and 2008 for several watersheds in Mobile and Baldwin Counties that drain into Mobile Bay. The results of the analysis are summarized in Table 2-7 and graphically depicted in Figure 2-21.

As shown in Table 2-7, the urban expansion that occurred between 1974 and 2008 in the D'Olive Watershed is striking – 16% to 35%. The conversion to urban land use occurred at the expense of the forested acreage in the Watershed. For example, over this 34-year period, the total forested area within the Watershed declined from over 55% to 35%. The major point that can be concluded from this analysis is that by 2008, forested areas in the D'Olive Watershed continued to decline to accommodate increasing urbanization, with the net result being these two lands uses covered equal portions of the Watershed. Since 2008, the area in forest has continued to decrease while the amount of land in urban use continues to rise. This trend is anticipated to continue into the foreseeable future.

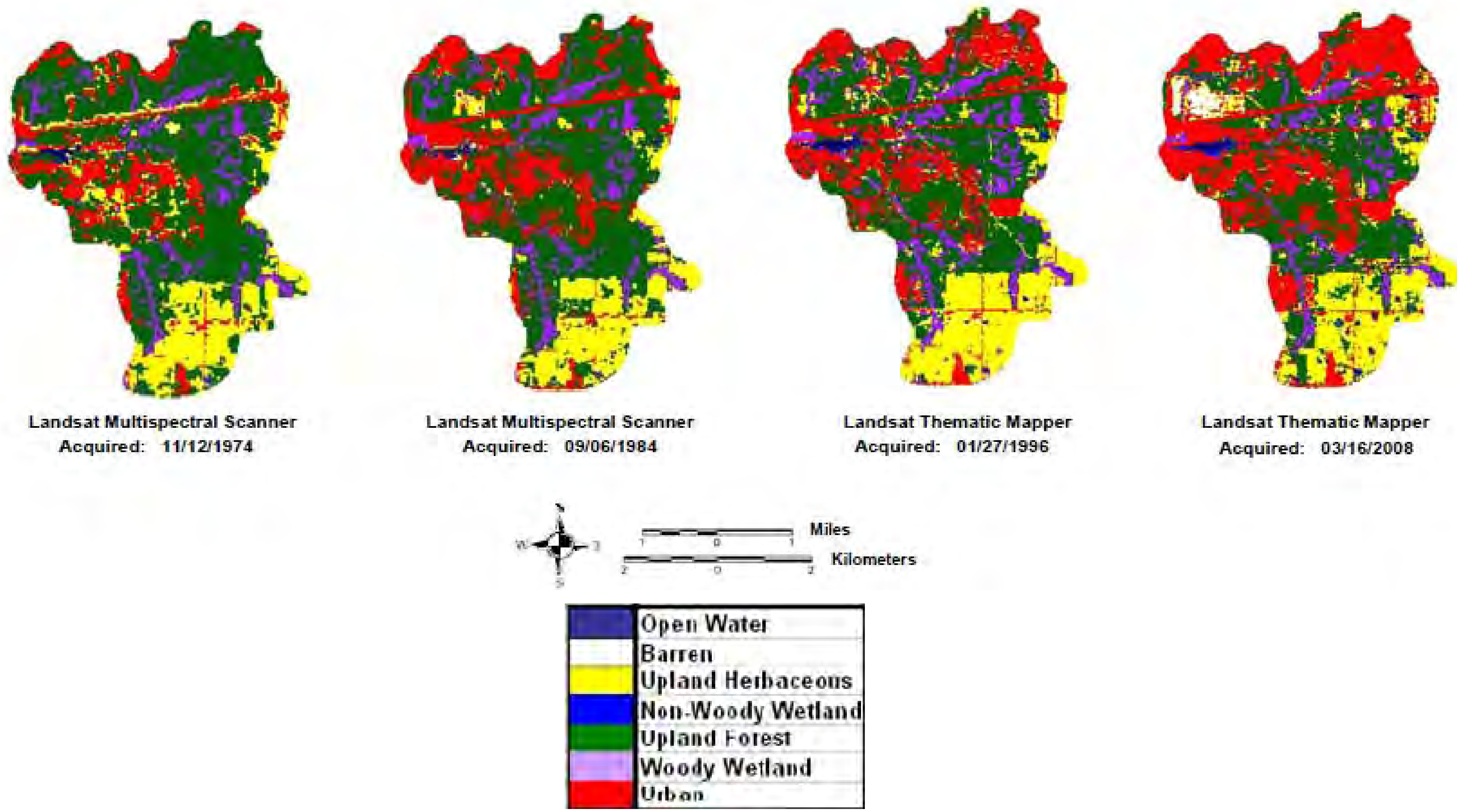

Figure 2-21. Comparison of Land Use/Land Cover Changes in the D'Olive Watershed for 1974, 1984, 1996, and 2008 (Source: Ellis *et al*, 2008)

Table 2-7 Comparison of Land Use/Land Cover Changes in the D'Olive Watershed for 1974, 1984, 1996, and 2008 [1]

LULC Category	1974		1984		1996		2008	
	Acres	Percent	Acres	Percent	Acres	Percent	Acres	Percent
Open Water	30.91	0.4	33.32	0.4	55.40	0.7	83.09	1.0
Barren	5.22	0.1	10.24	0.1	26.69	0.3	140.10	1.7
Agriculture	1,501.92	10.2	1,254.04	15.2	1,685.97	20.5	1,471.01	17.9
Upland Forest	4,596.08	55.8	4,258.28	51.7	3,400.85	41.3	2,914.12	35.4
Wetlands	783.18	9.5	853.22	10.4	1,015.19	12.4	742.63	9.0
Urban	1,317.87	16.0	1,826.07	22.2	2,051.07	24.9	2,884.22	35.0
Total	**8,235**	**100.0**	**8,235**	**100.0**	**8,235**	**100.0**	**8,235**	**100.0**

[1/] From NASA, 2008.

Interestingly, the total agricultural acreage remained relatively consistent over the 34-year period. This was attributed to prevailing agricultural market conditions that periodically caused various rural parcels to go into and come out of row crop production, pecan orchards, and pine plantations. All of the remaining agricultural acreage is located on arable flat lands that occur within the southeastern portion of the Watershed. However, over the last decade there appears to be an increasing trend for agricultural lands, both row crop and pecan orchards, to be converted to residential uses. This reflects the increasing value of these lands for residential development, compared to the vagaries associated with economic returns from traditional farming practices. Over the 10-year period covered by this WMP, it is anticipated that an increasing demand for residential lands will result in the conversion of essentially all of the agricultural lands to residential uses.

2.13.3 Current Land Use

2.13.3.1 2005 Baldwin County GIS Database

For the purposes of this WMP, current land use was determined from the LU/LC data contained in the 2005 Baldwin County GIS database. Although the information in that database was approaching 5 years of age at the time this WMP was prepared, as explained in Section 2.12.1, the Baldwin County GIS database represents the most accurate data set currently available to define the type and acreage of land use activities within the D'Olive Watershed. The land use classifications in the 2005 Baldwin County GIS were determined from an interpretation of detailed high altitude aerial photography, instead of satellite remote sensing. As a result, the analyses presented in this WMP rely almost exclusively on the 2005 database. However, where appropriate, the discussions will point out major land use changes that have occurred since 2005 that are not reflected in the Baldwin County GIS database. Figure 2-22 shows the current land use within the D'Olive Watershed. The Baldwin County LU/LC database assigns land use and land cover to a multitude of categories and types. To facilitate a comparison of the current land use with the historic data presented in Tables 2-6 and 2-7, the Baldwin County dataset has been reduced to create consolidated categories that closely correspond to the historic data. Table 2-8 shows the LU/LC data excerpted from the 2005 Baldwin County GIS database for the entire D'Olive Watershed and each of its nine subwatersheds (see Figure 2-22).

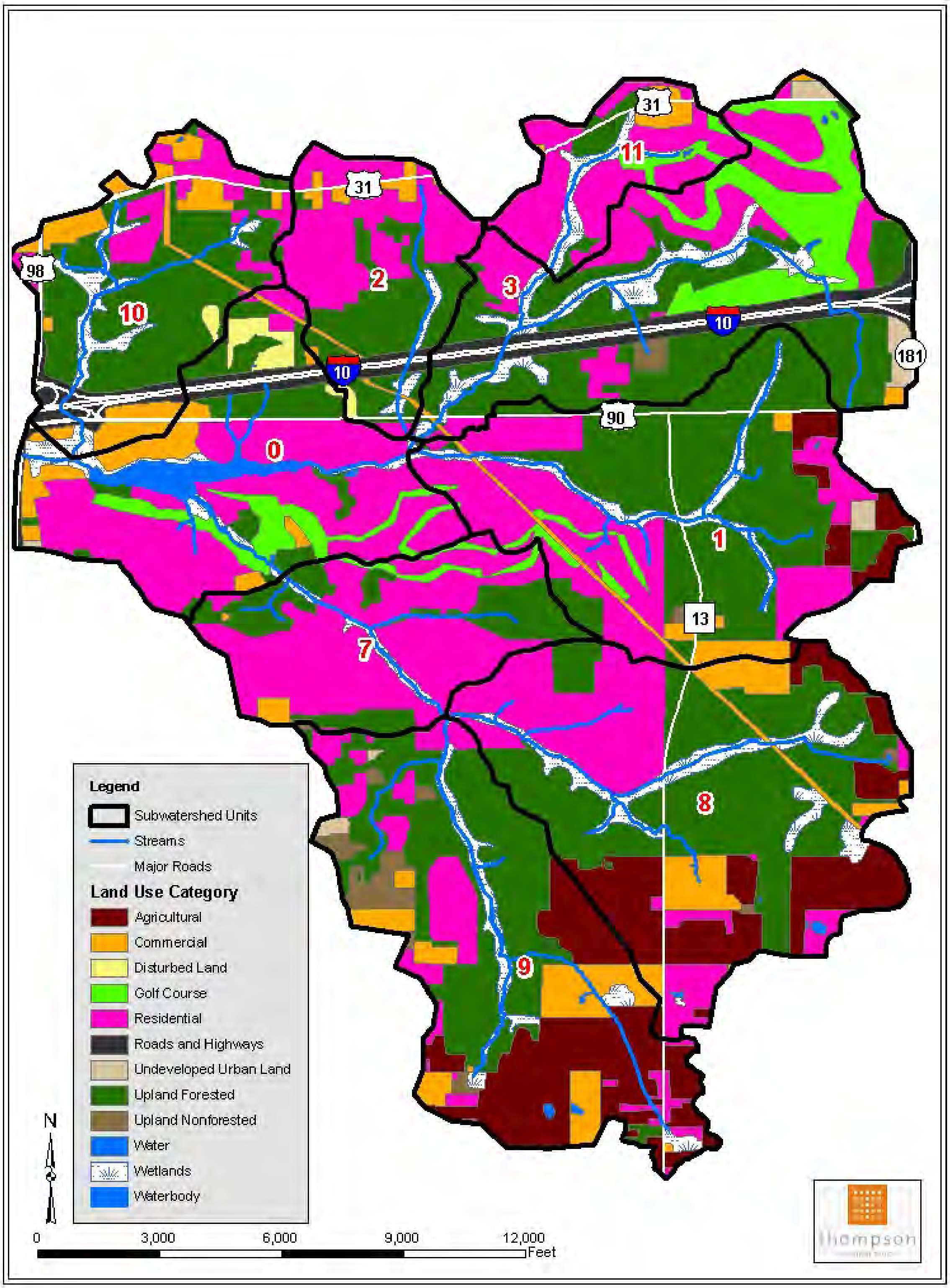

Figure 2-22. Current Land Use in the D'Olive Watershed
(Source: 2005 Baldwin County GIS database)

Table 2-8. Current Land Use/Land Cover for D'Olive Watershed and Nine Subwatersheds [1/]

LU/LC Type	Subwatershed No. [2/]										
	0	**1**	**2**	**3**	**7**	**8**	**9**	**10`**	**11**	**Total**	**Percent**
Open Water	54.27	0.25	-	3.12	3.88	6.18	3.76	0.26	0.58	**71.30**	**1%**
Upland Non-forest	-	4.93	4.76	11.55	1.86	3.26	53.73	-	-	**75.33**	**1%**
Upland Forest	127.85	590.07	173.47	408.64	155.54	539.62	400.51	322.25	33.89	**2,751.84**	**36%**
Agriculture	-	66.70	-	0.01	-	286.47	326.48	-	-	**679.66**	**9%**
Wetlands	37.09	62.60	14.87	103.88	13.19	96.91	59.44	55.25	34.65	**477.88**	**6%**
Urban	673.99	437.80	273.06	632.20	426.54	410.03	288.63	282.83	227.42	**3,656.78**	**47%**
Total	**893.20**	**1,161.87**	**466.16**	**1,158.40**	**601.01**	**1,342.47**	**1,132.55**	**660.59**	**296.54**	**7,712.79**	**100%**
Total Watershed Area = 7,713 acres											

[1/] Excerpted from 2005 Baldwin County GIS database.
[2/] See Figure 2-2 and Table 2-1 for location and descriptive information, respectively, on each of the subwatersheds.

Table 2-8 shows that urban land use currently comprises 47% of the D'Olive Watershed, while upland forest and agriculture areas cover 36% and 9%, respectively. Wetlands and non-forested uplands cover an additional 6% and 1%, respectively.

Examination of the distribution of LU/LC data among the nine individual subwatersheds allows the following broad generalizations to be made:

- Subwatersheds 0, 2, 7, 10, and 11 could be classified as primarily urban. With the exception of Subwatershed 10, urban development covers well over half of the area covered by these subwatersheds. In the case of Subwatershed 10, completion of the extensive Spanish Fort Town Center commercial complex since 2005 resulted in a significant amount of the forest area shown in Table 2-8 being converted to the urban category. Because of their respective locations in the Watershed, these subwatersheds have been impacted by development (i.e. accelerated stormwater runoff, channel degradation, and sediment accumulations) over a longer period and to a larger degree than have the other subwatersheds.

- Subwatersheds 1, 3, 8, and 9 are still dominated by upland forest and/or agricultural areas. However, residential and commercial developments have occurred in these subwatersheds. These four subwatersheds are located at the higher elevation areas and represent much of the headwater drainage of the D'Olive Watershed. Significant portions of the stream channels in these subwatersheds remain in relatively good shape. The stream degradation problems that do exist are located within the most downstream portions of their respective drainages.

- Most of the remaining agricultural lands in production (i.e., row crops and pecan orchards) are located in Subwatersheds 8 and 9. When land prices increase in value, it is highly likely that economic considerations will result in the conversion of these agricultural lands to residential uses. This will likely occur on an individual parcel basis over the 10-year period addressed by this WMP.

- Due to the relatively extensive forested tracts that remain in Subwatersheds 1, 3, 8, and 9, these four drainages have the greatest potential to offer sites for regional detention/retention facilities, as well as for the preservation of substantial tracts of green space and the conservation of riparian buffer habitats.

2.13.3.2 Residential Developments

Residential uses represent the dominant land cover type within the broad "urban" LU/LC category displayed in Figure 2-22 and summarized in Table 2-9. Figure 2-23 shows the extent of the Watershed presently covered by residential developments. Since a complete existing GIS data layer identifying each of the residential developments does not exist, the extent of the individual developments was determined by considering existing mapping, interpretation of aerial photography, and site inspections to ground-truth the subdivision limits. Figure 2-23 probably overestimates the exact acreage that is in residential use.

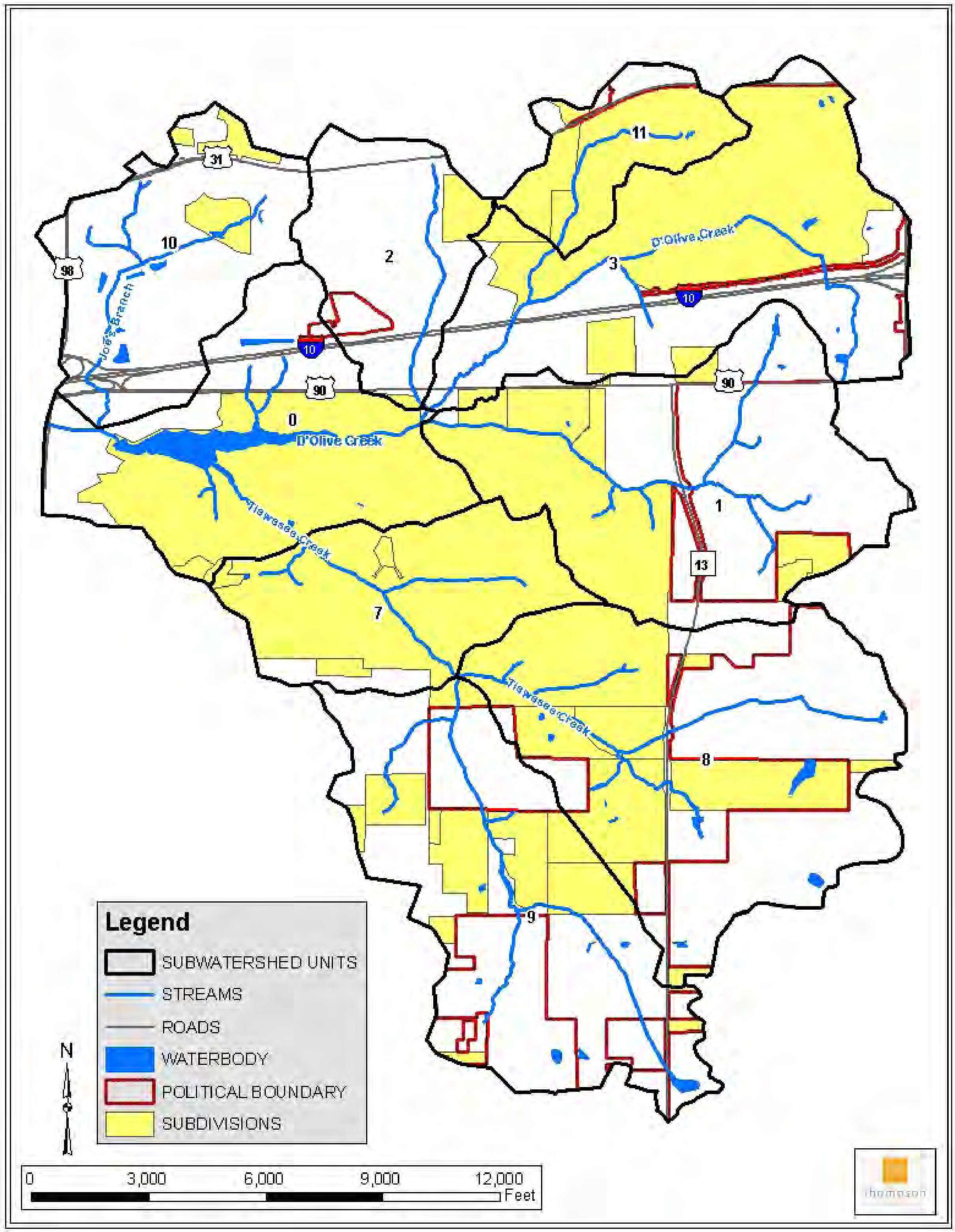

Figure 2-23. Extent of Residential Developments in the D'Olive Watershed

Table 2-9. Residential Subdivisions in the D'Olive Watershed

ID [1/]	Subdivision Name	Acreage in Watershed [2/]	Number of Detention Ponds [3/]
1	Lake Forest	1,660.8	0
2	Timber Creek	753.4	0
3	Canterbury Place	32.0	1
4	Bristol Creek	11.8	0
5	Sehoy	115.6	1
6	Sommerset Place	7.3	1
7	Estates of Tiawasee – Phase I	47.4	0
7	Estates of Tiawasee – Phase II	51.4	2
8	French Settlement	131.1	3
9	Brookhaven	57.9	0
10	Stratford Glen	52.8	0
11	Creekside	57.3	2
12	Brookside	4.9	0
13	Eagle Creek	38.8	1
14	The Park at Whispering Pines [4/]	8.0	1
15	Pecan Trace	6.3	1
16	Charleston Oaks	11.5	1
17	Caroline Woods	7.0	1
18	Timberline Court	10.0	1
19	Krystal Ridge	5.3	1
20	Oak Creek	21.0	2
21	Regency Oaks	34.3	0
22	D'Olive Estates	23.0	0
23	Wilson Heights	104.5	0
24	West Minister Gates	34.2	1
25	Spanish Village	21.3	0
26	Falls Church	4.9	0
27	Wakefield	6.3	0
28	Rolling Hills Place	6.6	1
29	Wood Forest	7.1	1
30	Oakstone	47.7	0
	Total	**3,381.5 acres**	**22**

[1/] ID numbers used to identify subdivision locations on Figure 2-24.
[2/] Acreage actually located within D'Olive Watershed. Portions of some subdivisions may extend into neighboring watersheds producing an overall total acreage larger than that listed in the table.
[3/] See Figure 6-12 which shows the locations of the individual detention ponds.
[4/] Group living facility (i.e., apartment complex).

However, it was beyond the scope of this WMP to develop detailed mapping to construct a more accurate residential GIS data layer.

Table 2-9 lists the 30 individual residential developments and the approximate acreage associated with each development. Residential developments cover a total of 3,381 acres which represents almost 45% of the D'Olive Watershed.

One of the residential developments is classified as a multifamily housing or group living facility. The remaining 29 developments are single family residential subdivisions that vary in lot size, minimum square footage of the homes, and the value of the structures. There is also considerable variation between the respective subdivisions in terms of topographic relief, residual forest coverage, and the extent of landscaping. Lastly, a number of the new subdivisions have not been fully built out with homes.

Lake Forest is reported to be the largest subdivision in Alabama. Approximately, 1,660 acres of this subdivision is located within the D'Olive Watershed. The other large subdivision located within the Watershed is Timber Creek. Table 2-9 and Figure 2-23 show only the portions of these two subdivisions that occur within the Watershed. Both of these subdivisions contain golf courses. Lake Forest has two golf courses (i.e., a 9-hole course and an 18-hole course) that are intermingled with the homes throughout a sizable portion of the subdivision. Timber Creek has a 27-hole golf course that is divided into three segments that are interspersed within the subdivision.

For the most part, the large forested tracts that formerly covered the development sites prior to their development have been eliminated, or are in the process of being cut to make room for road and home construction. However, Lake Forest and Timber Creek still have sizable tracts of interior forest lands (see Figure 2-24). These tracts total 204 acres in Lake Forest and 117 acres in Timber Creek. In addition, there are a number of undeveloped lots in the two subdivisions, particularly in Lake Forest, which have not yet been developed.

2.13.3.3 Commercial Developments

Commercial developments within the D'Olive Watershed represent a relatively minor use of the land in terms of the total acreage involved. As shown in Figure 2-25, for the most part, major commercial activities are located in proximity to the major roadway interchanges and to a lesser extent at other scattered locations within the Watershed. For the purposes of this WMP, commercial activities are considered to include businesses, light industry, institutional facilities, schools, churches, and utilities. Figure 2-25 shows the locations of the various commercial activities as extracted from the 2005 Baldwin County GIS database. It should be noted that Figure 2-25 does not depict the extensive Spanish Fort Town Center located to the northeast of the I-10-US 90 interchange, or the Eastern Shore Park located to the southwest of the I-10-State Road 181 interchange. These major commercial developments did not exist at the time the 2005 Baldwin County GIS land use data layer was developed.

2.13.4 Future Land Use

The accelerated rate of development that has characterized the D'Olive Watershed since the 1980s is expected to continue into the foreseeable future. By the end of the 10-year period (i.e., 2020) addressed in this WMP, all suitable Watershed areas that are not now developed are expected to be converted to urban uses. This will produce a condition that will closely approximate 100% "build-out" of available lands.

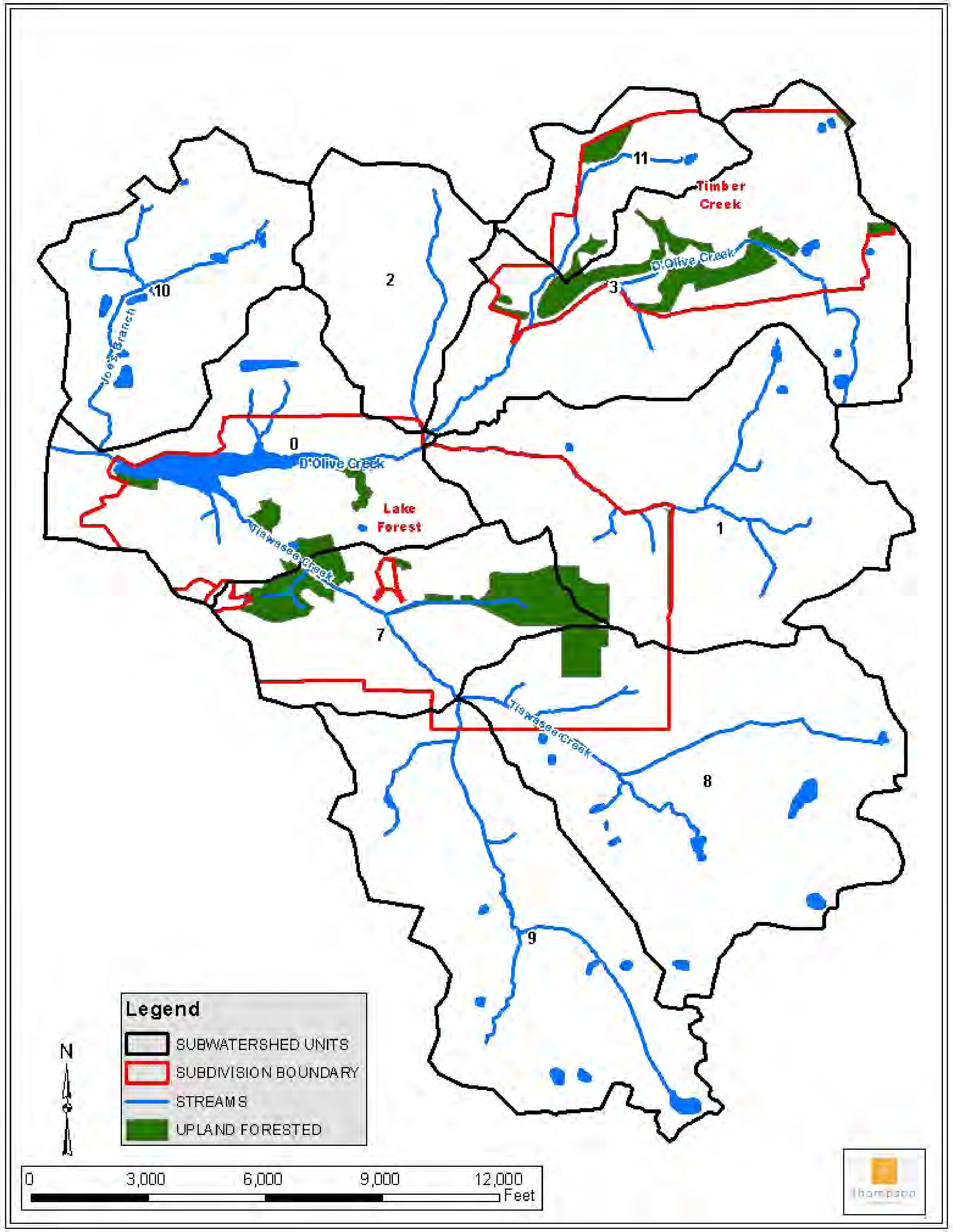

Figure 2-24. Forest Land Remaining in the Lake Forest and Timber Creek Subdivisions

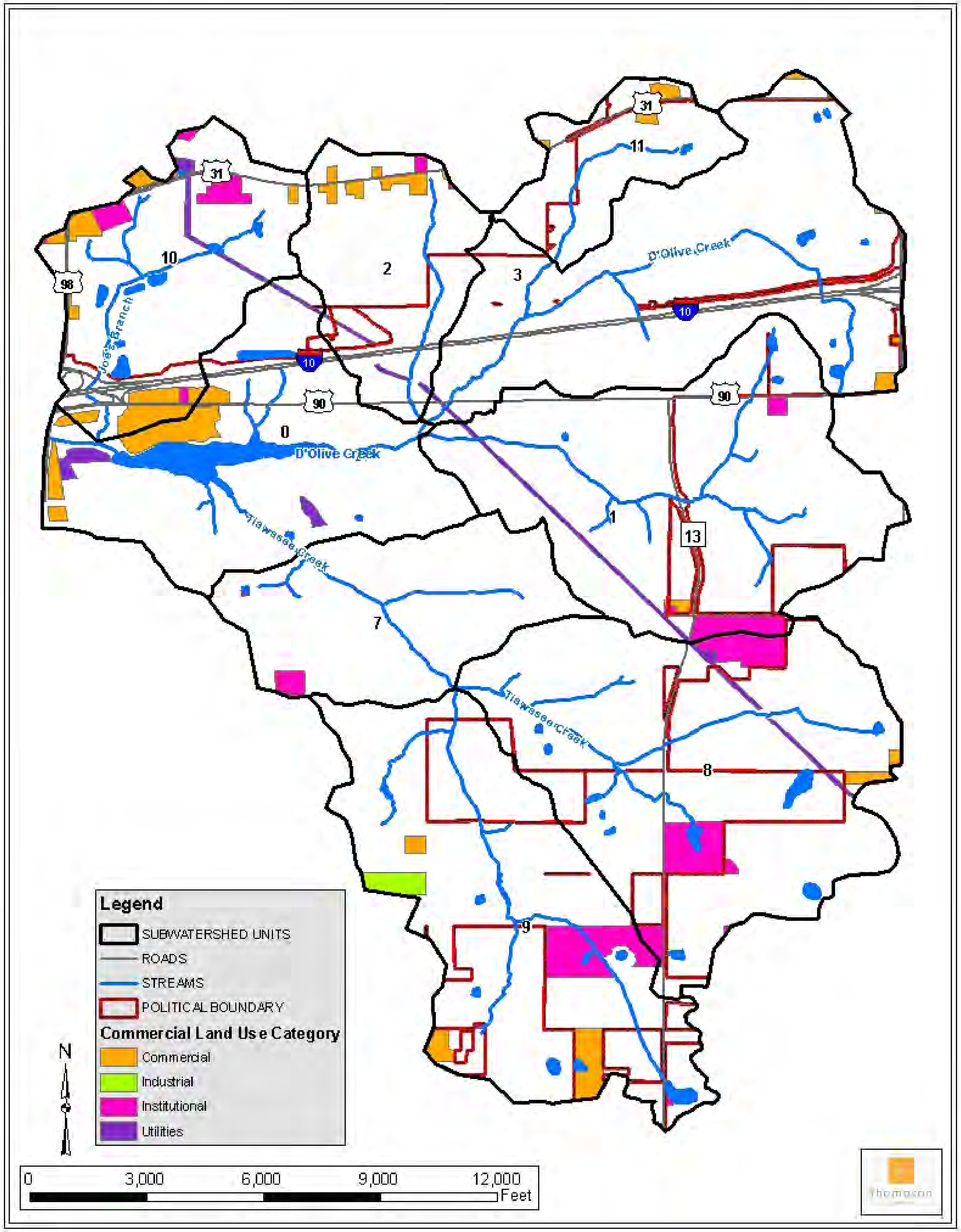

Figure 2-25. Commercial/Industrial Activities within the D'Olive Watershed

This growth will occur primarily through the conversion of the remaining large forested tracts and the agricultural lands now in row crop production and pecan orchards. Based on the Baldwin County 2005 database, approximately 2,000 acres of forest and around 500 acres of agricultural lands are currently not included in an approved development. Figure 2-26 shows the locations of these remaining forest and agricultural lands within each of the nine subwatersheds. The remaining forested tracts are scattered throughout the undeveloped portions of the Watershed, while the agricultural lands are restricted to the extreme southern and southeastern headwater areas.

2.13.4.1 Zoning

The best source of information to consider in projecting future land use for an area is to consider how the land in question has been zoned. The zoning plan developed for an area depicts the type and location of acceptable growth desired by the community, and, by exclusion, indicates that which is not considered acceptable.

The entire D'Olive Watershed has been zoned by the Cities of Spanish Fort and Daphne and by the residents of the unincorporated portions of the Watershed located in Baldwin County Planning District 15. Although each zoning effort was undertaken at different times and by different entities, the essential land use categories are similar. Figure 2-27 shows a zoning map prepared from consolidated GIS data for the portions of the Watershed occurring with Daphne and Baldwin County. Unfortunately, Spanish Fort's zoning plan is not yet available in a GIS compatible format which prevented it from being included in Figure 2-27 (Note the "grey" area in the northwestern portion of the Watershed in Figure 2-27.). The zoning information for Spanish Fort is shown separately in Figure 2-28. Table 2-10 summarizes the acreages associated with these zoning categories for each governmental entity.

Four major observations can be made by examination of Figures 2-27 and 2-28.

- First, with the exception of the wetland areas that are protected by statute and regulation and two small isolated parcels designated to remain in agriculture, the D'Olive Watershed is essentially zoned for complete development.

- Second, residential use will continue to represent the principal urban use in the Watershed. Of the 6,674 acres of the Watershed located within the City of Daphne and Baldwin County, a total of 4,323 acres are zoned for various types of residential uses, representing 65% of their combined land area.

- Three, business ranks a distant second in the total area designated for this urban use. Existing locations along the major transportation routes presently dedicated business activities will retain that designation. In addition, with the exception of an existing residential subdivision, the entire strip of land between I-10 and U.S. 90 is targeted for business development. A large area located immediately north of I-10 between U.S. 98 to the west and State Highway 181 to the east is also targeted for business development. However, the development of this last area will depend on the construction of a proposed service road connecting the two highway corridors. A

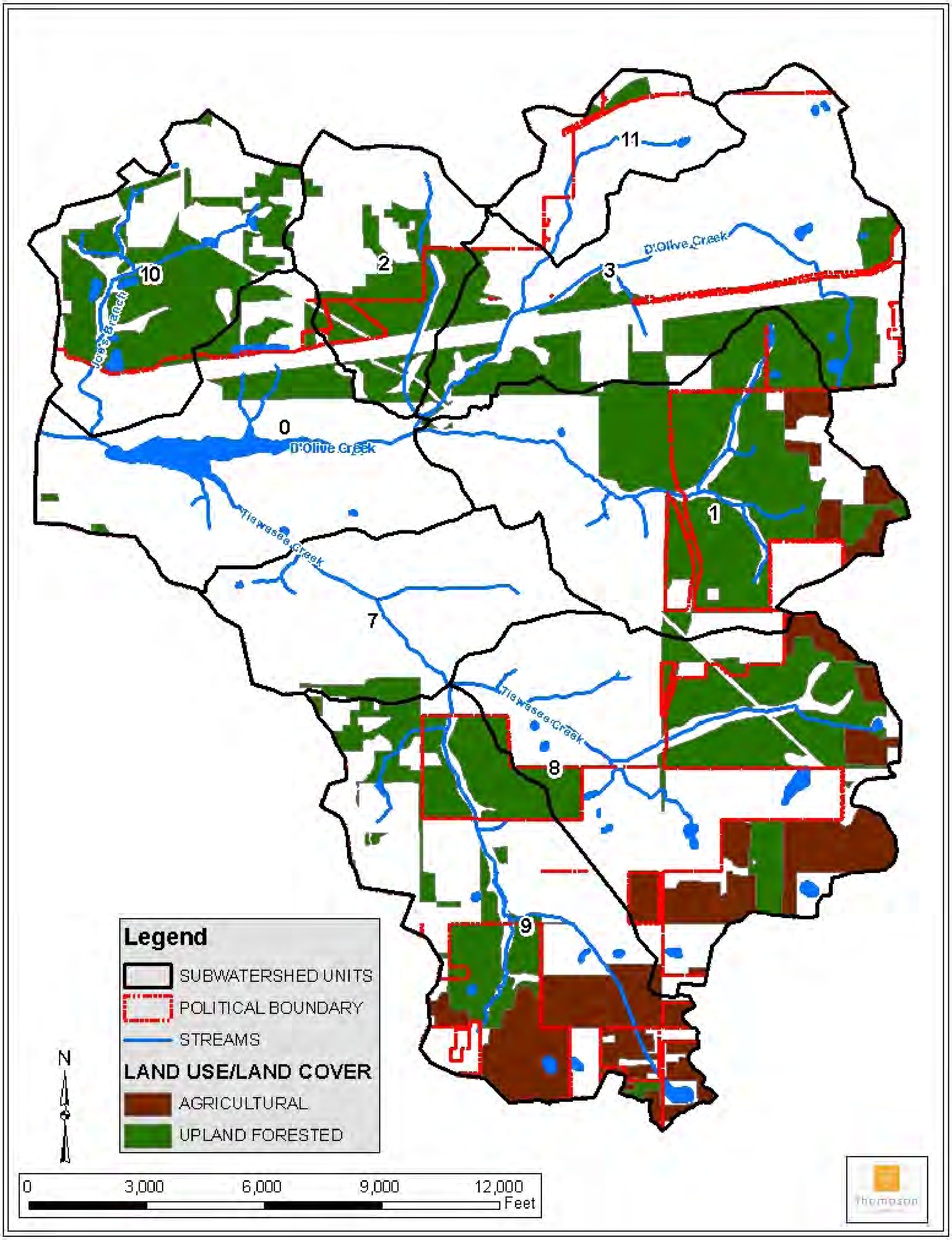

Figure 2-26. Current Forest and Agricultural Lands Not Included within Established Developments (source: 2005 Baldwin County GIS database)

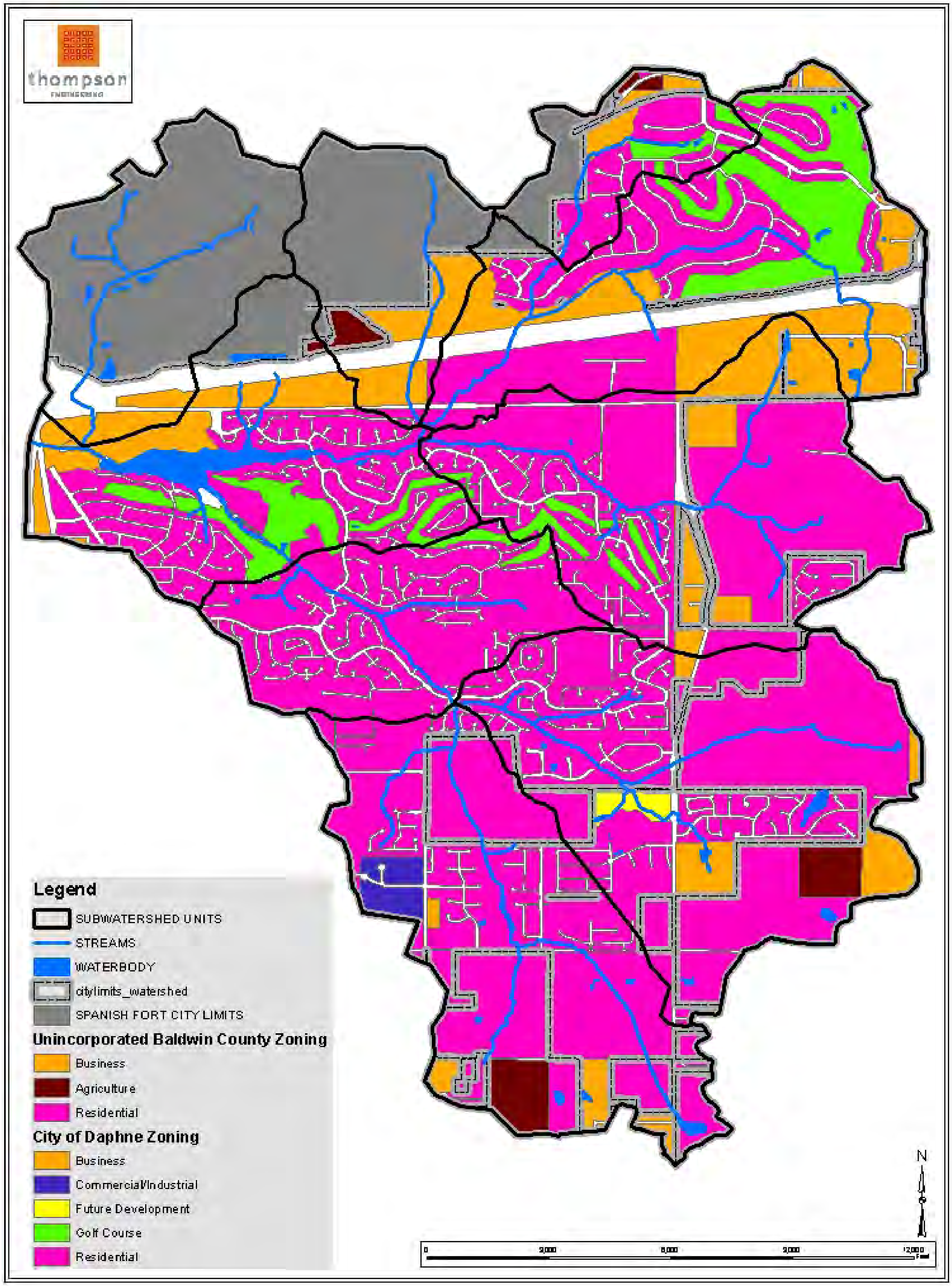

Figure 2-27. Zoned Land Use for Daphne and Baldwin County Portions of D'Olive Watershed

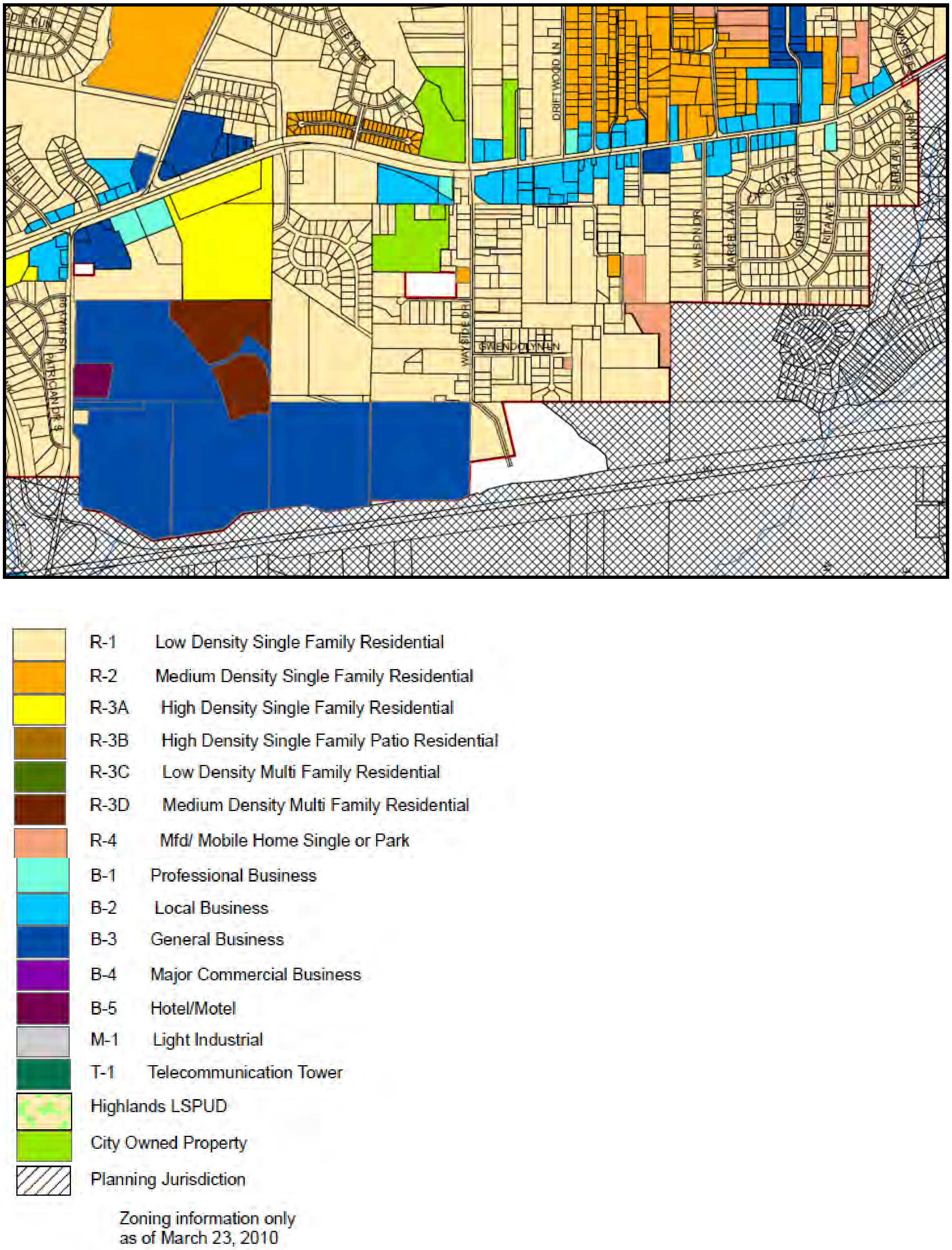

Figure 2-28. City of Spanish Zoning Map Included within D'Olive Watershed

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recent decision to postpone construction of the service road raises questions as to when development of the lands in that area will occur. All zoned new business growth is expected to occur through the conversion of forest lands.

- Fourth, present zoning of the Watershed does not include areas specifically designated for green space preservation or large regional stormwater detention/retention facilities.

Table 2-10. Summary of Zoned Land Uses for D'Olive Watershed

Principal Zoning Category	Political Entity			Shared by Entities	Total	Percent
	Daphne	Spanish Fort	Baldwin County			
Highways and Roads	-	-	-	282	282	3.7
Waterbodies	-	-	-	71	71	0.9
Wetlands	-	-	-	478	478	6.2
Business	766	260	159		1,185	15.4
Commercial/Industrial	41	-	-	-	41	0.5
Residential	2,997	779	1,326	-	5,102	66.1
Golf Course	400	-	-	-	400	5.2
Agricultural	-	-	128	-	128	1.7
Forest	-	-	-	-	0	0.0
Future Development	26	-	-	-	26	0.3
TOTAL	**4,230**	**1,039**	**1,613**	**831**	**7,713**	**100**

2.13.4.2 Baldwin County Horizon 2025 Plan

On January 7, 2009, the Baldwin County Commission adopted "Horizon 2025: the Baldwin County Comprehensive Plan 2008-2025". That plan provides guidance for the unincorporated portions of the county, including the 1,613 acres of the D'Olive Watershed that are not included in either Daphne or Spanish Fort. The purpose of the plan is "…to assist elected and appointed officials, planners and citizens in their efforts to guide the timing and quality of future development". The Horizon 2025 Plan was prepared as an overall guide to facilitate positive and constructive future development in Baldwin County. As such, its provisions are not mandatory, but offered as guidance only. Only development located in those Planning Districts within Baldwin County that have elected to come under the planning and zoning authority of the Baldwin County Commission fall within the scope of this document. Since Planning District 15 which includes the D'Olive Watershed has voted to come under the zoning authority, the provisions of the Horizon 2025 Plan apply to Baldwin County's portion of the Watershed.

Figure 2-29 displays the County's future use plan for the unincorporated portion of the D'Olive Watershed. The future land use plan is relatively consistent with zoning map shown in Figure 2-27 in that almost all of the County lands are projected to be used for residential purposes.

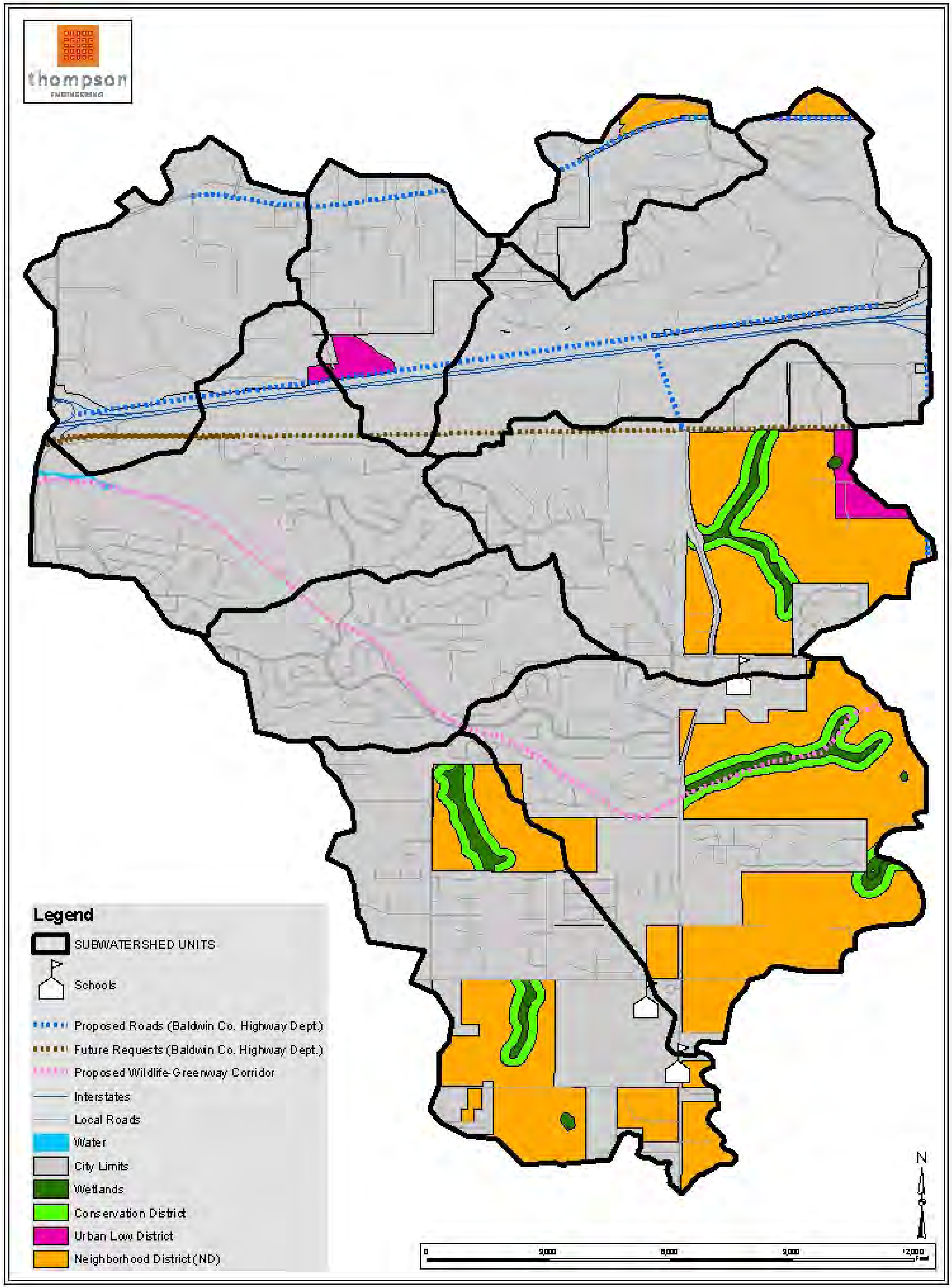

Figure 2-29. Baldwin County's Future Land Use Plan.
(Source: Baldwin County Horizon 2005 Plan)

Neighborhood District (ND). At 1,321 acres, the neighborhood district represents the dominant future use projected for the County's portion of the D'Olive Watershed as shown in Figure 2-29. As defined by the Horizon 2025 Plan:

> "The Neighborhood District consists predominantly of low density residential development, including single family dwellings. Other uses allowed in this designation include accessory structures; home occupations; limited public and institutional uses; limited retail and office uses; and utilities. Civic spaces in this District include parks, greens, and playgrounds. Retail and office uses should be at a neighborhood scale, meaning acceptable uses that will have a limited impact on adjacent residential areas especially in terms of lighting, signage, traffic, odor, noise, and hours of operation. Acceptable uses should be compatible with surrounding development in terms of scale/building size, building design, materials, and color, and located at the intersection of road facilities classified as "collectors" or higher. The maximum density for residential uses shall be four (4) units per acre. *The maximum intensity for non-residential uses shall be 0.60 Impervious Surface Ratio (ISR)* or 0.45 Floor Area Ratio (FAR), whichever is more restrictive. The preferred development in this District will occur in the form of neighborhoods, defined in general terms as an urban sector that is mixed use, mixed income, and limited in area by walking distance typically defined as a 10 minute/1.5 mile walk. The neighborhood is conceived to fulfill most ordinary human needs, including those of transportation. The neighborhood is served by a network of thoroughfares variously detailed for character and capacity, creating a public realm suitable to the pedestrian as well as the vehicle."

Conservation District. A total of 230 acres are designated as Conservation District lands. As shown on Figure 2-29, these lands are located along each of the major streams occurring within the D'Olive Watershed as well as around at least three Grady ponds. In addition, the main stem of Tiawasee Creek is proposed as a "wildlife corridor" to facilitate the movement of large wildlife species from the mouth of D'Olive Creek to more interior areas of the County. The Horizon 2025 Plan states that:

> "The Conservation District consists of lands unsuitable for development due to topography, hydrology, vegetation, or wildlife habitat. This designation protects environmentally sensitive areas, natural water bodies, and other unique or sensitive natural resources. Such resources include groundwater, floodplains, wetlands, streams, steep slopes, woodlands, wildlife habitats, beach dune areas, certain agricultural and forest lands, and areas depicted in the State Wildlife Action Plan. Uses allowed in this designation include natural preserves, reserves, recreation and camping areas; and structures limited to utility infrastructure and camp buildings. Single family residential dwellings will be allowed in the Conservation District by special exception. The maximum density for residential uses shall be one (1) unit per five (5) acres. As needed, some upland areas are included in this District to establish significant greenways and wildlife corridors to connect environmentally sensitive areas. Such greenways and corridors shall have a minimum width of four hundred feet (400')."

Urban Low Intensity District (ULD). This use would involve two parcels consisting of a total of 62 acres. This land use allows a variety of residential and non-residential uses as described in the following:

> "This District consists of medium density residential development; nonresidential development such as retail, office, institutional/public; light industrial uses; and civic spaces. Civic spaces in this District include greens, squares, and playgrounds. Residential uses shall be in the form of single family detached units, single family attached units, duplexes, townhouses, multi-family buildings, and apartments; nonresidential uses shall be allowed at a scale to serve the residents of the neighborhood and surrounding area. Other uses allowed in this designation include utilities and accessory structures. The maximum density for residential uses shall be eight (8) units per acre. *The maximum intensity for non-residential uses shall be 0.95 Impervious Surface Ratio (ISR)* or 1.0 Floor Area Ratio (FAR), whichever is more restrictive. The preferred development in this District will occur in the form of corridors, Traditional Neighborhood Developments (TNDs), Neighborhood Village Centers and Town Centers."

2.13.4.3 Road Improvements

As discussed in Section 2.13.1, future urbanization of the D'Olive Watershed will likely result in the need to improve the existing major traffic arteries, adding additional lanes and turn lanes. County Road 13 serves as a prime example of a current two-lane road that could probably require upgrading in the future to better provide access to the planned interchange at I-10.

As the remaining large tracts of land are developed, In addition, new roads and bridges will be constructed to provide effective access to the new homes and businesses. The large remaining undeveloped forest and agricultural tracts shown in Figure 2-26 indicate the likely locations where the new feeder roads will be constructed as these tracts are converted to urban uses. As these areas are developed and additional traffic enters the established County Road 13 and State Highway 181 corridors, improvements to these and other east-west roads will be needed.

2.13.5 Impervious Cover

As pointed out earlier in this section, four principal factors influence overland erosion: rainfall, soil characteristics, topography, and land cover. Of these, the most important factor in controlling soil loss is land cover. Land cover (in addition to topographic features and soil characteristics) is the variable most often influenced by man in developing landscapes. The potential for erosion increases as natural vegetation is replaced with by Impervious Cover in a developing watershed.

2.13.5.1 Background

Vegetative cover provides the soil stabilization factor or soil cover factor used in the Universal Soil Loss Equation. Vegetation cover protects the soil from raindrop impact, reduces stormwater runoff velocities, increases infiltration of rainfall, and holds soil in place with root structures. In addition, through the process of evapotranspiration, water present in the soil is "mined" up through the roots of plants and evaporated into the atmosphere. This process helps plants dry soils through evapotranspiration which increases the soil's capacity to hold water that in turn reduces runoff.

In the natural, undisturbed environment, rain that falls is intercepted by trees and other vegetation and/or infiltrates into the soil. When permeable soils are present, runoff typically occurs only with significant precipitation events (EPA, 2009).

Urbanization of a watershed results in the removal of the native vegetation. Traditional development practices cover large areas with impervious surfaces such as roads, driveways, sidewalks, and buildings. Land cover changes also increase soil compaction and alter natural drainage patterns. These changes increase the imperviousness of a watershed so that runoff occurs even during small precipitation events that would normally have been absorbed by the soil and vegetation. Figure 2-30 provides a conceptual comparison of the effects of urbanization on the hydrology of a site.

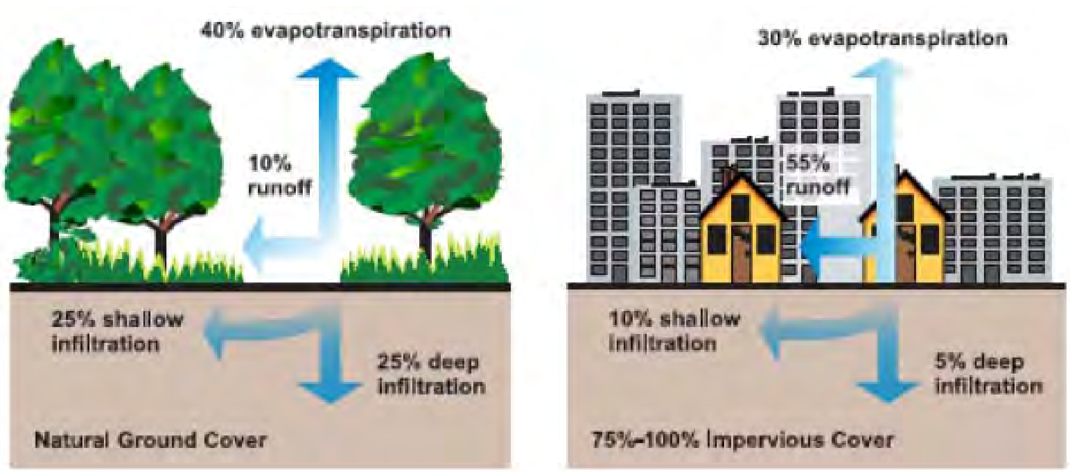

Figure 2-30. Comparison of Pre-Development and Post-Development Hydrology (Source: EPA, 2009)

The cumulative impacts of the land cover changes result in the natural hydrology of a site/watershed being altered, producing increased runoff volumes and peak runoff velocities. Development results in an increase in the impervious surface area, a higher degree of connectivity between impervious areas, and the loss of soils and vegetative cover that previously slowed or reduced runoff in the pre-developed condition. Figure 2-31 illustrates the impacts of development on runoff volume and timing of the runoff on the hydrograph of a receiving stream. Changes in the watershed land cover result in greater discharge velocities, greater volumes, and shorter discharge periods. As shown in Figure 2-31, pre-development runoff velocities are lower than those on developed sites and the discharges occur over a longer time period. The pre-development peak discharge rate is also much lower than the post-development peak discharge rate due to attenuation and absorption by soils and vegetation. In addition, development shortens the time before runoff begins

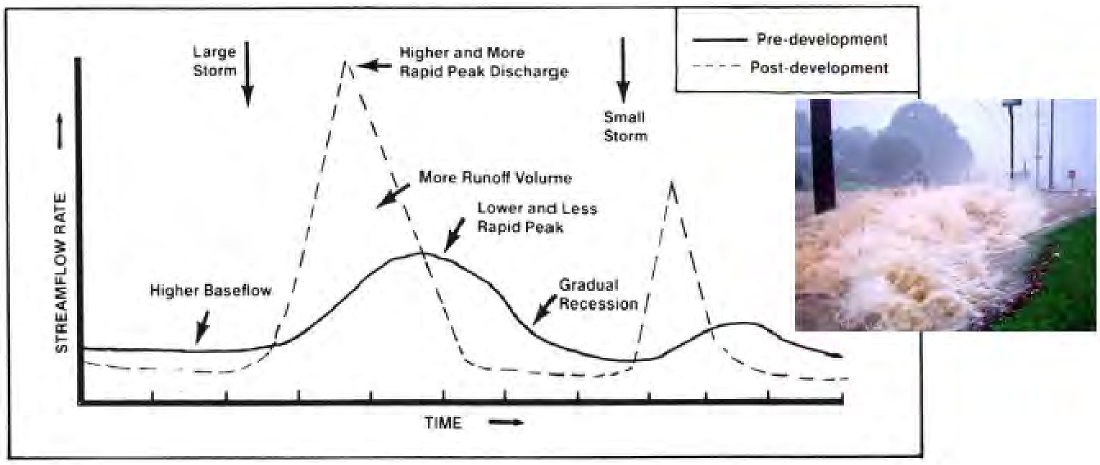

Figure 2-31. Comparison of Pre-Development and Post-Development Hydrographs (From Schueler, 2005)

Degradation of aquatic ecosystems can occur when the hydrology of a watershed is altered by large increases in impervious area. The collective force of the increased runoff scours streambeds, erodes streambanks, and causes large quantities of sediment and associated pollutants to enter streams each time it rains.

Impervious Cover (IC) is a collective term used to describe all hard surfaces (i.e., rooftops, driveways, roads, parking lots, swimming pools, patios, compacted soils, grassed lawns, golf courses, etc.) that permit little or no water infiltration into the soil. Impervious cover fundamentally alters the hydrology of urban watersheds by generating increased stormwater runoff and reducing the amount of rainfall that soaks into the ground.

Impervious cover is the best indicator to measure the intensity of watershed development and to predict the severity of development impacts on the network of streams within a watershed. The extent of impervious cover in a watershed is closely linked to the specific LU/LC cover types that reflect intensive land uses traditionally associated with urban growth. Typically, increases in Impervious Cover result in the fragmentation of natural area remnants; create interruptions in the stream corridor; reflect encroachments into and expansion of developments within floodplains; and increase the density of stormwater hotspots.

2.13.5.2 The Impervious Cover Model (ICM)

The Center for Watershed Protection (2003 and 2005) has developed an Impervious Cover Model (ICM) that can be used to predict changes in stream health as a consequence of watershed development and to assess the effectiveness of stream restoration. According to the ICM, when the imperviousness of a watershed begins to exceed 10%, increased nonpoint source pollutant loads begin to appear from urban runoff; stream temperatures become elevated due to reduced canopy cover; and increases in stream scour and channel instability begin which reduces the quality of stream habitat and diminishes biodiversity.

The ICM (CWP, 2005) identifies four classifications of urban streams based on the extent of Impervious Cover (IC) and future restoration potential (see Figure 2-32). The four types of streams are as follows:

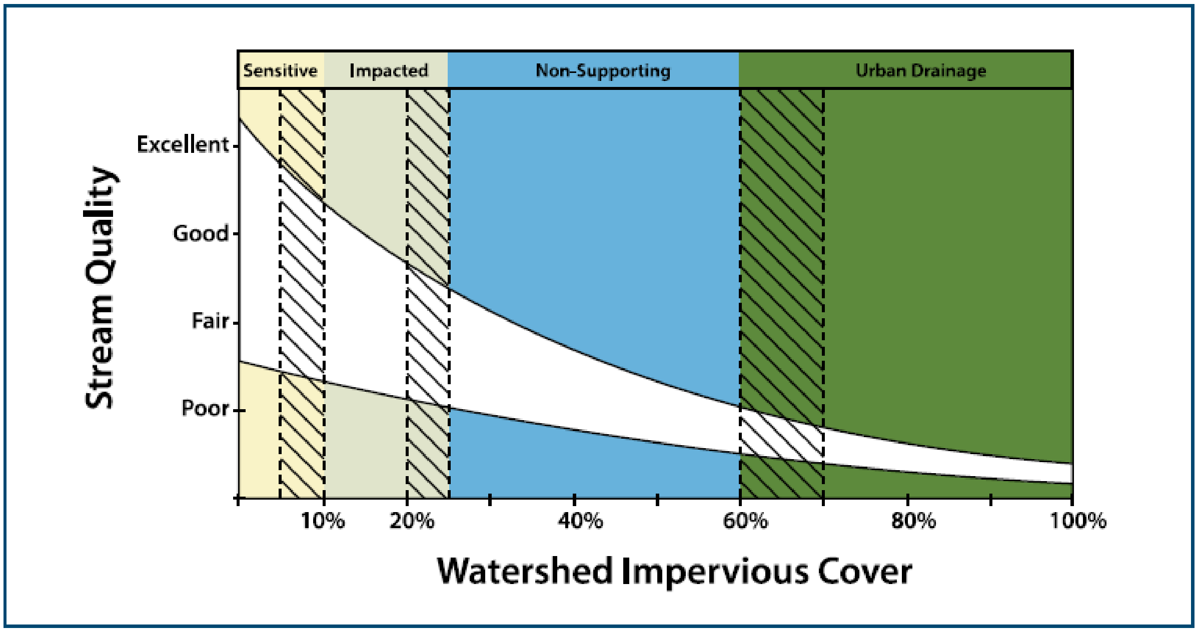

Figure 2-32. Relationship between Watershed Impervious Cover and Stream Quality (Source: Hirschman and Kosco, 2008)

- **High Quality Streams** have less than 10% IC in their contributing drainage area and generally retain their hydrologic function. Such streams support good to excellent aquatic diversity.

- **Impacted Streams** have between 10 and 25% IC in their supporting subwatershed, and show clear signs of declining stream health. Most indicators of stream health fall in the fair range, although some reaches may still be rated as being of good quality. These streams often exhibit the greatest restoration potential since they exhibit only moderate degradation, have an intact stream corridor, and usually have enough undeveloped land available in the watershed in which to install restoration practices.

- **Non-Supporting Streams** [1/] range between 25 and 60% IC in their supporting subwatershed. These streams no longer support their designated uses as defined by hydrology, channel stability, habitat, water quality and biological indicators. Subwatersheds at the lower end of the IC range (25 to 40%) may show promise for partial restoration, but are so altered that they normally cannot attain pre-development conditions for most indicators. In some circumstances, streams in the upper range of the non-supporting category (40 to 60% IC) may show some potential for stream restoration. In most circumstances, however, the primary restoration goals are to reduce pollutants, improve the stream corridor, or enhance community amenities.

- **Urban Drainage** refers to streams that have subwatersheds with more than 60% IC and where the stream corridor has essentially been eliminated or physically altered to the point that it functions merely as a conduit for flood waters. Water quality indicators are consistently poor, channels are highly unstable, and both stream habitat and aquatic diversity are rated as very poor or are eliminated altogether. Thus, the prospects to restore aquatic diversity in urban drainage are extremely limited, although it may be possible to achieve significant pollutant reductions.

The ICM displayed in Figure 2-32 expresses the IC/stream health relationship as a "cone" that is widest at the lower level s of IC and progressively narrows at higher levels of IC. At lower levels of IC (i.e., less than 10%), stream quality varies widely according to the amount of forest cover, road density, extent of riparian vegetative cover, and other factors that are present in less urban watersheds. At higher levels of IC, the correlation between IC and stream health is stronger. The transition between the four stream health categories is shown in Figure 2-32 as ranges (i.e., 5%-10%, 20%-25%, and 60%-70%) as opposed to sharply defined thresholds because of the variability between streams. The predominant type of pre-development land cover (i.e., forest and agriculture) is the most important parameter in applying the ICM within watersheds indicator of greatest concern in applying the ICM in watersheds, reflecting the importance of this parameter on stormwater runoff (Hirschman and Kosco, 2008).

According to the Center for Watershed Protection, use of the ICM to classify urban watersheds allows reasonable restoration expectations to be developed. The ICM helps define general thresholds at which current water quality standards or biological conditions cannot be consistently met during wet weather conditions. These predictions help set realistic objectives to protect stream quality based on current and future conditions.

2.13.5.3 Current Impervious Cover in the D'Olive Watershed

Impervious cover has unique properties that can be measured, tracked, forecasted, managed, regulated, and mitigated. The extent of impervious cover in a watershed can be accurately measured using either remote sensing or more detailed aerial photography. Impervious cover

[1/] The "Non Supporting" category used in the ICM is not synonymous with the terminology used in the 303(d) list of impaired streams and should not be confused with the 303(d) program.

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is usually reported as the percentage of impervious cover occurring within a specific area, which can range in size from an individual lot to an entire watershed. Figure 2-33 illustrates the impervious cover as measured for two individual residential lots.

Figure 2-33. Measured Percent Impervious Cover for Individual Residential Lots

Impervious cover is strongly correlated with LU/LC and zoning categories. A variety of studies have developed Impervious Surface Coefficients (ISCs) that can be assigned to specific land cover categories used to calculate the overall percent of Impervious Cover occurring within a watershed. This information allows planners to assess the current condition of a watershed, and to forecast how the imperviousness of a watershed can change over time in response to future development.

The scope of work for this WMP did not provide for a detailed analysis of the Impervious Cover occurring within the D'Olive Watershed. Therefore, it was necessary to rely upon established ISCs obtained from the watershed literature to determine the imperviousness of the Watershed. The ISCs were then applied to the appropriate LU/LC acreages in the Watershed as determined from the 2005 Baldwin County GIS database. To improve the quality of this analysis, the LULC categories considered were expanded from the six broad LULC types presented in Table 2-8 to the 18 LU/LC types shown in Table 2-11. The results of this analysis indicate that the current Percent Impervious Cover in the D'Olive Watershed is 19%.

However, since the LU/LC data does not reflect the existence of several major developments (i.e., Spanish Fort Town Center, commercial developments near the I-10 – State Highway 181 interchange, and the newest residential subdivisions) that were constructed after 2005, it is believed the actual Percent Impervious Cover within the D'Olive Watershed likely ranges somewhere between 20% and 25%. If this is the case, this level of imperviousness would place the D'Olive Watershed near the upper threshold of 25% for the Impacted Stream category which may make complete restoration of the Watershed's streams and reduction in stormwater runoff from the contiguous watershed areas problematic to achieve.

Table 2-11. Current Percent Impervious Cover in D'Olive Watershed

Land Use/Land Cover Type [1/]	Acreage	Impervious Surface Coefficient [2/]	IC Acreage
Agriculture	679.66	0.080	54
Upland Forest	2,751.84	0.020	55
Upland Non-forested	75.33	0.100	8
Disturbed Land	38.60	0.135	5
Undeveloped Urban Land	43.93	0.086	4
Recreational	39.49	0.139	5
Golf Course	358.38	0.120	47
Residential	2,389.30	0.350	836
Commercial and Services	201.90	0.722	146
Communication Facilities	4.75	0.150	>1
School, Churches, and Childcare	158.58	0.502	80
Institutional	42.44	0.344	15
Medical	9.09	0.737	7
Industrial	16.71	0.534	9
Roads and Highways	282.85	0.400	113
Utilities	70.76	0.700	50
Wetlands	477.88	0.020	10
Waterbodies	71.30	1.000	71
Total Acreage	**7,712.79**		1,516
Percent Impervious Cover	**19.7%**		

[1/] From the 2005 Baldwin County Land Use/Land Cover database.
[2/] From: Navajo County, undated; Futurity, undated; Cappiella, 2006; Office of Environmental Health Hazard Assessment, 2008; San Diego County, undated; and Dougherty, *et al*, 2004.

3.0 Watershed Conditions

3.1 Water Quality Standards and NPDES Permitting

3.1.1 Introduction

A review of existing Federal, State, and local regulations is presented within Appendix C. The primary "regulatory drivers" governing stormwater management within the D'Olive Watershed are Federal and State programs implemented pursuant to the Clean Water Act (CWA). These include the CWA Section 303(d) Impaired Waters and TMDL program, and the National Pollutant Discharge Elimination System (NPDES) Municipal Separate Storm Sewer System (MS4) program.

3.1.2 Water-use Classification and Water Quality Criteria

State water quality criteria (ADEM Admin. Code R. 335-6-10-xx) are based on water use classifications for each waterbody (ADEM Admin. Code R. 335-6-11-xx).

Use classifications utilized by the State of Alabama are:

Outstanding Alabama Water	OAW
Public Water Supply	PWS
Swimming and Other Whole Body Water-Contact Sports	S
Shellfish Harvesting	SH
Fish and Wildlife	F&W
Limited Warmwater Fishery	LWF
Agricultural and Industrial Water Supply	A&I

Use classifications apply water quality criteria adopted for particular uses based on existing utilization, uses reasonably expected in the future, and those uses not now possible because of correctable pollution but which could occur if the effects of pollution were controlled or eliminated. The assignment of use classifications must take into consideration the physical capability of waters to meet certain uses.

All waterbodies within the D'Olive Watershed are classified as Fish and Wildlife (F&W). In general, the conditions related to best usage of F&W waters are that "the waters will be suitable for fish, aquatic life and wildlife propagation". Waters classified for F&W may be used for incidental water contact and recreation and, under proper sanitary supervision by the controlling health authorities, should meet accepted standards of water quality for outdoor swimming. Specific water quality criteria for F&W waters are given at ADEM Admin. Code R. 335-6-10-.09(5). Under the "Antidegration Policy" of the ADEM Water Quality Criteria, existing instream water uses and the level of water quality to protect the existing uses shall be maintained and protected.

3.1.3 CWA Section 303(d) Impaired Waters and TMDL Program

Section 303(d) of the CWA requires that states develop lists of impaired waters that do not meet water quality standards for their designated uses. These listings must be approved by EPA and are published every two years.

The CWA also requires that states establish priority rankings for waters on the 303(d) lists and develop Total Maximum Daily Loads (TMDLs) for these waters. A TMDL is a calculation of the maximum amount of a pollutant that a waterbody can receive and still safely meet water quality standards. The TMDL calculates the maximum amount of a pollutant allowed to enter a waterbody (i.e., also known as the loading capacity) so that the waterbody will meet and continue to meet water quality standards for that particular pollutant. The TMDL allocates that pollutant load to point sources (Wasteload Allocation or WLA), and nonpoint sources (Load Allocation or LA) which include both anthropogenic and natural background sources of the pollutant.

D'Olive Creek, Tiawasee Creek, Joe's Branch, an unnamed tributary to D'Olive Creek, and an unnamed tributary to Tiawasee Creek were added to the Alabama Section 303(d) List in 2008. Based on a map of Tier 1 waters produced by ADEM (which includes 303(d) listed waters), the two unnamed tributaries appear to be those designated as DC and TC in this WMP (see Figure 2-2). The cause of the listing is given as "Siltation (habitat alteration)" due to "Land Development." The basis for addition to the list was cited as the Geological Survey of Alabama sediment loading rate study (Cook, 2007).

A TMDL has not yet been developed for the 303(d) listed streams in the D'Olive Watershed. The 2010 Alabama 303(d) List provides a Draft TMDL date of 2013 for these waters. The TMDL will be developed on an entire Watershed basis.

3.1.4 NPDES MS4 Program

Stormwater runoff in urbanized areas is subject to NPDES regulation by the Municipal Separate Storm Sewer Systems (MS4) program. Municipalities and other MS4 operators (such as departments of transportation, universities, and prisons) must obtain a NPDES permit and develop a stormwater management program. The Phase I MS4 program requires medium and large cities or certain counties with populations of 100,000 or more to obtain NPDES permit coverage for their stormwater discharges. Phase II requires regulated small MS4s in urbanized areas, as well as small MS4s outside the urbanized areas that are designated by the permitting authority, to obtain NPDES permit coverage for their stormwater discharges. Typically, Phase I MS4s are covered by individual permits and Phase II MS4s are covered by a general permit. Each regulated MS4 is required to develop and implement a stormwater management program (SWMP) to reduce the contamination of stormwater runoff and prohibit illicit discharges.

The entire D'Olive Watershed area lies within a Phase I MS4 permit area. An initial MS4 permit covering this area was issued in 1996, and reissued in 2001. The City of Daphne, the City of Spanish Fort, and Baldwin County are co-permittees to this permit (i.e., #ALS000002); along with the City of Fairhope, several Mobile County municipalities, and the Alabama Department of Transportation. The 2001 MS4 permit was scheduled to be reissued in 2006. However, the new permit has not yet been issued and the existing (2001) permit was administratively extended. The new permit, which is expected to be issued in late 2010, will be issued to Baldwin County permittees separately from Mobile County permittees.

As noted previously, MS4 permittees are required to develop and implement a SWMP. Although the specific requirements of MS4 permits may vary, major SWMP components typically include:

- MS4 public education and participation
- MS4 maintenance activities
- Construction site runoff activities
- Post-construction stormwater management controls
- Industrial/commercial facilities
- Illicit discharge detection and elimination

The delay in issuance of the new MS4 permits reflects a nationwide initiative by EPA to strengthen MS4 permits. Information from EPA and ADEM indicates that significant changes may be anticipated related to construction site runoff and post-construction stormwater management. Requirements for implementation of Low Impact Development / Green Infrastructure (LID/GI) practices, where feasible, are anticipated. Additionally, increased emphasis is expected for monitoring and evaluation/assessment programs, particularly for Impaired/TMDL Waters.

3.2 Future Impervious Cover in Watershed

As discussed in Section 2.13.5, Impervious Cover (IC) is the best indicator to measure the intensity of watershed development and to predict the severity of development impacts on the health of the network of streams within a watershed. The extent of IC in a watershed is closely linked to specific LU/LC cover types usually associated with urban growth, and is one of the most important factors influencing water quality. For example, an increase in the amount of impervious surface typically results in an increase in stormwater runoff which causes streambank and streambed erosion that in turn degrades water quality and habitat.

The relationship between watershed IC and stream quality is characterized in the Impervious Cover Model (ICM) (Schueler, 2005). When the imperviousness of a watershed exceeds 10%, increased nonpoint source pollutant loads begin to appear from urban runoff; stream temperatures become elevated due to reduced canopy cover; and increases in stream scour and channel instability begin which reduces the quality of stream habitat and diminishes biodiversity. Section 2.13.5.3 estimated the current percent of IC within the D'Olive Watershed to be between 20% and 25%. This level of imperviousness would place the D'Olive Watershed near the threshold that separates the Impacted Stream and Non-

Supporting Stream categories contained in the ICM (see Figure 2-33). The key features of those two categories as defined by the ICM are repeated below:

- **Impacted Streams** have between 10 and 25% IC in their supporting subwatershed, and show clear signs of declining stream health. Most indicators of stream health fall in the fair range, although some reaches may still be rated as being of good quality. These streams often exhibit the greatest restoration potential since they experience only moderate degradation, have an intact stream corridor, and usually have enough undeveloped land available in the watershed to install restoration practices.

- **Non-Supporting Streams** range between 25 and 60% IC in their supporting subwatershed. These streams no longer support their designated uses as defined by hydrology, channel stability, habitat, water quality and biological indicators. Subwatersheds at the lower end of the IC range (25 to 40%) may show promise for partial restoration, but are so altered that they normally cannot attain pre-development conditions for most indicators. In some circumstances, streams in the upper range of the non-supporting category (40 to 60% IC) may show some potential for stream restoration. In most circumstances, however, the primary restoration goals are to reduce pollutants, improve the stream corridor, or enhance community amenities.

Use of the ICM to classify urban watersheds allows reasonable restoration expectations to be developed and to assess the effectiveness of restoration that is undertaken (Schueler, undated). The ICM helps define general thresholds where current water quality standards or biological conditions cannot be consistently met during wet weather conditions. These predictions help set realistic objectives to protect stream quality based on both current and projected future conditions.

Historic trends, projected population increases, current zoning ordinances, and future land use planning data (see Sections 2.12 and 2.13) indicate that it is very likely that a 100% build-out condition of all developable lands within the D'Olive Watershed can be expected to take place within the 10-year period addressed by this WMP. The dominant proportion of the future development is expected to occur in the form of residential subdivision growth, primarily consisting of single family housing. A relatively minor amount of commercial development is anticipated to occur in the Watershed over this period.

To date, a variety of subdivision types have been developed within the Watershed. These subdivisions have varied with respect to lot sizes and the minimum square footages of the residential structures. Both lot size and dwelling size influence the relative imperviousness of an individual residential lot and the subdivision as a whole. The variability in subdivision type is expected to continue as the real estate market attempts to satisfy anticipated market demand for housing.

Figure 3-1 shows that as the density (i.e. number of dwelling units per acre (du/acre)) increases, the level of imperviousness also increases. The relationship depicted indicates that when a density of about 10 du/acre is reached, the curve begins to plateau. This is because the amount of buildable land becomes limiting and additional units on an acre of land are normally obtained by building up in apartment buildings rather than out as individual structures.

If land use controls, development criteria, and design standards are not modified and strengthened, the percent IC in the D'Olive Watershed will increase. Table 3-1 shows the estimated potential future percent IC that occur in the Watershed by 2020, as determined by using literature values for IC coefficients (also see Table 2-11). The acreages for each LU/LC type were estimated from the zoning and future land use planning information for Baldwin County. The results of this analysis indicate that the potential percent IC in the D'Olive Watershed could be 38% by 2020.

A 38% IC would place the streams in the D'Olive Watershed within the ICM Non-Supporting Streams category (see Figure 2-32). According to this classification, the Watershed streams may not be able to support their designated uses because of highly altered hydrology, unstable channels, degraded water quality, and impaired biological indicators. Because of the highly altered state of the streams and their contiguous subwatersheds, it may not be possible to restore the streams to their pre-development function and conditions. As such, the primary restoration goals could be limited to reducing the introduction of pollutants to the streams, improving the stream corridors, and addressing other aesthetic attributes of the streams. Although the ICM "Non-Supporting" category is completely unrelated to the 303(d) list of impaired streams on which the D'Olive Watershed Streams are presently included, the ICM category reflects the Watershed problems that led to the 303(d) listing.

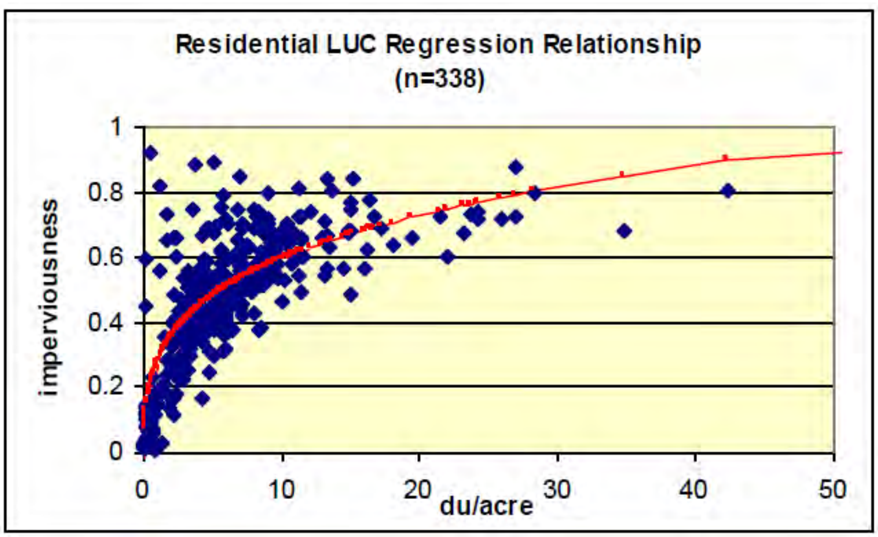

Figure 3-1. Relationship between Dwelling Units/Acre and Imperviousness (Source: Office of Environmental Health Hazard Assessment, 2008)

Table 3-1. Estimated Potential Future Percent Impervious Cover in D'Olive Watershed by 2020

Land Use/Land Cover Type [1/]	Acreage[2/]	Impervious Surface Coefficient [3/]	IC Acreage
Agriculture	128	0.080	10
Golf Course	400	0.120	48
Residential	5,102	0.350	1,786
Commercial and Industrial	41	0.722	30
Business	1,185	0.700	830
Future Development	26	0.700	18
Roads and Highways	282	0.400	113
Wetlands	478	0.020	10
Waterbodies	71	1.000	71
Total Acreage	**7,713**		2,916
Percent Impervious Cover	**38%**		

[1/] From the 2005 Baldwin County Land Use/Land Cover database.
[2/] From Table 2-10.
[3/] From: Navajo County, undated; Futurity, undated; Cappiella, 2006; Office of Environmental Health Hazard Assessment, 2008; San Diego County, undated; and Dougherty, *et al*, 2004.

3.3 Flow Data

A permanent flow monitoring gage has never been established within the streams of the D'Olive Watershed. Over the years, limited flow data has been collected in connection with specific studies. The most recent flow data were collected by the Geological Survey of Alabama from a series of nine separate sampling dates between October 23, 2007 and August 25, 2008 (Cook and Moss, 2008). The results of their investigation are discussed in the following, with Table 3-2 being constructed from their data.

Streams within the D'Olive Watershed generally attain low flow conditions during July or August and most of their discharges. Typical of streams in this portion of Baldwin County that drain from the Coastal Lowlands, most of the discharge during August, September, and October is attributed to groundwater discharge. However, tropical storms and hurricanes can significantly increase surface runoff and flows in the D'Olive Watershed streams.

The GSA field observations indicate that stormwater runoff is flashy and characterized by rapid rises and falls in water levels. Overbank flows can occur periodically due to spring weather fronts or by summer and fall tropical storms and hurricanes.

Extreme storm events can produce excessive surface runoff, causing rapid rises in stream levels and high velocities. Such an event occurred on March 28, 2008, causing a failure in the culvert passing under U.S. 90 on Tributary DA (see Figure 2-2) and similar issues with the main stem of D'Olive Creek immediately downstream of the I-10 crossing. This same storm caused mass-wasting of streambanks at several downstream locations, along with some property damage and localized flooding problems. Smaller recent storm events,

Table 3-2. Flow monitoring sites in the D'Olive Watershed
(from Cook and Moss, 2008)

GSA Stream Monitoring Site [1/]	Represents Subwatershed [2/]	Discharge (cfs)			Average stream flow velocity (fps)
		Maximum	Minimum	Average	
Unnamed tributary to D'Olive Creek south side of U.S. Hwy. 90	1	16.0	2.0	5.7	0.89
D'Olive Creek at U.S. Hwy. 90 crossing	3 and 11	32.9	1.7	9.68	0.91
Tiawasee Creek about 500 feet upstream from Lake Forest	7	110	3.3	25.0	0.76
Unnamed tributary to Tiawasee Creek at Ridgewood Drive	8	24.7	0.6	7.84	0.36
Unnamed tributary to Tiawasee Creek at Greenwood Drive	9	52.9	0.7	9.3	0.76
Joe's Branch immediately upstream from the confluence with D'Olive Creek	10	8.7	0.34	2.8	0.58
D'Olive Creek west of U.S. Hwy. 98 near D'Olive Bay	0	n/a	n/a	n/a	n/a

[1/] Stream monitoring sites used in Alabama Geological Survey Study.
[2/] Subwatersheds located upstream of monitoring sites (see Figure 2-2).

some of which occurred during the preparation of this WMP accelerated head-cutting at a number of locations throughout the Watershed.

The effects of these recently observed storm events are consistent with the following consequences of accelerated runoff reported in the literature (EPA, 2009):

- *Increased volume of runoff.* With decreased area for infiltration and evapotranspiration due to development, a greater amount of rainfall is converted to overland runoff which results in larger stormwater discharges.

- *Increased peak flow of runoff.* Increased impervious surface area and higher connectivity of impervious surfaces and stormwater conveyance systems increase the flow rate of stormwater discharges and increase the energy and velocity of discharges into the stream channel.

- *Increased duration of discharge.* Detention systems result in greater flow volumes and velocities. The prolonged higher discharge velocities undermine the stability of the stream channel and induce erosion, channel incision, and bank cutting.

- *Increase pollutant loading.* Impervious surfaces are a collection site for pollutants. When rainfall occurs, the pollutants are mobilized and transported directly to stormwater conveyances and receiving streams via the impervious surfaces.

- *Increased temperature of runoff.* Impervious surfaces absorb and store heat and transfer it to stormwater runoff. Higher runoff temperatures may have deleterious effects on receiving streams. Detention basins magnify this problem by trapping and discharging runoff that is heated by solar radiation.

If substantial actions are not undertaken, the projected development over the next 10 years will add to the magnitude of the overall stream degradation problems experienced throughout the D'Olive Watershed.

3.4 Sediment Transport and Sedimentation Conditions

A description of the current erosion rates, stream sediment loads, and areas of sedimentation characterizing the D'Olive Watershed is provided below. This information is presented for D'Olive Bay, Lake Forest Lake, and the Watershed streams in ascending order through the drainage basin. As will be noted from this discussion, the type and scope of erosion, sediment transport, and sediment accumulations vary at each of these general locations within the Watershed.

3.4.1 D'Olive Bay and the Lake Forest Yacht Club

The Mobile-Tensaw River system is reported to carry approximately 5,000,000 tons of sediment into Mobile Bay each year. A significant portion of that sediment load is delivered by the Blakeley River which flows by D'Olive Bay. The bedload materials transported by the Blakely River are deposited within the Upper Mobile Bay and contribute to the ongoing delta building process. A portion of the Blakeley River sediment load is deposited within D'Olive Bay.

Between 1967 and the 1980s, development of the Lake Forest Subdivision was responsible for the excessive sediment accumulations that occurred within D'Olive Bay. However, recent evidence indicates improved construction practices and regulatory controls within the Watershed have significantly reduced the sediment load conveyed through Lake Forest Lake and into D'Olive Bay since the 1980s.

Despite the reduced sediment discharges into D'Olive Bay, shoaling is still occurring in the Lake Forest Yacht Club entrance channel near the southern end of the bay. However, it is believed those sediments primarily originate from the Blakeley River, with the deposition of those sediments in the vicinity of the yacht club being representative of the natural deltaic processes at work in Upper Mobile Bay and are not the direct result of conditions within the D'Olive Watershed.

3.4.2 Lake Forest Lake

Isphording (1984) estimated that between 1967 and 1982, approximately 48,000 tons of sediment per year was deposited in Lake Forest Lake, with an additional 24,000 tons per year passing through the lake to be deposited in D'Olive Bay and Mobile Bay. The recent sediment loading study conducted by the Alabama Geological Survey (Cook and Moss, 2008) indicates that the total sediment loads now being delivered to Lake Forest Lake are approximately 7,800 tons per year. The sediment loads considered in the Isphording and Cook studies represent the combined suspended and bedloads.

The great differences between the 1984 and 2008 sediment loading estimates for Lake Forest Lake indicate that the load has dropped off significantly since the 1980s. As discussed in Section 2.10.4, even at the present reduced loading rate, the sediment loads now entering Lake Forest Lake are still high, being 14 times the expected erosion rate of an undeveloped watershed.

Lake Forest Lake is sufficiently large to trap most of the bedload sediments delivered by D'Olive Creek and Tiawasee Creek, thus preventing that portion of the sediment load from reaching D'Olive and Mobile Bays. However, the sediment loads are steadily reducing the sediment free volume of the lake and shortening its usable life as a recreation resource. The remaining sediment free volume of the lake is not known at this time. As a result, it is not possible to forecast the future timeframe within which the lake will become completely filled if actions are not taken to remove the accumulated sediments and/or to reduce the amount of bedload materials delivered to the lake each year.

3.4.3 Watershed Streams

Sediment discharge in the D'Olive Watershed is high because of: (1) the extensive dissection (i.e., deeply eroded stream valleys with relatively steep slopes and numerous tributary segments) that characterizes the Watershed; and (2) the inherent instability of most of the exposed sediments. Slopes within the D'Olive Watershed, especially in the lower reaches of the drainage, are unusually steep for a location near the Gulf Coast. Sheet wash in unprotected areas, especially on slopes, rapidly removes soil cover, further exacerbating soil losses. As slope steepness increases, there is a corresponding rise in the velocity of surface runoff and increased erosion. Doubling the velocity of the surface runoff produced by increasing the degree and length of the slope enables water to move particles 64 times larger, allowing the runoff to carry 32 times more soil material, making the total erosive power a total of 4 times greater. High erosion rates also reduce the amount of water that infiltrates into the ground.

Sediment loads in streams are composed of relatively small particles suspended in the water column (suspended solids) and larger particles that move on or periodically near the stream bed (bedload). Bedload sediment is composed of particles that are too large or too dense to be carried in suspension by stream flow. These particles roll, tumble, or are periodically suspended as they move downstream. Traditionally, bedload sediment has been difficult to quantify due to deficiencies in monitoring methodology or inaccuracies of estimating volumes of sediment being transported along the streambed. This is particularly true in streams that flow at high velocity or in streams with excessive sediment loads.

Sediments originate from erosion of the land surface within the watershed and from erosion of channel streambeds (i.e., through channel incision, head-cutting, and meandering) and the mass-wasting of the flanking streambanks. The relative contribution of sediments from overland erosion and channel erosion within the D'Olive Watershed is not quantified at this time. However, intuitively it is believed channel erosion presently provides significant quantities of sediment given the numerous locations at which channel incision, head-cutting, and mass-wasting have been observed to occur throughout the Watershed. Conversely, improved construction practices and regulatory monitoring appear to have been effective in reducing sediments transported from construction sites.

In 2007-2008, Cook and Moss collected sediment transport data from selected streams in the D'Olive Watershed upstream of Lake Forest Lake. The location of the sampling sites and the subwatersheds that they represent are described in Table 3-2. Figure 2-2 shows the location of the individual subwatersheds. As indicated in Section 3.1.4, the data reported by Cook and Moss (2008) were considered by the Alabama Department of Environmental Management in the determination to add major streams and tributaries of the entire D'Olive Watershed to the State's 303(d) list of impaired streams. The impairment status is tied to excessive sediment loads transported by the streams in the Watershed.

Total suspended sediment (TSS) in high flow samples ranged from 9 to more than 100 times greater than samples collected during low flow. When the TSS loads were normalized with respect to unit watershed area, three tributaries had the largest suspended sediment loads: (1) Tributary DA (Subwatershed 1) – 352 tons/mile^2/year; (2) the main stem D'Olive Creek (Subwatersheds 3 and 11) – 331 tons/mile^2/year; and (3) Joe's Branch (Subwatershed 10) - 330 tons/mile^2/year. The suspended sediment loads shown in Figure 3-2 indicate that loads estimated between October 2007 and October 2008 were 2 to 7 times greater than those estimated for the period October 2006 through October 2007. This was attributed to increased construction and land disturbance in the Watershed and a 40 percent increase in rainfall (74.1 inches compared to 44.7 inches) over the latter period investigated (Cook and Moss, 2008).

After normalization of bedload data, D'Olive Creek (Subwatersheds 3 and 11) had the largest load (1,656 tons/mile^2/yr) during the period October 2007 to October 2008. This amount is approximately six times larger than the load estimated during the October 2006 to October 2007 period (see Figure 3-3). This was attributed to the massive erosion of the main stem D'Olive Creek channel upstream of the sampling location (Cook and Moss, 2008).

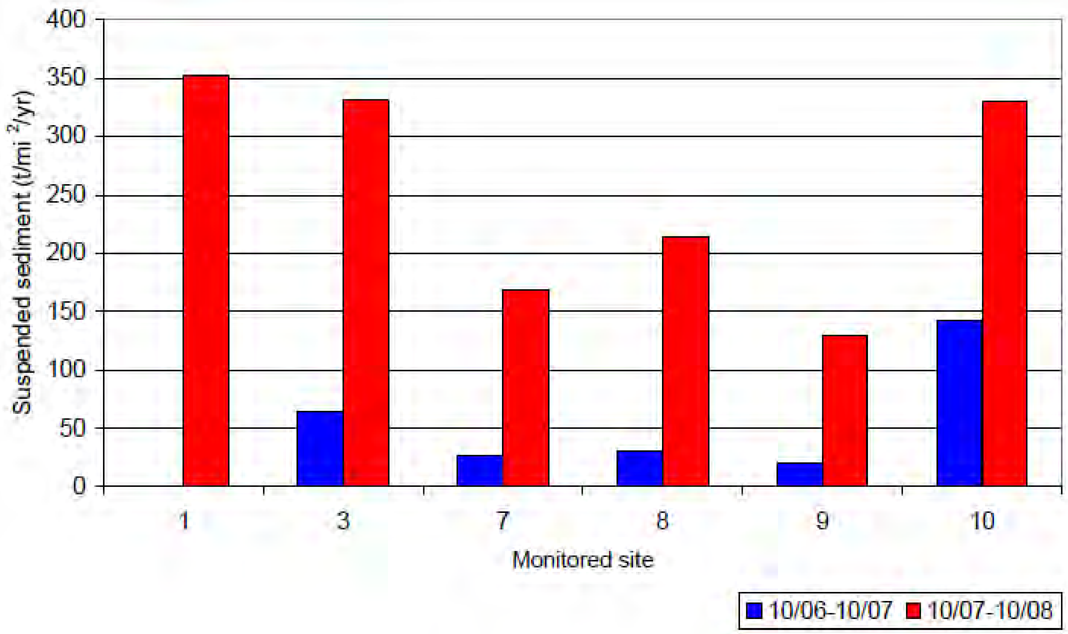

Figure 3-2. Annual Estimated Normalized Suspended Sediment Loads for Selected Streams in the D'Olive and Tiawasee Creek Subwatersheds
(Source: Cook and Moss, 2008)

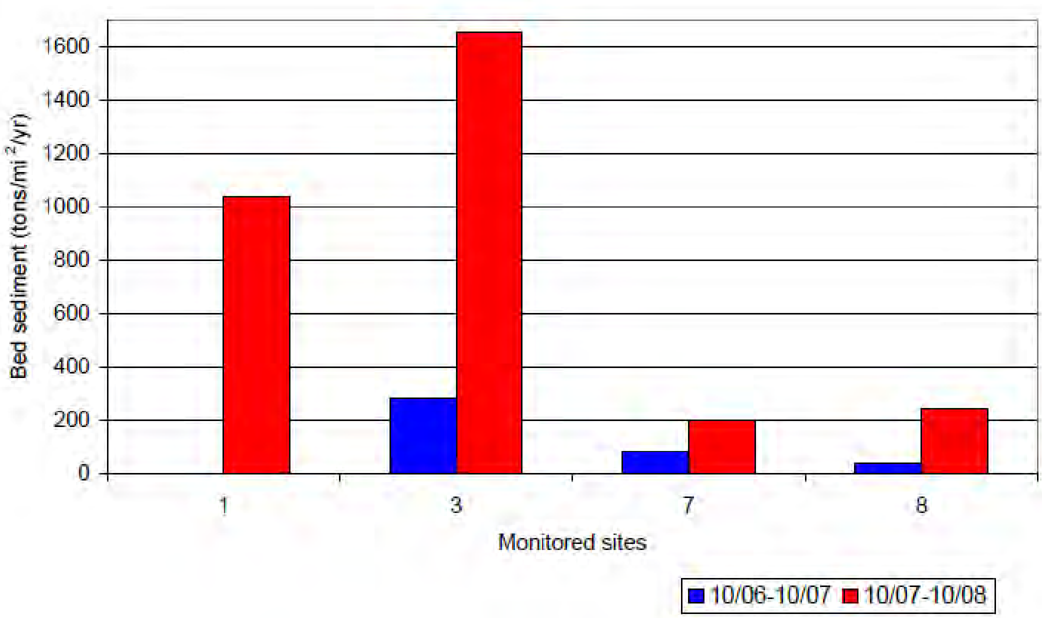

Figure 3-3. Estimated Annual Normalized Sediment Bedloads for Selected Streams in the D'Olive and Tiawasee Creek Subwatersheds
(Source: Cook and Moss, 2008)

Total sediment loads are composed of suspended and bed sediment. Cook and Moss (2008) also estimated total annual sediment loads for the D'Olive Watershed streams as shown in Figure 3-4. Sediment loads in the D'Olive and Tiawasee drainages are primarily composed of bed sediments. When total sediment loads were normalized with respect to watershed area, the largest total loads were estimated for D'Olive Creek (Subwatersheds 3 and 11) (1,987 tons/mile^2/yr). Cook and Moss (2008) determined that the D'Olive Creek load was about 31 times the natural geologic erosion rate of 64 tons/mile^2/yr. When they compared the Tiawasee Creek and D'Olive Creek loads with the loads of other streams throughout Alabama they observed that the D'Olive and Tiawasee watersheds are comparable to the sediment loads from watersheds experiencing similar types of anthropogenic erosion impacts (i.e., urban, residential, unpaved roads, and construction).

Figure 3-4 compares the total sediment loads by subwatershed. This comparison indicates that for the period 2007-2008, the Upper D'Olive Watershed (i.e., Subwatersheds 1, 3, and 11) was the dominant contributor of sediments in the Watershed. Subwatersheds 3 and 11 collectively contributed nearly half the total sediment load of the entire D'Olive Watershed, while Subwatershed 1 contributed just under one third. Tiawasee Creek's lowermost Subwatershed 7 (through which the total sediment load of the entire Tiawasee drainage passes) contributed the remaining approximately one quarter of the total load for the Watershed.

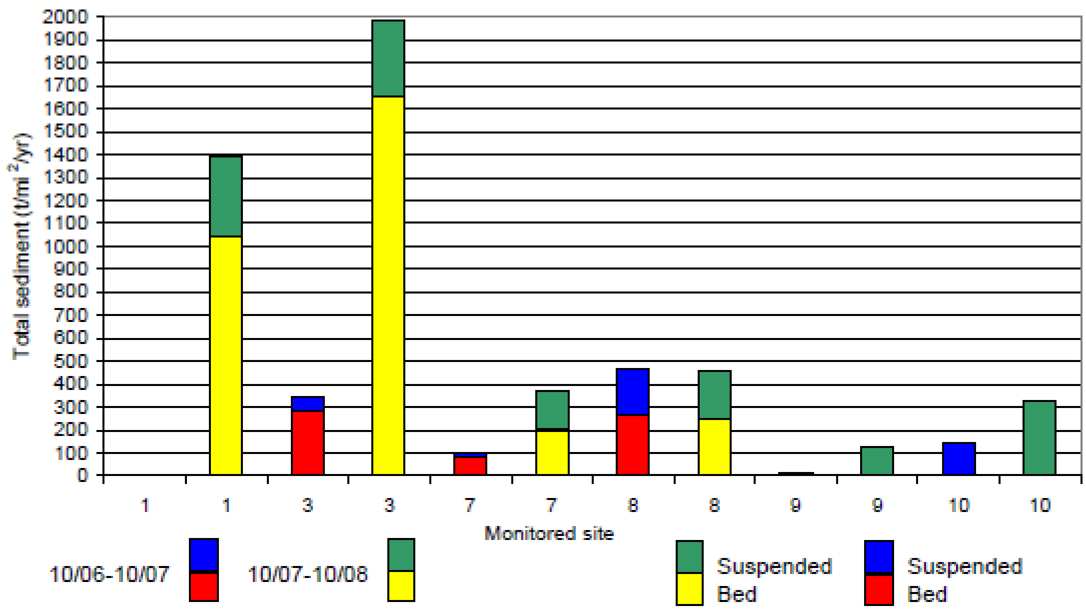

Figure 3-4. Estimated Normalized Total Annual Sediment Loads for Selected Streams in the D'Olive and Tiawasee Creek Subwatersheds
(Source: Cook and Moss, 2008)

During the 2007-2008 period, land within the north central portion of Subwatershed 0 to the north of Lake Forest Lake and I-10 underwent development as part of the Spanish Fort Town Center complex. The total sediment load draining this area was low. However, because that area was so small (i.e. a fourth of a square mile), the normalized sediment loading rate in tons per square mile per year was very high. Subwatersheds 2 and 9 (tributaries DB and the upper portion of T) were essentially insignificant contributors to the total sediment loading of Lake Forest Lake during this time period.

Only Joe's Branch (Tributary J), draining Subwatershed 10, does not discharge into Lake Forest Lake. However, its watershed does contribute a moderate amount of sediment directly into D'Olive Bay.

The high sediment transport rates in the D'Olive Watershed are expected to continue through the 10-year period addressed by this WMP (i.e., ends in 2020). The projected increases in Impervious Cover (IC) (see Section.3.3) could contribute to an overall increase in the sediment transport rates as more of the Watershed is converted to urban land uses; stormwater runoff volumes and rates increase; and additional channel erosion is induced.

3.5 Assessment of Watershed Streams

A detailed reach-by-reach field investigation of the D'Olive Watershed streams was conducted during the development of this WMP to define watershed sedimentation and stream stability problems. The investigation included three components:

- Erosion activity assessment. This assessment involved locating 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.

- Evaluating the causes of the erosion.

- 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.

The following discussion summarizes the results of the watershed assessment, with the full report being contained within Appendix A. The stream segments shown in Figure 2-3 and listed in Table 2-2 were assessed at either: (1) their respective confluences with D'Olive Creek, Tiawasee Creek, and D'Olive Creek; or (2) one or more sites along the course of their channels.

The highest intensity erosion appears to be located immediately downstream of head-cuts and gullied stream reaches immediately below head-cuts. The locations of the head-cuts, gullies, and locations of potential high channel instability are identified in the data tables in Attachment A and on Maps 2 through 8 contained in Appendix A. Noteworthy locations are listed in Table 3-3. Channel instability is so great in the reach of Tributary DA containing steep slopes between Sites DA9 through DA33 [1/] that homes and infrastructure are seriously threatened (see Table 3-3). Figure 3-5 provides an example of one such location where a home was almost loss to mass-wasting that occurred during the March 28, 2009 storm event. The remaining erosion "hot spots" in the Watershed can be prioritized based on the percent of reach undergoing erosion by mass-wasting, streambed scour, or proximity to infrastructure.

Table 3-3. Locations of High Channel Instabilities within the D'Olive Watershed

Subwatershed	Stream Segment	Site [1/]	Map in Appendix A	Description of Problem
2	D	D3 to D5	3	Active mass- wasting of incised channel is occurring, with large woody debris (LWD) jams exacerbating erosion
1	DA	DA9 to DA33	5	Active mass-wasting along reach with highest banks in Watershed. Homes threatened by bank instability.
1	DA	DA36	5	Active mass-wasting is occurring beneath power line easement.
1	DA	DA40 to DAC2	5	Active large head-cuts just above confluence of these two streams.
9	TC	TC2 to TC5	6	Actively advancing head-cut resulting in incised channel with mass-wasting banks. LWD jams exacerbate erosion.
10	JA	JA to JA5	2	Actively advancing head-cut resulting in incised channel with mass-wasting banks.
10	JB	JB5 to JB6	2	Actively advancing head-cut resulting in incised channel with mass wasting banks.
7	U	U38	7	Actively advancing head-cut threatens to undermine Country Club Road.

[1/] See Appendix A for location of individual sites investigated along stream segments.

Since it was not possible to discover every problem location during the field assessment, areas bordering the streams with steep slope gradients were also identified as being potential erosion "hot spots" (see Map 7 in Appendix A). These include by are not limited to the following locations:

- The apparent gully west of Crestview Circle and South of Buena Vista Drive.

[1/] See Appendix A and its accompanying maps for locations of the sites investigated along stream segments.

Figure 3-5. Example of Home Threatened by Mass-Wasting of Streambank from March 2009 Storm Event

- Tributary TB northwest of Marc Circle and at the headwaters of Tributary TB.
- Apparent gully south of the headwaters of Tributary TAA

Each of these locations should be investigated for the potential to produce high sediment loads and for potential impacts to roads and residences. The cause of the gullying and rapid head-cut advancement is attributed to increases in stormwater runoff (i.e., both discharge velocities and volume) due to past and recent land use changes.

Tributaries draining areas with unimproved roads and construction sites are heavily impacted by sedimentation. Because they are unprotected from raindrop impact and sheet erosion, these areas are significant contributors 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 loads entering Lake Forest Lake and D'Olive Bay.

Typically, headwater tributaries below active construction sites and recently developed areas have heavy sediment deposits on their floodplains. 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 (see footnote on page 3-14):

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

The source of the heavy sediment deposits in Tributary JB between Sites JB1 and JB5 has not been positively identified. For Tributary JB, the gully and head-cut at Site JB6 is a source, but the quantity of sediment deposited along the 1,500 feet of stream and floodplain between JB5 and JB1 is so large that other sources are likely. Possible contributors include the utility crossing at Site JB3, the power line corridor just south of U.S. 31, the gravel drive leading to the water utility station north of U.S. 31, and possibly other unidentified sources.

Two other small tributaries were also impacted by high sediment deposition: (1) DA below U.S. 90, and (2) TG below the French Settlement Subdivision construction site.

In conclusion, generally, 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. These stream segments do not appear to be sediment sources at the present time, but potentially are conduits to transport sediment eroded from upland sources.

3.6 Wetlands

A wetland condition evaluation of the wetlands in the D'Olive Watershed was conducted in conjunction with development of this WMP. The evaluation was restricted to the 404(b)(1) jurisdictional wetlands as defined by the Corps of Engineers. Table 3-4 identifies the characteristics considered to evaluate the current condition of the Watershed wetlands, while Figure 3-6 graphically displays the results of the evaluation. The full results of the evaluation are contained within Appendix B.

Primary adverse impacts to all wetlands within the D'Olive Watershed are related to sedimentation and/or hydrologic modifications that have altered stream channel characteristics. The individual subwatersheds have been heavily developed, with much of the development having taken place on steep slopes that serve as the upland buffers surrounding wetlands occurring within the Watershed.

Best Management Practices (BMPs) were not always used during the construction that occurred prior to the 1990s, and large quantities of sediment washed into the wetlands during heavy rain events. In the early 1990s, BMPs began to be required for construction.

Severe stream and channel erosion in the Watershed is causing impacts to the adjacent wetlands in many areas. Large trees growing alongside the streams frequently fall into the streams as unstable streambanks collapse (i.e. mass-wasting) due to erosion. 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 trees decay, exotic species often become established due to their ability to out-compete native species.

Table 3-4. 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.

When wetlands in the Watershed 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.

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

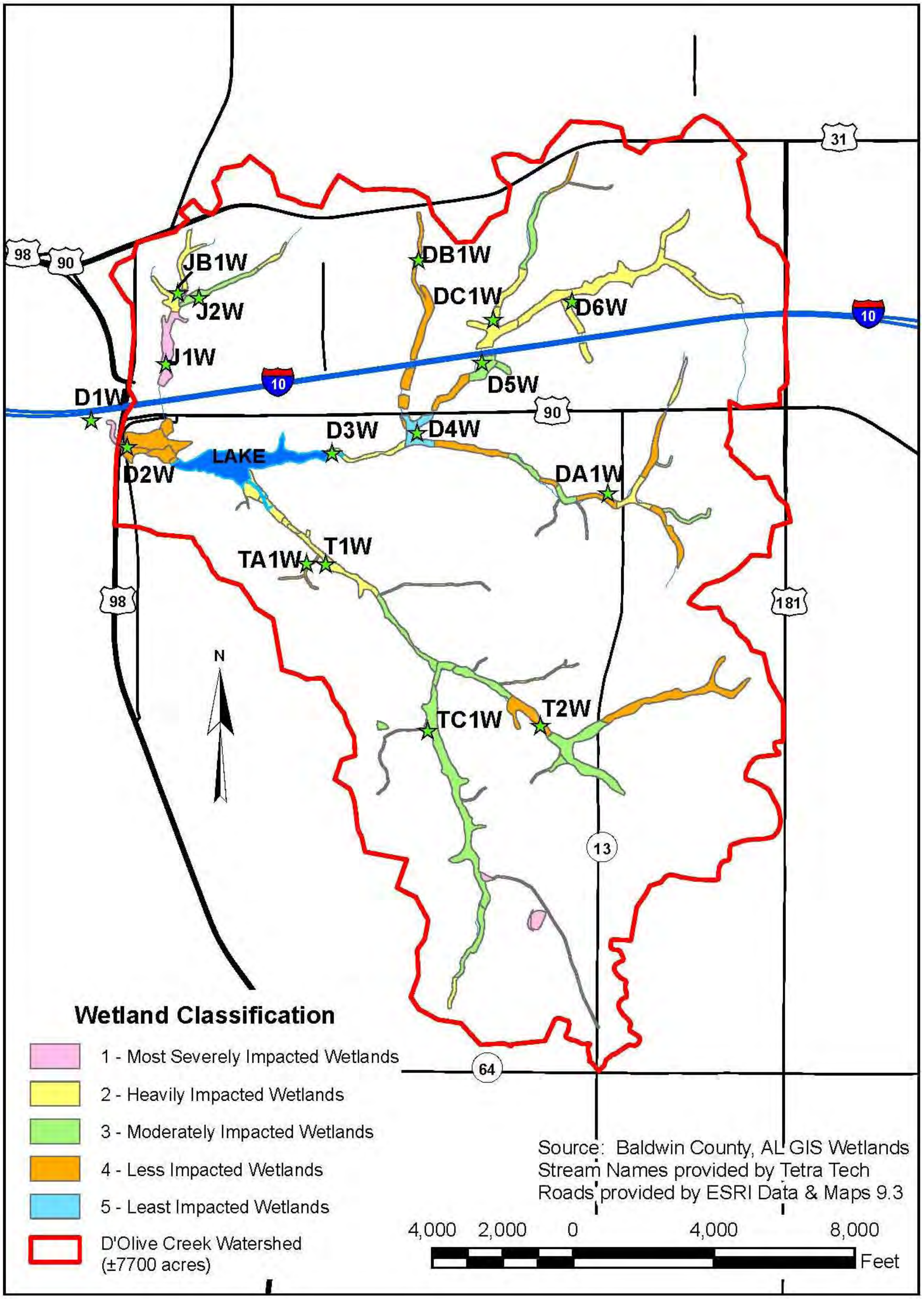

Figure 3-6. Condition of Wetlands in D'Olive Watershed
(see Appendix B)

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.

D'Olive Creek. D'Olive Creek and its associated wetlands have been severely impacted within the majority of the subwatershed because of dense commercial and residential development. The construction of the Lake Forest Subdivision impacted the western half of the creek. 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 the Timber Creek Subdivision 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, driveways, roofs, and grassed lawns 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.

3.7 Water Quality and Biological Data

Water quality and biological data are limited for the D'Olive Watershed. The most recent data were collected by Cook and Moss (2008). These data, which are summarized below, provide another source of information from which the effects of accelerated stormwater runoff, unstable channel morphology, high sediment loads, and sedimentation can be interpreted.

3.7.1 Water Quality

Following is a summary of the results of the water quality samples analyzed by Cook and Moss between October 2007 and August 2008. The following conclusions were reached:

- The maximum temperature standard of 32.2ºC established by ADEM was not exceeded in any stream sampled
- No significant issues were observed with specific conductance values.
- pH levels were normal.
- Dissolved oxygen (DO) levels were well above the 5 mg/L ADEM minimum standard at all stations sampled, with the exception of one, with levels generally being 95% of atmospheric saturation. The only location that experienced lower DO levels was the sampling station on D'Olive Creek downstream of the Lake Forest Dam and

the confluence of Joe's Branch, but immediately upstream of the point where D'Olive Creek flows into D'Olive Bay.

- Biochemical Oxygen Demand (BOD) levels were general below 5 mg/l and reflected no problems.

- Turbidity values can be utilized to estimate long-term trends of total suspended solids (TSS). Turbidity levels measured by Cook and Moss (2008) are presented in Table 3-5.

Table 3-5. Turbidity measured in monitored streams in the D'Olive Watershed (from Cook and Moss, 2008)

GSA Stream Monitoring Site [1/]	Representing Subwatershed [2/]	Turbidity (NTU) [3/]		
		Maximum	Minimum	Average
Unnamed tributary to D'Olive Creek south side of U.S. Hwy. 90	1	417	1	106
D'Olive Creek at U.S. Hwy. 90 crossing	3 and 11	360	1	120
Tiawasee Creek about 500 feet upstream from Lake Forest	7	140	1	53
Unnamed tributary to Tiawasee Creek at Ridgewood Drive	8	175	4	83
Unnamed tributary to Tiawasee Creek at Greenwood Drive	9	184	3	37
Joe's Branch immediately upstream from the confluence with D'Olive Creek	10	400	11	101
D'Olive Creek east of U.S. Hwy. 98 near D'Olive Bay	0	440	5	79

[1/] Stream monitoring sites used in Alabama Geological Survey Study.
[2/] Subwatersheds located upstream of monitoring sites (see Figure 2-2).
[3/] NTU – Nephelometric Turbidity Unit

- Thirty-three percent of the nitrate samples collected at Tiawasee Creek for Subwatershed 7 were equal to or exceeded 0.5 mg/L. The highest nitrate loads were transported by Tiawasee Creek and the lowest loads by Joe's Branch. Estimates from 20 streams throughout Alabama indicate that nitrate loads for selected sites in the D'Olive Creek watershed are comparable to nitrate loads for watersheds with similar types of land-use impacts.

- Although no official water-quality criterion for phosphorus has been established in the United States, total phosphorus should not exceed 0.05 mg/L in streams or 0.025 mg/L within a lake or reservoir to prevent the development of biological nuisances.

Joe's Branch and D'Olive Creek transported the largest loads of phosphorus per unit watershed area. Estimates from 16 streams throughout Alabama indicate that phosphorus loads for selected sites in the D'Olive and Tiawasee Creek watersheds are smaller than loads from streams with treated wastewater, but are larger than streams dominated by forests.

- Analyses of bacteria levels can be used to assess the quality of water and to indicate the presence of human and animal waste in surface and ground water. The limit for fecal coliform bacteria, established for surface waters classified as Fish and Wildlife, is 2,000 colonies per 100 milliliter sample for single samples. Between 25% and 50% of all samples exceeded the standard in all three drainages within the D'Olive Watershed.

- Twelve metallic elements from the aquatic life criteria list were analyzed. No significant concerns were detected.

- Typical Total Organic Carbon (TOC) values for natural waters vary from 1 to 10 mg/L. The average TOC ranged between 2.7 and 5.1 mg/l depending upon the sampling site considered.

3.7.2 Biological Data

As permanent residents of streams within the D'Olive Watershed, aquatic organisms are exposed to the physical and chemical stresses associated with stormwater runoff, unstable channels, high sediment loads, and sediment deposition. The response of aquatic communities to these habitat factors is indicated by the types of species and the numbers of individuals within species.

Six of the seven sites in the D'Olive Watershed were sampled in two seasons October 2007 and May 2008) for biological and habitat characteristics during this study (Cook and Moss, 2008). The conclusions reached by Cook and Moss (2008) are repeated in the following:

- A total of 9,041 aquatic organisms were collected in the D'Olive Watershed during this study, 5,168 in October 2007 and 3,873 in May 2008. These organisms represented 127 benthic macroinvertebrate taxa including annelid worms, mollusks, crustaceans, mites, and aquatic insects.

- Joe's Branch (Site 10) had the lowest number of taxa and catch per sample and the highest Hilsenhoff Biotic Index (HBI), indicating fair to poor biological conditions during both sampling seasons.

- Within D'Olive Creek, the number of taxa was slightly greater than Joe's Branch, while catch per sample was similar to or slightly greater than that at Joe's Branch. The HBI for site 1 indicated good biological condition and was the best of all sites sampled in the D'Olive Creek drainage.

- The number of taxa was greater and catch per sample was substantially greater at the sample sites in the Tiawasee Creek drainage compared to Joe's Branch and the D'Olive Creek. The HBI indicated only fair biological condition for the sites in the Tiawasee Creek drainage.

3.8 Stakeholder Input

3.8.1 D'Olive Watershed Working Group

The views of the D'Olive Watershed Working Group (DWWG) were sought throughout the preparation of this WMP. The DWWG was briefed on the results of the problem identification efforts and on the conceptual measures proposed for inclusion in the WMP. Individual representatives of the DWWG provided critical information and offered their professional views during key work phases. Finally, the DWWG was provided a Preliminary Draft of the WMP for review prior to it being made available for consideration by the public.

3.8.2 Draft WMP Public Meeting

The Draft WMP was presented to the public at a public meeting on June 29, 2010. The meeting was held at the Alabama Department of Conservation and Natural Resources' Five Rivers Delta Resource Center in Spanish Fort. The meeting was attended by over 40 individuals. Following the meeting, the Draft WMP was made available for public review for a 30-day period that ended on July 29, 2010. During that period, hardcopies of the Draft WMP were placed at libraries and other public locations within the Watershed. An electronic copy of the Draft WMP was also linked to the Mobile Bay National Estuary Program's website. In addition to the views and questions expressed at the public meeting, three written comments were received. Appendix E contains the minutes documenting the principal discussions held during the public meeting and the written comments that were received.

In general, the views, opinions, and comments received from the public were supportive of the observations and recommendations contained in the Draft WMP. However, concerns were expressed that the WMP should present detailed plans for implementation in lieu of the conceptual approach that was followed to develop the management measures considered in the plan.

In addition, strong support was voiced for strengthening the regulatory environment dealing with stormwater management and for avoiding future developments on unsuitable sites due to topographic and soils considerations. Support was also voiced to increase the amount of greenspace that would be protected from future development.

Lastly, views were expressed that the plan should be implemented on a watershed basis without the management measures being limited by governmental boundaries.

4.0 Identification of Critical Areas and Issues

4.1 Introduction

This section identifies the critical areas within the D'Olive Watershed that have already been impacted by channel degradation and excessive sedimentation and those areas that are anticipated to be impacted over the 10-year period addressed by this Watershed Management Plan (WMP) (i.e., through 2020). Since the instream problems are the direct result of land use practices and related surface runoff conditions within the Watershed, this section addresses the critical resource needs influencing surface runoff.

Grant monies provided under Section 319 of the Clean Water Act may be used to implement specific components of this WMP. Element "a" of the Section 319 grant guidelines requires the identification of the causes and sources of pollutant problems that must be controlled to achieve the load reductions and other watershed management goals of the WMP. This section of the WMP complies with that requirement.

Excessive sediment loads have resulted in several streams in the D'Olive Watershed being included on the list of 303(d) impaired streams in Alabama. The sediments are derived from two principal sources: (1) overland erosion of surface soils; and (2) instream erosion of streambeds and streambanks due to channel instability. The proportion of sediments that are contributed by each source is not known with specificity. During the 1970s and 1980s, overland erosion resulting from poor construction practices provided the major portion of the heavy sediment loads transported by the Watershed streams. Since the 1990s, increased regulatory controls, intensified monitoring, greater public awareness, and improved construction practices have combined to significantly reduce sediment loads from overland sources. However, channel instabilities and instream erosion have intensified primarily due to increases in stormwater runoff during this latter period.

While the quantities of sediments transported from the D'Olive Watershed have been reduced since the 1980s, the current sediment loads still significantly exceed natural loading rates (Cook and Moss, 2008). Present loading rates and channel instability problems are the direct result of stormwater runoff volumes, velocities, and timing of discharges. Land Use/Land Cover issues within the upland areas of the Watershed have a major influence on stormwater runoff which in turn influences the amount of sediments carried by Watershed streams and where that sediment is deposited. The following discusses the critical resources and locations within the Watershed addressed by this WMP. Figure 4-1 illustrates the extent of stream and wetland problems within the D'Olive Watershed.

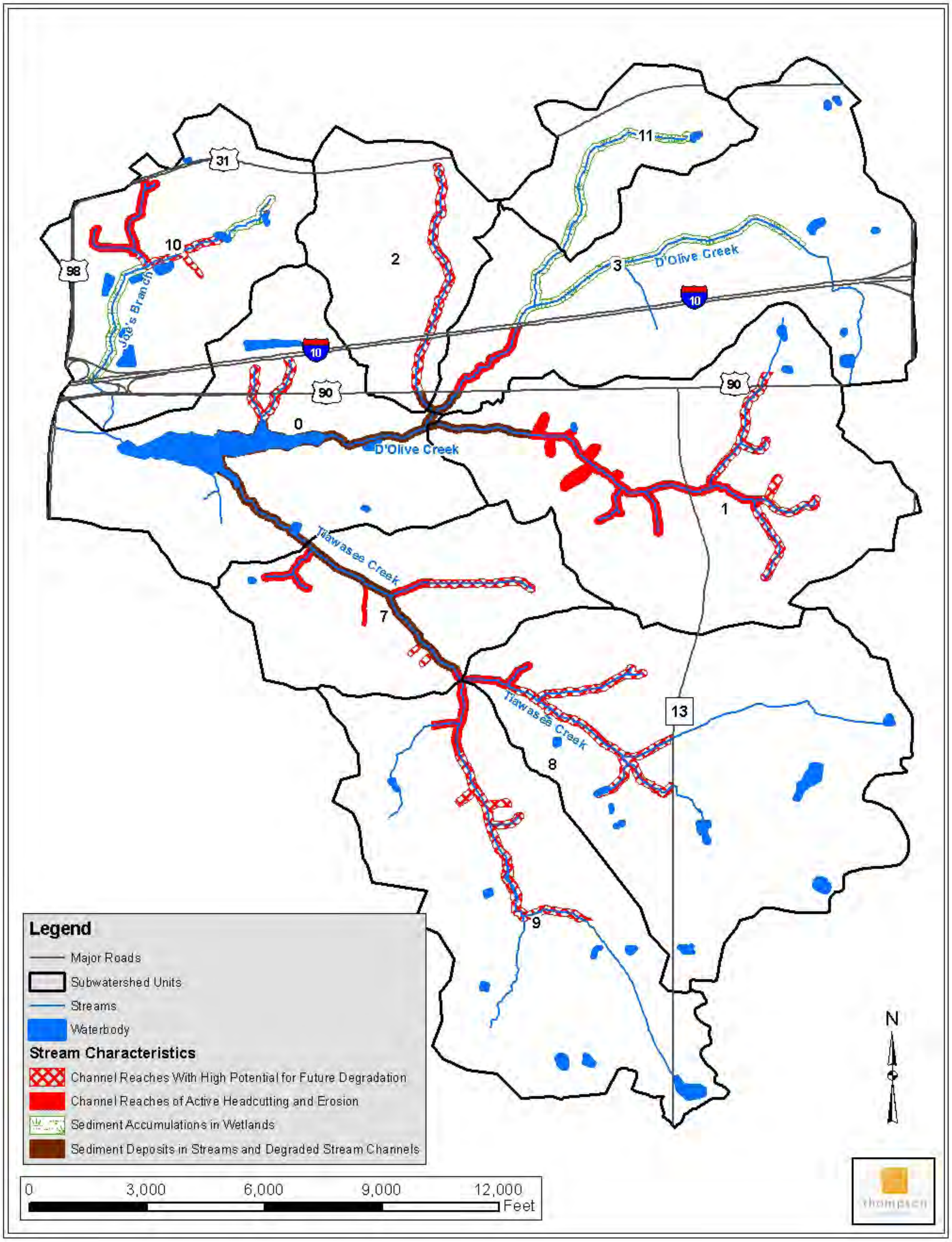

Figure 4-1. Stream and Wetland Degradation Problems in the D'Olive Watershed

thompson
ENGINEERING

4.2 Degraded Streams

Most of the streams within the D'Olive Watershed have been affected to varying degrees by urban development. For the purposes of this WMP, the Watershed stream segments of critical concern are assigned to one of the following three impact categories: (1) reaches with excessive sediment accumulations within the stream channels; (2) reaches experiencing active head-cutting and channel erosion; and (3) reaches having a high potential to experience future degradation from the continued upstream expansion of head-cutting and channel erosion. The three categories are depicted on Figure 4-1 and are discussed below. Figure 4-1 is based in part upon information contained within Appendices A and B. Lastly, Figure 2-3 and Table 2-2 were used to determine the stream lengths assigned to each category.

4.2.1 Reaches with Excessive Sediment Accumulations

Figure 4-1 shows that the streambeds of the lowest reaches of D'Olive Creek and Tiawasee Creek contain heavy sediment accumulations. The sediment deposits are the result of both historic and ongoing erosion from upland and in channel sources. Figures 4-2 and 4-3 provide representative views of the sediment laden reaches of D'Olive Creek and Tiawasee Creek, respectively.

Figure 4-2. Excessive Sediments in D'Olive Creek Downstream of US 90

Figure 4-3. Excessive Sediments in Tiawasee Creek Downstream of Tributary TB

Sediment accumulations affect approximately 6,100 feet of D'Olive Creek and its tributaries extending upstream from Lake Forest Lake to the Highway 90 Bridge and upstream within Tributary DA. Sediment accumulations also affect approximately 4,540 feet of Tiawasee Creek from Lake Forest Lake upstream to the confluence of Tributary TB. The respective slopes of these two stream segments are generally less than 1.00% (see Table 2-2). Typically, such gentle slopes do not allow flows that generate energy sufficient to efficiently transport all of the sediments received from upstream higher gradient reaches.

4.2.2 Reaches Experiencing Active Head-Cutting and Channel Erosion

As described in Section 2.6, head-cutting of streams is a major problem within the D'Olive Watershed. Head-cutting is the major factor contributing to mass-wasting of streambanks, channel incision, streambed erosion, and overall channel instability. These conditions are collectively responsible for the large volumes of sediments generated from degradation of the stream channels.

As shown in Figure 4-1, head-cuts are occurring at numerous locations within each of the D'Olive Watershed's three principal drainages. The locations of the head-cuts, gullies, and locations of potential high channel instability are identified in the Appendix A data tables (see Attachment A Maps 2 through 8). Noteworthy locations are listed in Table 3-3. Channel instability is so great in the steep gradient reach of Tributary DA between Sites DA9 through DA33 [1/] that homes and infrastructure are seriously threatened. Figure 3-5 shows one such location at which a home was almost lost to mass-wasting during the March 28, 2009 storm event.

[1/] See Appendix A and its accompanying maps for locations of the sites investigated along stream segments.

While the leading front of each head-cut is focused on attacking the major location of the gradient differential between the upstream and down channel reaches, the entire head-cut affects a considerable length of the steam downstream of the actual "point of attack". The youngest portion of a head-cut occurs at its leading edge, while the oldest portion is located at the most downstream area affected by the slope change.

As head-cuts in the Watershed's principal streams progress upstream, their channels continue to incise until an equilibrium slope is achieved. To keep pace with the changing stream gradients in the main stem stream channels, the head-cuts tend to extend laterally into the tributary streams, eventually affecting the entire drainage network within a subwatershed. The long-term consequence of this action is the gradual entrenchment of the entire stream valley, to include the surrounding uplands, as the surface elevations of the entire watershed are lowered in response to associated overland erosion through a process known as "dissection". While this process typically occurs on a geologic time scale, artificially altering the hydrology of a watershed can accelerate the process. Figure 4-4 illustrates the effects of head-cutting and dissection on the surface morphology of the D'Olive Watershed on a geologic timescale (Cook, 2010).

It takes many years for the change in gradient downstream of a head-cut to reach a relative equilibrium condition. During that timeframe, the streambed continues to incise and the flanking streambanks are eroded, collapsing into the channel (i.e., mass-wasting) as the cross-sectional area of the channel adjusts to the changed elevation and slope conditions. As the changes in channel geometry occur, water and sewer pipe lines (see Figure 4-5); bridges (see Figure 4-6) and other public infrastructure facilities can be vulnerable to damage.

The presence of a grade control structure can slow or halt the upstream progression of a head-cut. This can be a natural geological feature that is resistant to erosion (see Figure 2-7), or it could be a man-made structure such as box culvert road crossing.

A number of grade control structures have already been constructed within the D'Olive Watershed, particularly along the main stem Tiawasee Creek channel (see Figure 4-7). The most substantial grade control structures constructed in the D'Olive Watershed to date is the dam that created Lake Forest Lake. The lake, with a permanent pool elevation of approximately 18 feet above msl, established the lower grade elevations for the lower reaches in both D'Olive Creek and Tiawasee Creek. That elevation now prevents D'Olive Creek and Tiawasee Creek and their associated tributaries from incising to elevations below 18 feet.

Historically, other grade control structures have been constructed at locations downstream of actual head-cuts in attempts to address severe erosion problems at those locations. In general, more substantial remedial measures that would prevent the further movement of the head-cut upstream have not been pursued. However, the box culverts constructed at major road crossings (i.e., U.S. 90, I-10, and County Road 13) often serve as fortuitous grade control structures to halt the progression of local head-cuts upstream of the box culverts.

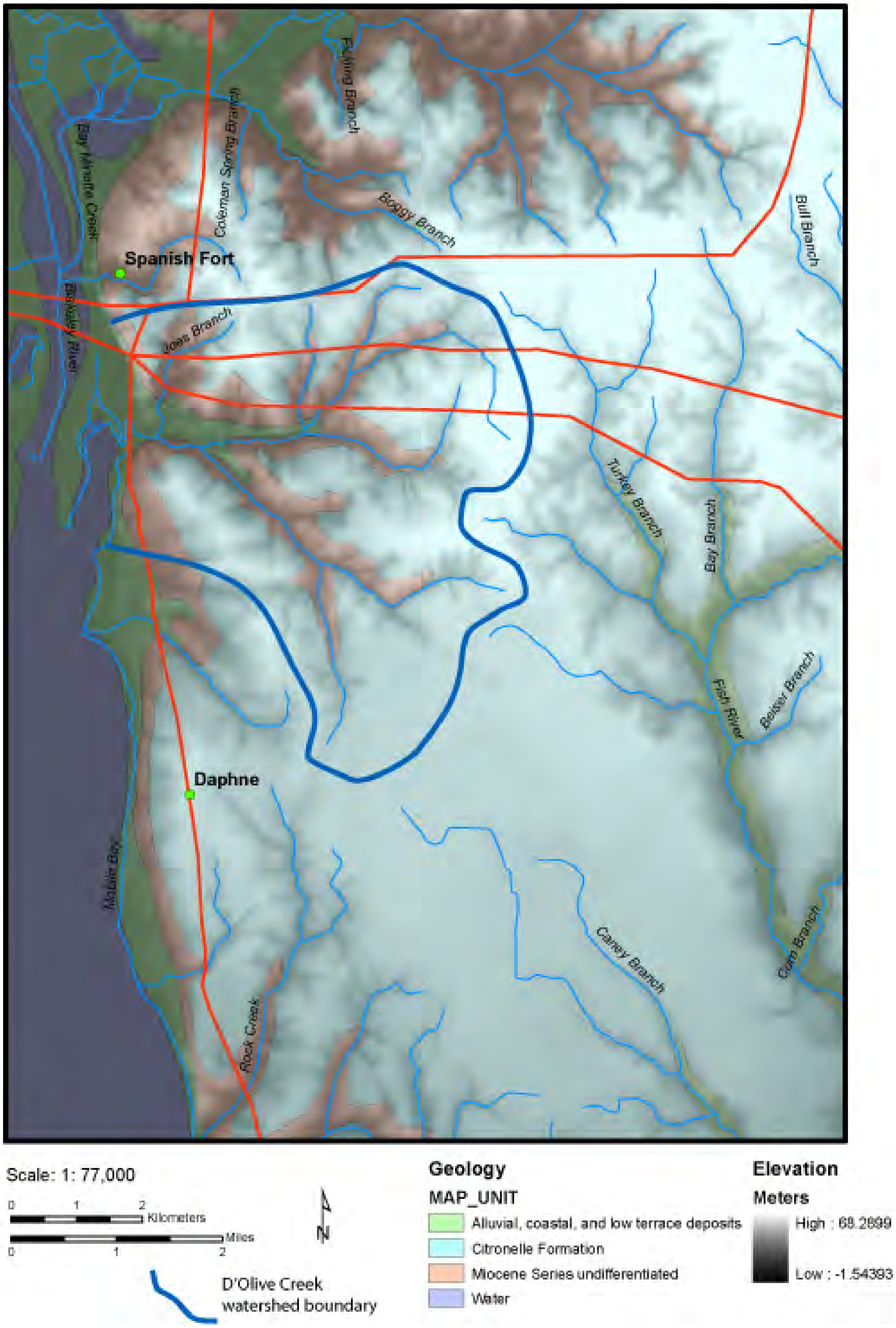

Figure 4-4. Consequences of Long Term Head-Cutting on the Surface Morphology of the D'Olive Watershed
(Source: Cook, 2010)

Figure 4-5. Pipeline Crossing on Tiawasee Creek Upstream of Confluence with Tributary TC Protected from Head-Cutting Induced Erosion

Figure 4-6. Riprap Downstream of I-10 Bridge Crossing on D'Olive Creek to Protect Against Head-Cutting Induced Erosion

Figure 4-7. Existing Grade Control Structure on Tiawasee Creek Downstream of Tributary TB

The rate of head-cutting is influenced by several factors, including the type of geological material comprising the streambed, the prevailing stream gradient, and the amount of flow conveyed by the channel. Figure 4-1 shows the locations of the channel reaches that were experiencing active head-cutting at the time this WMP was prepared. Table 4-1 summarizes the approximate channel lengths within each of the three principal Watershed drainages that are being affected by active head-cuts. Table 4-1 indicates the active head-cutting that is currently affecting 8,350 feet of streams within the D'Olive Creek portion of the overall Watershed; 8,550 feet within the Tiawasee Creek portion; and 3,450 feet in the Joe's Branch drainage. Figures 4-8, 4-9, and 4-10 illustrate the effect of head-cuts within the Joe's Branch, D-Olive Creek, and Tiawasee Creek drainages, respectively.

Table 4-1. Stream Segments Currently Affected by Active Head-Cuts

Principal Stream	Subwatershed [1]	Stream Segment [2]	Approximate Length Affected (feet)	Total Stream Length Affected (feet)
D'Olive Creek	3	D6	2,300	
	1	DA1	2,500	
	1	DA2	600	
	1	DA3	850	
	1	DA4	300	
	1	DA5	400	
	1	DA6	300	
	1	DAC1	1,100	8,350
Tiawasee Creek	8	T4	1,100	
	8	T5	700	
	8	TA	1,300	
	8	TAA	600	
	8	TB	1000	
	8	TD1	700	
	9	TC1	1,150	
	9	TC2	1,000	
	9	TCA1	1,000	8,550
Joe's Branch	10	JA	1,350	
	10	JB2	1,700	
	10	JB3	150	
	10	JB4	250	3,450
			TOTAL	**20,350**

[1] See Figure 2-2 and Table 2-1 for identification of subwatersheds.
[2] See Table 2-2 for identification of stream segments.

Figure 4-8. Head-cut on Tributary JA to Joe's Branch

Figure 4-9. Head-cut on D'Olive Creek between U.S. 90 and I-10

Figure 4-10. Head-cut on Tributary TC to Tiawasee Creek

4.2.3 Reaches with the Potential to Experience Future Degradation

Head-cuts are not static geological phenomena. Instead, they represent a vibrant physical process that is constantly at work, shaping the morphology of stream channels. The power to feed a head-cut is derived from the volume of stream flow while the energy is provided by the drop from the higher elevation upstream reach to the lower elevation downstream reach.

Unless effective corrective measures are implemented, the existing head-cuts are anticipated to continue moving upstream of their existing locations over the 10-year period addressed by this WMP. As the head-cuts progress upstream, they will continue to permanently consume the main stem channel segments and then extend upslope into the numerous smaller tributary drains that empty into the main channels. These changes will continue to cause the overall drainage network to incise into streambeds, reshape localized channel geometries, and increase the quantities of eroded channel materials and sediment volumes transported downstream.

At present, the only potential deterrent to the progression of the existing main stem head-cuts are the existing box culverts that provide crossings for the major roadways over the streams. Many of the locations of these roadways are shown on Figure 2-3 and are listed in Table 2-2. Figure 4-1 shows the anticipated streams reaches that have been identified as having a high potential to experience future channel degradation. Table 4-2 summarizes the approximate channel lengths within each of the three principal Watershed drainages that could be affected in the future. Over the next 10 years, continuation of the ongoing head-cutting processes could affect (see Table 4-2) an additional 15,100 feet of streams within the D'Olive Creek portion of the overall Watershed; 14,650 feet within the Tiawasee Creek portion; and 2,300 feet in the Joe's Bluff drainage. Figures 4-11 and 4-12, respectively, illustrate the current conditions on Tributary DA to D'Olive Creek and on the main stem of Tiawasee Creek a short distance upstream of the existing head-cuts on these two streams.

Table 4-2. Streams Potentially Affected by Progression of Head-Cuts Through 2020

Principal Stream	Subwatershed [1/]	Stream Segment [2/]	Approximate Length Affected (feet)	Total Stream Length Affected (feet)
D'Olive Creek	2	DB	6,000	
	1	DA6	1,050	
	1	DA7	1,400	
	1	DA8	200	
	1	DA9	1,800	
	1	DACA1	2,200	
	1	DAC2	1,700	
	1	DAD	750	15,100
Tiawasee Creek	8	T6	2,400	
	8	T7	1,150	
	8	TB	2,250	
	8	TG1	300	
	8	TG2	1,350	
	8	TGA1	850	
	9	TC2	1,700	
	9	TC3	2,700	
	9	TC4	100	
	9	TCC1	1,150	
	9	TCB1	700	14,650
Joe's Branch	10	J4	1,800	
	10	JB1	500	2,300
			TOTAL	**31,050**

[1/] See Figure 2-2 and Table 2-1 for identification of subwatersheds.
[2/] See Table 2-2 for identification of stream segments.

Figure 4-11. Tributary DA to D'Olive Creek Upstream of Existing Head-Cut

Figure 4-12. Tiawasee Creek Upstream of Existing Head-Cut

4.3 Degraded Wetlands

Section 3.6 summarized the results of the wetland condition evaluation that was conducted in conjunction with development of this WMP. Figure 3-6 displayed the results of the evaluation, with the full results of the evaluation being contained within Appendix B. Sediment accumulations are common in a large number of the wetlands flanking the D'Olive Watershed streams. The principal wetland impacts are associated with Joe's Branch and D'Olive Creek and their respective tributaries. Wetlands along the lower reaches of the main stem Tiawasee Creek channel and along its tributary TCC have also been affected to varying degrees. Figure 4-1 depicts the extent of the critical wetland impact areas as they existed at the time this WMP was prepared. Invasive (i.e., exotic) plants have invaded almost all of the wetlands in the Watershed. The following discusses the nature of the impacts associated with the most impacted wetlands.

4.3.1 Joe's Branch

The wetlands surrounding Joe's Branch are the most severely impacted of those found within the three principal drainages in the D'Olive Watershed. The impacts, which are related to severe erosion and high sediment loads, are affecting Tributaries JB and JA to Joe's Branch upstream of the Spanish Fort Town Center.

Wetlands adjacent to the reach of Joe's Branch between Bass Pro Drive and Town Center Avenue have been severely impacted by sedimentation. Approximately 50% of the mature, native canopy trees are dead or dying (see Figure 4-13) and the understory is dominated by exotic species (see Figure 4-14). The sediment deposits are over 12 inches deep across much of the wetland, and the upland buffer has been cleared.

Figure 4-13. Large Openings in Forested Wetland Tree Canopy Along Lower Joe's Branch Caused by Tree Death and Defoliation Due to Stress of Sedimentation.

Figure 4-14. Open Tree Canopy along Lower Joe's Branch Caused by Sedimentation Stresses Allows Increased Light Penetration and Invasion of Exotic Plants

The sources of the sediments are not known, but appear to be coming from areas upstream of the Spanish Fort Town Center. Although the recently constructed Spanish Fort Town Center cannot be excluded as a possible source of some of the sediments in this reach of Joe's Branch, it appears that the most significant sources have originated from upstream of the Town Center (see Figures 4-15 and 4-16).

Figure 4-15. Sedimentation in Wetlands of Tributary JB to Joe's Branch Upstream of Town Center Avenue

Figure 4-16. Sedimentation in Wetlands of Tributary JB to Joe's Branch Downstream of US Highway 31 Crossing

Sedimentation in the wetlands is apparent south of Maury Court, which is located in the Westminster Gates Subdivision. At the time this WMP was prepared, several homes in this subdivision were under construction or had been built within the last few years. The detention pond serving this subdivision does not appear to have been effective in retaining sediments originating from within the subdivision and/or upstream sources.

Actively advancing head-cuts on Tributaries JA and JB are resulting in channel incision and streambank erosion and the production of sediments. The thin fringes of wetlands flanking these two tributaries have been impacted by fresh layers of sediment and contain very little understory vegetation. The wetlands adjacent to Tributary JB have been affected more severely than have the wetlands adjacent to Tributary JA.

4.3.2 Tiawasee Creek

Over the past few decades, the lowest reach of Tiawasee Creek between Lake Forest Lake and the confluence of Tributary TB has been heavily impacted by sedimentation. Although the stream channel still shows evidence of the excessive sediment loads, the adjacent wetlands have recovered in many cases.

Tributary TCC and its associated wetlands is the most heavily impacted area within the Tiawasee Creek drainage. Tributary TCC is actually a channelized ditch, constructed many years ago to drain a Grady pond (see Figure 2-3) at its extreme southerly end and to facilitate rainfall runoff from the historic agricultural fields that once covered most of this relatively flat southern headwater area of the D'Olive Watershed. It is possible construction of this ditch may have resulted in the capture of a portion of the drainage area that formerly was a component of the Rock Creek Watershed to the south. Past agricultural practices in the area have cleared most of the native vegetation from the area flanking this artificial water course. The drainage ditch now controls water levels within the Grady Pond. Over the years, a large number of homes have been constructed along Tributary TCC. The limited wetlands that flank the drainage ditch are of low quality, as shown in Figure 4-17.

4.3.3 D'Olive Creek

The wetlands associated within much of D'Olive Creek and its tributaries have been severely impacted by sedimentation. The conditions vary significantly by 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.

Construction of the Lake Forest Subdivision impacted the western portion of the creek. More recently, development of the Timber Creek Subdivision has contributed to the rapid degradation of habitat quality within the northeastern region of the main steam D'Olive Creek channel. Home building within the Timber Creek Subdivision has contributed large quantities of sediment to the upper reaches of D'Olive Creek and its tributaries. In addition, the subdivision's road network, golf course, and driveways/roofs of homes have all contributed to the amount of stormwater runoff that the creek must accommodate. Although

Figure 4-17. Limited Wetland Habitat along Tributary TCC to Tiawasee Creek

stormwater runoff has caused a lot of these sediments to be carried downstream, large quantities of sediments that originated from historic construction and continue to be generated by ongoing construction activities are present in the wetland areas flanking the main steam D'Olive Creek and Tributary DC. The following summarizes some of the observed effects on wetlands (see Appendix B for more detail).

- Almost all of the wetlands along the short reach of D'Olive Creek downstream of the Lake Forest Lake Dam have been severely altered or filled.

- The lowest reach of D'Olive Creek between Lake Forest Lake and the confluence of Tributary DA has been heavily impacted by sedimentation. The stream channel and narrow fringe of wetlands demonstrate the effects of the excessive sediment loads

- The narrow wetland buffers in the vicinity of the confluence of Tributaries DA and DAC have been heavily impacted by head-cutting and the erosion of the streambanks.

- The upper reach of the main stem of the D'Olive Creek upstream of I-10 and the lower reaches of Tributary DC are located within the Timber Creek Subdivision. Unlike much of the D'Olive Watershed, the wetlands along these stream reaches are relatively wide. As illustrated in Figure 4-18, these wetlands have been heavily impacted by sedimentation. Many of the large native canopy trees have died or under stress because of the deep sediment deposits, allowing invasive exotic plant species to thrive.

Figure 4-18. Stress of Sediments on Wetlands Flanking D'Olive Creek Upstream of I-10

4.3.4 Invasion of Exotic Plants

When wetlands become heavily impacted by sediments, the native vegetative structure of historical bottomland hardwood communities may be altered. As the large trees growing alongside the streams die due to sediment accumulations or lean over due to their root systems being undercut by bank erosion, the smaller native shrub and herbaceous species are often crushed, creating openings in both the canopy and understory. Seeds from aggressive exotic species such as Chinese privet (*Ligustrum sinense*), Chinese tallowtree (*Triadica sebifera*), cogongrass (*Imperata cylindrica*) and camphortree (*Cinnamomum camphora*) germinate quickly where competing native species have either died or become stressed by freshly deposited sediments. Exotic species are less desirable than native species. Exotics often out-compete the native species that would occupy a similar niche in the 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 to varying degrees in almost all of the wetlands within the D'Olive Watershed.

4.4 Stormwater Runoff

Increased stormwater runoff is the major factor contributing to stream channel degradation in the D'Olive Watershed. The rate of head-cutting described above is a direct result of excessive volumes of high velocity stormwater runoff being received by the streams throughout the Watershed. In addition, the transport of the large quantities of sediments, generated by overland erosion and by instream channel erosion, is determined by the volume and rate of rainfall runoff entering the streams.

Within the D'Olive Watershed, land use/land cover (LU/LC) is a primary influence on surface runoff volumes and velocities. As discussed in Sections 2.13.5.3, the percent of Impervious Cover (IC) in the Watershed is currently estimated to range between 20% and 25%. Section 3.2 projects the percent of Impervious Cover could increase to around 38% by 2020 based on anticipated population growth rates, existing zoning plans, and future land use information. According to the Impervious Cover Model (ICM), such a change in the percentage of IC would mean that streams within the D'Olive Watershed would, over the next 10 years, move from their present "Impacted" designation to the "Non-Supporting" category (Center for Watershed Protection, 2005 and Hirschman and Kosco, 2008).

Stormwater issues are pervasive throughout the entire D'Olive Watershed. Given the historic development patterns that have occurred to date and the projected future land uses for the Watershed, stormwater runoff reduction measures must be considered for the entire Watershed. Control of stormwater runoff is a Watershed-wide issue of critical importance that must be addressed in a holistic fashion if the stream degradation and sediment transport problems are to be resolved.

Stormwater runoff problems can be solved by: (1) reducing the overall amount of Impervious Cover within the Watershed; and (2) implementing retrofits that promote retention /infiltration of rainfall where it falls in lieu of the current practice of short term detention. Impervious Cover is the single most critical parameter that must be controlled within the Watershed to have a measurable impact in reducing stormwater runoff. Impervious Cover can be controlled within the D'Olive Watershed by pursuing "smart growth" techniques without sacrificing projected growth within the community.

4.5 Overland Erosion of Sediments

Since the 1990s, improved construction methods, application of BMPs, and improved monitoring and enforcement have collectively contributed to a reduction in the amount of sediments delivered by overland erosion into the D'Olive Watershed streams. While sedimentation has been reduced significantly since the 1970s and 1980s, the volume of sediments transported still exceeds natural loads by a factor of around 14 (Cook and Moss, 2008).

Evidence of the continuing problems with overland erosion was observed during the stream and wetland assessments conducted for this WMP (see Appendices A and B). Tributaries that drain areas with unimproved roads and/or active construction sites are still heavily impacted by sedimentation. Rainsplash and sheet erosion of unprotected soils by vegetation or other means are still a significant contributor of sediment to streams in the D'Olive Watershed. Typically, headwater tributaries below active construction sites and recently developed areas have heavy sediment deposits in their floodplains, and in some cases the channels are choked with sediment. Since many of the tributaries draining these areas were judged to be stable with respect to streambank erosion, the source of the sediments was attributed to upland sources (see Appendix A).

Numerous examples of individual overland erosion problems were observed during preparation of this WMP. These problems, while individually minor, collectively deliver large quantities of sediments to the D'Olive Watershed streams. Figure 4-19 illustrates that sediments can continue to escape from construction sites and enter drainage structures that eventually empty into Watershed streams. Figure 4-20 provides an example of unconfined fill dirt that is not yet being used for construction. Figure 4-21 shows the erosion occurring on large segments of the major power line rights-of-way that traverse the Watershed.

As is the case with stormwater runoff, curbing overland erosion problems must continue to be viewed as a Watershed-wide issue. Increased attention must be given to post-construction management of overland erosion issues within the Watershed and not just during the period of active construction.

Figure 4-19. Sediments from Construction Sites Entering Drain Outlet

Figure 4-20. Unconfined Fill Dirt Not Yet Used for Construction

Figure 4-21. Erosion Occurring within a Power Line Right-of-Way

4.6 Lake Forest Lake

Constructed in 1973, Lake Forest Lake has essentially served as a "sediment trap" for 91% of the total drainage area served by the D'Olive Watershed. During the 1970s and 1980s, massive quantities of sediments were eroded from upstream sources during the peak period of construction of the Lake Forest Subdivision. These sediments were carried into the lake by D'Olive Creek and Tiawasee Creek. Figure 2-4 provides a 1980 aerial view of the D'Olive Creek arm of Lake Forest Lake. Figure 4-22 shows the sediment deposits that still flank the D'Olive arm of the lake today.

Figure 4-22. Sediment Deposits in D'Olive Creek Arm of Lake Forest Lake in 2010

The large quantities of coarse-grained bedload sediments received by Lake Forest Lake since 1973 have significantly reduced the volume of the lake (see Section 3.4.2). The exact magnitude of that impact is not known since a formal evaluation has not been conducted to date. The loss of lake volume has reduced the productive life of the lake as a biological, recreational, and aesthetic resource.

Although the rate of sediment transport into Lake Forest Lake has been reduced in recent years, continuation of the present loading rates (Cook and Moss, 2008) will accelerate the filling of Lake Forest Lake. Restoration of lake volumes is important to maintaining the recreational and aesthetic attributes of the lake, as well as the real estate value of nearby properties. From a larger perspective, it is important that Lake Forest Lake continue to serve as a functional sediment trap in order to reduce the consequences of sedimentation in D'Olive Bay and Mobile Bay should bedload sediments no longer be retained in the lake.

4.7 D'Olive Bay

While D'Olive Bay suffered from the effects of excessive sedimentation during the 1970s and 1980s (Isphording, 1981), recent evidence indicates that sediments are no longer being transported into the bay at high rates (Cook and Moss, 2008). It appears that today, most of the coarse-grained sediments carried by the D'Olive Creek and Tiawasee Creek drainages are being trapped within Lake Forest Lake, with only the smaller-grained suspended solids having the ability to stay in suspension long enough to pass through the lake and into D'Olive Bay during storm events.

However, since Joe's Branch empties into D'Olive Creek downstream of Lake Forest Lake Dam, that approximately 660-acre drainage is still transporting its total sediment load directly into D'Olive Bay. As discussed in Section 4.3.1, the Joe's Branch drainage is continuing to experience erosion issues. Addressing the origin and cause of the sediment problems in Joe's Branch, will benefit conditions within D'Olive Bay.

The Lake Forest Yacht Club basin and entrance channel has experienced sedimentation problems for years. After considering the location of this facility at the southern end of D'Olive Bay and its proximity to the Blakeley River channel, it is believed the sediment accumulations are largely the result of the natural deltaic processes that are continuously active within the Mobile-Tensaw Delta. Thus, the shoaling affecting the Lake Forest Yacht Club is probably due to deposition of sediments from the Blakeley River which transports a heavy bedload received from the extensive Mobile Bay drainage basin. It is likely the sediments being carried into D'Olive Bay from the D'Olive Watershed are not of sufficient volume to contribute significantly to the shoaling problem affecting the yacht club's basin and entrance channel.

4.8 Flooding

Localized flooding problems periodically occur within the D'Olive Watershed, particularly at specific locations in the Lake Forest Subdivision. A detailed flood analysis was not included as a task for the preparation of this WMP. However, a cursory examination of these problems revealed that the reported flooding situations are not related to classical conveyance issues where the Watershed streams do not have adequate cross-sectional capacity to pass high flow rainfall events. Instead, the flooding issues appear to be isolated; are directly related to local drainage issues; and are often located in elevated upslope areas far removed from defined stream channels.

Sediment accumulations do not appear to be a causative factor in all situations where flooding is reported to have occurred. Instead the flooding problems appear to be related to poor overland drainage situations.

The drainage issues are usually the direct result of dense developments having a high percentage of Impervious Cover within the affected upslope drainage area. Typically, insufficient drainage facilities are available to carry the high volumes of runoff that can be generated within a relatively short period of time during concentrated storm events. Localized flooding can occur where runoff volumes are constrained by manmade structures or natural features. In some cases, lawn flooding can escalate until waters enter the living areas of homes. By addressing, the stormwater runoff issues described in Section 4.4, many of the localized drainage problems could be resolved, while preventing the development of similar problems at other locations.

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5.0 Watershed Management Goals and Objectives

Development of this Watershed Management Plan (WMP) for the D'Olive Watershed is the product of years of concerns over the excessive quantities of sediments transported into Lake Forest Lake, D'Olive Bay and Mobile Bay; high stormwater runoff velocities and volumes; the continuing degradation of the Watershed streams; the increasing urbanization of the Watershed; and how the ongoing Land Use/Land Cover (LU/LC) changes will influence these conditions in the future

This WMP is constructed to address a variety of goals and objectives related to the management of stormwater runoff and related problems associated with overland erosion, channel instability, excessive sediment transport/sedimentation, and general degradation of the aquatic and wetland habitats within the D'Olive Watershed.

5.1 Goals Stated in Request for Qualifications (RFQ)

The four primary objectives were stated in the November 6, 2008 Request for Qualifications (RFQ) to guide development of this WMP:

- Reduce upstream sediment inputs into the Lake Forest Lake/D'Olive/Tiawasee system.
- Reduce outgoing sediment loads into D'Olive Bay and the Mobile Bay estuary.
- Remediate and restore past effects of these sediment loads, including lake restoration.
- Mitigate future impacts of development in the watersheds, where feasible.

The Lake Forest Property Owners Association specifically desires that Lake Forest Lake be restored and that sedimentation impacts at the Lake Forest Yacht Club on D'Olive Bay be eliminated.

The following additional objectives were included in the RFQ. Each of these objectives support one or more of the above listed goals. General objectives for the WMP include the identification of necessary:

- Financing strategies and options including revenue sources;
- Creation of public private partnerships; and
- Changes to local regulatory framework.

Finally, the RFQ stated the WMP should reflect a commitment to the following stakeholder values:

- Support a regional approach to stormwater runoff and nonpoint source pollution management.
- Maintain the ecological integrity of the Watershed.

- Protect threatened, endangered, or otherwise "at-risk" flora and fauna.
- Preserve archeologically sensitive sites (if any).
- Preserve and enhance wetlands, particularly as they relate to flood protection and treatment of stormwater runoff.
- Protect the Watershed such that no further degradation occurs as a result of implementation of any construction or management practice.

5.2 Section 319 Grant Element Requirements

The RFQ requires that the WMP contain components that comply with Section 319 nonpoint source (NPS) grant guidelines. Satisfaction of these elements of the Section 319 guidelines was required, in part, to satisfy the grant requirements used in part to fund development of this WMP.

Section 319 was added to the Clean Water Act (CWA) in 1987 to establish a national program to address NPS sources of water pollution. Section 319(h) specifically authorizes the EPA to award grants to states with approved Nonpoint Source Assessment Reports and Nonpoint Source Management Programs. The funds are to be used to implement programs and projects designed to reduce NPS pollution. As required by Section 319(h), the Alabama's Nonpoint Source Management Program describes the state program for NPS management and serves as the basis for how funds are spent.

To ensure that Section 319 funded projects make progress towards restoring waters impaired by NPS pollution, watershed-based plans that are developed or implemented with Section 319 funds to address Section 303(d)-listed waters must address the nine "a-i" Section 319 grant guideline elements listed below.

a. An identification of the causes and sources or groups of similar sources that will need to be controlled to achieve the load reductions estimated in the WMP (and to achieve any other watershed goals identified in the watershed-based plan), as discussed in item (b) immediately below. Sources that need to be controlled should be identified at the significant subcategory level with estimates of the extent to which they are present in the watershed (e.g., X number of dairy cattle feedlots needing upgrading, including a rough estimate of the number of cattle per facility; Y acres of row crops needing improved nutrient management or sediment control; or Z linear miles of eroded streambank needing remediation).

b. An estimate of the load reductions expected for the management measures described under paragraph (c) below (recognizing the natural variability and the difficulty in precisely predicting the performance of management measures over time). Estimates should be provided at the same level as in item (a) above (e.g., the total load reduction expected for dairy cattle feedlots; row crops; or eroded streambanks).

c. A description of the NPS management measures that will need to be implemented to achieve the load reductions estimated under paragraph (b) above (as well as to achieve other watershed goals identified in this watershed-based plan), and an identification (using a map or a description) of the critical areas in which those measures will be needed to implement this plan.

d. An estimate of the amounts of technical and financial assistance, associated costs, and/or the sources and authorities that will be needed and relied upon to implement this plan. As sources of funding, States should consider the use of their Section 319 programs, State Revolving Funds, USDA's Environmental Quality Incentives Program and Conservation Reserve Program, and other relevant Federal, State, local and private funds that may be available to assist in implementing this plan.

e. An information/education component that will be used to enhance public understanding of the project and encourage their early and continued participation in selecting, designing, and implementing the NPS management measures that will be implemented.

f. A schedule for implementing the NPS management measures identified in this plan that is reasonably expeditious.

g. A description of interim, measurable milestones for determining whether NPS management measures or other control actions are being implemented.

h. A set of criteria that can be used to determine whether loading reductions are being achieved over time and substantial progress is being made towards attaining water quality standards and, if not, the criteria for determining whether this watershed-based plan needs to be revised or, if a NPS TMDL has been established, whether the NPS TMDL needs to be revised.

i. A monitoring component to evaluate the effectiveness of the implementation efforts over time, measured against the criteria established under item (h) immediately above.

5.3 Total Maximum Daily Load (TMDL)

Section 303(d) of the Clean Water Act requires that each state identify those waters that do not currently support designated uses, and to establish a priority ranking of these waters by taking into account the severity of the pollution and the designated uses of such waters. For each waterbody on the list, the state is required to establish a Total Maximum Daily Load (TMDL) for the pollutant or pollutants of concern at a level necessary to implement the applicable water quality standards. The TMDL schedule provides the expected date by which the specific TMDL will be drafted and submitted for public notice and comment. .

As discussed in Section 3.1.4, the major streams and tributaries of the D'Olive Watershed are included in the State of Alabama's 303(d) list of impaired waterbodies. The impairment designation is due to habitat alteration resulting from "siltation" associated with land development activities. The TMDL to address this water quality problem is scheduled for 2013.

It is possible the WMP could be utilized to develop the required TMDL for the D'Olive Watershed. This possibility adds even greater emphasis on satisfying the specific elements of the Section 319 grant requirements so as to provide reasonable assurance that the NPS load allocations identified in the NPS TMDL for the Watershed will be achieved.

5.4 Comprehensive Conservation and Management Plan for Mobile Bay

The D'Olive Watershed WMP will contribute toward meeting the objectives and plans contained within the Comprehensive Conservation and Management Plan (CCMP) for Mobile Bay (MBNEP, 2002). The CCMP recognized that humans are an integral part of the Mobile Bay estuary ecosystem, and the needs of humans must be considered in developing a sustainable conservation and management plan for the Mobile Bay ecosystem. Reflective of that recognition, the CCMP contains the following objective to guide the development of future Human Uses (HU) strategies:

> "Provide consistent, enforceable, regional land and water use management that ensures smart growth for sustainable development and decreases the negative impacts of growth-related activities on human, health, and safety, public access, and quality of life by developing and implementing plans consistent with the CCMP…"

To fulfill the above HU objective, the following three priority issues were identified in the CCMP that must be addressed in future management planning and decisions:

- Sustainable land use planning
- Hydrologic modifications
- Public access

Of the three priority issues, sustainable land use planning and hydrologic modifications are directly applicable to the D'Olive Watershed WMP. In particular, the CCMP envisioned that sustainable land use planning "…should include efforts to curb urban sprawl, promote wise land use, encourage redevelopment of existing structures, educate citizens, and coordinate all levels of government with regards to sustainable land use". Relating to the hydrologic modifications issue, the CCMP conveyed the need to protect, manage, and restore natural stream banks and bottoms and to minimize erosion in order to reduce locally generated sediment loads entering Mobile Bay.

The CCMP identified define the following action plans to address the above identified two priority issues (i.e., sustainable land use planning and hydrologic modifications):

- HU-A1 – Develop and implement land use planning that ensures smart growth for sustainable development designed to abate sprawl and loss of aesthetically pleasing environment.

- HU-B1 – Assess and remediate negative hydrologic effects of past land management objectives.
- HU-B2 – Restore to more natural hydrological conditions where feasible, MBNEP waters that have been adversely impacted by artificially created structures.
- HU-B3 – Reduce the impacts of erosion and sedimentation on streambanks and bottoms from construction, road building, and unimproved roads, agriculture, silviculture, waterfront property development, dirt/soil mining and utilities work site runoff.

While this WMP is not intended to undertake the detailed planning and engineering studies necessary to fully implement the above four action plans, watershed management measures are addressed at the conceptual level. These action plans are directed at restoring the Watershed's natural pre-development hydrology where feasible by controlling stormwater runoff, reducing sediment loads, and encouraging sustainable land use management.

5.5 Do Not Exceed 25% Impervious Cover in the Watershed

The D'Olive Watershed's stormwater and sediment transport problems have been 40 years in the making. As stated in the November 6, 2008 Request for Qualifications (RFQ) that led to the preparation of this WMP:

> "…the situation is complicated by decades of inaction, disputes over responsibility and by controversy regarding the extent to which public funds should be used on private property and the degree of public benefit that can be gained by such actions."

In many cases, the damages that have occurred over the years within the Watershed's impacted stream segments are irreparable, while in other situations it is possible to pursue actions to mitigate, restore, and even preserve other stream segments before they also experience similar fates.

Based on an application of the Impervious Cover Model (ICM) (see Sections 2.13.5 and 3.2), the D'Olive Watershed is currently on the verge passing from an "impacted stream" to a "non-supporting stream" status. The relative percentage of Impervious Cover (IC) within the Watershed is largely responsible for this situation. Once the Watershed's streams become firmly established as "non-supporting", restoration options become limited and the potential for restoration successes is increasingly constrained.

Although, it is not realistic to expect that the Watershed's impacted streams can be restored to the "high quality" status that characterized the basin prior to development, it is possible to prevent further deterioration of the streams and to chart a course toward restoration and preservation of a significant number of the stream segments. This will require establishing a goal of no more than 25% Impervious Cover within the Watershed and pursuing a variety of Low Impact Development (LID), and Green Infrastructure (GI) management measures in an attempt to assure that level is not exceeded. To reach that goal, it is crucial that a variety of management actions be pursued in a timely manner on multiple fronts. It is important to understand that "smart growth" techniques to accomplish urban development in a high quality fashion without sacrificing the ability for communities to grow.

5.6 Conceptual Management Measures

The scope of work for the WMP called for the management measures to be developed to the conceptual level only. The following objectives guided development of the management options presented in Section 6.0.

- Implement engineering measures in developed areas to restore natural watershed hydrology to the extent feasible, by increasing retention of runoff and thereby reducing runoff rate, volume, and duration.

- Implement engineering measures in stream corridors to mitigate adverse effects (i.e., channel incision, accelerated head-cutting, stream bank erosion) caused by development-induced hydrological modifications.

- Remediate and restore waterways, wetlands, and floodplains which have been adversely impacted by sediment deposition and accumulation.

- Minimize further alteration of hydrology within undeveloped or low-development areas by establishing more effective standards and criteria for runoff retention and erosion control.

6.0 Management Measures

6.1 Introduction

This section of the WMP summarizes information on the wide variety of management options considered to have merit in addressing the stormwater runoff and sediment transport problems within the D'Olive Watershed. These measures are described and discussed at the conceptual level only. None are intended to be "stand alone" fixes for the Watershed's many problems. Instead, it is envisioned that these options will be combined with one another, as appropriate, to develop a holistic implementation strategy for the entire Watershed (see Section 8).

For presentation purposes, the management options are divided into two major groups.

- The first group of measures (see Section 6.2) is principally directed at repairing existing problems, such as curtailing head-cutting, stabilizing eroding banks; removing sediments from Lake Forest Lake; etc. None of the measures included in this group are aimed at addressing the stormwater runoff issues.

- The second group of measures (see Section 6.3) shares the common goal of addressing stormwater runoff problems and restoring the D'Olive Watershed's hydrology. The measures in this group target the root cause of the increased stormwater runoff problems which will contribute to the long term success of the restoration efforts outlined in the WMP.

Management measures from both groups can be combined as appropriate to develop comprehensive approaches to address the surface runoff, erosion, sedimentation, and channel instability problems affecting the D'Olive Watershed. Where possible, rough-order-of-magnitude (ROM) cost estimates are provided for initial consideration.

The discussions that follow provide fundamental information for Watershed leaders and stakeholders to consider in deciding which management measures will be selected for detailed planning, design and implementation. Some of the measures fall within the purview of the municipal and county governments. Others represent actions that could be taken by individual property owners.

6.2 Repair Immediate Problems

The management measures included in this category will not materially influence the hydrology of the D'Olive Watershed. Instead they represent site-specific corrective fixes that address historical and ongoing problems within the Watershed requiring immediate attention. As such, these measures include actions that could be taken to prevent future channel degradation, reduce sediment sources, and/or address sediment accumulations.

6.2.1 Stream Restoration

6.2.1.1 Introduction

Severe degradation of streams is an ongoing problem in the D'Olive Watershed (see Section 4.2). Stream degradation is the result of hydrologic modification (i.e., increased stormwater runoff rate, volume, and duration) caused by the greater levels of Impervious Cover associated with traditional development activities. Based on the present percentage of Impervious Cover (see Section 2.13.5), the D'Olive Watershed is approaching the non-supporting threshold for viable stream restoration. Although opportunities still exist for stream restoration, if Watershed development is allowed to progress without pursuing more effective stormwater runoff management, the scope of those opportunities will diminish over time. However, even if the present-day Impervious Cover and runoff conditions could be "frozen in time," stream degradation would continue because of the aggressive nature of head-cutting processes and the magnitude of existing stormwater runoff volumes and velocities.

Active head-cutting and channel erosion exist in all major streams and tributaries of the D'Olive Watershed (see Figure 4.1). The degradation caused by head-cutting and channel incision contributes to a substantial sediment load to downstream reaches and threatens infrastructure (i.e. bridges, sewer lines, etc.). Therefore, stabilization and/or restoration of these areas are considered to be a priority. As shown in Table 4-1, stream segments currently affected by active head-cuts total approximately 20,350 linear feet (LF) (D'Olive – 8,350 LF; Tiawasee – 8,550 LF; Joe's Branch – 3,450 LF).

Existing stream restoration and/or stabilization projects have been conducted in response to threatened infrastructure. Because of funding limitations, these projects have been limited in scope and implemented in a "piecemeal" fashion, with work generally being performed in the lower portions of a head-cut reach. A programmatic approach for prioritizing, funding, planning, design, construction, and maintenance of stream restoration/stabilization measures is needed. Such a program should be developed in concert with overall Watershed restoration planning, including riparian (stream corridor) management and Watershed runoff reduction.

6.2.1.2 Stream Restoration/Stabilization Techniques

One objective of this WMP is to protect, preserve, or restore the streams and riparian corridors in the Watershed. In many locations, the streams have been severely degraded and remain in an unstable condition. Stabilization of these stream reaches is necessary to minimize further head-cutting, channel incision and bank erosion processes that are continuing to contribute substantial sediment loads downstream. If properly planned and designed, stream restoration techniques, can provide the stabilization needed in most cases. However, "hard construction stabilization" measures must be considered when stream restoration techniques are infeasible due to physical constraints and/or concerns for public safety, infrastructure, and/or property.

The following discussion summarizes the basic practices and highlights important considerations associated with stream stabilization measures. It is not intended to be a comprehensive presentation of these practices. One good reference for more detailed information is a Center for Watershed Protection (CWP) manual on "Urban Stream Repair Practices" (CWP, 2004).

Grade Control Practices. Grade control structures will play a major role in any channel stabilization measure selected. Grade control structures are installed to maintain a desired streambed elevation by preventing channel incision. They are used either to raise the stream invert (i.e. bottom of the streambed) to reverse past channel incision, or to maintain the channel invert at a current elevation in order to prevent channel incision. Almost all stream restoration projects incorporate some form of grade control practice in the project design. Grade control practices create a "hardpoint" along the channel, preventing the streambed from degrading below the top elevation of the structure. Stability can be enhanced by creating backwater situations between grade control structures. This backwater effect lowers flow velocity which lessens scour potential.

Grade control structures for "natural" stream restoration applications include practices such as rock vortex weirs, rock cross vanes, step pools, and V-log drops. Grade control structures more typical of "hard construction" applications include weirs, chutes, and pipes:

- A ***weir*** allows water to run over the edge like a miniature waterfall, typically dropping down onto a stabilized or hardened apron. The apron safely absorbs the impact of the falling water and the water continues downstream.
- When the drop in grade is more dramatic, a ***chute*** can be used to prevent severe erosion. As the name implies, water moves down a chute of riprap, concrete or other type channel lining material.
- ***Pipes or culverts*** can also act as grade control structures. The embankment fill of a roadway and the culvert through the fill perform the same function as a grade control structure.

The type of grade control practices that is used in a particular situation depends on the hydrologic conditions, sediment size and loading, channel morphology, floodplain and valley characteristics and the availability of construction materials.

When the objective is to raise the bottom elevation of a stream reach, it is possible to use several grade control structures in combination. This will create a "stair step" stream in profile view as one descends downstream.

Grade control structures will be required to address head-cutting problems in streams. Historically, grade control projects constructed in the Watershed have been installed in the lower reaches of stream segments to remediate specific problems that were created by active head-cutting. To arrest the continued upstream progression of head-cuts, priorities should be devoted to constructing appropriately designed grade control structures at the upstream ends of all head-cuts. If this priority is not followed, the stream reaches classified as having the "potential to experience future degradation" will increasingly be converted to the "active" head-cutting category (see Figure 4-10).

Examples of grade control structures that currently exist within the Watershed are shown in Figures 6-1 through 6-4, and in Figure 4-7. As demonstrated in these photos, it is possible for grade control structures to accomplish several concurrent functions (i.e. prevent channel incision, road stream crossings, protect sewer lines, trap sediments, etc.).

Flow Deflection/Concentration Practices. The purpose of flow deflection/concentration practices is to change the direction of stream flow or to concentrate stream flow. These structures are used to deflect flow away from eroding stream banks, concentrate the flow in the center of the channel, redirect water in and out of meanders, and/or enhance pool and riffle habitats. In stream restoration applications, flow deflection practices may typically include: wing deflectors (single or double); log, rock, and J-rock vanes; cut-off sills; or linear deflectors.

Bank Protection Practices. Bank protection practices are designed to protect the streambank from erosion or potential failure. They are typically used along stream reaches where eroding streambanks threaten private property or public infrastructure, or where available space or highly erosive flows are a constraint.

In stream restoration applications, bank protection may include hard-bank or soft-bank stabilization methods. Hard bank methods include practices such as boulder revetments, rootwads, imbricated rip-rap, A-jacks, and cribwalls. Soft bank methods include practices such as coir fiber logs, erosion control fabrics, live stakes, live fascines, brush mattresses, or vegetation establishment.

In "hard construction stabilization" applications, channel and bank lining materials fall into two classes: rigid or flexible. From an erosion control standpoint, the primary difference between rigid and flexible channel linings is their response to changes in channel shape (width, depth and alignment). Flexible linings are able to adjust to some change in channel shape, while rigid linings cannot. Three common practices to provide flexible channel/bank lining are riprap, engineered concrete armor (ECA), and Gabion systems. However, a rigid lining may resist an erosive force of high magnitude better than a flexible one. Stabilization of the stream may require the use of a rigid lining when: (1) erosion has progressed to the point at which property, infrastructure or public safety are at risk; or (2) there is limited space to install the corrective measures. Cast-in-place (CIP) concrete and sheet pile are common types of rigid linings.

Figure 6-1. Stream Restoration Grade Control Structures on D'Olive Creek South of I-10

Figure 6-2. Grade Control at Tiawasee Creek Tributary (TC) Road Crossing

Figure 6-3. Riprap Grade Control Structure on Tiawasee Creek

Figure 6-4. Sheetpile Grade Control Structure on Tiawasee Creek

6.2.1.3 Important Planning and Design Considerations

To meet the stream restoration goals of the community, stream restoration/stabilization should be performed as part of broader, comprehensive planning that includes other stream corridor and upland watershed management practices. A systematic approach to stream restoration is preferable to selecting projects based on targets of opportunity or in response to "emergency" situations.

Most of the streams within the D'Olive Watershed are actively adjusting their respective channel cross-sections in response to past development. Consequently, designers should anticipate the future geometry of the channels and not base design efforts solely on current dimensions. Additionally, if future development is anticipated to significantly increase the amount of Impervious Cover in the subwatersheds, changes in the hydrologic regime should also be considered.

Major restoration/stabilization projects, such as channel re-design, require a high degree of expertise from multiple disciplines, as well as extensive stream assessment and hydraulic modeling. Channel re-design is a comprehensive stream restoration project that alters the dimensions, pattern and profile in order to create a new channel that will neither aggrade nor degrade, given its projected hydrologic regime and sediment load.

Modeling of future hydrology and sediment transport is essential to support the design of comprehensive stream restoration/stabilization projects. To develop accurate predictions, modeling requires excellent characterization data for the subwatershed within which a stream segment is located as well for the actual project reach being addressed by the project. The purpose of hydraulic modeling is to determine the magnitude of future discharges to the stream reach being addressed by the project to define the corresponding forces exerted on the channel boundary; and to determine the sheer stress and scour velocities to which the channel will be exposed.

Potential impacts of construction on adjacent riparian areas should be evaluated during the selection and design of alternative restoration options and procedures. Methods of construction to minimize impacts can often be utilized, but may increase construction costs significantly.

Four priorities, devised by Rosgen (1997), are commonly adopted to deal with incising urban streams, providing a useful strategy for planning and implementing a stream restoration program.

- Priority 1 – Establish bank-full stage at historical floodplain elevation
- Priority 2 – Create new floodplain and stream pattern with the streambed remaining at the present elevation
- Priority 3 – Widen the floodplain at the existing bankfull elevation
- Priority 4 – Stabilize existing streambanks in place

Illustrations extracted from the North Carolina Stream Restoration Institute and North Carolina Sea Grant "Stream Restoration – A Natural Channel Design Handbook" (Doll, et al., 2003) depicting Priority Options 1, 2, and 3 are presented in Figure 6-5.

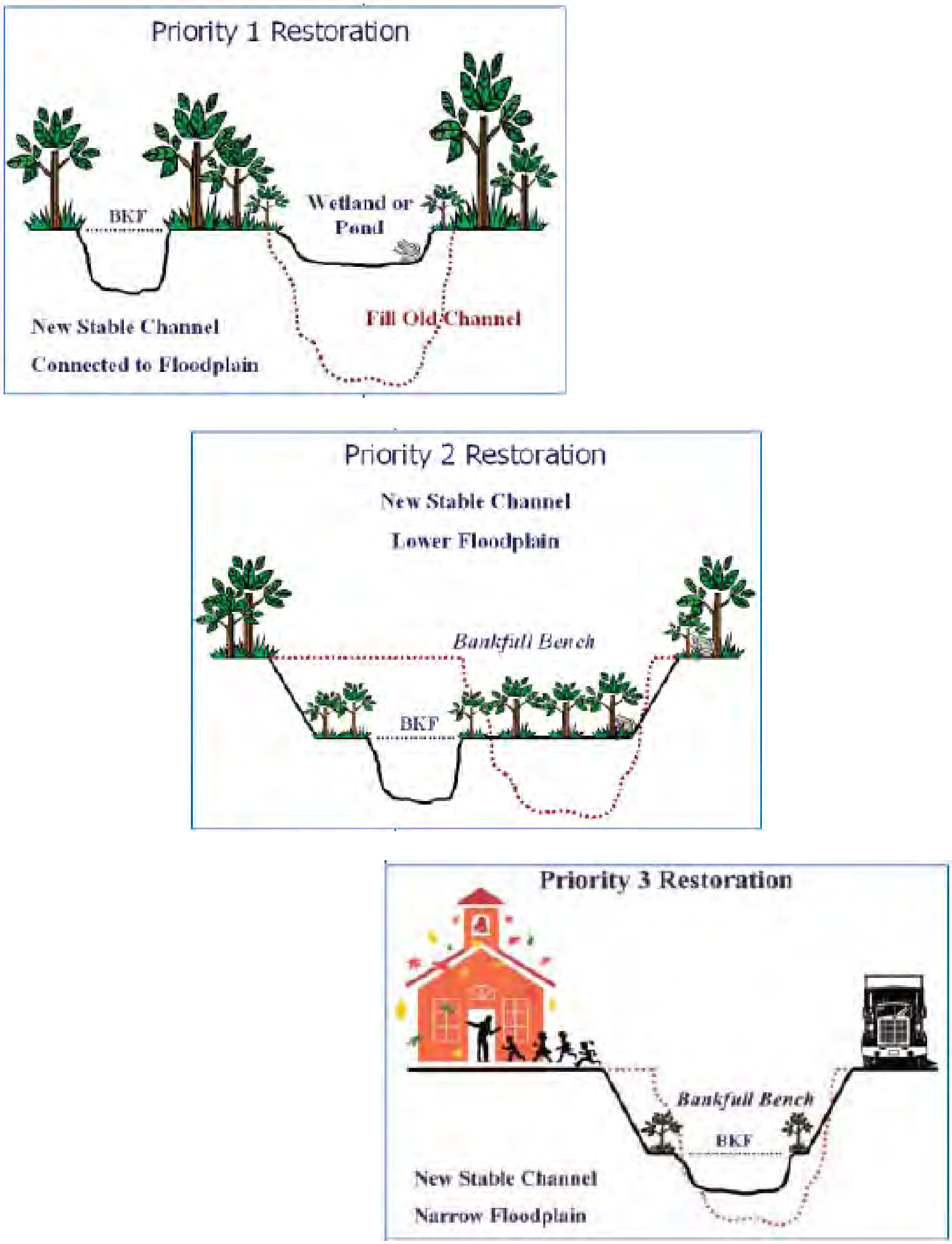

Figure 6-5. Priority Stream Restoration Options (Rosgen, 1997; Doll, et al., 2003)

Following identification of priority projects, an initial concept design should be developed to provide a general sense of the type of practices to be applied, along with their cost and feasibility. Feasibility factors to be considered include, but are not limited to, the following:

- Land ownership
- Available riparian corridor
- Corridor vegetation
- Degradation severity
- Upstream/downstream condition
- Construction access to stream
- Infrastructure constraints
- Restoration outcome success potential

The concept design and feasibility evaluation will facilitate a ranking and selection process that can be used along with funding availability and budget constraints, to establish a design and construction implementation schedule. Scheduling for the construction projects should allow sufficient timeframes for investigations and surveys, permitting, hydraulic and other analyses, final design, and procurement.

6.2.1.4 Monitoring After Construction

The complicated nature of comprehensive channel redesign projects requires careful monitoring following completion of construction. During the first year following construction, vegetation and channel stability should be inspected after major storms, with observed problems being immediately repaired. Long-term monitoring should include permanent cross-sections in order to track channel dimensions and identify problems before they pose a threat to channel stability.

If properly designed and installed, stream restoration practices should require relatively little long-term maintenance

6.2.1.5 Costs

Costs for individual stream restoration/stabilization projects can vary substantially, depending on the size of the stream segment; the type and complexity of the restoration/stabilization methods selected; and market conditions at the time of restoration. To develop rough-order-of-magnitude (ROM) cost estimates for a comprehensive stream restoration/stabilization program, available information that relates construction costs on a "per linear foot" basis was reviewed both for "stream restoration" and "hard construction stabilization" applications.

Recent local experience with stream restoration projects in the City of Daphne indicates that construction costs are in the range of \$250 to \$350 per linear foot of stream. Although this range is based on a limited number of projects, it appears consistent with literature values. For example, the Center for Watershed Protection's Urban Stream Repair Manual (CWP,

2004) indicates a construction cost range of $100 to $300 per linear foot for comprehensive channel redesign projects.

The construction cost figures do not include the costs for planning, investigations and surveys, permitting, detailed evaluations and design, construction inspection and oversight, or monitoring and maintenance. Such costs can be expected to vary widely depending on the type of project considered. A range of 25% to 50% (of construction costs) should accommodate the costs of these activities. Thus, the overall planning level ROM cost for **stream restoration projects** is expected to range between **$300 and $500 per linear foot** of stream.

Costs for "hard construction stabilization" projects (where flexible or rigid channel and bank linings such as riprap, ECA, Gabions, CIP concrete, or sheetpile are required) are higher than those for the stream restoration cost range presented above. Current construction costs for such methods have been evaluated and extrapolated to a "per linear foot" basis, considering typical channel dimensions expected for the Watershed. This analysis suggests an average construction cost range of approximately $500 to $800 per linear foot. Considering an additional 20 to 40% for investigations and surveys, permitting, final design, etc., an overall planning level ROM cost range of **$700 to $1100 per linear foot** is suggested for **"hard construction stabilization"** projects.

Finally, assuming that 75% of the projects will involve "stream restoration" methods and 25% will involve "hard construction stabilization" techniques, the **overall planning level** ROM cost for implementing a stream restoration/stabilization program is estimated at **$400 to $700** per linear feet of stream. Applying this average planning level cost to the approximate 20,000 linear feet of priority stream reaches leads to an overall programmatic cost range estimate of **$8 million to $14 million**.

The above ROM estimates do not include costs of land acquisition, legal fees, in-house staff resources, etc., that may be associated with implementing the stream restoration/stabilization program.

6.2.2 Restoration of Lake Forest Lake

6.2.2.1 Introduction

As discussed in Section 4.6, the large quantities of sediments received by Lake Forest Lake since it was built in 1973 have significantly reduced the volume of the lake (see Section 3.4.2). The exact amount of sediments deposited in the lake has not been determined. However, the loss of lake volume is known to have reduced the productive life of the lake as a biological, recreational, and aesthetic resource.

Although the rate of sediment transport into Lake Forest Lake has been reduced in recent years, continuation of the present loading rates estimated by Cook and Moss (2008) (see Section 3.4.3) will accelerate the filling of Lake Forest Lake. Restoration of lake volumes is important to maintaining the recreational and aesthetic attributes of the lake, as well as the real estate value of nearby properties. From a larger perspective, it is important that Lake Forest Lake continues to serve as a functional sediment trap, intercepting and retaining sediments that would otherwise be transported downstream into D'Olive Bay and Mobile Bay.

6.2.2.2 Lake Restoration Goals and Objectives

To develop a conceptual plan to restore of Lake Forest Lake, realistic goals and objectives need to be clearly defined. Several basic questions must be answered to allow a more detailed evaluation of alternative methods.

- What portion (area) of the lake should be restored for recreational use? It may not be feasible to return the entire lake shoreline to its original dimensions, because of cost, land ownership, or legal constraints, and/or regulatory requirements.

- How much sediment should be removed from the lake, to what depths, and from what locations? If it is not feasible to remove all of the deposited sediments (i.e., to the original subsurface contours), what are the priorities?

- What can be done to better control and manage the future sediment load entering the lake? Better watershed management can reduce the sediment loads entering the lake, but accomplishing significant reductions should not be expected in the short term. Are there specific measures upstream in the immediate vicinity of the lake that can be implemented to allow capture and removal of sediments before they enter the open water areas of the lake?

- Where can the sediments removed from the lake be placed on a permanent basis? Restoration will involve removal of sediments, either by hydraulic dredging or by mechanical excavation. Hydraulic dredging, if used, will require a disposal area in close proximity (preferably within a ½ mile or the lake) to be cost effective. If mechanical excavation is used, a nearby location for dewatering would be beneficial because of the difficulties and expense involved with hauling wet sediments.

A key factor influencing lake restoration planning is the decision of what to do in the tributary arms of D'Olive Creek and Tiawasee Creek. The majority of the incoming sediments have occurred where the flowing water of these two streams meets the slack water of the lake. The sediment deltas formed at the entrances of these two streams has continued to encroach farther into the lake over time (see Figure 4-22). This pattern is expected to continue. Restoration costs will be influenced by how far a project extends from the mouth upstream into the tributaries. The presence of opportunistic wetland vegetation in these areas is a concern, as is physical access and land ownership constraints, particularly for the D'Olive Creek arm of the lake.

Additional data are needed for evaluation of lake restoration alternatives and planning-level cost estimation. Most importantly, a bathymetric survey is needed to determine present depths in the open water portions of the lake, along with topographic surveying of the above-water sediments that have been deposited in the tributary arms. Information from these surveys will allow the volume of accumulated sediments to be calculated. Sediment physical properties (i.e., geotechnical testing), site information for access and material disposal/management areas, and other data would also be helpful. These data are not as critical for the early stages of conceptual planning, but will be needed as engineering evaluations and design progresses.

6.2.2.3 Previous Investigations

The only comprehensive quantitative estimate of lake sedimentation volumes and velocities was conducted by Isphording (1981). A later cursory evaluation was performed for the Lake Forest Yacht and Country Club in 1994 by Scott L. Douglass, Ph.D., P.E., (Douglass, 1994). However, in his report, Douglass caveats the limitations of his evaluations given the lack of documentable data. Review of the Douglas report (1994) indicates that the data limitations preclude its usefulness as a "point in time" reference to compare quantitatively against Isphording's 1981 assessment or against a sedimentation assessment if one were performed today. However, the Douglass (1994) report does provide qualitative insight into the progression of the tributary "deltas" over time.

The original extent of the lake shoreline can be estimated from the 1974 photo-revision of the U.S. Geological Survey (USGS) "Bridgehead, Ala." quadrangle map (see Figure 6-6). This map shows a narrow inundated area extending approximately 2,000 feet up D'Olive Creek upstream of Bay View Drive. A somewhat wider inundated area extends approximately, 1,500 feet up Tiawasee Creek above the golf course cart bridge between holes No. 7 and No. 8. (The cart bridge location is shown on the 1982 photo-revision of the "Bridgehead, Ala." map.) The original area of the lake was about 52 acres according to the lake boundary shown on the 1974 Bridgehead Quadrangle map.

Isphording (1981) collected depth measurements along several transects across the lake as depicted in Figure 6-7. Also shown in Figure 6-7 is the extent of surface deposition of sediment, which can be seen to have extended downstream of Bay View Drive in the D'Olive Creek arm of the lake (see also Figure 2-4) and to just past the cart bridge on the Tiawasee Creek arm of the lake. Isphording compared the 1981 measurements to the original lake area topographic contours from the 1967 photo-revision of the Bridgehead, Ala. Quadrangle map. He calculated that the original lake volume was 620 acre-feet, and that the volume remaining in 1981 was 265 acre-feet, indicating a sediment deposition volume of 355 acre-feet at that time. Isphording's 1981 estimate indicates that over half of the lake's original volume had become filled with sediments in only the first 8 years of it existence.

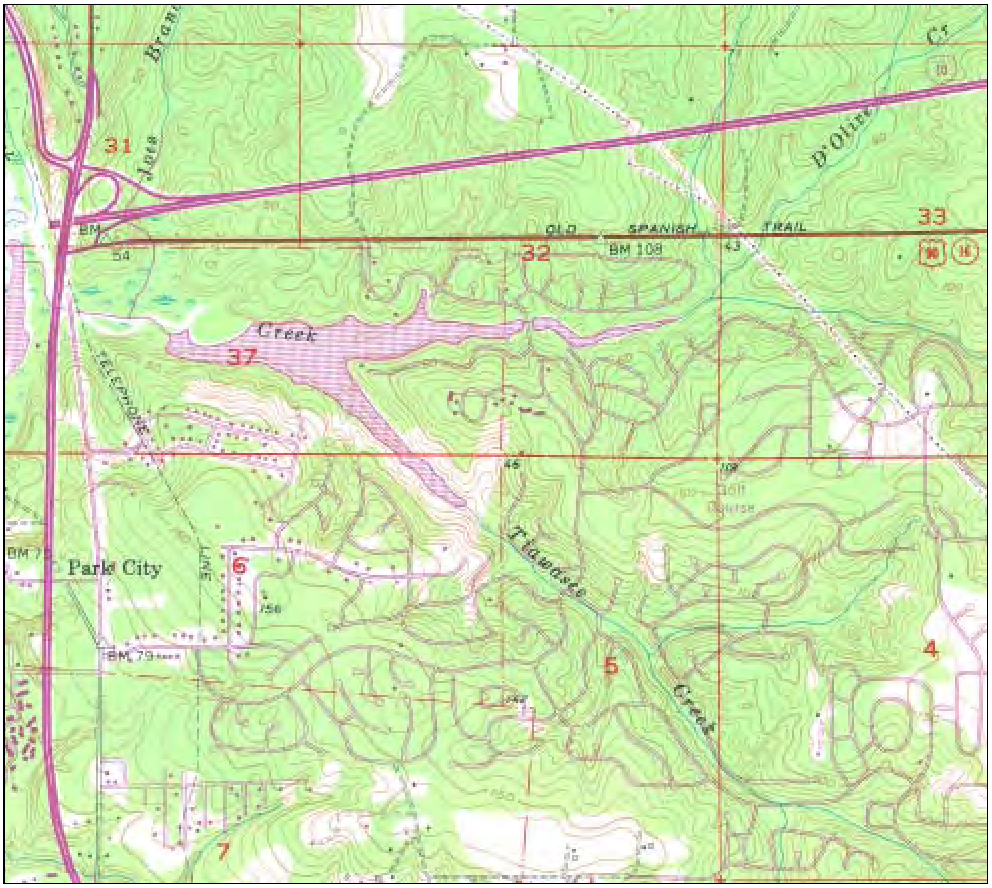

Figure 6-6. Lake Forest Lake Surface Area in 1974 (Source: USGS Quadrangle Map for Bridgehead, Ala. Photo-revised 1967 and 1974)

It is assumed that the vast majority of the sediment volume reported by Isphording (1981) was represented by the deposits in the tributary arms. Although it is not possible to calculate the volumes directly from Isphording's report, his report did include transects (see Figure 6-7) containing plots of the bottom depths that existed in 1981. However, the transect plots did not compare the ambient bottom depths against the pre-impoundment lake contours. If a bathymetric survey were performed today and included the same transect areas, it would be possible to make a general volumetric estimate of the deposition that has occurred within the "open water" portions of the lake between 1981 and present. It would also be possible to "re-construct" the original pre-impoundment lake contours based on the USGS 1967 quadrangle map. However, the accuracy of the "re-constructed" original lake contours would be limited because only 10-foot contour intervals are represented on these early maps.

As noted previously, data limitations of the Douglass (1994) report do not allow a quantitative comparison of sedimentation volume or lake capacity which existed at that time. However, a sketch in that report indicates that the surface deposits in the D'Olive Creek arm

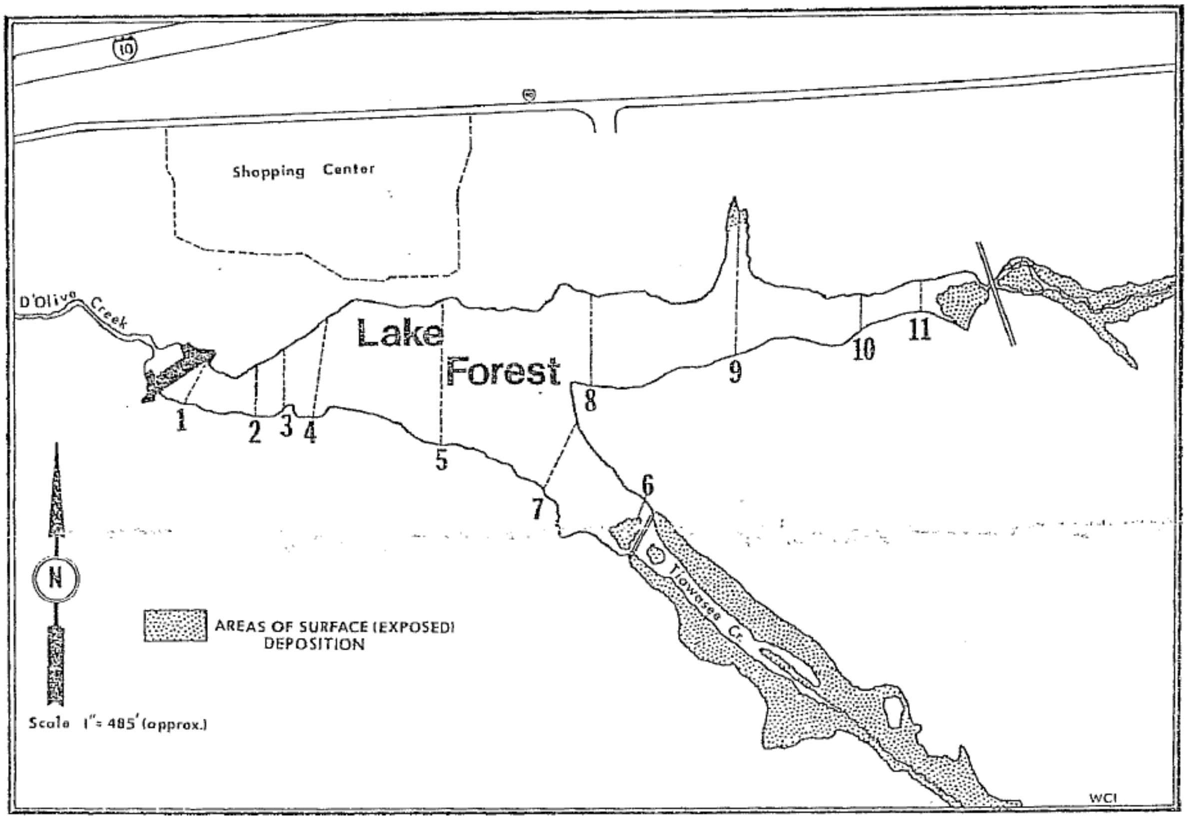

Figure 6-7. Extent of Exposed Sediment Deposits in Lake Forest Lake in 1981
(Source: Isphording, 1981)

of the lake had extended downstream to around Isphording's (1981) Transect 10 (see Figure 6-7), and in the Tiawasee Creek arm to beyond Transect 7.

The 2007-2008 Geological Survey of Alabama studies (Cook, 2007; Cook and Moss, 2008) provide quantitative estimates of the recent sediment loads entering Lake Forest Lake during that time period (see Sections 3.4.2 and 3.4.3). Those studies indicate that total sediment loads entering the D'Olive Creek arm (Subwatershed 3, GSA Station 3 - D'Olive Creek at Hwy. 90 plus Subwatershed 1, GSA Station 1 - unnamed tributary DA) were 2,228 tons per year. The total sediment loads entering the Tiawasee Creek arm (Subwatershed 7, GSA Station 7 - Tiawasee Creek at Bay View Drive) were 1,818 tons per year. In 2007, total sediment loads were also measured at the drainage conveyances crossing Highway 90 upstream of Tom's Cove (GSA Stations 4 and 5 in Cook and Moss (2008)), and their combined total sediment loads totaled 280 tons per year. Considering the overall sediment load received by Lake Forest Lake, the loadings entering Tom's Cove are considered to be relatively minor.

Sediment loads were not measured downstream of the Lake Forest Lake dam, so it is not possible to precisely estimate the quantity of sediment deposition that occurred in the lake during 2007-2008 time period. However, it is reasonable to assume that the lake "trapped" all of the bedload. Some fraction of the suspended sediment load would also be expected to have been deposited, mostly within the lower portions of the lake, but the deposition cannot be quantified with the available data.

Considering the bedload portion of the total sediment loadings, the GSA studies measured 4,762 tons per year (83%) entering the D'Olive Creek arm (GSA Stations 1 and 3) with 983 tons per year (17%) entering the Tiawasee Creek arm (GSA Station 7). Obviously, the D'Olive Creek sediment loads are much more significant in terms of the total sediment load received by the lake. It is also noteworthy that about 65% of the bedload entering the D'Olive Creek arm came from the unnamed Tributary DA (GSA Station 1) with 35% coming from D'Olive Creek (GSA Station 3).

Using an assumed factor for deposited sediment of 1.35 tons per cubic yard (cy), which is equivalent to 100 lbs. per cubic foot (cf), the volume of bedload sediments entering the tributary lake arms equate to 3,527 cy per year for the D'Olive tributary system and 728 cy per year for the Tiawasee drainage. Assuming that these annual sediment loadings have occurred evenly over the 26-year period between Isphording's 1981 report and the Cook and Moss 2007 study, the D'Olive Creek drainage would have delivered a total of 57 acre-feet of sediments and the Tiawasee Creek drainage would have contributed an additional total of 12 acre-feet. These amounts are considered to be extremely conservative since the sediment loads transported during the early portion of the 26-year period were undoubtedly much larger than the loads reported by Cook and Moss during the final two years of that period. Nevertheless, accepting these conservative loading rates and adding them to the previous sediment volumes previously reported by Isphording in 1981 would produce a total sediment load received by Lake Forest Lake between 1973 and 2007 of at least 424 acre-feet (i.e., 355 + 57 + 12 acre-feet). When that volume is compared to the estimated volume of 620 acre-feet that was available immediately after the lake was initially impoundment in 1973, results in the conclusion that over two thirds of the lake volume has been lost to sediment deposits. Since the total 414 acre-feet estimate of sediment accumulations is considered to be very conservative, it is more likely that at least 70% of the lake's total volume has been filled with sediments as of the time this WMP was prepared.

The available data do not allow a determination to be made exactly where within the lake and its tributary arms those bedload sediments have deposited, but it is reasonable to assume that the majority of deposition has occurred within the tributary arms and the outer limits of the "deltas" which have progressively extended farther downstream into the lake with time.

6.2.2.4 Lake Restoration Approach and Engineering Considerations

The suggested approach to lake restoration approach should involve construction of sedimentation basins within each tributary arm of the lake to "trap" sediments. This should be followed by removal of sediment accumulations within the remaining portions of the lake that are chosen to be maintained as "open water" for recreational use and aesthetics. Prior to conceptual design and projections of cost, additional investigations of the lake conditions (i.e., the surveys discussed above) will be necessary. Community consensus, regulatory constraints, and funding availability will influence the lake restoration decisions.

The most practicable locations for the sedimentation basins in the tributary arms appear to be downstream of Bay View Drive on D'Olive Creek, and at the present "delta" area on Tiawasee Creek downstream of the cart bridge. These general locations are shown on Figure 6-8.

Figure 6-8. Lake Forest Lake (2009) with Possible Sedimentation Basins

The purpose of the sedimentation basins is to capture sediment before it enters the open water portions of the lake. The sedimentation basins would trap the sediment in a location that would allow it to be easily removed. The accumulated sediment deposits must be periodically removed as needed to maintain the sediment trapping capacity of the basins.

The basic concept involved in sedimentation basins is to create an area of relatively low velocity in order to induce sediments to settle out of the flow. Sediment basins are typically designed with a downstream flow control in the channel that creates an upstream pool, and may include an excavated basin to enlarge the cross section. Flow control devices are required to create and operate the sedimentation basin. The outlet controls create a damming effect, while inlet controls divert low or high flows from the stream to the sedimentation basin to isolate the trap and create a bypass during maintenance operations. Flow control devices include weirs, slots, gates and flashboard risers. It is important to consider the hydraulic conditions for each component of the structure. The stage-discharge relationships for the various flow control structures involved in the project (e.g. slots and weirs) and channels may have different flow depths for a given flow.

If sediment removal maintenance was programmed for 2-year intervals, then the bedload loading rates presented previously indicate that minimum "live" sediment storage volumes would need to be approximately 7,054 cy (190,458 cf or around 4 acre-feet) in the D'Olive Creek embayment and 1,456 cy (39,312 cf or around 1 acre-foot) in the Tiawasee Creek arm. Assuming a 4-foot sediment storage depth, these volumes translate to areas of about 1.1 acres in the D'Olive arm and 0.25 acre in the Tiawasee arm.

However, storage for sedimentation represents only a portion of the area that would be required. A hydraulic flow regime must be established to prevent short-circuiting (such as baffle walls) and to maintain velocities that are slow enough to promote sedimentation. This must be done even during high storm flows, otherwise sediments in the basin will scour and resuspend. To design the sediment basins, detailed hydraulic analyses (which were beyond the scope of this WMP effort) must be performed. For a preliminary planning analysis, a 3-acre sedimentation maintenance area in the D'Olive arm and a 1-acre sedimentation maintenance area in the Tiawasee arm are considered herein.

Sedimentation maintenance areas should be located to minimize impacts to the surrounding locale, and to reduce potential environmental impacts from construction and subsequent operation. The sites should be readily accessible to equipment, such as front-end loaders, excavators, and dump trucks. As the sedimentation basins fill, routine maintenance will be required at about 2-year intervals to maintain their functionality.

There are two major components of sediment detention construction – excavation of the basin and construction of control structures. Control structures may be constructed from a wide variety of materials and methods. Typically, the excavation of sediment detention basins is a very intrusive endeavor and requires the movement of large volumes of material. To reduce impacts and facilitate construction, all construction activity should be conducted in a dewatered environment. Information from Lake Forest Property Owners Association representatives indicates that the lake can be lowered from 6 feet to 8 feet, which will be necessary if the basins are situated within the D'Olive Creek and Tiawasee Creek embayments. During construction, stream flow coming into the area will need to be diverted around the excavation areas to minimize water quality impacts.

Operation and maintenance efforts will be required to insure that the sedimentation basins function as designed. Sediment accumulations should be monitored so that removal can be initiated as the two basins near their respective capacities. In addition, the structural integrity of the basin components should be periodically monitored.

Removing sediment deposits from the remaining portions of the lake not included in the sedimentation basins would have to be accomplished by hydraulic dredging and/or mechanical excavation. The cost-effectiveness of the methods will depend upon the locations and depths of the desired sediment removal efforts.

Mechanical excavation is generally less expensive, when it can feasibly be performed. As noted previously, the lake level can be lowered 6 to 8 feet, and mechanical excavation may be feasible above these elevations if an extended drying period is allowed and access constraints are not restrictive. The feasibility of mechanical excavation will also depend on the sediment characteristics, which affect dewatering and equipment handling considerations. This approach will also require an acceptable location be identified to contain the excavated sediments.

Hydraulic dredging will likely be the method of choice for removal of underwater sediments. A disposal area with outflow controls will be required to prevent unacceptable suspended sediment (i.e. creation of turbidity) concentrations in the return flow. The size of a disposal area will depend on the sediment characteristics (i.e., sands dewater much faster than silts and clays); the volume of the material to be dredged;, the dredge pump rate; and whether the entire dredging operation is conducted in a single operation or sequentially phased so that disposal area sediments are removed between dredging projects.

6.2.2.5 Costs

The uncertainties of project scope at this stage of planning, allows only a preliminary cost range to be projected:

Sedimentation Basins

Construction

Structures	$250,000 to $500,000	
Excavation	$600,000 to $900,000	(based on *60,000 cy @ $10 -$15 per cy)*
	$850,000 to $1,400,000	

Maintenance (approximately every 2 years)

Excavation **$85,000 to $128,000** (based on *8,500 cy @ $10 - $15 per cy)*

Lake Dredging

Initial Dredging * **$3,000,000 to $6,000,000** (based on *200,000 cy to 300,000 cy @ $15 - $20 per cy)*

* Performed one time during 10-year period addressed by WMP

Total Preliminary Cost Range for Lake Restoration: $3.85 to $7.4 million (excluding maintenance)

6.2.3 Wetland Restoration/Enhancement

Four areas within the D'Olive Watershed have been identified as potential wetland restoration or enhancement sites (Figure 6-9). The actions suggested below would serve to reduce future downstream sediment loads, and improve the habitat quality within the wetland areas. However, if upstream sources of sedimentation are not controlled, the actions detailed below will have little long-term benefit to the overall health and stability of wetlands within the Watershed. In addition, acquisition of conservation easements for all restored areas should be considered to insure future protection of the restored areas.

Control of exotic (invasive introduced) plant species could require years of treatment, depending upon the severity of the infestation. Costs to control these exotic species are uncertain and depend upon the success of the initial treatment, the amount of existing seed-containing sediment removed from each site, and the density of seed-producing exotic species upstream of the treated areas. The rough costs discussed below for each wetland restoration/enhancement action are for the initial treatment only.

6.2.3.1 Area 1

The first area is a portion of Joe's Branch surrounding Site J1W, adjacent to the new Spanish Fort Town Center, between the southern entrance road (Bass Pro Drive) and the northern entrance road (Town Center Avenue) (see Figure 6-9). This section of Joe's Branch has been severely impacted by sedimentation. Restoration activities could include mechanical removal of the sediment deposits, removal of exotic species from the mid and understories, and supplemental planting of desirable native trees and shrubs to replace weak or dead canopy trees.

The sediment deposits could be removed by mechanical excavation with a track-hoe in the most heavily impacted areas; or hand-labor and a conveyor system in areas where the deposits are not as deep. Exotic species could be controlled by a combination of hand-pulling (small seedlings), cutting and treating the stumps with herbicide (saplings up to three inches in diameter at the root collar), and herbicide injections (trees larger than three inches in diameter). After the exotics and the accessible sediment deposits have been removed, the wetland could be replanted with native tree species such as swamp tupelo gum (*Nyssa biflora*), red maple (*Acer rubrum*), yellow-poplar (*Liriodendron tulipifera*), pond cypress (*Taxodium ascendens*), and willow oak (*Quercus phellos*).

Costs associated with the restoration/enhancement of Area 1 would vary based upon the method chosen to remove the sediments from the wetland. Removing the sediments would be very difficult and costly within the defined 8-acre wetland. The width of the wetland would make it difficult to reach the sediments in the middle of the wetland. In addition, moving the material uphill to a point where it could be loaded into trucks for removal from the site would be difficult because of the high/steep slopes surrounding the area. It would be more realistic to pursue a permit that would allow the excavated sediments to be permanently placed in the lowest quality areas within the wetland. The permanent stockpile sites could then be armored with straw blanket and hydro-seeded to prevent the sediment from eroding

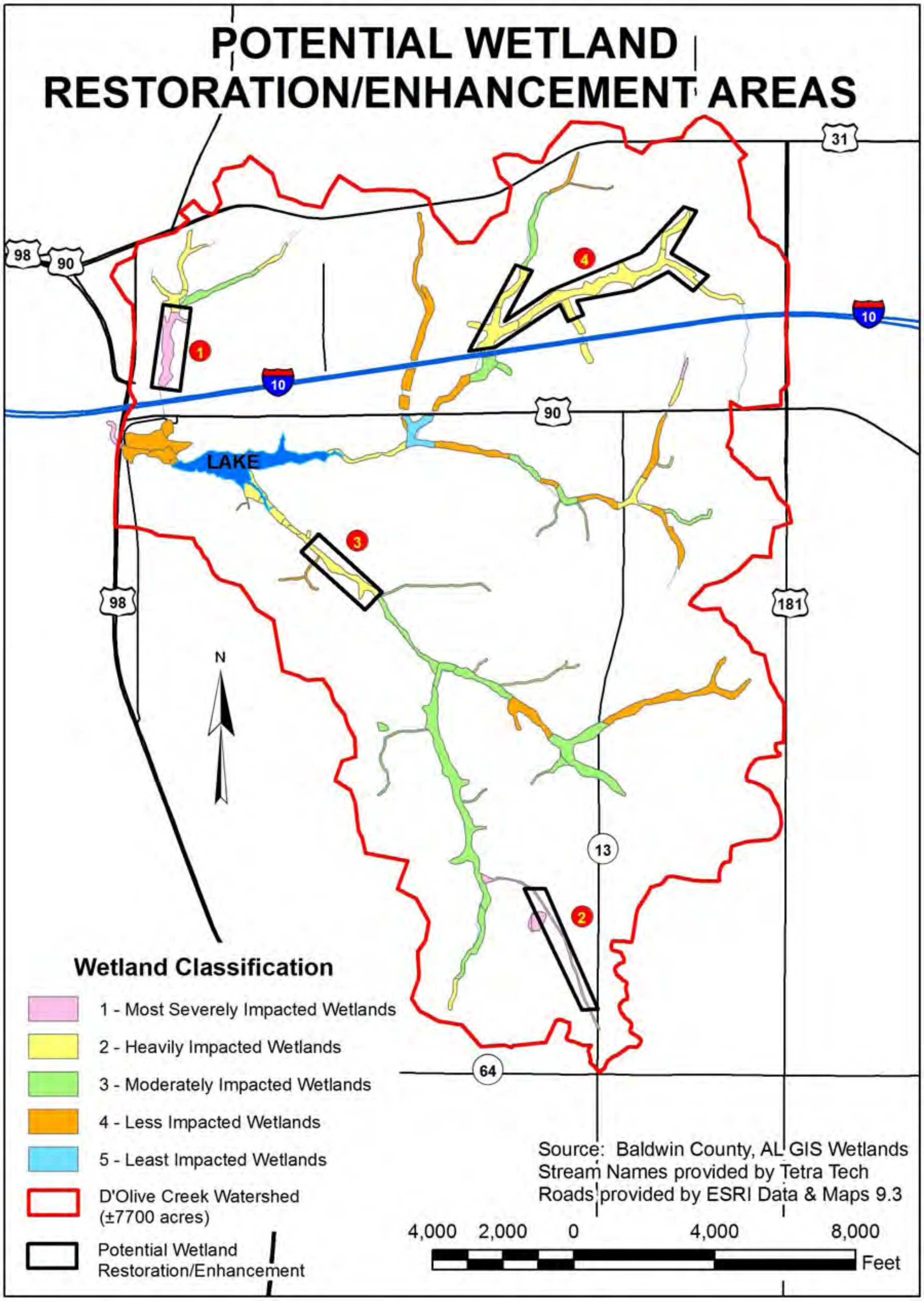

Figure 6-9. Potential Wetland Restoration/Enhancement Areas in D'Olive Watershed.

during heavy rain events. That approach would save costs by eliminating the need to move excavated sediments upslope for transport to an off-site disposal area.

If sediment deposits average 6 inches deep across the 8-acre site, approximately 6,500 cubic yards of sediment would need to be removed and disposed of in an approved area. Cost per cubic yard of sediment removed could range from $8 to $20 per cubic yard depending upon the chosen method of disposal. Total cost for the excavation could range from **$52,000 and $130,000.**

A 4-man crew could clear approximately one half-acre per day of exotic species using the methods described above. The cost for the operation could range from **$15,000 to $25,000** depending upon labor rates. Replanting would be best performed in late Fall using gallon containerized trees. Roughly 200 trees per acre would need to be planted at a cost of six dollars each for a total tree planting cost of approximately **$9,600.**

6.2.3.2 Area 2

The second area recommended for wetland restoration or enhancement area is a sub-tributary of Tiawasee Creek (see Figure 6-9). 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 Tributary TCC scored a "1" because of their extreme historical manipulation (see Table 3-4). These wetlands could be restored or enhanced by partially re-establishing the historic riparian area and natural stream sinuosity (i.e., addition of meanders).

Currently, the wetland area is confined to a ditched stream and a very narrow riparian area that is vegetated with a mixture of native trees and exotic shrubs and trees. Excavating to re-establish an average 100-foot-wide natural riparian area would create/restore approximately 6.9 wetland acres with minimal impact to surrounding land use (the restorable area is approximately 3,000 feet long). To make it effective, the excavation would need to begin at the current water level of the stream, and slowly grade up to the surrounding uplands. To achieve that result, approximately 18 inches of fill material would need to be removed throughout the newly designated riparian boundary, resulting in a total of 16,700 cubic yards of excavated material. At a cost of $8 to $15 per cubic yard, total cost of the excavation could be between **$135,000 and $250,000.**

After the excavation and grading of the new riparian area is complete, the site could be planted with native tree species using the methods and species described above. Approximately 3,000 trees would be required if the entire acreage was planted on ten foot centers. At a cost of roughly $6 dollars per tree, the total cost of the planting would be **$18,000.**

Implementation of this measure would require the agreement of neighboring landowners whose properties border the east side of Tributary TCC. In addition, reconfiguring the channel to add meanders would have to be closely coordinated with the City of Daphne which has plans to construct football/soccer fields in Trione Park which is located on the west side of the stream.

6.2.3.3 Area 3

The third area recommended for restoration and enhancement activities is a section of Tiawasee Creek that starts just south of the Lake Forest Golf Course and extends approximately 1,100 feet upstream (see Figure 6-9). Over 20 years ago, the approximately 120-foot wide (average) riparian zone of that reach of Tiawasee Creek was cleared of the native tree canopy and planted with pines. Sedimentation has altered the natural hydrology of the wetland to the point that upland exotics such as cogongrass (*Imperata cylindrical*) and camphor tree (*Cinnamomum camphora*) have become established in areas along the creek that were historically bottomland hardwood swamp.

Restoration or enhancement of the area could be performed using the same methods described for Area 1. However, removing the sediment from Area 3 would be less problematic, because of the ease of access and shallow slope of the flanking uplands. Planted pines would have to be removed prior to excavation of the sediment. Many of these pines would be of merchantable size at the time of clearing. It is estimated that an average of 12 inches of sediment would have to be removed from the roughly 3-acre area. Total sediment removed would be approximately 5,000 cubic yards at an estimated cost of $8 to $12 per cubic yard. Total cost for the excavation could be between **$40,000 and $75,000.**

Once the pines and excess sediment are removed, a diverse selection of native trees of the type described above could be replanted on 10-foot centers to accelerate re-establishment of a natural bottomland canopy. Approximately 300 trees per acre would need to be planted Area 3 at a rough cost of six dollars each for a total tree planting cost of approximately **$5,400.**

6.2.3.4 Area 4

Figure 6-9 shows the fourth area suggested for watershed restoration/enhancement which is located within the sections of D'Olive Creek and Tributary DC north of I-10. This area scored a 2 on the wetland grading scale (see Table 3-4). The site, which is located within the Timber Creek Subdivision, has been heavily impacted by sedimentation and a proliferation of exotic species.

The restoration or enhancement approach for this area would be very similar to the method detailed above for Areas 1 and 3. However, removal of the excess sediment would be more problematic than in Area 3 because of the density of homes on the surrounding uplands and limited access points into the affected areas.

Area 4 is the largest of the four identified sites. Approximately 10,000 linear feet of the 250-foot wide (average) riparian area wetlands could be included in the restoration for a total of approximately 57 acres.

The primary enhancement activities in Area 4 would consist of treatment of the dense exotic species that dominate the understory. A combination of manual labor and mechanical clearing would be needed efficiently treat such a large area. A tracked skid-steer with forestry cutter head can clear approximately one acre per day, at a cost of $800 to $1,100 per day. A four-man crew could then move through the areas where the machine could not cut and finish the job using the methods described for Area 1. The estimated cost for the exotic species treatment in Area 4 is **$70,000 to $120,000.**

Excavation of the sediments would be difficult unless low-quality zones within the wetland could be permitted for use as stockpile areas, as in the case of Area 1 above. If the sediment averages 6 inches deep across the entire acreage, approximately 46,000 cubic yards of material should be excavated at a cost of $8 to $5 per cubic yard. The total cost for excavation is estimated to range between **$370,000 and $690,000.**

6.3 Restore Watershed Hydrology

The management options presented in this subsection have the common goal of restoring the hydrology of the D'Olive Watershed. While each measure differs in how it would work to achieve that goal, they all have the potential to positively influence stormwater runoff. It is important to note that these measures are not mutually exclusive. In fact, it would be desirable and more effective to develop a holistic management approach for the entire Watershed that incorporates as many of these measures as possible. Lastly, the measures discussed in the following can be, and should be, combined with those presented in Section 6.1.

6.3.1 What does "Restore Watershed Hydrology" mean?

In the 1970s and 1980s, excessive sediment loads entering Lake Forest Lake, D'Olive Bay, and Mobile Bay from upstream construction were of primary concern. Since those early years of suburban growth, a greater understanding has developed that the heavy sediment loads actually serve as an indicator of a more pervasive problem affecting the D'Olive Watershed. That problem deals with accelerated stormwater runoff and the absence of effective measures to control runoff during post-construction conditions. The runoff volumes and velocities that exceed natural levels by a considerable margin are at the root cause of the ongoing head-cutting and channel erosion problems affecting the Watershed.

Effective, sustained post-construction management of stormwater runoff will help solve the present channel degradation problems affecting the streams of the D'Olive Watershed. By initiating proactive measures to address the stormwater management problems, it should be possible to reduce the amount of public tax dollars required to correct these ever-increasing problems in the future.

The projected future dominant land use in the D'Olive Watershed is residential (see Section 2.13.4). Over the 10-year period addressed by this WMP, it is possible that the percentage of the Watershed in residential use could increase from the current 2,389 acres (Table 2-11) to

5,100 acres by 2020 (see Table 3-1). Should that occur, Impervious Cover (IC) within the Watershed could increase from the current 20%-25% to 38% by 2020. The higher IC percentage would clearly designate the Watershed streams as being "non-supporting" (see Section 2.13.5).

A central precept of this WMP, and one that will be repeated frequently as the below management options are discussed, is the need to restore the hydrology of the D'Olive Watershed to pre-development levels to the greatest extent possible. It is recognized that this is an ambitious goal that will in all likelihood never be completely achieved. Nevertheless, it serves as a principal goal of this WMP and the specific management measures described below.

Restoration of the hydrology of the D'Olive Watershed will depend on the engineering criteria applied to site designs. Three concepts for site designs are briefly addressed in the following section.

Detention of "Peak Flow" Concept. This concept has guided the design of all detention facilities constructed in the D'Olive Watershed to date. The peak flow detention concept addresses flood control objectives only. Traditional detention storage usually targets relatively large, infrequent (i.e. 10-year/24 hour) storms for peak flow rate control. However, flow velocities from the smaller, more frequently occurring storms typically exceed those that existed prior to development. The increased runoff volumes and velocities of these more numerous, smaller storms typically create flows that are erosive to downstream channels.

Under this concept, detention has been employed to mitigate increased peak runoff velocities. However, this approach is not adequate to protect downstream hydrology because of the following inherent limitations (see Figure 6-10):

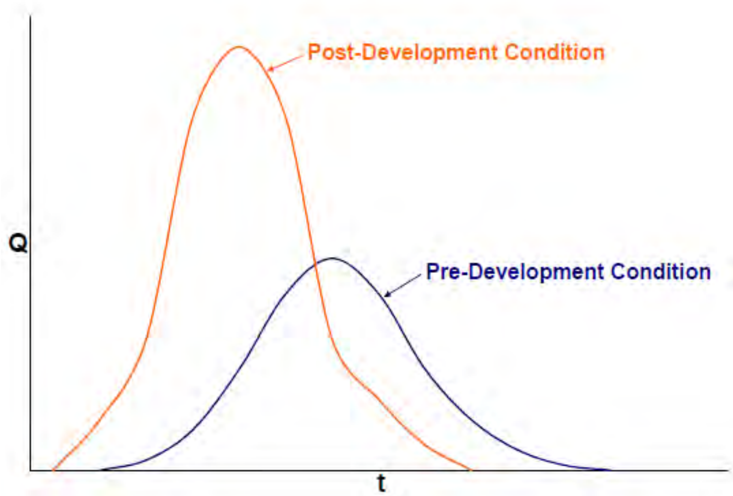

Figure 6-10. Comparison of Pre-Development and Post-Development Hydrographs
(Q = volumetric flow rate and t = time)
(from EPA, 2008)

- Provides poor peak control for small, frequently occurring storms
- Has negligible runoff volume reduction
- Increases the duration of peak flows

Detention for "Water Quality" Concept. This concept recognizes that many water quality concerns with urban non-point source runoff stem from the "first flush" of pollutants that occurs during the initial stages of a rainfall event. Therefore, the detention and treatment (i.e. BMPs) of smaller rainfall events can dramatically improve the water quality of runoff. Often, the 90^{th} percentile rainfall event is selected as a "water quality capture volume." While this concept has been extensively incorporated into stormwater management programs in other parts of the country over the past two decades, its use in the Southeast, and in Alabama in particular, has been very limited.

Volume-Based Hydrology Concept. A new approach has evolved in recent years to eliminate or reduce the amount of water that runs off a site and ultimately is discharged into adjacent waterbodies. That concept is often referred to as "Volume-Based Hydrology" (VBH). The fundamental principle of this approach is to employ systems and practices that use or mimic natural processes to: (1) infiltrate and recharge; (2) evapotranspire; and/or (3) harvest and use precipitation near to where it falls to earth.

The key to the long-term success of watershed restoration efforts is the inclusion of measures that return watershed hydrology to a semblance of "natural" or "pre-development" levels to the greatest extent possible. While such measures often target the removal of nonpoint source (NPS) contaminants (i.e. sediments, nutrients, etc.), runoff volume is actually the real issue that should be addressed (Reese, 2009). By solving the runoff volume problem, many NPS pollutants typically associated with urban areas can be minimized, while reducing erosion of stream channels.

What is significant about the VBH concept is that it is not aimed at maintaining the "existing hydrology" of the site, but instead it emphasizes restoration of the site's "pre-development" hydrology of the site. Ideally, VBH development designs should include features to assure that post-construction stormwater runoff will not exceed the natural runoff velocities and amounts that typified the site prior to initial development within the Watershed (EPA, 2009).

6.3.2 Application of VBH in the D'Olive Watershed

Application of VBH to address the erosion, stream degradation, and sedimentation problems in the D'Olive Watershed is an essential component of this WMP. Watershed managers must look beyond traditional BMPs measures that have been devoted to peak flow control and pollutant removal, and place more attention on controlling the total volume and timing of "post-construction" surface runoff. Further, greater attention will need to be devoted to post-construction surface runoff and the cumulative consequences of total development within the Watershed when considering the hydrologic effects of individual projects. Implementation of Low Impact Development/Green Infrastructure (LID/GI) measures incorporate VBH concepts since they are aimed to reduce surface runoff by retaining as much precipitation as possible on-site.

While the WMP recognizes that the application of "during construction" BMPs continues to be important in controlling stormwater runoff and sediment transport, this WMP places emphasis on improving post-construction management of stormwater runoff. The often "invisible" but always "chronic" effects of inadequate management of "post-construction" stormwater runoff can be more damaging to the ecosystem over the long-term, compared to the more "visible" short-term effects that occur "during construction".

6.3.2.1 Runoff Reduction (RR) Method

One approach that applies VBH is referred to as the *Runoff Reduction* Method (RR) (Hirschman, *et al.*, 2008). The goal of RR is to mimic natural systems as rain travels from the roof to the stream through the combined application of a series of small practices distributed throughout a development site. The total volume of runoff is reduced through canopy interception, soil infiltration, evaporation, rainfall harvesting, engineered infiltration, extended filtration and/or evapotranspiration. The overall site design objective is to replicate the runoff coefficient for all storms up to a certain design storm event for the native pre-development land cover.

Runoff reduction practices include rain tanks, rain gardens, infiltration, bioretention, dry swales and linear wetlands, among others. The comparative runoff reduction rate achieved by various stormwater practices varies greatly, as shown in Table 6-1. Several traditional stormwater practices, such as ponds and sand filters have little or no capability to reduce incoming stormwater runoff volume (Strecker et al. 2004), although other practices can achieve annual runoff reduction volumes ranging from 40 to 90%, depending on their design.

Typically, multiple practices are needed at each site to incrementally reduce the total stormwater runoff volume delivered to a stream. The major challenge with runoff reduction is how to size and arrange the individual practices to meet the appropriate stream protection objective within a subwatershed. The most recent approach is to define a variable runoff reduction volume based on the subwatershed management designation. The shift to runoff reduction is quite recent, so monitoring efforts to demonstrate the effects on improving stream quality indicator scores at the subwatershed scale have yet to be completed. Several recent studies have shown that LID or runoff reduction approaches can be effective at the scale of the individual site (Phillips et al, 2003, Selbig and Bannerman, 2008).

The RR Method was developed by the Center for Watershed Protection (CWP), the Chesapeake Stormwater Network (CSN), and the Virginia Department of Conservation and Recreation to promote better stormwater design (Hirschman *et al*, 2008). Although the RR Method was developed to specifically address reductions in phosphorus and nitrogen pollutant loading in the Chesapeake Bay Region, it has direct application to the D'Olive Watershed stormwater reduction issues.

Table 6-1.: Comparative Runoff Reduction (RR) Volumes of Selected Stormwater Practices in the Chesapeake Bay (Source: Hirschman, *et al.*, 2008)

Practice	Level 1 RR (%) [1/]	Level 2 RR (%) [2/]
Infiltration	50	90
Bioretention	40	80
Pervious Paver	45	75
Green Roof	45	60
Dry Swale	40	60
Rain Tanks/Cisterns	10	40
Rooftop Disconnection	25	50
Grass Channel	15	30
Dry ED Pond	0	15
Wet Pond	0	0
Constructed Wetland	0	0
Sand Filter	0	0

[1/] Level 1 represents the "standard design" that achieves median value of Runoff Reduction and Pollutant Removal.

[2/] Level 2 represents "enhanced design" achieves the 75th percentile Runoff Reduction and Pollutant Removal.

The RR Method focuses on determining the capacity of BMPs to reduce the overall volume of runoff as well as pollutant removal. The BMPs include conventional and innovative practices (e.g., permeable pavement, sheet flow to filter areas or open space, vegetated roofs, downspout disconnection, etc.). The method also incorporates built-in incentives for environmental site design, such as forest preservation and the reduction of soil disturbance and impervious surfaces.

The RR Method utilizes two different spreadsheets to evaluate project proposals: (1) new development projects; and (2) re-development projects. The spreadsheets include both traditional and innovative BMPs in evaluations to reduce runoff volumes and pollutant loads. This approach "credits" site design measures that reduce stormwater impacts through BMP selection. While evaluating individual projects, the RR Method can also be used to address the overall goal of reducing total suspended sediment loads in the D'Olive Watershed.

The RR Method acknowledges that a broad range of land covers (including forest, disturbed soils, and managed turf) can significantly influence water quality and the health of the receiving streams. The method also provides built-in incentives to protect or restore forest cover and reduce the amount of Impervious Cover and disturbed soils. The RR Method incorporates research findings on BMPs that reduce runoff volumes and replicate pre-development hydrologic conditions, protect downstream channels, recharge groundwater, and reduce nuisance flooding. Lastly, the RR Method provides guidance linking design features with performance to achieve a target level of pollutant removal (i.e. reduction of sediments).

The RR Method relies on a three-step process (see Table 6-2). The process is usually conducted in an iterative fashion in order to allow prior the steps to be reconsidered to achieve the desired reduction in runoff volume and suspended solids transported from the site. The final outcome of the evaluation is a post-construction runoff condition that can be applied to determining pollutant loads. It is possible the RR method could be helpful in future sediment TMDL management efforts.

Table 6-2. Practices Included in Runoff Reduction Method [1/]
(from Hirschman et al, 2008)

<table>
<tr><th>Step 1: Environmental Site Design (ESD)</th><th>Step 2: Runoff Reduction (RR) Practices</th><th>Step 3: Pollutant Removal (PR) Practices</th></tr>
<tr><td>Forest conservation</td><td>Sheetflow to conserved open space</td><td>Filtering practices</td></tr>
<tr><td>Site reforestation</td><td rowspan="3">Rooftop Disconnection
➢ Simple
➢ To soil amendments
➢ To rain garden or dry well
➢ To rank tank or cistern</td><td>Constructed wetland</td></tr>
<tr><td rowspan="2">Soil restoration (combined with or separate from rooftop disconnection)</td><td>Wet swale</td></tr>
<tr><td>Wet pond</td></tr>
<tr><td rowspan="7">Site design to minimize Impervious Cover and soil disturbance</td><td colspan="2">Green roof</td></tr>
<tr><td colspan="2">Grass channels</td></tr>
<tr><td colspan="2">Permeable pavement</td></tr>
<tr><td colspan="2">Bioretention</td></tr>
<tr><td colspan="2">Dry swale (water quality swale)</td></tr>
<tr><td colspan="2">Infiltration</td></tr>
<tr><td colspan="2">Extended detention pond</td></tr>
</table>

[1/] Practices in shaded cells achieve both Runoff Reduction (RR) and Pollutant Removal (PR) functions, and can be used for Steps 2 and 3 depicted in Figure 1. See Appendices B and C for documentation.

<u>Step 1: Apply Site Design Practices to Minimize Impervious Cover, Grading and Loss of Forest Cover</u>. This step focuses on implementing Environmental Site Design practices during the early phases of site layout. The goal is to minimize Impervious Cover and mass grading, and maximize retention of forest cover, natural areas and undisturbed soils (especially those most conducive to landscape-scale infiltration). Runoff coefficients are computed for forest, disturbed soils, and Impervious Cover and a site-specific target treatment volume is calculated.

<u>Step 2: Apply RR Practices</u>. In this step, the designer experiments with combinations of nine RR practices on the site. In each case, the designer estimates the area to be treated by each RR practice to incrementally reduce the required treatment volume for the site. The method encourages the designer to use RR practices in series within

individual drainage areas (such as rooftop disconnection to a grass swale to a bioretention area) in order to achieve a higher level of runoff reduction.

Step 3: Compute Pollutant Removal (PR) By Selected BMPs. In this step, the designer uses the spreadsheet to determine if the pollutant (i.e. suspended sediments in the case of the D'Olive Watershed) reduction has been achieved by the application of RR practices. If the target pollutant reduction is not reached, the designer can select additional, conventional BMPs -- such as filtering practices, wet ponds, and stormwater wetlands -- to meet the remaining load requirement.

Table 6-3 shows the percent RR that typically results from the identified design BMPs. The effectiveness of the individual BMPs in removing phosphorus and nitrogen is also shown. What is important to note in Table 6-3 is that detention ponds (which employ the "peak flow" detention concept and are the method most commonly employed BMP in the D'Olive Watershed to date to manage stormwater) are actually one of the least effective BMPs in terms of reducing runoff.

Table 6-3. Comparative Runoff Reduction and Removal of Phosphorus and Nitrogen (from Hirschman *et al*, 2008)

Design BMP Practice	Runoff Reduction (%)	NPRPD[1/] – Median to 3rd quartile (Q3)	
		Phosphorus	Nitrogen
Green roof	45 to 60	NR	NR
Rooftop disconnection	25 to 50	NR	NR
Raintanks and cisterns (i.e., rainwater harvesting)	40	NR	NR
Permeable pavement	45 to 75	NR	NR
Grass channel	10 to 20	24 to 46	56 to 76
Bioretention	40 to 80	5 to 30	46 to 55
Dry swale	40 to 80	NR	NR
Wet swale	0	NR	NR
Infiltration	50 to 90	65 to 96	42 to 65
Extended detention	0 to 15	20 to 25	24 to 31
Soil Amendments	50 to 75	NR	NR
Sheetflow to open space	50 to 75	NR	NR
Filtering practice	0	59 to 66	32 to 47
Constructed wetland	0	48 to 76	24 to 55
Wet pond	0	52 to 76	31 to 41

1/ National Pollutant Removal Performance Database
2/ NR – not researched

6.3.2.2 Stormwater Runoff "Capture"

Stormwater runoff "capture" is another approach that applies the concept of VBH to reduce stormwater runoff. This approach is actually a variant of the RR Method. The stormwater runoff "capture" approach is included in this discussion because of stringent new EPA guidelines to control stormwater runoff from Federal facilities to comply with the Energy

Independence and Security Act of 2007. Guidance was recently released for implementation to all Federal agencies (EPA, 2009):

> "Storm water runoff requirements for Federal development projects. The sponsor of any development or redevelopment project involving a Federal facility with a footprint that exceeds 5,000 square feet shall use site planning, design, construction, and maintenance strategies for the property to maintain or restore, to the maximum extent technically feasible, the predevelopment hydrology of the property with regard to temperature, rate, volume, and duration of flow."

The designer can reduce the overall volume of runoff leaving a site by considering runoff coefficients for specific land cover types and applying site design, structural, and nonstructural practices. Stormwater runoff "capture" aims at retaining a specific volume of stormwater runoff on site.

Runoff "capture" rules are based on a regional analysis of the rainfall frequency spectrum that is unique to the specific area of interest. Figure 6-11 shows the rainfall frequency spectrum for the Mobile Regional Airport from data for the period 1900 to 1997. The information contained in Figure 6-11 is representative of rainfall conditions experienced by the D'Olive Watershed. This figure shows the percentage of rainfall events that are equal to or less than an indicated rainfall depth in inches. As shown in Figure 6-11, the majority of storm events are relatively small. Generally, rainfall amounts less than 0.1 inch do not produce runoff. Fortunately, those rainfall events that produce the highest volumes of runoff are the less frequently occurring storms. Effective stormwater runoff management should attempt to capture and retain on site as many of the rainfall events (i.e. volumes) as possible over the course of the year.

The new guidance for Federal agencies specifies capturing the 95th Percentile Storm volume (EPA, 2009), which means that the runoff from all lesser storm events would also be retained on site. Although volumes from storm events exceeding the 95th Percentile would not be fully retained, all rainfall below that percentile would be retained even during a major storm event.

The 95th Percentile Storm Event was identified and recommended because for most watersheds this storm size represents the volume that is fully infiltrated in a natural condition. It is believed that prior to development of most watersheds, natural treatment and flow attenuation on most sites were sufficient to infiltrate or evaporate the full volume of the 95th percentile storm. Therefore, the 95th percentile rainfall amount should be managed onsite to restore and maintain the pre-development hydrology for duration, rate, and volume of stormwater flows. Lastly, small, frequently occurring storms account for a large proportion of the annual precipitation volume, and the runoff from those storm events also significantly alters the discharge frequency and rate. The runoff produced by the small storms and the initial portion of larger storms has a strong negative cumulative impact on receiving water hydrology and water quality.

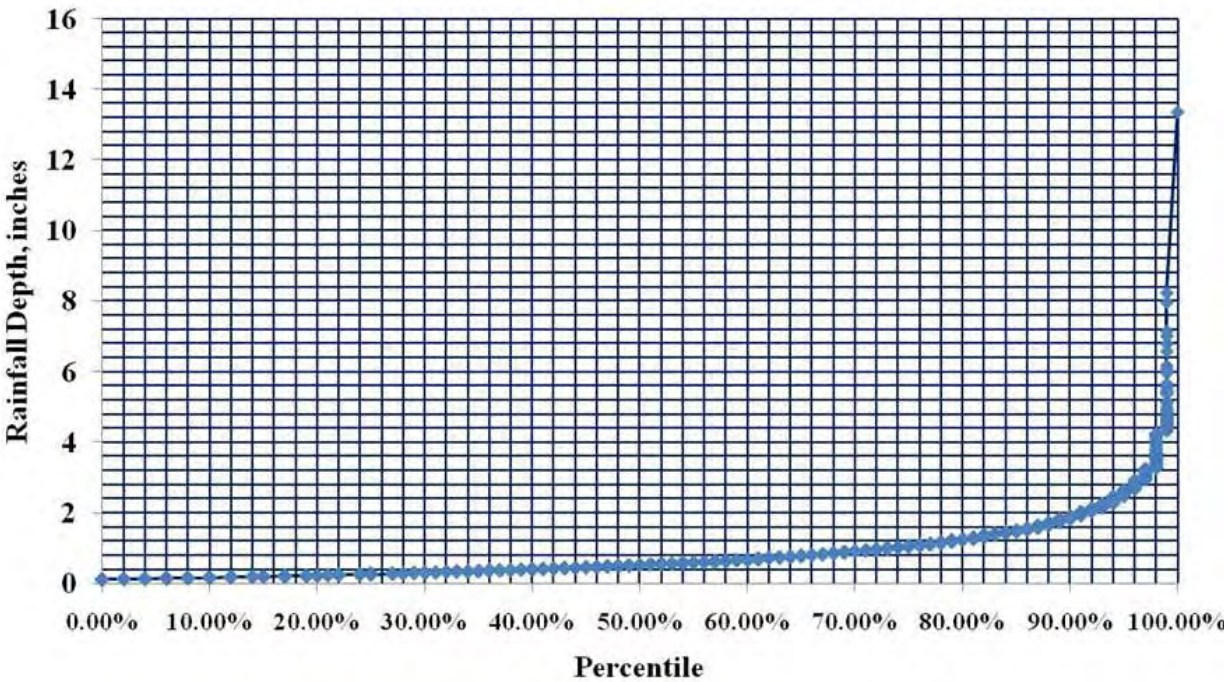

Figure 6-11. Rainfall Percentiles for Mobile Regional Airport for Period 1900-1997 (from ADEM, 2010)

It is important to note that this new EPA guidance applies only to Federal facilities. Other runoff "capture" approaches specify smaller percentile volumes. This discussion is only provided for information purposes because of its new more stringent requirements dealing with the on-site retention of stormwater runoff. The 95th Percentile Storm Event for the D'Olive Watershed is 2.46 inches as shown in Figure 6-11.

6.3.3 Stormwater Retrofits

6.3.3.1 Introduction

Although extensive development has already occurred within the D'Olive Watershed, considerable area still remains available for new development (see Section 2.13.4). Based on the present level of Impervious Cover, the Watershed is approaching the non-sustainable threshold for viable stream restoration (see Section 2.13.5). Therefore, it is paramount to develop management measures that address both existing developed areas as well as future new development.

For the purposes of this WMP, *stormwater retrofits* are defined as practices that modify existing stormwater systems or install new stormwater management facilities *within already developed areas*. The retrofits would assist in retaining large volumes of stormwater runoff, promoting a more natural hydrology, and reducing downstream channel erosion and sediment loadings to Watershed streams.

Much of the development in the D'Olive Watershed occurred before the stakeholders became aware of the effects of urbanization on stormwater runoff. Even for recent developments in the D'Olive Watershed, post-construction stormwater runoff requirements have been focused mostly towards flood management (i.e., peak flow control by detention basins) rather than on water quality or runoff volume retention. However, this has not been the case in many other areas of the country. Over the past two decades, a wealth of knowledge has been gained and considerable resources have become available to guide the development and implementation of a stormwater retrofit program. Notable among these resources are a Center for Watershed Protection – CWP (2007) manual for "Urban Stormwater Retrofit Practices," and information accessible through the Internet, including the EPA "Menu of BMPs": (http://cfpub.epa.gov/npdes/stormwater/menuofbmps/index.cfm).

Many, but not all, Low Impact Development/Green Infrastructure (LID/GI) stormwater practices applicable to new development and re-development projects can be utilized for retrofit projects. In many respects, selection and design of retrofit projects will differ when compared to the design of new stormwater systems. Retrofits are likely to be more complex and expensive, and be subject to more constraints. Typically, retrofit projects are sponsored by public entities and funded from public sources, rather than the costs being borne by developers. Retrofit projects should be selected carefully to maximize restoration objectives; be developed with input from Watershed stakeholders; and be responsive to overall community desires. An optimal retrofit project will be aesthetically pleasing, perform well for many years, and have a reasonable maintenance burden.

6.3.3.2 Capture and Storage

A core tenant for retrofit programs is to capture runoff before it enters the drainage system, and then utilize practices that enhance infiltration, evapotranspiration, rainwater harvest for re-use, and/or provide an extended detention period for removal of pollutants. Selection of "storage volume" targets and the identification of locations for retention/detention are important first steps for a Watershed-wide retrofit approach. As a general rule, "capturing rainfall close to where it falls to earth" works better than single, large "end of pipe" solutions to the problem of stormwater runoff.

Storage volume targets are based on the rainfall frequency spectrum for the locale (see Figure 6.11). For example, a target rainfall amount for "water quality" objectives is often set at the 90^{th} percentile storm, because the majority of stormwater pollutants over the course of the year typically come from the more frequent rainfall events. For the D'Olive Watershed, the 90^{th} percentile rainfall is about 2.0 inches (refer to Figure 6-11). Another storage target could be a "channel protection volume" which targets rainfall events that generate bankfull or sub-bankfull floods that cause channel enlargement. Runoff is stored and released over a 24-hour period so that critical erosive velocities in downstream channels are not exceeded during the entire storm hydrograph. The recommended channel protection criterion is 24 hours of extended detention for the runoff from a 1-year, 24-hour design storm (i.e., generally equivalent to the 99^{th} percentile storm). Referring to Figure 6-11, the 99^{th} percentile rainfall for the Watershed region represents a 4 to 5 inch rainfall event. Generally, the storage capacity needed to provide channel protection is about 60 % of the one-year storm runoff volume (CWP, 2007).

Practical considerations arise when selecting a target storage volume. Selection of a higher target volume will result in fewer retrofit sites being available. Selecting "channel protection" or even "water quality" targets may not be optimal, in that too few candidate sites may exist that could store these volume. However, a stormwater retrofit program for the D'Olive Watershed could still be effective. Target storage volumes for "runoff reduction" objectives are from 20% to 50% of target "water quality" storage volumes (CWP, 2007), suggesting that capturing rain events in the range of 0.4 to 1.0 inches may be an appropriate target for the D'Olive Watershed.

The Center for Watershed Protection (CWP) classifies retrofits by the amount of subwatershed area treated, with "storage retrofits" treating drainage areas of 5 to 500 acres, and "on-site retrofits" treating drainage areas of less than 5 acres (frequently less than one acre). Examples of common "storage retrofits" include adding storage to existing ponds, storage above roadway culverts, new storage below outfalls, storage in conveyance systems, storage in road right-of-ways, and storage near large parking lots. Residential applications may treat drainage areas as small as 500 square feet. Examples of common on-site retrofits include small parking lots, individual streets, individual rooftops, and hardscape landscapes. Most storage retrofits do not reduce runoff volume significantly, so multiple small on-site retrofits may be needed to achieve runoff reduction goals (CWP, 2007).

6.3.3.3 Retrofit Treatment Options

Retrofit treatment options presented in the referenced CWP retrofit manual include:

- extended detention
- wet ponds
- constructed wetlands
- bioretention
- filtering practices
- swales
- other (roof runoff treatment using rain gardens, rain barrels, planters, etc.)

In the CWMP manual, detailed information is presented on each treatment option, including how each works, applicability to candidate storage locations, and ranges of costs. Stormwater treatment options for retrofits differ greatly in pollutant removal capability, hydrologic benefit, and suitability.

The effectiveness of various treatment options varies widely with respect to the objective of runoff reduction. As would be expected, those practices which enhance infiltration or evapotranspiration provide the most benefit for runoff reduction, as is illustrated in Tables 6-1 and 6-3.

6.3.3.4 Possible Retrofit Applications in the D'Olive Watershed

A comprehensive evaluation of potential retrofit applications in the D'Olive Watershed was beyond the scope of this WMP effort. However, preliminary information was gathered that relates to these considerations.

Existing Detention Ponds. There was no consolidated list of existing detention ponds (or design data pertaining to same) maintained by the respective municipalities. As a result, field reconnaissance, aerial photography, and other available information were considered to identify the existing detention ponds. A total of 43 detention ponds were identified in the Watershed as depicted on Figure 6-12. The detention ponds are associated with residential subdivisions, commercial developments, or municipal facilities.

Detention ponds can be classified broadly as either "dry" or "wet." Dry ponds are designed strictly for peak flow control and not water quality treatment. Between rain events, there is no standing water above the base of the pond. If a dry pond is constructed with its base elevation sufficiently above groundwater and in permeable soils, some infiltration may occur when the pond is initially constructed. However, finer soil particles will settle out over time and "clog" the base of the pond such that infiltration is minimal.

A wet retains standing water between rain events. Wet ponds designed for only peak flow control may also provide some water quality benefit, because the suspended solids will tend to settle out in between rain events. Additionally, wetland vegetation may opportunistically grow which aids sedimentation, "filters" the flow, and evapotranspires retained water. However, if storm event flow through a wet pond is high relative to the "wet storage" capacity and residence time, the settled solids will resuspend, and minimal overall water quality benefits will be realized.

Typically, modifications to existing detention ponds provide only minimal runoff reduction (volume). However, they provide opportunities for increasing storage capacity, enhancing discharge water quality, and/or modifying discharge rate/duration patterns. Wet ponds, extended detention, and constructed wetlands can be used individually or in concert to improve the pollutant removal capabilities of the detention pond. Five strategies that can be used to retrofit storage in an existing pond include (CWP, 2007):

- Excavate the pond bottom
- Raise the embankment
- Modify the outflow structure
- "Steal" existing flood control storage
- Fix internal design geometry and/or add forebay

Within the D'Olive Watershed, detention ponds do not exist in the older, larger developments such as the Lake Forest and Timber Creek subdivisions. With the exception of certain recent commercial developments, most of the detention ponds observed within the Watershed are relatively small, and their characteristics vary considerably. However, significant advantages of retrofitting existing ponds are: (1) ownership is already vested in a

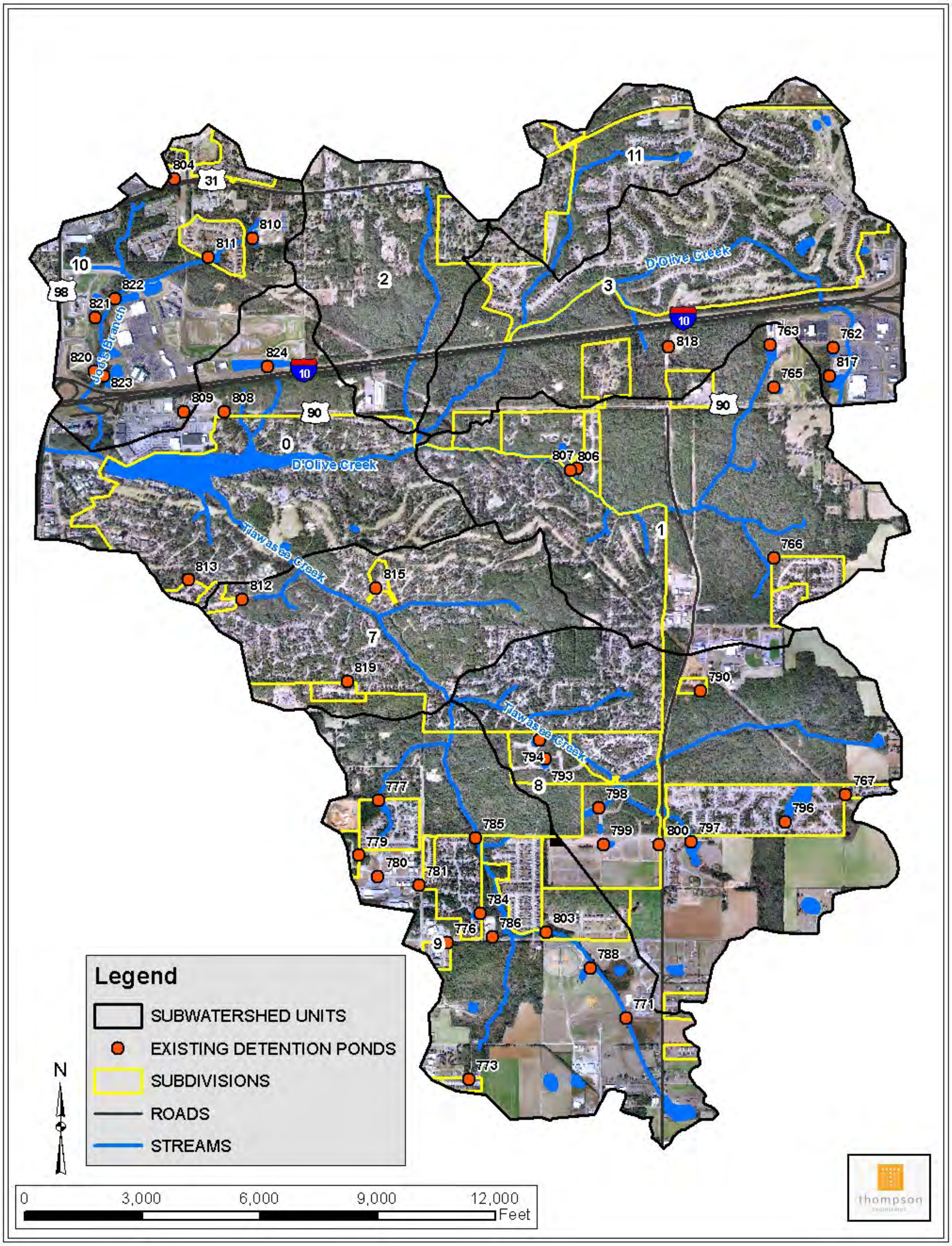

Figure 6-12. Existing Detention Ponds

single entity (i.e., a property owners association, etc.); and (2) construction costs should be minimal since much of the associated infrastructure is already in place.

Examples of existing detention ponds within the D'Olive Watershed are shown in Figures 6-13 through 6-17.

Bioretention areas, infiltration, swales, and similar retrofit opportunities. As noted previously, opportunities to find storage for retrofits may exist at numerous locations such as storage above or below roadway culverts, within conveyance systems, within highway or individual street right-of ways, near large and small parking lots, and others. Selection of the best type of retrofit for a given location will depend upon a number of factors: size of the drainage area captured; the area available to construct the retrofit; topography; soil characteristics (notably, infiltration capacity), etc. Certain retrofit practices address the D'Olive WMP objective of runoff reduction better than others (refer to Tables 6-1 and 6-3). Some of the practices that perform well for runoff reduction are also among the most cost-effective in terms of the volume of water treated. These include rain gardens, larger bioretention retrofits, and infiltration retrofits.

It was beyond the scope of this WMP effort to conduct a thorough reconnaissance of possible retrofit locations. However, several candidate locations were identified during other data gathering efforts, including the use of existing or created water features on the two existing golf courses in the Watershed. The potential locations are displayed in Figure 6-18. Figures 6-19 through 6-22 depict the site characteristics of representative potential retrofit locations identified during the course of development of this WMP.

Grady Ponds (see Section 2.8.2 and Figure 2-11) should be considered in selecting locations for stormwater retrofits. While Grady Ponds may provide only limited detention capacity, they can provide water quality functions and wetland benefits and should be considered in the planning of retrofit selections.

6.3.3.5 Process for Stormwater Retrofit Programs

A Watershed-scale retrofit program will be more cost-effective and better accomplish its objectives if it is planned and implemented with a programmatic approach. The Center for Watershed Protection retrofit manual (CWP, 2007) provides a good discussion of a sequential process for planning and implementing a retrofit program. Table 6-4 summarizes the tasks that should be performed in the recommended 8-step process.

Figure 6-13. Detention Pond at Caroline Woods Subdivision

Figure 6-14. Detention Pond at Holy Trinity Church

Figure 6-15. Detention Pond at Catherine Place

Figure 6-16. Detention Pond at Spanish Fort Town Center

Figure 6-17. Detention Pond at French Settlement Subdivision (on two different occasions)

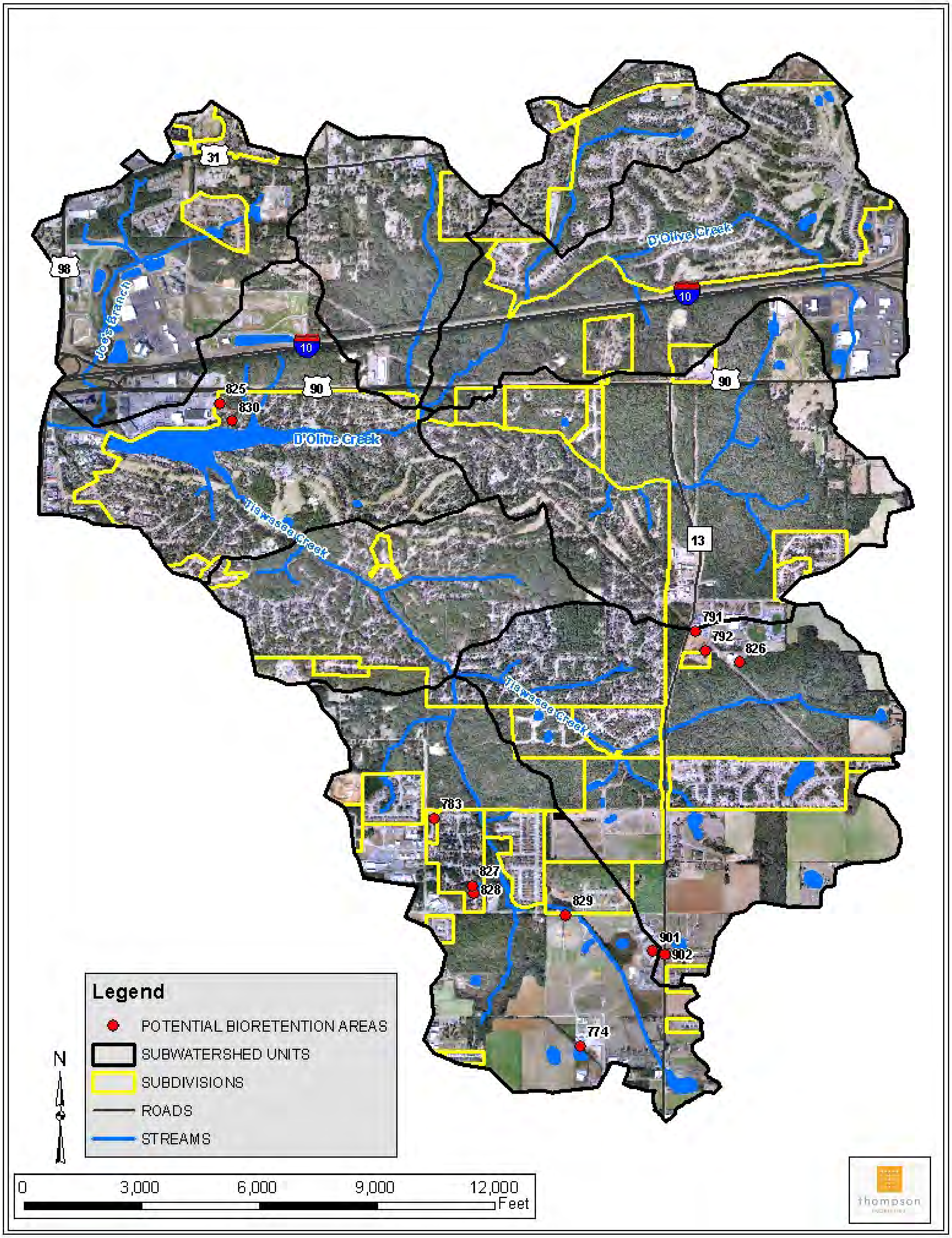

Figure 6-18. Example Locations for Potential Bioretention or Similar Retrofits

Figure 6-19. Possible Retrofit Location Waypoint 791 (Trojan Hall Fine Arts)

Figure 6-20. Possible Retrofit Location Waypoint 828 (Creekside Subdivision)

Figure 6-21. Possible Retrofit Location Waypoint 825 (Lake Forest North Entrance)

Figure 6-22. Possible Retrofit Location Waypoint 830 (Lake Forest Common Area)

Table 6-4. Eight Steps in the Stormwater Retrofit Process
(Source: CWP, 2007)

Step and Purpose	Key Tasks
Step 1: Retrofit Scoping Refine the retrofit strategy to meet local restoration objectives	• Screen for subwatershed retrofit potential • Review past, current and future stormwater • Define core retrofitting objectives • Translate into minimum performance criteria • Define preferred retrofit treatment options • Scope out retrofit effort needed
Step 2: Desktop Retrofit Analysis Search for potential retrofit sites across the subwatershed	• Secure GIS and other mapping • Conduct desktop search for retrofit sites • Prepare base maps for RRI
Step 3 : Retrofit Reconnaissance Investigation Investigate feasibility of retrofit sites in the field	• Advanced preparation • Evaluate individual sites during RRI • Finalize RRI sheets back in office
Step 4: Compile Retrofit Inventory Develop initial concepts for best retrofit sites **Step 5: Retrofit Evaluation and Ranking** Choose the most feasible and cost-effective sites	• Complete storage retrofit concept designs • Finalize on-site retrofit delivery methods • Assemble retrofit inventory • Neighborhood consultation • Develop retrofit screening criteria • Create retrofit project priority list
Step 6: Subwatershed Treatment Analysis Determine if retrofits can achieve subwatershed restoration objective **Step 7: Final Design and Construction** Assemble design package to lead to successful retrofit construction **Step 8: Inspection, Maintenance & Evaluation** Ensure retrofits are working properly and achieving subwatershed objectives	• Compute pollutant removal by storage retrofits • Compute pollutant removal by on-site retrofits • Compare against restoration objective • Secure environmental permits • Obtain landowner approval and easements • Perform special engineering studies • Put together final design package • Contract and project management • Construction inspection • Retrofit maintenance • Project tracking and monitoring

6.3.3.6 Costs

Implementing a retrofit program that can reasonably be expected to make a significant contribution towards the goals and objectives of the D'Olive WMP the Watershed will require substantial investment. Because of site constraints, higher excavation costs, greater design complexity, and other factors, the costs to construct retrofits can be expected to be 1.5 to 4 times greater than comparable practices at new developments. The CWP retrofit manual provides detailed information on the costs of various retrofit practices, compiled from an analysis of construction cost data from nearly 100 projects across the country. Figure 6-23 compares the median and quartile range of 18 different retrofit techniques.

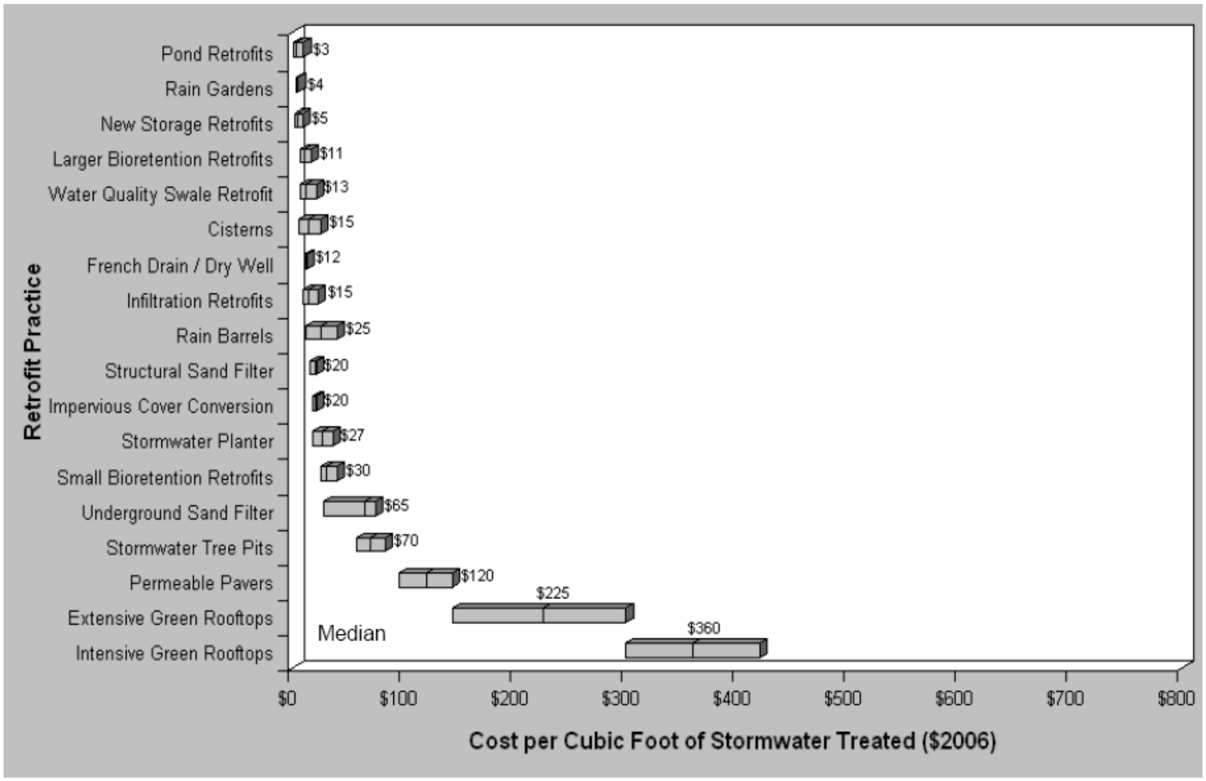

Figure 6-23. Range of Base Construction Costs for Various Retrofits
(Source: CWP, 2007)

A rough-order-of-magnitude (ROM) planning level cost estimate to construct retrofits across an entire Watershed could be developed by estimating the number and types of retrofits needed to meet storage capacity targets, and extrapolating unit rate costs. An analysis in the CWP retrofit manual using this approach provides a useful frame of reference to consider for the D'Olive Watershed. The CWP example uses a 5,000-acre Watershed with retrofit coverage of 70%. As would be expected, more storage is required and the costs are higher as Impervious Cover increases in a watershed. Other assumptions are that 80% of retrofits are larger "storage" retrofits and 20% are smaller "on-site" practices. Table 6-5 presents the results of the CWP cost analysis.

Table 6-5. Long-term Costs to Retrofit a 5,000-acre Subwatershed (Source: CWP, 2007)

Subwatershed Impervious Cover	Impervious Acres Treated	Number of retrofits required	Base Construction Costs	Total Restoration Cost
10%	353	OS = 141 SR = 6	$1,582,500 $3,579,000	$6,700,000
30%	1,088	OS = 435 SR =17	$4,892,500 $10,965,000	$20,600,000
45%	1,650	OS = 660 SR = 26	$7,425,000 $16,740,000	$31,400,500
60%	2,194	OS = 878 SR = 35	$9,900,000 $22,000,000	$41,500,000

Assumptions:
- 50 acres treated per storage retrofits and 0.5 acre treated per on-site retrofit
- 70% of the entire subwatershed area to be retrofit
- 80% of the watershed is treated by storage retrofits; 20% is treated with on-site retrofits
- Storage retrofits are equally split between pond retrofits and new facilities
- 25% of on-sites are on residential land and 75% are non-residential sites.
- Cost per impervious acre treated are: $9,500 for pond retrofits; $15,500 for new storage facilities; $15,000 for residential on-sites; $25,000 for non-residential on-site retrofits
- Total cost includes D&E at 32% of base construction cost

Development of a ROM cost estimate for a D'Olive Watershed retrofit program must consider many variables and make a number of assumptions using the data discuss above. The Watershed has 50% more overall area than the CWP example, but the "already developed" area (the area to be retrofitted) is only approximately 50% of the total instead of the example's 70%. Current Impervious Cover (IC) for the D'Olive Watershed has been estimated to range somewhere between 20% and 25%. All things considered, a ROM planning level cost estimate for a comprehensive retrofit program for the D'Olive Watershed is estimated to be in the range of **$10 million to $20 million**.

6.3.4 "Smart Growth" Concepts for Redevelopment and New Development

6.3.4.1 Introduction

Section 2.13.4 pointed out that approximately 2,000 acres of upland forest lands and 500 acres of agricultural lands remained in the D'Olive Watershed at the time this WMP was prepared. This acreage represents almost one third of the total land area contained within the Watershed boundary. Almost all of the undeveloped acreage in the Watershed is zoned for future residential use, with the remainder being targeted for commercial development. The manner in which post-construction management of stormwater runoff is accommodated during development of this acreage will determine the eventual health of streams within the D'Olive Watershed. Opportunities should also be pursued in all planned redevelopment projects to incorporate measures to restore the local hydrology of already developed portions of the Watershed. Every action taken individually to reduce runoff can ultimately produce significant cumulative positive impacts toward restoring the hydrology of the Watershed. To accomplish these goals, all new development and redevelopment projects in the D'Olive Watershed should adopt *smart growth* principals.

In 1996, the U.S. Environmental Protection Agency joined with several non-profit and governmental organizations to form the Smart Growth Network (SGN). The SGN Network was formed in response to increasing community concerns about the need for new ways to grow that boost the economy, protect the environment, and enhance community vitality. The SGN Network partners include environmental groups, historic preservation organizations, professional organizations, developers, real estate interests; and local and state government entities. The following discussion highlights some of the *smart growth* concepts that apply to stormwater runoff reduction.

Because of the magnitude of stormwater runoff and sediment loading problems historic developments, the design of new development and redevelopment projects in the D'Olive Watershed must address management of post-construction runoff. Otherwise, the public will eventually have to pay to remediate the adverse stormwater effects of ill-designed residential and commercial developments that do not recognize the fragility and limitations of the Watershed streams to handle post-construction stormwater runoff.

6.3.4.2 Land Use Planning as the "First" Stormwater BMP

Smart growth designs for new development and redevelopment projects embrace the concept of retaining rainfall runoff close to the point at which it falls. To accomplish this, proper upfront planning to retain stormwater runoff should be the first BMP applied. Hirschman and Kosco (2008) point out that a comprehensive stormwater management approach supports an interconnected network of open spaces and natural areas (i.e. forested areas, floodplains, and wetlands) that retain water and improve water quality while also providing aesthetic appeal, recreational opportunities, and wildlife habitat. *Smart growth* balances these open spaces with areas where growth and development are appropriate.

Smart growth principles attempt to keep the amount of Impervious Cover in an area as low as possible to reduce runoff velocities and volumes and to retain more rainfall on site. One method to accomplish this involves the manner in which the density of a development is designed. Figure 6-24 illustrates how the configuration and density of the development footprint within a parcel can influence Impervious Cover. As shown in Figure 6-24, although the individual sites within each scenario can have a very high "site-level" Impervious Cover, when the entire parcel is considered for each scenario the "parcel-level" Impervious Cover can actually be considerably reduced for "clustered" developments that retain large acreages of undeveloped lands within the parcel.

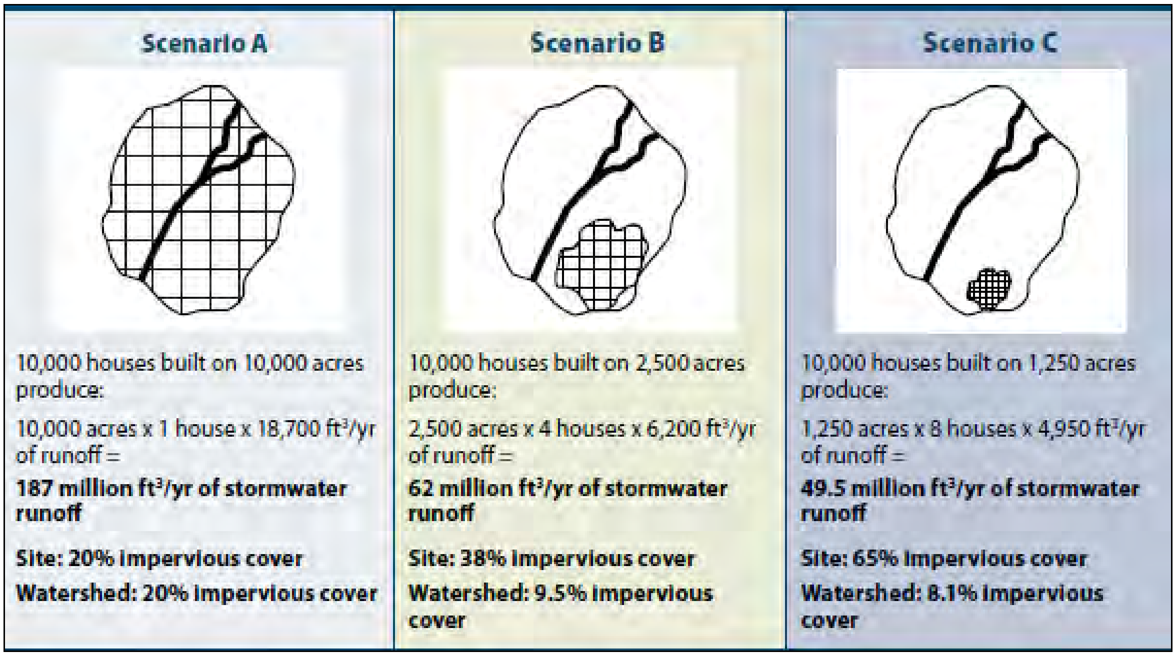

Figure 6-24. Watershed Impervious Cover at Different Development Densities (Source: Hirschman and Kosco, 2008)

The acceptability of design concepts like Scenarios B and C in Figure 6-24 will depend upon many factors. Among those is the regional character and expectation level of an area's population when it comes to acquiring a home. To adequately compete in the real estate market, aesthetic appeal, recreational opportunities, environmental awareness, and effects on real estate values will greatly influence the attractiveness of "clustered" development approaches like that shown in Scenario C above. Wise use of Green Infrastructure/Low Impact Development/Green Infrastructure (GI/LID) techniques should make such developments competitively marketable in the D'Olive Watershed.

6.3.4.3 Low Impact Development/Green Infrastructure

Traditional stormwater management programs have focused on contaminants (i.e., water quality) and have not emphasized the volume of stormwater (i.e., water quantity). In recent years, stormwater managers have concluded that conventional approaches to control runoff are not adequate to protect water resources. A growing body of evidence indicates that LID/GI techniques can be used to achieve the goal of restoring pre-development site hydrology as a component of development and/or redevelopment projects. This can only be accomplished by retaining rainfall on-site through measures that singularly, or in combination, promote infiltration, evaporation,/transpiration, and re-use to the same extent that occurred prior to development.

The objectives of LID/GI practices are: (1) to infiltrate and recharge; (2) to evapotranspire; and/or (3) to harvest and use precipitation near to where it falls to earth. LID/GI practices can be used at the site, neighborhood, and watershed-wide scales to replicate the pre-development hydrology to protect and preserve both the water resources on-site and those downstream. This has the benefit of delivering water to the stream at approximately the same rate, volume, duration, and temperature as the stream had naturally evolved to receive prior to development. This helps to eliminate or minimize erosion of streambeds and streambanks, significantly reduce the delivery of many pollutants to waterbodies, and retain historical instream temperatures.

Restoring or maintaining pre-development hydrology addresses the root cause of many stream impairments. Traditional runoff control approaches have addressed the symptoms of altered stream hydrology (i.e. peak flow and excess pollutants). Those approaches have not fully succeeded because of the scale of the problem, the cumulative impacts of multiple developments, and the need to manage impacts at both the site and watershed levels. If measures do not address hydrologic imbalance as the main problem, it is not possible to adequately protect and improve water quality (i.e. suspended solids and sediments).

LID/GI practices include green roofs, trees and tree boxes, rain gardens, vegetated swales, pocket wetlands, infiltration planters, porous, and permeable pavements, vegetated median strips, reforestation and revegetation and protection of riparian buffers and floodplains. The practices can be incorporated into any urban and/or suburban landscape.

LID/GI techniques can diminish or eliminate increases in runoff event frequency, volume, and rate. The positive benefits that can result from LID/GI practices are:

- Cost savings in many cases
- Improved environmental performance
- Reduce pollutant loadings
- Prevent pollution
- Effectively manage runoff volumes and velocities
- Enhance energy efficiency and conservation
- Are appropriate in a wide range of site condition and locations
- Are appropriate for new development and redevelopment projects
- Are appropriate at multiple scales of development, e.g., site, neighborhood, region.

6.3.4.3.1 "Green Streets"

Traditional development practices cover large areas of the ground with impervious roads, parking lots, and driveways. These hard surfaces do not allow rainwater to infiltrate into the ground. Instead, it runs offsite at much higher volumes and velocities than would naturally occur.

In the D'Olive Watershed, roads and parking areas contribute to excessive stormwater runoff velocities and serve as sources of urban nonpoint source contaminants. Within urban areas, roads, sidewalks, driveways, and parking lots are estimated to constitute almost two-thirds of the total impervious cover and contribute to a similar ratio of runoff (EPA, 2008).

Roads contribute to stormwater runoff problems in two ways. First, the impervious surfaces prohibit infiltration. Second, roads collect stormwater from adjacent areas and convey the runoff along gutters to inlets that eventually discharge highly concentrated flows to streams, which often do not have sufficient natural capacities to handle high flow volumes and velocities. In order to quickly remove water from roadways, road drainage is a primary design criterion; however, opportunities to incorporate environmental management measures are seldom considered.

As undeveloped areas in the D'Olive Watershed continue to be converted to residential and commercial uses (see Section 2.13.4), the associated roads, driveways, sidewalks, and parking areas will constitute a significant percentage of the Watershed's urban imperviousness because of their necessity to provide access to the new developments. This new construction, along with retrofitting of existing roadways and parking lots, will provide opportunities to apply LID/GI techniques to mitigate (i.e. reduce) surface runoff.

To demonstrate how wet weather can be managed by the use of GI techniques, the EPA (2008) published an action strategy for municipalities (i.e., Municipal Handbook entitled "Green Streets") that provides real world examples of how roadways can be constructed to reduce stormwater runoff. Design elements include trees bordering streets, landscaping, permeable pavements, bioretention areas, and swales. The objectives of these applications are to: (1) control of stormwater runoff near its source; (2) limit runoff and the conveyance of pollutants to stormwater collection systems; (3) encourage soil and vegetation contact and infiltration; (4) restore predevelopment hydrology to the extent possible; and (5) provide environmentally enhanced roads. The layout and design of new roads should be planned to minimize the extent of impervious area, while the redevelopment of existing streets should explore opportunities to eliminate unnecessary impervious areas. Once that is accomplished, GI techniques can be incorporated into a wide range of road types and parking lots.

Residential streets in subdivisions offer the greatest potential for building "Green Streets" in new neighborhoods or retrofitting existing streets because the streets are typically slower, less trafficked, and like to already have some landscape elements. Rain gardens (see Section 6.2.4.3.4) can be incorporated into the edges of the streets to allow stormwater to flow into a landscape area, or a portion of the paved area can be converted to landscaping to increase permeability. Permeable paving that is durable, load-bearing, can be constructed over permeable materials to store water prior to infiltration into the ground. These measures can assist residential streets to accommodate rain from small storms, while still conveying excess runoff from large storms to collection systems. Figures 6-25, 6-26, and 6-27 illustrate examples of the use of curb extensions, permeable paving, and vegetated swales, respectively, have been incorporated into different neighborhoods across the country to assist in reducing the amount of stormwater runoff.

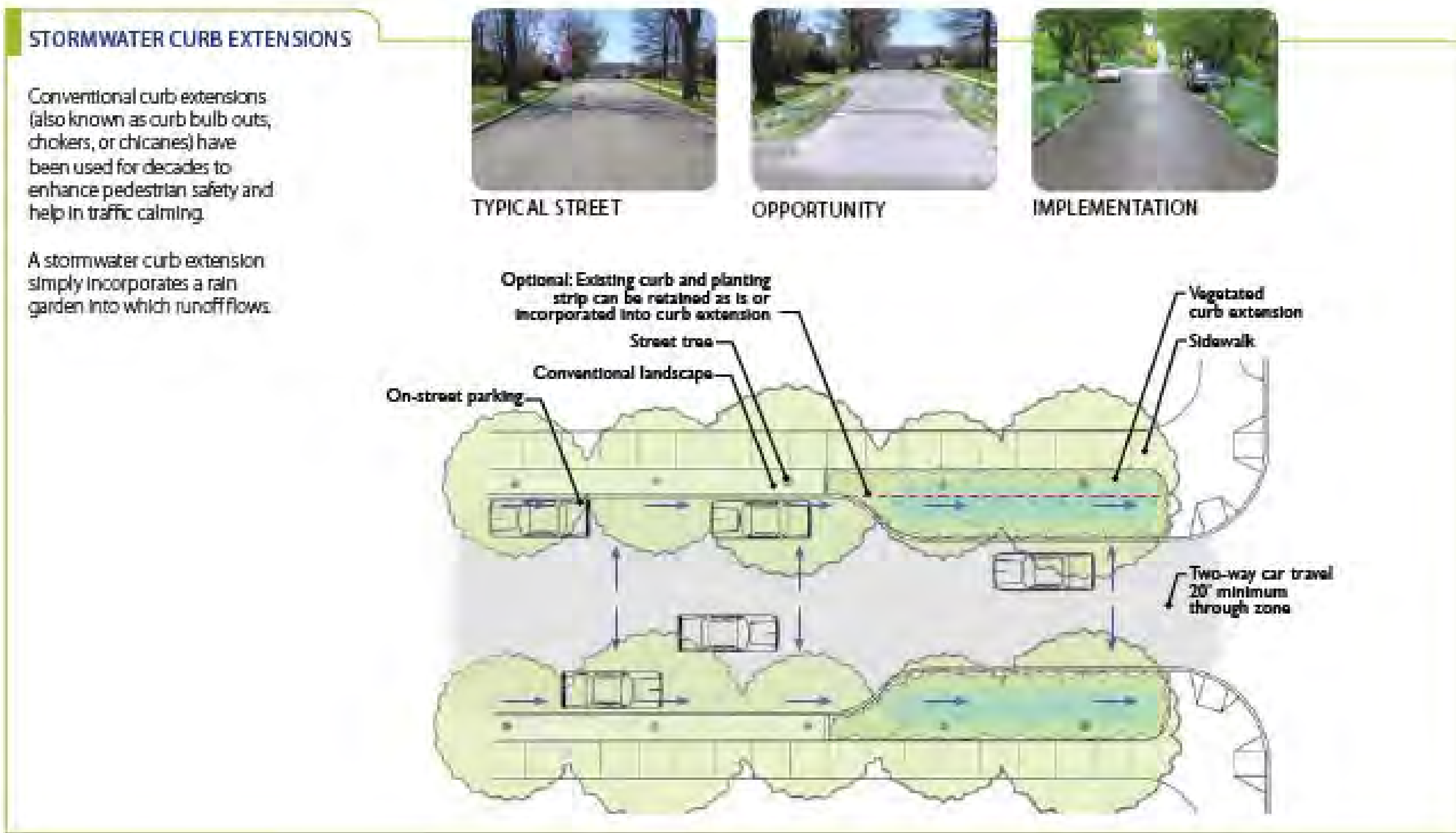

Figure 6-25. Example Application of Stormwater Curb Extensions in the Streets of a Residential Neighborhood (Source: EPA's 2008 Managing Wet Weather with Green Infrastructure)

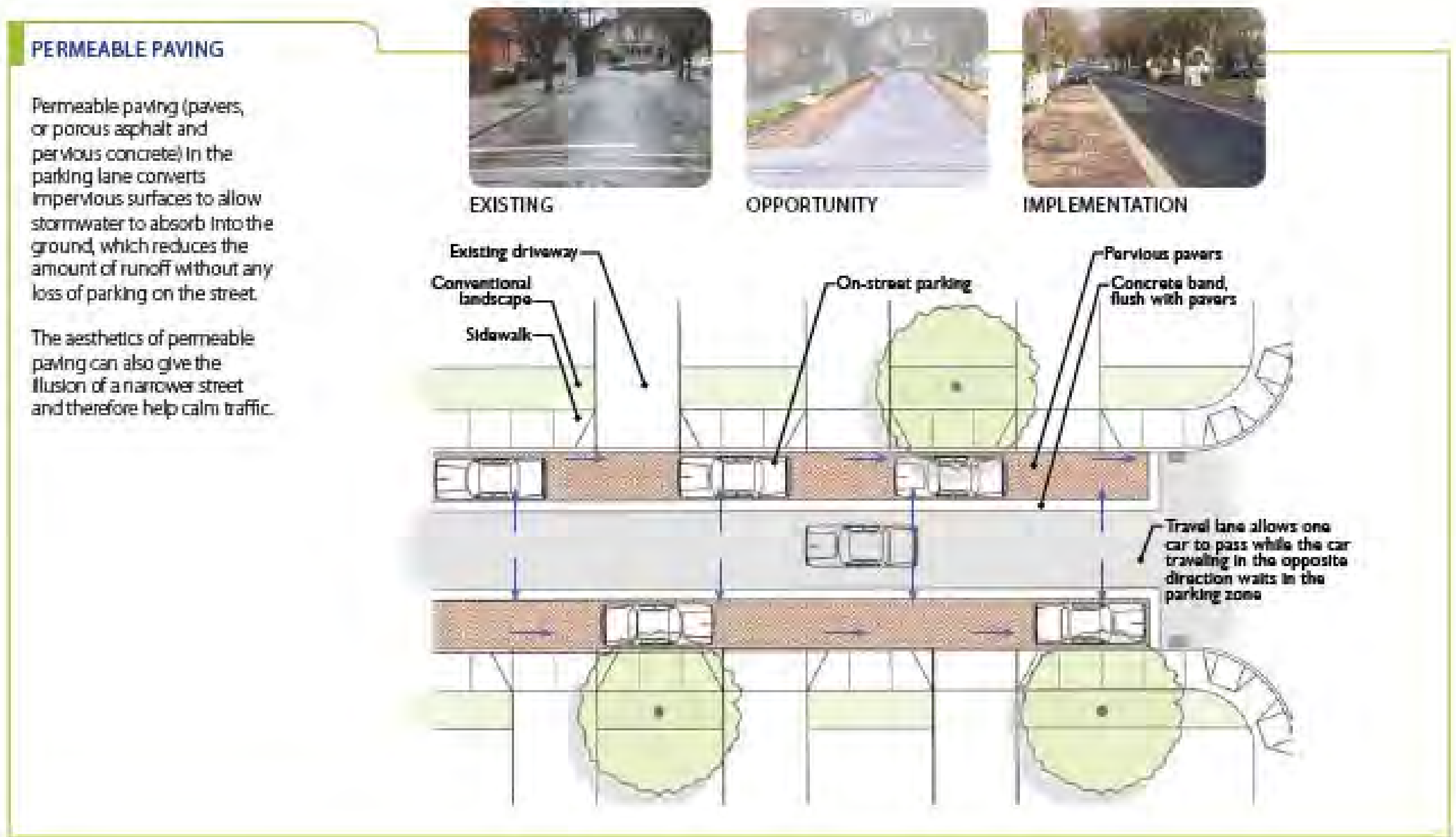

Figure 6-26. Example Application of Permeable Paving in the Streets of a Residential Neighborhood (Source: EPA's 2008 Managing Wet Weather with Green Infrastructure)

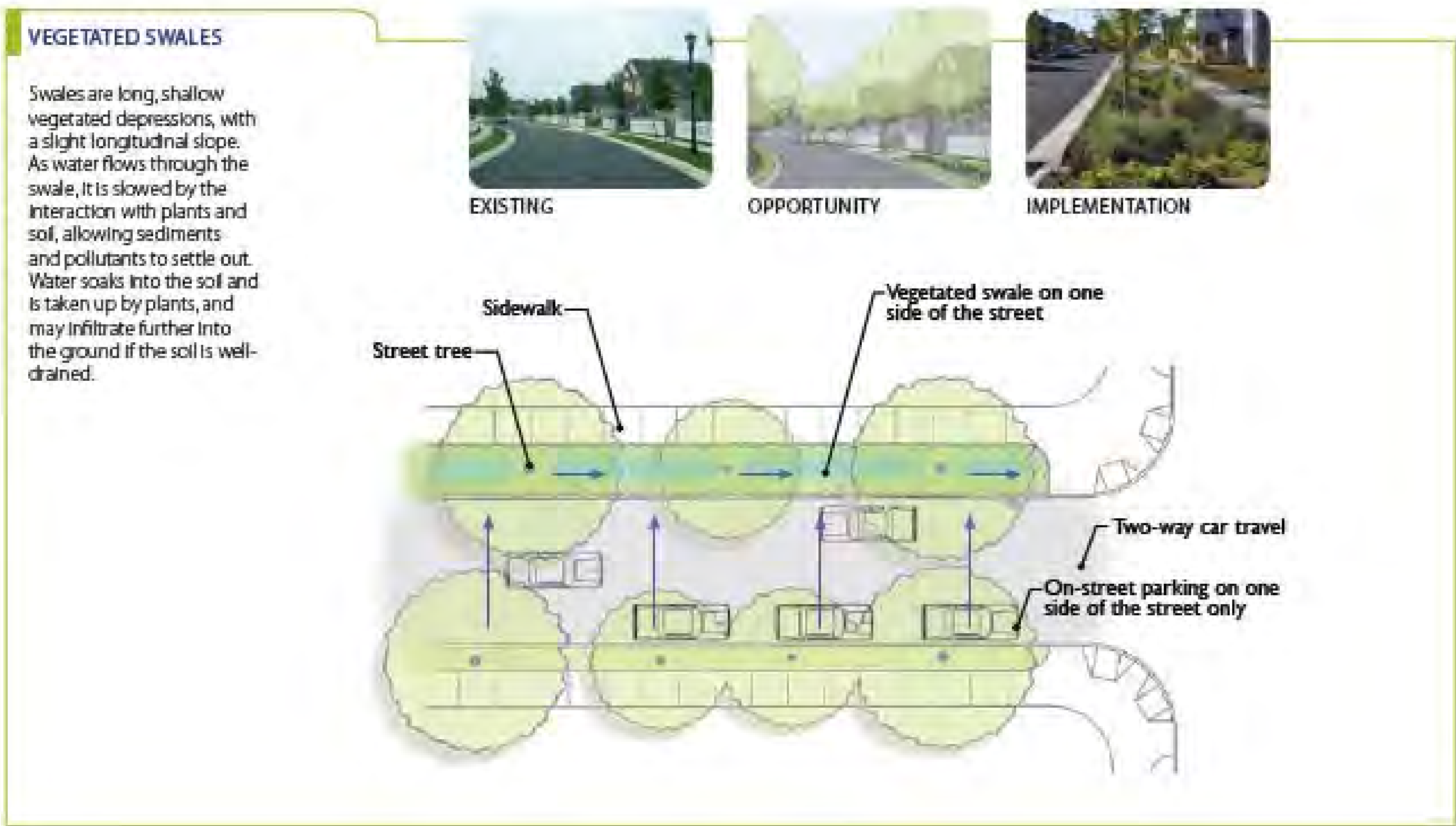

Figure 6-27. Example Application of Vegetated Swales in the Streets of a Residential Neighborhood (Source: EPA's 2008 Managing Wet Weather with Green Infrastructure)

Some roads within the D'Olive Watershed contain medians within which LID/GI measures could be incorporated to mitigate the adverse effects of stormwater runoff. Within the Lake Forest subdivision, the main access road is characterized by an extensive median that follows the length of the entire road. Although this median supports numerous native trees and is landscaped along short portions of its length, it is generally covered with a thin layer of topsoil that has experienced considerable erosion caused by surface runoff and vehicular informal crossovers and parking. Figure 6-28 illustrates the numerous erosion problem areas in the Lake Forest Subdivision road medians. Application of LID/GI techniques would reduce stormwater runoff, minimize the erosion of soils, and improve the aesthetic qualities of the roadway and the subdivision in general.

Commercial streets and parking lots also offer opportunities to integrate stormwater management into even the most active of urban areas. A key to incorporating LID/GI techniques into commercial hard travel and parking surfaces is to find adequate locations that accommodate multiple purposes while not conflicting with the primary objectives of the hard surface travel and parking areas. Figures 6-29, 6-30, and 6-31 illustrate how stormwater planters, stormwater curb extensions, and permeable paving, respectively, have been employed at various commercial developments around the country.

Lastly, LID/GI techniques can also be incorporated into the larger arterial roadways of communities that are often characterized by wide expanses of pavement, little greenery, and little infrastructure to address pedestrian needs. The amount of paved surface that is necessary to safely manage travel must be determined before deciding how much of that surface can be converted to green space. In addition to assisting in reducing stormwater runoff, alternative arterial roadway design approaches may offer opportunities to satisfy other needs, such as bike lanes, permeable side walks, and landscaping to enhance the aesthetic appeal of roadways. Figure 6-32 provides an example of how an arterial street was modified to incorporate vegetated swales and landscaping while also providing a bike lane and side walk to facilitate pedestrian use.

Property owners can also contribute to reducing stormwater runoff velocities from their individual residences by employing GI techniques in the design and construction of driveways serving their homes. For example, existing concrete driveways can be replaced with alternative materials such as pavers or permeable asphalt that are more conducive for handling lighter transportation loads (see Figure 6-33). Figures 6-34 and 6-35, respectively, show examples of the use of pavers and permeable asphalt.

Figure 6-28. Examples of Erosion Problems Affecting the Road Medians of the Lake Forest Subdivision

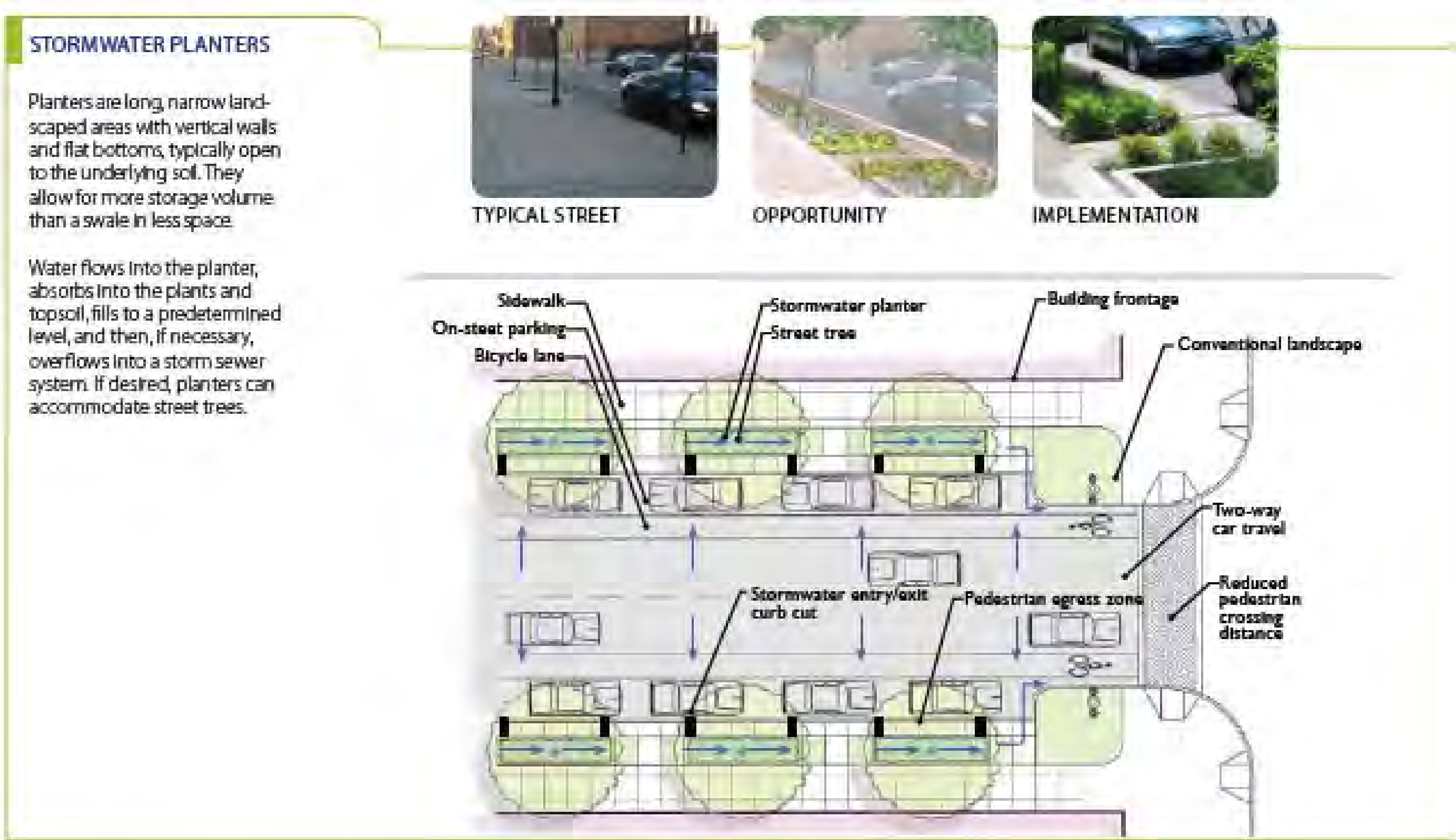

Figure 6-29. Example Application of Stormwater Planters along a Commercial Street (Source: EPA's 2008 Managing Wet Weather with Green Infrastructure)

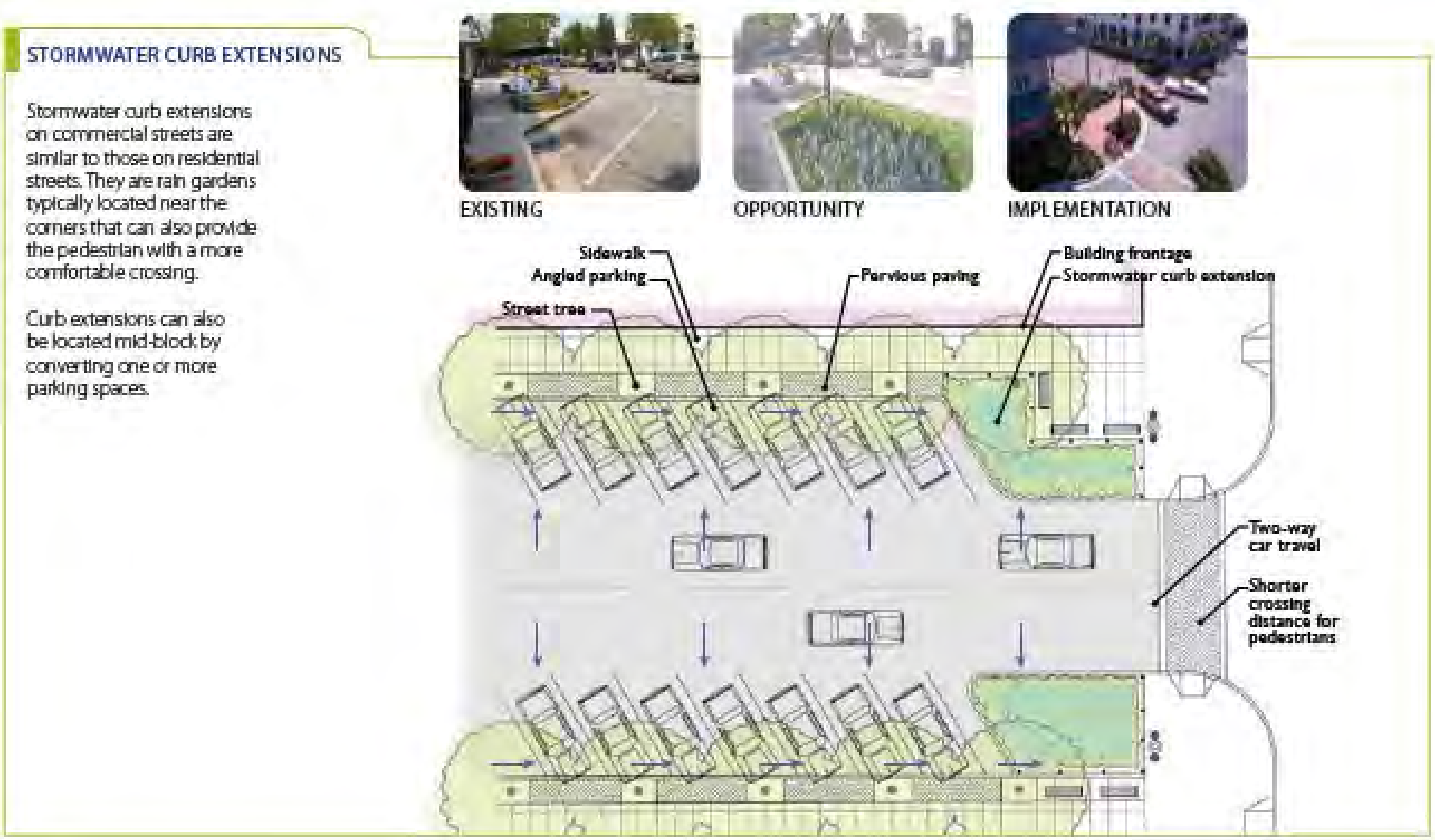

Figure 6-30. Example Application of Stormwater Curb Extensions in a Commercial Parking Lot (Source: EPA's 2008 Managing Wet Weather with Green Infrastructure)

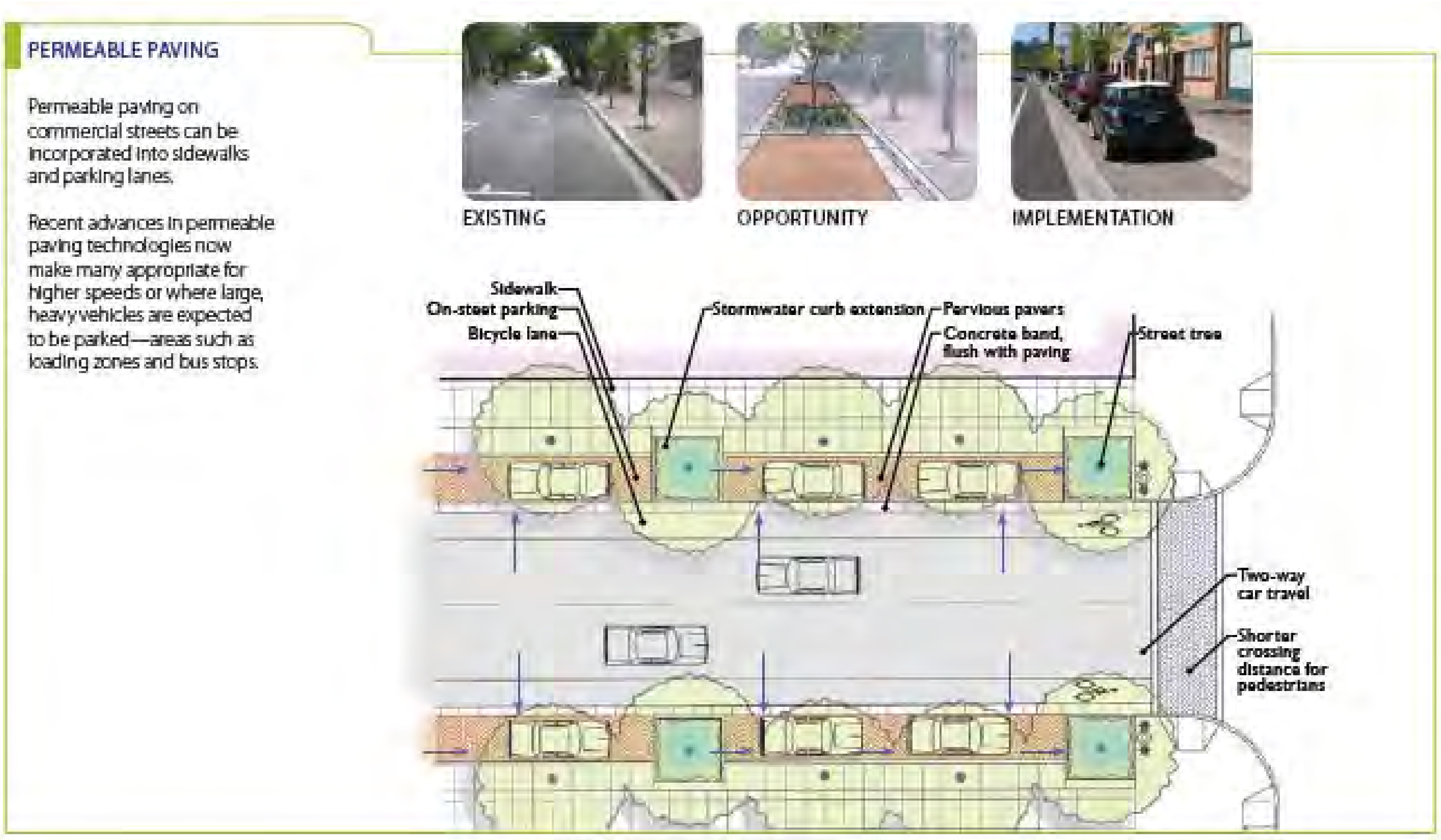

Figure 6-31. Example Application of Permeable Paving along a Commercial Street (Source: EPA's 2008 Managing Wet Weather with Green Infrastructure)

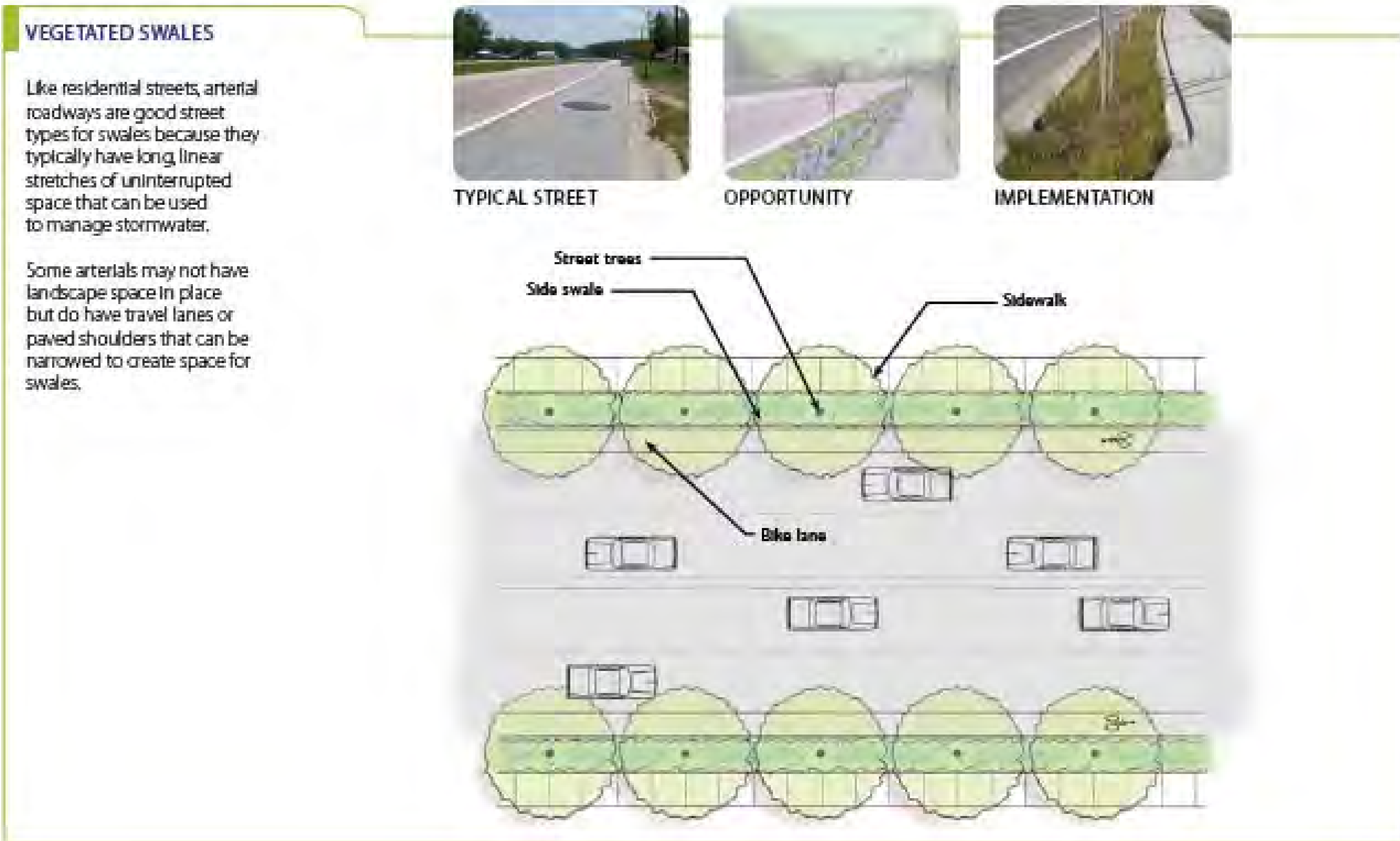

Figure 6-32. Example Application of Vegetated Swales along a Arterial Road
(Source: EPA's 2008 Managing Wet Weather with Green Infrastructure)

Figure 6-33. Driveway being replaced in the Lake Forest Subdivision

Figure 6-34. Example Application of Pavers in a Residential Driveway

Figure 6-35. Installation of Permeable Asphalt use Ground Tire Rubber

6.3.4.3.2 Forest Preservation within Individual Parcels

Too often, residential subdivisions clear all, or most, of the existing trees covering the site. Typically, this action is followed by the planting of ornamental trees and shrubs that provide less coverage than did the native vegetation that formerly covered the site. The net effect is that an important feature in reducing Impervious Cover is lost, while altering the aesthetic characteristics of the development site.

Forests with thick tree canopies and organic matter accumulations on the forest floor are more effective in holding soil in place on steep slopes than are manicured turf grass lawns. Forest preservation practices in new developments can be used to retain stormwater runoff and reduce soil loss concerns within the D'Olive Watershed. However, due to the shading effects and competition for moisture, trees can also reduce grass growth, resulting in denuded soil surfaces within lawns under trees. Where the growth of grass is restricted by shade from tree canopies, soils can be stabilized by planting shade tolerant ground cover and shrubs and/or applying landscape mulches.

6.3.4.3.3 Rainwater Harvesting

Rainwater harvesting involves capturing stormwater runoff and using it in place of a municipal supply. Typically, water is captured from rooftop runoff through gutters and downspouts, through which the stormwater is delivered and stored in either a rain barrel or cistern for later use.

Although rainwater harvesting has been practiced for thousands of years, recent concerns over water supplies and urban stormwater runoff have prompted homeowners, businesses, and municipalities to consider including rainwater harvesting systems. By using harvested rainwater for purposes that do not require treated drinking water (i.e., irrigation or washing cars), the demand/costs on municipal potable water supplies can be reduced, while a portion of the rainfall can be used productively.

A rainwater harvesting system can be used in a wide range of irrigation applications. A simple garden hose attached to a rain barrel or larger cistern can be used to water small trees, shrubs, and gardens surrounding a home or business without any additional equipment. Figure 6-36 shows a typical rain barrel in use.

Figure 6-36. Harvesting Water from a Rain Barrel to Water Plants

6.3.4.3.4 Rain Gardens

When rain falls on natural areas, such as a forest or meadow, the runoff that it produces is slowed down, filtered by soil and plants, and allowed to soak back into the ground. When rain falls on impervious surfaces like rooftops, roads, and parking lots, rain cannot soak into the ground, and stormwater runoff volumes are increased. In urban areas, stormwater runoff picks up pollutants such as fertilizer, pesticides, sediment, motor oil, litter, and pet and yard waste. These contaminants are then delivered via runoff to local streams and rivers.

Individuals who love to garden and landscape around their homes are in fact creating and maintaining rudimentary rain gardens. Improvements can be incorporated into these gardens to enhance their capacity to retain rainfall runoff. Backyard rain gardens are a fun and inexpensive way to improve water quality and enhance the beauty of an individual residence, neighborhood, or business. Rain gardens are placed between stormwater runoff sources (i.e., roofs, driveways, parking lots, etc.) and runoff destinations (i.e., storm drains, streets, streams, etc.).

A rain garden can be a shallow depression (see Figure 6-37) in the earth that fills with a few inches of water after a storm, and the water slowly filters into the ground. A rain garden can intercept and capture runoff from a home driveway or roof and allows it to infiltrate into the soil, rather than running across roads, capturing pollutants, and delivering them to a stream. Plants and soil work together to absorb and filter pollutants, returning cleaner water through groundwater recharge to nearby streams or by evaotranspiring moisture to the atmosphere. Rain gardens can also reduce flooding by encouraging the water to infiltrate into the ground, rather than run off into the street. Further, rain gardens provide habitat for beneficial insects and urban wildlife.

Figure 6-37. Example of Depressional Rain Garden.

Because of the relatively rugged topography of the D'Olive Watershed, it can be difficult to create depressional rain gardens. Nevertheless, heavy ornamental plants, ground cover, and mulch all contribute to reducing stormwater runoff. Figure 6-38 shows one home in the Watershed that has developed an excellent "rain garden." (Note: This may not classify as a rain garden in the strictest sense, but demonstrates how residential horticultural practices can provide a positive influence towards stormwater management objectives.) Figure 6-39 shows another residence constructed on a site having a similar slope that only is covered in grass. Comparison of these two photos shows how a rain garden can positively influence the aesthetics of a home and/or neighborhood, while also benefiting the environment by reducing stormwater runoff.

Figure 6-38. Home with a Rudimentary Rain Garden Incorporated into Front Lawn

Figure 6-39. Home without Rain Garden

6.3.4.3.5 Bioretention Areas

A bioretention area is a stormwater treatment system that is a depression integrated into the landscape (Figure 6-40). Bioretention areas function similarly to rain gardens. Typically, bioretention areas are used in larger commercial projects (i.e., depressed islands of vegetation in parking lots) to accommodate runoff requirements. Bioretention areas can also be incorporated into the common areas of residential developments.

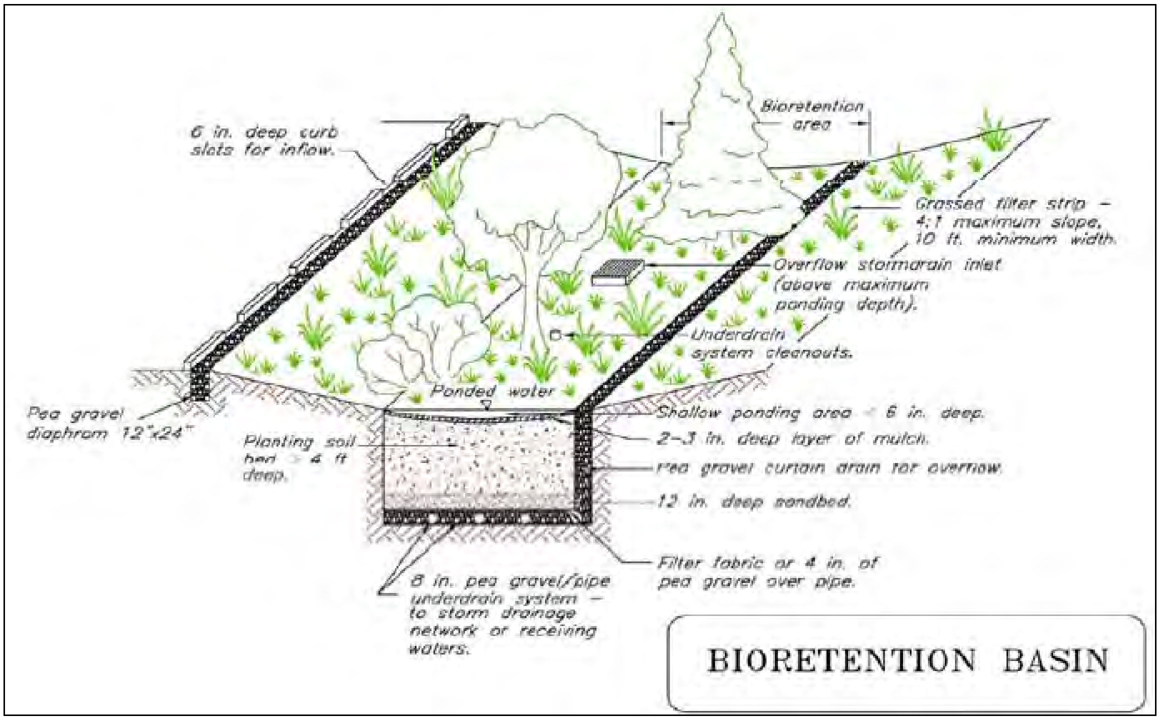

Figure 6-40. Typical Bioretention Area.

A bioretention area captures runoff from an impervious surface and allows that water to infiltrate through the soil media. As the water infiltrates, pollutants are removed from the stormwater runoff through a variety of mechanisms including adsorption, microbial activity, plant uptake, sedimentation, and filtration. Some of the incoming runoff is temporarily held by the soil of the bioretention area and later "leaves" the system by way of evapotranspiration or infiltration into the ground. Besides retaining stormwater runoff, bioretention areas have been found to remove metals, nutrients, sediment, and fecal coliform, provided they are situated, designed, constructed, and maintained appropriately.

Several excellent examples illustrating how bioretention facilities can be included in a redevelopment project are provided in the plans to redesign the existing hard surface parking lot in Jubilee Square in Daphne in the D'Olive Watershed. Figure 6-41 reproduces a selected example design of a portion of the Jubilee Square redevelopment project from a presentation prepared by the designers, Goodwyn, Mills, and Cawood.

Figure 6-41. Example Application of Bioretention Area in Redevelopment Proposal for the Jubilee Square Shopping Center in Daphne.
(Source: Presentation prepared by Goodwyn, Mills, and Cawood)

6.3.4.3.6 Regional Stormwater Facilities

As public and private entities continue to embrace Low-Impact Development (LID) and associated micro-scale onsite facilities such as porous landscape retention, parking lot swales, rain gardens, and others, it is important to recognize that larger, "regional" stormwater management facilities are valuable as well. The multipurpose benefits of regional facilities such as wet ponds, extended detention basins, full-spectrum detention, aboveground sand filter basins, wetlands, and wide major drainage-ways that are natural in appearance and that integrate water-quality and channel stability features are numerous. When combined, LID and regional stormwater facilities can contribute to accomplishing the ultimate goal of restoring a watershed's hydrologic regime by combining stormwater reduction measures. Regional stormwater facilities provide the following benefits:

- Provide much-needed open space in urban areas and integrate nicely into a network of undeveloped major drainage-ways that feature parks, trails, ponds, wetlands, and ample "green space."
- Provide active and passive public recreational opportunities, in a safe manner.
- Create wildlife and aquatic life habitat.
- Increase residential and commercial property values and neighborhood appeal.
- Attenuate peak discharges from new and existing development for a wide range of storms.
- Play an important role in maintaining downstream channel stability.
- Facilitate maintenance and reduce maintenance costs, by storing/treating a comparatively large runoff volume for larger tributary areas into few locations.
- Be utilized by land planners and landscape architects as strategic features in overall community development plans.
- Be integrated into major drainage-way master plans, site drainage plans, and watershed plans.

Experience also shows that with proper planning, design, construction, and assured long-term monitoring and maintenance, the benefits of regional facilities listed above are attainable. Such facilities can be vital components in public and private stormwater management programs.

One challenge to developing regional detention facilities is to find enough storage to make a real difference in detaining/retaining stormwater runoff. As would be expected, costs increase as the size of detention sites increase and the number of such facilities considered are multiplied. To justify such facilities, it is important to be able to clearly document the public benefits that can be gained by investing in such facilities as a component of a comprehensive Watershed-wide stormwater reduction program.

It should be recognized, however, that locating suitable sites for "regional" stormwater facilities becomes much more difficult in already-developed areas because of numerous constraints (landownership, topography, etc.). Therefore incorporation of such facilities into the planning phases of overall watershed stormwater management programs is paramount. Figures 2-24 and 2-26 show the locations of the largest tracts of remaining undeveloped lands that existed within the D'Olive Watershed based on 2005 GIS data. Such areas probably present the most feasible locations at which regional detention facilities could be located in combination with other measures. Major among the engineering considerations that would have to be considered in determining feasible sites is the enormous challenges posed by the Watershed's extremely steep topography and the highly incised stream channels that characterize most of the streams in the Watershed (see Figure 2-5).

Figure 6-42 provides a concept rendering of the Browne Mountain Stormwater Detention Facility constructed by the Spokane County Washington Stormwater Utility. This figure displays how a regional detention facility can be designed in such a manner as to provide aesthetic and recreational benefits while meeting the primary goal of reducing stormwater runoff velocities. Figure 6-43 displays how a similar regional detention facility in Austin, Texas, makes use of wet ponds to detain stormwater runoff from 180 while being incorporated as an attractive feature into the landscape. Figure 6-44 shows a contrasting situation in Griffin, Georgia, where a regional detention facility serving 218 acres was constructed to satisfy only the stormwater detention purpose without regard to aesthetic or recreational considerations. What can be gained from these examples is that a multitude of community objectives can be accomplished simultaneously when considering the value of regional detention facilities to reduce stormwater runoff volumes and velocities.

6.3.4.3.7 Preservation of Green Space

The explosive population growth experienced by the D'Olive Watershed since the 1990s has resulted in many land development decisions being made that have not given equal consideration to the value of preserving strategic green space within the Watershed. This is due in part to cultural attitudes common in the South that often fail to understand the inherent value provided by "neighborhood" green space on a Watershed scale basis. Instead, the general regional abundance of undeveloped lands outside of the Watershed can obscure an appreciation of the intrinsic value of green space areas being intermingled within developed areas.

Green space serves a variety of functions of value to society. First, vegetative growth, particularly that containing varying layers of forest canopy, midstory growth, ground cover, and thick leaf litter, collectively contributes to retaining surface runoff, encouraging infiltration into the ground, minimizing overland erosion, and reducing stream channel erosion problems. Second, islands of green space contribute to the aesthetic qualities of urban environments. Third, green space areas provide urban wildlife habitat that serve as travel corridors connecting larger areas outside of the Watershed. Fourth, green space can meet the demands for low impact recreation activities and provide islands of solitude in urban settings. Lastly, strategically placed green space can increase real estate values as residents and prospective businesses purposefully seek to locate near such areas due to an understanding of the quality of life values that well designed green space can provide.

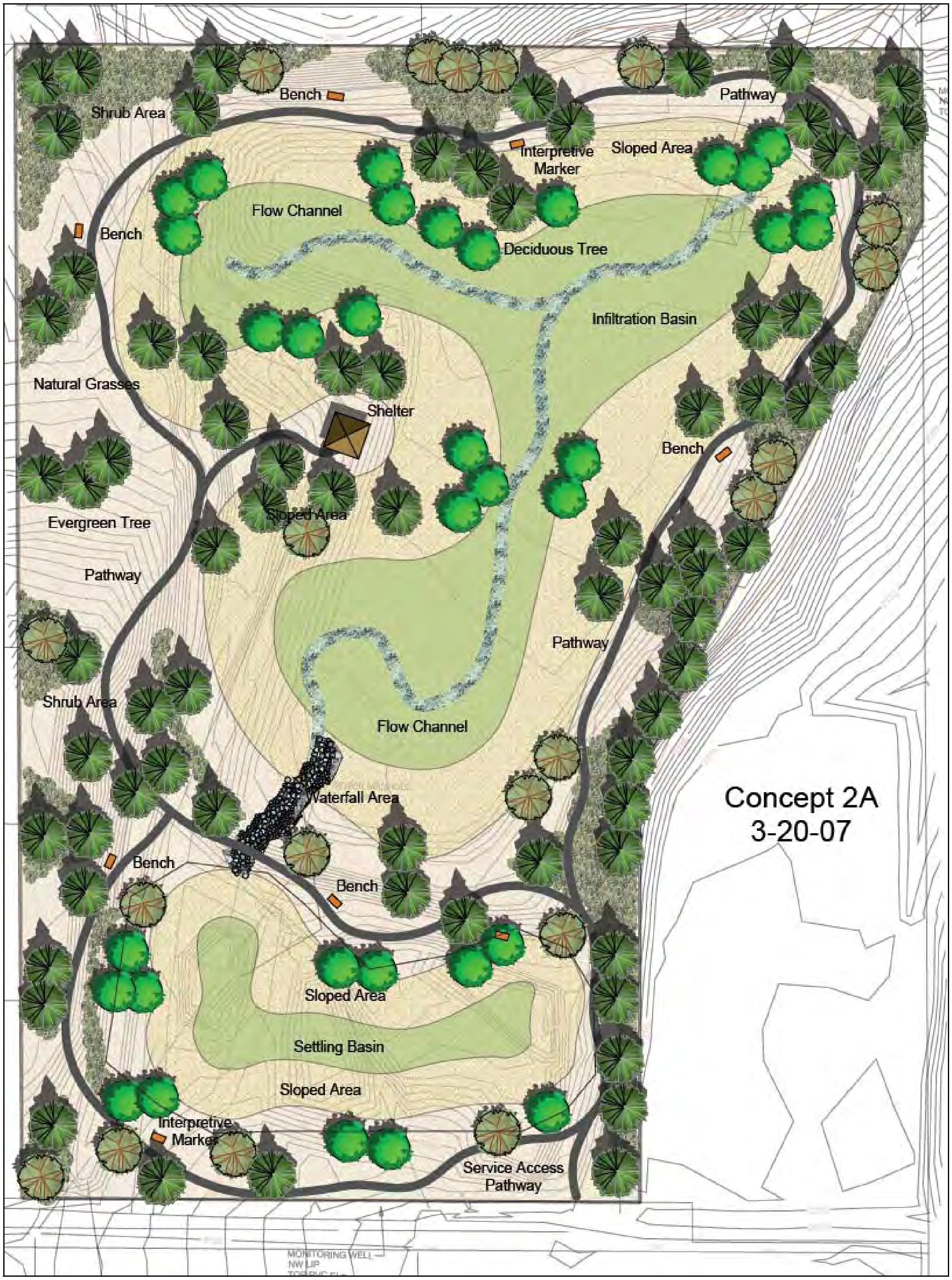

Figure 6-42. Concept Drawing of Retention Facility at Browne Mountain, Washington (source: Spokane County Stormwater Utility in Washington)

Figure 6-43. Regional Detention Facility in Austin, Texas

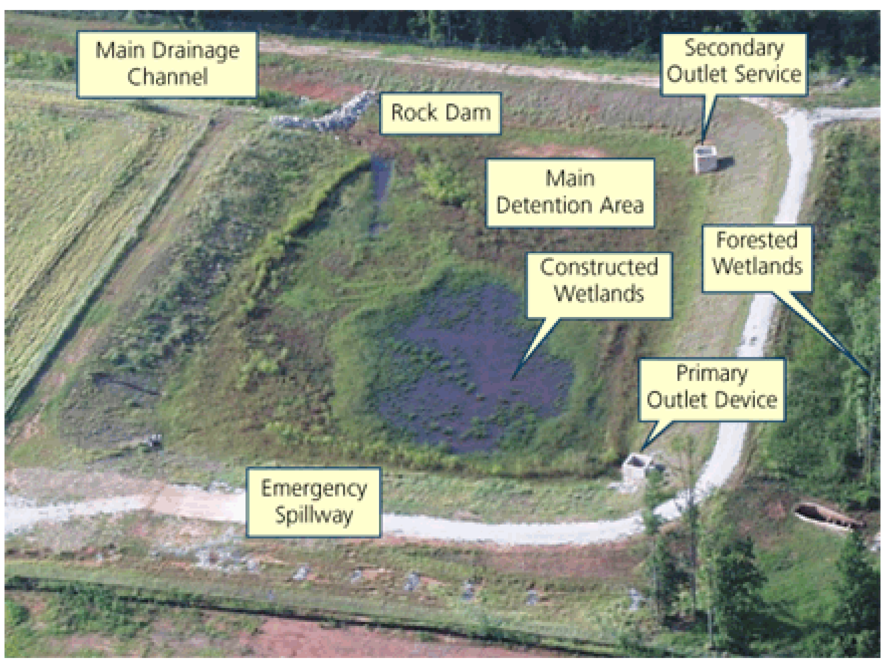

Figure 6-44. North Griffin Regional Detention Facility in Griffin, Georgia

Presently, the largest intentionally designed green space areas within the D'Olive Watershed are associated with the Lake Force and Timber Creek golf courses. In addition, Figure 2-24 shows that within the Lake Forest Lake Subdivision, a combined 204 acres of upland forest still exists within several relatively large parcels. A similar situation, involving a total of 117 acres, occurs within the Timber Creek Subdivision. Of even greater significance, approximately 2,000 acres of upland forest and 500 acres of agricultural lands still exist in relatively large tracts scattered throughout the Watershed as shown in Figure 2-26.

The relative abundance of these large remaining undeveloped tracts within the D'Olive Watershed offers an ideal opportunity for proactive measures to be taken by Watershed interests to preserve the most significant of these areas. A variety of measures may be available to pursue preservation of green space, including fee acquisition, purchase of conservation easements, establishment of tax incentives not to develop certain areas, pursuit of partnerships, enactment of land use ordinances, and construction of regional detention facilities. One workable option to preserve green space would be to pass a land development ordinance that specifies a percentage of the area within all new commercial and residential developments be dedicated to undeveloped uses.

The Baldwin County's Horizon 2025 Plan (see Section 2.13.4.2) has partially addressed the need to preserve green space within the D'Olive Watershed through the identification of conservation district lands. However, the Horizon 2025 Plan is offered as guidance only for consideration by the unincorporated portions of the County, with there being no requirement that the suggested land uses be implemented. Figure 2-29 shows the lands identified for conservation purposes that are associated with the principal Watershed streams. However, a similar designation does not exist for the contiguous stream segments located within the Cities of Daphne and Spanish Fort. Thus, no D'Olive Watershed-wide green space preservation plan has been developed to date that has the power and funding to be successfully implemented.

The recent history of rapid growth within the D'Olive Watershed indicates a relatively narrow window may exist going forward to develop and implement decisions to preserve designated green space. A major assumption inherent in this WMP is that 100% "build-out" of the Watershed's developable lands could occur by the end of the 10-year period (i.e. by 2020) addressed by this Plan. Thus, over that 10-year period, as new residential and commercial projects consume increasing quantities of the presently undeveloped lands, the economic value of the remaining tracts will increase making it more expensive and difficult in the future to remove these lands from the real estate market. Therefore, the opportunity to successfully preserve remaining green space in the D'Olive Watershed will be time sensitive. The ultimate success of such efforts will depend in large part upon gaining community-wide understanding of the importance of and support for the preservation of green space within the Watershed.

The following management measures could be considered to preserve green space within the D'Olive Watershed:

- Develop a Watershed-wide public education program that transcends municipal and unincorporated boundaries explaining the importance of and value to the community of preserving green space.

- The Cities of Daphne and Spanish Fort and Baldwin County should consider preparing a "green space preservation plan" for the D'Olive Watershed that would identify the most significant tracts for preservation, establish a priority of implementation, and a strategy to fund and implement the preservation plan.

- A land development ordinance could be considered that would require future residential and commercial developments to set aside a specific percentage of the proposed development parcel to green space uses.

6.3.4.3.8 Preserve/Restore Riparian Buffers

A subset of management measure to preserve green space involves the reservation/restoration of riparian buffer lands that are associated with stream corridors within the D'Olive Watershed. Figure 2-5 demonstrates the extreme topographic relief characterizing the D'Olive Watershed which results in most of the main stem streams, their principal tributaries, and the associated ephemeral drainages being confined within steep ravines. Figure 2-10 further emphasizes the limited extent of the floodplains within the Watershed. As a result of these conditions, riparian habitats are represented by relatively narrow bands of vegetation flanking the stream courses. The narrow strips of riparian vegetation serve as a buffer between upland areas and streams and wetlands, trapping sediments and slowing stormwater runoff draining into Watershed streams.

Portions of the riparian habitat within existing subdivisions have been cleared to the margin of streambanks. However, large segments of riparian buffer still remain intact. For example, streams draining the Timber Creek Subdivision are flanked by much of the original riparian vegetation, albeit portions of that habitat have been affected by sediments originating from construction activities in the subdivision. In addition, portions of the approximately 2,000 acres of forest tracts that have not yet been developed (see Figure 2-26) contain riparian buffers flanking the Watershed streams traversing those parcels.

The Baldwin County Horizon 2025 Plan designates the riparian lands located along each of the major stream segments in the D'Olive Watershed to be Conservation District lands (see Figure 2-29). These lands are intended to serve as greenways and wildlife travel corridors having a minimum width of 400 feet. A total of 230 acres of the County's 1,613 acres in the Watershed are designated Conservation District lands. While this designation represents a positive action, it is provided as guidance only with no real requirement that the designated lands be preserved as the parcels containing these areas are developed in the future.

The following measures could be undertaken to preserve and restore riparian buffer areas.

- For consistency purposes, the Cities of Daphne and Spanish Fort could consider developing a riparian buffer protection designation mirroring the Baldwin County's

Horizon 2025 Plan. The buffer should be applied to continue, where possible, the "conservation district" like designation to the riparian habitat of the same streams flowing through the municipalities.

- Criteria for future residential and commercial developments should be implemented requiring a minimum width buffer to protect riparian habitat. That criteria should also require disturbed riparian habitat be restored.

- A public education program should be developed to explain to individual property owners the importance of maintaining a riparian buffer between Watershed streams and the developed portion of their properties. This effort could identify actions property owners could take to restore damaged riparian habitat on their property.

6.3.4.3.9 Alternative Vegetation Management

This WMP has consistently pointed out that topography, rainfall, soil characteristics and land cover are the four principal factors influencing erosion from stormwater runoff. Of these land cover is the one factor that is almost completely within man's control to influence.

Of the varied land cover types that can characterize land areas, vegetation has the most positive effect in reducing stormwater runoff velocities. Depending upon the type, density, and quality of vegetative cover, overland runoff volumes from D'Olive Watershed lands can be slowed to varying degrees, with natural forest conditions contributing to the infiltration of rainfall into the ground.

Figure 2-22 shows the land use/land cover that existed (based on 2005 data) in the D'Olive Watershed at the time the WMP was prepared. Based upon present zoning ordinance maps and projected population growth rates, Figures 2-27 and 2-28 portray the essential 100% "build-out" condition that could characterize the Watershed by the end of the 10-year period (i.e. 2020) addressed by the WMP. Varying amounts of vegetative cover will be associated with the different land use conditions. The manner in which that vegetation is managed will have a major influence on stormwater runoff volumes. The following discussion addresses alternative vegetation management practices that could be pursued to reduce surface runoff.

Golf Courses. Two golf courses are located within the D'Olive Watershed, both of which are associated with existing subdivisions. The fairways of both courses are intimately associated with their surrounding residential subdivisions. The two courses cover a collective total of 358 acres which represents less than 5% of the Watershed's total surface area.

The Lake Forest Golf Course is the oldest of the two courses, being built in the early 1970s at the time the Lake Forest Subdivision was originally developed. The Lake Forest facility consists of a driving range, a 9-hole course, and an 18-hole course. Over 117 acres are contained with the Lake Forest Golf Course property. The course is owned and operated by the Lake Forest Property Owners Association.

The Timber Creek Golf Course was constructed in the 1990s, at the time the Timber Creek Golf Subdivision was developed. The golf operation consists of a driving range and a 27-hole course that is divided into three separate increments that are named: Magnolia, Dogwood, and Pines. A total of 241 acres are included with the Timber Creek golf course operation. The Timber Creek course is privately owned and is not directly associated within the subdivision.

There are considerable differences between the two courses. The Lake Forest Golf Course is located within the portion of the D'Olive Watershed having the greatest relief. Elevations rise rapidly from around 20 feet mean sea level (MSL) bordering Lake Forest Lake to almost 150 feet MSL. The course is primarily located within Subwatershed 0 and a small portion of Subwatershed 1. This area is area is highly dissected. Numerous ravines and very steep slopes characterize the golf course layout. Since the course includes some of the lowest elevation areas within the Watershed, outcrops of the more erodible Miocene sediments can be found at certain locations (see Section 2.10.1). Examination of Figure 2-16 shows that the course is largely located within the portion of the Watershed having the highest Erosion Hazard Areas as shown in Figure 2.16. Over the years, erosion has taken its toll on the golf course lands, leaving a very thin veneer of topsoil that is easily carried away by stormwater runoff in sparsely vegetated areas.

Management of stormwater runoff poses a continuous problem for the Lake Forest Golf Course. Most of the runoff problems actually result from the neighboring upslope residential areas that border the golf course and subdivision roads that characteristically lack a well-designed stormwater collection and drainage system. As a result, the golf course receives uncontrolled runoff that tends to concentrate and follow natural topographic features that cross the various fairways. The closely-cropped grass covering of the fairways contribute to further speeding the runoff to downslope areas off the course where numerous areas of erosion occur along the fairway margins due to head-cutting effects as the runoff exits the course.

The Lake Forest Golf Course is approaching 40 years of age. Over that time, the course has lost many of the native trees that originally bordered the course and served to provide separation between the fairways (see Figure 6-45). Most of the trees that remain are dominated by pines that are of about the same age (i.e. 40 to 50 years). Over the 10-year period addressed by this WMP, additional trees will undoubtedly be lost to age, disease, wind, and lightening strikes. To compensate for the lost trees, mowing of the non-play areas has increased over time to create an open park-like condition among the trees. As the tree canopy has thinned, little understory has been allowed to develop and replacement trees have not been planted. Over the years, the leaf litter has been gradually lost. The absence of a full tree canopy allows falling raindrops to hit the ground at full force and the lack of a thick ground cover fails to slow runoff across the course fairways, eroding away the already thin topsoil.

Figure 6-45. Example of Aged Remnant Forest at Lake Forest Golf Course Separating Fairways showing Absence of Understory and Bare Soils

The Timber Creek Golf Course is located within the higher elevation headwater areas of Subwatershed 3 along D'Olive Creek. Elevations range from around 150 feet to 180 feet within the course. Generally, slopes are less steep within the Timber Creek course compared to the Lake Forest course. Due to its relative young age, soil conditions appear to be adequate to support a healthy coverage of grass, and the flanking residual forest areas are characterized by trees of various ages that combine to produce a dense canopy (see Figure 6-46).

The Timber Creek Golf Course does not appear to experience the same degree of stormwater problems that are affecting the Lake Forest course. This is due in part to more gentle topographic conditions and to an extensive internal runoff collection and drainage system that was designed within each of the fairways. In addition, the Timber Creek Subdivision road network also contains a curb and gutter system that collects a large amount of the subdivision runoff which prevents stormwater runoff from running across the fairways. Additional investigations are required to assess the conditions below each of the drainage outlets exiting the course to determine if the stormwater discharges are creating any problems below the outlets.

On December 26, 2008, the owner (i.e., Timber Creek Investments, LLC) of the Timber Creek Golf Course entered into a Conservation Easement with the North American Land Trust for 144.2 acres that included two of the three 9-hole golf course segments (i.e.

Figure 6-46. Example of Younger Forest Remnants with Understory at Timber Creek Golf Course Separating Fairways

Dogwood and Pines). In addition to the golf course fairways, the easement states that the Conservation Area contains the drainages that empty into the main stem of D'Olive Creek. Additional development is precluded within the Conservation Area. While golf and other outdoor recreation activities are permitted, the stated intent of the Conservation Easement is to preserve the water courses, wetlands, riparian, and other habitats in the condition that existed when the Conservation Area was consummated. In addition, all future activities within the Conservation Area shall be conducted so as to avoid the occurrence of soil erosion and sedimentation in streams or other water courses.

Site inspections conducted during the course of work on this WMP, resulted in the following management measures that could be pursued to address stormwater runoff issues.

- A reforestation program should be implemented at selected locations on the Lake Forest Golf Course to promote the establishment of replacement forest and a future healthy leaf litter layer. Not only would this measure contribute to reducing the physical impact of falling raindrops, but could also enhance the long-term aesthetic appeal of the golf course.

- As discussed above, many of the surface runoff problems experienced by the golf courses are actually caused by stormwater runoff that originates from neighboring upslope residential properties. Many of the residences that border the golf course fairways have elected to keep their lawns in a cleared and grassed condition all the way to golf course fairway boundary. Figure 6-47 illustrates this condition in which stormwater runoff has contributed to the removal of topsoil to expose the more erodible subsoils. Figure 6-48 provides a contrasting situation in which this home owner has elected to maintain a jasmine ground cover as a landscape separation from the golf course. This approach maintains the viewshed of the golf course while providing a vegetative covering that effectively slows stormwater runoff. The Lake Forest and Timber Creek property owners associations could initiate an education program explaining the positive benefits that could be gained by each homeowner implementing landscaping features designed to slow runoff to and from the golf course fairways. This program should emphasize the positive effects that could be accrued to the individual lots in terms of aesthetics and property values without having to give up the ability to maintain the desired views of the golf course.

- Eliminate mowing of "no play" boundary areas and reduce the frequency of mowing within those portions of the "in play" areas of the fairways into which golf balls are seldom hit (i.e., areas behind the tees and past the greens; a specified distance down the fairway from the tees; and the connecting areas between the fairways. Figure 6-49 shows the effects of frequent mowing in one area connecting two of the Lake Forest fairways. This is compared to the condition shown in Figure 6-50 that can be provided by not mowing connecting areas between fairways on the same course. In addition to reducing stormwater runoff volumes, reduced mowing can result in annual operation and maintenance costs by reducing fuel consumption and labor expenses. However, since most golfers prefer "clean cut" courses, to successfully implement this measure, it will be necessary for the property owners associations and golf courses to conduct a sustained public education program to make sure golfers and adjacent property owners understand the basis for the change in mowing practices.

- Berms should be constructed at strategic locations where stormwater runoff either carries eroded sediments onto the courses or the volume of flow is so concentrated that the fairways can be eroded (see Figure 6-51). The berms could aid in slowing the velocity of runoff water while not adversely play on the course. Related actions should also be pursued to correct head-cutting problems at downslope locations where the runoff exits the golf course margins. Figure 6-52 provides an example of one such erosion problem where sediments are being eroded by head-cutting, posing localized damage to the golf course while contributing sediments to Watershed streams.

- Perform a detailed inventory of all drainage outlets serving the golf course properties to assure that stormwater runoff volumes and velocities are not contributing to downstream erosion and/or sediment accumulations as the stormwater runoff exits the golf courses. If problems are identified, the problems should be prioritized and appropriate measures developed and implemented to correct the problems.

Figure 6-47. Home without Landscape Vegetation Separating Lawn from Golf Course

Figure 6-48. Example of Landscape Vegetation to Separate Lawn from Golf Course

Figure 6-49. Frequent Mowing Practices Reduce Height of Grass in "No Play" Areas

Figure 6-50. Example of the Grass Height that Can be Attained in "No Play" Areas by Reduced Mowing

Figure 6-51. Example of Stormwater Runoff and Sedimentation across the Driving Range

Figure 6-52. Example of Downslope Head-cutting Erosion from Stormwater Runoff Across Golf Course Fairway

Highway Right-of-Ways. Due to the highly developed nature of the D'Olive Watershed, roads are by necessity a major land use. Additional road networks will be constructed in the future to provide access into the presently undeveloped 2,500 acres of large forest tracts and agricultural parcels as these areas are converted to zoned residential uses.

Although a relatively small portion of the D'Olive Watershed lands is typically associated with roads, these lands can have a significant impact on post-construction runoff volumes and velocities. For example, the I-10 corridor only contains 248 acres, representing 3.2% percent of the entire Watershed area. Runoff from I-10's relatively small acreage can produce localized adverse effects because of the concentrated volumes that can be produced and the discharge volumes that can exceed the natural volumes that some small tributary drainages have evolved to accommodate.

Road surfaces and their associated right-of-ways accelerate stormwater runoff and contribute to the percentage of Impervious Cover within the D'Olive Watershed (see Tables 2-11 and 3-1). Another factor affecting stormwater runoff is the design and construction of roads that can require modifications of local topographic conditions which serve to concentrate and funnel runoff through artificial ditches. This results in larger volumes of runoff being discharged into Watershed streams than occurred under pre-development conditions.

Generally, smaller subdivision and municipal roadways have limited right-of-ways as they pass through crowded neighborhoods and business areas. On the other hand, the larger, particularly multi-lane, national, state, and county roads usually are flanked by wider cleared right-of-ways to comply with established safety criteria and to accommodate potential future roadway expansions. Section 2.13.1 identifies the six major highways that serve the D'Olive Watershed and Figure 2-19 shows their respective locations within the Watershed.

Of these six principal highways, four (I-10, US 90, State Road 181, and County Road 13) have relatively wide right-of-ways. The right-of-ways are traditionally maintained in a cleared condition, with the grassed surfaces being regularly cut for maintenance and aesthetic considerations.

A number of management measures could be pursued to modify vegetation management practices and related maintenance practices that cumulatively could contribute to lessening post-construction runoff volumes and velocities from the larger highways in the Watershed.

- Reduce height of cut and/or frequency of mowing of cleared right-of-ways in order to maintain higher grassed conditions to slow runoff volumes. Explore the use of specific herbicides to slow the growth rate of grasses instead of killing the plants as an aid to reducing mowing. Due to longstanding cultural attitudes, many local interests perceived well manicured right-of-ways to be more aesthetically pleasing than higher grassed conditions. Explanatory signage and public education programs should be pursued to explain the positive environmental benefits that can accrue from reducing the amount of mowing of right-of-ways.

- Eliminate mowing altogether on steep slopes exceeding 1:2 to avoid disturbing the vegetative cover and exposing the underlying soils to erosive runoff. The Alabama Department of Transportation (ALDOT) is already considering such a policy for that section of I-10 within the D'Olive Watershed.

- Allow trees and shrubs to reclaim a portion of the right-of-ways, particularly on the steeper slopes, that do no conflict with established safety criteria. The increased tree canopy cover would intercept falling rain before it hits the ground which should contribute to reducing the erosive force associated the initial impact of raindrops.

- Presently I-10 has two interchanges within the D'Olive Watershed: US 98 and State Road 181. Presently, maintenance of the interchanges is performed by the Cities of Spanish Fort and Daphne, respectively, under agreements with ALDOT. Under these agreements, the interchanges are maintained in a grassed condition that is regularly mowed. Selective planting of trees, ornamental shrubs, or other vegetation could materially reduce runoff from these locations while contributing to the aesthetic appeal of the interchange locations. These plantings could be accomplished in a strategic manner so as not to interfere with required safety site lines for merging traffic. A planting plan could be developed to accomplish a variety of simultaneous objectives. A third interchange is planned to be constructed in 2011 for the new County Road 13 crossing. The site design for the new interchange could easily be modified to retain selected native vegetation and/or incorporate landscape plants.

- Opportunities also exist within the interchanges' drainage features to incorporate small bioretention features that could serve to retain a portion of stormwater runoff velocities while improving the visual appearance of the interchange locations.

- The existing collection/drainage ditches of most of the large highways are lined with concrete as shown in Figure 6-53. Use of concrete is a traditional design practice to reduce erosion of ditches. However, experience over time has shown that shifting soil, mowing, and erosion can cause concrete linings to deteriorate as shown in Figure 6-54. The Alabama Department of Transportation has already implemented a maintenance program on I-65 where the concrete linings of the drainage ditches are being replaced with more flexible rock. Use of rock has the advantage of being able to adjust with shifting changes in the land surface, while slowing runoff velocities because of the added friction and allowing some of the runoff to infiltrated into the ground. The Alabama Department of Transportation should be encouraged to replace the existing concrete ditch linings with rock.

- Explore with the Alabama Department of Transportation and the Baldwin County Highway Department the possibility of developing a "Demonstration Project(s)" that would incorporate the above identified management measures.

Figure 6-53. Existing Concrete-Line Drainage Ditch Along I-10

Figure 6-54. Example of Erosion Caused Damage

Utility Right-of-Ways. The major right-of-ways are primarily associated with Riviera Utilities and Alabama Power Company transmission lines. The 2005 Baldwin County GIS indicates approximately 70 acres of the D'Olive Watershed are contained in utility right-of-ways, representing >1% of the overall Watershed area. The contribution of eroded sediments eroded from the utility right-of-ways exceeds the relatively small proportion of the Watershed making up these areas. The right-of-ways follow straight line paths that traverse the Watershed terrain, navigating both gentle and steep slopes, crossing the numerous tributary streams, and passing through urban areas and undeveloped parcels alike.

Two physical features are common to the right-of-ways. First, vegetative cover is maintained at a low height to avoid potential problems with the overhead power lines. This is accomplished through periodic bushhogging or through the application of chemical herbicides. Second, for maintenance and inspection purposes, an unimproved, dirt access road follows the path of each right-of-way. The roads follow the steep slopes, stopping only at the stream crossings. The exposure of the roads to the relatively steep slopes and their unarmored surfaces exposes them to erosion. Figure 6-55 illustrates the condition of the right-of-ways showing their susceptibility to erosion.

Figure 6-55. Typical Erosion Associated with Power Line Right-of-Ways

Since the power line right-of-ways cross many of the Watershed's roads, they are easily accessed by ATV and four-wheel drive vehicles that purposely seek the unimproved utility alignments for off road recreational uses (see Figure 6-56). The off road activities damage the utility roads which further contributes to increased rutting and erosion of the unimproved surfaces and the delivery of eroded soils to Watershed streams. The City of Daphne is considering an "off road" ordinance that would make unauthorized activities illegal, with a monetary fine being imposed for violations.

Figure 6-56. ATV Activity on Utility Right-of-Way.

The following management measures are offered for consideration.

- The City of Daphne should pass the considered "off road" ordinance. The City of Spanish Fort and Baldwin County should pass similar ordinances to address the utility right-of-ways within their respective areas of jurisdictional responsibility. One passed, enforcement actions should be consistent, with conviction of violators being publicized to deter others from similar actions.

- The utility companies responsible for operation and maintenance of the right-of-ways should be encouraged to install signs at each of the road crossings clearly stating that off road activities are illegal. For the greatest problem areas, consideration should be given to installing gates that cannot be passed by ATVs.

- The utility companies should be required to more aggressively manage stormwater runoff and remediate the erosion problems affecting the unimproved access roads in order to prevent sediments being delivered to Watershed streams. This could include construction of berms to slow runoff.

- Where right-of-ways cross Watershed streams, proactive measures should be taken to prevent erosion of the streambanks.

- Governmental representatives should conduct a joint annual inspection of the right-of-ways each year to monitor the state of the roads and to determine if additional corrective actions are appropriate.

Public Lands. Several parcels of public lands are included among the much more numerous tracts of privately owned lands within the D'Olive Watershed. The largest of the public parcels are associated with Daphne High School, Daphne Middle School, Daphne Elementary School, Daphne's Trione Park Sports Complex, and Spanish Fort's Spirit Park.

These public parcels contain various combinations of large buildings, parking lots, ball fields, related facilities, and undeveloped lands. Traditionally, much of the undeveloped lands that are not used for a specific purpose are maintained in a closely mowed condition. Opportunities exist to explore alternative vegetative cover management strategies and other actions with the goal of retaining larger quantities of stormwater runoff on site. Section 6.3 provides an example management approach that could be followed on the largest public parcel on which Daphne Middle School, Daphne Elementary School, and the Trione Park Sports Complex are located.

6.3.4.3.10 Soils Management

Table 2-11 shows that around 680 acres of agricultural lands were located in the D'Olive Watershed in 2005 based on the Baldwin County GIS. Most of the agricultural lands are located in the southeastern portion of the Watershed (see Figure 2-23). Agricultural lands consume precipitation by infiltration, and have much lower stormwater runoff volumes than developed urbanized areas with impervious surfaces.

The post-construction BMPs addressed in other sections of this WMP are likely to be universally applicable to the various upland superficial soils found in the Watershed. However, areas located on the Citronelle Formation are expected to have reduced infiltration rates and retention BMPs will not function as effectively. Depending on the thickness of the Citronelle Formation, infiltration could be increased with engineering practices such as infiltration ditches.

These soils are flat and are considered prime agricultural lands. No till agricultural practices should be included in the farm plans for these lands. Conversation tillage will increase infiltration of precipitation and reduce erosion. Farmers should be encouraged to leave a vegetative filter strip or zone around their row crop areas. This will intercept nutrients, pesticides and sediment before these pollutants are transported into agricultural drainage improvements that drain to streams. If farmers can be encouraged to continue to operate on prime agricultural lands with conservation tillage practices in the Watershed, it will greatly reduce the potential increase in runoff that occurs with ultimate urbanization.

6.4 Case Study: Trione Park-Schools Complex

6.4.1 Introduction

This WMP has consistently emphasized that Land Use/Land Cover (LU/LC) has a major influence on surface runoff within the D'Olive Watershed. Again, of the four principal variables that influence runoff and erosion/sedimentation (i.e., soil characteristics, topographic relief, rainfall, and land cover), land cover is the one variable that man has almost complete control over. It is also the variable that man is responsible for modifying.

Application of Green Infrastructure/Low Impact Development (GI/LID) techniques can beneficially influence land cover to encourage rainfall to be retained at or near the site at which it falls. This in turn reduces surface runoff volumes. The potential to apply GI/LID techniques depends upon a number of factors. Important among these factors are the compatibility of alternative land cover types with desired land uses; appropriateness of terrain; anticipated runoff volumes; and the desires and capabilities of the landowner to support implementation of alternative land cover types.

This section summarizes the results of a case study approach to apply GI/LID techniques and related measures aimed at reducing stormwater runoff from a sizable parcel of land within the D'Olive Watershed, while not impeding its existing uses and contributing at the same time to the overall aesthetic appeal of the parcel.

6.4.2 Site Description

The Trione Park-Schools Complex in the southern portion of the D'Olive Watershed provides an excellent case study illustration to demonstrate how to apply various management measures on a relatively large tract of land can conceptually reduce stormwater runoff and accomplish other positive objectives as well. The land cover options and stormwater management alternatives considered are believed to be compatible with the current uses being made of the site, and in fact could actually improve the site's overall aesthetic appeal. The exact contribution of the considered measures to reduce stormwater runoff could be determined through hydrologic/hydraulic modeling.

The Trione Park-Schools Complex is located largely within Subwatershed 9 (see Figure 2-2). The overall parcel is divided by Tributary TCC which flows from the southeast to the northwest through the site. An aerial photograph of the site is included in Figure 6-57. The site is bounded on the east by County Road 13, the north by Whispering Pines Road, the west by a forested tract, and the south by Well Road and the Daphne Public Works Department's

Figure 6-57. Trione Park and Daphne Elementary and Middle Schools Complex in the City of Daphne

trash recycling facility. In total, the site consists of approximately 140 acres owned by the Baldwin County Board of Education as a designated 16th Section parcel.

Three prominent facilities are located on the site. The lands on the east side of Tributary TCC contain the Daphne Middle School which was constructed in 1990s and the Daphne Elementary School, the construction of which was completed at some time after 2000. These two schools can be seen in Figure 6-57 which clearly shows the considerable amount of Impervious Cover associated with the building roofs and hard surface parking areas.

The City of Daphne entered into a lease in 1995 from the Board of Education for the land on the west side of Tributary TCC. The lands of direct interest in this evaluation are used for recreational purposes. The Trione Sports Complex was established and a cloverleaf of four baseball/softball fields and a hard surface parking lot was constructed shortly after the lease was signed (see Figure 6-57). The City subsequently developed a plan to add soccer/football fields and associated parking areas in a three-phased development (see Figure 6-33) to be

Figure 6-58. Proposed Phased Development of the Trione Park

better able to satisfy anticipated future recreation demands as Daphne continued to grow. Phases II and III improvements shown in Figure 6-58 are targeted to occur over the next 30 years, pending future recreation demands. The entire park is a popular recreation facility for the residents of Daphne and receives considerable use on a daily basis, particularly individuals that utilize the "dog park" within the site.

The 140-acre site is located within the headwaters of the Tiawasee Creek drainage on relatively flat terrain. Because of its generally flat nature, the entire tract was used for row crop agriculture prior to its conversion to school and recreational uses. It is believed that Tributary TCC is not a natural channel and was excavated to speed drainage of the site and the area farther to the south. Overall drainage is toward the north where it is collected by Tributary TC which in turn flows into Tiawasee Creek. Most of the site that is not included in buildings, parking lots, and recreation facilities is mowed on a regular basis to keep the grass closely cropped. Frequent mowing encourages rapid runoff of rainfall which in turns exacerbates downstream channel instability and sediment transport problems in Tributary TC and Tiawasee Creek that are currently experiencing active head-cutting (see Figure 4-1). The only wetlands presently occurring on the site are restricted to the narrow fringe of riparian habitat immediately adjacent to Tributary TCC and the below described "mini-forest."

A large Grady pond (see Section 2.8.2) exists adjacent to the Daphne Middle School. This pond can be easily seen on Figure 6-59 as the circular body of water labeled "Enhanced Wetlands". This natural geologic and wetland feature captures runoff received from its small surrounding drainage, as well as stormwater delivered by a series of ditches that were included in the site design for the schools. During the 1990s, a science teacher at the Daphne Middle School initiated an effort to restore the wetlands within the pond that had been degraded by historic drainage activities. A sign still exists today announcing the presence of the "Wetlands Restoration Project" (see Figure 6-59). With the assistance of the U.S. Fish and Wildlife Service, a small water control structure was installed several years ago at the point where the Grady pond drains into Tributary TCC. The water control structure has been damaged in recent years and is not completely functioning as intended. Examination of Figure 6-59 shows a sizable area of planted trees immediately to the south and west of the Grady pond. Many of these trees were planted in the 1990s to create a "mini forest" on former farmland in connection with efforts to restore the Grady pond wetlands.

The site design for the two schools included a series of graded depressions and connecting ditches to intercept rainfall runoff and divert it toward the Grady pond. The most prominent of these ditches are located along the eastern side of the schools near County Road 13. These ditches are interconnected by a series of concrete culverts through which water is eventually drained toward the Grady pond.

A detention pond was included in the construction of the Daphne Elementary School. The existing detention pond is shown on Figure 6-59. Limited observations of the parcel indicate this detention pond captures more than just the local runoff generated by the school property. The east-west ditch that parallels the entrance road immediately to the south of the school appears to receive drainage from lands to the east of County Road 13. If this is true, the effect of this additional drainage area and its associated runoff volumes appears to overwhelm the detention capabilities of this facility. The overflow spillway separating the detention pond from Tributary TCC is set at a low elevation and appears to allow drainage from the tributary to back into the detention pond.

A second existing detention pond is located within the Trione Sports Complex. Because of its more natural configuration and the trees that border the pond, this drainage feature contributes positively to the aesthetic appeal of the park. It is not known how effective the detention pond is in managing stormwater runoff generated from within the park.

Examination of the topographic contours (see Figure 2-5) along Tributary TCC near the southern end of the site indicates an additional Grady pond formerly existed at that location. However, when Tributary TCC was excavated, the channel alignment passed through the middle of the pond. This has essentially resulted in the destruction of this pond. Nevertheless, the remnant contour information indicates this pond could be restored with relatively minor dirt work and with the installation of a water control structure.

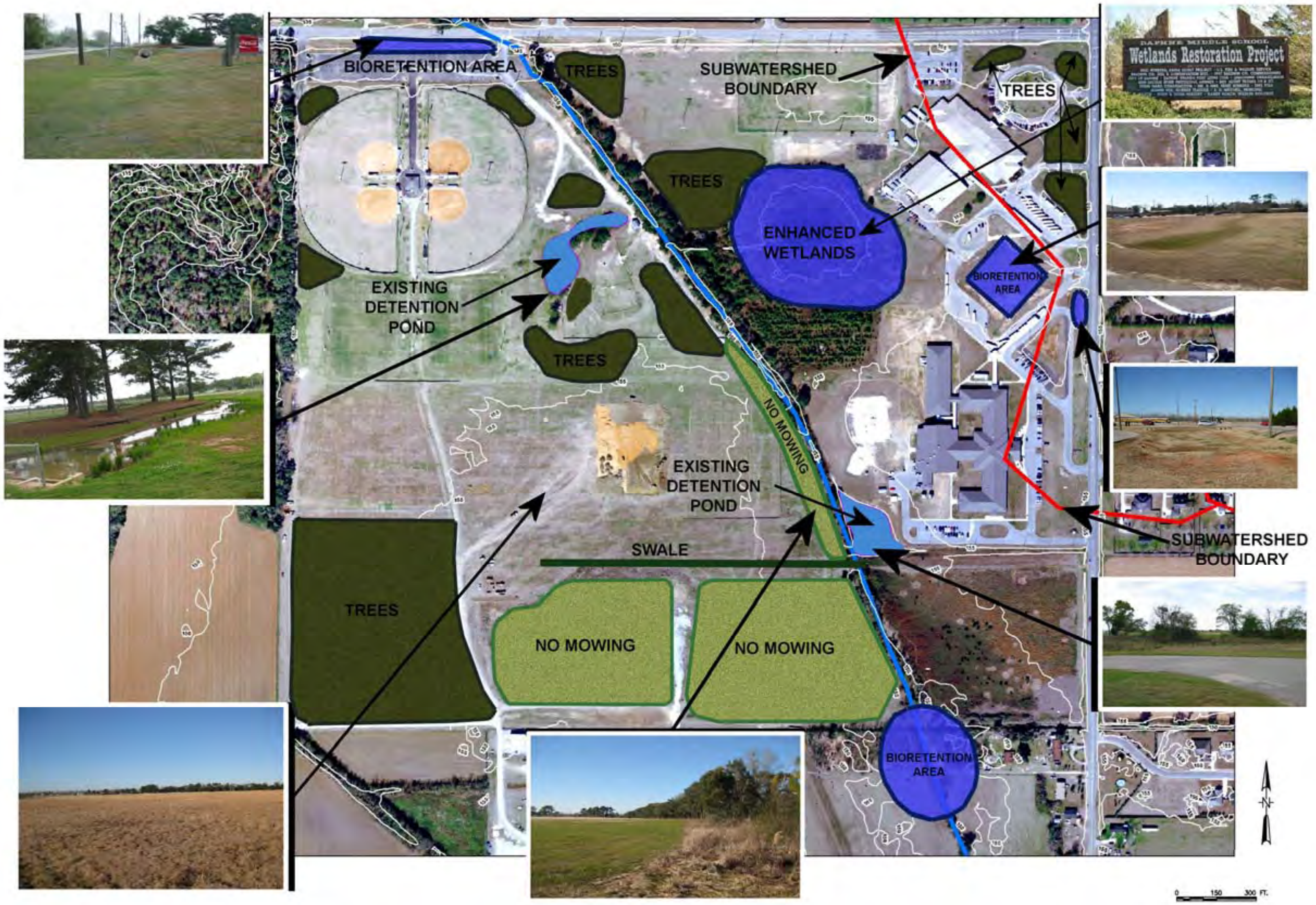

Figure 6-59. Conceptual Land Cover Alternative for Daphne's 140-acre Trione Park-School Complex

Table 2-2 shows Tributary TCC upstream of Whispering Pines Road to have a slope of only 0.16%. This is considerably less than most of the streams within the D'Olive Watershed. This extremely gentle gradient is the direct result of the surrounding flat nature of the terrain and the relatively shallow depth to which the drainage ditch was originally excavated.

Examination of the 5-foot topographic contours in Figure 2-5 also shows that the Whispering Pines Road stream crossing is functioning as a grade control structure which is preventing Tributary TC head-cutting from progressing upstream of the road. This positive effect of Whispering Pines Road is not expected to change in the reasonable foreseeable future.

6.4.3 Alternative Land Cover and Stormwater Management Approach

The alternative land cover and stormwater management approach considered for the 140-acre Trione Park-School complex could consist of the following elements as described below and graphically portrayed in Figure 6-59.

- Mowing should cease on those areas of the site not used to accommodate education or recreation needs. Natural succession, with control of exotic species as necessary, should be allowed to reclaim those areas. The higher and denser vegetation would provide better root structure to hold the soils in place; assist in reducing the impact energy of falling raindrops; and slow offsite drainage while encouraging retention of rainfall runoff through infiltration into the ground. Specific areas within the site that would benefit from reduced mowing are:
    - ➢ The portion of the site designated for Phase III development of future soccer/football fields (see Figure 6-58). Evidence indicates these additional improvements will not be undertaken until a considerable time in the future.
    - ➢ An approximate 30-foot band bordering the narrow existing western fringe of riparian habitat flanking Tributary TCC (see Figure 6-59). This would increase the buffer on the west side of the stream which should contribute to reducing stormwater runoff while enhancing the wildlife habitat value of the lands bordering the stream.
- The opportunity exists to reforest several areas scattered through the 140-acre site as noted on Figure 6-59. Ornamentals and/or native tree species could be selected to add either color, texture, or a natural "feel" to the reforested areas. Planting should be undertaken with the goal of assuring overlap of the resulting canopies to intercept rainfall and soften its fall to the earth, while encouraging the portion of the rainfall that clings to the tree limbs, leaves, etc. to be evaporated from above. All reforestation sites identified on Figure 6-59 were selected to avoid disruption of existing uses made of the park and the school facilities.
- The large upland area on the southwestern portion of the site designated for trees (see Figure 6-59) could be planted in pines that could be commercially harvested before Phase III expansion of the park is pursued (see Figure 6-58). Alternatively, the site

could be used to support a City run nursery to grow landscape trees and shrubs to a larger and more attractive size. The plants could then be used to accommodate varying planting needs within the D'Olive Watershed or at other locations around the City. The nursery could be operated until the Phase III expansion takes place.

- The existing water control structure in the Grady pond (see "Wetland Enhancement" feature shown on Figure 6-59) outlet should be repaired and upgraded with a vandalism-resistant structure. This will stabilize water levels within the pond and improve its ability to retain water. Native wetland shrub, tree, floating and emergent vegetation species will be allowed to flourish. The increased wetland vegetative cover will allow the pond to again serve as a bioretention site in which a larger portion of the retained water will be returned to the atmosphere through evapotranspiration.

- Figure 6-59 shows several locations within the site at which new bioretention facilities could be constructed at relatively minimal effort and cost. This would involve a small amount of grading to increase the available depth. The existing culverts could be modified in place with water control structures only being added to slow drainage from stormwater runoff. The added depth in the ponds would allow these sites to hold water longer after a rainfall event and encourage the establishment and maintenance of naturally occurring wetland plant species. Both of these actions would further the water retention goals of these bioretention sites. To assure that these features are not viewed negatively, their fringes could be planted with cypress trees that contribute to making these sites appear more natural as they matured in age. The minor dirt amounts that may have to be excavated could be used at other locations within the 140-acre site to improve individual storage volumes where needed.

- The existing detention pond serving the Daphne Elementary School should be modified. The existing water control structure should be improved to prevent backwater from Tributary TCC from flowing into the detention which adversely affects its stormwater storage capacity. A slight increase in its depth would not only increase the storage volume of this facility, but also enhance its ability to establish and support a wetland vegetation community on a sustained basis. Again, cypress trees could be planted along its margin to improve its aesthetic impact. The various actions would cumulatively contribute to the conversion of the existing detention pond to a bioretention area.

- Pending the successful resolution of any difficulties that may be encountered with neighboring private landowners to the east of Tributary TCC, it may be possible to restore the water retention capability of the former Grady pond (see Figure 6-59). As mentioned above, the available topographic data indicate a sufficient amount of residual topography may still be available to allow this former natural pond to be restored by utilizing some or all of the dirt that would be excavated from the other bioretention areas discussed above.

In addition to retaining an increased amount of the stormwater runoff within the 140-acre site, the conceptual land cover management measure discussed above would produce a number of other benefits:

- The amount of labor and funds now devoted annually to frequent mowing could be substantially reduced. The saved funds and labor could be diverted to other City projects.
- The possibility exists that the City could actually generate revenue in a future tree harvest as discussed above when the Phase III park improvement is pursued.
- Should a small scale tree and shrub nursery be operated on the site to grow plants to a larger size before planting, the City should be able to save those costs now paid to commercial nurseries.
- The overall aesthetic appeal of the entire 140-acre site would be enhanced by reducing the amount of mowing, planting of trees, and managing the site to produce a more diverse vegetation community.
- The wildlife habitat value of the site would be enhanced which would provide increased opportunities for recreational visitors to view a greater variety of wildlife and bird species.

Implementation of the above described management measures could allow the entire 140-acre site to serve as a "Demonstration Project" to illustrate the advantages of pursuing GI/LID concepts in a practical manner in a real world example.

6.5 Strengthen Regulatory Controls

Effective pursuit of "smart growth" development utilizing GI/LID to reduce stormwater runoff begins out of necessity with a strong regulatory foundation to guide land use planning, design, construction, and post-construction management of stormwater runoff.

6.5.1 Regulatory Overlap

Federal, State and local requirements overlap within the Watershed. The over-arching Federal and State water quality regulations apply to all areas of Baldwin County and within the Cities of Daphne and Spanish Fort. Any proposal to fill jurisdictional wetlands, no matter where located within the D'Olive Creek Watershed, must have:

- A proper permit application for a CWA § 404 permit with review by all agencies and the public (unless authorized by a NWP);
- ADEM water quality certification;
- Consideration of CWA § 303(d);
- ADEM coastal program consistency determination if in the coastal area; and
- A CWA § 402 NPDES – ADEM Admin. Code Reg. 335-6-12 construction stormwater permit (if greater than 1 acre will be disturbed).

The extra-territorial jurisdictions of Daphne and Spanish Fort extend beyond their boundaries for up to five miles for planning purposes, overlapping into the unincorporated portions of Baldwin County, but not the adjacent municipality. Each municipality exerts its jurisdiction and permitting requirements within their respective geographical boundaries. Each local entity requires permits for development, land disturbance and building construction, depending on jurisdiction, that are in addition to the federal and state permit requirements. Often the federal or state permit is a prerequisite to issuance of the local permit. Where municipal and County jurisdictions overlap, it is customary for the "more stringent" requirements to apply. In general, the current level of regulatory overlap is not considered a significant issue relative to stormwater management within the D'Olive Watershed.

6.5.2 Analysis of Regulatory Framework

The existing regulatory environment governing stormwater runoff and land development within the D'Olive Watershed was examined. Representatives of various governmental entities and landowners were also interviewed to seek their views on specific management measures addressed in this WMP. See Appendix C for the complete results of the regulatory evaluation. This effort revealed the following common issues for the D'Olive Watershed:

- Need for updated provisions in local ordinances addressing development, redevelopment, retention of stormwater runoff and velocities, continued maintenance of retention-detention ponds, additional inspection, monitoring and reporting (recordkeeping) requirements, training for inspectors, more enforcement, and protection and restoration of wetlands, riparian zones and streams.

    - Municipal and county officials recognize the need for better communication between and among the various regulatory agencies and regulatory consistency.

    - Problems with stormwater runoff volumes, velocity, lack of adequate stream and wetland buffers, lack of post-construction maintenance of detention facilities, historical erosion problems within, or due to, older subdivisions and commercial developments, and the identification of responsible parties for costs, maintenance and additional stormwater controls.

- The acreage of undeveloped land within the Watershed has been significantly reduced over the past three decades. Additional efforts may be required to implement innovative practices on these remaining areas to protect downstream areas. Further development and redevelopment should consider protection of drainage systems by employing buffers, preservation areas, and reduction and retention of stormwater runoff.

- Road construction and design at the County and State level must be undertaken in a manner that will protect the D'Olive Watershed streams from increased volumes and velocities of stormwater, erosion and sedimentation, and other nonpoint source contaminants.

- Existing problems must be corrected, either voluntarily or by regulation, at the time of redevelopment and through structural and nonstructural processes (such as education).

A regulatory "matrix", based on several elements deemed critical to effective stormwater management programs, was created to assist in the review process. The matrix is contained in Table 6-6. The rows in Table 6-6 list the four review elements considered: (1) construction phase BMPs"; (2) post-construction stormwater management; (3) wetland protection; and (4) coastal area protection. The columns summarize the results of the review of the regulations or ordinances for each of the four regulatory entities having jurisdiction within the D'Olive Watershed: Alabama Department of Environmental Management (ADEM), Baldwin County, Daphne, and Spanish Fort. The footnotes in Table 6-6 reference the regulations and ordinances upon which the information is based.

The problems and needs identified in the regulatory analysis were grouped into the following five issue areas:

- Eliminate Regulatory Inconsistencies
- Resolve Regulatory Deficiencies
- Limit Variance and Waivers
- Improve Enforcement
- Improve Protection of Wetlands

A series of recommendations were identified to address these issues. The recommendations are listed in Table 6-7.

Table 6-6. Regulatory Matrix

		ADEM	Baldwin County	Daphne	Spanish Fort
Construction Phase BMPs		Yes	Yes	Yes	Yes
	Design Standards	AL Handbook*[1]	AL Handbook[3]	AL Handbook[5]	Not Specified
	Design Storm	2yr-24hr[2]	25 yr[4]	10 yr[6]	10 yr[7]
	Site Size	>1 ac[1]	Any[3,10]	>1,000 sf[5]	>1 ac[7]
	Stabilization Time	13 days[1]	10 or 13 days[3]	30 days[6]	30 days[7]
	Inspections	I/month + 3/4" rain[1]	Yes[11]	Yes[11]	Yes[11]
	BMP Repair/Maint. Time	7 days[1]	Not Specified[9]	48 hours[5]	Not Specified[9]
	Non-compliance Reporting	Yes[1]	No	No	No
	Buffer Requirement	None	Yes-unspecified width[4]	Yes-unspecified width[6]	Yes-unspecified width[8,7]
Post Construction SW Mngt		No	Yes	Yes	Yes
	SW Quality	No	No	No	No
	SW Quantity	No	Yes	Yes	Yes
	Design Storm	N/A	2 thru 100 yr[4]	25yr or 24hr[6]	2 thru 100 yr[8]
	Site Size	N/A	Any[4, not applicable to SFR]	1 ac[6]	1ac/5ac[7] - 5ac/10ac[8]
	Inspection	N/A	Yes[12]	Yes[12]	Yes[12]
	Maintenance	N/A	Developer/Owner Assoc.[4]	Developer/Trustee[6]	Developer/Owner[8]
	Reporting	N/A	No	No	No[14]
	Calculation Method	N/A	Prohibits Rational Method**[4]	Not Specified	Rational Method[8]
Wetland Protection					
	Permit Requirement	Yes[13, only in coastal area]	ADEM/COE	ADEM/COE	ADEM/COE
	Setback Requirement	No	30 feet[3,4]	No	No
	Buffer Requirement	No	5 feet[4]	No	No
Coastal Area Protection		Yes[13]	No	Yes[6]	Yes[7]

* *Alabama Handbook for Erosion Control, Sediment Control and Stormwater Management on Construction Sites and Urban Areas* , March 2009

Foot Notes:

1 ADEM Administrative Code R. 335-6-12, January 23, 2003 (Construction Stormwater NPDES Program)
2 ADEM CBMPP Guidance issued July 2009
3 Baldwin County Zoning Ordinances, Section XIII, January 1, 2008; amended July 21, 2009 (Applicable only to zoned areas of County)
4 Baldwin County Subdivision Regulations, January 1, 2008 (Applicable County wide)
5 City of Daphne Ordinance No. 2008-54, November 3, 2008 (Applicable to SF residential)
6 City of Daphne Land Use and Development Ordinance, September 3, 2002 (Applicable to commercial developments and subdivisions)
7 City of Spanish Fort Zoning Ordinance, Article VIII, May 31, 1996
8 City of Spanish Fort Subdivision Regulations, Article VIII, June 1999
9 Although no timeframe is specified in the local ordinances, a stop work order may be issued for "non-conformance"
10 Requirements for ESC plans on sites <1 acre are less prescriptive than those for sites >1 acre
11 Regulation indicates that permitting authority may do inspections but frequency is not indicated - no requirement for self-monitoring/reporting
12 Stormwater control structures only inspected at completion ("as-built") to insure confromance with approved plans
13 ADEM Administrative Code R. 335-8, June 30, 1994 (Coastal Program)
14 Spanish Fort indicates that they are now requesting annual monitoring of stormwater facilities and reporting to the City but noting has been codified
** Regulation prohibits the use of the Rational Method or Modified Rational Method on sites >40 acres

Table 6-7. Recommended Modifications to Stormwater Management Regulatory Framework

Issue Area	Problems & Needs	Responsibility Entity	Recommendations
Regulatory Inconsistencies	Inconsistent stormwater management ordinances	Baldwin County, Daphne, and Spanish Fort	• Resolve existing inconsistencies between local stormwater management ordinances – both construction phase and post-construction requirements. Each entity should also review their respective flood control and overall development requirements for potential conflicts with stormwater management goals.
	Improved BMP planning and implementation	Baldwin County, Daphne, and Spanish Fort	• Adopt consistent requirements for BMP plan preparation by a qualified professional; a construction phase BMP design storm equivalent to the 2-year 24-hour event (~6 inches). Other design parameters should be consistent with, or reference, the current version of *The Alabama Handbook for Erosion Control, Sediment Control, and Stormwater Management on Construction Sites and Urban Areas (March 2009)*. • Adopt consistent requirements for BMP plan objectives and content following, at a minimum, EPA or ADEM guidance documents. • Adopt consistent requirements regarding the "self-inspection" of construction sites by the operator to include, at a minimum: initial inspection prior to major land clearing and grading; once per week during active construction; and at the time of final site stabilization. Documentation of all inspections and observations should be kept. • Adopt consistent requirements regarding the timely repair and maintenance of BMPs such that deficient BMPs are repaired or replaced with functional BMPs within 48 hours of discovery.
Regulatory Deficiencies	No applicable Federal or State level regulations pertaining to post-construction stormwater management	ADEM ADEM and ADCNR	• Promulgate updated construction stormwater regulations (currently in process) and develop post-construction stormwater management regulations applicable, at a minimum, to Watersheds where urban runoff is an identified cause of water quality impairment. • Focus on resolving the outstanding federal concerns relating to the unapproved Management Measures in the ACNPCP, particularly those related to Urban- New and Site Development; Urban-Watershed Protection and Existing Development; Urban-Construction Site Erosion and Sediment Control & Chemical Control; Urban-Roads, Highways and Bridges; Wetlands, Riparian Areas and VTS; and Hydromodification.
	Need local stormwater	Baldwin County, Daphne, and	• Formulate a consistent set of post-construction stormwater

	management regulations and ordinances that exceed State or Federal requirements	Spanish Fort	management requirements. These requirements should focus on stormwater runoff total volume reduction using Low Impact Development (LID) concepts and stormwater retention (Volume Based Hydrology (VBH)), and runoff velocity and peak flow management where and when appropriate. • Work collectively with an appropriately qualified engineering firm to develop a common set of post-construction stormwater technical design standards focused on runoff reduction (VBH) applicable, at a minimum, to the D'Olive Creek Watershed. • Either employ or contract for the services of a qualified professional engineer with experience in stormwater management to review engineering design plans related to post-construction stormwater management.
	Improve inspection, maintenance, and reporting on operational condition of long-term construction projects	Baldwin County, Daphne, and Spanish Fort	• Formulate a consistent set of post-construction stormwater control structure inspection, maintenance and reporting requirements.
	Minimize extent and duration of exposed soils during construction	Baldwin County, Daphne, and Spanish Fort	• Develop consistent construction site management requirements that incorporate the use of phasing, limited clearing (10-20 acres maximum), and prompt (7-day) re-stabilization of exposed soils.
	Timely discovery and repair of construction BMPs	Baldwin County, Daphne, and Spanish Fort	• Develop and implement a consistent set of construction site management requirements that address routine self-monitoring and reporting to include, at a minimum: initial inspection prior to major land clearing and grading; once per week during active construction; and at the time of final site stabilization. • Develop and implement a consistent set of construction site management requirements such that deficient BMPs are repaired or replaced with functional BMPs within 48 hours of discovery.
	Subdivision rules and regulations aimed at stormwater management on individual lots	Baldwin County, Daphne, and Spanish Fort	• Catalogue and thoroughly review each of the existing subdivisions and corresponding subdivision restrictions to identify the ones that need to be updated to better protect natural resources and streams; control construction stormwater and post-construction stormwater; and encourage stormwater reduction and/or retention practices. • Encourage, through education and outreach programs, the cooperation

			and interaction of subdivisions and property owners. Emphasis should be placed on explaining the cumulative effect of existing and future drainage practices exercised on each lot and development; the importance of protecting and maintaining natural and pervious areas; and highlighting respect for offsite (upstream and downstream) impacts. • Provide examples and assistance to property owners and property owners associations about upgrading subdivision restrictions to address stormwater control and retention; post-construction practices for erosion and stormwater control; maintenance and renovation of control structures; and implementation of new and innovative practices.
Variances and waivers	Waivers and variances should not undermine objectives of stormwater management rules	Baldwin County, Daphne, and Spanish Fort	• Develop and implement a consistent set of guidelines on the issuance of waivers and variances that will insure the ultimate goals of this WMP will be met.
Enforcement	Enforcement should be timely, meaningful, consistent, and impartial	Baldwin County, Daphne, and Spanish Fort ADEM	• Develop and implement a consistent enforcement strategy within the D'Olive Watershed. • consider developing an enhanced enforcement strategy within the D'Olive Watershed consistent with the 303(d) listing of the major tributaries
Protection of Wetlands	Adequate buffer and setbacks to protect wetlands needed.	ADEM Baldwin County, Daphne, and Spanish Fort	• Through its water quality and coastal management programs, should develop and implement wetland and riparian buffer and setback requirements applicable, at a minimum, to Watersheds having 303(d) listed streams. • Work with an appropriately qualified wetland expert to develop a common set of wetland and riparian setback and buffer requirements applicable, at a minimum, to the D'Olive Watershed.

6.6 Estimate of Sediment Load Reductions

To ensure that Section 319-funded projects make progress towards restoring waters impaired by non-point source (NPS) pollution, watershed-based plans that are developed or implemented to address Section 303(d)-listed waters must address nine "a-i" Section 319 grant guideline elements, one of which is "b" that states:

> An estimate of the load reductions expected for the management measures …………. (recognizing the natural variability and the difficulty in precisely predicting the performance of management measures over time). Estimates should be provided at the same level as … (e.g., the total load reduction expected for dairy cattle feedlots; row crops; or eroded streambanks).

The Section 319 grant guidelines recognize the difficulty in acquiring or developing some of the information needed to address the "a-i" components, but stress the importance, at the *subwatershed* level, for reasonable efforts to be made to: (1) identify significant sources; (2) identify the management measures that will most effectively address those sources; and (3) broadly estimate the expected load reductions that will result. The underlying objective is to provide focus and direction to plan implementation.

In order to estimate sediment load reductions from various management options, the sources of the sediment loadings must be understood. The sources of the sediment loadings may generally be categorized as stormwater runoff from upland erosion (before it enters the stream) and erosion within the stream (channel incision and bank erosion). The Geological Survey of Alabama (GSA) studies in 2007-2008 (Cook, 2007; Cook and Moss, 2008) have provided a comprehensive assessment of sediment loadings in the Watershed streams for the time period studies. The GSA studies measured sediment loadings spatially across the D'Olive Watershed over a two-year period with highly variable rainfall conditions that resulted in highly variable sediment loadings. Also, the GSA studies included measurements of both the suspended solids fraction (smaller grain size soil particles) and bedload fraction (i.e., larger grain size soil particles). These studies did not directly measure the origin of the sediment load (upland runoff vs. stream erosion). However, the GSA data coupled with the erosion activity assessment performed for this WMP allows some generalized assumptions.

The highest total sediment loadings, both in terms of annual load (tons/yr.) and normalized for drainage area (tons/mi^2/yr) came from Subwatersheds 1 (D'Olive Creek) and 3 (unnamed tributary to D'Olive Creek – DA). After Tributary DA and D'Olive Creek join, their combined total sediment load represented over 75% of the total sediment load entering the Lake Forest Lake. These sediment loadings were predominantly (83%) bedload materials (see discussion in Section 6.1.2.4).

The severe stream erosion activity that has been documented in both Subwatersheds 1 and 3 indicates that stream degradation is a substantial source of the sediment loads in the D'Olive Creek system, and the same can be said for Tiawasee Creek and Joe's Branch as well. Management options that directly or indirectly address stream degradation are expected to achieve a substantial reduction of sediment loads. Nevertheless, this does not discount upland runoff as also being a significant source. Clearly, a multi-prong approach addressing both in stream and upland sources is needed.

Implementing the WMP in a comprehensive, holistic manner (i.e., including a full complement of integrated management options) can be expected to achieve significant sediment load reductions. Stream restoration/stabilization measures may provide the most immediate results. However, runoff reduction measures which address the "root cause" problem of hydrologic modification from urbanization should yield long term benefits.

Pollutant loadings, by definition, are a factor of flow-times-concentration. Management measures aimed at restoring hydrology (reducing stormwater flow) typically will reduce the pollutant concentrations (i.e., suspended sediment) carried by runoff, providing a double benefit towards sediment load reduction. Reduction in stormwater runoff into the streams also contributes to more stable and less erosive stream conditions. It would not make sense to invest significant resources in an attempt to restore/stabilize the streams without also implementing measures that are aimed at restoring a hydrologic regime that allows stable stream conditions to be maintained in the future.

Overall, the implementation of the D'Olive WMP in a comprehensive, integrated manner can be expected to achieve sediment load reductions in the range of 40 to 60% compared to those reported by the GSA studies.

7.0 Cost Estimates

Section 6 identified a wide array of management measures that could be implemented in the D'Olive Watershed to variously reduce stormwater runoff volumes and velocities; repair unstable stream channels; reduce overland erosion; remove excessive sediment accumulations; and modify existing and future land cover/land use practices. Each of the management measures discussed would individually contribute to the collective goal of restoring the hydrology of the D'Olive Watershed.

As discussed in Section 6, the various management measures could be implemented individually or combined to create comprehensive approaches to address both short-term and long-term solutions to the problems that are being experienced within the D'Olive Watershed over the 10-year life (i.e. through 2020) of this WMP and beyond. Some of the measures discussed can be implemented by individual property owners; neighborhoods and property owner associations; future developers; or governmental institutions having jurisdictional responsibility within the Watershed.

Where possible, Section 6 included rough-order-of-magnitude (ROM) cost estimates for each of the management measures. Preparation of detailed cost estimates were not possible due to the conceptual level of planning that guided development of this WMP. This Section summarizes the available preliminary cost estimates to assist in preparing potential budgetary projections required to implement the management measures contained in this WMP.

Table 7-1 presents a summary of the cost data extracted from Section 6. In considering this information, the reader is cautioned that the preparers of the WMP acknowledge that the ROM cost estimates are not comprehensive because of the limitations of data and the scope of the investigations performed for the WMP. These ROM cost estimates are intended only for preliminary budgetary considerations. However, what is clear is that the costs of correcting the significant hydrological and sediment problems affecting the D'Olive Watershed will be substantial, and are anticipated to range between **$22 and $44 million**.

What must be acknowledged by D'Olive Watershed interests is that the costs of doing nothing, or at greatly reduced scales, will also result in deferred costs that will eventually have to be paid at some time in the future. The piecemeal actions that have traditionally been undertaken in the Watershed after major storm events to repair road stream crossings, stabilize stream channels, and address eroded streambanks that threaten private property are representative of such deferred costs.

Table 7-1. Summary of Potential Costs to Implement D'Olive Watershed Management Plan

Management Measures	Responsible Entity for Implementation	Total Cost Range	Recommended Timeframe for Implementation	Remarks
Stormwater Retrofits of Existing Developments	Responsibility for implementation will vary depending upon the measure selected. Governmental entities should take the lead role, in collaboration with property owners associations, developers, individual property owners, and commercial interests.	\$10 to \$20 million.	Implementation should begin within the first year after the WMP is adopted.	See Section 6.3.3. It is not possible to estimate the costs to implement the stormwater retrofits without identifying the specific measures, their scope and locations. See Figure 6-23 for a range of construction costs based on unit cost basis.
Strengthen Regulatory Controls	Baldwin County and Cities of Spanish Fort and Daphne	No cost to Governments	Efforts to amend existing ordinances and regulations controlling development should begin soon after adoption of the WMP.	See Section 6.4 for a description of the regulatory modifications that have been identified within this WMP.
"Smart Growth" concepts (including "Green Streets," rainwater harvesting, rain gardens, green space preservation, bioretention, regional stormwater detention facilities, preservation of riparian habitat, alternative management of vegetation on golf courses and public lands.	For existing developments, responsibilities will be shared among Governmental and non-governmental entities. For new developments and redevelopment projects, the private entities pursuing the projects will be responsible. Government will be responsible for public projects.	To be determined	Modifications to the regulatory framework to support "Smart Growth" concepts with all future development and redevelopment projects should be pursued immediately upon adoption of the WMP and instituted as soon as practicable. Measures undertaken by individual homeowners, property owners associations, and commercial interests can be pursued immediately upon adoption of the WMP.	See Section 6.3.4. To institutionalize the application of "Smart Growth" concepts as integral components of projects and other endeavors undertaken in the D'Olive Watershed it will be necessary for the regulatory framework to be modified.

Table 7-1 (cont'd). Summary of Potential Costs to Implement D'Olive Watershed Management Plan

Management Measures	Responsible Entity for Implementation	Total Cost Range	Recommended Timeframe for Implementation	Remarks
Stream Restoration	Government	\$8 to \$14 million	Initial 3 years after WMP adopted	See Section 6.2.1. If restoration of the 20,000 linear feet of stream experiencing active head-cutting is not accomplished within 3 years, the eventual cost of restoration should be expected to increase as additional stream segments continue to be degraded.
Lake Forest Lake: • Construction of sedimentation basins in D'Olive and Tiawasee embayments • Maintenance of sedimentation basins by removing sediment accumulations • Lake dredging	Government, in collaboration with Lake Forest Property Owners Association	\$850,000 to \$1,400,000 \$85,000 to \$128,000 per 2-year interval \$3 to \$6 million	2nd year after WMP adopted Performed at 2-year intervals One time event performed at some time during the 10-year period addressed by WMP. Subsequent dredging efforts will depend upon future shoaling rates and community goals.	See Section 6.2.2.
Wetland Restoration • Area 1 • Area 2 • Area 3 • Area 4	Government	\$76,600 to \$164,600 \$153,000 to \$268,000 \$45,400 to \$80,400 \$440,000 to \$810,000	Wetland restoration should be pursued as soon as practicable, contingent upon successful implementation of upstream erosion control measures where needed.	See Section 6.2.3 for discussion of methods to restore the wetlands at the four identified sites.

Table 7-1 (cont'd). Summary of Potential Costs to Implement D'Olive Watershed Management Plan

Management Measures	Responsible Entity for Implementation	Total Cost Range	Recommended Timeframe for Implementation	Remarks
Utility Rights-of-Way	Riviera Utilities	To be determined	Measures to reduce stormwater runoff and erosion of soils on utility right-of-ways should begin within the first year after adoption of the WMP and continue through the entire 10-year period addressed by the WMP.	See Section 6.2.4.3.9
Highway Rights-of-way	Alabama Department of Transportation, Baldwin County, and the Cities of Spanish Fort and Daphne	To be determined	Modifications to management of highway rights-of-way should begin as soon as approvals are developed by the various roadway interests.	See Section 6.2.4.3.9
Total		**$22.6 to $42.7 million** (excluding maintenance, administrative, and similar costs)		

What is not included in the costs shown in Table 7-1 are the added costs that could be borne by future developments to implement the "Smart Growth" measures discussed in Section 6. Although governmental entities will out of necessity be required to take a lead role in addressing many of the existing problems, these governmental entities can also pursue regulatory changes to reform future development practices. Such changes could make significant contributions to reducing the likelihood for similar problems to occur in the future as the remaining 2,500 acres of the Watershed zoned for development are converted primarily to residential and commercial uses. That can be accomplished by strengthening regulatory controls and adopting an enhanced land use development philosophy that emphasizes restoration/preservation of the Watershed's hydrology and by requiring developmental interests to design their facilities accordingly and to bear the upfront costs during development.

8.0 Implementation Strategies

8.1 Introduction

Section 6 outlined a wide range of measurement measures to address the stormwater runoff, channel instability, and excessive sedimentation problems affecting the D'Olive Watershed. Successful implementation of these measures will require that an equally diverse array of implementation strategies be employed. These strategies will involve all levels of stakeholders within the Watershed: appropriate State agencies (Alabama Department of Environmental Management (ADEM), Department of Transportation, etc.); Baldwin County and the Cities of Daphne and Spanish Fort; other organizations (Mobile Bay National Estuary Program (MBNEP), non-governmental organizations, etc.); property owners associations, and individual property owners. To more effectively coordinate the efforts of these various entities to implement the management measures, it would be helpful to establish a special task force (i.e. Watershed Restoration Task Force) to focus on implementation of specific measures and actions. Addressing the over-arching institutional measures that deal with the regulatory framework controlling development within the Watershed will continue to rely with the existing governmental entities responsible for planning and stormwater management within the Watershed.

8.2 Implementation Actions

The following outlines the activities that should be pursued at a minimum to implement the management measures recommended in this WMP. These efforts should be initiated as soon as possible and pursued in a concurrent fashion.

8.2.1 Watershed Restoration Task Force

Many of the problems affecting the D'Olive Watershed extend across governmental boundaries. To effectively address these situations, the Baldwin County Commission; the Cities of Spanish Fort and Daphne; the ADEM; and the MBNEP should cooperate to create an intergovernmental "Watershed Restoration Task Force." The Task Force would collaborate to provide guidance and oversight that could address the following:

- Serve as the single point-of-contact to coordinate the activities and efforts of the various stakeholder groups that are active in the Watershed.
- Assist local government entities and stakeholder groups pursue sustained, long-term funding to implement the WMP.
- Guide a sustained effort to design and construct projects to halt the active head-cutting and channel erosion processes that are affecting over 20,000 linear feet of streams in the D'Olive Watershed.

- Evaluate options to prevent head-cutting spreading to the 31,000 linear feet of streams that have the potential to be affected if actions are not taken.
- Develop the design and pursue the construction of a Lake Forest Lake Restoration and Maintenance Project.
- Propose a specific Riparian/Wetland Habitat Conservation Plan to restore presently damaged habitats from existing urban development and identify and rank other undeveloped habitats for preservation as green space.
- Work with governmental and private interests throughout the Watershed to develop implementation plans for selection, design, and construction of stormwater retrofit projects in existing residential and commercial developments.

The Task Force could be populated by existing staff members of the entities identified above. If the Task Force workload justified a specific Watershed Coordinator, consideration could be given to establishing and funding that position.

The Task Force would report directly to the city governments of Daphne and Spanish Fort and the Baldwin County Commission. All work proposals would be approved by these three local governmental institutions.

The Task Force could also serve as the vehicle to engage the public, work with property owner groups, and foster community outreach and education.

Given the severity of the problems facing the Watershed, the Task Force should be established as soon as possible following adoption of this WMP so that restoration work could begin.

8.2.2 Prioritize Stream Reaches Affected by Active Head-Cutting

Repair of the 20,000 feet of stream reaches in the D'Olive Watershed being affected by active head-cutting and channel incision (see Figure 4-1) should be pursued immediately after the WMP is approved. If the present head-cuts are not halted from their ongoing upstream movement, the risk for future substantial stream channel and floodplain damages is high.

The major goal of this effort would be to arrest the progression of head-cuts along the main stem stream channels and the numerous tributaries and smaller drainages that are being damaged by this extremely damaging channel degradation process. Initial work should be focused on the most upstream leading edges of the head-cuts on each stream to prevent further movement, with subsequent efforts being devoted to restoring the stream gradients downstream of the initial projects. Detailed site-specific solutions that employ the most appropriate corrective measures should be developed to best satisfy the needs and meet the challenges at each unique location.

A master implementation schedule and cost estimate should be developed that reflects work priorities and risks to resources. This information should guide a programmatic stream restoration approach for advanced planning, design and construction activities in a systematic and comprehensive manner.

In prioritizing the stream restoration work, emphasis should be placed on D'Olive Creek (between Hwy. 90 and I-10) and its tributaries (particularly Tributary DA) since Cook and Moss (2008) estimated 83% of the total sediment load entering Lake Forest Lake was contributed by the D'Olive Creek drainage, while only 17% of the sediment load was delivered by Tiawasee Creek and the minor tributaries immediately surrounding the lake. Within the D'Olive Creek drainage, initial emphasis should be placed on Tributary DA which was responsible for 65% of the overall D'Olive sediment load, with 35% coming from the main stem of D'Olive Creek. The tributaries to Joe's Branch should also receive priority attention because of the ongoing excessive sediment loading in the headwater areas that is damaging the downstream wetlands.

Time is critical to prevent the existing stream degradation problems from extending further upstream at new numerous locations in the Watershed. Thus, work should begin immediately to identify funding, develop designs and pursue construction of the corrective measures as the first priority of interest after the WMP is adopted.

8.2.3 Lake Forest Lake Restoration Plan

Although Lake Forest Lake is privately owned by the Lake Forest Property Owners Association, the lake has become a *de facto* sediment deposition basin for 91% of the total D'Olive Watershed. The drainage from over 7,050 acres of the Watershed passes through Lake Forest Lake. Of that total acreage, only 1,600 acres originates within the Lake Forest Subdivision, with the remaining 5,450 acres (77% of the lake's total drainage area) being located in upstream areas not associated with the Lake Forest Subdivision. A substantial amount of these areas have either been recently developed or have a high potential to be developed over the 10-year period addressed by this WMP. Thus, the non-Lake Forest Subdivision developments are contributing to the stormwater runoff and channel instability problems that are contributing the sedimentation problems in Lake Forest Lake.

Further, the coarse-grained bedload sediments delivered by the Watershed area draining into the lake are prevented from entering the D'Olive Bay/Mobile Bay system. This important contribution of Lake Forest Lake does not appear to be fully understood or appreciated by Watershed stakeholders. The Lake Forest Property Owners Association should mount a sustained campaign to get this "message" out in order to seek public support and funding for lake-restoration projects.

The Watershed Restoration Task Force could cooperate with the Lake Forest Property Owners Association to conduct the appropriate engineering investigations to develop a firm restoration plan, cost estimate, and implementation schedule.

Concerns over the "shallowing" of Lake Forest Lake and the loss of usable volume due to sediment deposition have existed since the early 1970s. However, the volume of accumulated sediments in the lake remains a major unknown. Hydrographic and topographic surveys should be conducted, along with geotechnical analyses of the deposited materials, as soon as possible to gain a specific understanding of the magnitude of the sedimentation problems before a corrective solution can be designed and pursued.

8.2.4 Retrofit Existing Developments

Stormwater retrofits have been defined in this WMP as practices that modify existing stormwater systems or install new stormwater management facilities in already developed areas. Selection and design of retrofit projects will differ when compared to design of stormwater systems for new developments, and will likely be more complex and expensive because of the limitations of available undeveloped space and challenges imposed by terrain. Typically, retrofit projects are sponsored by public entities and funded by public sources, rather than the costs being borne by the original developers of the established projects within which the retrofits would be constructed. Securing long-term and sustainable funding may be the most important first step for implementation. Retrofit projects will usually require the cooperation and/or permissions of private entities (i.e., property owners associations, business owners, etc.). Coordination with and support from the community is a critical element.

A Watershed-scale retrofit program will be most cost-effective and better accomplish its objectives if it is planned and implemented with a programmatic approach. A sequential process for planning and implementing a retrofit program has been discussed in Section 6.3.3.5, and is summarized below:

- Refine retrofit strategy to meet local restoration objectives
- Identify potential retrofit sites and investigate their feasibility
- Inventory and prioritize retrofit projects
- Design and construct selected retrofit projects
- Inspect, maintain, and evaluate following construction

8.2.5 Modify Regulatory Framework

To accommodate the anticipated population growth and the conversion of forested and agricultural lands to residential uses, the three governmental entities primarily responsible for the D'Olive Watershed should develop consistent zoning plans and subdivision design standards that emphasizes minimization of Impervious Cover; reduces the width of subdivision roads; emphasizes retention of rainfall runoff; applies incentives to encourage Low Impact Development/Green Infrastructure techniques; requires a percentage of new subdivision land areas be devoted to common green space use; minimizes tree removal and/or requires that replacement trees be planted; and conserves riparian habitat. Applicable "smart growth" concepts should be employed to the maximum extent possible to guide future subdivision and commercial designs.

The WMP includes twenty-four recommended modifications to the existing regulatory environment for development activities and stormwater management within the D'Olive

Watershed. These recommendations are suggested to eliminate regulatory inconsistencies; resolve regulatory deficiencies; limit variances and waivers; improve enforcement; and improve protection of wetlands. During the first year following approval of the WMP, the identified entities responsible for each regulatory action should consider the individual recommendations and initiate implementation as appropriate.

The existing planning and zoning entities at the County and municipal levels should collaborate to develop consistent codes and organizations that transcend governmental boundaries to create Watershed-based design, construction, and post-construction stormwater management standards. Equally important, Daphne, Spanish Fort, and Baldwin County should work together to develop one set of consistent land development codes and ordinances that are focused on Watershed-wide stormwater management.

8.2.6 Design Standards for New Residential and Commercial Developments

Residential subdivisions represent the dominant existing land use within the D'Olive Watershed. According to existing zoning plans, residential land use could increase to around 5,100 acres or 66% of the total Watershed by 2020. Although, relatively minor in terms of total acreage involved in commercial developments, such developments are important because they can typically concentrate high percentage of Impervious Cover on a relatively small acreage of land.

In coordination with local development interests and the engineering community, the three governmental entities responsible for regulating development in the D'Olive Watershed should begin cooperative efforts to develop consistent new design standards that embrace the recommendations of this WMP.

8.2.7 Develop and Pursue Community Relations and Public Awareness Program

Implementation of the recommended management measures advocated in this WMP will depend upon the understanding and support of the general public and specific Watershed stakeholders. A sustained, targeted public education and community outreach program will be critical to assure that the need for action is appreciated. Initiation of that program will begin with the Public Meeting at which the Draft WMP will be introduced for review and comment. After the WMP is completed, regular efforts that utilize a variety of techniques will be required to keep the message fresh and in front of the Watershed stakeholders. The Community Relations and Public Awareness Program conceptually described in Section 10 should be further defined to identify the specific communication measures that need to be employed and appropriate entities that should be involved to assure the Watershed community is effectively informed of the issues and needs.

8.2.8 Implement Monitoring Program

The Watershed Restoration Task Force should also develop and implement a regular monitoring program to assess and evaluate conditions within the D'Olive Watershed over the

10-year period addressed by this WMP. The monitoring program should embrace, at a minimum, the recommendations described in Section 11.

The parameters and approach for the monitoring program should be formally agreed to following adoption of the WMP and monitoring efforts should be initiated as soon as possible in order to build a dependable database upon which to base future management decisions in the Watershed.

8.2.9 Funding

The Task Force should consider the potential funding sources identified in Section 9 and work with grant writers for the organizations active in the Watershed to develop a well-coordinated funding request program that marries the most appropriate funding sources with specific management measures.

The Task Force should maintain a relationship with the Baldwin County Watershed Coalition to monitor the success of efforts to establish a public corporation in Baldwin County and a fee structure to construct and manage solutions to stormwater management programs.

Also, the Baldwin County Commission and Cities of Daphne and Spanish Fort should continually consider other opportunities to fund the various management measures outlined in this WMP.

8.3 Implementation Schedule

To ensure that Section 319 funded projects make progress towards restoring waters impaired by nonpoint source pollution, watershed-based plans that are developed or implemented with Section 319 funds to address Section 303(d)-listed waters must address item "f" of the Section 319 grant guidelines which states "…A schedule for implementing the NPS management measures identified in this plan that is reasonably expeditious".

Table 8-1 presents a recommended schedule to implement the major program elements of the D'Olive WMP.

Table 8-1. Recommended Implementation Schedule for D'Olive Watershed Management Plan

Major Program Element	Schedule for Implementation
Establish Watershed Restoration Task Force	Immediately upon adoption of WMP
Pursue sustainable, long-term funding	• Initiate immediately • Continue throughout 10-year implementation period of WMP
Development and implement comprehensive stream restoration program	Targeted completion of priority stream segments within 3 years
Lake Forest Lake restoration • Planning and design • Construct sedimentation basins in tributary arms • Lake dredging	 • Within 1st year of adoption of WMP • 2nd year after adoption of WMP • Perform within the WMP 10-year period
Wetland restoration	As soon as practicable, contingent upon successful upstream erosion control measures
Stormwater retrofits in already developed areas • Refine retrofit program scope, identify and prioritize potential projects • Plan, design and construction retrofit projects	 • Within the 1st year r of adoption of WMP • Perform within the 10-year implementation period of the WMP
Modify regulatory framework and revise standards for new development and re-development projects	Within 1 year of adoption of WMP
Implement improved vegetative management practices for highway and utility right-of-ways and other areas	• Initiate within 1st of adoption of WMP • Continue throughout 10-year implementation period of WMP
Public education and outreach	• Initiate immediately • Continue throughout 10-year implementation period of WMP
Monitoring program	• Conduct baseline monitoring during 2010 • Continue throughout 10-year implementation period of WMP

9.0 Financing Alternatives

9.1 Introduction

Funding water quality improvements on a watershed basis is a challenging concept. This is because the political jurisdictions necessary to provide such funding do not necessarily follow watershed boundaries, as is the case for the D'Olive Watershed.

A watershed approach to the design, construction, and maintenance of stormwater improvements will require a significant and steady stream of funding. Municipalities and other political subdivisions should consider and compare various funding options for stormwater management, such as the creation of a stormwater utility authority and/or public-private partnerships.

There are a number of different financial structures that could facilitate funding for the projects identified in this Watershed Management Plan (WMP). Some structures could be helpful across the entire Watershed and some within limited areas. Many would require public-private partnerships in the sense of cooperation among landowners and governments rather than being imposed by governmental entities.

Fourteen alternatives for funding and financing stormwater improvements in the D'Olive Watershed are discussed in Sections 9.2 through 9.15:

- Water use service fees (i.e., stormwater utility fees) (see Section 9.2)
- Property, sales, or other taxes paid into general funds (see Section 9.3)
- Federal grants, loans, and revenue sharing (see Section 9.4)
- "Green" stimulus funding (see Section 9.5)
- Non-governmental organizations and other private funding (see Section 9.6)
- Mitigation banks (see Section 9.7)
- Impact fees (see Section 9.8)
- Special assessments (see Section 9.9)
- System development charges (see Section 9.10)
- Environmental tax shifting (see Section 9.11)
- Municipal bonds (see Section 9.12)
- Capital improvement cooperative districts (see Section 9.13)
- Alabama improvement districts (see Section 9.14)
- Tax increment financing districts (see Section 9.15)

Additional funding sources and methods may be identified through participation in selected regional collaboration opportunities (see Section 9.16). Finally, a bibliography of resources for funding/financing stormwater improvements is presented in Section 9.17.

9.2 Stormwater Utility Fees

According to the U.S. Environmental Protection Agency, the most stable source of funding for stormwater management is the stormwater utility (EPA, 2008). Stormwater utility fees typically provide the most equitable and transparent source of funding for stormwater management.

A stormwater utility is an integrated stormwater management solution that provides a stable, predictable, long-term funding mechanism dedicated to stormwater improvements. The stormwater utility facilitates planning and construction programs and enables resolution of chronic problems. Sustainable revenues based on consumption are generated through a user fee-based service enterprise (Spitzer, 2010).

Stormwater utility authorities are used extensively in many areas of the country, but their implementation requires that several issues be addressed. In the State of Alabama, the authority to create a local stormwater utility must be granted by legislative statute. It may take several years to successfully study, establish, and begin operating a stormwater utility authority. Among the policy options to be considered in creating a stormwater utility are fee (rate) methodologies; billing/collection mechanisms; credits and surcharges; and fee exemptions (Spitzer, 2010).

Typically, the stormwater user fee appears as a separate line item on residential or commercial water/sewer bills; as a special assessment on property tax bills; or on a stand-alone bill. Therefore, these fees are highly visible to the general public. The concept that stormwater must be "managed" can be difficult for the average citizen to grasp, resulting in skepticism about the need to assess stormwater user fees. The user fee, particularly if it is a large amount, is often interpreted as a tax. Thus, it can be subject to legal challenges. The local stormwater ordinance must be modeled carefully to prevent such challenges.

Stormwater user fees may be based on parcel size and/or the impervious areas within the parcel. Residential fees may be calculated differently from fees for commercial properties (e.g., a fixed fee for each residential parcel vs. a fee based on the amount of impervious area for commercial parcels). Surcharges or credits may be allowed for on-site attenuation and/or treatment of stormwater; for the type of land use or industrial activity present on the site; or for watershed stewardship activities. Stormwater fee collection is commonly enforced by utility shut-off or by tax liens on the owner's property. The majority of stormwater utilities allow exemptions for certain categories of property. Typically, streets/highways, undeveloped land, and railroad rights-of-way are exempt from paying stormwater user fees (Spitzer, 2010 and Leo, 2010).

In 1986, the City of Tallahassee, Florida implemented the first stormwater utility in the Southeastern United States. Currently there are approximately 300 stormwater utilities in the Southeast, with 150 of these located in the State of Florida. The nearest municipality to the D'Olive Watershed with a stormwater utility is the City of Pensacola, which assesses a monthly rate of $4.40 per 2,575 sq. ft. The stormwater management authority that operates in Jefferson County, Alabama and which includes five cities located within that county imposes a monthly rate of $0.42 per parcel (EPA, 2010). Based on a 2009 survey of stormwater utilities in the Southeast, the Southeast Stormwater Association (Spitzer, 2010) found that:

- 93% of the stormwater utilities operate with a user fee
- 66% use impervious area on the parcel as a basis for the user fee
- 69% are operated by cities only
- 8% are operated on a watershed basis
- Average population served equals 121,000
- Average physical area served equals 102,000 acres
- 43% are affiliated with a city/county public works department
- Average stormwater utility rate is $3.22 per month
- Standardized rate per unit area is $1.31 per 1,000 sq. ft.
- Average revenue is $4,200,000 per year.

For most municipalities, the fees are adequate for meeting most, but not all, of the costs of operating the stormwater program.

9.2.1 Baldwin County Assessment Statute

Beginning in 2004, efforts began in Baldwin County to establish a regional/cross-jurisdictional stormwater authority. In 2006, a Feasibility Assessment conceptually outlined how such an authority might be developed. Since Alabama constitutionally denies cross jurisdictional cooperation between municipalities and county governments, establishment and existence of this authority depended on the passage of enabling legislation. In 2008, the Alabama Legislature passed constitutional Amendment 15 and Section 45-2-243.50 Code of Alabama, permitting the State Legislature to form districts for the purpose of establishing and maintaining drainage systems and assessing properties benefited by the improvements. The State Legislature passed Act 2008-507, enabling local governments to proceed with establishing a Baldwin County regional stormwater authority. This amendment allows Baldwin County residents to vote in a November 2010 referendum to authorize the "formation of a public corporation for the purpose of managing stormwater in the county."

9.2.2 Baldwin County Watershed Coalition

Realizing the ever increasing need for better stormwater management, the Baldwin County Watershed Coalition (BCWC) formed as a result of collaboration among municipal and county representatives (comprised of both staff and elected officials), representatives of local environmental organizations, state legislators, and representatives of local business and development interests. The Mobile Bay National Estuary Program (MBNEP) has served as a facilitator for the group.

The mission of the BCWC is to act as a voluntary, non-regulatory association of local interests that will operate on a regional/watershed scale "*to support local communities in managing flooding, drainage, and issues related to stormwater runoff in Baldwin County while preserving and improving water quality and the use of our water resources.*" Towards this end, State legislation specific to Baldwin County (HB50 – Act 2008-507) was passed to allow for the creation of a public corporation that is authorized to collect stormwater service fees to fund stormwater improvement projects recommended by the BCWC. By statute, 80% of all revenue generated from "stormwater service charges" is required to be used for "on the ground" projects. A referendum will be placed before the voters of Baldwin County in the general election in November 2010 to approve the creation of the public corporation.

The MBNEP has hired an engineering firm to consult on the design and implementation of a regional public stormwater corporation in Baldwin County (*Alabama Current Connection*, 2010). The consulting firm has facilitated a decision-making process to determine how the public stormwater corporation will be governed and implemented. The firm is currently overseeing the development of a financing strategy, including how user fees and incentives will be established as well as an organizational structure for administering the public corporation.

The public corporation would be funded by a small, equitable user fee, based generally on the area of impervious surface on the user's property, with credits for innovative stormwater management features. The functions of the public corporation will include watershed stewardship provisions, standards and criteria development, regulatory compliance coordination, stream system management, and partnership in local stormwater programs.

Currently the BCWC is working to have the structure of the public corporation and fee structure prepared for public dissemination prior to the referendum. It is envisioned that the BCWC membership would elect the Board of Directors of the corporation and continue to serve in an advisory capacity tasked with proposing stormwater projects to the Board for funding and public education. The BCWC has already developed a list of 15 priority projects, one of which is developing regional detention within the D'Olive Creek Watershed (D'Olive Creek between I-10 and U.S. 90). Based on various preliminary fee structures being considered, the potential revenue that could be generated by the public corporation is estimated to range between \$1.5 million and \$3 million annually.

9.2.3 Evaluation of Stormwater Utility Fee Approach

Advantages – Unlike most other vehicles, this financing mechanism potentially allows benefited properties to be assessed a fee.

Disadvantages – The assessment power is effectively divided between the county and any municipality in which the properties and improvements are located. Many of the properties served by the improvements may not be "benefited" by the improvements in the sense of having their value increased, since they may be located upstream from the problems. There likely would be political issues with any assessment scheme over a broad area.

9.3 Property, Sales, or Other Taxes (General Fund)

Use of a "general fund" to finance stormwater improvements is undesirable for many reasons. When there is no dedicated source of continuing and consistent funding, the success of a stormwater program is limited. When governments depend upon general funds for stormwater maintenance and construction projects, such projects must compete with other community needs for dollars. In such situations, stormwater projects often lose out to other priorities, such as police, fire, and emergency medical personnel, and are sensitive to budget cuts (Spitzer, 2010).

Many communities have funded stormwater management from property taxes paid into their general funds. The total cost of stormwater management is not readily apparent when these costs are sprinkled among general fund departmental budgets. As stormwater management costs increase, general fund budgets are often not increased to meet those needs. In addition, tax-exempt properties do not support any of the costs, even though it can be shown that many of them, such as governmental properties and schools, are major contributors of stormwater runoff. Finally, property taxes are based on assessed property value, not on the amount of impervious surfaces on the property. The cost of stormwater service to individual properties also bears no relationship to the assessed value of the property. Therefore, this method of recovering stormwater management costs might not be equitable (EPA, 2008).

Because of their unpredictable nature, general sales taxes are often inappropriate for long-term infrastructure maintenance and capital improvement planning (Leo, 2010). A Special Purpose Local Option Sales Tax (SPLOST) has been used to fund stormwater improvements on a county-wide basis. For example, five SPLOSTs that have been implemented in the City of Athens, Georgia and other municipalities in Clarke County, Georgia generate approximately $25 million per year for county-wide stormwater projects (Berahzer, 2010a). Typically, a referendum is required to implement a SPLOST.

Other types of taxes to finance environmental improvements may include levies on tourism (hotels and convention centers), gasoline, cigarettes, and concessions at stadiums.

9.4 Federal Grants, Loans, and Revenue Sharing

9.4.1 Introduction

The United States Federal government provides numerous sources of grants, loans, and revenue sharing that may be used by municipalities and non-profit groups to conduct studies and construct projects related to watershed protection, stream restoration, and stormwater management. A composite list of Federal funding opportunities is included in Table D-1 in Appendix D. The name of the funding program, contact information (including a web site), a description of the program, and the current application deadline (if applicable) are included in this tabular list. The following two searchable electronic databases are listed first in Table D-1.

- The Clearinghouse for Federal Grant Opportunities (also known as Grants.gov) is a central storehouse for information on over 1,000 grant programs providing approximately $500 billion in annual awards. The site also includes information about project funding that is available under the American Recovery and Reinvestment Act (i.e., "Stimulus Funding").

- The EPA Catalog of Federal Funding Sources for Watershed Protection is a searchable database of financial assistance sources available to fund a variety of watershed protection projects.

Also, 38 specific funding programs offered by 9 different Federal agencies are summarized in Table 9-1 and listed separately in alphabetical order by agency name in Table D-1 in Appendix D.

Table 9-1. Federal Agencies Offering Funding Programs

Acronym	Agency Name	Number of Programs
EPA	Environmental Protection Agency	8
FEMA	Federal Emergency Management Agency	2
NOAA	National Oceanic and Atmospheric Administration	5
USACE	U.S. Army Corps of Engineers	7
USDA	U.S. Department of Agriculture	6
USDOI	U.S. Department of the Interior	2
USDOT	U.S. Department of Transportation	1
USFWS	U.S. Fish and Wildlife Service	5
USHUD	U.S. Housing and Urban Development	2

9.4.2 Current Local Funding

Several governmental entities and non-profit groups in Baldwin County have already applied for and/or received funding from these and other agencies/programs to finance projects and studies for environmental improvements in the D'Olive Watershed. The majority of the applications for financial assistance have been made to address particular problem areas, issues, or conditions. Examples include the following:

- Daphne has applied for USDOI Coastal Impact Assistance Program grants for the restoration of an unnamed tributary of D'Olive Creek, the restoration of an unnamed tributary of Tiawasee Creek, and for assistance in developing a D'Olive Watershed Foundation to administer a stream and wetland mitigation bank.
- Daphne was awarded a grant from the USDA Natural Resources Conservation Service (NRCS) for two streambank stabilization projects in the Watershed, the construction of which were underway at the time this WMP was prepared.

- Daphne completed a NRCS stream restoration project in 2009.
- Daphne has also submitted several proposals to the USFWS for stream restoration and land preservation projects that could be funded under that agency's recently expanded Coastal Program.

Daphne is also addressing redevelopment issues related to urban stormwater management through a planned retrofit of the Jubilee Square shopping center parking lot. The retrofit project is being funded in part through the Alabama Department of Environmental Management under an EPA Section 319 grant. The effort will involve the use of Green Infrastructure/Low Impact Development (GI/LID) techniques (see Section 6) to reduce impervious cover and enhance on-site infiltration and retention of stormwater runoff. Under the EPA State and Tribal Assistance Grants Program, Daphne has also applied for a special appropriations grant to conduct an inventory of the City's stormwater infrastructure.

The City of Spanish Fort is working with a consulting firm on a grant to fund needed drainage improvements. The drainage issue of primary concern to Spanish Fort is not in the D'Olive Watershed, but deals with stormwater flows from Spanish Fort Estates into Bay Minette Creek. To date, Spanish Fort has not pursued grant opportunities in the D'Olive Watershed because of limited manpower and experience with the process.

According to the Baldwin County grants coordinator, Baldwin County has not received any grants for projects in the D'Olive Watershed. Baldwin County does not have any watershed-related grant applications in progress, and does not keep records of grants applied for but not received.

9.4.3 Advantages and Limitations of Grant Funding

The efforts described above can and will result in incremental environmental improvements. However, one objective of this WMP is to coordinate the various projects and studies so that the overall needs of the D'Olive Watershed are met. Once the priority areas are identified, local governmental entities and non-profit groups will be better empowered to identify priority projects; choose potential funding opportunities and sources; coordinate the respective grant/loan application processes; and ultimately improve the chances of successfully obtaining funding from those sources.

Several of the potential funding sources included in Table D-1 in Appendix D are appropriate for projects, studies, or issues involving coastal and/or estuarine areas. These funding sources should be considered because of the close relationship of the D'Olive Watershed with D'Olive Bay and Mobile Bay.

The governmental entities and non-profit organizations having an interest in the D'Olive Watershed should also consider working with those Federal agencies (e.g., the USACE) that offer larger dollar-value grants and/or study opportunities that can lead to the funding of additional construction projects.

Governmental grants are popular because the funds received do not have to be repaid to the grantor agency. However, grants discourage consideration of long-term costs. The effort to apply for a grant may not pay off. Grant parameters are often force-fitted by grant writers in order to qualify for a particular opportunity. The matching funds required by some grants can be problematic. As dollars for grant funding decrease in the current economy, the grant writing process becomes highly competitive (Berahzer, 2010b).

9.4.4 State Revolving Funds

The EPA State Revolving Fund (SRF) Loan program (see Table D-1 in Appendix D) offers a more reliable source of funding (Berahzer, 2010b). There are separate SRFs for Clean Water and Drinking Water. Funds are provided annually to each state by the Federal government, with the states providing a 20% match. In order to be funded, a project must be on the State's annual "Intended Use Plan" (IUP) list. The IUP contains a "comprehensive" list and a shorter "fundable" or "priority" list. A public comment process is required for the IUP. Since 2007, the SRF has moved beyond the traditional "water treatment works" projects and has begun to emphasize nonpoint sources and estuary protection as funding priorities.

The 2009 American Recovery and Reinvestment Act (i.e., ARRA, Stimulus Act) provided additional funding for environmental projects. In 2009, the EPA introduced as a part of its SRF Loan Program an additional subsidization in the form of grants, low or negative interest loans, and/or loan forgiveness (Berahzer, 2010a). In 2010, at least 30% of the SRF funds must be made available to applicants in the form of forgiveness of principal, negative interest loans, and/or grants (compared with 50% in 2009).

A March 2010 survey of SRF managers in thirty-two states (Berahzer, 2010a) indicated that the State of Alabama, in order to meet this requirement, is considering using partial or complete principal forgiveness of its SRF loans, which avoids classification of the subsidy as a grant (and the attendant paperwork). The survey also indicated that Alabama will also give its 30% priority to "green" projects (see Section 9.5). A draft policy for administering the subsidization process was under review in Alabama, as of April 21, 2010. According to the ADEM web site at www.adem.alabama.gov/ programs/water/srf.cnt, the SRF program is seeking potential applicants for green infrastructure projects.

In Alabama, the Clean Water State Revolving Fund (CWSRF) and the Drinking Water State Revolving Fund (DWSRF) are low interest loan programs intended to finance public infrastructure improvements. The programs are funded with a blend of state and federal capitalization funds. ADEM administers the CWSRF and DWSRF, performs the required technical/environmental reviews of projects, and disburses funds to recipients. Any local governmental unit, including water boards and authorities, may apply for SRF financing in Alabama. An ability to repay must be substantiated, along with meeting other specified standards. .The benefits of an SRF Loan include:

- Loan interest rate of about 1.5%-to-2.0% less than the prevailing municipal bond rate available to "AAA" rated municipalities;
- Fixed interest rate with a 20-year payback;

- Loan repayment does not begin until construction completion date (capitalized interest accrues);
- Loan recipient is not required to pay any ongoing trustee expenses or rebate expenses normally associated with a local bond issue.

Projects that strengthen compliance with Federal and State regulations and/or enhance protection of public health are eligible for consideration to receive an SRF loan in Alabama. If a project qualifies, the engineering, inspection, and construction costs are eligible for reimbursement. Among the projects which qualify for funding are: publicly owned water or wastewater treatment works; sewer rehabilitation; interceptors, collectors, and pumping stations; drinking water storage facilities; new/rehabilitated water source wells; and water transmission/distribution mains. Drinking water projects that are primarily intended to serve future growth are not eligible.

9.5 "Green" Stimulus Funding

Under the 2009 American Recovery and Reinvestment Act (i.e., Stimulus Act), the EPA introduced as a part of its SRF Loan Program a Green Project Reserve and maintained this funding mechanism in FY 2010. The Green Project Reserve stipulates that not less than 20% of the SRF funds shall be used by the states for projects that address green infrastructure, water or energy improvements, or other environmentally innovative activities (Berahzer, 2010a). Some green infrastructure projects may fit into either the Clean Water or Drinking Water divisions of the SRF program. In general, the combination of the Green Project Reserve and the additional subsidization (see Section 9.4) could lead to better financing terms for stormwater projects.

ADEM has issued its FY 2009 Intended Use Plans for the Clean Water State Revolving Fund and the Drinking Water State Revolving Fund. The plan lists the eligible applicants that have been approved to apply for SRF/ARRA funding. ADEM continues to accept applications, especially for green infrastructure projects. Any applications received during this funding cycle will be held for standby funding should any of the applications on the funding list fail to comply with all requirements of the SRF and ARRA or if additional funding becomes available.

Many stormwater projects and Low Impact Development (LID) strategies may be considered "green" under this funding category. Examples include porous pavement, bioretention facilities, rain gardens, green roofs/walls/streets, wetland restoration, constructed wetlands, urban retrofit programs, LID projects, infiltration basins, landscaped swales, downspout disconnection, and tree planting. Land acquisition services and the actual cost for the purchase of land or easements may also be included in the scope of this definition. A March 2010 survey of SRF managers in thirty-two states indicated that communities need ideas for tapping into this potential source of "green" stimulus funding (Berahzer, 2010a).

9.6 Non-Governmental Organizations and Other Private Funding

Private foundations and corporations may be another source of funding for improvements in the D'Olive Watershed. Seven selected funding sources available from non-governmental organizations (NGOs) and other private entities are listed in Table D-2 in Appendix D. Contact information, a web site, and a description are provided for each funding source.

Three of the listings are searchable electronic databases of foundation and corporate grants in various fields: (1) the Chronicle of Philanthropy Guide to Grants; (2) the Community of Science Database; and (3) the Foundation Center. Local governmental entities and non-profit agencies involved with the D'Olive Watershed should investigate these databases with specific project objectives in mind.

The Kodak American Greenways Program, RBC Bank Blue Water Project Grants, and Surdna Foundation Sustainable Environmental Grants offer specific funding opportunities for environmental improvement projects related to watershed protection and Green Infrastructure (GI). These programs are listed because of their direct applicability to ongoing efforts in the watershed.

The Water Environmental Research Foundation Cooperative Agreement has been allocated $10 million in EPA funds to evaluate new technologies that will help utilities cope with aging and failing water and wastewater systems, including $6.25 million in research grants for innovative treatment technologies for stormwater and water reuse. This source of funds may prove useful to Baldwin County and to the Cities of Spanish Fort and Daphne.

9.7 Mitigation Banks

A mitigation bank is a designated and approved wetland or stream area that has been created, restored, enhanced, or preserved and set aside in perpetuity to compensate for future unavoidable impacts to wetlands and waters of the United States. Credits are purchased at the bank as compensatory mitigation for other development projects, ideally within the same watershed. Mitigation banking provides opportunities for a county or city to partner with land owners and land trusts; accrue financial resources for community improvements; create natural amenities in an urban setting; and enhance education about restoration and water quality (Leo and Tillery, 2010).

Authorized under federal environmental law and regulations, a mitigation bank provides an asset that can be sold to developers and government entities whose projects require mitigation of stream and/or wetland damage. If formed for all or part of an affected watershed, a mitigation bank effectively allows the sale of credits that can be used to offset some portion of the costs of the initial set-aside area. The regulatory process involves a prospectus and public notice; the development of a banking instrument; restrictive covenants, and coordination with various agencies that have jurisdiction over the process.

Municipalities are a major user of mitigation banks. The mitigation banking concept is based on supply and demand. The demand is determined by regulatory activities that require mitigation for impacts of specific projects, and the price of mitigation credits is variable and determined by the market (Leo and Tillery, 2010). Impacts to streams and wetlands are required to be mitigated per federal statutes, including Sections 404/10 of the Clean Water Act and the 2008 Federal Compensatory Mitigation Rule. Compensatory mitigation can be satisfied through mitigation banks, in-lieu fee programs, or permittee-specific mitigation.

In coordination with the USACE, unavoidable impacts to waters of the United States are determined by the loss of amount, function, and/or type. The loss is converted into a required credit value to offset the impact (adverse impact factors). The impacts must be offset through mitigation credits created by restoration activities. Credits impacts and credits generation are calculated based on USACE standard operating procedures, which may vary by region. Net benefit factors may be included in the calculation of mitigation credits (Leo and Tillery, 2010). A major factor affecting mitigation credit values is the "market" demand for wetland and stream mitigation and the extent of the "service area" designated for specific mitigation banks.

Advantages – Mitigation banks can be useful to fully or partially finance large-scale, expensive projects. May generate funding from outside the affected area, rather than relying on local assessments, fees, taxes, or other public revenues. Mitigation banks would allow a municipality, county, or non-governmental entity to become a generator of mitigation credits instead of being a consumer of those credits. Credits may be used for internal needs or sold to external purposes to generate funds. May be used as a revenue source to implement restoration projects and maintain compliance with the requirements of NPDES permits (e.g., TMDLs). Funds raised through the sale of mitigation credits may partially or completely offset the costs of some stormwater improvement projects.

Disadvantages – Effectively requires ownership or control of a large site on which to implement the mitigation bank. In most cases, this method of funding also requires regulatory approval and significant upfront capital to pay the initial costs of creating the improved streambeds and/or wetlands. It is not likely that the projected flow of funds would support the initial financing without other credit support. Considerable time and effort may be required to set up properly and implement mitigation banks. Requirements include a credit release schedule, monitoring requirements, biotic success criteria, maintenance and adaptive management, monitoring, and reporting requirements.

Possible Use – If one or more public bodies are willing and able to bear the risk of financing, later sales of mitigation credits could offset their eventual out-of-pocket costs of paying off the debt. The mitigation bank site should be watershed-based, have the potential to provide environmental benefits, and be located in a service area that has the potential for development (i.e., to promote the sale of future credits).

9.8 Impact Fees

Impact fees are paid by developers (usually at the time of development) in order to obtain a building permit. The fee is designed to reimburse the government for the additional "impact" a given improvement may have on the community. Impact fees may be for transportation (i.e., increased impact on roads/bridges as a result of constructing a development), water/sewer (i.e., repaying the government for the impact of taking capacity out of the system), or other public infrastructure. Typically, there must be a direct relationship between the development and the impact fee charged. Impact fees, which must often be authorized by statute, are used for capital improvements, not maintenance. They are paid one-time, up-front for new construction (Mustian, 2010).

Advantages – Impact fees allow funding to be generated from the entity actually causing the potential environmental impact.

Disadvantages – Impact fees do not necessarily fit well with stormwater improvements. Developers do not like impact fees. Such fees do not provide a steady source of revenue. Timely expenditure of funds can also be an issue.

Possible Use – Funds generated by impact fees can used to fund regional capital solutions, such as urban retrofits.

9.9 Special Assessments

A special assessment is a charge levied for the "benefit" a given property receives for a specific public improvement. The cost/benefit must be related to the property itself. Special assessments may be based on property area or frontage. Special assessments are distinguishable from taxes, but they have been challenged in court. They may be used to fund capital and operating costs. In some states, special assessments may be placed on the tax rolls and achieve the same status as ad valorem taxes. However, there may be issues with assessing governmental property and property owned by non-profits that are not on the tax rolls. Collection of special assessments can be spread out over time.

Special assessment fees for the maintenance of public sewers and septic tanks have been assessed in some communities. The Chesapeake Bay, Maryland Restoration Fund has a $2.50 per month "flush fee" that provides over $65 million per year for upgrades to wastewater treatment plants and $12.6 million per year for septic tank repair and cover crops (Berahzer, 2010a).

9.10 System Development Charges

System development charges (also known as connection fees or tie-in charges) are one-time fees commonly charged to new customers connecting to a water or sanitary sewer system to buy into the infrastructure that has already been built for them and/or to pay their fair share of the infrastructure expansion necessary to serve them. The amount of the new customer's system development charge is typically calculated on the basis of the potential water demand that the new customer will place on the system. Stormwater system development charges can also be used. The amount of a customer's stormwater system development charge is typically tied to the area of the customer's property (EPA, 2008).

9.11 Environmental Tax Shifting

Environmental tax shifting is a creative concept that has been proposed by environmental groups to redirect tax code incentives to support energy conservation and to sustain the environment. Examples include: (1) a pay-to-pave tax could be levied on newly paved surface on a per-square-foot basis; and (2) the discontinuance of the state tax exemptions for fertilizer and pesticide sales. The income from these measures could then be directed toward stormwater management or other environmental projects (EPA, 2008). Environmental tax shifting approaches may not receive the public or political support necessary for acceptance and implementation.

9.12 Municipal Bonds

States, cities, and other municipal subdivisions issue municipal bonds. Their purpose is to fund credit-worthy municipal projects, such as housing, hospitals, lighting systems, parking ramps, stadiums, factories, and sewer systems. There are two basic categories of municipal bonds: (1) general obligation; and (2) revenue bonds. The difference between the two types is the kind of collateral used to secure their payments of interest and principal.

According to Morningstar (i.e., http://news.morningstar.com/classroom2/), general obligation bonds offer investors a relatively safe investment vehicle while providing state and local governments with funds for community improvement. General obligation bonds finance projects that do not produce income but provide services for the entire community, such as roads and bridges or parks. General obligation bonds are typically backed up by ad valorem taxes. A double barrel, or combination bond, is a general obligation of the issuer and is also secured by a particular revenue source outside the general fund.

Revenue bonds are municipal bonds that finance income-producing projects. The income generated by these projects pays revenue bondholders their interest and principal. Projects funded by revenue bonds serve only those in the community who pay for their services (e.g., as line items on utility bills). Income from a municipal enterprise is put into a revenue fund. From this fund, expenses for operations are paid first. Only after operations expenses are paid do revenue bondholders receive their payments. Because they are not backed by the full faith and credit of a municipality as are general obligation bonds, they carry a somewhat higher default risk for which they offer higher interest rates.

Approximately 85% of bond sales (issues) are negotiated and 15% are competitive. Most bonds mature in 20 to 30 years. Not all the bonds in an issue mature at the same time. Bond issues with staggered maturity dates are known as serial bonds.

The financing team for a municipal bond deal may include an investment banker/underwriter; financial advisor; bond counsel; underwriter's counsel; disclosure counsel; government representatives; and a trustee. Current risk-averse conditions in the financial markets have negatively affected bond rates and liquidity, as well as the availability of credit and insurance (Noga, 2010).

9.13 Capital Improvement Cooperative Districts

Authorized under Chapter 99B of Title 11, Code of Alabama, capital improvement cooperative districts can be formed by one or more governmental entities, including counties, municipalities, public utilities and public corporations such as industrial or commercial development authorities. Once formed, the districts can finance and construct various capital improvements and can then enter into arrangements, such as leases or contracts, to make the improvements available to users. The members of the district (i.e., the public bodies) can also contribute funding to finance the projects.

Advantages – Cooperative districts offer great flexibility. They can be comprised of various public bodies with an interest in the project. They can finance any project that could be financed by any of its members, so they effectively could have a very broad reach in acquiring, constructing and improving capital items for both public and private use. Cooperative districts can also be used to shield a governmental body from the potential liability of ownership of a particular improvement.

Disadvantages – Cooperative districts have no authority to assess private users for the benefits offered. They can charge for services or facilities only on a bilateral basis in which the benefiting parties agree on the charges upfront through a contractual arrangement. Thus, they are most helpful when providing a service or facility needed by potential users (i.e., utilities or even buildings for private use) that agree to be assessed a fee for the service or facilities. Cooperative districts are not well-suited to situations in which the improvements to be financed, such as drainage improvements on public property, are not of a type for which the owners of the benefited property would be willing to pay voluntarily, unless another entity (such as a city or county) can assess for the improvements. A good example would be construction by a cooperative district of a sewage treatment plant for the use of multiple utilities, with which the district would have contracts for payment of the costs. In the case of stream or drainage improvements there is no obvious way to charge the benefited landowners without their consent.

Possible Use – If Baldwin County and the Cities of Daphne and Spanish Fort wanted to create a vehicle to collectively finance and make improvements on a watershed basis, they could form a cooperative district to facilitate that effort. Each could contribute to the costs incurred, either directly or through the payment of shares of the debt service on bonds issued by the district.

9.14 Alabama Improvement Districts

Authorized under Chapter 99A of Title 11, Code of Alabama, improvement districts are formed, upon application by all of the affected landowners, by a county or municipality. Once formed, they can acquire, construct and install a wide range of public infrastructure and can assess the landowners for their pro rata shares of the cost of the improvements. The assessments constitute liens against the land. Depending on the range of projects undertaken, the improvement districts can effectively become subunits of government for the purpose of providing services over and above those typically provided. For instance, they have been widely used for residential or multi-use developments as a means to provide for the initial and maintenance costs of infrastructure not provided by local government.

Advantages – The authority to assess and to create a lien on property provides a powerful financing alternative. Improvement districts are also ideally suited to construct and own public infrastructure.

Disadvantages – Landowner consent is obviously impractical across the area affected by the management plan.

Possible Use – If a particular project is proposed that affects a single significant property, or especially one required for the development or redevelopment of the property, an improvement district could be used to finance the project and assess the landowners for the cost. For instance, if Timber Creek or Lake Forest (or a smaller version of either) or a large shopping center were being developed that required drainage or retention facilities beyond the normal requirements, an improvement district could be a good vehicle.

9.15 Tax Increment Financing Districts

Authorized under Chapter 99 of Title 11, Code of Alabama, tax increment financing (TIF) districts have not been widely used in Alabama, but can be helpful under certain circumstances. They are designed for the redevelopment of blighted areas. In those areas, TIFs can effectively take the tax benefits of incremental increases in the value of the property vs. the status quo and apply the increases to the cost of the redevelopment. This is a unique financing structure based on a general obligation bond.

Advantages – Permits a municipality to take the increases in all local taxes to fund redevelopment projects. An improvement district does not require the consent of the property owners.

Disadvantages – TIF districts require significant time and effort to form, including an overall redevelopment plan and the opportunity for other taxing authorities to object. They also can be formed only where there is a finding of "blight," and as a practical matter can only finance projects in anticipation of significant increases in value of the surrounding property (i.e., requires growth).

Possible Use – Assuming an area within the D'Olive Watershed could be considered to be blighted, a TIF district could finance improvements (such as drainage facilities) that would be required in order to allow the construction of a significant development that would add to the tax value of the surrounding property.

9.16 Regional Collaboration Opportunities

The program name, contact information, description, and web site for five regional collaboration opportunities that are applicable to watershed projects are listed in Table D-3 in Appendix D. The EPA Region 4 sponsors the Green Infrastructure Partnership, Smart Growth Implementation Assistance, Southeastern Regional Water Quality Assistance Network, and Watershed Protection and Restoration Assistance collaboration opportunities. The Gulf of Mexico Alliance is a partnership of the states of Alabama, Florida, Louisiana, Mississippi, and Texas. Partnering with the Alabama Coastal Foundation, Daphne has applied to the Gulf of Mexico Alliance for an educational outreach grant to fund efforts to achieve community buy-in for the management measures that will be recommended in this WMP.

The primary goal of the Green Infrastructure Partnership is to reduce runoff volumes and sewer overflow events through the widespread use of Green Infrastructure management practices that help maintain natural hydrologic functions by absorbing and infiltrating precipitation where it falls.

The Smart Growth Implementation Assistance program is an annual, competitive solicitation open to state, local, regional, and tribal governments (and non-profit organizations that have partnered with a governmental entity) that want to incorporate smart growth techniques into their future developments.

The Southeastern Regional Water Quality Assistance Network (SERWQAN) is committed to strengthening the capacity of communities to develop and successfully implement watershed protection efforts. The network is based at the EPA Region 4 Environmental Finance Center, which helps governments at the local, state, and federal level answer the "how to pay" questions associated with environmental projects. SERWQAN, which is funded through the EPA Targeted Watershed Grant Program, currently provides technical, financial, community, and legal support to thirteen communities in the Southeast. The network has developed interactive tools that help communities make financial projections for the revenues needed for watershed protection, and has produced web sites that help communicate environmental educational messages to the general public.

Through the Watershed Protection and Restoration Assistance Partnership, the staff of EPA Region 4 works with state and local governments and watershed organizations to facilitate protection and restoration efforts in targeted watersheds.

The goal of the Gulf of Mexico Alliance is to significantly increase regional collaboration to enhance the ecological and economic health of the Gulf of Mexico. Priority issues for this group include water quality; habitat conservation and restoration; ecosystem integration and assessment; nutrients and nutrient impacts; coastal community resilience; and environmental education.

9.17 Bibliography of Stormwater Funding

Additional funding sources and methods may be identified by consulting a bibliography of stormwater funding options. An alphabetical list of 14 references related to stormwater funding (Table D-4 of Appendix D) is included to assist in this effort.

10.0 Community Outreach and Public Education

10.1 Introduction

This section of the Watershed Management Plan (WMP) outlines the Public Outreach and Education Plan that will be followed to address the diverse needs and responsibilities of affected stakeholders living or doing business within the D'Olive Watershed. Given the varying degrees of knowledge regarding the effects of ongoing urbanization on land use and water quality issues in the Watershed, outreach and education products will be developed that target different messages to different target audiences on issues relating to implementation of the WMP.

10.2 Purpose

The purpose of the Public Outreach and Education Plan is to create a strategy for building widespread community understanding of the water quality issues affecting the D'Olive Watershed and, through this understanding, to foster increased stewardship of the Watershed as addressed in the recommendations presented in this WMP.

10.3 Goal

The goal of the Public Outreach and Education Plan is to inform, educate, and engage key stakeholders in an effort to improve the water quality of the D'Olive Watershed and Mobile Bay estuary through the reduction of stormwater runoff and the mitigation of its impacts throughout the Watershed.

10.4 D'Olive Watershed Working Group

In 2005, after recognizing that a solution to the problems affecting the D'Olive Watershed would require a regional approach, local political and property owner representatives requested that a working group be formed to establish a systematic and scientifically-based approach to address water quality and nonpoint source pollution management issues. This led to the formation of the D'Olive Watershed Working Group (DWWG). The DWWG is a coalition of Federal, State and local agencies, county and local governments, property owners, developers, and commercial interests. Since its establishment, the DWWG has worked to gain an understanding of the magnitude, causes, and range of solutions needed to address the erosion and sedimentation issues affecting the D'Olive Watershed.

In 2009, the Mobile Bay National Estuary Program and the DWWG cooperated in issuing a Request for Qualifications to develop this WMP for the D'Olive Watershed. Throughout the watershed planning process, the DWWG served as an advisory board to ensure that the WMP reflects a commitment to: (1) supporting a regional approach to managing stormwater runoff and nonpoint source pollution; (2) maintaining the ecological integrity of the Watershed; and (3) protecting the Watershed from further degradation. The DWWG met periodically with the Contractor Team during work on the WMP to oversee and guide its development.

10.5 Primary Audiences

Local Government Officials: Local government officials are on the front lines of planning for the development of their communities, including taking actions necessary to protect the D'Olive Watershed. This stakeholder group includes Baldwin County Commissioners, Mayors, City Councilmen/Councilman, and City and County administrators.

Local Resource Managers: Although elected officials make the final decisions about issues related to management of the D'Olive Watershed, municipal and/or County staff members may offer recommendations to these officials. In addition, many State, Federal and private entities are engaged in watershed management protection activities. This stakeholder group would include municipal and County planning, parks and recreation, and engineering staffs; non-profit organizations such as the Alabama Coastal Foundation, Smart Coast, etc.; and representatives from the ADEM, ADCNR, ALDOT, U. S. Fish & Wildlife Service, and the U. S. Army Corps of Engineers.

Local Economic Development Planners/Recruiters: Maintaining a robust quality of life is a critical to economic development recruitment efforts. In coastal Alabama, "quality of life" issues are intrinsically tied to the region's rich and diverse environmental resources. This stakeholder group would include, but not necessarily be limited to, local chambers of commerce, business and development communities, and real estate companies.

Property Owners: Wise property management is a key to reducing stormwater runoff that is the root cause of the sediment transport and sedimentation issues within the D'Olive Watershed and D'Olive Bay. In addition, property owners are the primary beneficiaries of positive environmental changes that occur through effective watershed management. This stakeholder group consists of both residential and commercial property owners.

General Public: The everyday activities of individuals in the community can have a significant impact on the health of the D'Olive Watershed. This stakeholder group includes all members of the general public.

10.6 Targeted "Value Messages"

Implementation of the WMP will address different values that are important to each of the target audience groups. Outreach activities will be tailored to address the interests and needs of each target audience to address the particular "value added" needs of the members of the respective audiences that will be gained through the implementation of the WMP. The following target value messages will guide and be incorporated in outreach activities pursued for each stakeholder group:

Local Government Officials: Local government officials are charged with developing their communities to promote growth while avoiding negative costly impacts to the environment. The WMP includes information related to land use planning, including the adoption and enforcement of development codes, ordinances, and other regulations intended to preserve natural resources and encourage/require best management practices (BMPs) that address stormwater quality and quantity issues and impacts. The "value message" for this stakeholder group is:

> ***The WMP will provide local government officials with the information necessary to make wise decisions related to land use and transportation planning; development of construction regulations and BMPs; and recreational and economic development opportunities.***

Local Resource Managers: The WMP identifies conceptual management measures related to watershed protection, restoration, and conservation, as well as an estimate of the costs of those projects. The WMP also identifies and maps critical areas and discusses management issues that need to be addressed to improve the overall health of the D'Olive Watershed. The "value message" for this stakeholder group is:

> ***The WMP provides information necessary to ensure water quality and habitat protection that is central to preserving the natural resources considered critical to the "quality of life" for those residing and/or working within the D'Olive Watershed.***

Local Economic Development Interests: The WMP will be valuable for guiding new industrial, commercial, or residential growth within the D'Olive Watershed. The WMP identifies Green Infrastructure/Low Economic Development measures that can contribute to maintaining the percentage of Impervious Cover below 25% within the overall Watershed. Pursuit of a variety of retrofits will help reduce stormwater runoff rates and volumes. "Smart development" practices will contribute to increasing property values and maintaining the "quality of life" characteristics of the D'Olive Watershed that have made this area attractive for residential development. Such growth can continue while at the same time placing greater focus on maintaining, conserving, and preserving important environmental resources within the Watershed that contribute to reducing stormwater runoff. The "value message" for this stakeholder group is:

> ***The WMP provides information necessary to make informed decisions regarding economic growth within the watershed while protecting waters and habitats that contribute to the coastal quality of life.***

Property Owners: Property owners can play a key role in reducing stormwater runoff volumes and rates. Implementation of the WMP can be a positive tool for homeowners, since they are often directly impacted by the effects of failing to effectively manage stormwater runoff. The "value message" to use in conducting outreach to this stakeholder group is:

> ***The WMP provides guidance to property owners to enable them to individually manage stormwater runoff on their property, while identifying the benefits that can result from implementation of the recommendations that protect property throughout the D'Olive Watershed.***

General Public: Individual community members play an important role in maintaining a level of water quality that will support the quality of life used to promote economic growth. The "value message" to use for this broad stakeholder group is:

> ***The WMP represents a successful community-based, public-private partnership approach to take the actions necessary to protect the water quality, habitats, and living resources of an individual watershed to maintain economic, recreational, and aesthetic values.***

10.7 General Public

Webpage: The DWWG webpage, hosted at www.mobilebaynep.com and created during the watershed planning process, should continue to foster awareness of and education on watershed protection issues at the community or regional level. The webpage should also serve as an information clearinghouse for other educational materials and provide data and resources for target groups.

Contributions to Local Newsletters: Articles providing updates on the progress of implementation of the WMP should be submitted to existing newsletters issued by the individual property owners associations, other interest groups, businesses, or municipal and County governments.

Press: Many people receive their news primarily from television or radio. The DWWG should work with the media to ensure coverage of WMP implementation milestones. Story ideas regarding WMP implementation should be provided to the following:

WALA – Fox 10

WKRG –Channel Five

WPMI – Channel 15

Mobile *Press Register*

Baldwin Register

Mobile Bay Times

The Daphne Bulletin

The Spanish Fort Sun

Mobile Bay Monthly

Television Public Service Announcements: Creating PSAs for television and radio provides an immediate impact with a visual and/or audio message. Different target audiences can be reached at specified times of the day by broadcasting messages on certain cable television and radio stations.

Other Advertising: Other advertising such as billboards and newspaper or magazine ads may also be considered to encourage actions that promote implementation of the WMP.

Demonstration Projects: Demonstration projects can be very helpful in showing that: (1) better watershed management practices are attainable and (2) actions similar to those prescribed in the WMP will reduce stormwater impacts. Undertaking demonstration projects in subdivisions, on government-owned properties, or in private commercial developments provide real life examples of actions that can be taken to reduce non-point source pollution and stormwater runoff and the challenges associated with those actions.

10.8 Local Government Officials

Nonpoint Education for Municipal Officials (NEMO) Workshops: The NEMO program, coordinated by the Alabama Department of Environmental Management (ADEM) Office of Education and Outreach, provides free workshops for municipal officials regarding the impacts of land use on water quality and how to manage those impacts. NEMO workshops should be coordinated and planned in partnership with ADEM and the Coastal Alabama Clean Water Partnership to provide more in-depth information pertaining to the recommendations presented in the WMP, including Low Impact Development design and Green Infrastructure planning.

Local Resolutions: The commitment of local municipal officials to the goals of the WMP is critical to its successful implementation. The Cities of Daphne and Spanish Fort and Baldwin County should be encouraged to pass resolutions that call for the adoption of the D'Olive WMP and state a commitment to achieve the goals outlined within the WMP.

10.9 Local Resource Managers

Technical Information Library: Data, publications, reports, and other information related to the D'Olive Watershed should be cataloged and made available through the DWWG webpage.

GIS Data Transfer: Specific GIS data created for the WMP should be reproduced and distributed to local resources managers to better inform decision-making and planning efforts in the D'Olive Watershed. This information should also be made available through the DWWG webpage and updated as necessary.

Green Infrastructure Planning Workshops: The NOAA's Coastal Services Center facilitates workshops that are designed to provide an overview of Green Infrastructure planning to local resource managers and other interested stakeholders. Green Infrastructure workshops should be presented in coordination with the Coastal Services Center to educate local resource managers about implementing Green Infrastructure into future land use planning efforts in the D'Olive Watershed.

10.10 Local Economic Development Interests

Economic Development Community Meetings: To mitigate the impacts on stormwater runoff from future development within the D'Olive Watershed, it is important that local economic development interests are informed of the goals of the WMP and provided an opportunity to discuss ways that they can contribute to its implementation. In partnership with the Baldwin County Watershed Coalition (BCWC), a roundtable to accomplish this objective should be planned for developers, commercial property owners, chambers of commerce, real estate companies, and other key development and business interests. A recognition program, developed in partnership with the BCWC, should also be developed to acknowledge businesses that adhere to the BMPs prescribed in the WMP.

Low Impact Design Courses: Several local organizations work with realtors and developers and have developed workshops and online courses pertaining to land use issues. In partnership with these organizations, an effort should be made to provide workshops or online courses with a focus on educating realtors, developers, and businesses in the D'Olive Watershed about Low Impact Development design concepts.

10.11 Property Owners

To address priority issues affecting the D'Olive Watershed, public education programs should focus on communicating the importance of landscaping, lawn care, onsite retention of stormwater, and the prevention of riparian buffer encroachment.

Riparian Buffer Education: Maintaining the integrity of riparian buffer systems will require a strong education program for the owners of property adjacent to streams in the D'Olive Watershed. In order to prevent homeowner encroachment on key buffer areas, property owners adjacent to these areas should be educated about the importance of riparian buffers to water quality protection.

Pilot Rain Barrel Installation Program: A pilot rain barrel installation program should be implemented to increase the visibility of rain barrels and to promote the use of this and other stormwater retention techniques by property owners. In addition, information about rain barrels and stormwater retention should be disseminated through other outlets such as property owners associations, garden clubs, and at public outreach events.

Water Quality Monitoring: Implementation of a formal volunteer water quality monitoring program within the D'Olive Watershed is recommended to increase the understanding of water quality impacts from non-point pollution sources; to increase public stewardship; to provide for long-term water quality data to guide local decision making; and to measure the progress toward meeting water quality goals as they relate to reduction in sediment transport in the Watershed.

11.0 Monitoring

A monitoring program to track the efforts and success of this Watershed Management Plan (WMP) should be developed and pursued in a consistent fashion. The Monitoring Program should clearly define the questions that need to be answered. Monitoring should be focused on assessing the implementation of recommended management measures and the success of those measures in accomplishing the goals and objectives stated in Section 5 of this WMP. Development of the Monitoring Program complies with the specific grant requirements of Section 329i of the Clean Water Act. The Monitoring Program should include at a minimum the activities described in the following subsections.

11.1 Joint Annual Inspections

Following approval of the WMP, Baldwin County, Spanish Fort, Daphne, the Alabama Department of Environmental Management, and the Mobile Bay National Estuary Program should establish an intergovernmental "Watershed Restoration Task Force." Based on the recommendations within this WMP, the Task Force should collaborate in developing a "Programmatic Watershed Restoration Plan" to guide a sustained effort to implement measures aimed at reducing stormwater runoff; halting active head-cutting and channel erosion processes that are affecting the streams in the D'Olive Watershed; and reducing the delivery and transport of sediments to Watershed streams. The Task Force should conduct a joint annual inspection of the Watershed. To assure consistency, the annual inspections should occur during September or October of each year.

The first annual inspection should be conducted in 2010 to establish the baseline conditions against which the results of subsequent annual inspections will be measured. Using GPS, permanent photo points should be established to assure consistency in the field photos taken over the ten-year life of this WMP.

The annual inspections should be focused on monitoring the current condition of the Watershed streams to address that status of the stream and wetland degradation areas identified in Figure 4.1 and quantified in Table 4-1 and 4-2. The annual inspections should attempt to (1) determine if the major problem areas are expanding or have been effectively mitigated; (2) assess the effectiveness of management measures implemented to date; (3) assess the overall implementation status of recommended management measures against the Master Implementation Schedule discussed in Section 11.3; and (4) reconsider the implementation priorities to determine if adjustments are in order.

The observations developed from the annual inspections will be documented in an "Annual State of the D'Olive Watershed Report" that will be submitted to the Daphne and Spanish Fort City Councils, Baldwin County Commission, Alabama Department of Environmental Management, Mobile Bay National Estuary Program, and D'Olive Watershed Working Group. The data collected in the field should be presented in an electronic map form, which can be used to prepare annual inspection data layers that are compatible with the Baldwin County GIS. As appropriate, the Task Force may elect to incorporate sediment loading and Impervious Cover information if current data are readily available.

The 2015 evaluation of the WMP should summarize the results of the first five "Annual State of the D'Olive Watershed Reports." That summary should determine if any trends in the overall condition of the streams can be ascertained since the WMP was approved in 2010 and implementation of the recommendations in the WMP was begun.

11.2 Watershed Condition Indicators

Two parameters have been identified that can be effectively used to "indicate" the overall condition of the D'Olive Watershed: (1) sediment loading; and (2) percent Impervious Cover. Both parameters can be measured by accepted methods and procedures. An existing, though admittedly limited, database is available for historic comparison purposes. Attempts should be made to begin collecting the data for these two parameters in 2010, following approval of the WMP.

11.2.1 Sediment Loading

The effects of excessive stormwater runoff are manifested in the resulting sediment loads carried by the Watershed streams. The sediment loads are greatly elevated over naturally generated levels by a considerable margin. Sediment loads provide the most obvious indication that the D'Olive Watershed is experiencing accelerated erosion due to stormwater runoff. Suspended solids contribute to the "muddy" water seen after heavy rain events that can extend well into Mobile Bay. The bedload component mostly accumulates in the lower reaches of D'Olive Creek, Tiawasee Creek, and Joe's Branch; or becomes deposited in Lake Forest Lake. The effectiveness of this WMP will be assessed in part by how much sediment loading rates are reduced in the future as the recommended management measures are implemented.

As discussed in Section 3.1.3, the D'Olive Watershed streams are included on the State's 303(d) list of Impaired Waters. The impairment is attributed to "siltation" (habitat alteration) due to "Land Development." A sediment loading TMDL has been scheduled by ADEM for development by 2013. Timely and meaningful development of an effective TMDL will be facilitated by the availability of sediment data directly applicable to the D'Olive Watershed. The Geological Survey of Alabama has developed baseline sediment loading data that can be considered for that purpose (Cook and Moss, 2008). Additional sediment loading data collected before 2013 will strengthen the TMDL development process.

Over the next ten years, discharge and sediment loading data (i.e. total suspended solids fraction, bedload fraction, and total sediment load) should be measured a minimum of four times each year to better capture variabilities in discharge and sediment loadings over the course of each year. The sampling efforts should be devoted to collecting sediment data under a range of flow conditions to better define sediment and discharge rating curves and to determine if any shifts in these curves occur over the 10-year period addressed by this WMP. To facilitate comparisons with historical data, the sampling methodology utilized by Cook and Moss (2008) should continue to be followed, with samples collected at each of the primary sampling sites used in their study of the D'Olive Watershed.

In addition, flow gauges should also be established on D'Olive Creek and Tiawasee Creek immediately upstream of their entry into Lake Forest Lake. Interpreting temporal variability of sediment loading from differing rainfall/flow conditions will be essential in order to ascertain long-term trends. If it is possible to assemble reliable sediment and flow databases for the Watershed streams, an attempt should be made to improve upon the existing sediment rating curves (i.e. stream discharge vs. sediment loads) developed by Cook and Moss (2008).

An annual data report should be submitted to Baldwin County, Daphne, Spanish Fort, Alabama Department of Environmental Management, Mobile Bay National Estuary Program, and the D'Olive Watershed Working Group. In 2015, the accumulated annual data reports should be analyzed to assess the effectiveness of the WMP management measures implemented as of that timeframe and to determine if any mid-course adjustments are required in the implementation of the "Programmatic Watershed Restoration Plan." The analysis will determine if a trend can begin to be ascertained for stormwater runoff and sediment loading rates between 2010 and 2015.

Monitoring sediment loading will assist in satisfying the requirements of Section 319h which requires:

> "…A set of criteria that can be used to determine whether loading reductions are being achieved over time and substantial progress is being made towards attaining water quality standards and, if not, the criteria for determining whether this watershed-based plan needs to be revised or, if a NPS TMDL has been established, whether the NPS TMDL needs to be revised."

11.2.2 Impervious Cover

The percentage of Impervious Cover for the D'Olive Watershed serves as a major indicator of watershed condition. The literature contains numerous examples where remote sensing imagery and technology has been employed to measure and monitor changes in Impervious Cover (IC) over time. An accepted and consistent methodology should be used to develop IC estimates.

IC should be measured periodically through 2020. IC measurements should be targeted to occur at 2-year intervals, depending upon the availability and quality of adequate remote sensing imagery and the costs to perform the required analyses of that imagery. The resulting data should be reported in electronic map format, with accompanying attribute tables to facilitate future data interpretation and analysis. The electronic map format should be compatible with the Baldwin County GIS so that separate Impervious Cover data layers could be prepared for each period.

Preparation of the initial baseline Impervious Cover data layer effort should include a related and necessary additional task to develop Impervious Surface Coefficients (ISCs) that reflect conditions within the D'Olive Watershed. Appropriate ISCs should be prepared to match each of the major Land Use/Land Cover categories reported in the Baldwin County GIS.

The 2015 analysis of the implementation status and effectiveness of the WMP should include an evaluation of Impervious Cover within the D'Olive Watershed as of that timeframe. For that purpose, the baseline and subsequent Impervious Cover data layers should be analyzed, by applying the ISCs developed for the Watershed to determine the percentage of Impervious Cover. To the extent allowed by available data and recent trends, a projection should be made on the anticipated percentage of Impervious Cover that could exist in the Watershed by 2020. This evaluation will also include an analysis of the effects of the WMP on Impervious Cover issues within the Watershed.

11.3 Implementation Schedule

A Master Implementation Schedule for the WMP should be prepared and centrally maintained by the "Watershed Restoration Task Force." The schedule should address each of the specific recommendations (i.e. management measures) contained in Section 12 of the WMP. Each recommendation should be listed as a major task, with necessary subtasks being included to facilitate implementation and monitoring efforts. The schedule should show "start" dates for each recommendation, and, where appropriate, "end" dates should be projected. As appropriate, important milestone dates should be identified and highlighted. In all cases, the entity charged with the responsibility for implementation of each recommendation should be clearly identified.

Development of the Master Implementation Schedule will satisfy the requirements of Section 319f and g:

f. A schedule for implementing the NPS management measures identified in this plan that is reasonably expeditious.

g. A description of interim, measurable milestones for determining whether NPS management measures or other control actions are being implemented.

The Master Implementation Schedule should be maintained on a regular basis, with the status of the schedule reported annually prior to the development of the governmental budgets for the upcoming fiscal year. Should the City Councils of Daphne and/or Spanish Fort and/or the Baldwin County Commission request more frequent updates, such requests should be honored.

In 2015, the schedule will serve as an important tool to assess the implementation status of the WMP and to suggest corrective actions to address any perceived deficiencies in the conduct of the overall management program.

11.4 Anticipated Costs

It is believed an adequate Monitoring Program can be established and pursued at a cost ranging between $100,000 to $150,000 each year. Following approval of this WMP and the creation of the "Watershed Restoration Task Force," the specific costs of the Monitoring Program should be determined by the Task Force based on more detailed scopes of work for the various monitoring program elements. It should be possible to apportion the monitoring costs between Daphne, Spanish Fort, Baldwin County, the Alabama Department of Environmental Management, and the Mobile Bay National Estuary. During preparation of the WMP, discussions with the Geological Survey of Alabama indicated that agency may have the capability of sharing in the annual costs of collecting the discharge and sediment loading data.

12.0 Recommendations

The following recommendations are identified for implementation during the ten-year period addressed by this Watershed Management Plan (WMP). The recommendations are not presented in any particular order of priority. Bullets are used to list the recommendations to better convey the message that the last recommendation is just as important as the first.

All of the recommendations should be implemented by the Watershed stakeholders to (1) restore the Watershed's hydrology to the extent feasible; (2) reduce sediment loads transported downstream to Lake Forest Lake and the D'Olive Bay/Mobile Bay system; (3) remove the D'Olive Watershed streams from ADEM's 303(d) list of impaired streams; (4) contribute to maintaining quality of life issues within the D'Olive Watershed; and (5) reduce the amount of future public funds which could ultimately be required to repair degraded streams in the Watershed. Many of the recommendations can be combined for strategic implementation purposes.

A major assumption considered in preparing the WMP is that the aggressive growth rate experienced by the D'Olive Watershed in recent years will continue, potentially producing an approximate 100% "build-out" condition by 2020. Without more effective stormwater management, the projected level of growth will greatly constrain viable stream restoration options. Time is of the essence, given the ongoing channel degradation problems that are being exacerbated with each significant rain event.

- Following approval of the WMP, Baldwin County, Spanish Fort, Daphne, the Alabama Department of Environmental Management, and the Mobile Bay National Estuary Program should establish an intergovernmental "Watershed Restoration Task Force." The Task Force would collaborate to provide guidance to implementing parties, monitor and evaluate the effectiveness of WMP implementation, seek funding, and promote education and outreach activities. A Watershed Coordinator position could be created to help coordinate the work of the Task Force and conduct the wide range of duties required to implement various provisions of the WMP. The Task Force could rely also upon a Citizen Advisory Committee composed of interested DWWG representatives to engage Watershed residents in restoration efforts.

- A "programmatic" stream restoration approach should be implemented, with oversight by the Watershed Restoration Task Force, as a sustained effort to halt the active head-cutting and channel erosion processes that are affecting the streams in the D'Olive Watershed. Over 20,000 linear feet of streams are estimated to currently be experiencing extreme channel degradation at a rapid rate. The major goal of this effort should be to arrest the further progression of head-cuts along the main stem stream channels and the numerous tributaries and smaller drainages that are being damaged by the extreme head-cutting processes. Initial work should be focused on the most upstream leading edges of the head-cuts on each stream to prevent further movement, with subsequent efforts being devoted to restoring the stream gradients downstream of the initial projects. Detailed site-specific solutions that employ the most appropriate corrective measures should be developed to best satisfy the needs and meet the challenges at each unique location. A master implementation schedule and cost estimate should be developed that reflects work priorities and risks to resources. From a work priority standpoint, emphasis should be placed on the tributaries to Joe's Branch and on D'Olive Creek (between Hwy. 90 and I-10) and its tributaries (particularly Tributary DA) since Cook and Moss (2008) estimated 83% of the total sediment load entering Lake Forest Lake was contributed by that drainage, while 17% of the sediment load is being delivered by Tiawasee Creek. Within the D/Olive Creek drainage, initial emphasis should be placed on Tributary DA which was responsible for 65% of the overall D'Olive sediment load, with 35% coming from the main stem of D'Olive Creek.

- Over 32,000 additional linear feet of D'Olive Watershed streams have the potential to be affected by the continued upstream progression of head-cutting and channel incision. If the present head-cuts are not halted from their ongoing upstream movement, the risk for future substantial stream channel and floodplain damages is high. The recommended Watershed Restoration Task Force should also develop and implement a regular monitoring program to assess the upstream stream reaches at greatest risk. It is recommended that this monitoring document the consequences of the most significant rainfall events, which can generate the greatest stormwater runoff amounts with the most significant potential for channel degradation.

- Much of the development in the D'Olive Watershed occurred before the effects of urbanization on watershed hydrology and stormwater runoff were well understood. Even for recent developments, post-construction stormwater requirements have focused mostly towards flooding issues (i.e., peak flow control by detention basins) rather than on water quality or runoff volume retention. While more informed management of stormwater from new developments is a principal element of this WMP, that alone cannot be expected to achieve hydrologic restoration objectives unless corresponding improvements of stormwater management in *already developed* areas are implemented. It is recommended that a comprehensive Stormwater Retrofit program be implemented for already developed areas. Selection and design of retrofit projects will differ when compared to design of stormwater systems for new developments, and will likely be more complex and expensive. Typically, retrofit projects are sponsored by public entities and funded by public sources, rather than the costs being borne by developers. Retrofit projects will usually require the cooperation and/or permissions of private entities. Coordination with and support from the community is a critical element.

- To varying degrees, each of the D'Olive Watershed's nine subwatersheds is experiencing problems relative to stormwater runoff and sediment transport. The Watershed Restoration Task Force should establish subwatershed priorities to assure that the greatest impact areas are addressed first.

- Develop a comprehensive Watershed model (or models) to provide Watershed managers a useful tool(s) to implement the WMP. A Watershed modeling approach could be useful to:
  - Evaluate impacts from future growth (i.e., increased runoff, increased sediment loadings) from future growth. This capability could be used for consideration of land use planning and to help establish watershed-specific "target" rainfall amounts as a "capture volume" standard to be incorporated in stormwater ordinances and development manuals.
  - Assist managers evaluate proposed new developments with respect to compliance with any new stormwater related codes or standards that are established for such new developments.
  - Evaluate potential retrofit measures in already-developed areas: (1) aid in selection of watershed-specific retrofit retention/capture volume targets; and (2) aid in the determination of how many and what types of retrofits (i.e., relative effectiveness) are needed to meet capture volume targets.
  - Allow quantitative estimates of sediment loadings that simulate both upland runoff and in-stream processes. This could be useful in responding to forthcoming TMDL requirements.
  - Model the dynamics of stream segments for stream restoration/stabilization design.

- Given the continuing level of development projected to occur in the D'Olive Watershed through 2020, it is recommended that greater emphasis be placed on establishing additional "green space" within the Watershed. Green space would help reduce increases in stormwater runoff, protect residual natural habitats, provide sites for future parks, increase the aesthetic appeal of the designated areas, and provide refuges of solitude for individuals in an otherwise intensely developed urban Watershed. Candidate "green space" tracts exist in the 204 acres of contiguous forest lands in the Lake Forest subdivision and the 117 acres in the Timber Creek subdivision. At the time this WMP was prepared, an additional 2,000 acres of upland forest lands existed outside of established subdivisions. Some of these lands could be designated for "green space." A collaborative Green Space Plan should be developed for the Watershed to identify appropriate candidate areas and the manner in which these areas could be acquired and maintained in an undeveloped condition. These "green space" areas should be centered along the riparian corridors that border the Watershed streams.

- The Baldwin County Horizon 2025 Future Land Use Plan suggests that the major Watershed streams in the unincorporated portions of the D'Olive Watershed be flanked by buffer lands. The Horizon 2025 Plan refers to these greenways/corridors as Conservation District lands, which are to have a minimum width of 400 feet. It is recommended that the City of Daphne evaluate the possibility of designating similar greenways within the undeveloped lands along the downstream portions of these same streams within the city's area of jurisdictional control.

- Conservation easements should be acquired for the remaining Grady Ponds that exist within the headwater drainage areas of the southeastern portion of the D'Olive Watershed. Existing drainage pathways connecting the Grady Ponds with Watershed tributaries should be modified/restored to enable these natural features to resume capturing and retaining stormwater runoff without endangering the long term existence of these natural features. Water control structures should be added to optimize the storage retention capacities of the Grady Ponds. These areas should be revegetated to speed recovery of the vegetation communities that typically occur within Grady Ponds. These natural features should be incorporated into the overall stormwater management system developed for the Watershed.

- A wetlands restoration/enhancement program should be implemented, including the removal of accumulated sediments (where feasible), removal of exotic plants, and reestablishment of desirable wetland species.

- The percentage of Impervious Cover in a watershed is the best indicator of stream restoration feasibility. According to the literature, streams in watersheds with more than 25% cover are "non-supporting." The amount of Impervious Cover in the D'Olive Watershed has already exceeded 20% and has the potential to reach 38% by 2020. The Baldwin County GIS should be expanded to include a new Impervious Cover data layer, which should be regularly updated. The amount of Impervious Cover can be estimated and monitored using remote sensing technologies. Based on their prior involvement in the D'Olive Watershed, the NASA Stennis Space Center may serve as a potential vendor to develop a compatible GIS Impervious Cover data layer. Also, Impervious Surface Coefficients should be developed to supplement the literature-approximated values considered in this WMP.

- Consideration of the potential to impact groundwater resources should be included among the criteria evaluated when analyzing stormwater runoff reduction management measures for the D'Olive Watershed.

- Concerns over the "shallowing" of Lake Forest Lake and the loss of usable volume due to sediment deposition have existed since the early 1970s. Community stakeholders should further evaluate the feasibility and costs of alternative restoration approaches in order to establish consensus-based goals and objectives for restoration. However, the volume of accumulated sediments in the lake remains a major unknown. Before an adequate lake-restoration project can be developed and implemented, the volume of sediments within the lake must be accurately determined. This will allow effective lake-restoration goals to be developed and the amount of sediments targeted for removal to be established in an informed fashion. Hydrographic and topographic surveying should be conducted, as well as geotechnical analysis of the deposited materials to gain an understanding of their composition and potential to be beneficially used. In addition to cost issues for the lake restoration project, a major component of such a project will be the designation of suitable dewatering/disposal locations for the removed materials.

- Two sedimentation basins should be established within the principal arms of Lake Forest Lake: D'Olive Creek and Tiawasee Creek. These basins would function to slow the rate of movement of the prograding sediment deltas. The basins should be sized to accommodate one-to-two years of sediment accumulations between "clean-out" activities.

- While Lake Forest Lake was originally constructed as a recreation resource and aesthetic feature for the residents of the Lake Forest Subdivision, the lake has become a *de facto* sediment deposition basin for 91% of the total D'Olive Watershed. The drainage from over 7,050 acres of the Watershed passes through Lake Forest Lake. Of that total acreage, only 1,600 acres originates within the Lake Forest Subdivision, with the remaining 5,450 acres being located in upstream areas. Lake Forest Lake is capturing a substantial volume of the coarser-grained sediment bedload delivered by the entire Watershed area draining into the lake, which prevents this material from entering the D'Olive Bay/Mobile Bay system. It does not appear that this important contribution provided by Lake Forest Lake is fully understood or appreciated. The Lake Forest Property Owners Association should mount a sustained campaign to get this "message" out in order to seek public support and funding from outside of the subdivision proper for lake-restoration projects.

- Monitoring should be performed to assess the effectiveness of the management measures to reduce stormwater runoff and sediment load volumes. Flow gauges should be established within D'Olive Creek and Tiawasee Creek immediately upstream of their entry into Lake Forest Lake. A periodic sediment loadings assessment program should be pursued, with the approach modeled after the recent Geological Survey of Alabama studies of the D'Olive Watershed in 2007 and 2008. One objective of the monitoring program should involve an effort to determine the relative contributions of sediments from overland sources vs. sediments from channel erosion. The GSA and/or the U.S. Geological Survey should be contacted to help share in the costs of collecting such data. In addition, the U.S. Environmental Protection Agency should be contacted as a potential source of funds.

- All remaining unimproved roads within the Watershed should be stabilized (preferably with pervious material) to minimize erosion and to minimize sediments being transported to area streams.

- During the course of constructing subdivisions and other new developments, the developer should be required to stabilize all roads as soon as possible after completing clearing, grubbing, shaping, grading, and ditching to retain sediments on-site and to limit the amount stormwater runoff that leaves the site during construction. The stormwater management facilities (inlets, storm sewers, retention/detention facilities, etc.) for each new development should be installed first, and their functionality confirmed, to limit stormwater runoff from the developments.

- Daphne, Spanish Fort and Baldwin County should cooperate in assessing the potential to establish a stream/wetlands mitigation bank or in-lieu fee mitigation program within the D'Olive Watershed. The mitigation bank would accumulate mitigation credits by restoring damaged stream segments and wetlands. The credits could be used to satisfy the compensation needs associated with local public projects undertaken by these entities, or the credits could be sold commercially to other agencies or the private sector to meet the stream mitigation needs of their projects. The revenue generated through the sale of mitigation credits could be used to offset stream restoration costs. A consultant experienced in developing mitigation banks should be retained to analyze the feasibility of this recommendation. This analysis should include the following tasks: conduct a feasibility analysis to develop usable mitigation credits; determine local stream mitigation market demands; estimate potential income levels; and identify the obstacles that would have to be overcome to successfully establish an officially sanctioned mitigation bank.

- Although power line right-of-ways represent a relatively limited land use within the D'Olive Watershed, they represent favored locations for off-road recreational vehicle use. Four-wheel-drive trucks and ATVs create considerable soil disturbance, which leads to erosion, with the eroded soils eventually making their way into the Watershed streams. Ordinances should be passed to prevent these types of activities from occurring on power line and other right-of-ways. Strict enforcement of these ordinances should be pursued and the results of the punitive actions publicized to discourage others from violating the ordinances. Concurrent with enforcement, signage should be installed at road crossings. The utility companies that are responsible for maintenance of the right-of-ways should pursue remedial actions to repair the disturbed areas. If there is a strong recreational demand for ATV activities, Daphne, Spanish Fort, and Baldwin County may consider collaborating to establish a site dedicated to the exclusive use of ATVs, and which can adequately contain sediments produced from disturbed soils and retain stormwater runoff on site.

- Residential subdivisions represent the dominant land use within the D'Olive Watershed. At the time this WMP was prepared, subdivisions were estimated to occupy almost 3,400 acres or 44% of the total land area in the Watershed. According to existing zoning plans, residential land use could increase to around 5,100 acres or 66% of the total Watershed by 2020. To accommodate the anticipated population growth and the conversion of forested and agricultural lands to residential uses, the three governmental entities responsible for the D'Olive Watershed should develop consistent zoning goals and subdivision design guidance that emphasizes minimization of Impervious Cover; reduces the width of subdivision roads; emphasizes retention of rainfall runoff; applies incentives to encourage Low Impact Development/Green Infrastructure techniques; requires a percentage of new subdivision land areas be devoted to common green space use; minimizes tree removal and/or requires that replacement trees be planted. Applicable "smart growth" concepts should be employed to the maximum extent possible to guide future subdivision designs.

- Significant additional regulatory requirements affecting stormwater management responsibilities of Daphne, Spanish Fort, and Baldwin County can be anticipated in the near future. Notably, the NPDES Municipal Separate Storm Sewer System (MS4) permit re-issuance is anticipated late this year or early in 2011. It is expected that the new MS4 permit will have increased emphasis on "post-construction" stormwater management and require that Low Impact Development / Green Infrastructure techniques be utilized wherever feasible. The forthcoming MS4 permit revisions will be applicable to all portions of the permit's "urbanized" area, but the D'Olive Watershed is expected to receive special scrutiny because its streams have been given the 303(d) list "impaired waterbodies" status. Development of a draft Total Maximum Daily Load (TMDL) to address the 303(d) list status is scheduled for 2013. Aggressive implementation of the WMP's management measures will address the major provisions expected to emanate from these regulatory programs. It is recommended that close coordination be maintained among the Watershed Restoration Task Force and those responsible for MS4 permit compliance.

- A "Vegetation Management Plan" should be developed for the Lake Forest Golf Course. This course was originally constructed over 40 years ago. The course is located on some of the most highly dissected topography within the Watershed and within an area that has a high Erosion Hazard Index. Over the years, the forest areas flanking and separating the fairways have thinned as trees were lost to a variety of causes. Regular mowing of the "rough" enhances surface runoff rates across the fairways, because of the closely cropped nature in which the grass is mowed. One of the biggest issues facing the golf course is off-course stormwater runoff generated from neighboring residential lots. There are few vegetative barriers to slow such runoff and it is often delivered in torrents across the course, resulting in downslope erosion issues. The "Vegetation Management Plan" should be prepared in close coordination with the golf course stakeholders and the Lake Forest Property Owners Association. That Plan should emphasize reforestation; minimize mowing where play would not be significantly affected; and encourage property owners to install protective vegetation barriers bordering the course to slow stormwater runoff and foster on-site retention).

- The WMP includes twenty-four recommended modifications to the existing regulatory framework for construction activities, stormwater pollution prevention, and reduction of stormwater runoff within the D'Olive Watershed. These recommendations are suggested to eliminate regulatory inconsistencies; resolve regulatory deficiencies; limit variances and waivers; improve enforcement; and improve protection of wetlands. During the first year following approval of the WMP, the identified entities responsible for each regulatory action should consider the individual recommendations and initiate implementation as appropriate.

- To promote consistency in developing subdivisions in both incorporated and unincorporated areas of the D'Olive Watershed, it is recommended that Baldwin County, Daphne, and Spanish Fort consider implementation of Baldwin County's Horizon 2025 Plan which recommends consideration be given:

> "…to merging the County's zoning ordinance, subdivision regulations and other land use regulatory controls into a Unified Development Code (UDC) at such time as county-wide zoning is in effect. The UDC combines and consolidates all phases of the land development process from the zoning of a piece of property to the actual development of this property. Like its predecessor (the zoning ordinance), the UDC will continue to regulate the use of the lot, lot size, building bulk and height, and setbacks. In addition, it will regulate the manner in which land may be subdivided to ensure that each subdivision meets standards as to minimum block and lot sizes, streets, relationship to existing streets, and provisions for open space, schools, and other public facilities and the protection of natural resources. The UDC is a valuable tool for the implementation of the Comprehensive Plan and for the creation of quality developments within Baldwin County."

- Because highways cross varying terrain to connect locations, they necessarily must interrupt and intercept drainages and concentrate flow volumes, with the effect that stormwater runoff patterns are altered. The expansive right-of-ways and hard surface areas typically associated with major roadways have a significant influence on the Impervious Surface Coefficients normally assigned to highways. Innovative measures should be pursued to reduce the frequency of mowing; allow natural vegetation to reclaim as much of the cleared right-of-ways as possible consistent with safety design standards; promote the use of porous ditch-lining materials; provide energy dissipaters where ditch runoff is discharged into receiving streams; incorporate stormwater retention facilities within the roadway drainage facilities; and landscape/reforest portions the I-10 interchange areas to reduce the overall percentage of Impervious Cover assigned to the highway corridors.

- Implementation of the recommended management measures advocated in this WMP will depend upon the understanding and support of the general public and specific Watershed stakeholders. A sustained, targeted public education and community outreach program will be critical to assure that the need for action is appreciated. Initiation of that program will begin with the Public Meeting at which the Draft WMP will be introduced for review and comment. After the WMP is completed, regular efforts that utilize a variety of techniques will be required to keep the message fresh and in front of the Watershed stakeholders.

- In 2015, the effectiveness of the WMP should be formally evaluated to analyze the progress of the stream restoration program; evaluate the current status of stream degradation; assess the effectiveness of the management measures in accomplishing their respective goals and objectives; assess the status of Impervious Cover in the Watershed; and determine if any mid-term corrections in implementing the WMP are needed to address changing conditions.

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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

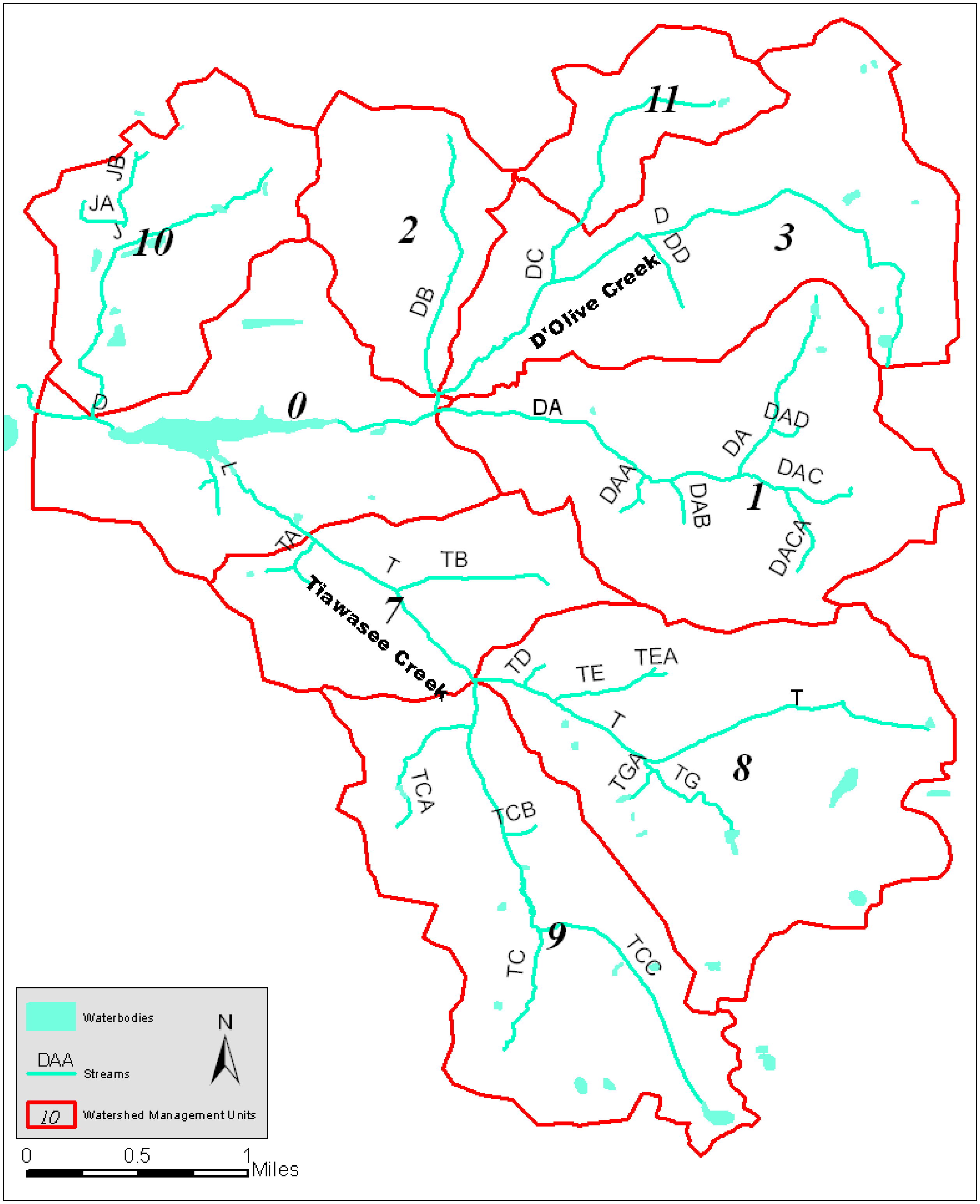

Figure ES-1. Watershed Management Units and Tributary Codes.

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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Attachment A (Maps and Data Tables)

Maps (11 x 17 Format)

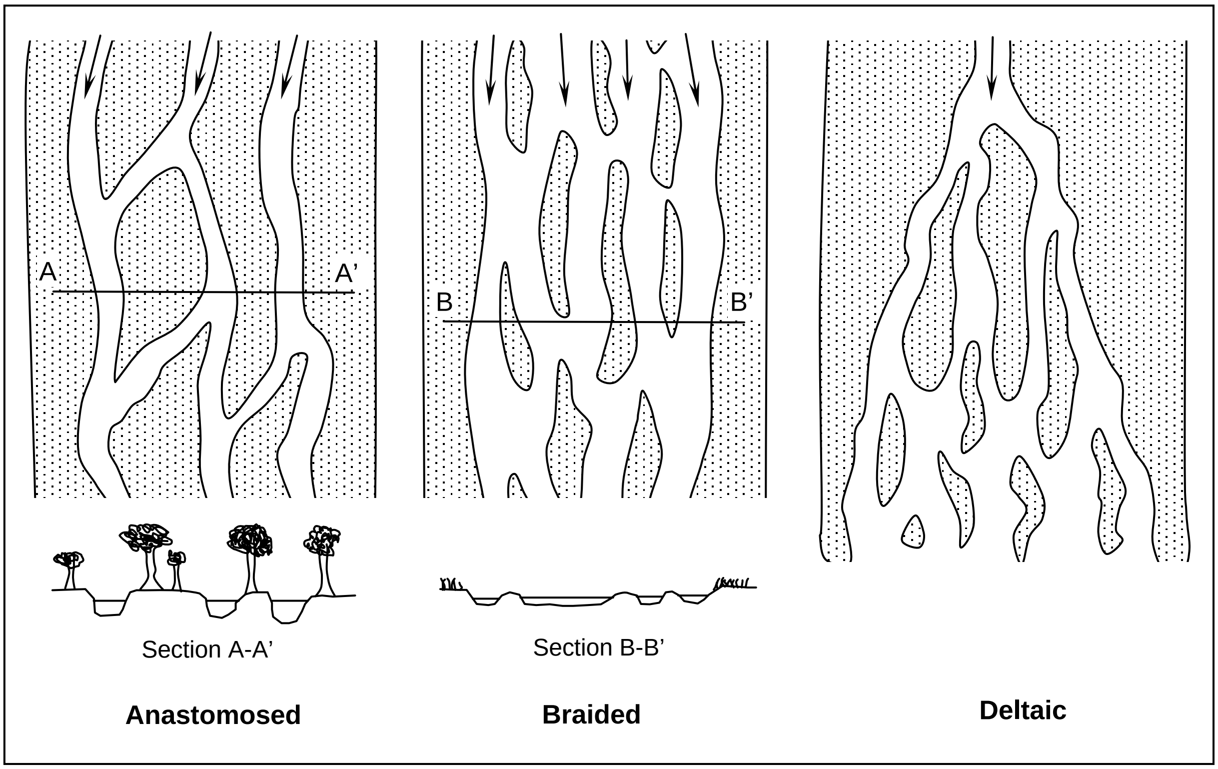
Data Tables (11 x 17 Format)

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.

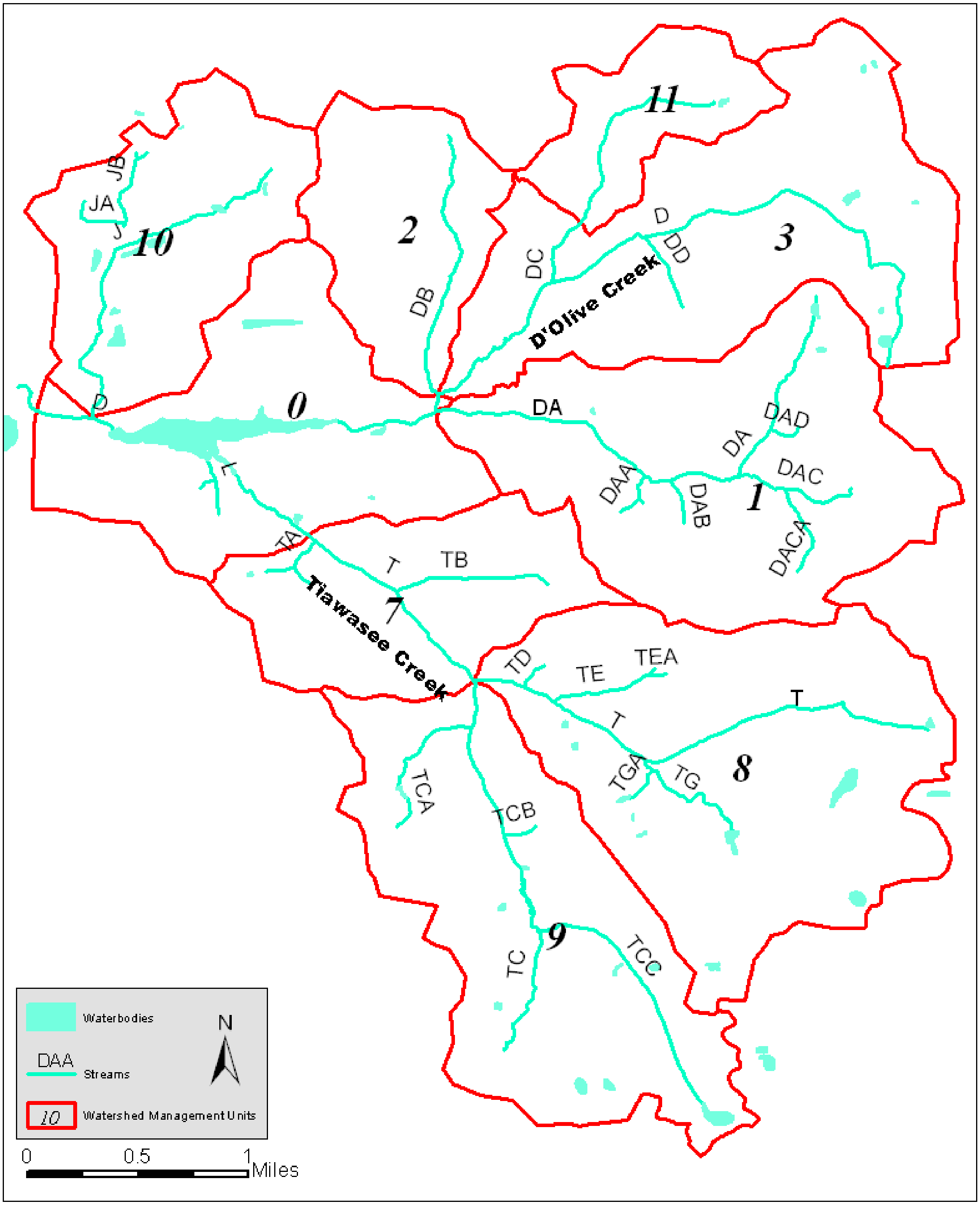


Figure 2-1. Watershed Management Units and Tributary Codes.

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.

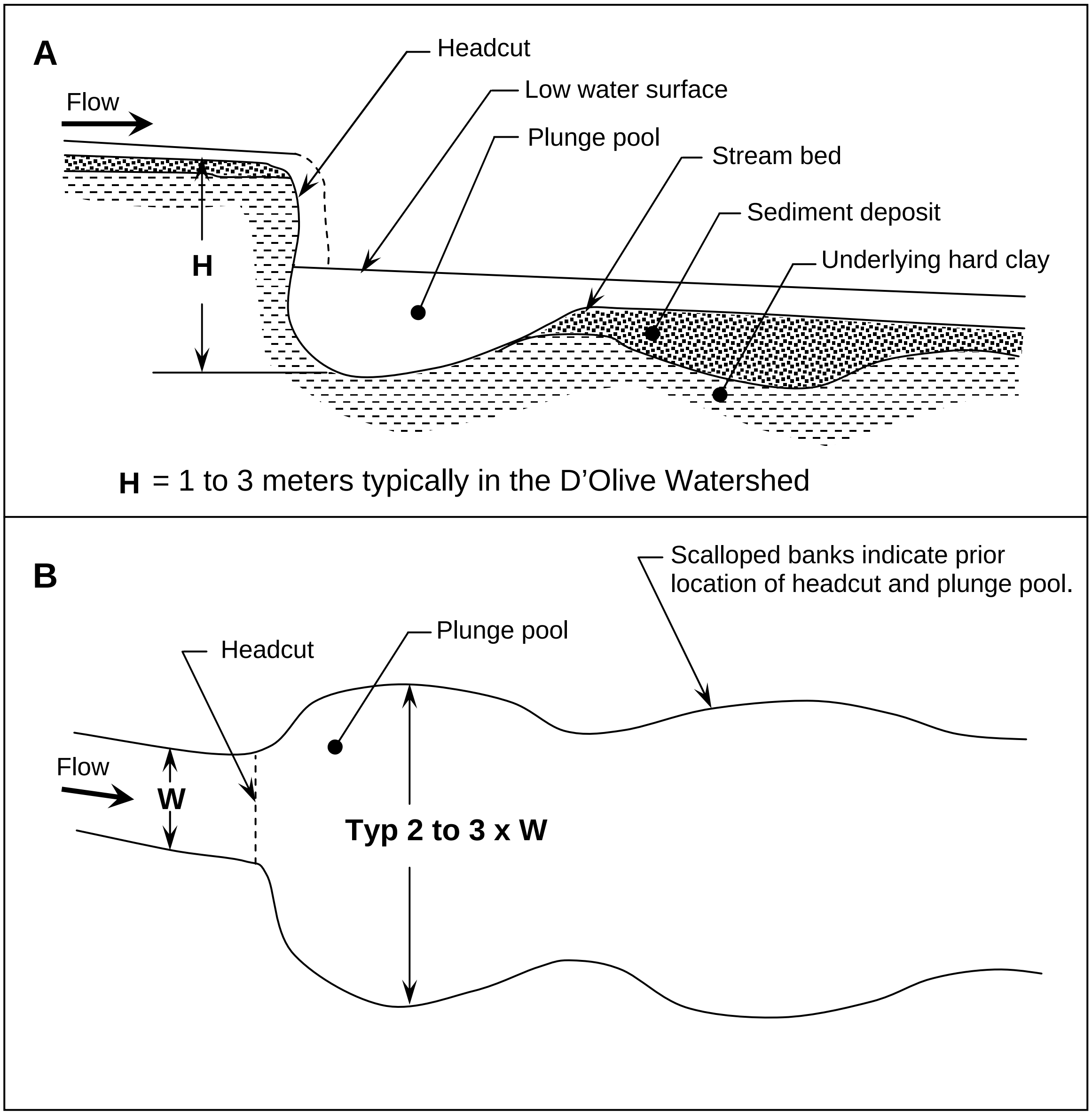


Figure 4-1. (A) Profile and (B) Plan View of a headcut typical to the D'Olive Watershed.

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.

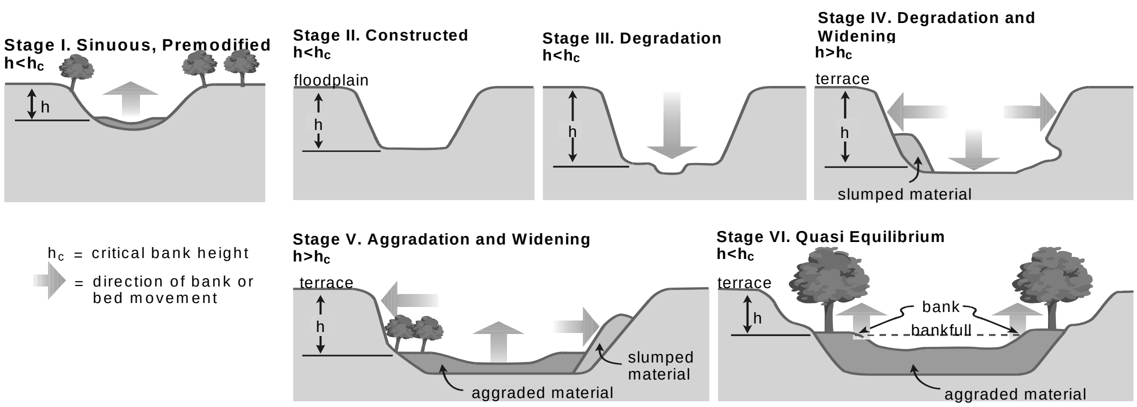


Figure 4-3. Six stages of the Channel Evolution Model (Alonso et al, 2002)

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.

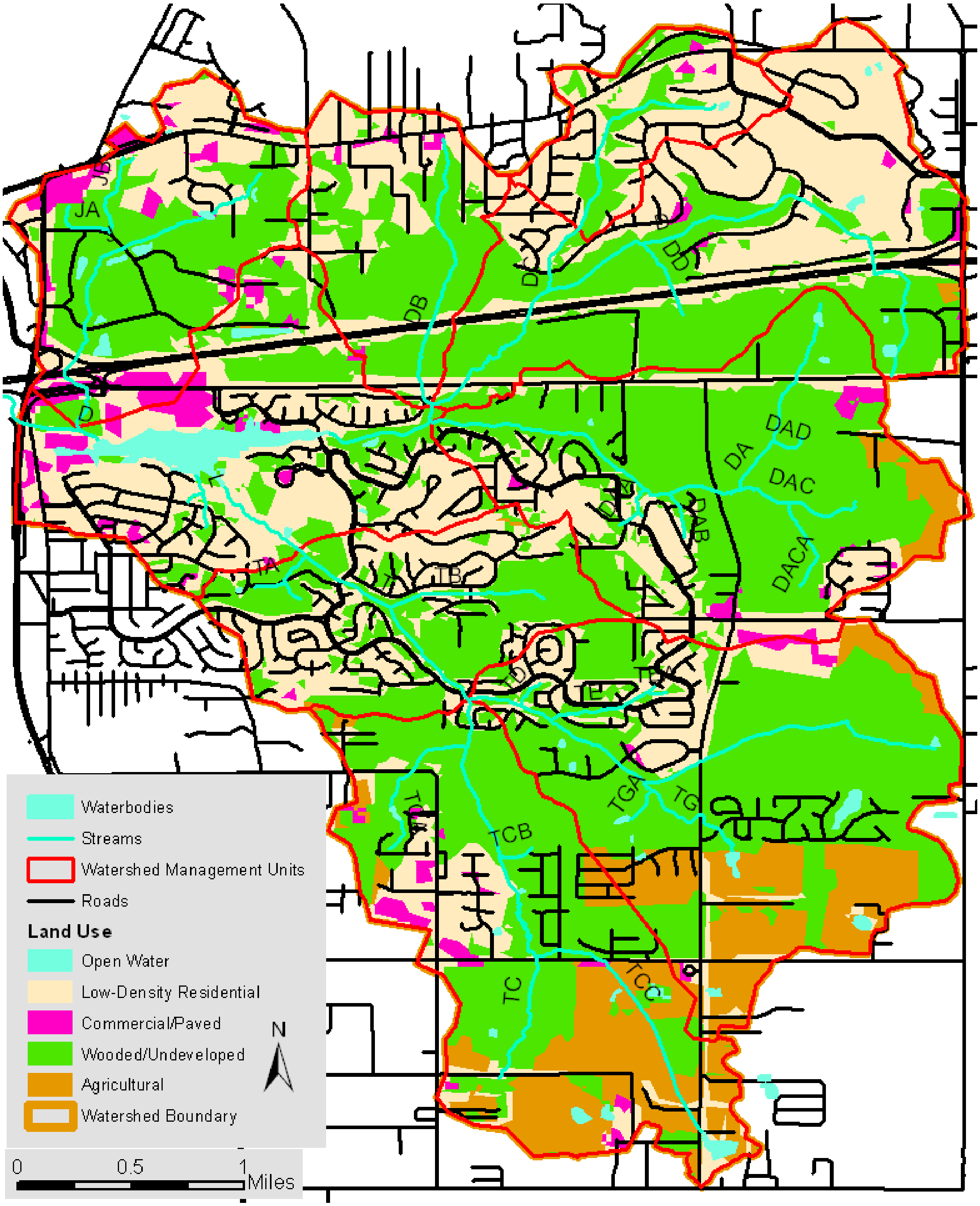


Figure 4-5. Land Use in the D'Olive Creek Watershed (Adapted from the 2001 NLCD).

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.

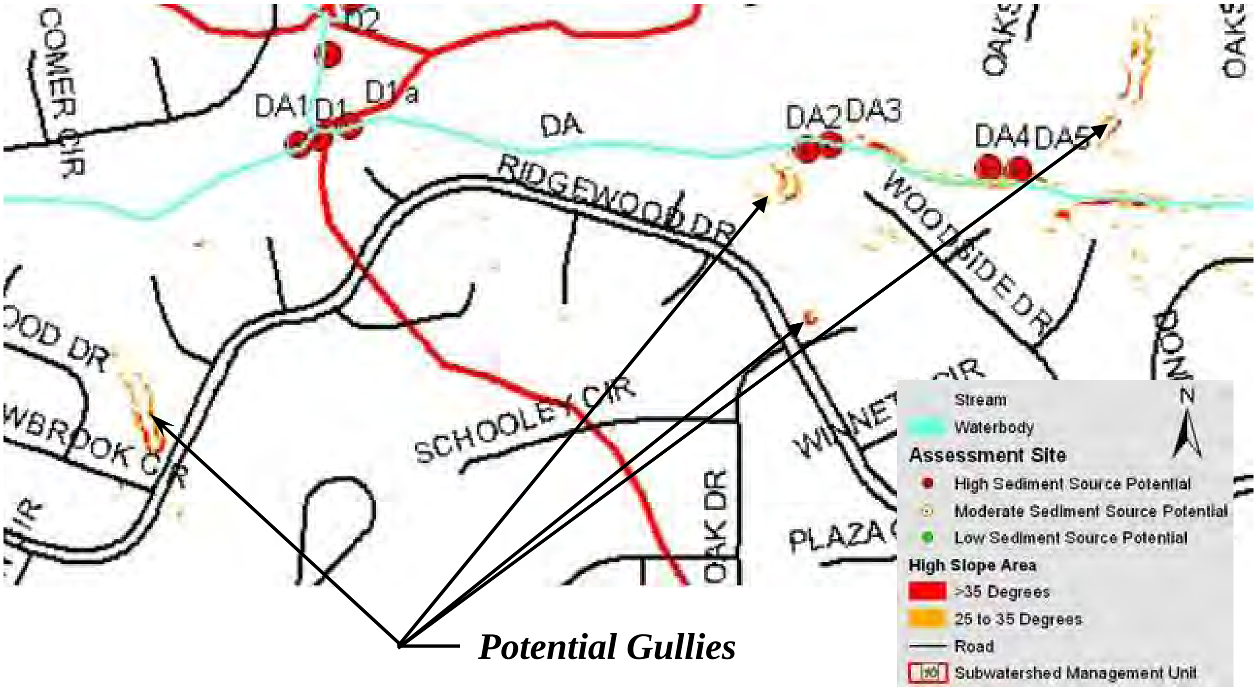


Figure 4-12. Narrow high-slope areas indicate the presence of gullies (Detail from Map 4).

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

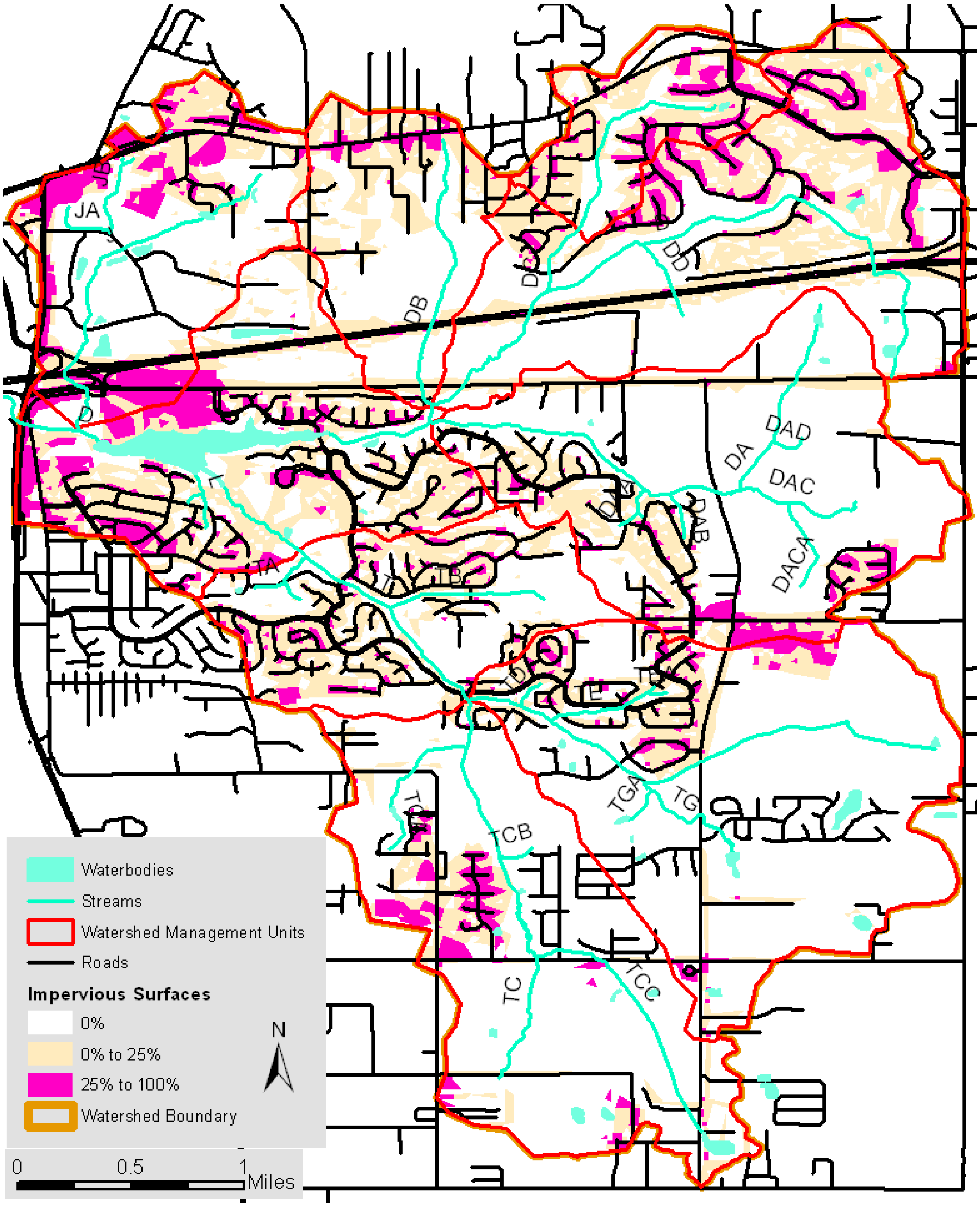


Figure 4-19. Impervious surfaces in the D'Olive Creek Watershed (Adapted from the 2001 NLCD).

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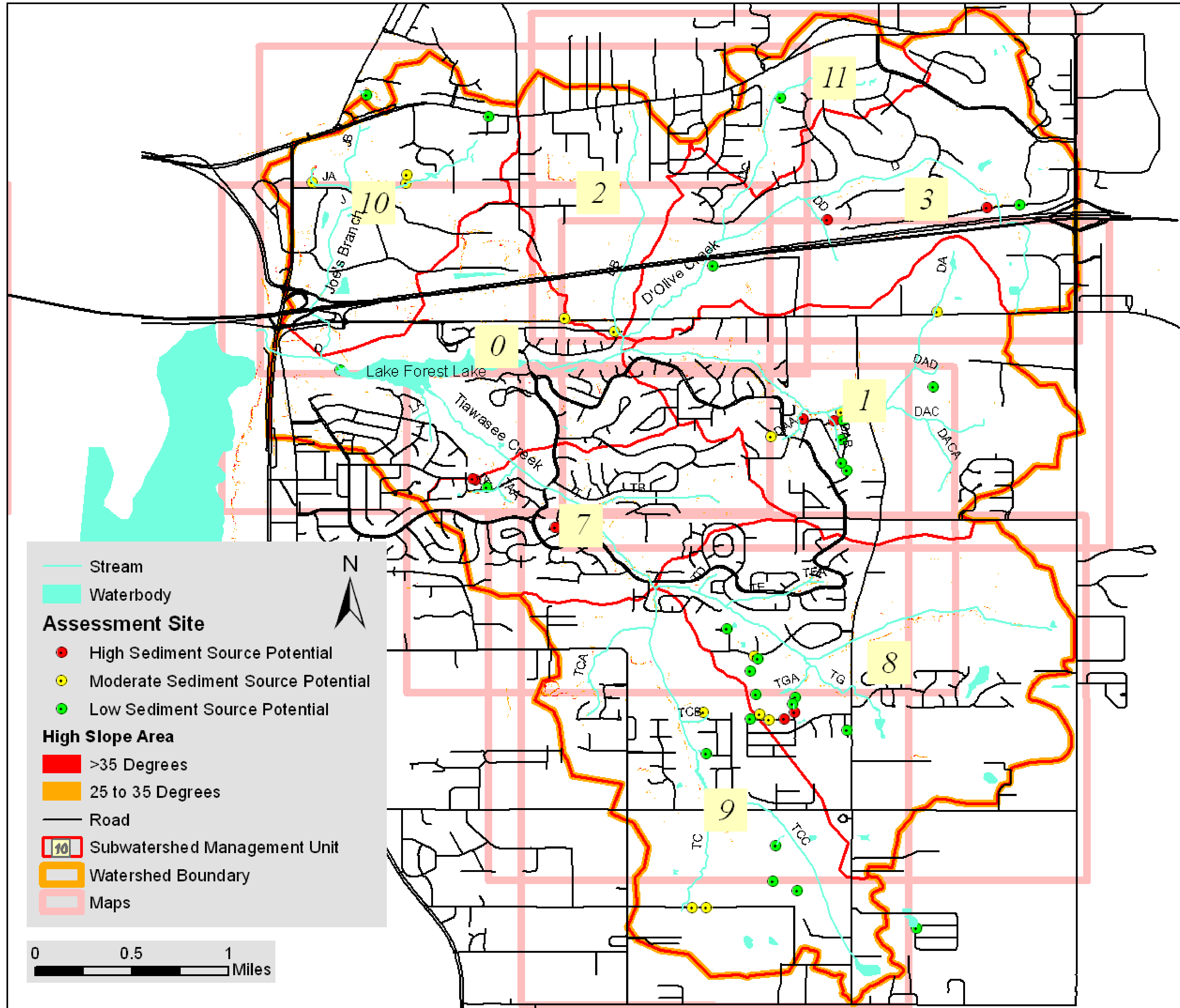
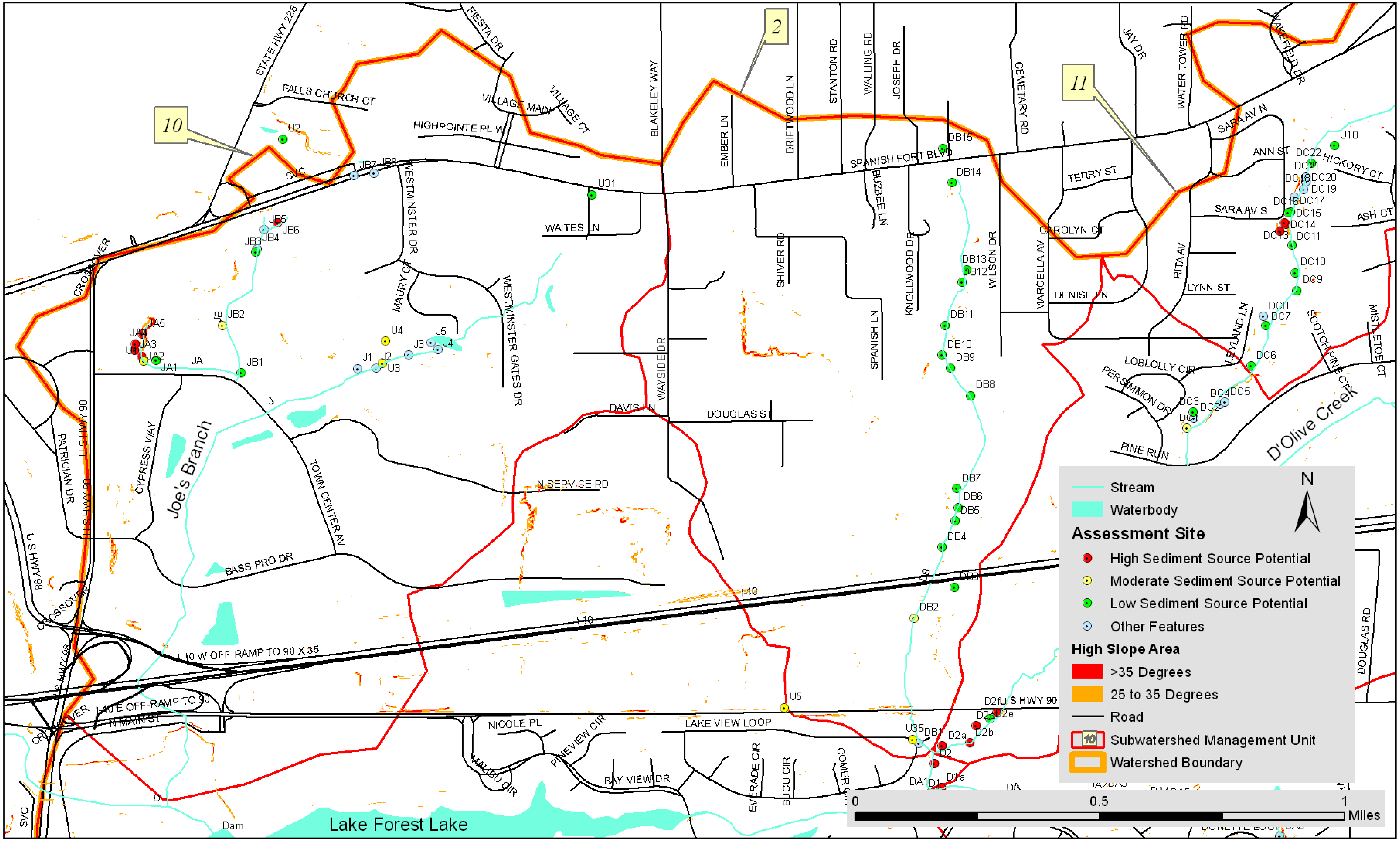
Map	Watershed Management Units
Map 1	Locator Map
Map 2	2 and 10
Map 3	3 and 11
Map 4	0
Map 5	1
Map 6	9
Map 7	7
Map 8	8

Map 1. Locator Map.



Map 2. Watershed Management Units 2 and 10.



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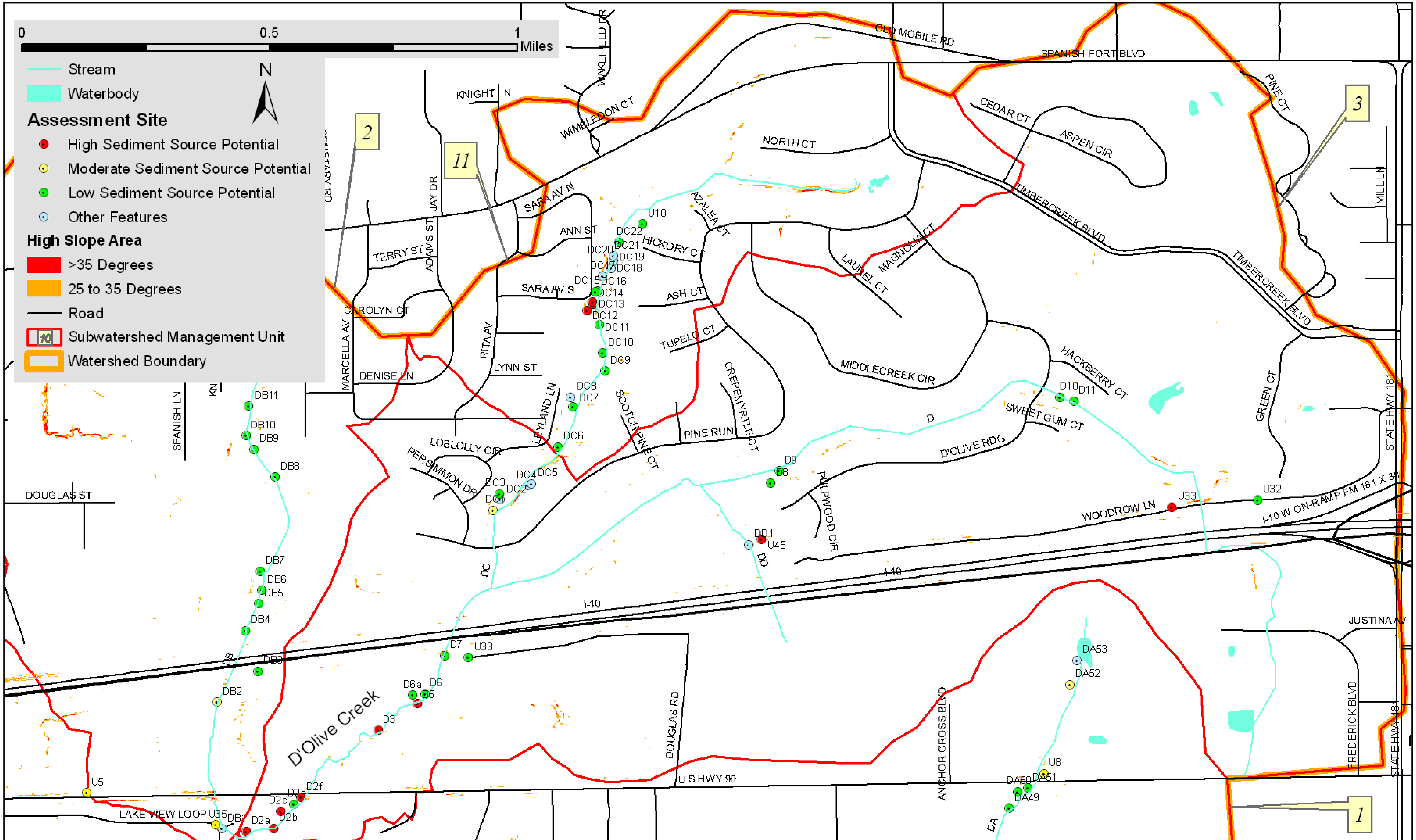
Map 3. Watershed Management Units 3 and 11.



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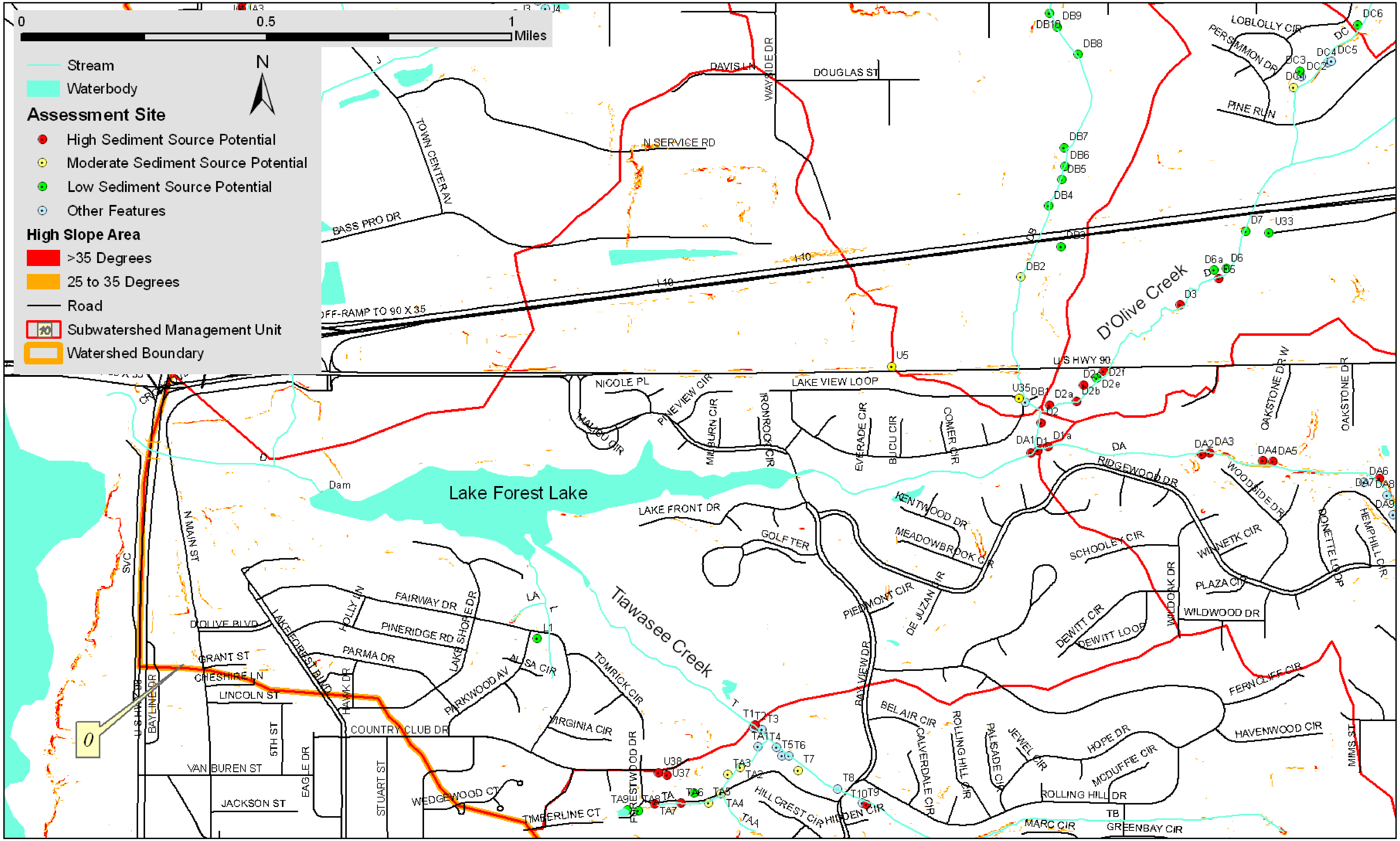
Map 4. Watershed Management Unit 0.



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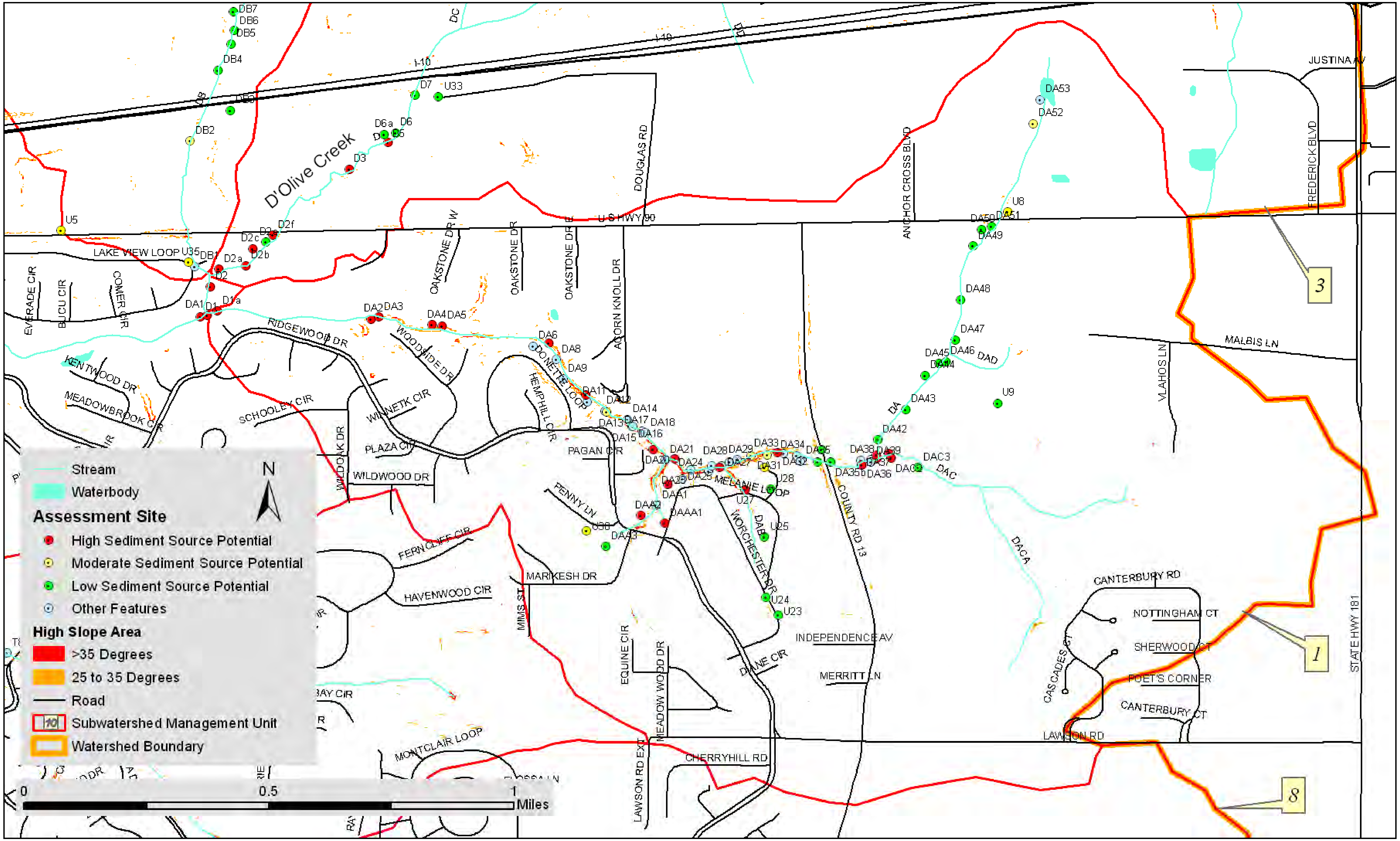
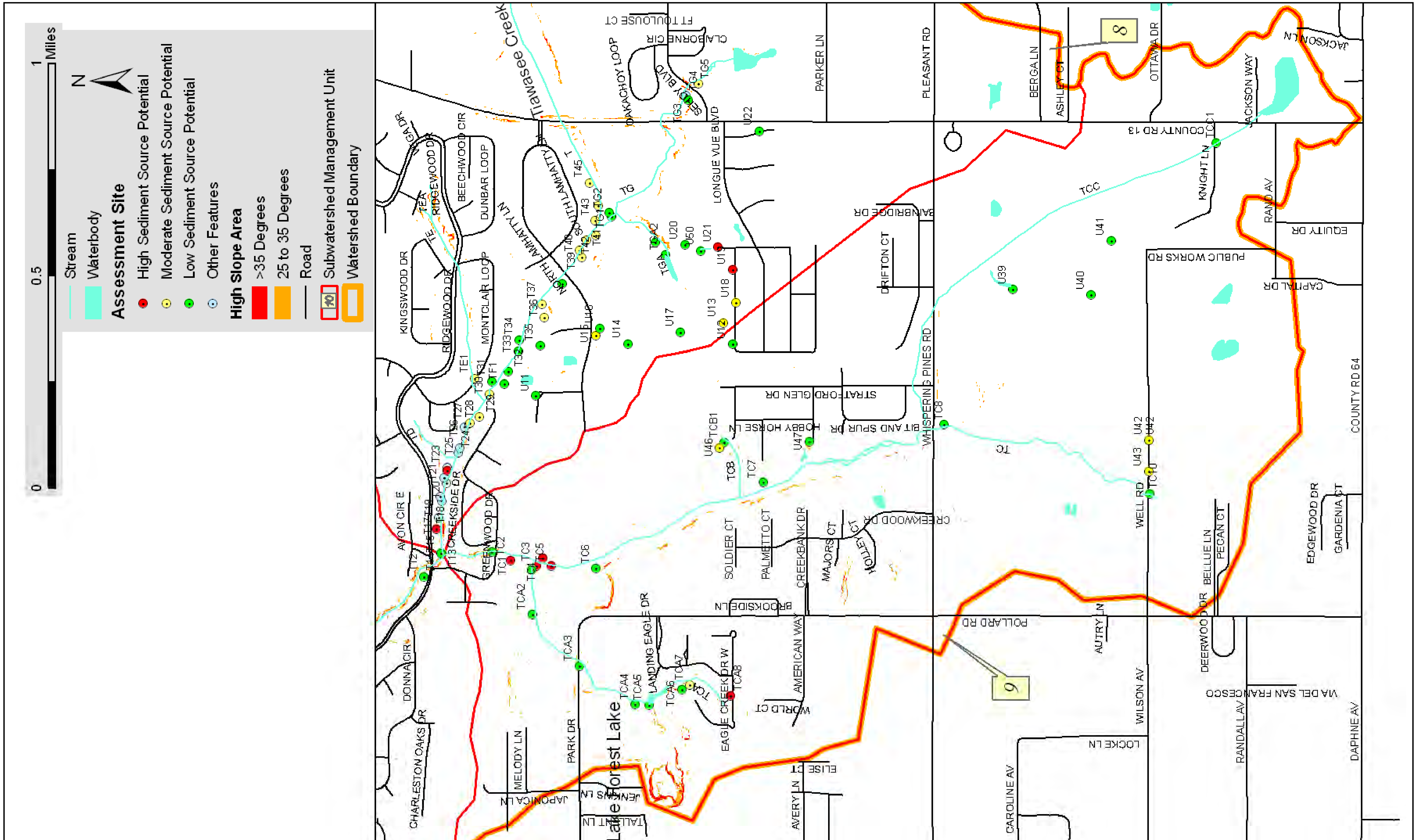
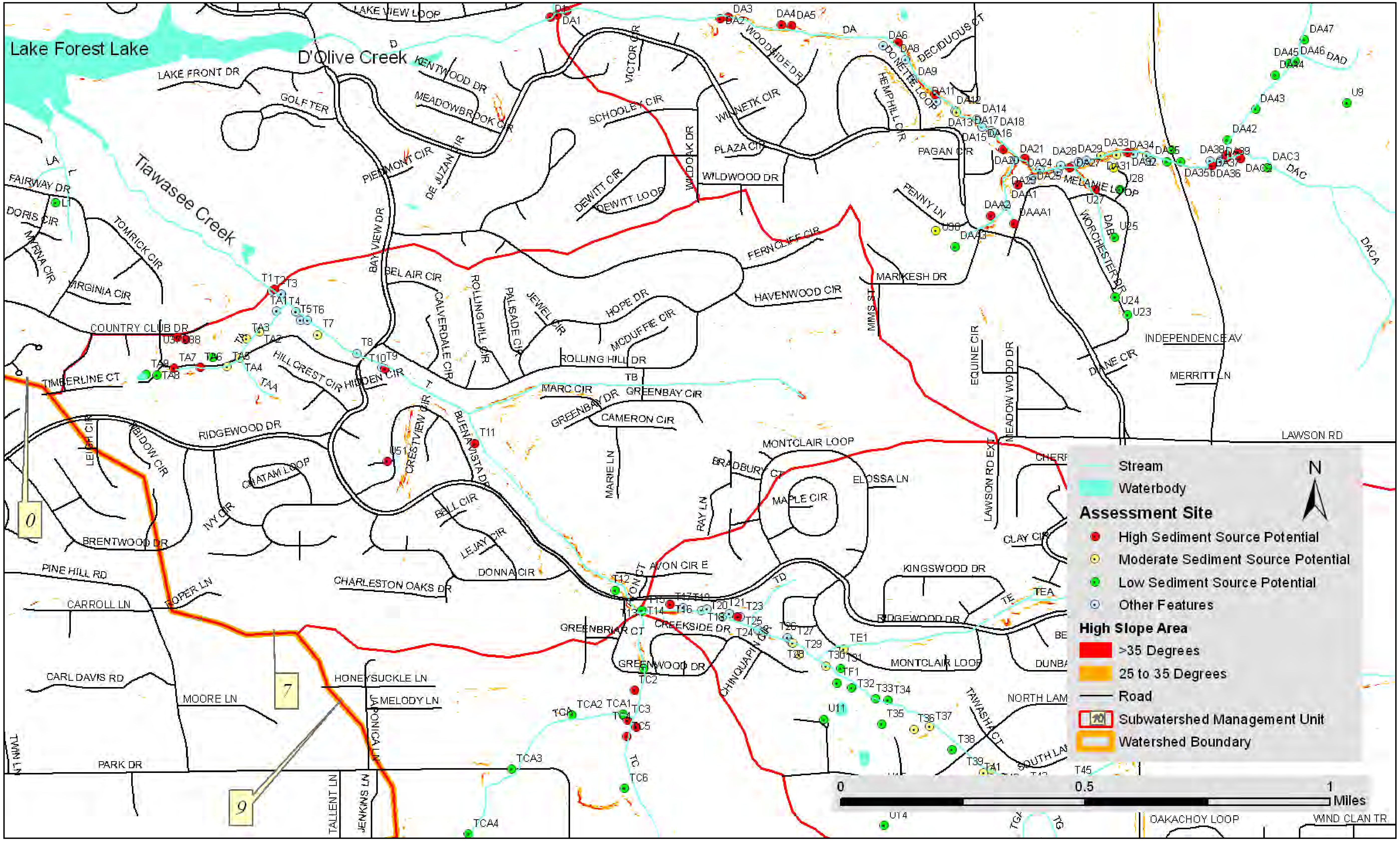
Map 5. Watershed Management Unit 1.



Map 6. Watershed Management Unit 9.



Map 7. Watershed Management Unit 7.



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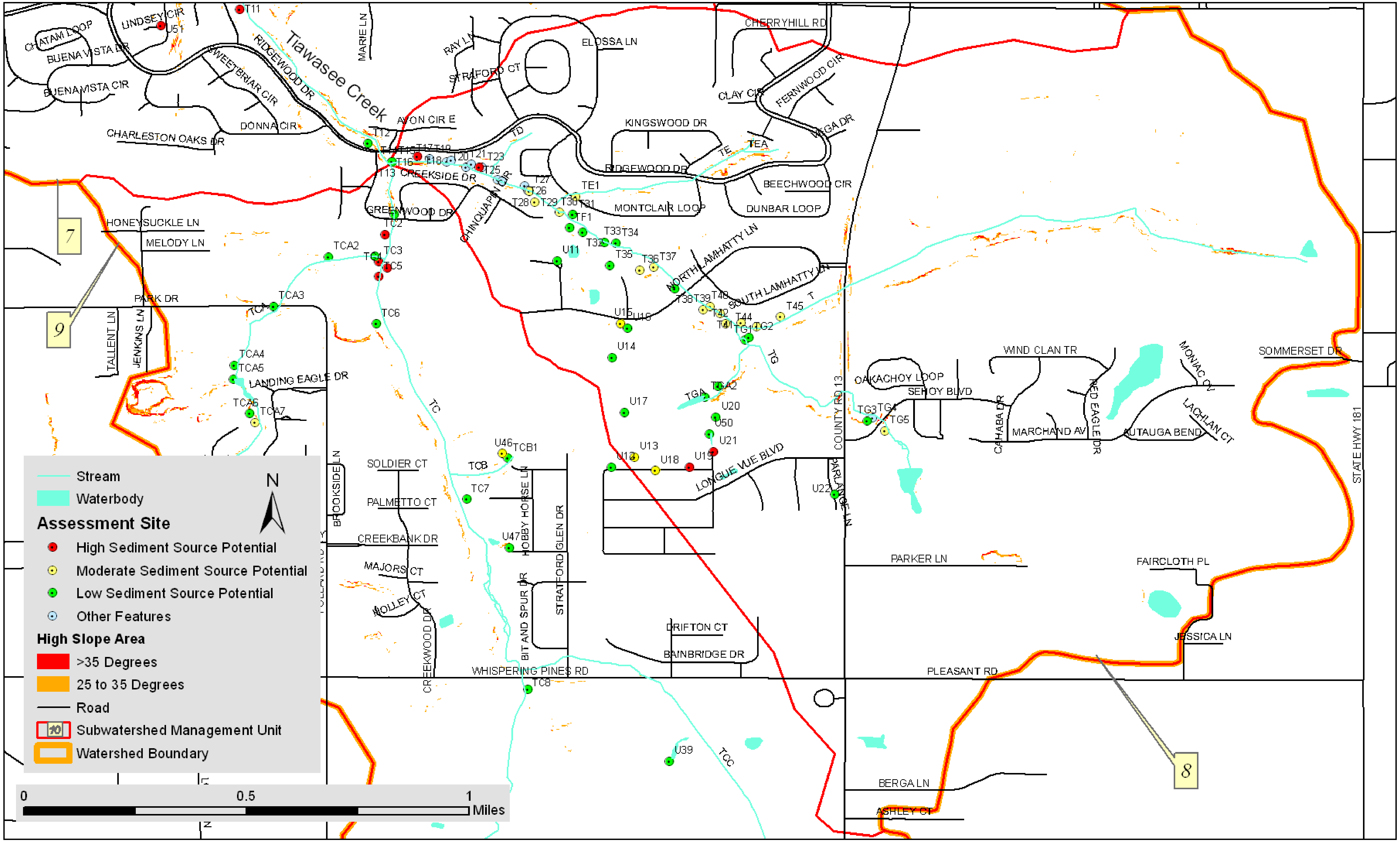
Map 8. Watershed Management Unit 8.



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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

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) LB	Bank Top Height (m) RB	Bankfull Height (m) LB	Bankfull Height (m) RB	Banktop Width (m)	Bed Material (dia in mm)	Surrounding Landuse	Riparian Zone Width (m) and Cover LB	LB Cover	RB	RB Cover	Bankface Protection % Density and Type LB	LB Type	RB	RB Type	Bank Erosion by Mass Wasting (%) LB	RB	Bank Erosion by Scour (%) LB	RB	Dominant Bank Material LB	RB	Bed Condition	Sediment Deposition	Channel Flow Status	CEM Class	Reach Type	Notes	Assessment Site
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	Latitude	Longitude	Other Location	Bank Top Height LB	Bank Top Height RB	Bankfull LB	Bankfull RB	Banktop Width (m)	Bed Material (dia in mm)	Surrounding Landuse	Riparian Zone Width (m) and LB	LB Cover	RB	RB Cover	Bankface Protection % Density and Type LB	LB Type	RB	RB Type	Bank Erosion by LB	RB	Bank Erosion LB	RB	Dominant Bank Material LB	RB	Bed Condition	Sediment Deposition	Channel Flow Status	CEM Class	Reach Type	Notes	Assessment Site
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***

				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		Assessment Site
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	st 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	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							
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	sandy 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				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		
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

thompson ENGINEERING

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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February, 2010

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.

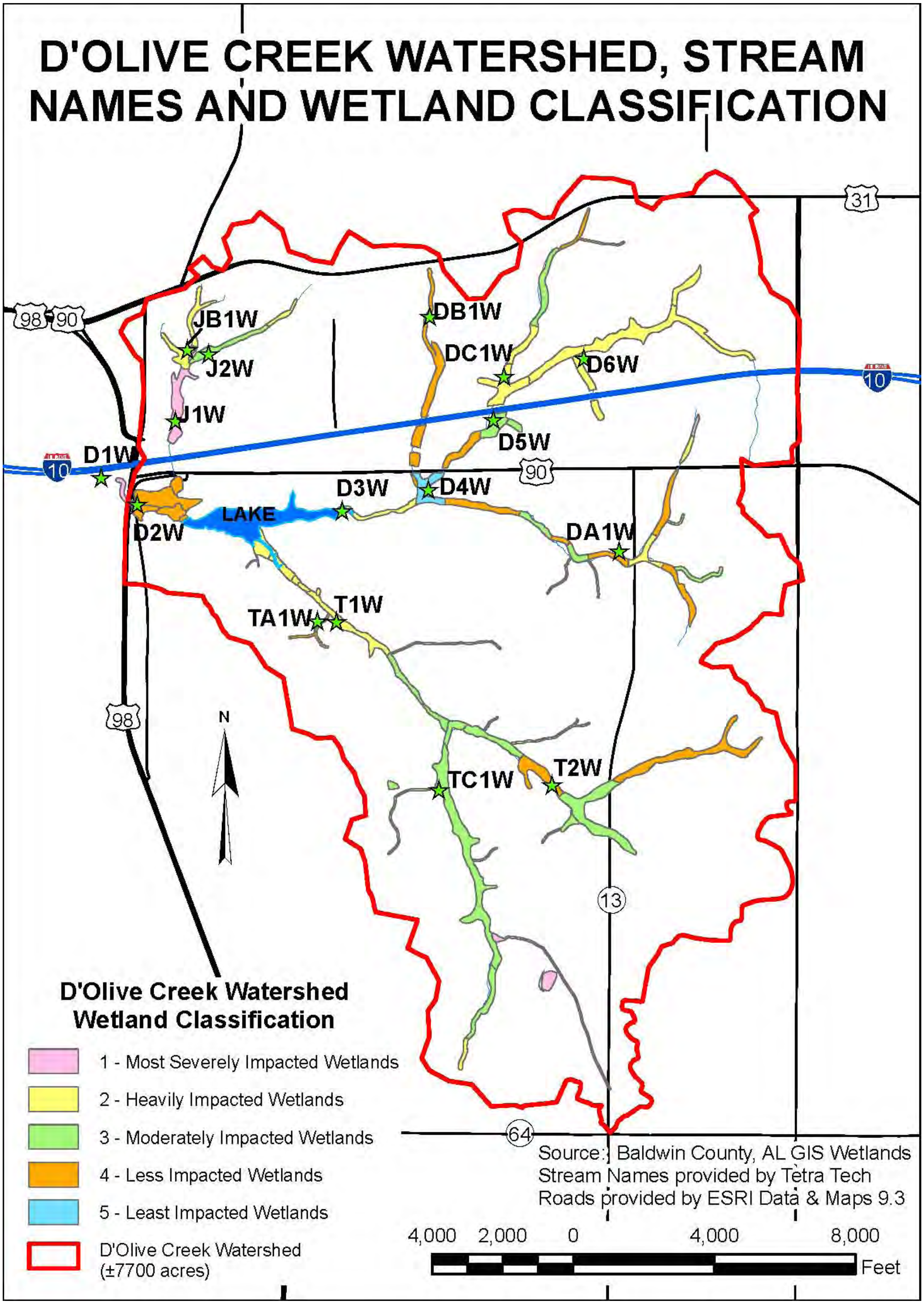
D'OLIVE CREEK WATERSHED, STREAM NAMES AND WETLAND CLASSIFICATION
JB1W
J2W
J1W
D1W
D2W
LAKE
D3W
D4W
DB1W
DC1W
D6W
D5W
DA1W
TA1W
T1W
TC1W
T2W
98
90
10
31
13
64
N
D'Olive Creek Watershed Wetland Classification
1 - Most Severely Impacted Wetlands
2 - Heavily Impacted Wetlands
3 - Moderately Impacted Wetlands
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.

APPENDIX C

Regulatory Review

Introduction

As part of the development of the Comprehensive Watershed Management Plan (CWMP) for the D'Olive Creek, Tiawassee Creek, and Joe's Branch watersheds in Baldwin County, Alabama, a review of existing regulations at the Federal, State, and local level was conducted. This review was conducted by John Carlton, CPESC, Senior Environmental Consultant to Thompson Engineering and Neil Johnston, Esq. of Hand Arendall, LLC.

The geopolitical boundaries of the D'Olive Creek Watershed include overlapping jurisdictions and adjacent portions of Baldwin County, the City of Daphne and the City of Spanish Fort with additional lands under State jurisdiction in the Watershed and in and along D'Olive Bay and Mobile Bay.

The past and current status of developments, ordinances, inspections, and compliance issues were discussed with each local government building official or their inspectors, as well as representatives of the Alabama Department of Transportation ("ALDOT"), the Alabama Department of Environmental Management ("ADEM"), the Lake Forest Property Owners Association, the U. S. Army Corps of Engineers, and committee members of the proposed Baldwin County Watershed Coalition.

The laws, regulations and ordinances reviewed focus on water quality; stormwater; erosion and sediment control; coastal issues; wetlands and streams; and land disturbance. The list includes:

- Clean Water Act, 33 USC § 1251, et seq.
- Alabama Water Pollution Control Act, Ala. Code § 22-22-1, et seq.
- ADEM Admin. Code Reg. 335-6-6 (NPDES)
  335-6-10 (water quality)
  335-6-12 (construction site stormwater control)
  335-8-1 (coastal area management)
- Baldwin County Zoning Ordinance (July 21, 2009)
- Baldwin County Subdivision Regulations (January 1, 2008)
- City of Daphne Ordinance No. 2008-54, Erosion and Sediment Control (November 3, 2008)
- City of Daphne Land Use and Development Ordinance (September 3, 2002)
- City of Spanish Fort Zoning Ordinance, Article VIII (May 31, 1996)
- City of Spanish Fort Subdivision Regulations, Article VIII (June, 1999)

Flood control ordinances were not specifically reviewed. However, flood control goals and stormwater treatment goals are often in opposition, the first trying to remove water a quickly as possible, the latter trying to slow release rates and/or volumes. A detailed review of flood control requirements and comparison to stormwater management requirements could be beneficial in identifying potential conflicts. Further, all aspects of local development requirements (e.g. parking space requirements) that could potentially conflict with stormwater management goals were not studied. A reduction in parking space requirements could result in a reduction in impervious area, therefore a reduction in stormwater runoff.

The Federal, State and local governments are all in the process of planning to change, developing proposed changes to, or have changed their existing regulatory procedures. Examples of such changes to regulations and requirements for compliance currently under consideration include:

- Baldwin County has recognized that the effects of stormwater, erosion and sedimentation are serious and critical issues that are costly to address, monitor, regulate and mitigate. The Baldwin County Watershed Coalition has proposed the formation of a Stormwater Authority with funding through a "stormwater fee" that will be proposed by referendum.

- The City of Daphne has proposed certain changes and amendments to the existing City Ordinances that address, among other things, land disturbance, stormwater erosion control and "pre," "during" and "post" construction stormwater controls and enforcement.

- The City of Spanish Fort has been considering a number of amendments to, updates of and modifications to the existing stormwater and land disturbance ordinances.

- ADEM is considering changes to their 335-6-12 regulations pertaining to construction sites as part of its five-year review process. In January, 2010, ADEM published notice of review requesting public comments. ADEM will also consider changes based on the new EPA requirements for construction sites described below, as well as changes to the Phase I and Phase II MS4 stormwater discharge permits.

- In December 2009, EPA issued the Final Rule regarding additional construction site/land clearing requirements for stormwater and erosion control. The Final Rule establishes additional limits on the discharges of pollution from construction sites, including numeric limits on certain non-conventional pollutants (i.e. turbidity). **(Final Rule – December 1, 2009 – Effluent Limitation Guidelines and Standards for the Construction and Development Industry 74 Fed. Reg. 62996, 40 CFR 450.)**

- In 2009, the Corps of Engineers adopted new rules for wetland jurisdictional determinations, wetland compensatory mitigation, and stream compensatory mitigation:

    - **Regulatory Guidance Letter No. 08-02 – Jurisdictional Determinations (June 22, 2008).**
    - **Compensatory Mitigation for Losses of Aquatic Resources; Final Rule – 73 Fed. Reg. 19594, April 10, 2008; 33 CFR 325; 40 CFR 230.**
    - **Standard Operating Procedure (SOP), Compensatory Stream Mitigation Guidelines, Mobile District Corps of Engineers, 2009 (updated March 1, 2010).**

Discussion of Laws, Regulations and Ordinances

Federal

The Federal Water Pollution Control Act and the Clean Water Act (CWA) amendments. The Federal Water Pollution Control Act and the Clean Water Act (CWA) amendments provide the basis for the primary federal regulatory and permitting procedures relating to stormwater management within the D'Olive Bay Watershed. The following specific sections of the CWA are particularly pertinent to controlling stormwater runoff and erosion and sedimentation problems within the Watershed.

CWA § 404. Wetland and stream protection, proper permitting and compliance and protection of water quality are concerns addressed by the Corps of Engineers and EPA. The Corps of Engineers is the primary permitting authority for wetland and stream impacts. A CWA § 404 permit is required before any person or entity can fill wetlands or streams, or change or relocate stream channels. The permit must also meet State water quality standards and coastal requirements, and be consistent with each program. The Corps and EPA have adopted regulations pertaining to the CWA § 404, 33 CFR 320, 40 CFR 230.

CWA § 402. EPA has primary authority over the CWA § 402 water quality program and is responsible for administering the regulations for the National Pollutant Discharge Elimination System ("NPDES") (40 CFR 122) and permitting discharges from point sources to waters of the United States, such as D'Olive Creek, Tiawasee Creek, Joe's Branch, D'Olive Bay and Mobile Bay. The NPDES program covers point source discharges from industrial facilities, municipal stormwater conveyances, concentrated animal feeding operations (CAFO), land clearing and construction sites, publicly owned treatment works (POTW), combined sewer overflows (CSO) and sanitary sewer overflows (SSO).

EPA has delegated the authority to administer the NPDES program to ADEM, who by ADEM Admin. Code Reg. 335-6-6, regulates and permits certain point source discharges. By ADEM Admin. Code Reg. 335-6-12, ADEM regulates discharges from construction sites and land clearing; imposes requirements for erosion and sediment control and the use and maintenance of best management practices; as well as imposes requirements for inspections, reporting and enforcement. In December 2009, EPA issued a Final Rule addressing a phased-in program for numeric and non-numeric effluent limits on sediment/erosion control at construction sites, focusing on stormwater discharge turbidity. (74 Fed. Reg. 62996; 40 CFR 450).

In addition to construction site and land clearing jurisdiction, ADEM (through delegation from EPA) regulates discharges from municipal separate storm sewer systems (MS4). ADEM requires municipalities and utilities to obtain and comply with the terms of a NPDES permit to control the discharges from such stormwater collection systems pursuant to ADEM Admin. Code Reg. 335-6-6.

CWA § 303(d). The Clean Water Act, Section 303(d) [33 USC § 1313(d)], mandates that EPA develop pollutant loading capacities for receiving streams such as those occurring within the D'Olive Creek Watershed. The loading capacities are termed "total maximum daily loads"

(TMDLs) and are used to set limits on the amount and type of pollutant discharges that can be made to the stream without further degradation. Once a stream or stream segment has been classified as impaired (i.e. listed on the State's 303(d) list) and the contaminant identified, EPA and ADEM must perform inspections and samplings to determine the amount or limit of the loading to the stream.

ADEM has determined that the water quality of D'Olive Creek, Joe's Branch , Tiawasee Creek , and two unnamed creeks in the watershed, is impaired due to sedimentation and habitat alteration and the streams are therefore impaired by sediment. No TMDL has yet been established for the watershed (draft TMDL due in 2013). However, once TMDLs are established, additional sediment discharges could be limited. Listing of the streams within the D'Olive Creek Watershed results in a more in-depth review of NPDES applications and registrations by ADEM.

Coastal Zone Management Act (P.L. 92-583; 16 U.S.C. §1451 et seq). The Coastal Zone Management Act is administered by the National Oceanic and Atmospheric Administration (NOAA) and provides coastal states an opportunity to develop and implement coastal area management programs. States electing to do so are provided with funding support. The Act places certain requirements on federal agencies to ensure that their activities (and the activities they permit) are consistent with approved state programs (15 CFR 930).

Alabama developed a coastal area management program in 1979 and continues to maintain a federally approved program (see program description under State Regulations). The federal consistency provisions most relevant to the Watershed Management Plan include the requirement that CWA §404 and §402 permits comply with Alabama's Coastal Area Management Program. ADEM has also developed a non-regulatory Coastal Non-point Pollution Control Program pursuant to Section 6217 of the Act.

State

Several of the State statutes that affect activities in the D'Olive Creek Watershed have been mentioned in the discussion of the federal statutes. ADEM is the primary State environmental regulatory agency in Alabama. In addition, the Alabama Department of Conservation and Natural Resources (ADCNR) may also have jurisdiction over certain activities that affect State waters, State natural resources (such as fish and wildlife), and State lands.

CWA and Alabama Water Pollution Control Act. The Alabama Water Pollution Control Act, Alabama Code § 22-22-1, like its federal counterpart (CWA), prohibits the discharge of pollutants to waters of the State without a permit and provides the foundation for the State's delegated authority to implement various water quality programs, including the NPDES permit program.

CWA §401(a) Water Quality Certification. CWA § 404 permit applications, pursuant to CWA §401(a), must be submitted to ADEM for review of the proposal's consistency with the State's water quality program. ADEM reviews applications to insure that the proposed discharge of fill material will not cause or contribute to a violation of State water quality standards as set forth in ADEM Admin. Code Reg. 335-6-10.

Construction Site Stormwater. As part of the NPDES program, ADEM adopted ADEM Admin. Code Reg. 335-6-12 in January of 2003, replacing the general NPDES construction site permit with "permit by rule". Prior to any land clearing activity of sites greater than one acre, the applicant must apply for a NPDES construction site permit to address stormwater discharges. The regulations require the filing of a notice of registration (NOR), preparation and implementation of a "Construction Best Management Practices Plan" (i.e. an erosion control plan) with certifications from a qualified credentialed professional as defined by the regulations. The plan must include identification of erosion and sediment prevention measures or "best management practices" (BMPs), which are to be implemented and maintained throughout the construction phase of a project. ADEM also has monitoring, inspection, reporting and recordkeeping requirements as well as enforcement authority. The listing of D'Olive Creek, Joe's Branch and Tiawassee Creek on the State's 303(d) list will now require that CWA §402 permit applicants (and ADEM Admin. Code Reg. 335-6-12 registrants) submit a Construction Best Management Practices Plan for ADEM's review prior to commencement of stormwater discharges or land disturbance activities.

In January, 2010, ADEM published notice requesting public comments on an impending review of ADEM Administrative Code Reg. 335-6-12. ADEM has not yet addressed the new EPA requirements issued in the Final Rule of December 2009, 40 CFR 450, imposing numeric and non-numeric limits on stormwater runoff discharges. It is anticipated that these requirements will be addressed by ADEM during the review process currently underway. Recent conversations with ADEM personnel indicate that it has not been decided yet whether they will keep the present "permit by rule" approach; develop a statewide general permit; or a combination of the two. Depending on the approach, implementation of revised construction stormwater regulations could be occur as soon as mid-2010, or could extend into 2011.

MS4 General NPDES Permit. In general, municipalities within "urbanized areas" are subject to MS4 permits (either Phase I or Phase II). Portions of Baldwin County, Daphne, and Spanish Fort, including the entire D'Olive watershed, are within a Phase I MS4 permitted area. The existing Phase I permit for this area expired in 2006 but was administratively extended until issuance of a new permit. The permit renewal process is underway and could be finalized as early as this year (2010). Upon renewals of the MS4 permits, in addition to traditional provisions, significantly increased requirements are expected for both construction site stormwater control and post-construction stormwater management. Notably, it is anticipated that Stormwater Management Plans (SWMPs) developed by municipalities pursuant to their MS4 permit must implement Low Impact Development / Green Infrastructure (LID/GI) practices, "where feasible." Also, increased requirements for monitoring and evaluation/assessment of impaired/TMDL waters are anticipated.

CWA § 303(d). ADEM is required by EPA to designate streams or stream segments that are impaired and do not meet the State's water quality classification set forth in ADEM Admin. Code Reg. 335-6-10. The impairment, which could be organic (pathogens), chemical or metal (mercury, lead, arsenic) or habitat alteration (sediment), must then be sampled and a total maximum daily loading (TMDL) amount or limit must be calculated.

In the D'Olive Creek Watershed, D'Olive Creek and an unnamed tributary (UT), Tiawassee Creek and a UT, and Joe's Branch have been determined to be impaired by sediment. No total maximum daily load (TMDL) has been calculated for these D'Olive Creek Watershed streams at this time (draft TMDL due in 2013). However, any development or redevelopment activity affecting these streams should take the listing and impairment into consideration and increased regulatory agency scrutiny of proposed activities is expected.

Coastal Zone Management. The Alabama Coastal Area Management Act, Alabama Code § 9-7-1 et seq., provides the statutory authority for the State to develop and implement a coastal area management program. ADEM, through ADEM Admin. Code Reg. 335-8-1, et seq., regulates the filling and excavation of wetlands and certain types of development within the coastal area, requiring a determination of consistency by the applicant proposing the activity. This is usually part of the CWA § 404 joint application process initially filed with the Corps of Engineers. The ADEM coastal area management plan (now administered by ADCNR) and the ADEM Coastal Regulations (administered by ADEM) are limited to the coastal area, an area having an outside, or upland, boundary determined by the continuous 10 foot contour in Mobile and Baldwin Counties. The last time any significant changes, updates, or amendments were made to the Coastal Regulations was in 1995 [**NOTE:** There are certain general or nationwide permits issued by the Corps of Engineers that presently have been given coastal program and regulation consistency for discharging fill to wetlands in the coastal area, such as NWP18. The present consistency determination was made by ADEM in July, 2007, for a period of five years.].

ADEM and ADCNR have also developed a Coastal Non-point Pollution Control Program (ACNPCP) pursuant to §6217 of the Coastal Zone Management Act. This program is non-regulatory, relying heavily on existing State, County and local programs to address a variety of non-point sources of pollution impacting coastal waters. The basic Management Measures that comprise the State's program include: Coastal 6217 Management Boundary; Agriculture; Forestry; Urban Development; Marinas; Hydromodification; and Wetland and Riparian Areas. To date the program has undertaken or funded a number of projects designed to gather data on existing or potential pollutant sources, test new technology through pilot projects, assist property owners and regulators in developing and implementing pollution controls in the coastal counties. The State program is currently considered "conditionally approved" by NOAA.

Baldwin County

Baldwin County Zoning Ordinance (July 2009). The Baldwin County Zoning Ordinance is administered County-wide in unincorporated areas that have voted for zoning by the Baldwin County Commission and the Planning and Zoning Department. The ordinance establishes planning districts and sets forth zoning requirements within the County related to various land uses. All County controlled areas within the D'Olive Creek Watershed are in Zoning District 15. Article 13, Section 13.12 of the Ordinance mentions stormwater management only to the degree that a stormwater management plan is required for all major projects (defined by type of use, not acreage) and that "reasonable provisions for handling surface drainage have been made."

Section 13.13 (effective Jan. 2008) deals specifically with erosion control practices required during land disturbing construction activities. It sets forth various design principles and design criteria, standards and specifications to reduce erosion and sedimentation during construction. Section 13.13 requires activities be covered under a County permit; an erosion control plan be prepared and implemented; BMPs be implemented and maintained; and final site stabilization once construction is complete.

Section 10.4 establishes a Wetland Protection Overlay District that applies to all zoned areas and requires that a Corps of Engineers permit be obtained prior to County approval of projects involving the filling of jurisdictional wetlands. It also establishes a 30-foot development setback/easement for jurisdictional wetlands [**NOTE**: These requirements are in addition to those required by Federal and State agencies.].

Baldwin County Subdivision Regulations (January 2008). The Baldwin County Subdivision Regulations are administered County-wide by the Baldwin County Commission and Planning and Zoning Department. These regulations were designed primarily to set standards for the subdivision and development of property and relate primarily to lot sizes and the planning and construction of public streets and drainage. Portions of Article 5 (Sections 5.8 through 5.11) address drainage, erosion and sediment control (during construction) and stormwater management. Section 5.9 requires that an erosion and sedimentation control plan be included in the construction plans, sets forth basic objectives and design requirements/standards; and requires the implementation and maintenance of BMPs during construction. Section 5.10 addresses post-construction facilities requiring that post-construction runoff rates not exceed pre-construction runoff rates for 2 year through 100 year 24 hour storm events. Section 5.2.2 requires that applicants obtain a Corps of Engineers permit for wetland fill and establishes a 30-foot building setback from wetlands and a 5-foot buffer around jurisdictional wetlands.

Baldwin County Watershed Coalition

Realizing the ever increasing need for better stormwater management, the Baldwin County Watershed Coalition (BCWC) formed as a result of collaboration among municipal and county representatives (comprised of both staff and elected officials), representatives of local environmental organizations, state legislators, and representatives of local business and development interests. The mission of the BCWC is to act as a voluntary, non-regulatory association of local interests that will operate on a regional/watershed scale "*to support local communities in managing flooding, drainage, and issues related to stormwater runoff in Baldwin County while preserving and improving water quality and the use of our water resources.*" Additional information on this effort can be found in the "Financing Options" portion of the plan.

City of Daphne

City of Daphne's Land Use and Development Ordinance (September 2002). This ordinance is administered by the City of Daphne Planning Department. This ordinance establishes planning districts and sets forth the zoning requirements and development standards within the City's jurisdiction related to various uses of lands. It is applicable to subdivisions and commercial developments. Provisions for drainage, storm sewers, erosion and sediment control and stormwater detention are found in Article XVIII and are focused primarily on safety issues and property damage that could be caused from surface runoff. The ordinance does require the preparation and submittal of erosion and sediment control plans; sets forth basic control objectives; and establishes certain design and performance standards for BMPs and post-construction stormwater management facilities. Post-development stormwater release rates are not to exceed pre-development rates based on a 25 year 24 hour storm event. Coastal Protection is found in Article XX and basically mimics portions of ADEM's coastal program relative to scope and applicability. Article XX imposes no additional requirements above the ADEM/COE requirements [**NOTE**: At the time of the review, this ordinance was being considered for update or revisions by the City.].

City of Daphne's Ordinance No. 2008-54 (November 2008). This ordinance is administered by the City of Daphne Building Department. This ordinance regulates erosion and sediment control for residential dwellings and other land disturbance activities (only single-family residential and small commercial) with the jurisdiction of the City of Daphne. It applies to disturbances of more than 1,000 square feet and requires the preparation and implementation of an erosion and sediment control plan and establishes certain minimum requirements.

City of Spanish Fort

City of Spanish Fort's Subdivision Regulation (June 1999). This regulation relates to the "coordinated and efficient development of the City of Spanish Fort" and mentions "ecological and aesthetic environments." The primary focus of the regulation is on street layout and construction, lot size and building setbacks. Article VIII addresses various "Required Improvements" including storm sewers and drainage structures, and establishes design and performance criteria for handling stormwater. Post-development release rates shall not exceed that of pre-development for 2 year through 100 year storm events, and stormwater detention is required for sites 5 to 10 acres or larger (i.e., road construction and multi-family residential developments >5 acres and single-family developments >10 acres). City officials indicate that erosion and sediment controls are also being required on smaller sites, particularly if a problem is noted.

City of Spanish Fort Zoning Ordinance (May 1996). This ordinance establishes land use and development standards within the City's jurisdiction. Article VIII requires that an erosion and sediment control plan be prepared as part of the construction plans for tracts more than one acre in size; sets forth basic objectives for the plan; and establishes minimum design standards for erosion and sediment control during construction. Relative to the downstream protection of channels and stream banks, storage and controlled release of stormwater is required for all highway construction and commercial, industrial, educational, institutional, and multi-family developments of one acre or more; and for single-family developments of 5 acres or more. Coastal Protection is found in Article IX and basically mimics portions of ADEM's coastal program relative to scope and applicability. Article IX imposes no additional requirements above the ADEM/Corps of Engineers requirements. The City of Spanish Fort is also considering updating the ordinances, but city staffing and local economics may slow the process.

Subdivision and Restrictive Covenants

There are presently approximately 32 platted subdivisions and phases of subdivisions within the D'Olive Creek Watershed comprising nearly 46% of the total land area of the watershed. Property owners' associations have been incorporated for most and subdivision restrictions have been recorded and imposed to regulate the activities within the subdivisions. The subdivisions identified in the D'Olive Creek Watershed are listed in Table C-1.

Table C-1 – List of Subdivisions in D'Olive / Tiawasee / Joe's Branch Watershed

Daphne:	
D'Olive Estates	
Oakstone	
Oak Creek	
Regency Oaks	
Lake Forest	31 phases
Canterbury Place	4 phases
Bristol Creek	
Krystal Ridge	
Tiawasee Trace	
Sehoy	5 phases - Annexed by Ordinance No. 2000-19
French Settlement	2 phases
Catherine Place	Annexed by to Ordinance No. 2001-32
Brookhaven	
Stratford Glen	4 phases
Creekside	
The Park at Whispering Pines Apts	
Pecan Trace	
Brookside Patio Homes	No regulations
Eagle Creek	
Caroline Woods	No regulations
Timberline Court	Lake Forest, Unit 28
Rolling Hill Place	No regulations
Wood Forest	
Timbercreek	10 phases Annexed by various ordinances

Spanish Fort:	
Westminster Gates	
Westminster Village	Not found
Spanish Village	Not found
Wilson Heights	
Wakefield	4 phases
Falls Church	

Baldwin County:	
Sommerset Place	

The restrictions of some of the older subdivisions and phases address routine issues regarding yard and side setbacks, building signs, and permissible land uses, but do not address land clearing, erosion control, wetland and stream protection, or stormwater issues. It is evident that the trend of erosion control and land clearing concerns within the Watershed has evolved over time, with increased requirements being placed on the newer subdivisions developed, beginning in the 1990s. Most of the subdivisions, and the phases thereof, located in the Watershed were constructed and made subject to recorded declarations of covenants and restrictions or subdivision restrictions. The restrictions were intended to be the Rules of Conduct for the lot owners governing their use and activity on each lot and a common area to protect and preserve the character, and to some extent, the natural features of the subdivision. Not all subdivisions have recorded restrictions, and in some instances, only a portion of the subdivision may be within the Watershed. Subdivision restrictions are limited and temporary in nature. They are not designed to be perpetual or permanent, recognizing that over time, attitudes and practices do change. However, most have a long initial term (usually several years) with provisions for automatic extensions of the term unless a contrary vote of lot owners entitled to vote is made to permeate or replace the restrictions. Concerns over stormwater volume, stormwater velocity, use of low impact development practices to control stormwater and erosion as well as protection of natural features such as streams, wetlands and riparian buffers have only recently been expressed. These are not the types of negative or positive covenants normally found in subdivision restrictions. By their nature, subdivision restrictions look inward without consideration of neighboring and unrelated subdivision developments within the same Watershed or the same community.

Within the D'Olive Creek Watershed, the existing subdivision restrictions could be amended according to their terms by a vote of the membership, normally the lot owners, and perhaps the property owner's associations. The challenge will be to have the older existing subdivision lot owners agree that a change is necessary, to accept additional responsibility and agree to have someone (such as the property owner's association) enforce the provisions to maintain compliance. Newer subdivisions or those developed in the future, could certainly be made subject to innovative and updated covenants and restrictions drafted to address storm water issues, volume and velocity controls and retention, erosion control, post-construction practices, maintenance of buffers, and low impact management practices. All the inhabitants in each subdivision (and all subdivisions) need to recognize that individually and collectively they do affect the resources and total health of the Watershed. Once restrictions are imposed, enforcement then becomes an issue. Enforcement is an expensive procedure normally funded by dues, assessments or fees from the lot owners who are governed. To be effective, enforcement must be impartially pursued by the person or entity with the authority to do so, which may include a neighbor of any lot owner, the property owner's association or a third-party given the right to do so.

A challenge in the Watershed will be to work with each of the existing subdivisions and property owners' associations to protect the D'Olive Watershed. Under the existing governmental regulatory framework, implementation of measures to control the volumes and velocities of stormwater within established subdivisions will have to be pursued on an individual subdivision or neighborhood basis and will depend upon the voluntary commitment of the residents within each subdivision. Effective public education is a necessary first step to create an understanding and recognition of the need for new and additional protection and control measures. Subsequent implementation of the measures will then depend upon consistent, compatible and cooperative relationships among the property owners within each subdivision and in the overall Watershed.

Regulatory Overlap

Federal, State and local requirements overlap within the Watershed. The over-arching Federal and State water quality regulations apply to all areas of the County and within in the Cities of Daphne and Spanish Fort. Any proposal to fill jurisdictional wetlands, no matter where located within the D'Olive Creek Watershed, must have:

- A proper permit application for a CWA § 404 permit with review by all agencies and the public (unless authorized by a NWP);
- ADEM water quality certification;
- Consideration of CWA § 303(d);
- ADEM coastal program consistency determination if in the coastal area; and
- A CWA § 402 NPDES – ADEM Admin. Code Reg. 335-6-12 construction stormwater permit (if greater than 1 acre will be disturbed).

The Cities' extra-territorial jurisdictions extend beyond their boundaries for up to five miles for planning purposes and overlap into the County, but not the adjacent municipality. Each City exerts its jurisdiction and permitting requirements within their respective geographical boundaries. Each local entity requires permits for development, land disturbance and building construction, depending on jurisdiction, that are in addition to the federal and state permit requirements. Often the federal or state permit is a prerequisite to issuance of the local permit. Where City and County jurisdictions overlap, it is customary for the "more stringent" requirements to apply. In general, the current level of regulatory overlap is not considered a significant issue relative to stormwater management within the watershed.

General Observations

The common issues in the D'Olive Creek Watershed recited by the City, County and/or landowners interviewed included the following:

- Need for updated provisions in local ordinances addressing development, redevelopment, retention of stormwater runoff and velocities, continued maintenance of retention-detention ponds, additional inspection, monitoring and reporting (recordkeeping) requirements, training for inspectors, more enforcement, and protection and restoration of wetlands, riparian zones and streams.

    - Each City and County official recognized the need for better communication between and among the various regulatory agencies and regulatory consistency.

- Problems with stormwater runoff volumes, velocity, lack of adequate stream and wetland buffers, lack of post-construction maintenance of detention facilities, historical erosion problems within, or due to, older subdivisions and commercial developments, and the identification of responsible parties for costs, maintenance and additional stormwater controls.

- The amount (acreage) of undeveloped land within the Watershed has been significantly reduced over the past three decades. Additional efforts may be required to implement innovative practices on these remaining areas to protect downstream areas. Further development and redevelopment should consider protection of drainage systems by buffers, preservation areas, and reduction and retention of stormwater runoff.

- Road construction and design at the County and State level must be undertaken in a manner that will protect the streams and Watershed from increased volumes and velocities of stormwater, erosion and sedimentation, and other nonpoint source contaminants.

- Existing problems must be corrected, either voluntarily or by regulation, at the time of redevelopment and through structural and nonstructural processes (such as education).

A regulatory "matrix", based on several elements deemed critical to effective stormwater management programs, was created to assist in the review process. The matrix is contained in Tables C-2 and C-3. The rows in both tables list the four review elements considered: (1) construction phase BMPs"; (2) post-construction stormwater management; (3) wetland protection; and (4) coastal area protection. The columns in Table C-2 summarize the results of the review of the regulations or ordinances for each of the four regulatory entities having jurisdiction within the D'Olive Watershed. Table C-3 lists the regulatory citations upon which the information in the matrix was based. The footnotes reference the regulations and ordinances upon which the information is based.

Tables C-2 and C-3 provided the foundation of the review and served to focus the agency interviews that were conducted. It is apparent that there is some degree of consistency among the various programs with regard to the elements that are actually addressed (e.g. all programs require some type of construction phase BMPs, address stabilization time, etc.). However, there are significant differences between the specific requirements of each of the regulatory entities as stated in the regulations or ordinances (e.g. design storm, etc.). These differences and any perceived deficiencies are addressed in the following sections.

Table C-2 Regulatory Matrix – Comparison of Requirements

		ADEM	Baldwin County	Daphne	Spanish Fort
Construction Phase BMPs		Yes	Yes	Yes	Yes
	Design Standards	AL Handbook*[1]	AL Handbook[3]	AL Handbook[5]	Not Specified
	Design Storm	2yr-24hr[2]	25 yr[4]	10 yr[6]	10 yr[7]
	Site Size	>1 ac[1]	Any[3,10]	>1,000 sf[5]	>1 ac[7]
	Stabilization Time	13 days[1]	10 or 13 days[3]	30 days[6]	30 days[7]
	Inspections	I/month + 3/4" rain[1]	Yes[11]	Yes[11]	Yes[11]
	BMP Repair/Maint. Time	7 days[1]	Not Specified[9]	48 hours[5]	Not Specified[9]
	Non-compliance Reporting	Yes[1]	No	No	No
	Buffer Requirement	None	Yes-unspecified width[4]	Yes-unspecified width[6]	Yes-unspecified width[8,7]
Post Construction SW Management		No	Yes	Yes	Yes
	SW Quality	No	No	No	No
	SW Quantity	No	Yes	Yes	Yes
	Design Storm	N/A	2 thru 100 yr[4]	25yr or 24hr[6]	2 thru 100 yr[8]
	Site Size	N/A	Any[4, not applicable to SFR]	1 ac[6]	1ac/5ac[7] - 5ac/10ac[8]
	Inspection	N/A	Yes[12]	Yes[12]	Yes[12]
	Maintenance	N/A	Developer/Owner Assoc.[4]	Developer/Trustee[6]	Developer/Owner[8]
	Reporting	N/A	No	No	No[14]
	Calculation Method	N/A	Prohibits Rational Method**[4]	Not Specified	Rational Method[8]
Wetland Protection					
	Permit Requirement	Yes[13, only in coastal area]	ADEM/COE	ADEM/COE	ADEM/COE
	Setback Requirement	No	30 feet[3,4]	No	No
	Buffer Requirement	No	5 feet[4]	No	No
Coastal Area Protection		Yes[13]	No	Yes[6]	Yes[7]

* *Alabama Handbook for Erosion Control, Sediment Control and Stormwater Management on Construction Sites and Urban Areas*, March 2009

** Regulation prohibits the use of the Rational Method or Modified Rational Method on sites >40 acres

Footnotes:

1 ADEM Administrative Code R. 335-6-12, January 23, 2003 (Construction Stormwater NPDES Program)
2 ADEM CBMPP Guidance issued July 2009
3 Baldwin County Zoning Ordinances, Section XIII, January 1, 2008; amended July 21, 2009 (Applicable only to zoned areas of County)
4 Baldwin County Subdivision Regulations, January 1, 2008 (Applicable County wide)
5 City of Daphne Ordinance No. 2008-54, November 3, 2008 (Applicable to SF residential)
6 City of Daphne Land Use and Development Ordinance, September 3, 2002 (Applicable to commercial developments and subdivisions)
7 City of Spanish Fort Zoning Ordinance, Article VIII, May 31, 1996
8 City of Spanish Fort Subdivision Regulations, Article VIII, June 1999
9 Although no timeframe is specified in the local ordinances, a stop work order may be issued for "non-conformance"
10 Requirements for ESC plans on sites <1 acre are less prescriptive than those for sites >1 acre
11 Regulation indicates that permitting authority may do inspections but frequency is not indicated - no requirement for self-monitoring/reporting
12 Stormwater control structures only inspected at completion ("as-built") to insure conformance with approved plans
13 ADEM Administrative Code R. 335-8, June 30, 1994 (Coastal Program)
14 Spanish Fort indicates that they are now requesting annual monitoring of stormwater facilities and reporting to the City but nothing has been codified

Table C-3 Regulatory Matrix - Citations

		ADEM	Baldwin County	Daphne	Spanish Fort
Construction Phase BMPs		Yes	Yes	Yes	Yes
	Design Standard	1 @ 335-6-12-.21(1)(a)	3 @ 13.13.4	5 @ Sec. IV.1	N/A
	Design Storm	2 @ Section 1.5	4 @ 5.9.3(b)	6 @ 18-24	7 @ 8.62
	Site Size	1 @ 335-6-12-.02(m)	3 @ 13.13.7	5 @ Sec. I	7 @ 8.1
	Stabilization Time	1 @ 335-6-12-.21(2)(b)5	3 @ 13.13.5(f)-(l)	6 @ 18-23(c)-(d)	7 @ 8.612-8.613
	Inspection Requirement	1 @ 335-6-12-.28	N/A	N/A	N/A
	BMP Repair/Maint. Time	1 @ 335-6-12-.15(11)	N/A	5 @ Sec. IV.2	N/A
	Reporting	1 @ 335-6-12-.33	N/A	N/A	N/A
	Buffer Requirement	N/A	4 @ 5.9.3(a)1	6 @ 18-23(a)	7 @ 8.61 / 8 @ 804.2.3
Post Construction SW Management		No	Yes	Yes	Yes
	SW Quality	N/A	N/A	N/A	N/A
	SW Quantity	N/A	4 @ 5.10.1	6 @ 18-28	8 @ 804.2.3
	Design Storm	N/A	4 @ 5.10.2(d)	6 @ 18-38	8 @ 804.2.3
	Site Size	N/A	4 @ 5.10.1	6 @ 18-25(a)	8 @ 804.2.3
	Inspection	N/A	N/A	N/A	N/A
	Maintenance	N/A	4 @ 5.10.5	6 @ 18-50	8 @ 804.1.8
	Reporting	N/A	N/A	N/A	N/A
	Calculation Method	N/A	4 @ 5.10.2(d)	N/A	8 @ 804.2.3
Wetland Protection		Yes	Yes	No	No
	Permit Requirement	13@335-8-2-.02	3 @10.4.4	N/A	N/A
	Setback Requirement	N/A	3@10.4.5-.5; 4@5.2.2	N/A	N/A
	Buffer Requirement	N/A	4@5.2.2	N/A	N/A
Coastal Area Protection		13	No	6 @ Article XX	7 @ Article IX

Footnotes:

1 ADEM Administrative Code R. 335-6-12, January 23, 2003 (Construction Stormwater NPDES Program)
2 ADEM CBMPP Guidance issued July 2009
3 Baldwin County Zoning Ordinances, Section XIII, January 1, 2008; amended July 21, 2009 (Applicable only to zoned areas of County)
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Regulatory Inconsistencies

Observation No. 1. Consistency among the local government ordinances will be a key factor in effectively implementing the management measures necessary to protect the Watershed's natural resources. Although there was a great deal of consistency among the local government ordinances, likely due to their common origin (SARPC), a number of inconsistencies relating to stormwater management were noted (e.g. design storm, site stabilization time frame, BMP repair time frame, etc.). In short-sightedness, local governments may use regulatory differences and waivers or variances to promote new development, and usually end up "throwing the baby out with the wash water". The long term costs to a community and its citizens will be realized as flooding increases; flood zones expand increasing insurance rates; and waterbodies become polluted prompting increased stormwater treatment costs; and stormwater conveyance, maintenance and dredging costs manifest and increase.

- **Recommendation:** Baldwin County, Daphne and Spanish Fort collectively should work to resolve existing inconsistencies between local ordinances related to stormwater management (both construction phase and post-construction requirements). Each entity should also review their respective flood control and overall development requirements for potential conflicts with stormwater management goals.

Observation No. 2. Effective erosion and sediment control on construction sites is dependent on good BMP design, proper BMP installation and routine monitoring, maintenance and modification. If any one of these three critical elements is lacking, there is a good chance for BMP failure and off-site impacts. It all starts with a good design. EPA and ADEM offer excellent guidance on the preparation of BMP (CBMPP, SWPP) plans. BMP plans should be prepared and certified, and updated or modified as necessary, by a professional with experience in erosion and sediment control and in consideration of a particular design storm event. The current Federal and State guidance is to use a 2-year 24-hour storm event for design of construction phase BMPs. This equates to approximately 6 inches over 24 hours in the Daphne, Alabama area. Statistically, this storm event has a 50 percent chance of occurring during any one year time period. Larger design storm events (e.g. 10-year or 25-year; +9 inches and +10 inches, respectively) are not practical for construction phase BMPs.

Improperly installed BMPs do not function as intended, are a waste of time and money, and are likely to underperform or fail completely. Installation should be performed by qualified individuals or overseen/directed by qualified individuals. An initial inspection and confirmation of proper installation should be performed prior to the commencement of major land clearing and grading.

Construction sites, by nature, change shape on a daily or even hourly basis. Therefore routine monitoring and inspection to determine the condition and effectiveness of BMPS are essential. Early detection and correction of BMP deficiencies are key components in reducing, minimizing and/or eliminating pollutants in stormwater discharges. The earlier potential problems are identified and corrected, the less erosion and sedimentation will impact off-site areas. Timely repair and maintenance of BMPs are also critical to reducing construction phase stormwater impacts. Poor BMP maintenance is arguably the number one cause of construction site non-compliance noted by ADEM.

- **Recommendation:** Baldwin County, City of Daphne and City of Spanish Fort should adopt consistent requirements for: BMP plan preparation by a qualified professional; a construction phase BMP design storm equivalent to the 2 year 24 hour event (~6 inches). Other design parameters should be consistent with, or reference, the current version of *The Alabama Handbook for Erosion Control, Sediment Control, and Stormwater Management on Construction Sites and Urban Areas (March 2009).*

- **Recommendation:** Baldwin County, City of Daphne and City of Spanish Fort should adopt consistent requirements for BMP plan objectives and content following, at a minimum, EPA or ADEM guidance documents.

- **Recommendation:** Baldwin County, City of Daphne and City of Spanish Fort should adopt consistent requirements regarding the "self-inspection" of construction sites by the operator (see also Observation No. 7). Documentation of all inspections and observations should be kept.

- **Recommendation:** Baldwin County, City of Daphne and City of Spanish Fort should adopt consistent requirements regarding the timely repair and maintenance of BMPs (see also Observation No. 7).

Regulatory Deficiencies

Observation No. 3. Excepting those pertaining to flood control, there are currently no applicable Federal or State level regulations pertaining to post-construction stormwater management. Although EPA has announced through public notice that they are considering such regulations, it is anticipated that the process will require several years. Federal and State level regulations often are minimum "fall back" requirements that would apply where there are no local requirements, or they serve as the impetus for local ordinances. Without this foundation, it is difficult to achieve regulatory consistency among local units of government. Even when State and Federal regulations are in place, they are usually of such a broad nature and scope (national or statewide) that they may not be meaningful at a watershed specific level. In such cases it falls to the local units of government to adopt and implement regulations that are effective in achieving specific watershed management goals.

- **Recommendation:** ADEM should promulgate updated construction stormwater regulations (currently in process) and develop post-construction stormwater management regulations applicable, at a minimum, to watersheds where urban runoff is an identified cause of water quality impairment.

- **Recommendation:** ADEM and ADCNR should focus on resolving the outstanding federal concerns relating to the unapproved Management Measures in the ACNPCP, particularly those related to Urban- New and Site Development; Urban-Watershed

Protection and Existing Development; Urban-Construction Site Erosion and Sediment Control & Chemical Control; Urban-Roads, Highways and Bridges; Wetlands, Riparian Areas and VTS; and Hydromodification.

Observation No. 4. Development and implementation of local stormwater management regulations and ordinances that exceed State or Federal requirements are often the best or only ways to achieve water resource protection and/or address local stormwater related impacts. Such local programs have utilized various methods and rationales to develop design standards to address local pollutants of concern within specific watersheds (usually § 303(d) listed and/or TMDL limited) or other geographical areas (e.g. Georgia's Coastal Stormwater Supplement[1], and Virginia Department of Conservation and Natural Resources Stormwater Management Regulations[2]). Recent EPA post-construction stormwater management guidance for federal facilities subject to Section 438 of the Energy Independence and Security Act encourages retention of the local 95th percentile storm event. Various other guidance documents and programs reference the local 90th through the 75th percentile storm event. ADEM has estimated the 95th percentile storm event for the Mobile area at 2.46 inches. The theory has been that if X% of the runoff is eliminated a corresponding reduction in pollutant loading will result. Some recent opinions (Andrew Reese in *Stormwater*, Vol. 10 No. 6) are that even the traditional methods of using pre-and post-construction peak discharge limitations to address flooding and downstream impacts and/or pollutant reductions may not be as an effective approach as originally thought, and that the total pre-and post-construction discharge volume should be considered (an idea known as Volume Based Hydrology). Reese also postulates that peak discharge controls may even exacerbate downstream erosion, particularly in humid climates, by forcing larger volume flows into the channel cross-section rather than allowing them to flow partially along floodplain paths. For the D'Olive Creek Watershed, this last statement appears to be directly on target. Additionally, the different methods utilized to estimate pre and post construction stormwater runoff can yield radically differing results. The rational method commonly employed is believed to underestimate runoff on larger sites (according to Practices in Detention of Urban Stormwater, American Public Works Association Special Report #43, "use of the rational equation should be limited to drainage areas of less than 20 acres.")

- **Recommendation:** Baldwin County, City of Daphne and City of Spanish Fort should work collectively to formulate a consistent set of post-construction stormwater management requirements. These requirements should focus on stormwater runoff total volume reduction using Low Impact Development (LID) concepts and stormwater retention (Volume Based Hydrology (VBH)), and runoff velocity and peak flow management where and when appropriate.

- **Recommendation:** Baldwin County, City of Daphne and City of Spanish Fort should work collectively with an appropriately qualified engineering firm to develop a common set of post-construction stormwater technical design standards focused on runoff reduction (VBH) applicable, at a minimum, to the D'Olive Creek Watershed.

[1] Coastal Stormwater Supplement to the Georgia Stormwater Management Manual First Edition, April 2009
[2] Virginia Code of Regulations 4VAC-20 et.seq.

- **Recommendation:** Each local government requiring the preparation and submittal of engineering design plans related to post-construction stormwater management should employ, or otherwise have access to (e.g. contract for consultant services), a qualified professional engineer with experience in stormwater management to review such submittals.

Observation No. 5. Inspection, maintenance and reporting on the operational condition of long-term post-construction stormwater management controls are common issues among the local governments within the Watershed. Routine inspection by qualified individuals is necessary to determine maintenance needs and identify performance issues. Financial and logistical (access) provisions are essential to implementing repair and maintenance activities, and reporting is necessary in documenting continuing compliance with stormwater management requirements.

- **Recommendation:** Baldwin County, City of Daphne and City of Spanish Fort should work collectively to formulate a consistent set of post-construction stormwater control structure inspection, maintenance and reporting requirements.

Observation No. 6. Controlling erosion on construction sites and minimizing off-site sedimentation are primarily functions of the extent and duration of exposed soils. The larger the exposed area and the longer that area remains exposed, the more erosion and sedimentation are likely to occur. Conversely, the smaller the area exposed and the shorter the duration of the exposure, the more easily erosion and sediment are controlled. A number of the Federal, State and local regulations target this concept by limiting (or encouraging the limitation of) the acreage that is exposed (e.g. the new EPA effluent guideline for turbidity will not apply on sites with less than 20 acres disturbed) and by establishing a stabilization timeframe (e.g. ADEM's 13-day rule). The use of "procedural BMPs", like phasing construction activities, just in time clearing and stabilize as you go, are very effective practices from both an environmental aspect as well as an economic aspect.

- **Recommendation:** Baldwin County, City of Daphne and City of Spanish Fort should collectively work to develop consistent construction site management requirements that incorporate the use of phasing, limited clearing (10-20 acres maximum), and prompt (7-day) re-stabilization of exposed soils.

Observation No. 7. The timely discovery and repair of construction phase BMPs is critical to maintaining effective erosion and sediment controls. ADEM requires that daily observations be made of active work areas and that comprehensive inspections be performed and recorded by permittees at least monthly and after qualifying rainfall events (¾ inch within 24 hours). ADEM requires that non-functioning temporary BMPs be repaired or replaced with functional controls within 7 days of discovery. The local governments currently have no requirements for routine self-inspection and repair/maintenance timeframes vary by jurisdiction.

- **Recommendation:** Baldwin County, City of Daphne and City of Spanish Fort should work collectively to develop and implement a consistent set of construction site management requirements that address routine self-monitoring and reporting to include, at a minimum: initial inspection prior to major land clearing and grading; once per week during active construction; and at the time of final site stabilization.

- **Recommendation:** Baldwin County, City of Daphne and City of Spanish Fort should work collectively to develop and implement a consistent set of construction site management requirements such that deficient BMPs are repaired or replaced with functional BMPs within 48 hours of discovery.

Observation No. 8. Often, efforts to change how individual actions may impact the environment are most effective the "closer to home" they are applied. This is where subdivision rules and restrictions can play an important part in implementing various strategies to reduce or better manage storm water runoff, particularly those practices or programs aimed at individual homeowners or lots (e.g. gutter disconnect, greener by the yard, etc.).

- **Recommendation:** Catalogue and thoroughly review each of the existing subdivisions and corresponding subdivision restrictions to identify the ones that need to be updated to better protect natural resources and streams; control construction stormwater and post-construction stormwater; and encourage stormwater reduction and/or retention practices.

- **Recommendation:** Encourage, through education and outreach programs, the cooperation and interaction of subdivisions and property owners. Emphasis should be placed on explaining the cumulative effect of existing and future drainage practices exercised on each lot and development; the importance of protecting and maintaining natural and pervious areas; and highlighting respect for offsite (upstream and downstream) impacts.

- **Recommendation:** Provide examples and assistance to property owners and property owners associations about upgrading subdivision restrictions to address stormwater control and retention; post-construction practices for erosion and stormwater control; maintenance and renovation of control structures; and implementation of new and innovative practices.

Variance and Waivers

Observation No. 9. Variances and waivers to the various requirements imposed by rule and regulations are a "necessary evil". It is not possible or practical to envision every possible scenario during the development of a rule and site specific circumstances may occasionally dictate that some specific requirement(s) be waived. Also, there must be some flexibility to allow innovative practices to be employed to achieve the desired objectives. However, the ultimate objective of the rule should be kept in mind and whatever requirements that may be waived should not undermine that objective. A mere "hardship", as described in several of the existing local ordinances as a basis for a waiver, has the potential for abuse.

- **Recommendation:** Baldwin County, City of Daphne and City of Spanish Fort should work collectively to develop and implement a consistent set of guidelines on the issuance of waivers and variances that will insure that the ultimate goals of the Watershed Management Plan will be met.

Enforcement

Observation No. 10. Rules, regulations, ordinances, restrictions and the like usually require some degree of enforcement to insure compliance. To achieve the ultimate objective of the rule, enforcement must be timely and meaningful. Further, to maintain the integrity of the implementing agency, enforcement must be consistent and impartial. Each program reviewed contained enforcement provisions ranging from "stop work orders" to civil or criminal penalties. However, most local agencies indicated that formal enforcement was "rare" [**Note:** A detailed review of each agency's enforcement history was not performed.].

- **Recommendation:** Baldwin County, City of Daphne and City of Spanish Fort should work collectively to develop and implement a consistent enforcement strategy within the D'Olive Creek Watershed.

- **Recommendation:** ADEM should consider developing an enhanced enforcement strategy within the D'Olive Creek Watershed consistent with the 303(d) listing of the major tributaries.

Wetland Protection

Observation No. 11. The value of wetland and riparian areas for wildlife habitat, floodwater storage, water quality treatment (i.e., sediment and nutrient removal, temperature control, etc.) and the like is well documented. The protection and restoration of these systems will be a critical component in achieving the overall goals of the D'Olive Creek Watershed Management Plan. The results of the wetland condition evaluation (Appendix B) indicate that significant portions of the Watershed's wetlands have been impacted to various degrees by direct filling for development, sedimentation and by channel incision that has reduced the extent of overbank inundation of these areas during high flow events.

Local governments often assume that the maze of federal and state permitting requirements will be sufficient to protect the natural function of these systems. Unfortunately, this is rarely the case. The State of Alabama currently has no codified buffer or setback requirements and Federal and State permits are routinely issued that allow wetlands to be impacted either directly or indirectly. Although mitigation for stream and wetland impacts may be required by the permit, mitigation often takes place outside of the watershed in which the impacts actually occur. Therefore, local governments will play a critical role in protecting these vital resources from both direct and indirect impacts associated with development.

There is currently much debate and study over what constitutes an adequate buffer or setback (Ruppercht, et.al.)[3], depending largely on what specific goals are trying to be attained. Adequate buffer and setback widths may also be dependent upon the type of wetland system to be

[3] Ruppercht, et.al., Riparian and Wetland Buffers for Water Quality Protection, *Stormwater* Nov-Dec 2009.

protected; position on the landscape; slope, soil type and cover of adjacent lands; and other similar factors. It is also known that the functions of setbacks and buffers are enhanced by the use of construction-phase and post-construction stormwater BMPs.

- **Recommendation:** ADEM, through its water quality and coastal management programs, should develop and implement wetland and riparian buffer and setback requirements applicable, at a minimum, to watersheds having 303(d) listed streams.

- **Recommendation:** Baldwin County, City of Daphne and City of Spanish Fort should work collectively with an appropriately qualified wetland expert to develop a common set of wetland and riparian setback and buffer requirements applicable, at a minimum, to the D'Olive Creek Watershed.

APPENDIX D

Financing Alternatives

Table D-1. Composite List of Federal Funding Opportunities (i.e., Grant, Loans, and Revenue Sharing)

Funding Program	Funding Program	Funding Program	Funding Program
Clearinghouse for Federal Grant Opportunities (Grants.gov)	Grants.gov Contact Center Phone: 1-800-518-4726 (24 hours/day, 7 days/week)	Administered by the U.S. Department of Health and Human Services, Grants.gov is a central storehouse for information on over 1,000 grant programs and provides access to approximately $500 billion in annual awards. This site also includes information about project funding that is available under the American Recovery and Reinvestment Act. www.grants.gov www.grants.gov/ForApplicants www.grants.gov/GetStarted	Various
EPA Catalog of Federal Funding Sources for Watershed Protection	N/A	The Catalog of Federal Funding Sources for Watershed Protection Web site is a searchable database of financial assistance sources (grants, loans, and cost-sharing) available to fund a variety of watershed protection projects. http://cfpub.epa.gov/fedfund	Various
EPA Clean Water and Drinking Water State Revolving Loan/Grant Funds (FY 2010)	James Dailey ADEM P.O. Box 301463 Montgomery, AL 36130-1463 334-271-7805 Email: jwd@adem.state.al.us	The Clean Water State Revolving Fund and the Drinking Water State Revolving Funds (SRF) are low-interest loan programs intended to finance public water and wastewater infrastructure improvements in Alabama. ADEM administers these funds for EPA, performs the required technical/environmental reviews of projects, and disburses funds to recipients. In 2010, project assistance loans totaled $43,450,775 in the CWSRF. In addition, $7,411,000 was available to fund green infrastructure, water and energy efficiency, and other environmentally innovative projects. The states establish limits for project awards; there is no statutory limit. www.adem.state.al.us/waterdivision/SRF/SRFMainInfo.htm www.adem.state.al.us/programs/water/srf.cnt	Pre-application 12/31/09 Funding decisions February 2010 Full application 5/1/10
EPA Community Action for Renewed Environment (CARE) Grants	Michelle Boyd Office of Policy & Management EPA Region 4 boyd.michelle@epa.gov 404-562-8159 Davian Marraccini marraccini.davina@epa.gov 404-562-8293	Community Action for a Renewed Environment (CARE) is a competitive grant program that offers an innovative way for a community to organize and take action to reduce toxic pollution in its local environment. Through CARE, a community creates a partnership that implements solutions to reduce releases of toxic pollutants and minimize people's exposure to them. By providing financial and technical assistance, EPA helps CARE communities get on the path to a renewed environment. www.epa.gov/care	3/9/10

Table D-1. Composite List of Federal Funding Opportunities (i.e., Grant, Loans, and Revenue Sharing)

Funding Program	Funding Program	Funding Program	Funding Program
EPA Five-Star Restoration Program Grants	Myra Price USEPA Wetlands Division Washington, DC price.myra@epa.gov 202-566-1225 Gail Harrison, Water Mgmt. Div. EPA Region 4 harrison.gail@epa.gov 404-562-9410	This program provides challenge grants, technical support and opportunities for Information exchange to enable community-based projects that restore wetlands and streams. Grant awards typically range from $5,000 to $20,000. www.epa.gov/wetlands/restore/5star www.epa.gov/water/funding.html (List of funding and financing resources)	2/11/10
EPA Gulf of Mexico (GOM) Program	Esther Coblentz USEPA Gulf of Mexico Program Office, Mail Code EPA/GMPO Stennis Space Center, MS 39529 228-688-1281 coblentz.esther@epa.gov	The goals of the GOM Program are: (1) to assist states, Indian Tribes, interstate agencies, and other public or nonprofit organizations in developing, implementing, and demonstrating innovative approaches relating to the causes, effects, extent, prevention, reduction, and elimination of water pollution: and (2) to expand and strengthen cooperative efforts to restore and protect the health and productivity of the Gulf of Mexico in ways consistent with the economic well-being of the region. Focus is on the states of Alabama, Florida, Louisiana, Mississippi and Texas. Grant awards typically range from $13,000 to $330,000. www.epa.gov/gmpo www.cfda.gov (Search for Program 66.475.)	TBA
EPA Non-Point Source Grant Program (Clean Water Act Section 319)	Federal and State Funds administered by states in EPA Region 4.	Through its 319 program, EPA provides formula grants to the states and tribes to implement nonpoint source projects and programs in accordance with Section 319 of the Clean Water Act (CWA). Nonpoint source pollution reduction projects can be used to protect source water areas and the general quality of water resources in a watershed. Examples of previously funded projects include the design and implementation of BMP systems for stream, lake and estuary watersheds. Grant awards vary by State. For individual state contacts in Region 4, visit www.epa.gov/region4/water/nps/grants/index.html	Check with appropriate State Contact.
EPA Region 4 Special Appropriations Grants (State and Tribal Assistance)	Natalie Ellington, Chief Infrastructure Section 404-562-9453 ellington.natalie@epa.gov	Special appropriations grants fund special projects that are specifically identified in the State and Tribal Assistance Grant (STAG) account of the EPA appropriation. The recipient and amount of each grant are identified by Congress. These special projects implement the planning, design, and construction of a variety of water and wastewater infrastructure projects. Eligible costs may include planning, design, land acquisition, and construction to the extent that they are reasonable to the project objectives. Recipients prepare a plan that describes how the environmental or public health objectives will be achieved. Grant amounts vary by project. www.epa.gov/region4/water/gtas/specialappropriations.html	9/1/09 for FY2010

Table D-1. Composite List of Federal Funding Opportunities (i.e., Grant, Loans, and Revenue Sharing)

Funding Program	Funding Program	Funding Program	Funding Program
EPA Targeted Watershed Grants (and Water Trading Funding)	Bob Rose, Office of Water, EPA Washington, DC rose.bob@epa.gov 202-564-0322 Morgan Jackson EPA Region 4 jackson.morgan@epa.gov 404-562-9393	Established in 2003, the Targeted Watersheds Grant program is designed to encourage successful community-based approaches and management techniques to protect and restore the nation's watersheds. Grant awards typically range from \$300,000 to \$900,000. In 2010, EPA plans to award up to \$600,000 under this program to an eligible entity to manage an Urban Watershed Capability Building Grant. www.epa.gov/owow/watershed/initiative	5/19/10 for Urban Watershed Grant
EPA Wetlands Program Development Grants (State- Tribal-Local Governments and State Universities only)	Contact Region 4 EPA office. Morgan Jackson EPA Region 4 jackson.morgan@epa.gov 404-562-9393	The EPA Wetland Program Development Grants are intended to encourage comprehensive wetlands program development by promoting the coordination and acceleration of research, investigations, experiments, training, demonstrations, surveys, and studies relating to the causes, effects, extent, prevention, reduction, and elimination of water pollution. Projects build the capacity of states, tribes, and local governments to effectively protect wetland and riparian resources. Projects funded under this program support the initial development of a wetlands protection, restoration or management program or support the enhancement/refinement of an existing program. Non-profits are not eligible to compete under the current RFP. Grant awards will range from \$100,000 to \$600,000. Anticipate 10 awards and total program funding of \$2,300,000. Some award may involve or relate to geospatial information. www.epa.gov/region4/water/wetlands.wetlands grants.html www.epa.gov/owow/wetlands/grantguidelines/	6/15/10 Grants are usually approved within four months of receipt of application.
FEMA Flood Mitigation Assistance Program	Lloyd Hake Public Assistance Branch Recovery Division 500 C Street, SW Washington, DC 20472 202-646-3428 lloyd.hake@dhs.gov	The Flood Mitigation Assistance (FMA) program provides funding to states, federally-recognized Indian tribal governments, and communities so that cost-effective measures are taken to reduce or eliminate the long-term risk of flood damage to buildings, manufactured homes, and other structures insured under the National Flood Insurance Program (NFIP). The long-term goal of FMA is to reduce or eliminate claims under the NFIP through mitigation activities. Three types of grants are available under FMA: Planning, Project, and Technical Assistance. Grants cannot exceed \$50,000 to any community applicant. www.fema.gov/government/grant/government www.dhs.gov	TBA

Table D-1. Composite List of Federal Funding Opportunities (i.e., Grant, Loans, and Revenue Sharing)

Funding Program	Funding Program	Funding Program	Funding Program
FEMA Hazard Mitigation Grant Program	Contact your state Hazard Mitigation Officer and local government official(s) for specific details.	The Federal Emergency Management Agency Hazard Mitigation Grant Program (HMGP) provides states and communities with resources to invest in long-term actions that help to reduce the toll from potential natural and manmade hazards. The program also supports the implementation of mitigation measures during the Immediate recovery from a disaster. The HMGP funds projects to protect either public or private property, as long as the project fits within the overall mitigation strategy of the state an/or local government and complies with program guidelines. In response to flood hazards, eligible projects include the elevation, relocation or acquisition and demolition of flood-prone structures, stormwater management projects and certain types of minor flood control projects. The state Is responsible for setting priorities for funding and administering the HMGP. www.fema.gov/government/grant/hmgp.index.shtm	Applications must be submitted within 12 months of the date of each disaster declaration.
NOAA Broad Agency Announcement (BAA)	Steve J. Drescher Policy Advisor Steve.j.drescher@noaa.gov	The purpose of this notice is to request proposals for special projects and programs associated with NOAA's strategic plan and mission goals, as well as to provide the general public with information and guidelines on how NOAA will select proposals And administer discretionary Federal assistance under this BAA. Funding for potential projects in this notice is contingent upon the availability of Fiscal Year 2010, Fiscal Year 2011 and Fiscal Year 2012 appropriations. Publication of this Announcement does not oblige NOAA to review an application beyond an initial administrative review, or to award any specific project, or to obligate any available funds. www.nmfs.noaa.gov	9/30/11
NOAA Coastal Services Center Cooperative Agreements	James L. Free U.S. Department of Commerce National Oceanic and Atmospheric Administration National Ocean Service Coastal Services Center 2234 South Hobson Avenue Charleston, SC 29405-2413 843-740-1185 James.L.Free@noaa.gov	The National Oceanic and Atmospheric Administration (NOAA) guides the conservation and management of coastal resources through a variety of mechanisms, including collaboration with the coastal resource management programs of the nation's states and territories. The mission of the NOAA Coastal Services Center is to support the environmental, social, and economic well being of the coast by linking people, information, and technology. The vision of the NOAA Coastal Services Center is to be the most useful government organization to those who manage and care for our nation's coasts. Grant awards typically range from $40,000 to $1,700,000. www.csc.noaa.gov/funding	Varies depending on opportunity

Table D-1. Composite List of Federal Funding Opportunities (i.e., Grant, Loans, and Revenue Sharing)

Funding Program	Funding Program	Funding Program	Funding Program
NOAA Coastal Zone Management Administration Awards	John King U.S. Department of Commerce National Oceanic and Atmospheric Administration National Ocean Service 1305 East-West Highway 11th Floor Silver Spring, MD 20910 301-713-3155 john.king@noaa.gov	The program assists states in implementing and enhancing Coastal Zone Management programs that have been approved by the Secretary of Commerce. Funds are available for projects in areas such as coastal wetlands management and protection, natural hazards management, public access improvements, reduction of marine debris, assessment of impacts of coastal growth and development, special area management planning, regional management issues, and demonstration projects with potential to improve coastal zone management. Grant awards typically range from $900,000 to $2,700,000; the median award is $2,300,000. www.coastalmanagement.noaa.gov	Varies by state. Funds typically available in July and December.
NOAA Community-Based Habitat Restoration Partnership Grants	Melanie Gange U.S. Department of Commerce National Oceanic and Atmospheric Administration Office of Habitat Conservation, HC-3 1315 East-West Highway Silver Spring, MD 20910 301-713-0714 Melanie.Gange@noaa.gov	The NOAA Community-based Restoration Program provides funds for small-scale, Locally driven habitat restoration projects that foster natural resource stewardship within communities. The program seeks to bring together diverse partners to implement habitat restoration projects to benefit living marine resources. Projects might include restoring salt marshes, mangroves, and other coastal habitats; improving fish passage and habitat quality for anadromous species; removing dams; restoring and creating oyster reefs, removing exotic vegetation and replanting with native species; and similar projects to restore habitat or improve habitat quality for populations of marine and anadromous fish. www.nmfs.noaa.gov/habitat/restoration/funding_opportunities/funding.html	For FY 2010, 9/30/09. Proposals are solicited every three years.
NOAA Estuary Habitat Restoration Project Funding	See web site link at right.	The Estuary Restoration Act (ERA) Council seeks projects that achieve cost-effective restoration while promoting partnerships among agencies and between public and private sectors. Eligible habitat restoration activities may include (but are not limited to) improvement of estuarine wetland tidal exchange or re-establishment of historic hydrology; dam or berm removal; improvement or re-establishment of fish passage; appropriate reef/substrate/habitat creation; planting of native estuarine wetland and submerged aquatic vegetation; reintroduction of native species; control of invasive species; and establishment of riparian buffer zones in the estuary. Projects will be evaluated for their support of the Estuary Habitat Restoration Strategy. Awarded proposals may be funded by any of the five ERA agencies, depending on annual appropriated ERA funds. http://era.noaa.gov	3/16/10

Table D-1. Composite List of Federal Funding Opportunities (i.e., Grant, Loans, and Revenue Sharing)

Funding Program	Funding Program	Funding Program	Funding Program
U.S. Army Corps of Engineers Aquatic Ecosystem Restoration (CAP Section 206)	Todd Boatman Mobile District Office 251-694-4101	Work done under this authority may carry out aquatic ecosystem restoration projects that will improve the quality of the environment, are in the public interest, and are cost-effective. There is no requirement that an existing Corps project be involved. The median grant awarded under this program is $300,000. A ceiling of $5,000,000 is established for each project. http://www.sam.usace.army.mil/pd/custguide/custguide.htm	None
U.S. Army Corps of Engineers Emergency Streambank and Shoreline Protection (Section 14)	Todd Boatman Mobile District Office 251-694-4101	Section 14 of the 1946 Flood Control Act provides authority for the Corps of Engineers to develop and construct emergency streambank and shoreline protection projects to prevent erosion damages to endangered highways, highway bridge approaches, public work facilities such as water and sewer lines, churches, public and private non-profit schools and hospitals, and other non-profit public schools and hospitals, and other non-profit public facilities. Each project is limited to a Federal cost of $1,000,000. http://www.sam.usace.army.mil/pd/custguide/custguide.htm	None
U.S. Army Corps of Engineers Environmental Infrastructure Program (Section 219)	Todd Boatman Mobile District Office 251-694-4101	Section 219 of the Water Resources Development Act of 1992 provides authority for the Corps of Engineers to assist non-Federal interests carry out water-related environmental infrastructure and resource protection and development projects. Such assistance may be in the form of technical planning, design assistance, and construction assistance. http://www.sam.usace.army.mil	None
U.S. Army Corps of Engineers General Investigation Study	Todd Boatman Mobile District Office 251-694-4101	Authority for the study must be provided by a specific Congressional resolution or identified in a Water Resources Development Act. The Congressional authority determines the purpose and scope of the study. Funds to conduct the study must be specifically identified for that purpose in an Appropriations Act. Studies could lead to recommendations for construction of a Corps construction project. http://www.sam.usace.army.mil	None

Table D-1. Composite List of Federal Funding Opportunities (i.e., Grant, Loans, and Revenue Sharing)

Funding Program	Funding Program	Funding Program	Funding Program
U.S. Army Corps of Engineers Planning Assistance to the States (Section 22)	Todd Boatman Mobile District Office 251-694-4101	Section 22 of the Water Resources Development Act of 1974 provides authority for the Corps of Engineers to assist the States, local governments, and other non-Federal entities in the preparation of comprehensive plans for the development, utilization, and conservation of water and related land. Federal allotments for each State are limited to $500,000 annually, but are typically much less. Typical cost of an individual study is $25,000 to $75,000. The studies generally involve the analysis of existing data for planning purposes using standard engineering techniques, although some data collection is often necessary. Most studies become the basis for State and local planning decisions and can lead to a project under Section 206 or a congressionally authorized project in a future Water Resources Development Act. http://www.sam.usace.army.mil	None
U.S. Army Corps of Engineers Small Flood Damage Reduction Projects (CAP Section 205)	Todd Boatman Mobile District Office 251-694-4101	Work under this authority provides for local protection from flooding by the construction or improvement of structural flood damage reduction features such as levees, channels and dams. Non-structural alternatives are also considered and may include measures such as installation of flood warning systems, raising and/or flood proofing of structures, and relocation of flood prone facilities. http://www.sam.usace.army.mil/pd/custguide/custguide.htm	None
U.S. Army Corps of Engineers Watershed and River Basin Assessments (Section 729)	Todd Boatman Mobile District Office 251-694-4101	Section 729 of the Water Resources Development Act of 1986 provides for the assessment of the water resource needs of river basins and watersheds, including needs relating to watershed protection. Congress can issue a resolution giving the Corps authority to conduct a study, but must also appropriate funding for the study. There is no Federal cost limit. The usual product of such a study is a watershed planning document that integrates water resources management, evaluating a range of project options simultaneously to determine the best combination of projects to achieve multiple goals over the entire watershed rather than examining each potential project in isolation from others. The assessments may or may not recommend further studies or projects by the Corps or other Federal or State agencies. http://www.sam.usace.army.mil	None

Table D-1. Composite List of Federal Funding Opportunities (i.e., Grant, Loans, and Revenue Sharing)

Funding Program	Funding Program	Funding Program	Funding Program
USDA Forest Service Urban and Community Forestry Challenge Cost-Share Grants	Nancy Stremple Urban and Community Forestry Staff, Mail Stop 1151 USDA Forestry Service 1400 Independence Avenue, S.W. Washington, DC 20250-1151 202-205-7829 nstremple@fs.fed.us	The U.S. Forest Service Urban and Community Forestry Challenge Cost-Share Grant Program seeks to establish sustainable urban and community forests by encouraging communities to manage and protect their natural resources. The program works to achieve a number of goals, including (1) effectively communicating information about the social, economic, and ecological values of urban and community forests ; (2) involving diverse resource professionals in urban and community forestry issues; and (3) supporting a holistic view of urban and community forestry. In particular, the program supports an ecosystem approach to managing urban forests for their benefits to air quality, stormwater runoff, wildlife and fish habitat, and other related ecosystem concerns. The Forest Service awards these grants based on recommendations made by the National Urban and Community Forestry Advisory Council, a 15-member advisory council created by the 1990 Farm Bill to provide advice to the Secretary of Agriculture on urban and community forestry. Grant awards typically range from $3,000 to $250,000. www.fs.fed.us/ucf/nucfac www.treelink.org/nucfac	Typically February, with selection in June
USDA Natural Resources Conservation Service (NRCS) Emergency Watershed Protection Program	Contact your local USDA Service Center. For a list, see www.usda.gov/offices.html. Click on the County Office Locator.	The USDA NRCS Emergency Watershed Protection (EWP) program helps protect lives and property threatened by natural disasters such as floods, hurricanes, tornadoes, droughts, and wildfires. EWP provides funding for such work as clearing debris from clogged waterways, restoring vegetation, and stabilizing river banks. The measures that are taken must be environmentally and economically sound and generally benefit more than one property owner. EWP also provides funds to purchase floodplain easements as an emergency measure. Floodplain easements restore, protect, maintain, and enhance the functions of the floodplain; conserve natural values including fish and wildlife habitat, water quality, flood water retention, ground water recharge, and open space; reduce long-term federal disaster assistance; and safeguard lives and property from floods drought and the products of erosion. EWP can provide up to 90 percent cost share in limited resource areas as determined by the U.S. Census. Grant awards typically range from $22,000 to $6,000,000. www.nrcs.usda.gov/programs/ewp	N/A Funds issued on an emergency basis only. Sponsor has 60 days from the time of an emergency declaration to request assistance.

Table D-1. Composite List of Federal Funding Opportunities (i.e., Grant, Loans, and Revenue Sharing)

Funding Program	Funding Program	Funding Program	Funding Program
USDA Natural Resources Conservation Service (NRCS) Watershed Protection and Flood Prevention Program	Contact your local NRCS office. Information listed on the web at http://offices.usda.gov or www.nrcs.usda.gov/ about/organization/regions.html #regions.	Also known as the "Watershed Program" or the "PL 566 Program," this program provides technical and financial assistance to address water resource and related economic problems on a watershed basis. Projects related to watershed protection, flood mitigation, water supply, water quality, erosion and sediment control, wetland creation and restoration, fish and wildlife habitat enhancement, agricultural water conservation, and public recreation are eligible for assistance. Technical and financial assistance is also available for planning new watershed surveys. www.nrcs.usda.gov/programs/watershed	None
USDA Natural Resources Conservation Service (NRCS) Watershed Rehabilitation Program	Russell Morgan NRCS Conservation Planning and Technical Assistance 14th and Independence Avenue, S.W. Washington, DC 20250 202-690-4231 russell.morgan@wdc.usda.gov	This program provides Federal cost-share funding for the rehabilitation of aging dams that were installed primarily through the Watershed Protection and Flood Prevention Program over the past 55 years. The purpose for rehabilitation is to extend the service life of dams and bring them into compliance with applicable safety and performance standards or to decommission the dams so they no longer pose a threat to life and property. Grants typically range from $30,500 to $1,500,000; the median grant award is $200,000. www.nrcs.usda.gov/programs/WSRehab	Applications may be submitted any time during the year.
USDA Natural Resources Conservation Service (NRCS) Wetlands Reserve Program	Contact local or state NRCS office or Conservation District office. Information listed on the web at http://offices.usda.gov	Through this voluntary program, the NRCS provides landowners with financial incentives to restore and protect wetlands in exchange for retiring marginal agricultural land. To participate in the program landowners may sell a conservation easement or enter into a cost-share restoration agreement (landowners voluntarily limit future use of the land, but retain private ownership). Landowners and the NRCS jointly develop a plan for the restoration and maintenance of the wetland. Specific grants assist landowners with this process may also be available to eligible organizations. There is no maximum award and the award size varies by state. www.nrcs.usda.gov	Applications are accepted year-round.
USDA Rural Development Water and Environment Program	Contact one of the Rural Development State or Area offices. Bay Minette Service Center 207 Faulkner Drive Bay Minette, AL 36507 251-937-3297, Ext. 4	The American Recovery and Reinvestment Act provides approximately $3.7 billion in loans and grants for rural water and wastewater infrastructure through the existing USDA Rural Development Water and Waste Disposal (WWD) loan and grant program. The WWD provides loans, grants, loan guarantees and technical assistance for drinking water, sanitary sewer, solid waste and storm drainage facilities in rural areas and cities and towns of ≤10,000. Public bodies, nonprofit organizations and federally recognized Indian tribes may qualify for assistance. Preference for funding will be given to projects that are ready to commence. http://www.usda.gov/rus/water/index.htm	Applications accepted on a continuous basis.

Table D-1. Composite List of Federal Funding Opportunities (i.e., Grant, Loans, and Revenue Sharing)

Funding Program	Funding Program	Funding Program	Funding Program
U.S. Department of Interior Coastal Impact Assistance (CIAP) for Non-Construction (Alabama Recipients Only)	Paula L. Barksdale Office of Minerals Management Services 703-787-1070 paula.barksdale@mms.gov	Funds are available to eligible counties within the State of Alabama to mitigate the impacts of outer continental shelf oil and gas activities (based upon allocation formulas prescribed by the Energy Policy Act). The purpose of the CIAP is to disburse funding ($250 million for each of the fiscal years 2007 through 2010) to eligible producing states and coastal political subdivisions for the purpose of conservation, protection, or restoration of coastal areas including wetlands; mitigation of damage to fish, wildlife, or natural resources; planning assistance and the administrative costs of complying comprehensive conservation management plan; and, mitigation of the impact of outer continental shelf activities through funding of onshore infrastructure projects and public service needs. The award floor is $1,000 and the award ceiling is $25,000,000. http://www07.grants.gov/search/basic.do (Search for Funding Opportunity Number MMS09HQPA0013.) http://www.mms.gov/offshore/ciapmain.htm	5/18/10
U.S. Department of Interior Gulf of Mexico Energy Security Act (GOMESA)	Marcia Oliver Office of Minerals Management Services marcia.oliver@mms.gov	The Gulf of Mexico Energy Security Act of 2006 (GOMESA) shares leasing revenues for the four Gulf oil and gas producing states of Alabama, Louisiana, Mississippi, and Texas, and to their costal political subdivisions. GOMESA funds are to be used for coastal conservation, restoration, and hurricane protection. Under this act, Baldwin County was allocated $75,122 and the State of Alabama was allocated $651,166 in FY2009. http://www.mms.gov/offshore/GOMESARevenueSharing.htm	N/A
U.S. Department of Transportation Federal Highway Administration National Scenic Byways Discretionary Grant Program	Collette E. Boehm Special Projects Director Alabama's Coastal Connection P.O. Drawer 457 900 Commerce Loop (36542) Gulf Shores, AL 36547 251-974-4632 cboehm@gulfshores.com Cindi Ptak National Scenic Byways Program Manager 202-366-1586	To implement projects on roads designated as National Scenic Byways or All-American Roads, State scenic byways, or Indian tribe scenic byways. Eligible projects must be from one of the following eight eligible activities: State or Indian tribe Scenic Byway Programs, Corridor Management Plans, Safety Improvements, Byways Facilities, Access to Recreation, Resource Protection, Interpretive Information or Marketing. Alabama's Coastal Connection is a designated Scenic Byway. http://www.bywaysonline.org/grants	4/16/10

Table D-1. Composite List of Federal Funding Opportunities (i.e., Grant, Loans, and Revenue Sharing)

Funding Program	Funding Program	Funding Program	Funding Program
U.S. Fish and Wildlife Service Coastal Program (Northern Gulf Coastal Program)	Dr. Ronnie J. Haynes U.S. Fish & Wildlife Service 1875 Century Blvd. Atlanta, GA 30345 PHONE: 404-679-7138 FAX: 404-679-7081 Email: Ronnie_Haynes2fws.gov Patrick Harper USFWS – Coastal 1208-B Main Street Daphne, AL 36526 PHONE: 251-441-5847 FAX: 251-441-6222 Email: Patric_Harper@fws.gov	The U.S. Fish and Wildlife Service Coastal Program works to conserve healthy Coastal habitats on public or private land for the benefit of fish, wildlife, and people in 22 specific coastal areas. The program forms cooperative partnerships designed to (1) protect coastal habitats by providing technical assistance for conservation easements and acquisitions: (2) restore coastal wetlands, uplands, and riparian areas: and (3) remove barriers to fish passage in coastal watersheds and estuaries. Program biologists provide restoration expertise and financial assistance to federal and state agencies, local and tribal governments, businesses, private landowners, and conservation organizations such as local land trusts and watershed councils. Grants made under this program typically range from $5,000 to $50,000. http://www.fws.gov/coastal/ In March 2010, the Northern Gulf Coast was added to the list of coastal areas and monies were appropriated for coastal restoration projects in Alabama, Mississippi, and Louisiana. http://www.fws.gov/daphne	Contact your local Coastal Program Office to find out if there funds available and any deadlines. 5/24/10
U.S. Fish and Wildlife Service Landowner Incentive Program	Contact the state Fish and Wildlife office directly. See web site link at right.	The U.S. Fish and Wildlife Service Landowner Incentive Program (LIP) grant program provides competitive matching grants to states to establish or supplement landowner incentive programs. These programs provide technical and financial assistance to private landowners for projects that protect and restore habitats of listed species or species determined to be at-risk. LIP projects involve activities such as the restoration of marginal farmlands to wetlands, the removal of exotic plants to restore natural prairies, a change in grazing practices and fencing to enhance important riparian habitats, instream structural improvements to benefit aquatic species, road closures to protect habitats and reduce harassment of wildlife, and acquisition of conservation easements. Although not directly eligible for these funds, third parties such as nonprofit organizations may benefit from these funds by working directly with their states to see if either grants or partnering opportunities are available. Grants typically range from $180,000 to $960,000. http://wsfrprograms.fws.gov/Subpages/GrantPrograms/LIP/LIP.htm	Typically late summer or early fall. No funding appropriated since FY2007.

Table D-1. Composite List of Federal Funding Opportunities (i.e., Grant, Loans, and Revenue Sharing)

Funding Program	Funding Program	Funding Program	Funding Program
U.S. Fish and Wildlife Service National Coastal Wetlands Conservation Grant Program	Christy Kuczak Vigfusson Wildlife and Sport Fish Restoration Program U.S. Fish and Wildlife Service FA4020 4401 N. Fairfax Drive Arlington, VA 22203 703-358-1748 christy_vigfusson@fws.gov	The U.S. Fish and Wildlife Service National Coastal Wetlands Conservation Grant Program provides matching grants to states and territories for coastal wetland conservation projects. Funds may be used for acquiring land or conservation easements, restoration, enhancement, or management of coastal wetland ecosystems. Projects must provide for long-term conservation of coastal wetlands. Grants typically range from $200,000 to $1,000,000 per project. http://www.fws.gov/coastal/CoastalGrants/ www.cfda.gov (Search program number 15.614.)	6/25/10
U.S. Fish and Wildlife Service North American Wetlands Conservation Act Grants Program	U.S. Fish and Wildlife Service North American Waterfowl and Wetlands Office 4401 North Fairfax Drive Room 110 Arlington, VA 22203 703-358-1784 dbhc@fws.gov	The U.S. Fish and Wildlife Service Division of Bird Habitat Conservation administers this matching grants program to carry out wetlands and associated uplands conservation projects in the United States, Canada, and Mexico. Grant requests must be matched by a partnership with nonfederal funds at a minimum 1:1 ratio. Conservation activities supported by the Act in the United States and Canada include habitat protection, restoration, and enhancement. Project proposals must meet certain biological criteria established under the Act. The maximum standard grant award is $1,000,000 and the maximum small grant award is $50,000. http://birdhabitat.fws.gov www.cfda.gov (Search program number 15.623.)	Typically March and August.
U.S. Fish and Wildlife Service Partners for Fish and Wildlife Program	U.S. Fish and Wildlife Service Branch of Habitat Restoration Division of Fish and Wildlife Management and Habitat Restoration 4401 North Fairfax Drive Room 400 Arlington, VA 22203 703-358-2201	The Partners for Fish and Wildlife Program provides technical and financial assistance to private landowners to restore fish and wildlife habitats on their lands. Since 1987, the program has partnered with more than 37,700 landowners to restore 765,400 acres of wetlands; over 1.9 million acres of grasslands and other upland habitats: and 6,560 miles of in-stream and streamside habitat. In addition, the program has reopened stream habitat for fish and other aquatic species by removing barriers to passage. Grants awarded under this program typically range from $200 to $25,000, but may go higher for special projects. www.fws.gov/partners www.cfda.gov (Search program number 15.631.)	No deadline
U.S. Housing and Urban Development Community Development Block Grants (CDBG) Entitlement Grants	Contact state CDBG grantees. See list at web site to right.	The objective of this program is to develop viable urban communities, by providing decent housing and a suitable living environment, and by expanding economic opportunities, principally for persons of low and moderate income. Recipients may undertake a wide range of activities directed toward neighborhood revitalization, economic development and provision of improved community facilities and services. The average grant awarded under this program is $2,960,000. www.hud.gov/offices.cpd.communitydevelopment/programs.index.cfm	No earlier than 11/15 or no later than 8/16 of the FY for which the funds are allocated.

Table D-1. Composite List of Federal Funding Opportunities (i.e., Grant, Loans, and Revenue Sharing)

Funding Program	Funding Program	Funding Program	Funding Program
U.S. Housing and Urban Development Sustainable Communities Planning Grant Program	Dorthera Yorkshire Program Analysis 202-402-4336	The Sustainable Communities Planning Grant Program is intended to help build the capacity of communities to address the complex challenges of growth and revitalization in the 21st century in a comprehensive, multidisciplinary way. Funding from this program will support the development and implementation of Sustainable Regional Development Plans. A priority will be placed on supporting regions that demonstrate a commitment to take well-developed plans and move them into implementation. The Appropriations Act directs the Secretary of HUD to establish a regional planning grant program that provides grants to assist regional entities and consortia of local governments with integrated housing, transportation, economic development, water infrastructure, and environmental planning. HUD's Office of Sustainable Housing and Communities is working in partnership with DOT and EPA to define all aspects of this Program. HUD will serve as the lead agency for all grants and will consult with its agency partners throughout the program. http://www.hud.gov/sustainability	No funding associated with current posting – soliciting comments only.

Table D-2. Selected Non-Governmental Organization and Other Private Funding Opportunities

Funding Opportunity	Contact Information	Description / Web Site
Chronicle of Philanthropy Guide to Grants	The Chronicle of Philanthropy 1255 Twenty-Third Street, N.W. Seventh Floor Washington, D.C. 20037 PHONE: 202-466-1200 FAX: 202-466-2078	The Guide to Grants is an electronic database of all foundation and corporate grants listed in The Chronicle since 1995. To search this database, users must purchase a subscription; subscription rates are available for terms ranging from one week to one year. http://philanthropy.com/section/Guide-to-Grants/270
Community of Science Database (COS)	1 North Charles Street Suite 2305 Baltimore, MD 21201 PHONE: 410-563-2378 FAX: 410-563-5389	COS is the leading global resource for hard-to-find information critical to scientific research and other projects across all disciplines. The COS Funding Opportunities web site allows users to search more than 23,000 records, representing over 400,000 funding opportunities, worth over $33 billion. A subscription fee may be required, depending on the type of organization conducting a search. http://www.cos.com
The Foundation Center	Contact may be made through the web site address shown in the column to the right.	The Foundation Center Foundation Finder allows users to search for basic information (contact information, web site address, and IRS 990 form) on 70,000 private and community foundations in the United States (free service). They also offer two subscription-based online searchable databases, the Foundation Director and Foundation Grants to Individuals. http://foundationcenter.org
The Kodak American Greenways Program	Christopher Veronda (Kodak) 585-724-2622 Vanessa Vaughan (The Conservation Fund) 703-908-5809 Or send an email to kodakawards@conservationfund.org .	Eastman Kodak Company, the National Geographic Society, and The Conservation Fund are the partners in the Kodak American Greenways Program, an annual program that recognizes outstanding individuals and organizations for exemplary leadership in the enhancement of our nation's outdoor heritage. The program was established in response to the recommendation from the President's Commission on Americans Outdoors that a national network of greenways be created. Since the program's inception in 1989, more than $800,000 has been granted to nearly 700 organizations in all 50 states. The program also provides small grants to land trusts, watershed organizations, local governments and others seeking to create or enhance greenways in communities throughout America. www.conservationfund.org/kodak_awards
RBC Bank Blue Water Project Grants	Contact may be made through the web site address shown in the column to the right.	Ranging from $25,000 to $500,000, RBC Blue Water Project Leadership Grants focus on watershed protection and/or access to safe drinking water and are available to local, regional, national or trans-border organizations for projects in any of the countries in which RBC is located, including Canada, the United States, the Caribbean and the United Kingdom. Watershed protection programs and projects include watershed awareness, community-based watershed stewardship, protection and restoration or sensitive natural areas, or sustainable water use and conservation. Organizations applying for Blue Water Project grants must have their 501(c) 3 status in the U.S. Deadline for current year applications was March 12, 2010. http://www.rbc.com/donations/blue-water-apply.html

Table D-2. Selected Non-Governmental Organization and Other Private Funding Opportunities

Funding Opportunity	Contact Information	Description / Web Site
Surdna Foundation Sustainable Environments Grants	Surdna Foundation 330 Madison Avenue 30th Floor New York, NY 10017 212-557-0010 questions@surdna.org	The Surdna Foundation seeks to create just and sustainable communities where consumption and conservation are balanced and innovative solutions to environmental problems improve people's lives. The Foundation works from a sustainable development perspective to demonstrate that a healthy environment is the backbone of a healthy economy and a democratic society. They fund three key related priority areas – Climate Change, Green Economy, and Transportation and Smart Growth – that aim to transform how Americans work, consume and move. Grants are approved in February, May, and September. www.surdna.org
Water Environmental Research Foundation (WERF) Cooperative Agreement	Laurie Kusek Communications Director Water Environment Research Foundation (703) 684-2470 Ext. 7908 lkusek@werf.org	WERF will receive $10 million in EPA funds to evaluate new technologies that will help utilities cope with aging and failing water and wastewater systems. As the recipient of this cooperative agreement, WERF will administer $6.25 million to address wastewater and stormwater infrastructure research. Funding for the research is through EPA's Aging Water Infrastructure Research Program, a research agenda that supports efforts to put the nation's aging infrastructure on a pathway toward sustainability. Research efforts will include innovative treatment technologies for wastewater, stormwater, water reuse, and drinking water. The innovative tools and cost-effective solutions that will be developed through this research should provide assistance to municipalities in their ongoing efforts to serve the public and improve water quality. www.werf.org

Table D-3. Applicable Regional Collaboration Opportunities

Program	Contact Information	Description / Web Site
Green Infrastructure Partnership	**EPA Region 4** Jim Giattina 404- 562-9470 giattina.jim@epa.gov Mary Ann Gerber 404-562-9462 gerber.maryann@epa.gov	Formed in April 2007, the primary goal of this partnership is to reduce runoff volumes and sewer overflow events through the widespread use of green infrastructure management practices. On the regional scale, green infrastructure consists of the interconnected network of open spaces and natural areas that improve water quality while providing recreational opportunities and wildlife habitat. On the local scale, green infrastructure consists of site-specific management practices that are designed to maintain natural hydrologic functions by absorbing and infiltrating precipitation where it falls. http://cfpub.epa.gov/npdes/home.cfm?program_id=298
Gulf of Mexico Alliance	**Alabama Department of Conservation and Natural Resources (ADCNR)** Barnett Lawley ADCNR Commissioner 334-242-3486 dcnr_commissioner@dcnr.alabama.gov	The Gulf of Mexico Alliance is a partnership of the states of Alabama, Florida, Louisiana, Mississippi, and Texas, with the goal of significantly increasing regional collaboration to enhance the ecological and economic health of the Gulf of Mexico. The five U.S. Gulf States have identified six priority issues that are regionally significant and can be effectively addressed through increased collaboration at local, state, and federal levels: water quality; habitat conservation and restoration; ecosystem integration and assessment; nutrients and nutrient impacts; coastal community resilience; and environmental education. The Alliance's web site provides information about the Alliance partnership members, activities, priority issues, event announcements, and funding opportunities. http://gulfofmexicoalliance.org
Smart Growth Implementation Assistance	**EPA Region 4** Mary Jo Bragan 404-562-9275 bragan.maryjo@epa.gov	The SGIA program is an annual, competitive solicitation open to state, local, regional, and tribal governments (and non-profits that have partnered with a governmental entity) that want to incorporate smart growth techniques into their future development. Once selected, communities receive direct technical assistance form a team of national experts in one of two areas: policy analysis or public participatory processes. The assistance is tailored to the community's unique situation and priorities. EPA provides the assistance through a contractor team – not a grant. Through a multiple-day site visit and a detailed final report, the multi-disciplinary teams provide information to help the community achieve its goal of encouraging growth that fosters economic progress and environmental protection. www.epa.gov/dced/sgia.htm
Southeastern Regional Water Quality Assistance Network (SERWQAN)	**EPA Region 4** **Environmental Finance Center** Stacey Issac Berahzer P. O. Box 671346 Marietta, GA 30066 770-509-3887 isaac@sog.unc.edu	The SERWQAN is committed to strengthening the capacity of communities to develop and successfully implement watershed protection efforts. The group is a partnership of the EPA Region 4 Environmental Finance Center (EFC), University of North Carolina School of Government, Alabama Cooperative Extension System, North Carolina State University, and the Southeast Watershed Forum. The EFC helps governments at the local, state, and federal level answer the "how to pay" questions associated with environmental projects. Since its establishment in 1999, the Center has provided research and training on financial issues related to land conservation, waste management, wetlands, sustainability, drinking water, wastewater, and stormwater management. www.serwqan.org www.efc.unc.edu

Table D-3. Applicable Regional Collaboration Opportunities

Program	Contact Information	Description / Web Site
Watershed Protection and Restoration Assistance	**EPA Region 4** Bill Cox 404-562-9351 cox.william@epa.gov	EPA formed the Watershed Management Office in Region 4 to support our state and local partners" efforts to restore and protect the watersheds of the Southeast. Its mission is to coordinate the delivery of EPA programs to targeted watersheds using the Watershed Approach to meet national goals for water quality restoration. Each state has an EPA Coordinator. These coordinators, along with the EPA capacity building staff, work with state and local governments and watershed organizations in the targeted watershed to facilitate protection and restoration efforts.

Table D-4. Websites Containing Additional Information on Financing of Stormwater Projects

Source	Website
Black and Veatch Stormwater Utility Survey 2007	http://www.bv.com/Downloads/Resources/Brochures/rsrc_EMS_2007StormwaterUtilitySurvey.pdf
Center for Urban Policy and the Environment Internet Guide to Financing Storm Water Management	http://stormwaterfinance.urbancenter.iupui.edu/
EPA Financial Assistance Comparison Tool (FACT)	www.epa.gov/owm/cwfinance/cwsrf/fact.htm
EPA Guidebook of Financial Tools	www.epa.gov/efinpage/guidebook.htm
EPA, *Integrating Water and Wastewater Programs to Restore Watersheds: A Guide for Federal and State Program Managers*. August 2007	www.epa.gov/superfund/resources/pdfs/cross-program.pdf
EPA, *Managing Wet Weather With Green Infrastructure Municipal Handbook Funding Options*.	http://www.epa.gov/npdes/pubs/gi_munichandbook_funding.pdf
EPA Region III, *Funding Stormwater Programs* (EPA 833-F-07-012).	http://www.epa.gov/npdes/pubs/region3_factsheet_funding.pdf
EPA Sustainable Financing Examples from the National Estuary Program	www.epa.gov/owow/estuaries/fundexamples.html
EPA Watershed Funding	www.epa.gov/owow/funding.html
Florida Stormwater Association, *Establishing a Stormwater Utility*	http://www.florida-stormwater.org/manual.html
National Association of Flood and Stormwater Management Agencies, *Guidance for Municipal Stormwater Funding*.	http://www.nafsma.org/Guidance%20Manual%20Version%202X.pdf
Southeast Stormwater Association, *2007 Southeast Stormwater Utility Survey*.	http://www.seswa.org/surveys/2007/index.html
Stormwater: The Journal for Water and Wastewater Professionals. March-April 2010 edition.	http://www.stormh2o.com/issues/index.aspx
University of Maryland, Environmental Finance Center.	http://www.efc.umd.edu/

APPENDIX E

June 29, 2010 Public Meeting

A public meeting was conducted on June 29, 2010, to present the Draft Watershed Management Plan (WMP) to the Watershed stakeholders, including interested agencies, organizations, and members of the public. The meeting was held at the Alabama Department of Conservation and Natural Resources' Five Rivers Delta Resource Center in Spanish Fort. The meeting served as the initiation of the 30-day public review period that ended on July 29, 2010. This appendix presents the following information relative to the public review, including copies of the three sets of comments received following the meeting.

Page E-2: June 26, 2010 newspaper notice and article announcing public meeting.

Page E-3: Minutes prepared by the Mobile Bay National Estuary Program summarizing the results of public meeting

Page E-8: Sign-in sheets identifying public meeting attendees.

Page E-12: July 16, 2010 e-mail comments from Don Prosch

Page E-13: July 26, 2010 letter comments provided by The Mobile Bay Audubon Society

Page E-15: Response to comments of The Mobile Bay Audubon Society

Page E-16: August [sic] 28, 2010 letter comments provided by the Mobile Bay Group of Sierra Club

Page E-28: Response to comments of Mobile Bay Group of Sierra Club

2 BALDWIN REGISTER FRIDAY, JUNE 25, 2010

SoundOff
251-219-5496

For callers outside the local area:
1-800-395-4725

This is Baldwin Sound Off, where you may speak your mind on anything you wish. Because of the large number of calls we receive, we cannot publish all the comments.

Commissioners lookahead

■ Do people not understand that Mr. Gruenloh and the other commissioners are trying to put things into place that this county is going to need?

Feels county wasting more

■ I'd like to comment on the article about the county pondering BP claim action. This is absolutely ridiculous. They will start a legal suit that will take 20 to 30 years of our taxpayer money to fight. Yet they keep complaining that the schools don't have money, keep cutting jobs and moving people around. They should not waste taxpayers' money on this effort and instead should start looking at ways to conserve money. Commissioners, get your heads on straight, get to work and quit trying to waste taxpayer money.

Disappointed over tickets

■ The locals are the ones cleaning up the beaches and oil spill trying to get the tourists back, yet we can't even get a ticket. Morale is so low right now. The concert is what we were looking forward to. Why can't we even get a ticket to this concert when we are the ones doing the work? That's it. I don't care. This is just not working.

Welcome to Fairhope 'zoo'

■ The more I learn about politics in Fairhope the more I think it's like a zoo, lots of dinosaurs and ostriches.

Buy bleachers for circle

■ Daphne officials should build bleachers and sell tickets for the upcoming demolition derby that will take place at the new traffic circle they are building at Whispering Pines.

No basis for traffic circle

■ For a city to spend money on building a roundabout for an intersection where there has been absolutely no problem at all is absolutely insane.

Workers deserve fair share

■ I agree with the person saying that the CEOs who are in charge of million-dollar companies deserve to make good money. But the workers deserve to make good pay if they are making the company money. That's the way it's supposed to be. That's why unions were started years ago, because the people didn't pay their employees. We've gone backward in the last 10 years. People are entering jobs at less than what they used to and the CEOs are still making good money. That's the problem — the rich are getting greedy and richer and the workers aren't getting anywhere in life and that's not fair.

Douglasville alums slate 14th reunion

Submitted by J. Allison Boykin

The Douglasville Alumni Association will hold the 14th annual Scholarship Awards and Class Reunion Night on July 1 at the Bay Minette Civic Center.

Doors will open at 7 p.m. with the program to begin at 7:45. The program is free, but voluntary contributions to the Douglasville Alumni Association Scholarship Fund will be welcomed.

For more information, call 251-580-2091 or e-mail alboykin@aol.com.

BEN RAINES/Register

In the upper section of D'Olive Creek in this 2008 photo, the channel had begun to deepen rapidly, but had yet to begin getting wider. The exposed tree roots in the photo give a hint as to how much higher and narrower the streambed used to be. About 200 yards downstream, the channel was about 50 feet wider, and hundreds of trees had fallen in completely. The Comprehensive Watershed Management Plan hopes to find solutions to problems such as this to protect and restore the sensitive watershed. A meeting is planned for Tuesday.

Group continues work to preserve local watershed

▸ Public meeting planned Tuesday to discuss Comprehensive Watershed Management Plan

Submitted by Sara Shields

A public meeting will be held from 6 to 8 p.m. Tuesday at Five Rivers Delta Resource Center Theater in Spanish Fort to present the Comprehensive Watershed Management Plan for the watersheds of D'Olive Creek, Tiawassee Creek and Joe's Branch in Baldwin County.

The meeting will review identified watershed problems and highlight recommended solutions for restoring this watershed. Thompson Engineering, authors of the plan, and Mobile Bay National Estuary Program will be available to answer questions and record comments.

Since August 2009, a coalition of federal, state and local agencies, development and real estate interests, county and municipal staff and property owners have worked with Thompson Engineering to create the plan to tackle sedimentation, creek bank erosion, flooding and other problems associated with land-use change and development in the Daphne, Spanish Fort and Malbis communities.

Funding for the development of the plan has been provided by a partnership of the Alabama Department of Environmental Management, the Mobile Bay National Estuary Program, Mississippi-Alabama Sea Grant Consortium, the cities of Daphne and Spanish Fort, Alabama Power and the Lake Forest Property Owners Association.

"Poor stormwater management practices in the D'Olive watershed have degraded some of our most productive seagrass beds, critical nursery areas for commercial and recreational fish," said Roberta Swann, director of the Mobile Bay National Estuary Program. "When implemented, this plan will improve conditions necessary to re-establish critical habitats, strengthening our ecosystem's ability to recover from the oil spill."

For more information about this meeting, contact Sara Shields by calling 251-431-6409 or e-mail sshields@mobilebaynep.com.

SUMMER VACATION PHOTO GALLERY

Snapshots

It's summer time and readers invited to enter our **Summer Vacation Photo Gallery.** Whether it's a scenic or action photo, serious or silly, send us your best photo before **noon on July 31.**

Some of the photo entries will appear in the paper throughout the summer and all eligible photos will also be posted online at www.al.com/press-register/.

On Aug. 8, we'll publish the top photos as selected by our staff photographers. The decision of the judges will be final.

Here are some important tips for submitting photographs:

■ Photos must have been taken on or after May 29, 2010, and follow the theme of the gallery: Summer Vacation.

■ One photo per entrant and e-mail address will be accepted. Entries that contain multiple photos will be rejected.

■ Cropping is allowed, but images cannot be digitally manipulated. Turn off camera time stamp before taking photos. Photos that include a date before the start of the contest will not be accepted.

■ Photos must be taken by

cription of what the photo depicts must be provided.

■ Include your name, mailing address and daytime phone number in case more information is needed.

■ Photos submitted to the newspaper by e-mail must be in JPEG format at 300 dots-per-inch resolution or higher and must be 3 by 5 inches in size or larger.

When printing photographs at home, set the printer to "best" quality, and don't use imaging software to alter the photograph in any way. Photos must be printed on photo-quality paper. Altered photos will not be accepted. Multiple contest entries from the same person or e-mail address will not be accepted. Submitted prints will not be returned. Photo content and quality must meet newspaper publication requirements.

E-mail photos to baldwincontest@press-register.com; please put "summer vacation photo con-

PUBLIC NOTICE

Draft D'Olive Comprehensive Watershed Management Plan to be Presented to Public

A public meeting will be held on Tuesday June 29, 2010 from 6:00 p.m. to 8:00 p.m. at 5 Rivers Delta Resource Center Theater, 30945 5 Rivers Blvd., Spanish Fort, AL, 36527 to present the Comprehensive Watershed Management Plan for the watersheds of D'Olive Creek, Tiawassee Creek, and Joe's Branch in Baldwin County.

The meeting will review identified watershed problems and highlight recommended solutions for restoring this watershed. Thompson Engineering, authors of the plan, and Mobile Bay National Estuary Program will be available to answer questions and record comments.

For more information about this meeting, contact **Sara Shields by calling 251-431-6409** or emailing ***sshields@mobilebaynep.com***.

Minutes from Public Meeting

Five Rivers Delta Resource Center Auditorium
Tuesday, June 29, 2010
In attendance:

Thompson Watershed Management Plan Team:
Emery Baya, Thompson Engineering
John Carlton, Thompson Engineering
Glenn Coffee, Thompson Engineering
Neil Johnston, Hand Arendall
Carl Pinyerd, Thompson Engineering
Cindy Roton, Thompson Engineering

D'Olive Watershed Working Group (DWWG):
M. L. Auer, Lake Forest Property Owners Association (LFPOA)
Julie Batchelor, Baldwin County Commission
Mayor Joe Bonner, City of Spanish Fort
Bill Burdick
Marlon Cook, Geological Survey of Alabama
Representative Randy Davis, Alabama House of Representatives
Dave Gardner
Commissioner Charles "Skip" Gruber, Baldwin County Commission
Phillip Hinesley, ADCNR-State Lands Division, Coastal Section
Patti Hurley, ADEM
Kara Lankford, Baldwin County Commission
Chester McConnell, Audubon Society
Dorothy McConnell, Audubon Society
Christian Miller, AUMERC
Jeanine Normand, League of Women Voters of Baldwin County
Paulette Ouellette
Donald J. Ouellette
John Peterson, LFPOA
Don Prosch, LFPOA
Bruce Renkert, City of Spanish Fort
Victoria Phelps, Daphne Planning Commission
Ron Scott, City of Daphne
Bruce Steiner
LaDon Swann, Mississippi-Alabama Sea Grant Consortium (MASGC)
T. Tate, LFPOA
Joseph Thornton
Mike Traum
Leslie Turney
Sara Shields, MBNEP
Roberta Swann, MBNEP
Tom Herder, MBNEP

Media
Kelli M. Dugan, Daphne Bulletin

MBNEP Director Roberta Swann called the meeting to order at 6:10 p.m. and noted that the deadline for comment on the Draft D'Olive Creek Watershed Management Plan (WMP) is July 29, 2010. She recognized representatives of the funding agencies and governments present: Commissioner Gruber of Baldwin County, Patty Hurley of ADEM and the Clean Water Partnership, Dr. LaDon Swann of MASCG, John Peterson of the LFPOA, Councilwoman Cathy Barnette of the City of Daphne, and Mayor Joe Bonner of the City of Spanish Fort. Acknowledging the years of work leading up to development of the WMP, she yielded the floor to Rep. Davis.

Rep. Davis noted that work began in 1998, but activities leading up to WMP development began with the "third jump start" in 2003. He called the process a "textbook example" of how to do a project, noting the leadership, cooperation, and perseverance. He acknowledged MBNEP for "keeping it moving" and said that it is now the responsibility of elected officials like Skip Gruber and himself to find the money for implementation. He turned the floor over to Comm. Gruber for his remarks.

Comm. Gruber, the Chairman of the Baldwin County Commission, noted that his overall goal is to help with stormwater runoff. Regarding the conditions underlying stormwater runoff, he commented, "What's done is done. We need to correct problems that have started. Fix head-cuts. They'll only get worse." He noted that we need to look at different planning strategies to get water back into the ground and cited the practice of "paving for the day after Christmas" as "the worst thing we can do." He mentioned the importance of the November referendum for creation of a regional stormwater utility. He said that the WMP is very important, but he also noted the importance of upstream sediment sources like the Alabama River.

Ms. Swann introduced the members of the Thompson team and its partners present for the meeting and then, specifically, Glenn Coffee, Thompson's project manager for WMP development.

Mr. Coffee said that this was the most rewarding project on which he could end his career. He provided a presentation which can be viewed at http://www.mobilebaynep.com. His presentation began with an acknowledgement of the funding sources that were responsible for development of the WMP; a listing of the project team members; an explanation of the WMP goals and objectives. The balance of his presentation was organized to address the following topics:

- A description of watershed problems
- Conditions or factors underlying watershed problems
- A summary of management measures recommended in the CWMP

Among the data and information presented in the presentation were the following:

- Thompson believes that Lake Forest Yacht Club shoaling is primarily attributable to deltaic processes from the Blakeley River rather than sediment provided by the D'Olive Watershed.
- Lake Forest Lake receives drainage from 91% of the Watershed; its sedimentation rate is 14 times the natural rate; and 83% of sediments are delivered from D'Olive Creek and 17% from Tiawasee Creek. It is estimated 70% of the lake's total volume has been filled with sediments.
- Over half of the over 23 miles of streams in the 7,700-acre Watershed have been degraded.
- The factors affecting surface erosion and sedimentation in the Watershed include:
    - Rainfall
    - Topography
    - Erodible soils
    - Land Use/land cover which is the only factor in which man is in complete control
- Commercial areas comprise only 500 acres or 6% of the Watershed. Residential areas comprise 3,300 acres or 42% of the Watershed.
- In terms of governmental jurisdiction within the Watershed:
    - Daphne comprises 66% of the Watershed
    - Unincorporated Baldwin County comprises 21%
    - Spanish Fort comprises 13%

The implementation strategy for the CWMP includes eight actions:

1. Create intergovernmental "watershed restoration task force"
2. Repair 20,000 feet of streams affected by head-cutting
3. Develop Lake Forest Lake restoration plan
4. Implement watershed-wide stormwater retrofit program
5. Modify existing regulatory framework
6. Pursue community outreach and education
7. Implement a monitoring program
8. Develop program to obtain funds for implementation activities

Mr. Coffee announced that the comment period for the draft CWMP ends on July 29, 2010. Comments should be submitted to Emery Baya (ebaya@thompsonengineering.com). The floor was opened to attendees for questions and comments.

Victoria Phelps commented on partnerships between governments to obtain funding from the Federal government.

Chester McConnell called for elected officials to provide strong regulatory cooperation and asked Comm. Gruber about his outlook in that regard. Comm. Gruber noted that he has been preaching that a county-wide set of regulations that are uniform is needed. He admitted that this goal would be challenging, but he referred to Horizon 2025, the Baldwin County comprehensive plan for 2008-2025 as a step toward its realization. Cathy Barnette described possible collaboration between planning commissions for uniform regulation development.

An audience member asked if suggestions were included in the WMP. Mr. Coffee responded affirmatively.

Another audience member asked if there will be follow-up milestones/timelines. Ms. Swann said that the Baldwin County Watershed Coalition and MBNEP will use momentum created by the WMP to "push that way." The questioner asked if succinct dates will be established followed by a drive toward those dates. Mr. Coffee responded that generalized timeframes are identified in the WMP, but additional work is needed to develop specific timelines. He noted that the right people are already involved.

Another audience member asked, assuming funding is available, what are best- and worst-case timelines for dredging Lake Forest Lake? Mr. Coffee responded that first a design must be developed and a survey completed before that can happen. It also remains to be determined where the dredged materials would be placed. He said that the project could be undertaken within a year or less if funding was in hand. He noted that challenge exists with community issues and permitting, too.

John Peterson asked if there is any movement towards an in-stream restoration plan (noting that it was supposed to be a component of the connector road project between Highways 181 and 98). Mr. Baya responded that half way through the study, the Baldwin County Transportation Department asked for potential mitigation projects. He said that it was his understanding that impacts are there regardless of the service road, and that mitigation plans remain.

Dr. Swann noted that implementation of the WMP would depend upon "selling" the need for the plan. He asked whether Thompson has considered social marketing strategies in education and outreach. He asked about demographics in the watershed. Mr. Coffee noted that exact population numbers were not available for the Watershed boundaries. However, he did state that less than 20,000 live in Daphne, with around half of those individuals residing within the Watershed. In addition, Spanish Fort and the unincorporated areas of Baldwin County also contribute to the Watershed's overall population. Dr. Swann suggested identifying barriers and opportunities to be used in education and outreach.

Mr. Coffee said that there are many different values that can be gained implementation of the WMP. Specifically, he noted tax base and property values and things that can be benefited by implementation of the WMP recommendations.

Mr. Baya explained that many of the recommended actions contained in the WMP are already being pursued in other portions of the country. Regarding funding, he said that incentive programs associated with regional stormwater management should be considered. He felt that if low impact design produced incentives for developers and landowners, it would promote positive action.

An audience member questioned "legalities." He expressed that it seemed that those who built past developments should be held responsible if laws were broken. Mr. Coffee noted that some laws have been changed with hindsight, pointing out that no stormwater retention at all was included in the original Lake Forest developments. He pointed out that sediment volumes have decreased due to changes in regulations and better controls. John Peterson added that recent developments in Lake Forest include retention ponds.

An audience member commented that following work on a recent water main break, one to two cubic yards of material was let in the street. He noted that the entire volume was washed into a storm drain and then into the lake. He questioned the lack of enforcement associated with this type of event.

With no further questions or comments, the meeting adjourned at 8 p.m.

D'Olive Watershed Management Plan
Public Meeting - June 29, 2010
5 Rivers Delta Resource Center

NAME	ORGANIZATION	ADDRESS	CITY	STATE	ZIP	EMAIL	PHONE
M. L. Aurst	LFPOA Sine	17675 Co. Rd. 55	Summerdale	AL	36580	X	988-8549
John Peterson	LFPOA		Daphne	AL	36526	john.peterson@hatchmott...	251-978-2475
Victoria Phelps	Daphne Planning	111 Worchester Drive Daphne	Daphne	AL	36526	~~Victoria.Phelps~~	458-1014
Pauline Ouellette		Daphne, AL 7720 Elizabeth Dr	Daphne	AL	36526		626-6442
Donald Ouellette		"	"	"	"		"
Kelli M. Dugan	Daphne Bulletin		"	"	"	kellimdugan@yahoo.com	626-7220
T. Tate	Lake Forest Daphne	13 Lake Shore Dr	"	"	"		251 447 0203
Mallory Cook	GSA	Tuscaloosa					
Chester McConnell	Audubon	8803 Pine Run, Sp. Ft.	Spanish Ft.	AL	36527	[illegible]@bellsouth.net	626-2802
Dorothy McConnell	Audubon	"	"	"	"	"	"
John Carlton	T.E.	33507A Hwy 31	Spanish Fort	AL	36527	johncarlton@wildblue.net	625-2517
Randy Davis	State Legis	P.O. Box 1083	Daphne, AL	AL	36526	RMDAVIS14@AOL.com	621-0817
Bruce Steiner		107 Hidden Cir.	Daphne AL	AL	36526	BFSteiner@Yahoo.com	626-0330
Kara Lankford	Baldwin County						

D'Olive Watershed Management Plan
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NAME	ORGANIZATION	ADDRESS	CITY	STATE	ZIP	EMAIL	PHONE
Lawrence Wilson	Baldwin County Hwy	PO Box 220 Silverhill AL	Silverhill	AL	36576	LAWILSON@CO.BALDWIN.AL.US	251 976-8556
Elliott Riser	Lake View Prop. Owners	8 Lake Shore Dr	Daphne	AL	36526	RERISER@AOL.COM	251-626-6486
Path Henley	ADEM	PO Box 301463	Mont	AL	36130-1463	Pah@adem.state.al.us	334 394435
Charles Gruber	BCC	201 Sixth Ave	Foley	AL	36535		251 943 5061 Ext 8804
Christian Miller	AUMERC	4170 Commanders Dr	Mobile	AL	36615	[illegible]@auburn.edu	438 5690
Jean C. Bonner	City of S.F. AL.						
Peter Maschke	Mr. & Mrs	16 Lakeshore Dr Daphne		AL	36526		625 6273
Cathy Barnette	City of Daphne	PO Box 400	Daphne	AL	36526	cbarnette@daphneal	621-9000
Carl Pinyerd	Thompson Eng		Mobile	AL	36606	cpinyerd@thompsonengineering.com	665-5424
Bethany Walton	MBNEP		Mobile	AL		bwalton@mobilebaynep.com	
Gary Gover	FEATS	300 Lincoln St.	Fairhope	AL	36532	GOVERS@BELLSOUTH.NET	990-8662
Kathleen Roberts	AAMW	2570 [illegible] Row	Mobile	AL	36619	kokopelliclay@gmail.com	251 599 8805
Tony Jaffe		108 Lakefront Dr	Daphne	AL	36526		626 7312
Neil Johnston	Hand Arendall	PO Box 123 Mobile		AL	36601	NJohnston@HANDARENDALL.COM	694 6247

thompson
ENGINEERING

D'Olive Watershed Management Plan
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NAME	ORGANIZATION	ADDRESS	CITY	STATE	ZIP	EMAIL	PHONE
Phillip Hinesly	ADCNR	Five Rivers	Spanish Fort	AL	36527	Phillip.Hinesly@dcnr.alabama.gov	
Jeanine Normand	LWV-AL	Po Box 1107	Fairhope	AL	36533	DrJNormand@aol.com	928-2284
Leslie Turney		PO Box 2288	Mobile	AL	36628		251-662-5965
Julie Batchelor	BCC	312 Courthouse Sq.	Bay Minette	AL	36507	JBATCHELOR@CO.BALDWIN.AL.US	580-1655
Joseph Thornton		150 Bayview	Daphne	AL	36526	jthornton@fedmar.com	216 621 5108
Don Prosch	LFPOA	140 Bayview	Daphne	AL	36526	CHROSPACE@BELLSOUTH.NET	6254311
Bruce Renkert	Spanish Fort	PO Box 7226	SP Fort	AL	36527		626 4993

D'Olive Watershed Management Plan
Public Meeting - June 29, 2010
5 Rivers Delta Resource Center

NAME	ORGANIZATION	ADDRESS	CITY	STATE	ZIP	EMAIL	PHONE
Cindy Roton	Thompson Eng.	2970 Cottage Hill Rd. Ste 190 Mobile, AL 36606	Mobile	AL	36606	crotin@thompsonengineering.com	251-665-5414
Dave Gardner	Timber Creek	9468 Sweetgum Ct. Daphne 36527	Daphne	AL	36527	djgardner7@gmail.com	251-621-9557
Ron Scott	City of DAP		[illegible]	AL	36526	ronscott5@bellsouth.net	
Mike Traum		9565 Aspen Circle Daphne	Daphne	AL	36527	mike.traum@mchsi.com	251-442-9772
Bill & Marty Baer		171 Lakeview Loop	Daphne	AL	36526		625-0362
Bill Burdick		112 Brentwood Dr.	Daphne	Al	36526	bg_bd_billy@yahoo.com	626-1841

From: Don [mailto:gyrospace@bellsouth.net]
Sent: Friday, July 16, 2010 12:50 PM
To: Emery Baya
Subject: LFPOA lakefront owner

Greetings & thank you all for tackling this major problem. I live on the lake & probably use it more & know it better than anyone. I keep a couple of boats docked & kayak to the damn almost every evening. One of my greatest pleasures & reason to buy my house there.

Six years ago the lake was clear all the way across it & now I can barely get my kayak out because of the silt build-up, so obviously the sooner all of this gets remediated, the better for me & everyone. If there is anything I can do to support your efforts, please feel free to call on me. I could measure lake depth levels at different locations if that is useful to you or anything else that can expedite this.

Thanks again!

Don Prosch
6256-2240
www.gyrospace.com

Mobile Bay Group of Sierra Club

August 28, 2010

Mr. Emery E. Baya, P.E., Sr. Vice President
Thompson Engineering, Inc.
2970 Cottage Hill Road, Suite 190
Mobile, AL 36606

Dear Mr. Baya:

The Mobile Bay Group of Sierra Club has reviewed the Watershed Management Plan for the D'Olive Creek, Tiawasee Creek, and Joe's Branch Watersheds – Draft (WMP) and we appreciate the opportunity to offer our comments. We understand the need for solving the serious stormwater runoff situation which is causing severe soil erosion, stream head cutting, wetland damage, and siltation deposition in lakes and Mobile Bay. We understand that the combination of these problems is degrading water quality in the watershed and Mobile Bay. Regrettably the silt laden, polluted water flowing from the watershed is considered to be one of the major contributors of pollution in Mobile Bay.

We believe that a properly designed and implemented WMP could, under effective leadership, solve most of the problems currently existing and prevent many from occurring in the future. The question to be answered is, does the WMP, as currently written, provide adequate guidance to accomplish the desired goal? We have examined the WMP document and provide our views and recommendations.

Section 2, Watershed Description provides an excellent explanation of the 7,700 acre watershed. The poorly regulated, intensive development that has occurred since the 1970's has resulted in some serious problems. Much of the natural vegetation has been removed and replaced with numerous homes and businesses. Impervious materials such as paved roads and buildings now cover much of the landscape. Stormwater runoff flowing across the large amounts of impervious cover and down steep, erosive terrain has created serious problems in streams, lakes and Mobile Bay. The WMP paints a picture of a watershed with many past and potential future problems. With the expected increase in human population and development in the watershed, it will require a massive effort and strong leadership to correct current problems and prevent future ones.

Section 3, Watershed Conditions describes a watershed with many serious, and growing problems. Erosion, particularly in the streams is creating havoc. Headcutting and bank failures in streams is degrading habitats and threatening buildings, roads, bridges, sewage lines and other developments. Virtually all wetlands in the watershed have been degraded or destroyed, mostly due to sedimentation. This section, once again, explained that increased stormwater runoff caused by intensive development is the major cause of most other problems. Correction and future management of these numerous, serious problems will require strong, consistent leadership, tough regulations, strong enforcement and properly designed measures. Hopefully, this will occur.

approach to stream restoration is preferable to selecting projects based on targets of opportunity or in response to 'emergency' situations." In addition, concerning the restoration of watershed hydrology the WMP (6-23) explains that: **"In fact, it would be desirable and more effective to develop a holistic management approach for the entire Watershed that incorporates as many of these measures as possible".**

Section 6.5, Strengthen Regulatory Controls is essential to the success of the WMP. Regulatory controls and strong, effective enforcement should be the first order of business of the authorities administering the WMP. Of course this may be controversial but if effective stormwater runoff regulations cannot be adopted and enforced, the WMP will result in failure.

As described in the draft WMP, there are projections for a large increase in human population growth and residential/business development during the next 10 years. The watershed problems described in the WMP will certainly increase if effective measures are not implemented in the near future. The Mobile Bay Group of Sierra Club urges the planning team to add a specific watershed design section to the WMP to aid in gaining support from the public.

We appreciate the opportunity to explain our views.

Sincerely

David Underhill

David Underhill, Environmental Chair
Mobile Bay Group of Sierra Club

3

From: Roberta Arena Swann [mailto:rswann@mobilebaynep.com]
Sent: Friday, July 30, 2010 4:41 PM
To: 'David Underhill'
Cc: Glen Coffee; Emery Baya
Subject: FW: Sierra Club Statement on D'Olive Creek Plan

Dear Mr. Underhill,

Mobile Bay National Estuary Program (MBNEP) wholeheartedly agrees that "the WMP must be taken to the next level and include the appropriate management options in a well designed, detailed plan." However, it was never the intention to include that in this phase, due to funding limitations. MBNEP is committed to working with the WMP task force to develop the conceptual measures of this plan and will continue to seek out funding opportunities to realize on-the-ground actions. Unfortunately – funding has been very limited- thus the "conceptual" nature of the plan.

Many of your comments highlight the intense impacts that stormwater runoff can have on the environment. In fact, within the D'Olive Watershed, impervious area is significant, representing 20-25% of the total area, indicating severe impacts and clearly illuminating the need for improved runoff management and restoration. To this extent, MBNEP has been working with all fourteen municipalities, the County, chambers of commerce, home builders, road builders, realtors, utilities, community environmental organizations, the Baldwin County Congressional Delegation and many others to develop the Baldwin County Watershed coalition to improve management of stormwater runoff on a watershed scale- a key aspect of this effort being the establishment of a public corporation. This corporation would be authorized for the purpose of managing stormwater in the county, and to levy and collect of storm water service charges on certain properties with impervious area. The establishment of this corporation, which would provide much needed funding to address the impacts like those found in the D'Olive watershed, hinges on passage of a local referendum to be held November 2, 2010.

I would welcome the opportunity to meet with the Mobile Bay Chapter of the Sierra Club to provide more detail on MBNEP's commitment to the D'Olive Watershed Plan as well as the Baldwin County Watershed Coalition/local referendum. I can be reached at 251-431-6409.

Thank you for taking the time to review this rather comprehensive plan for improving one of Baldwin Counties most impacted areas. I look forward to hearing from you.

Regards,
Roberta

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The Mobile Bay Audubon Society

Chester McConnell
Vice President and Conservation Chairman
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Spanish Fort, AL 36527
Tel. no. 251-626-7804

July 26, 2010

Mr. Emery E. Baya, P.E., Sr. Vice President
Thompson Engineering, Inc.
2970 Cottage Hill Road, Suite 190
Mobile, AL 36606

RE: Watershed Management Plan for the D'Olive Creek, Tiawasee Creek, and Joe's Branch Watersheds - Draft

Dear Mr. Baya:

The Mobile Bay Audubon Society has reviewed the referenced *draft* watershed management plan (WMP) and we have explored much of the watershed. We offer our views and suggestions in hopes that a constructive, intelligent plan will evolve. First we compliment all who recognized the serious need for a watershed management plan and those who made the decision to develop a plan.

The leadership provided by the Mobile Bay National Estuary Program is especially noteworthy. And the special efforts made by the D'Olive Watershed Working Group (DWWG) are well-known. Second, we appreciate all who collected watershed data and those who prepared the draft plan. And last, but not least, we are grateful for those who must review public comments and consider their merit in developing the final plan.

Mobile Bay Audubon Society clearly recognizes the myriad, complex problems in the watershed. The WMP clearly describes the problems and the need to solve them. We will support a forthright, effective WMP that will, not only describe the watershed setting and problems, but also include much improved specific guidance and detailed plans to solve the serious problems in the watershed. At this stage, the draft WMP does not include any specific plans that describe what will be done and where specific projects will be done. For example we propose for the WMP to include design(s) of grade control structures and retrofit stromwater retention facilities with maps showing where these would be installed?

Our review of the WMP finds many positive elements but also some serious omissions. We believe that the problems and omissions can, and must be corrected for the plan to be successful. We will identify our concerns throughout this letter.

Section 2 of the WMP provides a detailed description of the 7,700 acre watershed and how intensive, largely unregulated development since the 1970's has created numerous problems. The watershed topography is steep and rugged and soils are highly erosive. Much of the native vegetative cover has been removed and replaced with large amounts of impervious cover. These measures have allowed larger volumes of stormwater runoff to flow more rapidly into the 477 acres of wetlands, the 23 miles of watershed streams, Lake Forest Lake and finally into Mobile Bay. The excessive runoff rushing through the streams has resulted in serious headcutting and massive stream bank failures. Some roads and buildings may soon face serious damages unless the stream problems are solved. Massive amounts of eroded soils now flow downstream with large quantities settling out in the 40 acre Lake Forest Lake and in Mobile Bay. Both the lake and Mobile Bay water quality are being degraded as well as the life forms living there.

A careful examination of the topographic map on page 2-15 (Figure 2-5) helps one to understand the watershed problems. The terrain is so steep in some locations that some areas should be zoned to prevent any development. Such environmentally sensitive areas could be zoned as "green space" to maintain them in their natural condition. It would be absurd if development were to be allowed on such steep, erosive areas when there is a serious objective to correct past abuses on similar areas. Any such additional development could be deemed as "spinning ones wheels" or "taking one step forward and two backwards". For the WMP to be successful, all concerned must recognize that intensive residential and industrial development would be entirely reckless on some locations.

Rainfall in the area averages about 67 inches per year. The resulting storm water flows through developed areas collecting a large variety and amount of polluted materials including oil, gas, pesticides, animal feces, etc. As the polluted waters mix with eroded soils the result is even more serious pollution. Concerns over water quality impacts and aquatic habitat degradation resulting from the land use changes in the watershed and their effects on Mobile Bay led to the decision to prepare the WMP.

In addition to surface water impacts, there is concern that the shallow unconfined Miocene-Pliocene aquifer beneath the watershed is considered to be highly vulnerable to contamination. There are six public drinking water wells within the watershed and seven additional public wells within 2,000 feet of the watershed boundary. All of the public's drinking is pumped from wells and careful monitoring of these sources should be a major part of the WMP. Contaminated aquifers are very difficult and expensive to decontaminate.

The combination of environmental problems in the Watershed has already had an adverse effect on fish and wildlife resources and could result in human health problems if left unchecked. Yet, weakly regulated and insufficiently planned development has, and continues to take place, in the watershed. All the factors causing the headcutting of stream beds and massive stream bank failures continue virtually unabated. On page 2-34 of the WMP it is acknowledge that despite some improvements, *"…ongoing urbanization has accelerated post construction surface runoff (i.e., volumes, velocities, and timing). The added runoff is contributing to channel instability and erosion problems."*

Section 2.12 describes historic and potential human population increases in the watershed. A "conservative estimate" was made that the population within the watershed would increase by 8,432 people and that there would be a need for 3,543 additional housing units to accommodate this population growth through 2025. According to the WMP, the actual acreage needed to satisfy the demands for new homes could range from a low of 590 acres if a lot size was one-quarter acre; and as much as 2,360 acres would be required during the next 10 years if lot sizes were one acre in size. Section 2.13.4 explains that: *"By the end of the 10-year period (i.e., 2020) addressed in the WMP, all suitable Watershed areas that are not now developed are expected to be converted to urban uses. This will produce a condition that will closely approximate 100% 'build-out' of available land."*.

Assuming that the one acre lot size is used for future homes and subtracting the 71 acres of water areas and the 478 acres of wetlands from the watershed land base, approximately 700 acres will remain undeveloped. Further, if the 3,543 additional homes needed by 2025 are considered, there would be virtually 100% development of all remaining land in the watershed. Mobile Bay Audubon Society recommends development of strong, effective regulations and strict enforcement to assure that Watershed conditions do not deteriorate further.

The information describing population increases and intensive development of all available land in the watershed is alarming. Figures 2-27 and 2-28 show zoned land uses for the watershed and virtually all acreage is zoned for intensive development. The WMP describes in great detail the existing fragile nature of the watershed. Then when one considers that most of the more geologically stable locations have already been developed, any additional development will be on the most unstable locations. We are very apprehensive that appropriate safeguards will not be implemented to compensate for the complex problems that are certain to occur under the projections for growth.

Mobile Bay Audubon Society urges planners to revisit the zoning plan. We recommend that much of the land on steep grades should be established as "green spaces". First, such "green spaces" could prevent the serious erosion and excessive storm water runoff that is certain to occur if these lands are developed. Secondly, the quality of life for humans would be improved by "green spaces" which could be converted into low impact natural parks. And, thirdly, we believe that natural habitats should be protected in urban settings to benefit wildlife and to enhance human experiences. The "green space" discussion on page 12-3 is excellent and we recommend using the 2,000 acres of upland forest land as a "green space" goal.

The discussion about roads in Section 2.13.1 almost evolves into a road promotion statement. Is that one purpose for the WMP? Of course well developed and properly maintained roads are a necessity but they are an expensive waste where they are not needed. A prime example is described on page 2-43. The last sentence on the page explains: *"Construction of a new service road paralleling the northern side of I-10 is proposed to connect the large commercial centers located on U.S. 98 and State Road 181. Construction of the road could serve as a catalyst to facilitate further economic development along that potential roadway."* Several items come to mind. First, the "service road" has been eliminated by the Baldwin County Commission and the Daphne Commission. Secondly, there are currently three parallel roads within a mile stretch that connect U.S. 98 and State Road 181. These are U.S. 90, I-10 and U.S. 31. A fourth road to connect the "commercial centers" is not needed and would be a waste of taxpayer dollars. And another road is certainly not needed in a severely burdened watershed.

On page 2-57, there is a discussion about areas zoned for business. Some of these locations are adjacent to residential subdivisions which were developed during the past 30 years. Citizens adjacent to the business zoned areas are highly concerned about their communities and are attempting to maintain their quality of life. One example is described on page 2-57. It is described that: *"A large area located immediately north of I-10 between U.S. 98 to the west and State Highway 181 to the east is also targeted for business development. However, the development of this last area will depend on the construction of a proposed service road connecting the two highway corridors. A recent decision to postpone construction of the service road raises questions as to when development of the lands in this area will occur. All zoned new business growth is expected to occur through the conversion of forest land."*

We view the description of the "service road" on page 2-57 to be in serious error. The road was not postponed, it was eliminated as a road project by the Baldwin County Commission and the Daphne City Commission. Residents in the adjacent Timber Creek subdivision are vehemently opposed to the road. Their strong concerns should ring a bell with elected and appointed officials that quality of life is of utmost importance.

Additional road construction in the watershed is likely the worst development that could take place when considering stormwater runoff, stream restoration and soil erosion. The numerous adverse consequences associated with roads in general have been well documented. If you need more information on this subject, we will supply it. The formerly proposed "service road" would have had serious effects on the watershed. The excessive amounts of erosion and additional storm water runoff into D'Olive Creek would have occurred at the most severe stream headcut in the watershed. If there were a way to measure, the cumulative adverse impacts from the formerly proposed "service road" may have cancelled out most of the beneficial effects from the positive proposals for the watershed. In addition, we view it as foolish for citizen tax payers to pay to construct another road that would serve no purpose except for business development.

We noted (page 2-61) that, unfortunately, *"present zoning in the watershed does not include areas specifically designated for green space preservation or large stormwater detention/retention facilities."* This is unfortunate indeed. The use of green spaces and stormwater detention/retention facilities are two major tools used in many watershed plans. We trust that the DWWG will work for needed changes for such land uses needed to improve the WMP.

The discussion about impervious cover (Section 2.13.5) is excellent. This section explains how additional development will increase impervious cover and the problems that will result.

Section 3.0, Watershed Conditions. This section contains an outstanding description of the current conditions in the watershed. The section is well written and contains sound data. Unfortunately the current conditions are a very sad story. We learned that major streams and several tributaries in the watershed are on the Alabama Section 303(d) list of impaired streams which indicates they are seriously polluted. Unfortunately the watershed is already approaching the 25% level of Impervious Cover (IC). According to the WMP, if the 25% level is reached the streams in the watershed would be designated as "non-supporting" as defined by hydrology, channel stability, habitat, water quality, and biological indicators. The writer clearly points out that, *"If land use controls, development criteria and design standards are not modified and strengthened, the percent IC in the D'Olive Watershed will increase"* (page 3-5). Mobile Bay Audubon Society believes strongly that if not done, the WMP will result in failure. There is a limit to how much development can take place in the watershed if we are to maintain a reasonable quality of life.

According to the WMP, stream channel instability is so great in some streams with steep slopes that homes and infrastructure are seriously threatened (page 3-14). Further, *"The cause of the gulling and rapid head-cut advancement is attributed to increases in stormwater runoff (i.e., both discharge velocities and volume) due to past and recent land use changes."* (page 3-15). Hopefully the DWWG, elected and appointed officials and watershed citizens will understand this clear message. **After designing strong regulations and enforcement measures, the next most important effort in the WMP should be to reduce stormwater runoff.** Courageous leadership will be needed at every level to improve our laws and regulations and to demand strong, effective enforcement. Elected and appointed officials and citizen's support will be needed to accomplish this.

Wetlands are among our most valuable natural resources and provide numerous free services and benefit for humans and other life forms. The draft WMP plainly describes the degraded condition of the vast majority of wetlands in the watershed. We urge the DWWG planners to take strong measures to protect and improve all existing wetlands. Here again, it is pointed out that stormwater runoff in the intensively developed watershed caused erosion and pollution to degrade and destroy wetlands. The draft WMP clearly spells out the causes on page 3-16: "*Primary adverse impacts to all wetlands within the D'Olive Watershed are related to sedimentation and/or hydrologic modifications that have altered stream channel characteristics. The individual subwatersheds have been heavily developed, with much of the development having taken place on steep slopes that serve as the upland buffers surrounding wetlands occurring in the watershed.*" Unfortunately, development on steeps sloped continues unabated today. The "required" BMP's to help control the erosion are either not adequate or are not being enforced.

Section 4.0, Identification of Critical Areas and Issues does an outstanding job of describing the "critical areas" within the watershed that have already been impacted by stream channel degradation and excessive sedimentation and those areas that are anticipated to be impacted in the next 10 years. The WMP also discusses critical resource needs influencing surface runoff. The photos clearly depict the problems The WMP (page 4-1) explains that since the 1990s regulatory controls and improved construction practices have combined to significantly reduce sediment loads from overland sources. However, it is admitted that stream channel instabilities and instream erosion have intensified primarily due to increased stormwater runoff. We believe that the real reason that sediment loads have been reduced is that the construction in Lake Forest and Timber Creek residential areas have been completed. Based on what we have observed in the watershed, we are not convinced that improved regulatory controls and construction practices have had much effect. According to the WMP (page 4-1), *"…current sediment loads still significantly exceed natural loading rates."*

The discussion concerning head-cutting and channel erosion in WMP streams describes very serious problems. Without **proper** corrective action, homes and infrastructure could be seriously damaged or destroyed. The proper corrective action we recommend is a well planned, comprehensive approach. No single approach, such as installation of grade control structures, will solve the serious problems in the watershed. Our experience is that many grade control structures fail over time. Failures are especially prevalent in steep gradient streams located in highly erosive soils such as D'Olive Creek Watershed. Stormwater flows provide the power to feed headcuts and controlling these flows provides the solution.

Mobile Bay Audubon Society concurs with the following statements found in the WMP:

- *"The power to feed a head-cut is derived from the volume of stream flow while the energy is provided by the drop from the higher elevation upstream reach to the lower elevation downstream reach."* (page 4-11)

- *"Increased stormwater runoff is the major factor contributing to stream channel degradation in D'Olive Watershed."* (page 4-19)

- *"The rate of head-cutting described above is a direct result of excessive volumes of high velocity stormwater runoff being received by the streams throughout the Watershed."* ((page 4-19)

- *"Stormwater issues are pervasive throughout the entire D'Olive Watershed. Given the historic development patterns that have occurred to date and the projected land uses for the Watershed, stormwater runoff reduction measures must be considered for the entire watershed."* (page 4-19)

- *"Control of stormwater runoff is a Watershed-wide issue of critical importance that must be addressed in a holistic fashion if the stream degradation and sediment transport problems are to be resolved."* (page 4-19)

- *"Stormwater runoff problems can be solved by: (1) reducing the overall amount of Impervious Cover within the Watershed; and (2) implementing retrofits that promote retention/infiltration of rainfall where it falls in lieu of the current practice of short term detention. Impervious Cover is the single most critical parameter that must be controlled within the Watershed to have a measurable impact in reducing stormwater runoff."* (page 4-19)

- Storm runoff management options: *"The measures in this group target the root cause of the increased stormwater runoff problem which will contribute to the long term success of the restoration efforts outlined in the WMP."* (page 6-1)

"The runoff volumes and velocities that exceed natural levels by a considerable margin are at the root cause of the on-going head-cutting and channel erosion problems affecting the Watershed." (page 6-23)

Based on the several direct quotes listed above, it seems crystal clear that stormwater runoff is the major problem in the watershed. This runoff causes the erosion of upland soils and the headcutting and bank failures in streams. And it transports polluted materials from uplands into wetlands, streams and eventually into Mobile Bay. The erosion, headcutting and bank failures are all symptoms of storm water runoff. Because all of this is factual, it appears logical to us that the initial efforts should be to develop and implement a plan to reduce and manage stormwater runoff. If various stream restoration (head cut projects) and Lake Forest Lake projects are done first, there is risk that these projects may be overwhelmed and destroyed by unchecked stormwater runoff. The following statement on page 6-101 of the WMP registers our sentiments: ***"It would not make sense to invest significant resources in an attempt to restore/stabilize the streams without also implementing measures that are aimed at restoring a hydrologic regime that allows stable stream conditions to be maintained in the future."***

It appears that the DWWG fully understands the relationship of stormwater runoff and stream restoration. On page 6.2 it is explained that, "*Although opportunities still exist for stream restoration, if Watershed development is allowed to progress without pursuing more effective stormwater runoff management, the scope of the opportunities will diminish over time."* While reading the WMP, we get the impression that some members of the DWWG have a desire to focus on stream restoration/headcuts as the first priority. We have some concerns about this approach and believe more careful analysis may be needed. Have some formerly heavily degraded channels become stabilized over time? Should stormwater runoff projects upstream of these areas be first priority? Should the DWWG focus first on protecting areas with no problems to prevent these from escalating into trouble areas (strong regulations/enforcement)?

Mobile Bay Audubon Society **supports** the WMP goals listed in Section 5.1. They are worthy goals and should be completely understood by those responsible for carrying out the WMP.

Mobile Bay Audubon Society **does not support** the decision in Section 5.6 that management measures will be developed to the "conceptual level only" (page 5-6). Section 6 Management Measures describes a number of management measures that may possibly be used to help solve the problems in the watershed. While we agree that these measures may help solve the problems, nothing in the WMP explains (1) specifically where these management measures may be applied; (2) how many of each specific measure would be applied; (3) how the various measures will be coordinated; and (4) the degree of effectiveness of the measures. As we understand the conceptual approach, it is little more than "a wish list". While we do have confidence that some worthwhile actions would be taken, there are no assurances contained in the WMP. A number of individual projects developed around the Watershed in an uncoordinated manner may result in only minimal usefulness.

We are in complete agreement with the following statements found on pages 6.2 and 6-23: *"A programmatic approach for prioritizing, funding, planning, design, construction, and maintenance of stream restoration/stabilization measures is needed. Such a program should be developed in concert with overall Watershed restoration planning, including riparian (stream corridor) management and Watershed runoff reduction (6-2)"*. Concerning the restoration of watershed hydrology the WMP explains that : *"In fact, it would be desirable and more effective to develop a holistic management approach for the entire Watershed that incorporates as many of these measures as possible"* (6-23). We agree.

The subject of "grade control structures" is discussed on pages 6-3 through 6-10. Those who wrote about this subject appear to be very knowledgeable. Grade control structures will be a necessary component of the overall Watershed project but, importantly, the sighting, design, determining the anticipated drop at the structures, spacing and other factors must all be determined by competent, trained professionals. Grade control structures can be very expensive and they can easily be destroyed is not designed, sited and installed properly. The WMP estimated costs for the stream restoration/stabilization, including grade control structures, on 20,000 linear feet of stream reaches ranged from $8 million to $14 million. Mobile Bay Audubon strongly agrees with the statement on page 6-7 as follows: *"To meet the stream restoration goals of the community, stream restoration/stabilization should be performed as part of broader, comprehensive planning that includes other stream corridors and upland watershed management practices. A systematic approach to stream restoration is preferable to selecting projects based on targets of opportunity or in response to 'emergency' situations."*

Mobile Bay Audubon Society agrees that the restoration of Lake Forest Lake (Section 6.2.2) is an essential component of the overall WMP. It is the key to trapping heavy sediment and stopping much of it from flowing into Mobile Bay. This section is well written and describes essential needs for additional data and investigations of lake conditions prior to making a conceptual project design to restore the lake (pages 6-12 and 6-15). The total preliminary cost range for lake restoration is $3.85 million to $7.4 million (excluding maintenance) (pages 6-18). We believe that it is crucial to first solve the stromwater runoff, erosion and stream restoration elements of the WMP prior to lake restoration. Upstream construction efforts will, for a time, increase migration of eroded soils to downstream areas. No one should want a restored lake to have to capture heavy loads of sediments soon after restoration.

We wholeheartedly support efforts to restore the four wetland areas in the Watershed (Section 6.2.3). Even though the restoration efforts will be difficult and costly, the benefits of healthy wetlands will pay high dividends over time. So much of the fish and wildlife wetland habitat in the area has been destroyed that special efforts are needed. Likewise the water quality restoration and water storage capacities of wetlands will be partially restored. We noted that the cost estimates for total restoration of the four wetland areas ranged from $715,000 to $1,312,400. Yet, we agree with the statement on page 6-19 as follows: *"However if upstream sources of sediment are not controlled, the actions detailed below will have little longterm benefit to the overall health and stability of wetlands within the Watershed."* Here again, we believe it is essential to control the runoff, erosion and sediment before attempting restoration of wetlands located in downstream areas.

Section 6.3, Restore Watershed Hydrology, causes us a great deal of concern. The section contains many interesting ideas and methods described under "Stormwater Retrofits" and "Smart Growth Concepts…". Without question all the <u>concepts</u> discussed could aid in restoring the watershed hydrology if implemented on a large scale throughout the watershed. The general rule of "capturing rainfall close to where it falls to earth" is certainly the ideal approach. Regrettably, we reiterate, there is not a single specific project or project design in this section of the WMP. Nothing explains specifically where, or if, any individual project or projects may be installed. The good concepts described are little more than a wish list. We urge the DWWG to go back to the drawing board and develop specific plans that describe what will be done and where it will be done and what effect it will have.

Section 6.5, Strengthen Regulatory Controls is a **most important** part of the WMP. The absence of adequate, strong laws and regulations and the lack of tough enforcement is what has allowed the mess we are in today. Developers and planners have known for many years about the problems with stromwater runoff on steep terrain with erosive soils. They did nothing about it because they were not forced to. Now it is up to citizen taxpayers to correct the irresponsibility and negligence of past developments.

The WMP explains that (page 6-93): *"Effective pursuit of 'smart growth' development utilizing GI/LID to reduce stormwater runoff begins out of necessity with a strong regulatory foundation to guide land use planning, design, construction, and post-construction management of stromwater runoff"*. **And we add emphatically that strong, effective enforcement of regulations is essential**. If elected and appointed officials are not willing to adopt strong regulations and mandate tough enforcement, then the WMP will be a waste of time. It appears that Watershed planners have made an excellent start in improving draft regulations as described in this section.

Section 6.6, Estimate of Sediment Load Reductions is difficult to comprehend. The last sentence on page 6-101 explains: *"Overall, the implementation of the D'Olive WMP in a comprehensive, integrated manner can be expected to achieve sediment load reductions in the range of 40 to 60% compared to those reported by the GSA studies."* We would like to know how these percentages were determined because there are no specific plan details in the WMP? Again, nothing in the WMP explains specifically where, or if, any individual project or projects may be installed.

Section 7.0, Cost Estimates once again describes the speculative nature of the WMP. The various management measures are again summarized and it is explained that: *"Some of the measures discussed can be implemented by individual property owners; neighborhoods and property owner associations; future developers; or governmental institutions having jurisdictional responsibility within the watershed."* (page 7-1). Regrettably, we do not have confidence that many of the watershed needs will be accomplished by simply hoping that some individual property owners or neighborhood groups will implement the management measures. Our experience with watershed projects is that some government entity must be responsible for carrying out a well designed plan. The government controlled entity may perform some of the projects and may contract with individual landowners or communities to do other projects. But there needs to be a detailed plan and funds to pay for all the work.

The WMP (page 7-1) explains that: *"Preparation of detailed cost estimates were not possible due to the conceptual level of planning that guided*

4*development of this WMP.”* However, the cost “…*will be substantial and are anticipated to range between **$22 and $44 million**.*” Due to the conceptual nature of the WMP, we have no way to visualize the cost involved.

Mobile Bay Audubon agrees with several of the items in Section 8, Implementation Strategies, and has problems with some. We strongly agree that a Watershed Restoration Task Force should be established. The Task Force leader should be a salaried employee. To be effective this Task Force should have broad, effective powers to set priorities without regard to city or county boundaries. They must have the firm support of elected and appointed officials. The Task Force should then be responsible for establishing priorities, final designs of projects and contracting to accomplish the task. Their priorities may differ from those listed in Section 8.2.1. Their first priority should be to develop strong regulations and enforcement mechanisms concerning issues currently adversely affecting the watershed and for all future development. Next the Task Force should determine funding to carry out all functions of the WMP. And, importantly, we believe that the Task Force should establish the priorities without political interference.

Mobile Bay Audubon Society explained on the first page of this letter that we will strongly support a forthright, effective WMP that will not only describe the watershed setting and problems, but include much improved specific guidance and detailed plans to solve the serious problems in the watershed. The current draft of the WMP is deficient in our view because it is simply a conceptual plan with no specific. We urge that a revised draft be prepared that describes specifically what will be done and where specific projects will be constructed.

Section 9.0 Financing Alternatives, describes a number of WMP funding options. At this stage, we have no preference for funding options. We are apprehensive that the public may not support funding until they know for certain what they are supporting.

Community Outreach and Public Education, Section 10, is an essential part of the WMP effort. We believe a revised plan, as we have recommended, will greatly aid in public education and support.

Monitoring as discussed in Section 11 is a very important of the WMP. It is necessary to determine what elements are successful and which are not. It is also important to be able to keep the community informed.

The numerous recommendations in Section 12 are mostly a repeat of what has already been covered in the plan. However several items are especially important. It appears that some believe there may be full development in the Watershed – … *“an approximate 100% ‘build-out’ condition by 2020”* (page 12-1). Hopefully this does not mean that every acre will be developed. If so, there will be much irresponsible development. Except for existing agricultural lands most of the suitable land has been developed for residential and business uses. There are many undeveloped acres that are too steep and erosive for intelligent development. Such areas should be established as "green space". A good discussion of the "green space" concept is on page 12-3. If such fragile undeveloped areas are developed, they should be compelled by strict regulations to retain stormwater runoff that occurs in the maximum 48 hour rainfall event. While this may appear tough on developers, the WMP is dealing with some unusually tough stormwater runoff problems. In addition, taxpayers are being asked to pay for problems caused by developers in past years.

Appendices A, B, C and D were exceptionally well prepared and provide excellent information for all concerned.

We appreciate the opportunity to provide our views and recommendations.

Sincerely,

Chester A. McConnell

cc: Mobile Bay National Estuary Program
U.S. Environmental Protection Agency
Alabama Department of Environmental Management
Baldwin County Commission
Mayor, City of Daphne
Mayor, City of Spanish Fort

MOBILE BAY NATIONAL ESTUARY PROGRAM

Mr. Chester McConnell
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8803 Pine Run
Spanish Fort, AL 36527

Dear Mr. McConnell:

On behalf of the Mobile Bay National Estuary Program (MBNEP) and the D'Olive Watershed Working Group, I want to express my appreciation for the Mobile Bay Audubon Society's thorough review of the Draft Watershed Management Plan (WMP) for the D'Olive Creek, Tiawasee Creek, and Joe's Branch Watersheds and the comments provided in your July 26, 2010, letter. We are grateful for your organization's many expressions of support for the information contained in the WMP and the recommendations contained therein. However, your letter also conveyed a number of comments and concerns. The following responds to those comments that are specifically directed at the WMP.

Comments on pages 1, 7, 9, and 10 of your letter express your position **that the WMP should provide specific information identifying the location, extent, costs, etc.** for projects that are recommended for implementation in lieu of the conceptual approach that was followed to develop the WMP. Due to the limitations of funding, it was not possible to develop the engineering designs and costs for the myriad projects that will eventually be pursued to address the stormwater runoff problems affecting the Watershed. Instead, it was agreed upfront that the WMP should identify the management measures at the conceptual level only with the assumption that the WMP would document conditions and management measures in a way that could be used to raise the funds necessary to develop detailed plans.

We believe the WMP has successfully accomplished that goal and provided the elected officials, agencies, organizations, and other stakeholders a viable menu of actions that should be pursued in the Watershed. It will now be the responsibility of the Watershed stakeholders through the development of a **Watershed Restoration Task Force, to take the next steps of turning the WMP recommendations into specific projects by initiating the necessary follow-up actions**, (i.e., identification of project priorities, engineering design, preparation of detailed cost estimates, identification of funding sources, obtaining real estate, etc.)

I assure you that this WMP is a **critical first phase** of what the MBNEP and Watershed stakeholders recognize to be a multi-phase process for restoring the area not only through capital projects but also through improved regulations (including "green space" zoning) and enforcement across the two municipalities as well as the County. To that extent, the Watershed Restoration Task Force will focus their attention on developing consistent and appropriate zoning regulations and ordinances to support the goals of the WMP to: 1) Reduce upstream sediment inputs, 2) Reduce outgoing sediment loads, 3) Remediate and restore past effects of

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these sediment loads, and 4) Mitigate future impacts of development in the watersheds. The **Watershed Restoration Task Force's specific objectives** include: 1) Development of financing strategies, 2) Creation of public-private partnerships to achieve goals, and 3) Implement changes to the regulatory framework of each of the governmental entities.

The comments that begin at the bottom of page 3 of your letter question whether Section 2.13.1 is intended to promote the construction of roads within the D'Olive Watershed. I can assure you that it is not the intent of the discussion. Instead, this section of the WMP attempts to provide a realistic narrative explaining that construction of new roads in the existing undeveloped portions of the Watershed and the improvement of existing roads in the present developed areas will be an inevitable consequence of the Watershed's continued transition to more intensive land uses. This discussion is intended to be a statement of fact, and not an expression of support for additional roads in the Watershed. Although the County and the City of Daphne voted to not pursue the service road project, **the WMP recognizes that the area between I-10 and U.S. 90 will continue to be targeted for business development and in the future could become a project proposal once again.** It is this <u>possibility</u> that prompts its inclusion in the WMP as an area of particular concern where rigorous runoff management and wetland protections must be implemented.

At the bottom of page 9 of your comment letter, it is asked how the "40 to 60%"sediment load reduction estimate was determined. Based on available data and literature research, this represents a "best professional" estimate of the sediment loading reduction to be expected with implementation of the WMP management measures in a comprehensive, integrated manner.

The suggestions that you posed on page 10 regarding the staffing of the recommended Watershed Restoration Task Force will be considered by the Task Force as part of its initial establishment. **MBNEP is currently seeking funding for such a facilitator/program manager and agree that the implementation of this plan will require a "champion"** who can guide project prioritization and execution as well as coordination among differing political entities for improved coordination of regulations, standards and criteria.

We are currently in the planning stages for the first Watershed Restoration Task Force meeting. Among its first tasks will be to seek adoption of the plan by the Cities of Spanish Fort, Daphne and Baldwin County, **begin the second phase** of planning by developing a program strategy for on the ground projects as well as regulatory reform, and pursue a course for obtaining the funding necessary to undertake the comprehensive restoration of the watershed.

In response to your recent letter to the editor, I must express disappointment at your public criticism that this work "fails miserably." As a credible and influential member of the community, your support and involvement in moving these conceptual measures forward- including your recommendations for *identifying various measures to be applied, where management actions need to be applied, and how various projects will be coordinated, and developing incentives that will be used to encourage private landowner participation-* will be incredibly valuable. Your rebuke of the DWWG efforts as "not enough" is equally detrimental to our common goals of taking this "conceptual plan" to an actual implementable program. The countless hours invested by the members of the DWWG and contractors in characterizing conditions, problems, and potential solutions was a necessary first step. A clear understanding of the complexity of issues and how they interrelate in terms of land area, environmental impacts, governance and economic growth is critical to effectively devising a comprehensive program for Watershed sustainability.

In November, Baldwin County voters will be asked to approve, or not, the formation of a public corporation for the purpose of managing stormwater in the county and to authorize that corporation to collect ***storm water service charges on certain properties containing impervious areas in the county***. As you are aware, proliferating impervious surfaces throughout the county, and most notably in the D'Olive Watershed, have caused increasingly daunting negative and costly environmental impacts. The fourteen municipalities and Baldwin County do not have consistent resources available to address these stormwater management challenges, many of which stem from activities outside of their jurisdictions. For the past four years, a coalition of private, public and community leaders have worked diligently to 1) understand the problem and its implications, 2) raise awareness within their constituent groups about the need for management of stormwater on a watershed scale, and 3) assess areas throughout the county in need of improved measures for managing increasing volumes and velocity of stormwater runoff. This local referendum is very specific in its purview - to create a mechanism (the corporation) and a dedicated revenue stream based on level of impact, to construct stormwater control projects on public lands in Baldwin County using at least 80% gross revenues for capital expenditures. Again, as a credible and influential member of the community, I encourage the Mobile Bay Audubon Society to become a member of the Baldwin County Watershed Coalition for a better understanding of and a voice in the development of this initiative.

Again, we appreciate your thorough review of the WMP and the comments that you provided. We encourage you and other stakeholders to remain actively engaged in matters affecting stormwater within the Watershed and in the follow-up actions to implement the recommendations offered in the WMP.

I would welcome the opportunity to meet with you and the Mobile Bay Audubon Society to provide more detail on MBNEP's commitment to the D'Olive Watershed Plan as well as the Baldwin County Watershed Coalition/local referendum. I can be reached at 251-431-6409.

Sincerely,

Roberta Swann
Roberta Swann
Director

cc: Emery Baya
Glen Coffee

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