Appendix A
Preliminary Restoration Plan

Available upon request

Appendix B
Project Management Plan

PROJECT MANAGEMENT PLAN

BUTLER CREEK SECTION 206
ECOSYSTEM RESTORATION PROJECT

BUTLER CREEK WATERSHED, COBB COUNTY, GEORGIA

US Army Corps
of Engineers ®

DRAFTED: DECEMBER 2010
MODIFIED: AUGUST 2011

STATEMENT OF CERTIFICATION
PROJECT MANAGEMENT PLAN
FOR
FEASIBILITY PHASE STUDY
Aquatic Ecosystem Restoration Project
Butler Creek Watershed, Cobb County, Georgia

This is to certify that the undersigned concur in the scope, structure, and cost estimate for the subject study based on FY 2011 salary levels.

L. Douglas Turney, P.E.

L. DOUGLAS TURNEY
Deputy District Engineer for Programs and Project Management

CURTIS M. FLAKES
Chief, Planning and Environmental Division

DOUGLAS C. OTTO
Chief, Engineering Division

WILLIE L. PATTERSON III
Chief, Real Estate Division

PROJECT MANAGEMENT PLAN
FOR
FEASIBILITY PHASE STUDY
Aquatic Ecosystem Restoration Project
Butler Creek Watershed, Cobb County, Georgia

STUDY TEAM MEMBERS

This is to certify that the undersigned have participated in the development of, reviewed, and concur in the scope, structure, and cost estimate for the subject study based on FY 2011 salary levels.

DEAN TRAWICK
Project Manager

MEREDITH HAZARD
Economist

JUDY WOOD
Archeologist

VINCE MOODY
Hydraulic Engineer, Project Architect/Engineer

TOM FENDELY/CH2M HILL
Environmental Engineer

KATHLEEN ROY/CH2M HILL
Cost Estimator

KERRY GATES
Plan Formulator

for
CHUCK SUMNER
Biologist

RUSSELL BLOUNT
Real Estate Specialist

LAUREN MURPHY
Environmental Scientist/Planner
CH2M HILL

CHRISSY THOMCH2M HILL
Environmental Scientist

MIKE BROSE
Project Scientist

PROJECT MANAGEMENT PLAN

BUTLER CREEK SECTION 206
ECOSYSTEM RESTORATION PROJECT

BUTLER CREEK WATERSHED, COBB COUNTY, GEORGIA

TABLE OF CONTENTS

PROJECT MANAGEMENT PLAN

BUTLER CREEK SECTION 206
ECOSYSTEM RESTORATION PROJECT

BUTLER CREEK WATERSHED, COBB COUNTY, GEORGIA

TABLE OF CONTENTS

PROJECT MANAGEMENT PLAN

BUTLER CREEK SECTION 206
ECOSYSTEM RESTORATION PROJECT
BUTLER CREEK WATERSHED, COBB COUNTY, GEORGIA

INTRODUCTION

This study plan is a narrative description that defines the products and services to be provided in developing the engineering and design activities and responsibilities required for monitoring and managing the efforts involved in restoring Butler Creek and habitat communities. The Project Management Plan (PMP) describes the scope, schedule, budget and overall management of the project through the feasibility phase.

PURPOSE

The purpose of the PMP is to serve as a living document that can be revised as work progresses. The goal of the project management is to complete the project on time and within budget through a logical sequence. The PMP is intended to facilitate that process.

PROJECT AUTHORITY

The Congress of the United States has delegated Continuing Authority through Section 206 of the Water Resources Development Act of 1996 (WRDA 96), as amended, to the Secretary of the Army to restore degraded aquatic ecosystems.

CONGRESSIONAL INTEREST

Georgia Congressional District 11, Phil Gingrey (R), Senators Johnny Isakson and Saxby Chambliss.

NON-FEDERAL SPONSOR

The Non-Federal Sponsor is Cobb County, Georgia.

PRIOR STUDIES AND PREVIOUS REPORTS

Total Maximum Daily Load Development
2002 - Entrix Problem Areas Report
2002 - Cobb County Watershed Assessment and Watershed Protection Plan
2007 – U.S. Fish and Wildlife Biological Opinion
2002 - Etowah Aquatic Habitat Conservation Plan

PROJECT LOCATION AND DESCRIPTION

The Butler Creek Watershed is located in the Etowah River Basin in northwestern Cobb County, Georgia, and drains into Lake Acworth (Figure 1). Lake Acworth is a subimpoundment of Lake Altoona, a federally managed multi-use reservoir. The Etowah River Basin is part of the larger

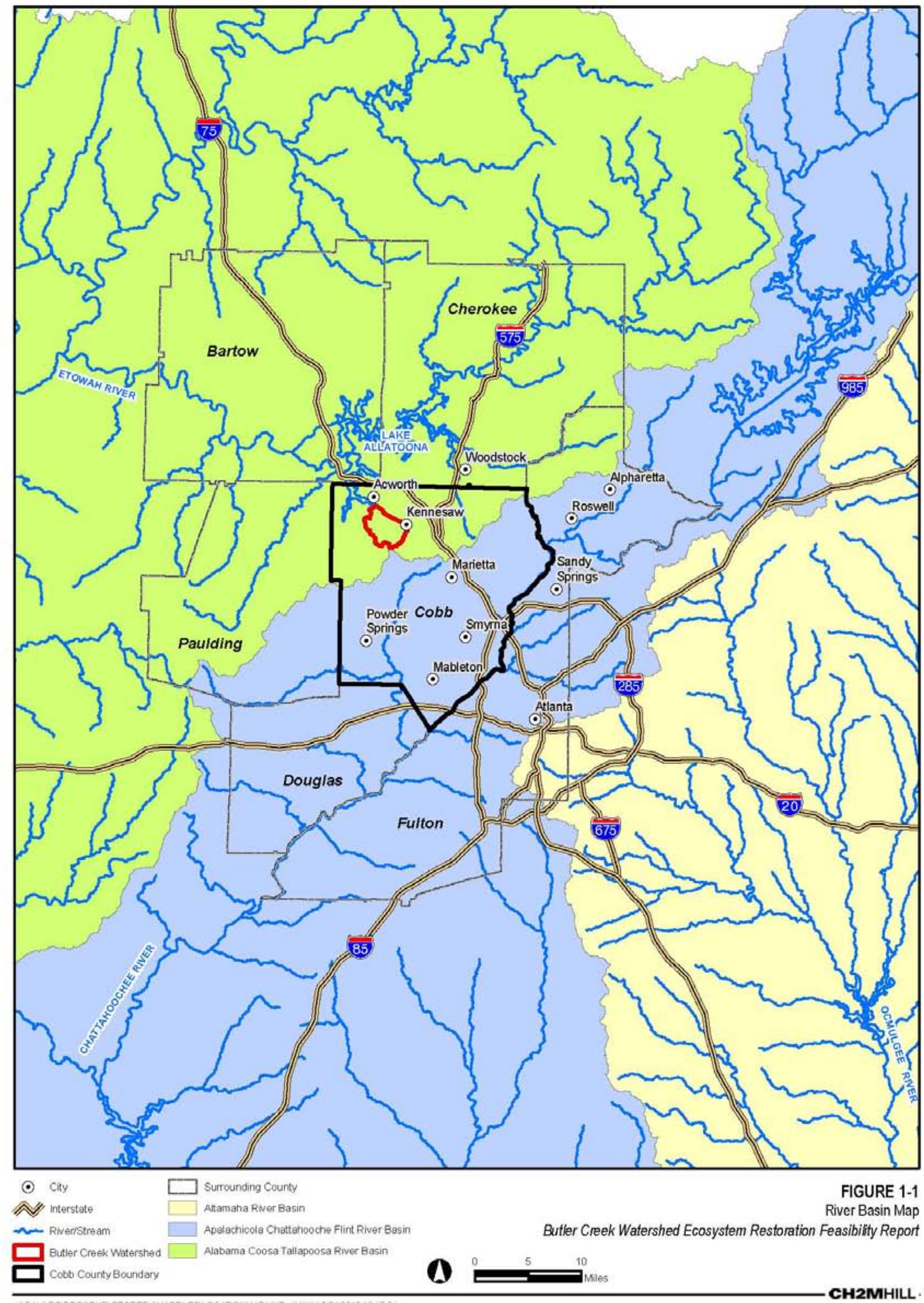

Cherokee
Bartow
ETOWAH RIVER
LAKE ALLATOONA
Woodstock
Acworth
Alpharetta
Roswell
Kennesaw
Marietta
Sandy Springs
Powder Springs
Cobb
Smyrna
Paulding
Mableton
Atlanta
Douglas
Fulton
CHATTAHOOCHEE RIVER
OCMULGEE RIVER
75
575
985
285
20
675
85
City
Interstate
River/Stream
Butler Creek Watershed
Cobb County Boundary
Surrounding County
Altamaha River Basin
Apalachicola Chattahooche Flint River Basin
Alabama Coosa Tallapoosa River Basin
0
5
10
Miles
FIGURE 1-1
River Basin Map
Butler Creek Watershed Ecosystem Restoration Feasibility Report
CH2MHILL

FIGURE 1

Coosa River Basin, which flows through Alabama, becoming the Alabama River as it joins with the Tallapoosa River. The Alabama-Coosa-Tallapoosa Rivers Basin (ACT Basin) flows enter the Gulf of Mexico.

The Butler Creek Watershed encompasses 6,016 total acres (9.4 square miles) and contains a total of approximately 12.7 stream miles (7 miles of main stem and 5.7 miles of tributaries) (Figure 1). Topography in the Butler Creek Watershed ranges from 1,100 feet above mean sea level (msl) in the headwaters to 850 feet above msl, where the stream enters the backwaters of Lake Acworth. Butler Creek and its watershed are located entirely within Cobb County, which is part of the northern Piedmont physiographic province. The watershed includes portions of the Cities of Kennesaw and Acworth and unincorporated areas of Cobb County, with the headwaters being the most developed portion of the watershed.

PROBLEMS

The Butler Creek Watershed was identified for an aquatic ecosystem restoration study based on degraded habitat conditions and a decline in the integrity and diversity of aquatic ecosystems and aquatic biological communities throughout the watershed. Instream and riparian habitats have been adversely affected by changes to natural stream hydrology, which have led to the scarcity of riffle/pool habitat critical to the federally threatened Cherokee darter and other sensitive aquatic species, increased peak instream flow velocities, and increased instream sedimentation and substrate embeddedness. The following four problems have been identified to support ecosystem restoration planning efforts for the Butler Creek Watershed:

1. The scarcity of riffle/pool habitats critical to the federally threatened Cherokee darter (*Etheostoma scotti)* and for other sensitive aquatic species.
2. Categorized as impaired due to decline in native, intolerant fish and macroinvertibrate species.
3. Hydrologic channel impacts including a limited connection to the floodplain and more intense peak instream flow velocities, which result in decreased habitat use for native, sensitive fish and macroinvertibrate species.
4. A high degree of instream sedimentation and substrate embeddedness, which is reducing the availability and quality of instream habitat.

OPPORTUNITIES

1. Protect the Cherokee darter population by increasing the frequency and quality of riffle/pool habitats in the watershed.
2. Restore native, intolerant aquatic species and increase species richness/evenness in the watershed.
3. Restore natural flow regimes to a practicable extent and reconnect the stream to the floodplain to dissipate the peak flow velocities, which increases the quality of instream and riparian habitats.
4. Reduce sedimentation and prevent further habitat embeddedness by improving bank stability and enhancing vegetated riparian buffers.

OBJECTIVES

1. To create sustainable riffle/pool habitats in impacted stream reaches by constructing instream habitat features.
2. To use rock/grade control to provide for an adequate frequency of riffles and diverse velocity/depth regimes (fast-shallow, fast-deep, slow-shallow, and slow deep).
3. To increase the species richness and evenness of native fish and benthic macroinvertebrates in the watershed.
4. To reduce peak flows by at least 5 percent by implementing flow attenuation measures, such as the creation of riparian wetlands in the floodplain or retrofits to existing detention ponds.
5. To implement stream channel restoration measures, including both stream stabilization and grade control, in highly degraded areas of the watershed.
6. To reduce bank erosion by one physical habitat condition category.

TASKS AND DISCIPLINES

PLAN FORMULATION AND EVALUATION

The feasibility phase study will follow the six step planning process specified in ER 1105-2-100. Steps in the plan formulation process will include:

- The specific problems and opportunities that will be addressed in the study will be identified, and the causes of the problems will be discussed and documented. Planning goals will be set, objectives will be established, and constraints will be identified.
- Existing and future without project conditions will be identified, analyzed and forecast. The existing condition of resources, problems and opportunities critical to plan formulation, impact assessment, and evaluation will be characterized and documented.
- The Project Delivery Team will formulate alternative plans that address the planning objectives. An initial set of alternatives will be developed and will be evaluated in order to identify the NER Plan, and the optimum tradeoff plan.
- Alternative plans will be evaluated for effectiveness, efficiency, completeness and acceptability. The impacts of alternative plans will be evaluated using the system of accounts framework (EQ, RED, OSE) specified in the Principles and Guidelines and ER 1105-2-100.
- Alternative plans will be compared. A cost effective, incremental cost analysis will be conducted to identify the NER Plan (plan with greatest net ecosystem restoration benefits). An optimum tradeoff plan will be developed to identify the plan having the greatest net sum of economic and restoration benefits. The public involvement program will be used to obtain public input to the alternative evaluation process.
- A plan will be selected for recommendation and a justification for plan selection will be prepared.

Project Management - Consists of oversight responsibility of all project activities. Functions include developing budgetary data, allocation of project funds, monitoring overall expenditures and obligations, review work progress in relation to costs, and updating the project management plan. The Project Manager (PM) in accordance with Engineering Regulation (ER) 5-7-1 will manage contingencies. The PM has approval authority over certain limited cost /contingency changes as outlined in the ER. Larger cost/contingency changes must be elevated for approval as outlined in the ER. The PM is responsible for identifying any changes due to inflation in the estimate obtained through the annual budget cycle.

Program Management - Consists of preparing budget documents, managing input into the budgetary process, providing notifications of work allowances, and processing requests for additional funds or for revocation of funds.

ECONOMIC TASKS

Economic Appendix. An Economic Appendix will be provided as an appendix to the Feasibility Report. The Institute of Water Resources (IWR) Plan model results were included in the September 2008 partial draft report, but shall be clearly displayed in an economic appendix. Pertinent results shall also be provided directly in the main report in accordance with format provided. The economic appendix shall clearly layout the screening process, reasoning and justification, and the tentatively selected plan as supported by IWR plan results. Discussion of alternatives being efficient, effective, complete, and acceptable is important to alternative comparison and ultimately plan selection.

Preliminary Screening: Check the simultaneous or combined effectiveness of small scale measures before eliminating them from consideration. If the cost of smaller scale measures is minimal, it may be cost-effective to implement these measures even though they do not have as large of an effect as some of the more costly measures. All measures that pass or are screened should include a description and explanation that point to the planning objectives they do or do not achieve.

IWR Plan: IWR Plan runs that incorporate the ERM modeling results. The results shall be included in the Ecosystem Restoration Report.

The appendix shall expand upon what the IWR Plan software is and explain how the IWR Plan Run results for this study were concluded. Excel spreadsheets, graphs, charts, etc. needed to clearly state how the tentatively selected plan, are to be included in the appendix. The explanation is to include the nine steps below:

1. Display outputs and costs - displays the environmental outputs and cost estimates of the increments of management measures.
2. Identify combinable management measures - reviews the management measures used to separate those that can be implemented together from those that cannot be implemented together.
3. Calculate outputs and costs of combinations - lists all combinations of the combinable management measures’ increments, and calculates each combination’s output and cost.

4. Eliminate economically inefficient solutions - identifies and eliminates inefficient solutions: If you can produce a given level of output in more than one way, only the least expensive choice makes economic sense for that level of output.
5. Eliminate economically ineffective solutions - identifies and eliminates ineffective solutions: If you can produce a greater level of output for the same or less cost, then only the greater output choice makes economical sense.
6. Calculate average costs - calculates the average cost of the cost effective solutions and identifies the solution with the lowest average cost.
7. Recalculate average costs for additional output - repeatedly asks the question: Of the remaining levels of output, which solution has the lowest average cost for additional output?
8. Calculate incremental costs - calculates incremental costs for the remaining levels of output.
9. Compare successive outputs and incremental costs - progressively compares successive levels of output and their incremental costs to provide decision makers with information that is useful in addressing the question: Is the environmental output worth its cost?

Planning Models - The following planning models are anticipated to be used in the development of the decision document: IWR Planning Suite Decision Support Software, and the Ecosystem Response Model. For this study the ERM has been approved as a plan formulation tool. IWR Planning Suite will be used to evaluate the cost effectiveness and incremental cost of each potential restoration alternative, based on an estimated cost and projected benefits.

Model Name and Version	Brief Description of the Model and How It Will Be Applied in the Study	Certification/Approval Status
IWR Planning Suite	For this study IWR Planning Suite will be used to evaluate the cost effectiveness and incremental cost of each potential restoration alternative, based on an estimated cost and projected benefits according to ERM results.	Certified
Ecosystem Response Model (ERM)	The ERM uses physical habitat and biological monitoring data, collected using GADNR guidance (GADNR, 2005; 2007), as an indicator of the overall stream ecosystem integrity. The ERM outputs a combined stream health score and Habitat Units, based on biological monitoring data, and a projected future combined stream health score and Habitat Units based on predicted future biological monitoring scores. This allows comparison of outputs under various conditions and provides an indicator of the extent of stream improvement that would result from implementation of restoration alternatives. The ERM was approved for use as a Plan Formulation tool by the ECO-PCX and endorsed by SAD for the North Georgia Piedmont Region projects.	Approved

ENVIRONMENTAL TASKS

Environmental Assessment (EA) - A document will be prepared, as required by the National Environmental Policy Act (NEPA) that evaluates the impacts of the project alternatives on the human environment. An EA and a Finding of No Significant Impact (FONSI) will be prepared, if appropriate. If significant impacts are identified, then an Environmental Impact Statement (EIS) will be prepared. All appropriate NEPA requirements will be met including Public Notices, 404(b) (1), Legal Notices and coordination with other state and federal agencies and the general public.

To comply with NEPA an inventory and description of environmental conditions will be prepared. The environmental portions of the aquatic ecosystem restoration study will survey existing environmental information as well as collecting field data, sampling and monitoring to establish baseline environmental conditions. This information will consist of searching available historic data as well as other state and federal databases, private environmental groups and will include the following:

The Fish and Wildlife Service will be consulted pursuant for the Environmental Site Assessment on the existence of any threatened and endangered species as well as sensitive species and critical habitat will be documented for the study area. Futhermore, a Fish and Wildlife Coordination Act will be conducted.

Fisheries and wildlife resources will be identified and documented for the study area by searching existing historical information and by searching available USFWS databases and other appropriate regional and local agencies.

Plant and timber resources will be identified and documented for the study area by searching existing U.S. Department of Agriculture survey information and through consultation with the U.S. Forest Service as well as other regional and local agencies.

Water quality conditions will be assessed to be used as the baseline for existing, future without project and future with project conditions.

Air quality will be determined within the study area as defined by the Environmental Protection Agency's Final Clean Air Act General Conformity Rule (1993).

Identification and evaluation of potentially affected Cultural Resources, assessment of effect, and consultation with the State Historic Preservation Officer (SHPO) will be documented for the study area.

Information assessing and comparing environmental and human health risks borne by populations identified by race, national origin, or income according to the Environmental Justice in minority populations and low-income populations will be documented and displayed for the study area.

Hazardous, Toxic, and Radioactive Materials/Wastes (HTRW). The appropriate HTRW field analysis will be performed during the study phase.

Wetland surveys will be performed to identify and evaluate the potential effects of the proposed project.

Attend and hold meetings to coordinate with the non-Federal sponsor, contractor, general public and state and federal agencies.

Field data collection and sampling will include fish, Indices of Biotic Integrity (IBI), macroinvertebrate biological assessments and habitat assessments that will be performed and used as the baseline for existing, future without project and future with project conditions.

Cultural Resources Plan. The Corp's archeologist will evaluate and determine the existence of or potential for impacts to cultural resources. This would also include any impacts to structures listed on the List of National Historical Places. This would be determined initially by a site files search and coordination with the State Historic Preservation Office and associated Native American tribes. In the event potential cultural resources are located on a site files search there would be an additional effort for surveying the site, depending on its size, location and potential.

Environmental Appendix. The Environmental Appendix shall include all data, photographs, etc. collected and the results of each subtask.

a. **Ecosystem Response Model (ERM)**. In order to define the baseline stream conditions, develop restoration features, and develop incremental environmental outputs for the project alternatives, the ERM developed by the North Georgia Water Resource Agencies (NGWRA) team for use on metro-Atlanta region aquatic ecosystem restoration projects shall be utilized. The ERM will be used to model the I+J alternatives selected for the tentatively selected plan and explain the results using graphs, charts, etc. The following sub-tasks describe the modeling process. These tasks have already been completed and are results are located in the draft report dated September 2008.

b. **Field Reconnaissance Trip**. Prior to any data collection within the study area, field reconnaissance trips will be conducted. These trips will be held for the purposes of selecting and delineating the biological data sample sites. The biological data sampling sites will be selected via the stratified random sampling protocol described in the model description. The sample sites will be randomly selected based on drainage area. The first sample site will be randomly located within the one square mile drainage area of the headwaters of the stream. Additional sample sites will be randomly located downstream within the reach of stream associated with an approximate doubling of drainage area. Selection of the sampling sites will also comply with the guidelines set forth in the protocols for the fish and macroinvertebrate assessments. Once the Government has approved the sampling site locations, data collection may begin.

c. **Fish Indices of Biotic Integrity (IBI)**. An IBI of the fish community will be conducted at each of the sample sites identified during the field reconnaissance trip. Collection methods and data analysis for the fish IBI will be conducted in accordance with Georgia Department of Natural Resources (GADNR) Standard Operating Procedures for Conducting Biomonitoring on Fish Communities in Wadeable Streams in Georgia. A copy of the Standard Operating Procedures can be found at the following World Wide Web link - http://georgiawildlife.dnr.state.ga.us/content/displaycontent.asp?txtDocument=436. The fish data collection shall occur within the specified seasonal period (generally April to mid-October).

d. Conduct Freshwater Macroinvertebrate Biological Assessment. A freshwater macroinvertebrate biological assessment will also be conducted at each of the sample sites identified during the field reconnaissance trip. Collection methods and data analysis for the macroinvertebrate biological assessment will be conducted in accordance with Georgia Environmental Protection Division's (GAEPD) Macroinvertebrate Biological Assessment of Wadeable Streams in Georgia Standard Operating Procedures. A copy of the SOP can be found at the following World Wide Web link – http://www.gaepd.org/Documents/WPB_Macroinvertebrate_SOP.html. In addition to the water quality data collection prescribed by the macroinvertebrate SOP, two other water quality data collections should be done to include biological oxygen demand (BOD) and chemical oxygen demand (COD). The water quality data collection will be consistent with the United States Environmental Protection Agency (USEPA)'s standard operating procedures. Quality Assurance/Quality Control (QA/QC): QA/QC will be utilized according to USEPA approved guidance and methodology, including chain-of-custody protocol. For QA/QC purposes, duplicate sampling will be conducted at one of the sampling sites and all sampling instrumentation will be calibrated according to the manufacturer and USEPA protocol. The macroinvertebrate data collection shall occur within the specified seasonal period (mid-September to February). As noted in the protocols, sampling of fish and macroinvertebrate communities in the same reach should not be done concurrently. "The process of sampling one of the communities will invariably disturb the other. If fish are sampled first then two weeks should be allowed for stabilization of the macroinvertebrate communities. If macroinvertebrates are sampled first there would be substantially less wait time for the fish communities to stabilize due to the higher mobility of fish" (GAEPD 2007). The raw data collected during the sampling effort can be applied to the ecoregion metric spreadsheets available at the above website to determine the individual site scores.

e. Habitat Assessment. A visual habitat assessment will be conducted at each of the sample sites identified during the field reconnaissance trip. A habitat assessment is conducted at each site during both the fish IBI and macroinvertebrate biological assessment data collections. Both the fish IBI and the macroinvertebrate biological assessment utilize the visual habitat assessment tool developed by GAEPD. The instructions for conducting the habitat assessment are included in both SOPs. The habitat assessments will be conducted in accordance with the SOPs. Final habitat assessment scores for each site will be calculated by averaging the independent scores collected during the sampling periods. By averaging the scores provided by different surveyors at different times, the subjectivity of the visual habitat assessment technique should be reduced.

f. Baseline Condition Analysis. Baseline condition shall be quantified (i.e., total stream health score) by applying the results of sub-tasks (c-e) to the ERM spreadsheet tool. The physical habitat (including flow regime) and water quality characteristics likely contributing to the fish IBI, macroinvertebrate biological assessment, and habitat assessment scores calculated at each site shall be evaluated. This evaluation will set the foundation for interpreting the Hydrology & Hydraulics (H&H) model outputs as they relate to the "Future Without" and "Future With" project analyses.

g. **"Future Without" Analysis**. The "Future Without" project condition (i.e., total stream health score) will be quantified. The "Future Without" project fish IBI, macroinvertebrate biological assessment, and habitat assessment scores for each site are calculated by predicting how the baseline condition scores for each site are likely to change based on the "Future Without" project H&H model results, including sediment analysis. The predictions represent "Best Professional Judgment" and should be based on the various habitat and life history requirements of the species described in the individual metrics for the fish IBI and macroinvertebrate biological assessment. The "Future Without" habitat predictions will likely provide the basis for this interpretation and should represent the conditions most likely to occur based on the H&H model results, including sediment transport. All individual metric score calculations shall be thoroughly documented and conclusions shall be peer reviewed and/or developed by the appropriate resource agency contacts and the PDT. The "Future Without" project condition (i.e., total stream health score) is calculated by applying the predicted scores to the ERM spreadsheet tool.

h. **"Future With" Analysis**. The "Future With" project condition (i.e., total stream health score) will be quantified. This process is identical to the "Future Without" project analysis, but incorporates the results of the various alternative "Future With" project H&H model results. The predictions represent "Best Professional Judgment" and should be based on the various habitat and life history requirements of the species described in the individual metrics for the fish IBI and macroinvertebrate biological assessment. The "Future With" habitat predictions will provide the basis for this interpretation and should represent the conditions most likely to occur based on the H&H model results. The "Future With" project condition (i.e. total stream health score) is calculated by applying the predicted scores to the ERM spreadsheet tool.

i. **Monitoring Plan**. A monitoring plan is to be developed and included in the feasibility report.

j. **Pre-construction Monitoring**. Biological monitoring in accordance with ERM protocols shall be conducted at each of the pre-defined monitoring stations for this project prior to construction.

k. **Post-construction Monitoring**. Monitoring will be conducted within the first and third years after construction at same pre-defined stations by the United States Army Corps of Engineers (USACE), in accordance with ERM protocols. Post-construction monitoring is not to exceed three years.

ENGINEERING TASKS

Engineering Appendix. An engineering appendix will be prepared describing the process and results. The Engineering Appendix to the Feasibility Report shall include the engineering and design effort during project formulation. The length and complexity of the Engineering Appendix shall be appropriate with the size and complexity of the project being formulated. The engineering appendix to the feasibility report shall include applicable items found in ER 1110-2-1150, Appendix C. Comparative studies, field investigations, design, and screening level cost estimates shall be in sufficient detail to substantiate the recommended plan and the baseline estimate.

a. Surveys and Mapping

Floodplain mapping is required for civil and hydraulic design and economic analysis activities. Prior surveys and plans prepared by Mobile District will be used as applicable. The U.S. Geological Survey, Natural Resources Conservation Service, and State planning agencies and universities will be contacted to locate and obtain any existing surveying and mapping data. Recent and historical aerial photography will also be obtained from available sources.

b. Surveys

Topographic Surveys. Aerial 2 feet contours will be sufficient to delineate the drainage area. At locations of hydraulic control (stream crossings, dams, major changes in channel geometry), detailed topographic surveys may be required to properly calibrate hydrologic and hydraulic models.

Cross-Sections. Cross section data will be obtained from either the aerial 2 feet contours or detailed topographic survey information. This information is needed for culvert and bridge detail and other structures or geologic features that will affect the stream hydraulics.

c. Mapping

Existing topographic mapping will be used for this phase of the study. Since the project is in an urban area, mapping of storm sewer lines and constructed drainage schemes that will affect the watershed hydrology may be requested of the non-Federal sponsor.

d. Hydrology and Hydraulic Studies/Report

A report will be prepared that details the results of hydrologic and hydraulic (H&H) studies conducted during the feasibility study to characterize the study area and design and evaluate alternative plans. The H&H studies will be accomplished using existing hydrologic and hydraulic data when available. These include models from prior Mobile District studies and Federal Emergency Management Agency Flood Insurance Studies. All models will be updated to current conditions and used as the existing condition model. Activities to be documented in the H&H report include: development of input data; development and calibration of hydrologic models; establishment of existing and future condition water surface profiles for various flow conditions; characterization of surface drainage patterns; model adjustment for future without-project conditions; alternative screening; detailed analyses of up to three alternatives; risk and uncertainty analysis; refinement of with-project hydrologic engineering analysis; activity estimate for PE&D phase; and preparation of the hydraulics and hydrology section of the Engineering Appendix. This task also requires attendance at project team meetings and coordination with the non-Federal sponsor’s staff. The Mobile District will:

- Prepare a hydraulic design study plan for the feasibility phase, including a listing of data input needs
- Required studies, and an analysis of prior studies by others
- Determine induced flooding potential and need for hydraulic mitigation
- Produce hydraulic design plans and profiles for selected alternatives
- Prepare a technical hydrology and hydraulics report suitable for incorporation as an appendix to the draft feasibility report

Engineering Models: The following engineering models are anticipated to be used in the development of the decision document: Watershed Characterization System (WCS), Sedimentation Impact Analysis Method (SIAM), Hydrologic Engineering Center – River Analysis System (HEC-RAS), and Micro-Computer Aided Cost Estimating System (MCACES) II. WCS, SIAM and HEC-RAS will be used to evaluate flow, velocity, sediment delivery, and sediment budget for existing conditions and for future conditions with and without restoration. MCACES II will be the cost estimating software used to prepare a detailed labor, equipment and material cost estimate.

Model Name and Version	**Brief Description of the Model and How It Will Be Applied in the Study**
Watershed Characterization System	Watershed Characterization System (WCS) provides users an initial set of watershed data along with analysis and reporting tools to process the data. The system can be applied to a broad range of TMDLs since the characterization process is relatively uniform and can be standardized regardless of the water body type and pollutant.
Sedimentation Impact Analysis Method	Sediment Impact Analysis Methods (SIAM) provides a framework for combining morphological, hydrologic, and hydraulic information. The results develop a quantitative picture of sediment movement through a watershed more detailed than a qualitative geomorphic evaluation and less intensive than a numeric mobile boundary model.
Hydrologic Engineering Center – River Analysis System	The Hydrologic Engineering Center's River Analysis System (HEC-RAS) program provides the capability to perform one-dimensional steady and unsteady flow river hydraulics calculations
Micro-Computer Aided Cost Estimating System II	The Micro-Computer Aided Cost Estimating System II (MCACES) is used to prepare a detailed labor, equipment and material cost estimate.

e. Hazardous, Toxic, and Radioactive Materials/Wastes (HTRW) Environmental Assessment: A Phase I Environmental Assessment shall be conducted at the subject site in accordance with the provisions of ASTM E 1527-05, "Standard Practice for Environmental Site Assessment: Phase I Environmental Site Assessment Process". The report shall utilize the "Recommended Table of Contents and Report Format" found in Appendix X4 of the standard.

f. Cost Estimating: A detailed labor, equipment and material cost estimate consistent with the level of design will be prepared. The tentatively selected plan should have a Micro-Computer Aided Cost Estimating System (MCACES) II level of estimate. The estimate shall reflect fair and reasonable costs that would be expected for a prudent, experienced construction contractor to incur to accomplish the work. MCACES, Second Generation (MII), Version 3.0 (or most recent version) will be used to prepare the estimate (hereafter noted as MCACES). An MCACES template will be furnished by the Government for overall structure and organization of the estimate.

The estimate shall include a statement as to the price level (month/year) of the estimate; escalation (to anticipated construction date) shall not be applied to the estimate. The estimate shall include project summary notes (i.e. in the project properties) to describe the scope of work, construction methods and sequence and any other pertinent information that is important to know that is not fully documented in the notations associated with specific line items and features. Costs in the estimate shall be based on: quantity take offs, backup data, drawings, sketches, quotes, etc. All supporting documentation shall be clearly labeled to correlate to specific line items in the estimate. The supporting documents shall be organized and included in a narrative report with the estimate. The following library files for the calculation of the MCACES estimate should be used:

- Unit Price Book: English Cost Book v3.0 (or most recent version).
- Crew: NA
- Labor: Nation Labor 2006 (or most recent version) (modified within the estimate to reflect Davis Bacon Wage Rates)
- Equipment: MII Equipment Region 5 2005 (or most recent version)

Quantities for all Work and Materials

Quantities for all work and materials to be incorporated into the detailed estimate shall be calculated and submitted as part of the estimate, with assumptions clearly stated. Only items not subject to variation shall be paid for as lump-sum items. Lump-sum items shall have detailed description of the lump-sum work and a description of any subsidiary work required for such payment. Items subject to variation shall be unit priced and measured.

Quantities shall also include approximations for waste/loss, swell, shrinkage etc. and be grouped into appropriate components of work. Material prices shall reflect actual costs (including freight, handling, storage, etc.) to the construction contractor during the period of construction. Supplier quotes shall be obtained for all major material components. Noted in the MCACES estimate the source for all quantities used and either include quantity calculations within the MCACES estimate or provide supporting documentation of quantity take off clearly labeled so that the quantity-take offs can be matched to a specific line item in the MCACES estimate.

Construction Plant and Equipment

All costs shall include appropriate charges for equipment, including mobilization and demobilization. Established hourly rates as determined by the appropriate provisions of EP 1110-1-8 (Vol. V), Construction Equipment Ownership and Operating Expense Schedule, shall be used to determine all equipment costs.

Labor

All costs for work shall include charges for bare, direct, and indirect labor. Davis Bacon Wage Rates appropriate for the project location shall be used. These costs shall be based on anticipated hourly wage rates and include appropriate taxes, insurance, and fringe benefits. All overtime charges necessary to accomplish work consistent with the construction scenario(s) used as a basis to develop the estimate will be estimated and included. Crew makeup, productivities, and other assumptions made with regard to labor costs, shall be clearly presented and documented to support the detailed cost estimate.

Contingency
Assignment of contingency factors shall be made at the most detailed level possible. Careful consideration shall be given to the determination of contingency assignments along with the insertion of notes with in the estimate to support the contingency factors used.

Assumptions
All assumptions shall be documented in the MCACES estimate. Notes shall be inserted at the appropriate feature or detail in which the assumption applies.

Cost Estimate Narrative Document
The narrative shall include a discussion of the construction task's scope of work, including discussion of construction methods, staging area requirements, work sequences for each of the structural features estimated, and perceived risks associated with construction. Also discussed will be the price levels used for the estimate, material prices, quantity calculations and development, contingency assignments and justification for such, the basis of assumptions used to develop the detailed estimate, material availability, and all other important information so that a full understanding of the parameters that went into the development of the estimate are communicated. In addition, all supporting documentation (i.e. quantity takeoffs, backup data, drawings and sketches, quotes etc.) shall be included.

REAL ESTATE STUDIES

Real Estate Planning: During the feasibility phase study, Real Estate Division (RE-P) will review selected alternatives to determine real estate requirements and appropriate real property interests. Real Estate (RE) personnel will prepare all real estate reports and cost estimates for the feasibility report. A Real Estate Plan (REP) will be prepared as an appendix to the Feasibility Report that outlines the minimum real estate requirements for the proposed project, in accordance with ER 405-1-12, Chapter 12. May 98. The REP contains a description of the area; the acreage and proposed estates, including non-standard estates, and reasons therefore; a discussion of any land owned by the Federal Government, the non-Federal sponsor or any public entity; an estimate of the Public Law 91-646 relocations; the Baseline Cost Estimate for Real Estate; a discussion of the non-Federal sponsor's ability to acquire Lands, Easements, Rights-of-Way, Relocations and Disposal area (LERRD); a discussion of mineral activity, if any, and the attitude of the landowner; a detailed schedule of land acquisition; a preliminary assessment of the facilities/utilities to be relocated; and any other relevant real estate information appropriate for the project. The appropriate interest to be acquired in properties identified in the proposed alternatives will be defined. RE will identify benefits available to displaced residents under Public Law 91-646. If necessary, the acreage needs for land mitigation (survey, description and appraisal) for affected wetlands will be established as required.

a. **Preliminary Real Estate Acquisition Maps:** RE will prepare an initial set of maps and drawings that delineate the real estate acquisition lines based on technical design drawings developed by Engineering Division (EN) during feasibility phase. Maps and drawings will reflect the minimum real estate required for project purposes.

b. **Physical Takings Analysis:** If necessary, a written legal opinion will be prepared as to whether flooding will be induced by the construction, operation or maintenance of the proposed project. If induced flooding is expected, a determination will be made as to whether it will rise to the level of a taking of an interest in real property for which just compensation must be paid to the owner of the real property. The opinion will describe the analysis of relevant information regarding the depth, frequency, duration, velocity and extent of induced flooding, as well as relevant State and Federal law, and will present a conclusion on the physical taking issue.

c. **Preliminary Attorney's Opinion of Compensability:** If necessary, a preliminary legal opinion will be prepared on whether provision of a substitute facility is required under the Fifth Amendment as compensation for a facility/utility being acquired for the project. The opinion makes findings on whether the owner has a compensable interest, whether the owner has the legal duty to continue to maintain and operate the facility/utility, and whether Federal law requires the provision of a substitute facility/utility rather than a mere payment of the market value for the property acquired. The preliminary legal opinion differs from the final legal opinion only in its acceptance as fact of the owner's statement of interest in the subject property, without a search of property records.

d. **Gross Appraisal:** A staff appraiser from USACE-RE-P will prepare a gross appraisal of appropriate real estate interests. The appraisal which will include a total estimated value for fee and easement estates, including improvements, minerals, and severance damages. It will also include any additional details or refinement beyond the Initial Real Estate Reconnaissance of the location and description of the area; the special features (i.e., timber, minerals, water rights, etc.); environmental concerns including potential HTRW or lack thereof; existing encumbrances; the highest and best use(s) involved; and the assumptions and limiting conditions. The gross appraisal will be of sufficient detail to provide an accurate cost estimate, which will be sufficient for authorization considering the cost growth limits of Section 902 of Public Law 99-662.

e. **Rights-of-Entry:** USACE-RE and/or the non-Federal sponsor will obtain any rights-of-entry needed for surveys or other preliminary work. At this time, the total numbers of right-of-entries needed for this project are not known. If any are required, an average cost of $200.00 per tract is anticipated.

f. **Relocations of Facilities and Utilities:** RE personnel will determine if alternatives for the project require the relocation of any existing facilities or utilities. A staff appraiser will determine the fair market value of any additional lands needed for the relocations. USACE Office of Counsel (OC) and RE Division will coordinate with the non-Federal sponsor to fulfill all legal obligations.

g. **Relocation Assistance and Advisory Services:** Section 205 of Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970 (Public Law 91-646), as amended, requires establishment of a relocation assistance advisory program for persons displaced as a result of Federal or Federally-assisted programs or projects. Programs or projects undertaken by USACE shall be planned in a manner that (1) recognizes, at any early stage in the planning of such programs or projects and before the commencement of any actions which will cause displacements of individuals, families, businesses, and farm operations, and (2) provides for the resolution of such problems in order to minimize adverse impacts on displaced persons and to expedite program or project advancement and completion.

h. **Participate in Meetings and Public Workshops:** RE personnel will attend (as needed) progress review meetings and all other pertinent public/private meetings. RE Division will provide all necessary real estate data for workshops, feasibility, and internal review. Preliminary Draft Real Estate Plan (REP): A preliminary draft REP will be prepared after the aforementioned real estate planning activities have been completed to an acceptable level. The REP will be fully coordinated and accomplished with PDT. Supervisory and OC review will be accomplished and the preliminary draft report will be revised to incorporate appropriate comments. The preliminary draft real estate report will be incorporated as an appendix into the preliminary draft feasibility report and distributed for the final technical review. Responses to technical review comments will be prepared and any necessary changes will be incorporated into the draft real estate report.

i. **Draft Real Estate Plan:** The draft REP will be prepared after the final technical review has been completed. The report will discuss and display all data, findings, procedures and assumptions used in the analysis. Changes to comply with appropriate comments from the final technical review will be incorporated into the draft real estate plan. Supervisory review will be accomplished and the draft real estate report will be revised to incorporate appropriate comments. The draft REP will be incorporated into the draft feasibility report.

j. **Final Real Estate Plan:** The final REP will be prepared and will be incorporated as an appendix into the final feasibility report. The report will discuss and display all data, findings, procedures and assumptions used in the analysis. Supervisory and OC review will be accomplished and the final report will be revised to incorporate appropriate comments.

k. **Other Real Estate Analyses/Documents:** No other Real Estate analyses/documents are anticipated.

PROJECT DELIVERY TEAM

Discipline	Office/Agency
Program Manager	CESAM-PM-CP
Project Manager	CESAM-PM-CM
Plan Formulator	CESAM-PD-FP
Environmental	CESAM-PD-EI
Cultural Resources	CESAS-PD-PE
Real Estate	CESAM-RE-P
Hydraulics/Modeling	CESAM-EN-HH
Geotechnical	CESAM-EN-GG
Cost Engineer	CESAM-EN-E
Environmental Scientist/Project Manager	CH2M HILL
Supporting Project Manager	CH2M HILL
Cost Engineer	CH2M HILL

REVIEW SCHEDULE

Milestone	Review	Schedule Dates
AFB	AFB by SAD	April 2004 A
Draft Report and Draft EA	ATR	Aug 2011
IPR	IPR at SAD	Aug 2011
Final Report and Final EA	ATR	Sep 2011

*Note: ATR on CAP are anticipated to be a continuum of the same review with backchecks at each of these milestones resulting in one ATR certification to be included in the Final Report and EA delivery to SAD for project approval.

FEASIBILITY PHASE COST ESTIMATE

Description	Cost
Hydrology and Hydraulics Studies/Report	$220,000
Geotechnical Studies/Report	20,000
HTRW Studies	$25,000
Cost Engineering	50,000
Engineering Management (PAE)	20,000
Reproduction & CADD	$5,000
Economic and Socioeconomic Studies	30,000
Real Estate Analysis/Report	50,000
Environmental Studies/Report	150,000
Biological Assessment	60,000
Section 404(b) 1 Evaluation	10,000
Fish and Wildlife Coordination Act Report	$15,000
Cultural Resources Studies/Report	45,000
Public Involvement Program	15,000
Plan Formulation and Evaluation	100,000
Report Preparation	$40,000
Agency Technical Review	40,000
Project Management and Budget Documents	80000
DQC	20,000
Value Engineering	20,000
Total	$1,015,000

FEASIBILITY COST SHARING AGREEMENT

Agreement between the Federal Government and the non-Federal sponsor to complete the Feasibility Study. The non-Federal sponsor invested considerable effort into this study during a period when the USACE was unable to obtain funding. No credit is expected from the non-Federal sponsor for work conducted during this period though their effort significantly reduced remaining study cost.

REVISIONS

The PMP is a living document and will be revised as necessary to keep it current and to document progress from initiation of design through project implementation and turnover of the completed project to the non-Federal sponsor.

Appendix C
Decision Document Review Plan

Continuing Authorities Program
Section 206, Water Resources Development Act of 1996, as Amended
Aquatic Ecosystem Restoration Projects

DECISION DOCUMENT REVIEW PLAN

USING THE PROGRAMMATIC REVIEW PLAN MODEL

BUTLER CREEK, COBB COUNTY, GEORGIA

MOBILE DISTRICT

South Atlantic Division (SAD) Approval Date: 19 Apr 2011
Last Revision Date: 12 Aug 2011

US Army Corps
of Engineers ®

DECISION DOCUMENT REVIEW PLAN
USING THE NATIONAL PROGRAMMATIC REVIEW PLAN MODEL

Section 206, Water Resources Development Act of 1996, as amended
Aquatic Ecosystem Restoration Decision Documents

TABLE OF CONTENTS

1. PURPOSE AND REQUIREMENTS

a. Purpose. This Review Plan defines the scope and level of peer review for the Butler Creek, Cobb County, Georgia Aquatic Ecosystem Restoration project Feasibility Report and Environmental Assessment (decision document) developed under Section 206, Water Resources Development Act of 1996, as amended.

The Continuing Authorities Program (CAP) consists of a group of ten legislative authorities by which the Chief of Engineers is authorized to plan, design, and construct certain types of water resource and environmental restoration projects of limited size, scope, cost and complexity without additional, project-specific Congressional authorization. Section 206 of the Water Resources Development Act of 1996, Public Law 104-303, is a CAP authority for aquatic ecosystem restoration projects with the objective of restoring degraded ecosystem structure, function, and dynamic processes to a less degraded, more natural condition considering the ecosystem's natural integrity, productivity, stability and biological diversity. This authority is primarily used for manipulation of the hydrology in and along bodies of water, including wetlands and riparian areas. This authority also allows for dam removal. The Federal share of costs for any one Section 206 project may not exceed $5,000,000.

b. Applicability. This review plan is based on the model National Programmatic Review Plan for Section 206 project decision documents, which is applicable to projects that do not require Independent External Peer Review (IEPR), as defined in EC 1165-2-209 Civil Works Review Policy. A Section 206 project does not require IEPR if ALL of the following specific criteria are met:

- The project does not involve a significant threat to human life/safety assurance;
- The total project cost is less than $45 million;
- There is no request by the Governor of an affected state for a peer review by independent experts;
- The project does not require an Environmental Impact Statement (EIS),
- The project is not likely to have significant economic, environmental, and/or social effects to the Nation;
- The project/study is not likely to have significant interagency interest;
- The project/study is not likely highly controversial;
- The decision document is not likely to contain influential scientific information or be a highly influential scientific;
- The information in the decision document or proposed project design is not likely to be based on novel methods, involve the use of innovative materials or techniques, present complex challenges for interpretation, contain precedent-setting methods or models, or present conclusions that are likely to change prevailing practices; and
- The project has not been deemed by the USACE Director of Civil Works or Chief of Engineers to be controversial nature.

If any of the above criteria are not met, the model National Programmatic Review Plan is not applicable and a study specific review plan must be prepared by the Mobile district, coordinated with the National Ecosystem Planning Center of Expertise (ECO-PCX) and approved by the SAD in accordance with EC 1165-2-209.

Applicability of the model National Programmatic Review Plan for a specific project is determined by the home MSC. If the SAD determines that the model plan is applicable for a specific study, the MSC Commander may approve the plan (including exclusion from IEPR) without additional coordination with the ECO-PCX or Headquarters, USACE. The initial decision as to the applicability of the model plan should be made no later than the Federal Interest Determination milestone (as defined in Appendix F of ER 1105-2-100, F-10.e.1) during the feasibility phase of the project. In addition, the Mobile district and SAD should assess at the Alternatives Formulation Briefing (AFB) whether the initial decision on the use of the model plan is still valid or if a project specific review plan should be developed based on new information. If a project specific review plan is required, it must be approved prior to execution of the Feasibility Cost Sharing Agreement (FCSA) for the study.

This review plan does not cover implementation products. A review plan for the design and implementation phase of the project will be developed prior to approval of the final decision document in accordance with EC 1165-2-209.

c. References

(1) Engineering Circular (EC) 1165-2-209, Civil Works Review Policy, 31 Jan 2010
(2) EC 1105-2-412, Assuring Quality of Planning Models, 2010
(3) Engineering Regulation (ER) 1110-1-12, Quality Management, 30 Sep 2006
(4) ER 1105-2-100, Planning Guidance Notebook, Appendix F, Continuing Authorities Program, Amendment #2, 31 Jan 2007
(5) ER 1105-2-100, Planning Guidance Notebook, Appendix H, Policy Compliance Review and Approval of Decision Documents, Amendment #1, 20 Nov 2007

d. Requirements. This programmatic review plan was developed in accordance with EC 1165-2-209, which outlines four general levels of review: District Quality Control/Quality Assurance (DQC), Agency Technical Review (ATR), Independent External Peer Review (IEPR), and Policy and Legal Compliance Review. In addition to these levels of review, decision documents are subject to cost engineering review and certification (per EC 1165-2-209) and planning model certification/approval (per EC 1105-2-412).

(1) District Quality Control/Quality Assurance (DQC). All decision documents (including supporting data, analyses, environmental compliance documents, etc.) shall undergo DQC as provided in EC 1165-2-209, paragraph 8.

(2) Agency Technical Review (ATR). ATR is mandatory for all decision documents (including supporting data, analyses, environmental compliance documents, etc.) as provided in EC 1165-2-209, paragraph 9.

For review of decision documents under the model National Programmatic Review Plan for Section 206 projects, the leader of the ATR team shall be from outside the home district, but may be from within the home SAD.

(3) Independent External Peer Review (IEPR). IEPR may be required for decision documents under certain circumstances, as provided in EC 1165-2-209, paragraph 10. There are two

types of IEPR: Type I is generally for decision documents and Type II is generally for implementation products.

(a) Type I IEPR. Type I IEPR reviews are managed outside the USACE and are conducted on project studies, as provided in EC 1165-2-209, paragraph 11.

For review of decision documents under the model National Programmatic Review Plan for Section 206 projects, Type I IEPR is not required.

(b) Type II IEPR.   Type II IEPR, or Safety Assurance Review (SAR), are managed outside the USACE and are conducted on design and construction activities for hurricane, storm, and flood risk management projects or other projects where existing and potential hazards pose a significant threat to human life, as provided in EC 1165-2-209, paragraph 12.   Type II IEPR panels will conduct reviews of the design and construction activities prior to initiation of physical construction and, until construction activities are completed, periodically thereafter on a regular schedule. The reviews shall consider the adequacy, appropriateness, and acceptability of the design and construction activities in assuring public health safety and welfare.

For review of decision documents listed in this review plan, prepared under the model National Programmatic Review Plan for Section 206 projects, Type II IEPR is not required.

(4) Policy and Legal Compliance Review. All decision documents will be reviewed throughout the study process for their compliance with law and policy, as provided in EC 1165-2-209, paragraph 14.

(5) Cost Engineering Review and Certification.

For decision documents prepared under the model National Programmatic Review Plan, Regional cost personnel that are pre-certified by the Cost Engineering Directory of Expertise (DX), located in Walla Walla District (DX) will conduct the cost estimate ATR. If pre-certified cost personnel are not in place, the cost estimate will be sent to Walla Walla. The DX will provide the cost engineering certification.

(6) Model Certification/Approval.   EC 1105-2-412 mandates the use of certified or approved models for all planning activities to ensure the models are technically and theoretically sound, compliant with USACE policy, computationally accurate, and based on reasonable assumptions. EC 1105-2-407 requires certification (for Corps models) or approval (for non-Corps models) of planning models used for all planning activities. The EC defines planning models as any models and analytical tools that planners use to define water resources management problems and opportunities, to formulate potential alternatives to address the problems and take advantage of the opportunities, to evaluate potential effects of alternatives and to support decision-making. The EC does not cover engineering models used in planning. Engineering software is being address under the Engineering and Construction (E&C) Science and Engineering Technology (SET) initiative. Until an appropriate process that documents the quality of commonly used engineering software is developed through the SET initiative, engineering activities in support of planning studies

shall proceed as in the past. The responsible use of well-known and proven USACE developed and commercial engineering software will continue and the professional practice of documenting the application of the software and modeling results will be followed.

For review of decision documents under a model National Programmatic Review Plan, use of existing certified or approved planning models is encouraged. Where uncertified or unapproved model are used, approval of the model for use will be accomplished through the ATR process. The ATR team will apply the principles of EC 1105-2-412 during the ATR to ensure the model is theoretically and computationally sound, consistent with USACE policies, and adequately documented. If specific uncertified models are identified for repetitive use within a specific district or region, the appropriate PCX, SAD(s), and home District(s) will identify a unified approach to seek certification of these models.

2. REVIEW MANAGEMENT ORGANIZATION (RMO) COORDINATION

The RMO is responsible for managing the overall peer review effort described in this review plan. The RMO for Section 206 decision documents is the home SAD. The SAD will coordinate and approve the review plan and manage the ATR. The Mobile District will post the approved review plan on its public website. A copy of the approved review plan (and any updates) will be provided to the National Ecosystem Planning Center of Expertise (ECO-PCX) to keep the PCX apprised of requirements and review schedules.

3. STUDY INFORMATION

a. Decision Document. The Butler Creek, Cobb County, Georgia decision document will be prepared in accordance with ER 1105-2-100, Appendix F. The approval level of decision documents (if policy compliant) is the home SAD. An Environmental Assessment (EA) will be prepared along with the decision document.

b. Study/Project Description. With cooperation with the City of Gainesville, GA and Hall County, Ga, the Butler Creek Watershed has been identified as an Aquatic Ecosystem Restoration Study. The study is consistent with the objectives of the U.S. Army Corps of Engineers aquatic ecosystem restoration program under the Section 206 Authority. Additionally, it is likely that an improvement of the Butler Creek Watershed by the Corps will complement the restoration plans envisioned by the non-Federal sponsor. The Preliminary Restoration Plan (PRP) was approved in 2001.

The Butler Creek watershed is located in the Etowah River Basin in northwestern Cobb County, Georgia, and drains into Lake Acworth (Figure 1). Lake Acworth is a subimpoundment of Lake Altoona, a federally managed multi-use reservoir. The Etowah River Basin is part of the larger Coosa River Basin, which flows through Alabama, becoming the Alabama River as it joins with the Tallapoosa River. The Alabama-Coosa- Tallapoosa Rivers Basin (ACT Basin) flows into the Gulf of Mexico.

The Butler Creek watershed encompasses 6,016 total acres (9.4 square miles) and contains a total of approximately 12.7 stream miles (7 miles of main stem and 5.7 miles of tributaries) (Figure 1). Topography in the Butler Creek watershed ranges from 1,100 feet above mean sea level (msl) in the headwaters to 850 feet above msl, where the stream enters the backwaters of Lake Acworth. Butler Creek and its watershed are located entirely within Cobb County, which is part of the northern

Piedmont physiographic province. The watershed includes portions of the Cities of Kennesaw and Acworth and unincorporated areas of Cobb County, with the headwaters being the most developed portion of the watershed.

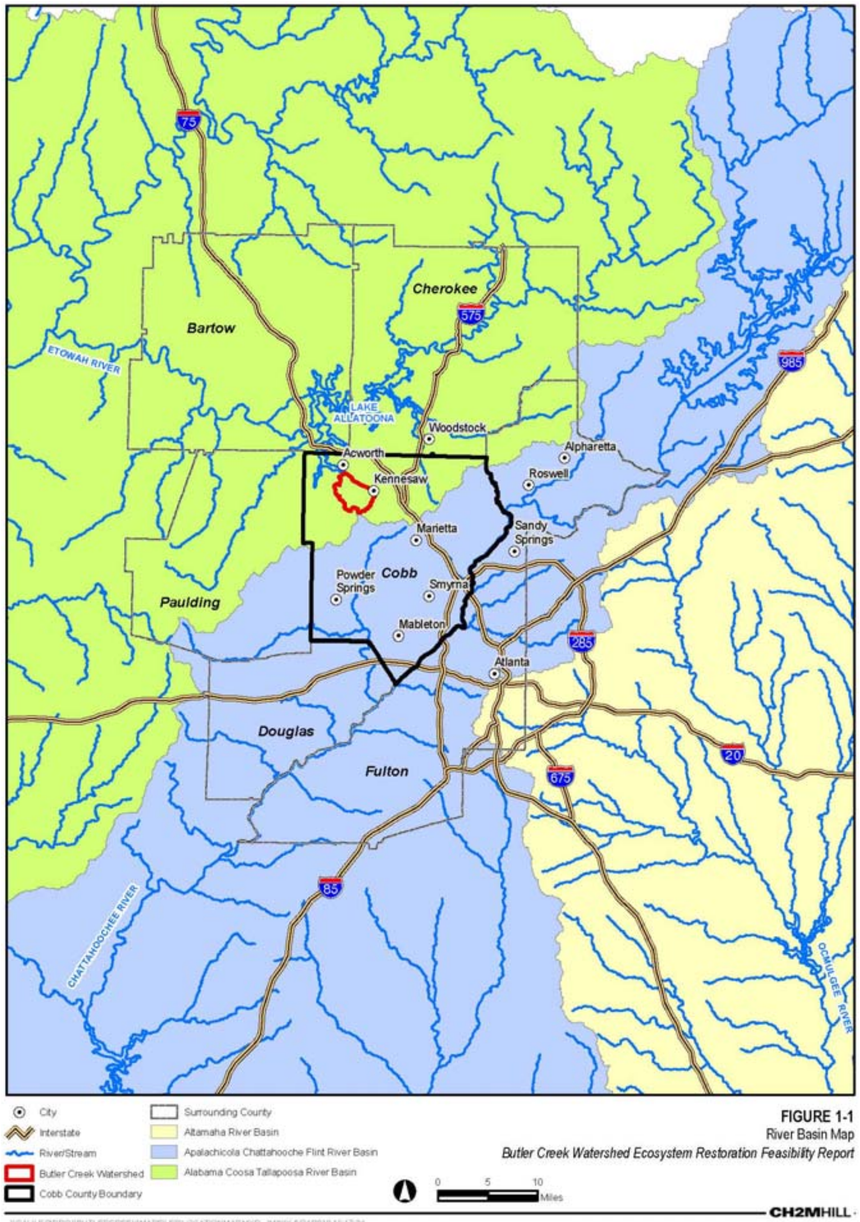


Figure 1

c. Factors Affecting the Scope and Level of Review. The parts of the study that will be challenging are the environmental and real estate. Some of the alternatives being proposed are located in wetland areas. The concern is the amount and quality of wetlands lost during the construction of the ecosystem restoration sites. All wetlands affected during construction will be returned to their natural state or better than their natural state at the completion of construction. Real estate may also be challenging due to steep banks and acquiring land interest on property for access and staging equipment.

The project is not likely to have significant economic, environmental, or social effects to the Nation or involve a significant threat to human life/safety. The project is an ecosystem restoration project consisting of wet detention, dry detention, underground storage, retrofitting existing lakes and wet detention, and stream restoration. The project will reduce flashy high peak flows, reduce channel embeddedness, stabilize banks, and reconnect floodplains. The project is not likely to have significant interagency interest, be highly controversial, contain influential scientific information or be a highly influential scientific assessment. The information in the decision document or proposed project design will not likely be based on novel methods, involve the use of innovative materials or techniques, present complex challenges for interpretation, contain precedent-setting methods or models, or present conclusions that are likely to change prevailing practices.

d. In-Kind Contributions. Products and analyses provided by non-Federal sponsors as in-kind services are subject to DQC and ATR, similar to any products developed by USACE. No in-kind contributions are anticipated. The non-Federal sponsor shall participate with cash reimbursement for 35% of the Feasibility Study cost.

4. DISTRICT QUALITY CONTROL (DQC)

All documents to be produced will undergo District Quality Control. The DQC review team will be responsible for performing a technical review of the Draft Feasibility Report including the Environmental Assessment, engineering, economics, real estate, cost and environmental appendices. The DQC review will be completed prior to submitting documents for ATR. Duties of the DQC team include the following:

1) Reviewing report contents for compliance with established principles and procedures, using clearly justified and valid assumptions.
2) Reviewing methods and procedures used to determine appropriateness, correctness and reasonableness of results.
3) Providing the review team leader with documentation of comments, issues, and decisions arising out of the DQC review. Comments, and resolutions, will be documented in a Microsoft Word document or by using DrChecks.
4) Capturing public input at scoping and public meetings. Public comments are solicited and accepted by various means: United States Postal Service, email, website, fax, or at the public and scoping meetings.

5. AGENCY TECHNICAL REVIEW (ATR)

a. Products to Undergo ATR. ATR will be performed throughout the study in accordance with the District and SAD Quality Management Plans. The ATR shall be documented and discussed at the AFB milestone. Certification of the ATR will be provided prior to the District Commander signing the final report. Products to undergo ATR include at a minimum the AFB submittal materials, the draft decision and NEPA documents, and the final decision and NEPA documents.

b. Required ATR Team Expertise. The ATR team will consist of the individuals that represent the significant disciplines involved in the accomplishment of the work. The RMO, in cooperation with the Project Delivery Team (PDT) and vertical team, will determine the final make-up of the ATR team. The RMO will coordinate with the Cost Engineering Directory PCX in Walla Walla District to provide the cost engineering review and resulting certification.

ATR will be managed within the Corps and conducted by a qualified team. HQUSACE guidance requires that the ATR Team Lead reside outside of the SAD that is producing the document, unless an exception is acquired. For this study, the ATR Team Lead will reside within the SAD, but outside of Mobile District, for the following reasons:

- ATR Team Lead is independent from the District that is preparing the decision document;
- SAD has the resident expertise within its jurisdiction to lead and perform the review;
- Efficiencies are gained by an ATR Team Lead being located with the SAD, such as timeliness of the review and subsequent ATR certification; and
- Study is low risk, does not involve a significant threat to human life, or possess safety concerns.

ATR Team Members/Disciplines	Expertise Required
ATR Lead	The ATR lead should be a senior professional with experience in preparing Section 206 decision documents and conducting ATR. The lead should also have the necessary skills and experience to lead a virtual team through the ATR process. Typically, the ATR lead will also serve as a reviewer for a specific discipline (such as planning, economics, environmental resources, etc).
Planning	The Planning reviewer should be a senior water resources planner with experience in ecosystem restoration projects and be experienced in general planning policy and guidance. The team member should also be familiar with the Ecosystem Response Model software used as Plan Formulation tool to evaluate alternatives.
Economics	Team member(s) should have extensive knowledge of the economic software IWR Planning Suite Decision Support Software and knowledge of CE/ICA.
Environmental Resources	Team member(s) should have extensive knowledge of the integration of environmental evaluation and compliance requirements, pursuant to national environmental statutes (NEPA), applicable executive orders and other Federal planning requirements, into the planning of Civil Works comprehensive plans and implementation projects. The team member(s) should also have a thorough understanding of the approved decision making tool used for this project (Ecosystem Response Model).
Hydrology & Hydraulics	Team member(s) should have a thorough understanding of computer modeling techniques used for this project (HEC-RAS).
Cost Engineering	Team member(s) should be familiar with the most recent version of MCACES II software and total project cost summary. The Cost Reviewer is required to coordinate with the Walla Walla Cost DX staff for further cost engineering review and resulting

	certification.
Real Estate	Team member(s) should have planning/appraisal/acquisition experience regarding ecosystem restoration type projects. Including, but not limited to, knowledge of estates to be acquired, induced flooding, zoning/buffer ordinances, and NFS acquisition responsibilities.

c. Documentation of ATR. DrChecks review software will be used to document all ATR comments, responses and associated resolutions accomplished throughout the review process. Comments should be limited to those that are required to ensure adequacy of the product. The four key parts of a quality review comment will normally include:

(1) The review concern – identify the product's information deficiency or incorrect application of policy, guidance, or procedures;
(2) The basis for the concern – cite the appropriate law, policy, guidance, or procedure that has not be properly followed;
(3) The significance of the concern – indicate the importance of the concern with regard to its potential impact on the plan selection, recommended plan components, efficiency (cost), effectiveness (function/outputs), implementation responsibilities, safety, Federal interest, or public acceptability; and
(4) The probable specific action needed to resolve the concern – identify the action(s) that the reporting officers must take to resolve the concern.

In some situations, especially addressing incomplete or unclear information, comments may seek clarification in order to then assess whether further specific concerns may exist.

The ATR documentation in DrChecks will include the text of each ATR concern, the PDT response, a brief summary of the pertinent points in any discussion, including any vertical team coordination (the vertical team includes the district, RMO, MSC, and HQUSACE), and the agreed upon resolution. If an ATR concern cannot be satisfactorily resolved between the ATR team and the PDT, it will be elevated to the vertical team for further resolution in accordance with the policy issue resolution process described in either ER 1110-2-12 or ER 1105-2-100, Appendix H, as appropriate. Unresolved concerns can be closed in DrChecks with a notation that the concern has been elevated to the SAD team for resolution.

At the conclusion of each ATR effort, the ATR team will prepare a Review Report summarizing the review. Review Reports will be considered an integral part of the ATR documentation and shall:

- Identify the document(s) reviewed and the purpose of the review;
- Disclose the names of the reviewers, their organizational affiliations, and include a short paragraph on both the credentials and relevant experiences of each reviewer;
- Include the charge to the reviewers;
- Describe the nature of their review and their findings and conclusions;
- Identify and summarize each unresolved issue (if any); and
- Include a verbatim copy of each reviewer's comments (either with or without specific attributions), or represent the views of the group as a whole, including any disparate and dissenting views.

ATR may be certified when all ATR concerns are either resolved or referred to the vertical team for resolution and the ATR documentation is complete. The ATR Lead will prepare a Statement of Technical Review certifying that the issues raised by the ATR team have been resolved (or elevated to the vertical team). A Statement of Technical Review should be completed prior to the District Commander signing the final report. A sample Statement of Technical Review is included in Attachment 2.

6. INDEPENDENT EXTERNAL PEER REVIEW (IEPR)

a. **Decision on IEPR.** Based on the information and analysis provided in paragraph 3(c) of this review plan, the project covered under this plan is excluded from IEPR because it does not meet the mandatory IEPR triggers and does not warrant IEPR based on a risk-informed analysis. At this time all of the criteria outlined in paragraph 1(b) would be met.

b. **Products to Undergo Type I IEPR**. Not applicable.

c. **Required Type I IEPR Panel Expertise**. Not Applicable.

.

d. **Documentation of Type I IEPR.** Not Applicable.

7. MODEL CERTIFICATION AND APPROVAL

a. **Planning Models.** The Institute of Water Resources (IWR) Planning Suite Decision Support Software and the Ecosystem Response Model (ERM) are the planning models anticipated for use in the development of the decision document. For this study the ERM has been approved as a plan formulation tool by the ECO-PCX. IWR Planning Suite will be used to evaluate the cost effectiveness and incremental cost of each potential restoration alternative, based on an estimated cost and projected benefits.

Model Name and Version	Brief Description of the Model and How It Will Be Applied in the Study	Certification / Approval Status
IWR Planning Suite	For this study IWR Planning Suite will be used to evaluate the cost effectiveness and incremental cost of each potential restoration alternative, based on an estimated cost and projected benefits according to ERM results.	Certified
Ecosystem Response Model	The ERM uses physical habitat and biological monitoring data, collected using GADNR guidance (GADNR, 2005; 2007), as an indicator of the overall stream ecosystem integrity. The ERM outputs a combined stream health score and Habitat Units, based on biological monitoring data, and a projected future combined stream health score and Habitat Units based on predicted future biological monitoring scores. This allows comparison of outputs under various conditions and provides an indicator of the extent of stream improvement that would result from implementation of restoration alternatives. The ERM was approved for use as a Plan Formulation tool by the	Approved

	ECO-PCX and endorsed by SAD for the North Georgia Piedmont Region projects.	

b. **Engineering Models.** The following engineering models are anticipated to be used in the development of the decision document: Watershed Characterization System (WCS), Sedimentation Impact Analysis Method (SIAM), Hydrologic Engineering Center – River Analysis System (HEC-RAS), and Micro-Computer Aided Cost Estimating System (MCACES) II. WCS, SIAM and HEC-RAS will be used to evaluate flow, velocity, sediment delivery, and sediment budget for existing conditions and for future conditions with and without restoration. MCACES II will be the cost estimating software used to prepare a detailed labor, equipment and material cost estimate.

Model Name and Version	Brief Description of the Model and How It Will Be Applied in the Study	Certification / Approval Status
Hydrologic Engineering Center – Hydrologic Modeling Systems	The Hydrologic Engineering Center's River Analysis System (HEC-HMS) is designed to stimulate the precipitation / runoff process of dendritic watershed systems. Hydrographs produced by the program are used directly or in conjunction with other software for studies of water availability, urban drainage, flow forecasting, future urbanization impact, reservoir spillway design, flood damage reduction, floodplain regulation, and systems operation.	Certified
Micro-Computer Aided Cost Estimating System II	The Micro-Computer Aided Cost Estimating System II (MCACES) is used to prepare a detailed labor, equipment and material cost estimate.	Approved

8. REVIEW SCHEDULES AND COSTS

a. **ATR Schedule and Cost.** The cost for ATR is estimated at approximately $25,000. The documents to be reviewed and scheduled dates for review are as follows:

Milestone	Review	Schedule Dates
AFB	AFB by SAD	April 2004 (Actual)
Draft Report and Draft EA	ATR	Aug 2011
IPR	IPR at SAD	Aug 2011
Final Report and Final EA	ATR	Sep 2011

b. **Type I IEPR Schedule and Cost.** Not applicable.

c. **Model Certification/Approval**. EC 1105-2-407 requires certification (for Corps models) or approval (for non-Corps models) of planning models used for all planning activities. The EC defines planning models as any models and analytical tools that planners use to define water resources management problems and opportunities, to formulate potential alternatives to address the problems and take advantage of the opportunities, to evaluate potential effects of alternatives and to support decision-making. The EC does not cover engineering models used in planning. Engineering software is being address under the Engineering and Construction (E&C) Science and Engineering Technology (SET) initiative. Until an appropriate process that documents the quality of commonly used engineering software is developed through the SET initiative, engineering activities in support of planning studies shall proceed as in the past. The responsible use of well-known and proven USACE developed and commercial engineering software will continue and the professional practice of documenting the application of the software and modeling results will be followed.

9. PUBLIC PARTICIPATION

State and Federal resource agencies may be invited to participate in the study covered by this review plan as partner agencies or as technical members of the PDT, as appropriate. Agencies with regulatory review responsibilities will be contacted for coordination as required by applicable laws and procedures. The ATR team will be provided copies of public and agency comments.

The review plan will be made accessible to the public through the Mobile District website link http://www.sam.usace.army.mil/. Public review of the review plan can begin as soon as it is approved by the SAD Commander and posted by the Mobile District. Comments made by the public will be available to the review team. Public and interagency review for the EA will be conducted in accordance with NEPA, as outlined in ER 1105-2-100.

The RP will be available throughout all public and agency scoping and other processes for this project. Public input from the NEPA workshops and the public meetings will be available to the ATR members to ensure that public comments have been considered in the development of reviews and final reports. Public comments will be solicited and accepted by multiple means: United States Postal Service, email, website, fax or at the public and scoping meetings.

10. REVIEW PLAN APPROVAL AND UPDATES

The SAD Commander is responsible for approving this review plan and ensuring that use of the Model Programmatic Review Plan is appropriate for the specific project covered by the plan. The review plan is a living document and may change as the study progresses. The Mobile district is responsible for keeping the review plan up to date. After approved by the SAD, minor changes to the review plan will be documented in Attachment 3 of this RP. Significant changes to the review plan (such as changes to the scope and/or level of review) should be re-approved by the SAD Commander following the process used for initially approving the plan. Significant changes may result in the SAD Commander determining that use of the Model Programmatic Review Plan is no longer appropriate. In these cases, a project specific review plan will be prepared and approved in accordance with EC 1165-2-209. The latest version of the review plan, along with the Commanders' approval memorandum, will be posted on the home district's webpage.

11. REVIEW PLAN POINTS OF CONTACT

Public questions and/or comments on this review plan can be directed to the following points of contact:

- Project Manager, 251-690-3254
- Plan Formulator, 251-694-3809
- South Atlantic Division Point of Contact 404-562-5229

ATTACHMENT 1: TEAM ROSTERS

Table 1 – Project Delivery Team Members

Discipline	Office/Agency
Program Manager	CESAM-PM-CP
Project Manager	CESAM-PM-C
Plan Formulator	CESAM-PD-FP
Environmental	CESAM-PD-EI
Economics	CESAM-PD-FE
Economics	CESAM-PD-FE
Cultural Resources	CESAS-PD-PE
Real Estate	CESAM-RE-P
Hydraulics/Modeling	CESAM-EN-HH
Geotechnical	CESAM-EN-GG
Cost	CESAM-EN-E

Table 2 – Agency Technical Review Team Members

Discipline	Name	Office/Agency
ATR Lead	TBD	TBD
Hydraulics and Hydrology	TBD	TBD
Environmental	TBD	TBD
NEPA	TBD	TBD
Cultural Resources	TBD	TBD
Economics	TBD	TBD
Plan Formulation	TBD	TBD
Cost Engineering	TBD	TBD
Real Estate	TBD	TBD

<u>ATTACHMENT 2</u>: SAMPLE STATEMENT OF TECHNICAL REVIEW FOR DECSION DOCUMENTS

COMPLETION OF AGENCY TECHNICAL REVIEW

The Agency Technical Review (ATR) has been completed for the CAP 206 Aquatic Ecosystem Restoration Report for Butler Creek, Cobb County, Georgia. The ATR was conducted as defined in the project's Review Plan to comply with the requirements of EC 1165-2-209. During the ATR, compliance with established policy principles and procedures, utilizing justified and valid assumptions, was verified. This included review of: assumptions, methods, procedures, and material used in analyses, alternatives evaluated, the appropriateness of data used and level obtained, and reasonableness of the results, including whether the product meets the customer's needs consistent with law and existing US Army Corps of Engineers policy. The ATR also assessed the District Quality Control (DQC) documentation and made the determination that the DQC activities employed appear to be appropriate and effective. All comments resulting from the ATR have been resolved and the comments have been closed in DrChecks^{sm}.

Name ATR Team Leader Office Symbol/Company	Date
Dean Trawick Project Manager CESAM-PM	Date
Kerry Gates Plan Formulator CESAM-PD-FP	Date
Name Review Management Office Representative Office Symbol	Date

CERTIFICATION OF AGENCY TECHNICAL REVIEW

Significant concerns and the explanation of the resolution are as follows:

As noted above, all concerns resulting from the ATR of the project have been fully resolved.

Douglas C. Otto Chief, Engineering Division CESAM-EN	Date
Curtis M. Flakes Chief, Planning Division	Date

ATTACHMENT 3: REVIEW PLAN MINOR REVISIONS

Revision Date	Description of Change	Page / Paragraph Number
19 Apr 2011	Approval Date and Latest Revision Date Updated	Cover Page
19 Apr 2011	"Required ATR Team Expertise": language pertaining to keeping the ATR lead within the MSC has been modified and explained.	Section 5b, Pages 6-7
12 Aug 2011	Approval Date has been changed to reflect the last approval date of the revised RP.	Front Page
12 Aug 2011	Last revision date changed.	Front Page
12 Aug 2011	Schedule has been updated.	Page 10
12 Aug 2011	List of models have been updated.	Page 10
12 Aug 2011	Names and direct phone numbers have been removed.	Page 12

ATTACHMENT 4: ACRONYMS AND ABBREVIATIONS

Term	Definition	Term	Definition
AFB	Alternative Formulation Briefing	MSC	Major Subordinate Command
ATR	Agency Technical Review	NER	National Ecosystem Restoration
CAP	Continuing Authorities Program	NEPA	National Environmental Policy Act
CE/ICA	Cost Effective/Incremental Cost Analysis	OMRR&R	Operation, Maintenance, Repair, Replacement and Rehabilitation
DQC	District Quality Control	PCX	Planning Center of Expertise
DX	Directory of Expertise	PDT	Project Delivery Team
EA	Environmental Assessment	PMP	Project Management Plan
EC	Engineer Circular	QA	Quality Assurance
ECO-PCX	Ecosystem Restoration Planning Center of Expertise	QC	Quality Control
ER	Ecosystem Restoration	RMO	Review Management Organization
ERM	Ecosystem Response Model	RP	Review Plan
GADNR	Georgia Department of Natural Resources	SAD	South Atlantic Division
HEC-RAS	Hydrologic Engineering Center - River Analysis System	SAR	Safety Assurance Review
HQUSACE	Headquarters, U.S. Army Corps of Engineers	SIAM	Sedimentation Impact Analysis Method
IEPR	Independent External Peer Review	USACE	U.S. Army Corps of Engineers
ITR	Independent Technical Review	WCS	Watershed Characterization System
IWR	Institute of Water Resources	WRDA	Water Resources Development Act
MCACES	Micro-Computer Aided Cost Estimating System		

Appendix D

Public Involvement and Coordination Report

BUTLER CREEK, COBB COUNTY

PUBLIC INVOLVEMENT APPENDIX

Public Involvement and Coordination

Public involvement and coordination is critical to the overall success of any planning project. USACE has four objectives for the public involvement component of planning studies: (1) provide information to the public, (2) make public input and concerns known to decision-makers, (3) consult with the public before making decisions, and (4) consider public views and input in reaching decisions (USACE, 2000). Throughout the planning process for the Butler Creek ecosystem restoration project, the USACE–Mobile and Cobb County, Georgia have cooperatively participated in interagency meetings and public involvement and coordination efforts.

Cobb County understands the importance of informing the public about projects that may affect the community. During development of this Detailed Project Report, public involvement and education were an important method of obtaining feedback from local citizens, as well as an avenue for promoting watershed management and stewardship. Butler Creek was presented at the following public meetings and conferences:

1) A public meeting was held in Acworth, GA on March 5, 2002. The purpose of this meeting was to invite the public to discuss problems and concerns witnessed in the Butler, Proctor and Allatoona Creek basins and the potential solutions.

2) Butler Creek was presented at the Georgia Water Resources Conference in March 2005 in Athens, GA.

3) A public meeting was held in Marietta, GA on September 8, 2009. This public meeting was held in order to present to the public, the results of the comprehensive watershed study of Butler Creek, from its headwaters in Kennesaw to its end at Lake Acworth in the City of Acworth.

Appendix D contains the public involvement reports summarizing each meeting as well as the PowerPoint presentation presented at the last public meeting on September 8, 2009. Additional details can be found in Section 9 “Summary of Public Involvement and Coordination” of the Detailed Project Report.

Appendix A

Marrietta Daily Journal - March 5, 2002

PUBLIC WORKSHOP - BUTLER, PROCTOR AND ALLATOONA CREEKS

The Mobile District, U.S. Army Corps of Engineers (Corps) is partnering with Cobb County, Stormwater Management in accordance with Section 206 of the Water Resources Development Act of 1996 to investigate the feasibility of improving habitat within Butler, Proctor and Allatoona Creeks for fish and other aquatic organisms with these creeks and tributaries. Other anticipated outputs consist of reduction of sediment loads and improved water quality in these streams and Lake Acworth as a result of implementation of bank stabilization and stormwater detention measures.

Concerned citizens are invited to attend a public workshop on March 5, 2002, to discuss problems witnessed in these basins and potential solutions. The workshop, arranged by the Corps, will be held from 3:00 p.m. to 7:00 p.m. at the Lake Allatoona Preservation Authority Office (4809 South Main Street) in Acworth. The workshop will be informal in nature. Meeting participants can view a brief slide presentation; discuss problems, concerns, etc. with Corps and other agency representatives; and prepare written comments concerning the project. Corps representatives will be available to explain the process by which restoration measures will be developed and implemented and how citizens may participate in the process.

[redacted]

Appendix B

Georgia Water Resources Conference - 2005

BUTLER CREEK AQUATIC ECOSYSTEM RESTORATION PROJECT

[redacted]

[redacted]

Abstract. The Butler Creek Aquatic Ecosystem Restoration Project is the first of many Section 206 projects of its kind identified by Cobb County, Georgia for the U.S. Army Corps of Engineers (Corps), Mobile District to study and implement solutions (under the Continuing Authorities Program) in the Metro-Atlanta area. The Section 206 authority allows for the Corps to participate, at the request of a non-Federal sponsor, in aquatic ecosystem restoration, if the project will improve the environment and is in the public interest. Butler Creek and several other creeks in this geographic area have been proven to support the Cherokee Darter, a small fish that is federally-listed as "threatened" by the U.S. Fish and Wildlife Service (USFWS). The Cherokee Darter is being adversely impacted because the rapid growth in the Kennesaw/Acworth areas of Cobb County is resulting in problems in the basin such as flashy stream flows, streambank erosion, and heavy deposits of silt in stream beds.

INTRODUCTION

Urbanization has significantly increased the overland flows throughout the Butler Creek Watershed resulting in increased flow and velocity in streams, heavy sedimentation, and streambank erosion. These problems are very common in metropolitan areas across the nation. Catching the frequent heavy rain events, and releasing them at a slower rate, is critical to the overall success of the recovery of many of these aquatic ecosystems. The USFWS and the U.S. Environmental Protection Agency (USEPA) have endorsed the concept of comprehensively addressing the impacts throughout this watershed and impacts (both beneficial and adverse) to the Cherokee Darter. Partnerships are critical to stabilizing and restoring the remnants of the piedmont region's stream habitat as found in the ever growing urban setting of North Georgia. This project will help to increase the potential for recovery and, therefore, provide a brighter future for aquatic species, including the Cherokee Darter. This paper will summarize the projects recommended measures and provide an update on the project status.

HABITAT ASSESSMENT

In 2001, an environmental consulting firm, Entrix, was contracted by the Corps to conduct stream walks and prepare a report of the problems they identified along Butler, Proctor, and Allatoona Creeks (all tributaries to Lake Allatoona). Aquatic habitat assessments were conducted using Georgia Department of Natural Resources (GADNR) stream assessment criteria and all parameters were qualitatively scored on a scale of 0 – 20, with the higher score being the best. These parameters consisted of 10 environmental metrics: epifaunal substrate/in-stream cover, embeddedness, velocity/depth combinations, channel alteration, sediment deposition, frequency of riffles, channel flow status, bank vegetation protection, bank stability, and riparian zone vegetation. A reference reach, based on the best habitat score, was established for each of the three watersheds.

The main contributors to the degraded habitat within this watershed were identified as flashy stormwater flows, associated sediment runoff from varying land usage within the basin, and bank erosion. While the environmental benefits for the proposed restoration project are widely recognized, the quantification of the environmental benefit is not quite so straightforward. No universally accepted environmental quantification "tool" or "method" is recognized. Therefore, the Corps, in consultation with an interagency team which included the USFWS, developed a habitat-based approach to quantify environmental benefits associated with the various measures considered as part of the restoration alternatives. Other associated separable environmental features were also evaluated during the plan formulation process for this project.

Figure 1. Severe Streambank Erosion In Butler Creek

Hydraulic engineers began modeling the basin for both flow and sediment to establish the existing hydraulic conditions and future conditions (to approximately 2030) based on land use predictions provided by Cobb County. Results of these models were used in combination with the GADNR scores to better define existing habitat conditions and anticipated future habitat conditions. New scores were assigned to each habitat assessment site to reflect the results of the modeling efforts. Each habitat score was expressed as a percentage of the same parameter for the reference reach.

In addition to habitat assessments, fish sampling was conducted by the University of Georgia's Institute of Ecology. This sampling was conducted to (1) obtain information on the diversity, health, and relative abundance of fishes, (2) determine the distribution of the Cherokee Darter, and (3) identify degraded habitats that would benefit from restoration activities. The results of this sampling effort revealed that the Cherokee Darter is widely distributed in the Butler, Proctor, and Allatoona basins. However, the population and diversity of fish species in each watershed is poor.

PROJECT EVALUATION

The Corps has partnered with the Cobb County Water System (the non-Federal sponsor) to take a comprehensive approach to address these problems throughout the entire watershed. A multi-discipline Project Delivery Team (PDT) was assembled consisting of members from the Cobb County, the Corps, the Cities of Kennesaw and Acworth, the USEPA, the USFWS, and the GADNR, including the Environmental Protection Division (GAEPD). This team is developing a plan which includes the construction of different stream stabilization measures (some general measures as recommended by Rosgen and other bioengineering techniques), re-vegetating riparian corridors, creating wetlands, constructing off-line retention/detention basins, and enhancing the level of inspection and enforcement of storm water quality regulations for all future development.

In 2004, the Butler Creek Watershed (6,016 acres) was the only creek of the three that received funding to continue study. The findings of the Entrix report and the fish sampling were further evaluated by the PDT to determine restoration reaches and begin preparation of conceptual restoration measures to address those physical problems that are negatively impacting aquatic habitat. A total of 16 project sites was selected for implementation of a measure or combinations of measures. The basin was divided into four distinct restoration reaches (A - D), each having 3 – 5 project sites located within them that are interdependent for the successful restoration of each reach. The restoration of each reach, individually, and in any combination with the other restoration reaches were considered as alternative plans. Coincidentally from the 16 project sites that were divided into four reaches, a total of 16 alternative plans were considered, including "no action".

The future watershed with project conditions (aquatic habitat scores) were then projected for each of the 16 alternative plans. The cost was also estimated for each of these plans. At this point, a detailed economic analysis was performed to evaluate the habitat unit outputs as compared to the price for each plan. This analysis eliminated inefficient and ineffective alternatives. It also identified which of the plans may be considered with Cobb County for the National Ecosystem Restoration (NER) Plan, in which the Corps may participate with a 35 percent cost share requirement from Cobb County, Georgia and the remaining 65 percent to be paid by the Corps. An incremental cost analysis is completed and then the successive outputs are compared to the incremental costs. That is, the results of the incremental costs are compared and then used as a decision-making tool by progressively proceeding through the available level of outputs and asking if the next level is "worth it" or "is the habitat value of the additional unit of environmental benefit in the next available level of output worth its additional monetary costs"?

After thorough scrutiny, four plans, including "no action" surfaced as potential NER Plans. The most comprehensive of these three plans was mutually selected for participation with Cobb County, thus becoming the "Recommended Plan". This plan included the

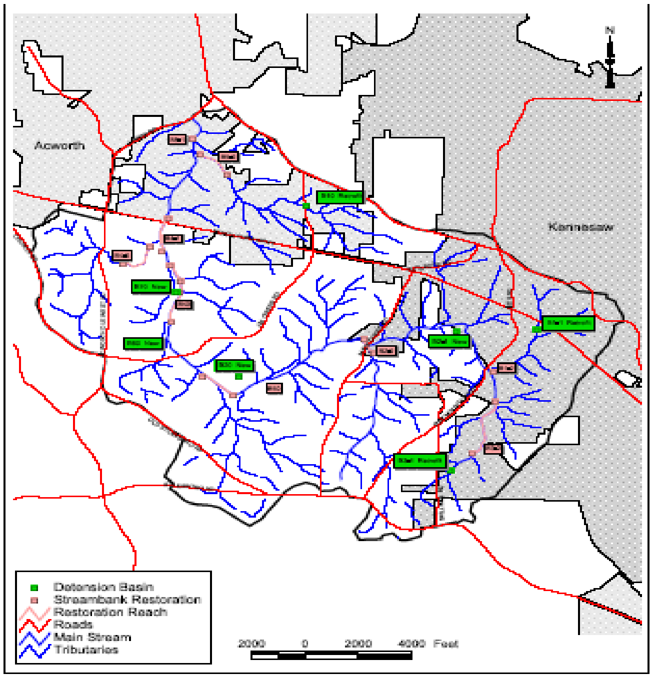


Figure 2. Butler Creek Proposed Projects

implementation of all measures at all 16 project sites identified for evaluation within the watershed and had a total project cost of approximately $5.5 Million to be cost shared 65%/35% with Cobb County.

RECOMMENDED PLAN

The Recommended Plan consists of implementing a wide variety of measures. Perhaps the most important of these are the seven (7) retention/detention sites, both retrofits of existing three structures and four new off-line sites along tributaries which do not support a base flow. Wetland creation is a planned feature at five (5) of these sites. In the final state, water will be captured from intermittent streams and some from the main stem of Butler Creek during high flow events and released over a twenty-four hour period excluding the minimum flow needed to support wetland vegetation. These measures accomplish multiple tasks, but primarily are designed to attenuate peak flows and capture sediment before it enters the main stem of Butler Creek.

In addition to retention/detention sites, a multitude of in-stream measures are planned. These include streambank protection by use of rootwads, where possible, in combination with longitudinal stone toe protection and riparian zone restoration. The flash effect from a two-inch rainfall event creates velocities throughout the watershed in excess of 4.5 feet per second (considered the channel forming velocity for the soils of this region). It is not feasible to use bioengineering, such as rootwads, without supplementing them with stone toe protection at the base of the stream bank. The combination of the root masses and the crevices between the stone toe protection provide excellent habitat for many fish species and the organisms on which they feed.

Debris dam removal, creation of channel benches, and the strategic placement of cross vanes and J-hooks complete the array of measures identified in the recommended plan for construction. This truly comprehensive approach to aquatic ecosystem restoration should prove very successful in the Butler Creek Basin.

PROJECT STATUS

Currently, all potential impacts to the Cherokee Darter, and its habitat, in the Butler Creek basin are being addressed through the formal consultation process with the USFWS as prescribed by Section 7 of the Endangered Species Act. The USFWS is partnering closely with the Mobile District to assure the best outcome to sustain and restore the habitat for the darter and other aquatic life. The recommended plan has also been presented to the USEPA, GADNR, and GAEPD to assure a truly collaborative and comprehensive effort is made to coordinate and accomplish the restoration goals. Once these peer reviews are complete and a final public workshop is held, the Ecosystem Restoration Report (ERR) can be completed, provided Federal funding becomes available.

CHALLENGES AHEAD

The Section 206 project authority of the Continuing Authorities Program, within which this project resides, is severely impaired nationwide by minimal funding. All of the projects funded nationwide have specific congressional language in recent Energy and Water Bills. Without congressional help, many of the aquatic ecosystem restoration projects already identified will sit dormant, perhaps for many years, as the conditions of the ecosystems degrade at an increasing rapid pace.

SELECTED REFERENCES

Entrix, 2002. Ecosystem Restoration Report, Problems Area Report, Butler, Proctor, Allatoona Creek Watersheds, Cobb County, Georgia

Freeman, B. J., University of Georgia Institute of Ecology, 2002. Fish Community Analysis of Butler Creek Watershed, Etowah River Basin, Cobb County, Georgia

Appendix C

Butler Creek Public Workshop -

8 September 2009

Butler Creek Ecosystem Restoration Project

Final Public Workshop

Where: Cobb County Training Facility, Cobb County Water System, Marietta, GA

When: 6 – 8 PM EDT, Tuesday, 8 September

Agenda: A presentation by US Army Corps of Engineers, Mobile District, of the results from the comprehensive watershed study of Butler Creek, from its headwaters in Kennesaw to its end at Lake Acworth in the City of Acworth. The public is invited to provide comments to complete the feasibility study process. Technical representatives from the Mobile District and Cobb County Water System will be available to answer any questions about the proposed projects and their purpose. Once this study is complete, this project will proposed for implementation as a cost-share project by the US Army Corps of Engineers (65%) and Cobb County Water System (35%). This is one of several creeks currently undergoing study for aquatic ecosystem restoration projects in the metro-Atlanta region by the US Army Corps of Engineers under the authority of Section 206 of Water Resources Development Act of 1996, as amended.

Butler Creek
Aquatic Ecosystem Restoration

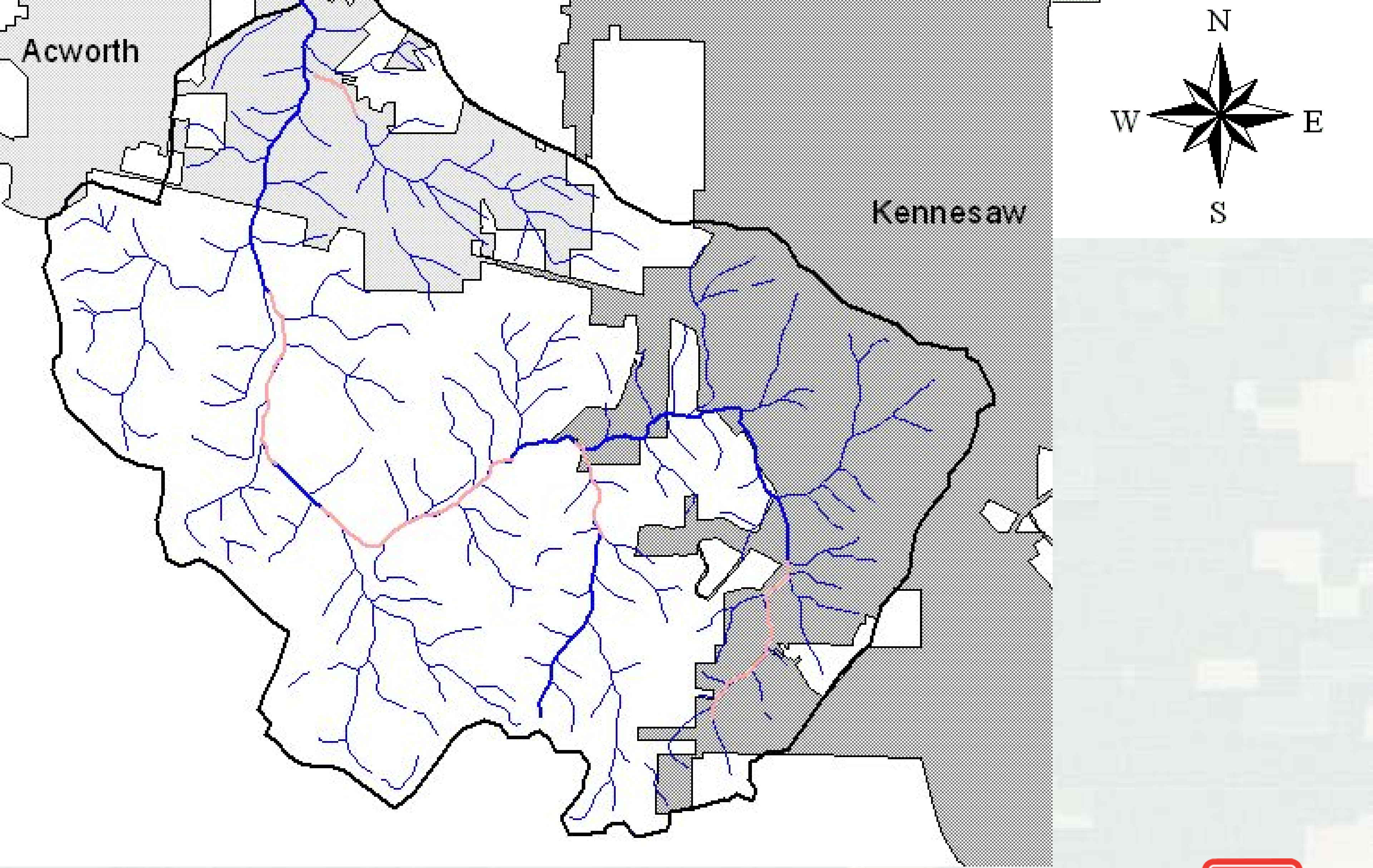
Sponsored by:
Cobb County Water System
and the US Army Corps of Engineers,
Mobile District

US Army Corps of Engineers
BUILDING STRONG®

PUB-12

Butler Creek Facts

- Headwaters in City of Kennesaw
- Watershed > 6,000 Acres
- Flows into Lake Acworth in City of Acworth
- Part of the Lake Allatoona/Etowah River basin
- Home of the Cherokee Darter



Butler Creek Watershed

Butler Creek Project Goal

Comprehensively restore the Butler Creek Basin to improve the habitat for various aquatic species of fish and organisms which have been significantly impacted by urbanization of past decades

Project Objectives

- Sustainable aquatic habitat restoration
- Reduction of “flashy” stream flows from normal rainfall occurrences
- Streambank stabilization
- Stream buffer restoration

Cherokee Darter

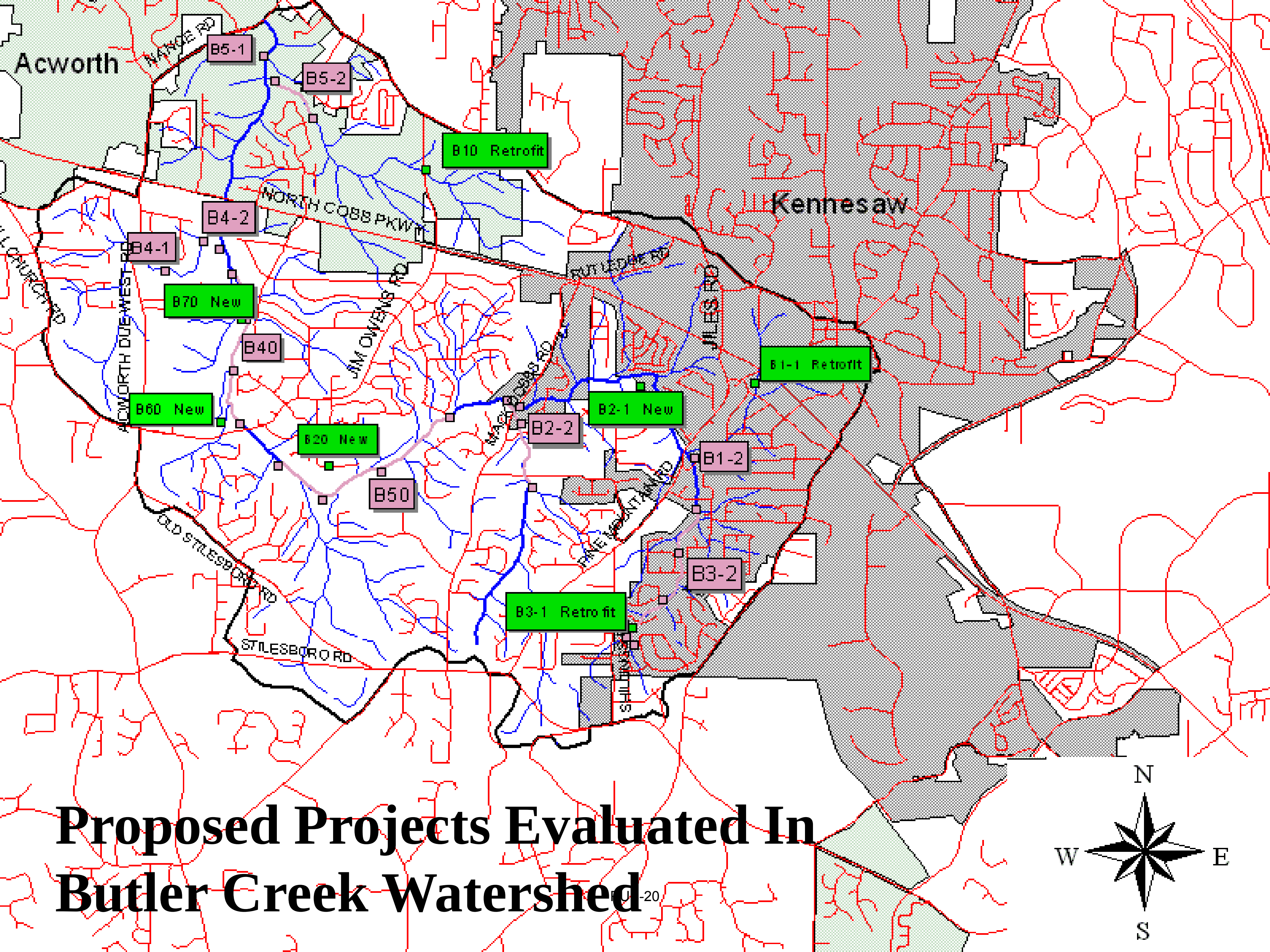
- Listed on the Federal Threatened and Endangered Species List
- Native to headwater streams of Etowah River system
- Heavily affected by land use changes resulting from urbanization of the region
- Biological Opinion Feb 07 - supports project as related to the Cherokee Darter

Planning Process

- Identify Goals and Objectives
- Evaluate Existing Data
- Acquire Additional Data as Necessary

Planning Process

- Determine significantly impacted sections of stream and the activity causing the impact
- Quantify current conditions and future conditions without intervention (model)
- Collaborate and coordinate with water resource agencies and stakeholders
- Develop sustainable restoration measures and alternatives to restore the stream



Proposed Projects Evaluated In Butler Creek Watershed

Alternative Evaluation

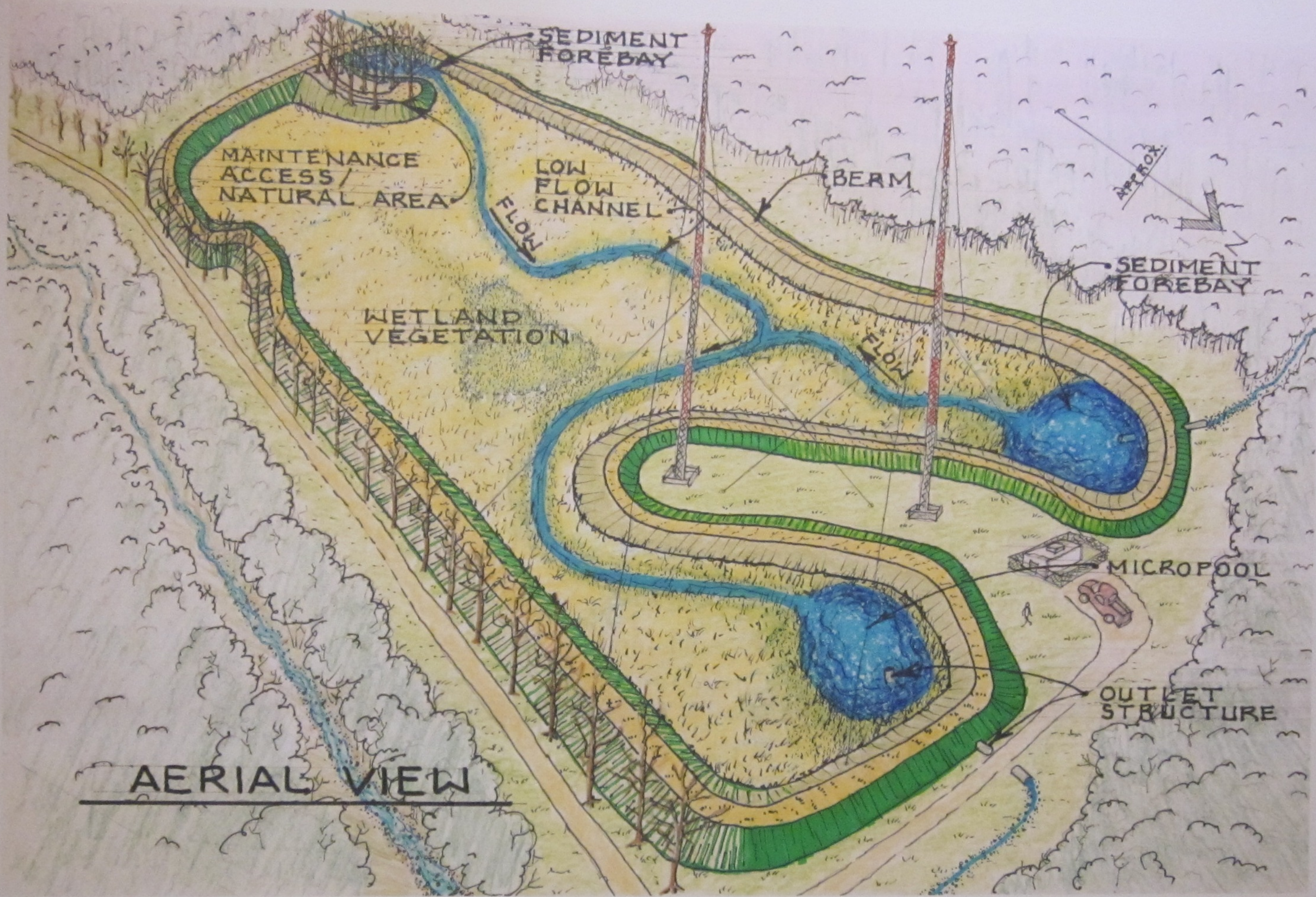
- Each alternative is evaluated for it's ability to restore aquatic habitat over time
- Cost estimates are developed for each effective alternative from conceptual designs
- An economic analysis is conducted to determine the most cost effective plan(s) to meet project objectives

Measures Proposed in the Recommended Plan

- Multi-purpose created wetlands and extended detention basins to reduce extreme peak flow which frequently harm the stream
- J-hooks, root wads, cross vanes, and stone-toe protection as needed to stabilize streambanks and streambeds
- Bank shaping and revegetation to reduce peak stream flow velocities

Completing the Process

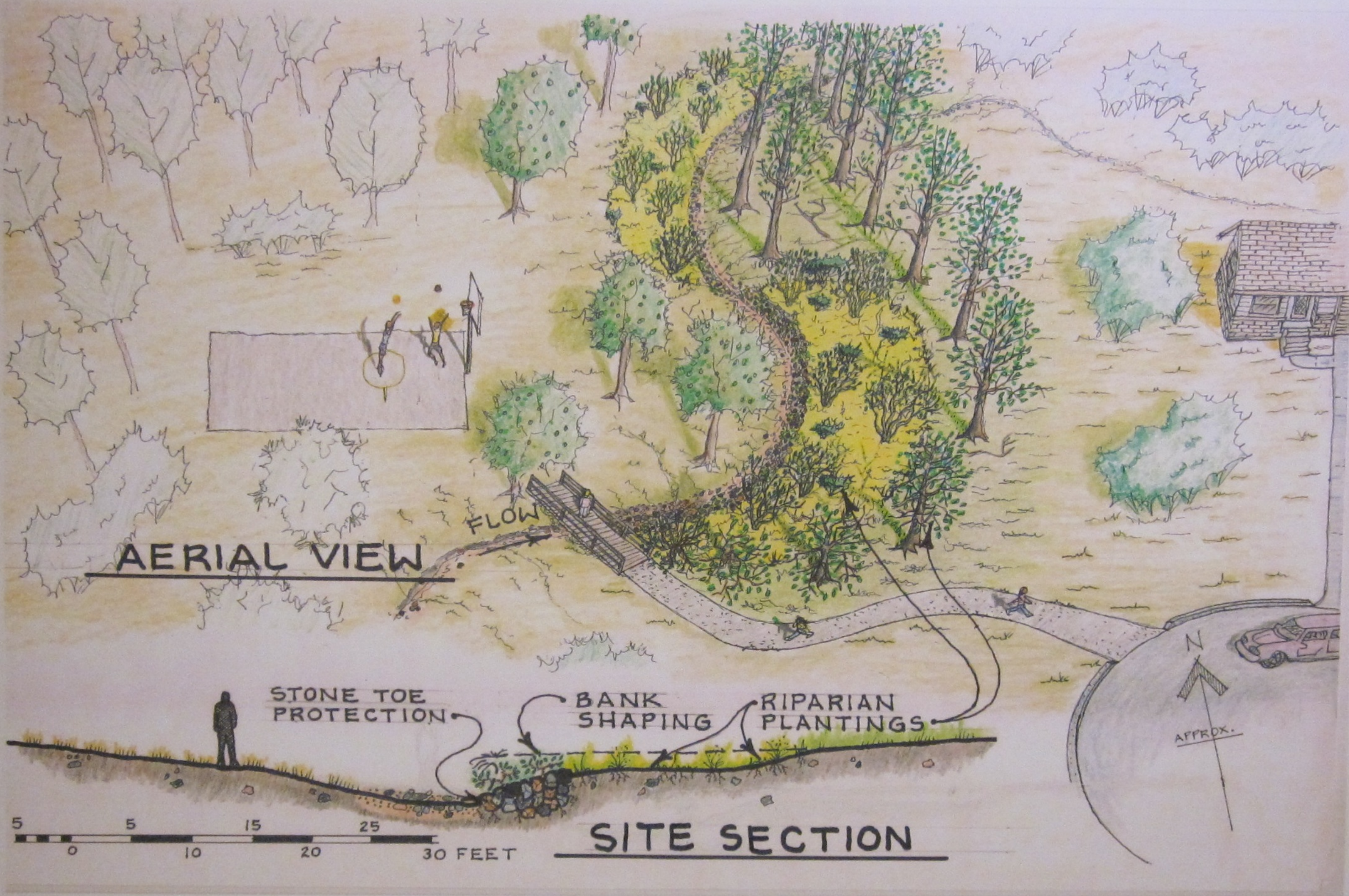
- Complete the environmental assessment and feasibility report, obtaining approval and funding to prepare detailed construction plans and specifications
- Prepare and sign Project Partnering Agreement with Cobb County Water System
- Construct the selected plan, cost shared at 65% Federal / 35% Cobb County



PEAK FLOW ATTENUATION

SITE B70 (ED STORMWATER WETLAND PLAN) FIGURE NO. C-13

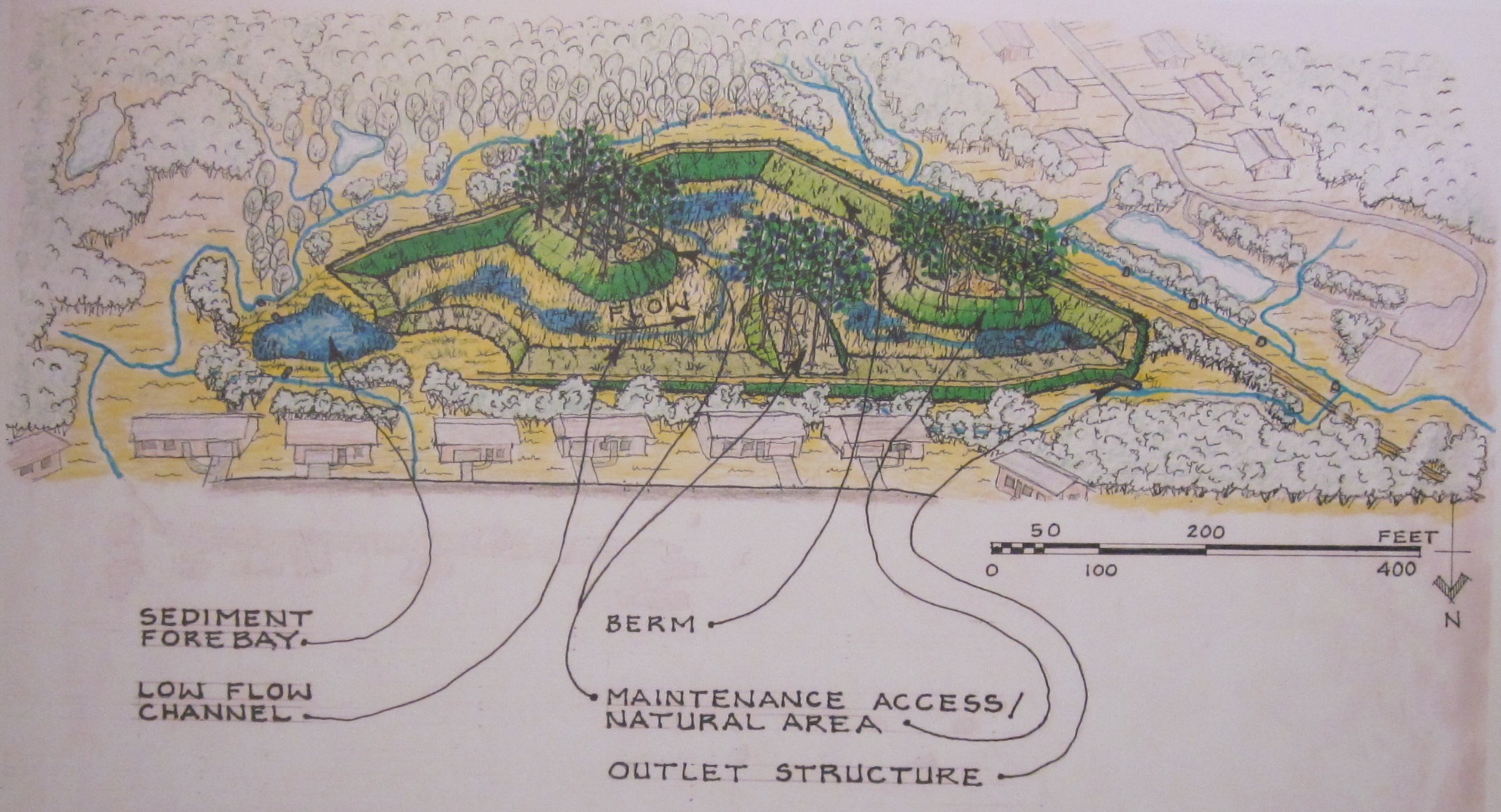
BUTLER CREEK, COBB COUNTY, GEORGIA.................................SECTION 206 ECOSYSTEM RESTORATION



BANK SHAPING and RIPARIAN RESTORATION

SITE B3-2 (STREAMBANK STABILIZATION PLAN) FIGURE NO. C-3

BUTLER CREEK, COBB COUNTY, GEORGIA..................................SECTION 206 ECOSYSTEM RESTORATION



AERIAL VIEW

PEAK FLOW ATTENUATION

SITE B20 (ED STORMWATER WETLAND PLAN) FIGURE NO. C-9

BUTLER CREEK, COBB COUNTY, GEORGIA................................SECTION 206 ECOSYSTEM RESTORATION

Appendix E
Engineering Appendix

APPENDIX E - ENGINEERING APPENDIX

BUTLER CREEK SECTION 206
ECOSYSTEM RESTORATION REPORT

SECTION I - HYDROLOGIC AND HYDRAULIC ANALYSES

1.0 GENERAL

The purpose of this appendix is to present the methodology used in the hydrologic and hydraulic analyses to support the Butler Creek Section 206 Ecosystem Restoration study. The appendix also includes the Hazardous, Toxic and Radioactive Waste results. The Butler Creek watershed is highly developed and urbanized. Hydrologic changes in the watershed due to urbanization have resulted in changed channel morphology (ENTRIX 2002) and a degraded ecosystem. The hydrologic and hydraulic analyses include existing conditions, future-without project conditions, and future-with project conditions.

The Butler Creek watershed is a portion of the Cobb County Priority Area 2 watershed. Parsons Engineering and Science, Inc. (Parsons) prepared a comprehensive Cobb County Priority Area 2 Basinwide Stormwater Capital Improvement Study for the Cobb County Water System, Stormwater Management Division (Parsons 1999). The study was used as the baseline for the development of the hydrologic and hydraulic models used for the Aquatic Ecosystem Restoration Section 206 study.

Butler Creek, located in northwest Georgia, is a tributary to Lake Acworth, a sub-impoundment of Lake Allatoona and has a total drainage area of 9.4 square miles. Figure EI-1 is a graphic showing the percentages of the Butler Creek watershed lying within the county and those portions lying within the cities of Acworth and Kennesaw. The headwaters of the Butler Creek watershed begin in the southwestern portion of the City of Kennesaw and discharge into Lake Acworth. A portion of the basin is also located within the City of Acworth. Figure EI-2 shows the watershed location.

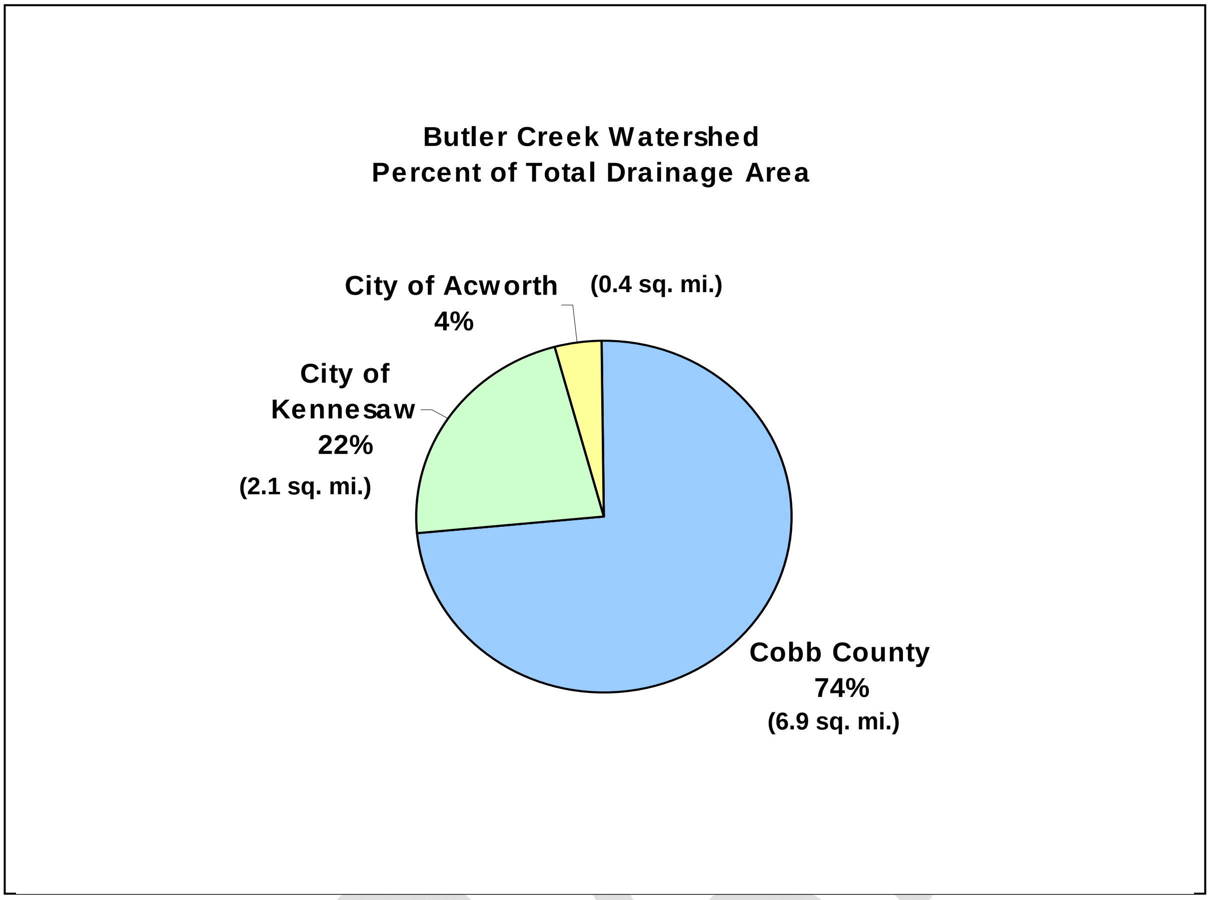

Butler Creek Watershed
Percent of Total Drainage Area
City of Acworth
4%
(0.4 sq. mi.)
City of
Kennesaw
22%
(2.1 sq. mi.)
Cobb County
74%
(6.9 sq. mi.)

Figure EI-1

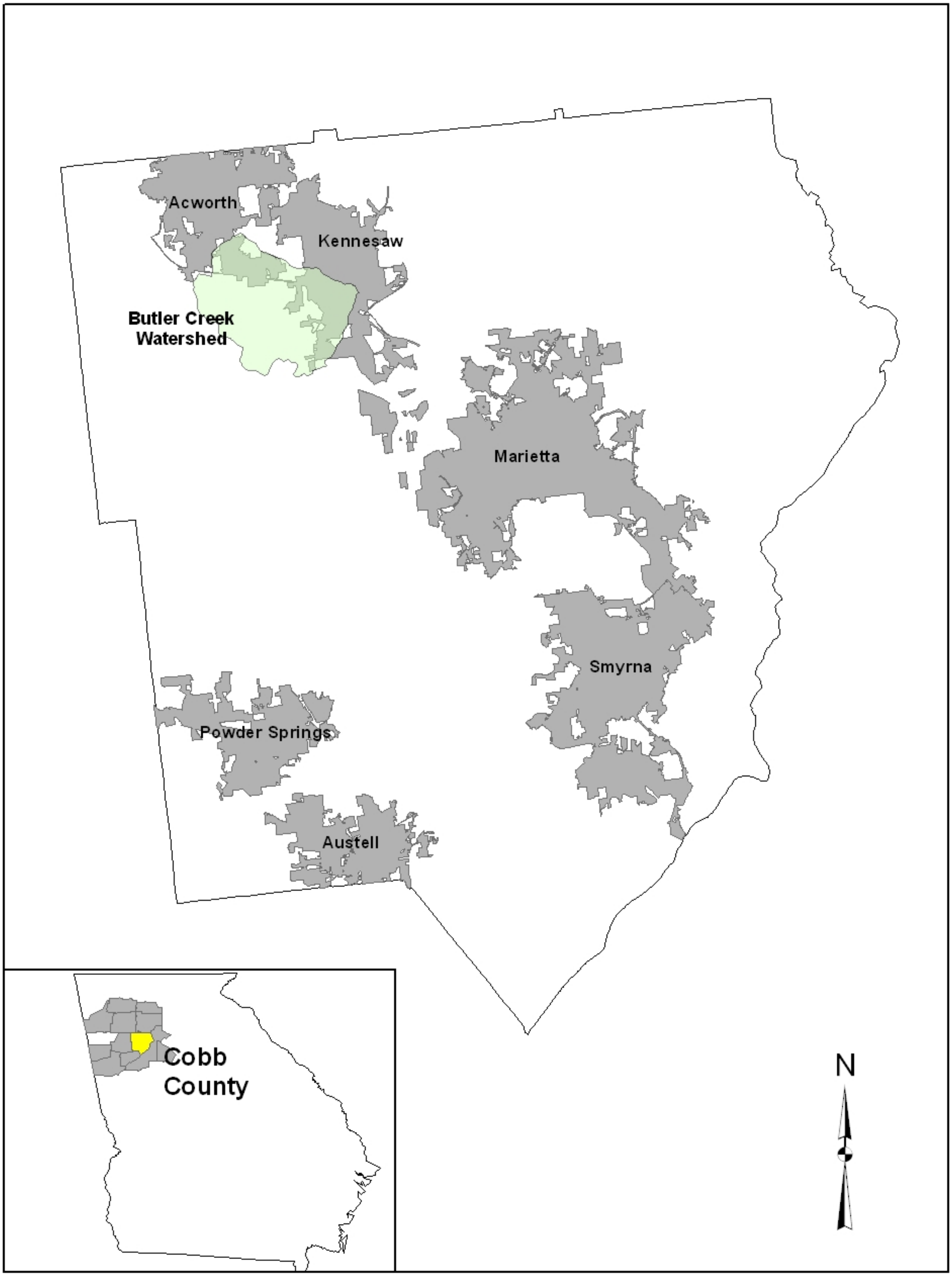


FIGURE EI-2 Butler Creek Location Map

2.0 CLIMATE AND PRECIPITATION

Cobb County, located in the Metro Atlanta region, is situated in the foothills of the Southern Appalachians in north central Georgia. The terrain slopes downward toward the east, west, and south. Drainage of the major river systems is generally into the Gulf of Mexico for the western and northern sections of the county and to the Atlantic Ocean from the east.

Metro Atlanta has a temperate southern climate with distinct changes of seasons. Summers are hot, but generally lack the high humidity of the Coastal Southeast. Winters are relatively mild, but occasional cold outbreaks do occur. Several storms consisting of light snow or wintry precipitation usually occur each winter. Rainfall is fairly well distributed throughout the year, although a well-marked dry period occurs in the fall months of September, October and November. By contrast, December through March is generally wet. There is also a maximum of local thunderstorms in July.

Average annual precipitation is about 50 inches a year. The wettest year on record was 1948, with 71.45 inches of rainfall. The driest year occurred in 1904, with only 33.13 inches. Maximum 24-hour rainfall ever recorded was 7.36 inches on March 29, 1886. The Rainfall Frequency Atlas of the United States, TP-40 (1961) provided the synthetic rainfall used to compute the discharge frequencies presented in Table E-I-1.

TABLE E-I-1
SYNTHETIC MASS RAINFALL CURVES
Storm Event Return Frequency

Duration	2 Yr	5 Yr	10 Yr	25 Yr	50 Yr	100 Yr	500 Yr
Hours	Inches Total	Inches Total	Inches Total	Inches Total	Inches Total	Inches Total	Inches Total
1-Hr	1.8	2.25	2.6	2.9	3.2	3.5	4.6
2-Hr	2.2	2.7	3.2	3.6	3.8	4.35	5.7
3-Hr	2.4	3.0	3.4	3.8	4.25	4.8	6.3
6-Hr	2.75	3.7	4.2	4.6	5.4	5.65	7.5
12-Hr	3.4	4.3	4.8	5.8	6.5	6.8	8.99
24-Hr	3.7	4.8	5.7	6.6	7.5	7.8	10.3
2 Day	4.5	5.5	6.5	7.5	8.6	9.0	11.9

3.0 HYDROLOGIC ANALYSIS

3.1 Hydrologic Model Development

A hydrologic model is a mathematical representation of the physical response of a watershed to precipitation. Models are widely used to predict the response of a watershed under conditions other than those experienced historically or in cases where no historic monitoring data exist.

The hydrologic study for Butler Creek was conducted to determine the relative frequency of certain recurrence interval stream flows corresponding to existing and future conditions. The major difference in the existing and future condition models is the change in land use and the corresponding change in runoff lag times. The hydrologic study was also performed to investigate the effectiveness of proposed measures to reduce the future condition flows within the watershed. The following sections discuss how the hydrologic model and associated parameters were developed and applied for the Butler Creek watershed.

3.1.1 Preliminary Models

Parsons supplied the Butler Creek watershed U.S. Army Corps of Engineers, (USACE) Hydrologic Engineering Center (HEC) HEC-1 models that were developed as part of the Priority Area 2 study. The principle component of rainfall runoff models is the conversion of rainfall to runoff. To represent the conversion of rainfall to runoff in the Butler Creek watershed, Parsons used the Natural Resource and Conservation Service's (NRCS) unit hydrograph method. To represent losses due to soil characteristics, the NRCS curve number and loss methodologies presented in the Technical Release 55 (TR-55) (NRCS 1986) were implemented. The NRCS curve number is primarily developed based on land cover and soil type.

Hydrologic routing represents the movement of a rainfall-runoff event through conveyances. The HEC-1 models prepared by Parsons for the Butler Creek watershed employed the Muskingum-Cunge routing method to route hydrographs within reaches. Section 2.1 of the Priority Area 2 report describes the development of the basin models.

3.1.2 Model Calibration

The Priority Area 2 report outlines the development of peak discharges using the USGS regression equations published in the Flood-Frequency Relations for Urban Streams in Georgia – 1994 Update (WRI Report 95-4017). The regression equation peak discharges were used for comparison with the results of the HEC-1 model. It was concluded that no changes in the HEC-1 peak discharges were necessary.

3.1.3 Hydrologic Modeling System

The USACE Hydrologic Modeling System (HEC-HMS) was selected to model the Butler Creek watershed for the Section 206 study. The existing conditions HEC-1 model input files were imported into the HEC-HMS model. The reservoir parameter data from the existing HEC-1 model was input into the HEC-HMS model. The HEC-HMS model used the same NRCS procedures as the HEC-1 models. The HEC-HMS base models were calibrated to the peak discharges of the original HEC-1 existing condition models. The discharges computed with the models matched those from the Priority Area 2 report reasonably well.

The future without project conditions HEC-HMS model was developed by modifying the existing conditions model to reflect anticipated future land use. The HEC-HMS models were updated using the most recent future land use data provided by Cobb County, the City of Acworth and the City of Kennesaw. The future land use data contained more impervious area than the existing land use, which resulted in higher runoff volumes and higher peak flows than the existing conditions model.

The future with project conditions HEC-HMS model was developed by modifying the future without project model. The SCS Curve Numbers, Percent impervious cover, and lag times were adjusted based on anticipated 2030 landuse obtained from the Atlanta Regional Commission. The future with project consists of seven separate detention basins, four of which are newly created and three are retrofits of existing outlet structures. To evaluate the independent effects of each of these basins, seven separate basin models were created in HEC-HMS. These basins models were copies of the future without project basin model with one of the proposed detention basins included in each of the seven basin models. Each detention basin was added as a reservoir component in HEC-HMS with appropriate elevation-storage and storage-discharge functions assigned. This method of modeling each detention basin separately allowed for the evaluation of the change in flow caused by each basin.

This entire process resulted in 10 basin models in HEC-HMS: Existing Conditions, Future without Project, Future with B10, Future with B1-1, Future with B20, Future with B2-1, Future with B3-1, Future with B60, Future with B70, and the Tentatively Selected Plan (Alternative 8). A schematic of the HMS project representing Alternative 8 is shown in Figures E-1-3 and E-1-4.

3.1.4 Land Use, Soils Data and Runoff Curve Numbers

The methodology used in the HEC-HMS model to convert rainfall to runoff followed the same procedures as outlined in the Priority Area 2 report. The main components of the NRCS curve number method are land cover and soil type. The permeability of various soil types is combined with the runoff generation potential of certain land covers to formulate a curve number. Tables presented in TR-55 provide curve numbers for typical land cover and soil class combinations.

The HEC-HMS models were updated using the most recent existing and future land use data provided by Cobb County, the City of Acworth and the City of Kennesaw. The land use classifications for each were converted to the NRCS land use descriptions provided in TR-55. Figures E-I-5 and E-I-6 depict the existing and future land use conditions for the Butler Creek watershed. The soils data for the Butler Creek watershed were taken from the Priority Area 2 report. The Hydrologic Soil Group B comprises over 90 percent of the drainage basin. Figure E-I-7 shows the Hydrologic Soil Group map for the Butler Creek watershed.

Geospatial Information System (GIS) layering of the soils and land use data was used to determine the curve number for each subbasin in the study area. A polygon was used for each unique combination of land use and hydrologic soil group, and a curve number was assigned to each polygon. Average curve numbers for each subbasin were developed using area weighting of the curve numbers for each polygon. The area-weighted curve numbers were used in the HEC-HMS model as the basis for the rainfall to runoff conversion. Subbasin delineations are shown in Figure E-I-8.

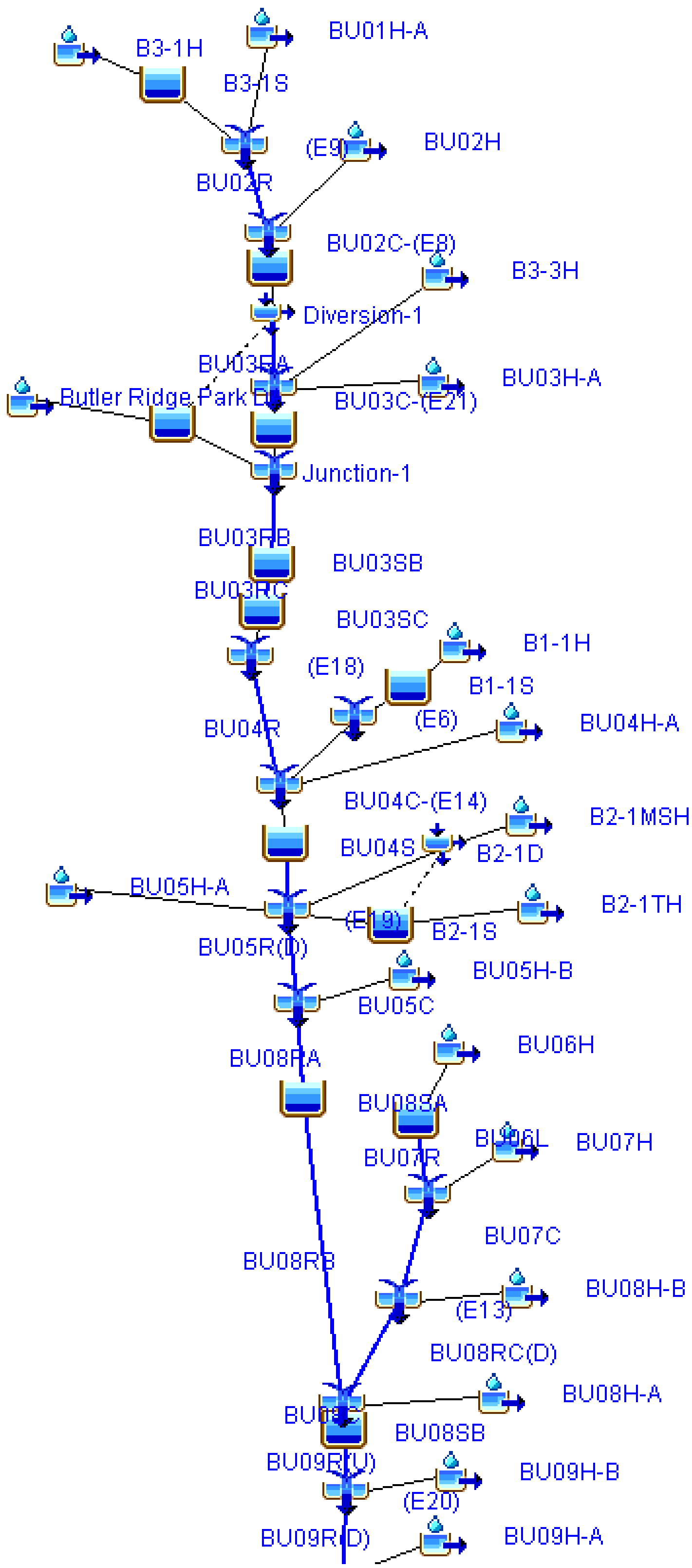


Figure E-1-3 HEC-HMS Schematic (1 of 2)

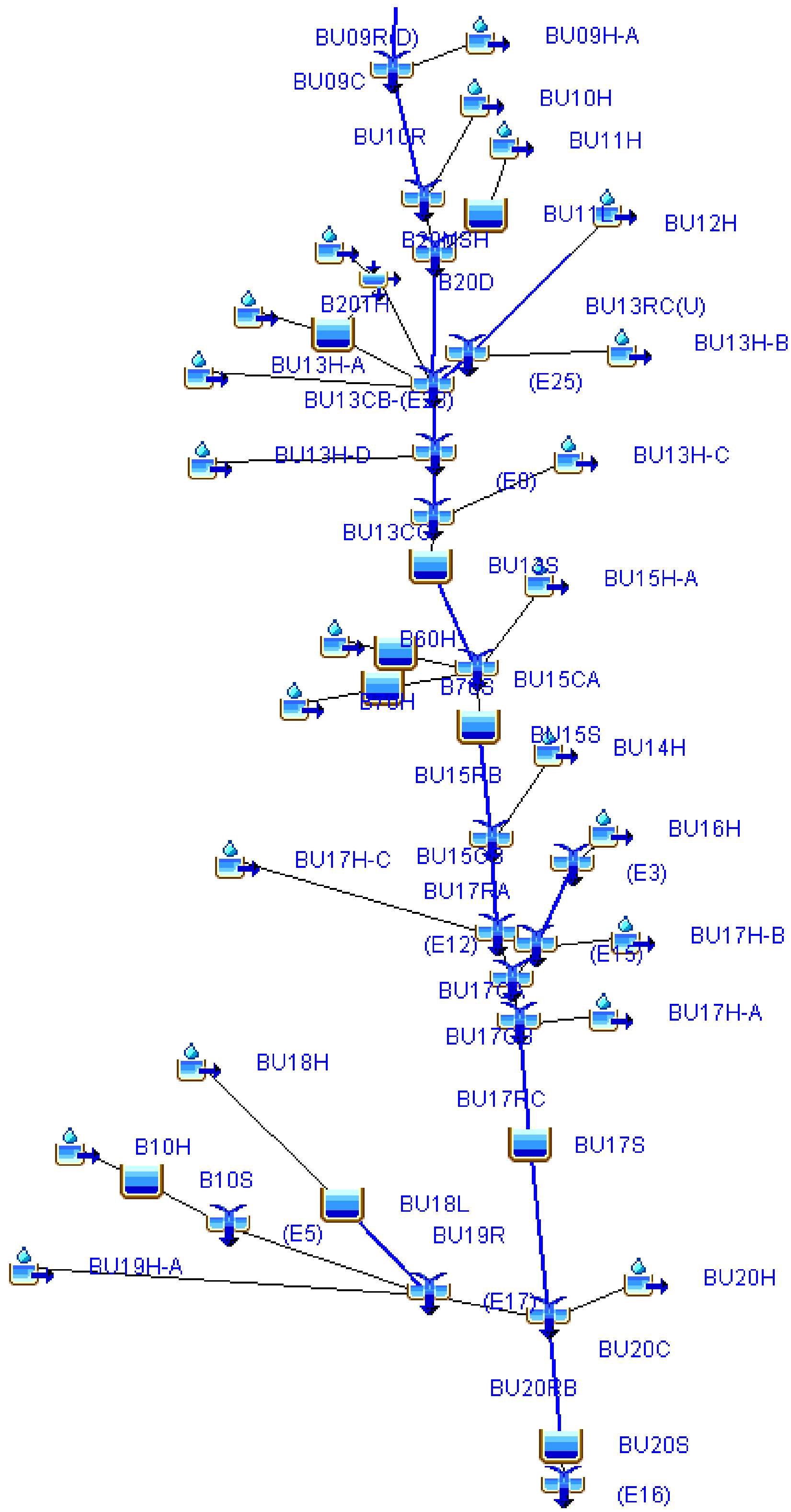


Figure E-1-4 HEC-HMS Schematic (2 of 2)

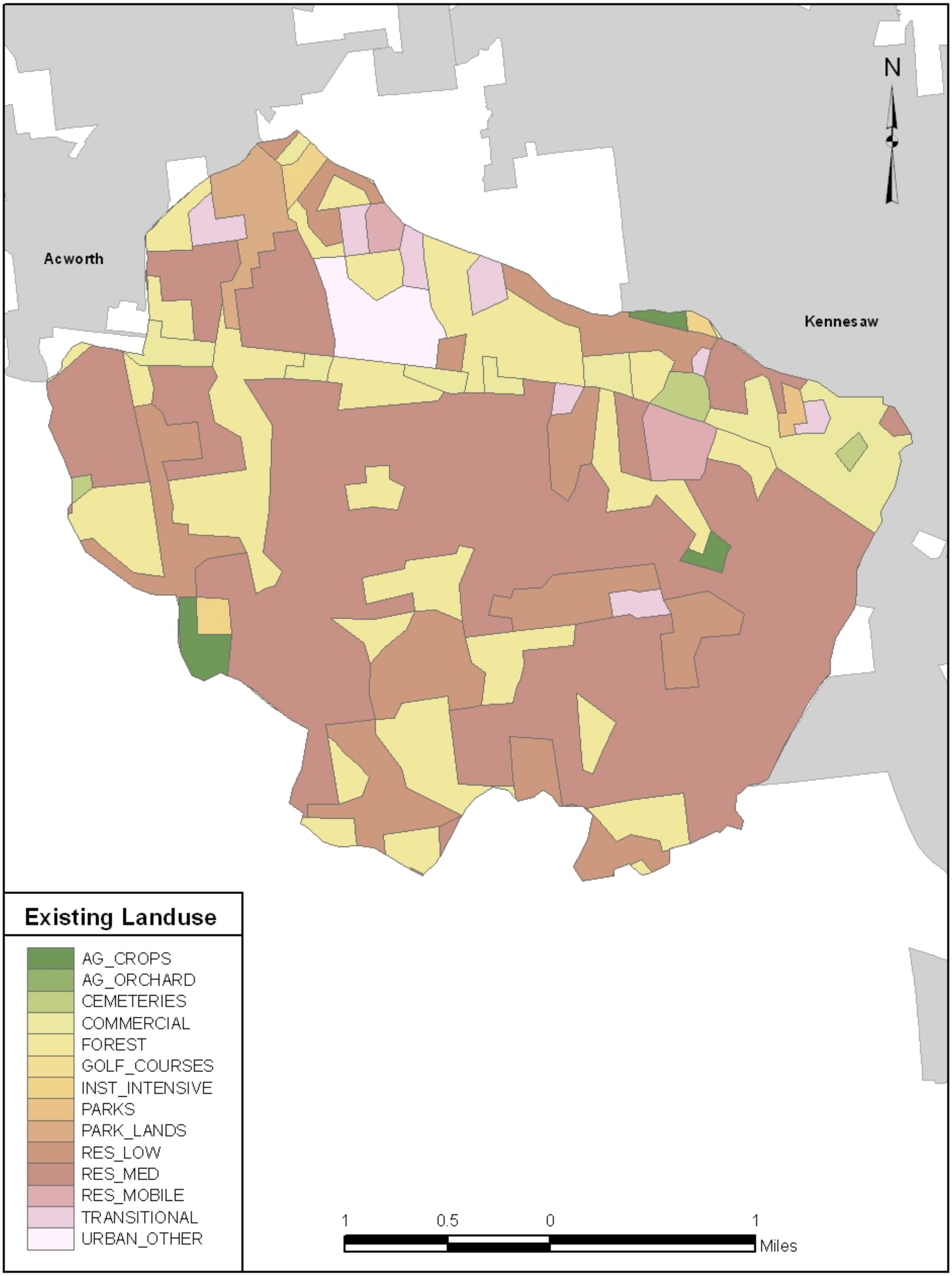


Figure E-I-5 Existing Land Use Map

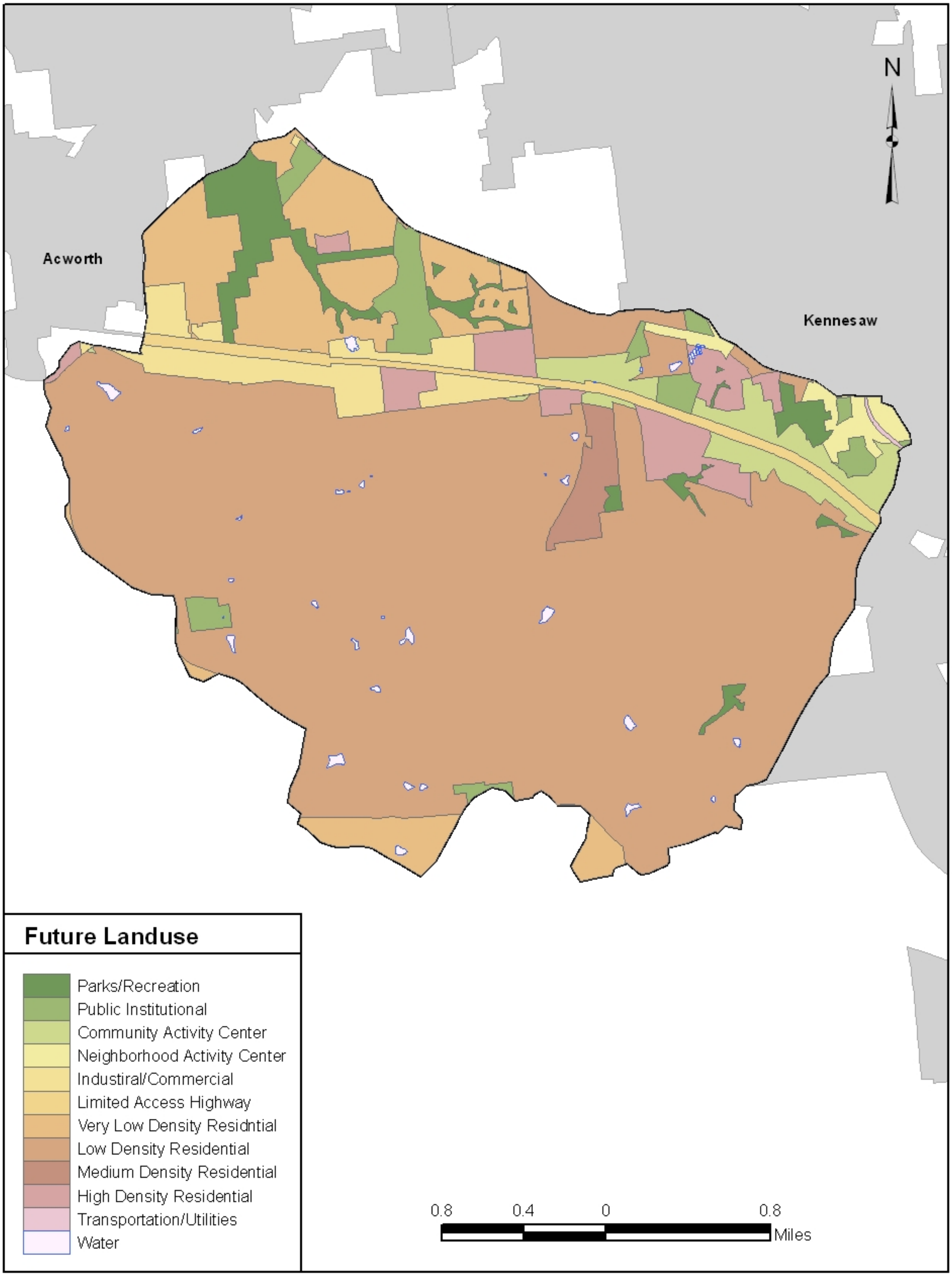


Figure E-I-6   Future Land Use Map

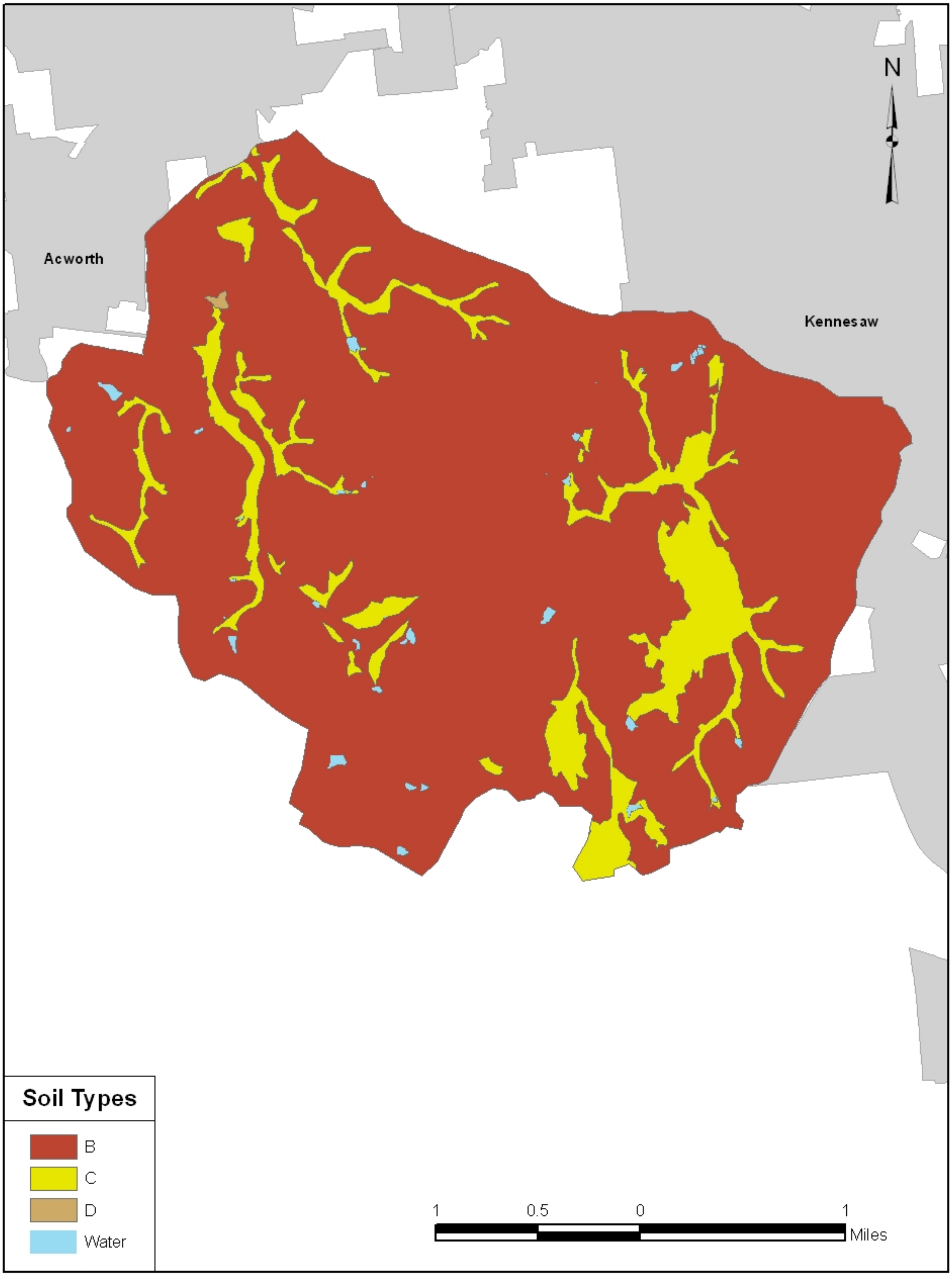


FIGURE E-I-7 Hydrologic Soils Group Map

Figure E-I-8 Watershed Subbasins

3.2 Frequency Results

Synthetic frequency rainfalls were then applied to the HEC-HMS existing and future condition basin models. The future without project conditions model serves as a baseline from which the benefits of potential project measures can be evaluated. The HEC-HMS model serves as a useful tool for assessing relative changes in the hydrology between existing and future land use conditions. The resulting peak discharges highlight the influence of increases in impervious areas. Tables E-I-2 (Existing Conditions), E-I-3 (Future Without Project Conditions) and E-I-4 (Future With Project Conditions) present the HEC-HMS discharges for the 2-, 5-, 10-, 25-, 50-, 100-, and 500-year recurrence intervals. The with-project conditions reflect the tentatively selected plan, Alternative 8 discussed in the main report. The discharges for each condition were used to size the outlet works and volume of project measures to reduce the flows in Butler Creek. The project measures were incorporated into the future conditions model. The updated features included reservoir parameter data and diversion elements for the detention measures. The project measures are described in Section III of this Appendix.

TABLE E-I-2
EXISTING CONDITIONS PEAK DISCHARGES

HMS	ENTRIX	Peak Discharge for Return Period						
Element	Subbasin ID	2	5	10	25	50	100	500
(E9)	9	146.05	233.61	294.23	366.17	424.55	474.09	573.16
BU02C-(E8)	8	298.48	482.68	610.6	757.44	876.84	981.1	1191.1
BU03C-(E21)	21	545.91	889.51	1130.3	1395.4	1604	1790.4	2165.7
(E18)	18	541.58	879.91	1116.2	1375.6	1579.3	1764.5	2139.6
(E6)	6	218.95	310.14	372.66	448.16	503.41	555.78	636.87
BU04C-(E14)	14	1082.6	1661.9	2059.9	2487.9	2803.4	3113.7	3731.8
(E19)	19	1121.9	1757.2	2245.7	2744.6	3112	3481.1	4205.4
(E13)	13	396.21	700.43	919.45	1158.8	1358.6	1547	1947.2
(E20)	20	1493.2	2337.9	2878	3453.8	3927.9	4421.7	5860.7
BU13CB-(E23)	23	1605.9	2657.1	3419.7	4214.1	4850.3	5496.5	6865.8
(E25)	25	294.32	556.39	747.89	960.17	1139.9	1297.3	1647.3
(E0)	0	1605.2	2641.1	3406.4	4204.5	4835.5	5486.5	6868.4
(E12)	12	1560.7	2625.3	3384.2	4191.6	4901	5588.6	7160.9
(E3)	3	174.24	344.72	472.99	617.63	740.7	847.45	1091.3
(E15)	15	204.67	401.43	553.31	715.62	841.91	961.06	1222.9
(E5)	5	229.4	396.2	514.42	652.38	766.44	862.98	1065.6
(E17)	17	704.4	1110.9	1396.8	1717.3	1979.7	2220.4	2702.4
(E16)	16	1649.3	2752.3	3559.9	4335.1	5180	5788.1	7451.6

HMS	BMP	Peak Discharge for Return Period						
Element	Site ID	2	5	10	25	50	100	500
B10H	B10	229.4	396.2	514.42	652.38	766.44	862.98	1065.6
B20TH	B20T	39.732	67.497	87.515	111.92	129.88	146.17	173.6
B20MSH	B20MS	5.978	10.025	12.942	16.501	19.028	21.41	25.099
B3-1H	B3-1	116.23	185.56	233.72	290.9	336.67	376.14	452.84
B1-1H	B1-1	218.95	310.14	372.66	448.16	503.41	555.78	636.87
B3-3H	B3-3	97.079	150.91	188.13	232.8	265.42	295.41	343.77
B2-1TH	B2-1T	26.24	41.978	53.231	66.937	76.53	85.734	99.412
B2-1MSH	B2-1MS	196.65	313.55	393.87	489.53	562.99	627.41	742.95
B70H	B70	39.332	94.58	136.2	186.99	227.69	261.08	331.13
B60H	B60	224.39	361.08	456.11	567.03	656.74	734.34	888.05

HMS	Priority Area 2	Peak Discharge for Return Period						
Element	Model ID	2	5	10	25	50	100	500
BU01H-A	BU01H-A	53.126	82.807	103.76	129.38	148.19	165.51	193.73
BU02C-(E8)	BU02C	298.48	482.68	610.6	757.44	876.84	981.1	1191.1
BU02H	BU02H	158.91	259.77	330	410.49	476.3	533.92	650.56
BU02R	BU02R	145.38	232.98	293.66	365.37	423.32	472.68	571.77
BU02S	BU02S	295.54	478.89	606.55	755.25	874.92	979.04	1188.6
BU03C-(E21)	BU03C	545.91	889.51	1130.3	1395.4	1604	1790.4	2165.7
BU03H-A	BU03H-A	225.87	368.15	466.93	578.07	669.31	750.27	913.54

TABLE E-I-2
EXISTING CONDITIONS PEAK DISCHARGES

HMS Element	Priority Area 2 Model ID	Peak Discharge for Return Period						
		2	5	10	25	50	100	500
BU03RA	BU03RA	294.12	475.84	603.11	747.79	863.47	963.88	1166.2
BU03RB	BU03RB	544.68	885.58	1124.2	1387.3	1597.8	1782.6	2156.5
BU03RC	BU03RC	541.52	879.89	1116.1	1375.3	1579.2	1764.6	2139.9
BU03SA	BU03SA	545.22	886.51	1127.1	1391.7	1603.3	1788.2	2164.6
BU03SB	BU03SB	543.35	882.12	1119.6	1385.5	1596.1	1779.7	2154.1
BU03SC	BU03SC	541.58	879.91	1116.2	1375.6	1579.3	1764.5	2139.6
BU04C-(E14)	BU04C	1082.6	1661.9	2059.9	2487.9	2803.4	3113.7	3731.8
BU04H-A	BU04H-A	506.27	728.72	877.4	1041.6	1172.5	1298.5	1523.4
BU04R	BU04R	539.6	876.44	1111.4	1371	1574	1757.6	2131.6
BU04S	BU04S	1078.4	1657.7	2058.8	2486.2	2801.2	3116.1	3731.6
BU05C	BU05C	1147.8	1838.2	2361.8	2911.3	3328.8	3765	4607.4
BU05H-A	BU05H-A	354.52	533.57	655.29	796.36	908.77	1009.2	1196.1
BU05H-B	BU05H-B	327.18	529.07	669.45	830.03	961.35	1076.8	1309.2
BU05R(D)	BU05R(D)	1039.8	1648.2	2086.6	2553.4	2905.1	3269.5	3951.6
BU05R(U)	BU05R(U)	979.38	1529.3	1915.4	2327.9	2644.5	2943.5	3528.9
BU06H	BU06H	33.129	57.021	73.937	93.901	110.28	124.1	152.94
BU06L	BU06L	1.9099	3.7905	5.8729	16.869	26.32	34.771	57.248
BU07C	BU07C	382.32	674.61	882.98	1112.2	1311	1492	1880.1
BU07H	BU07H	381.31	672.48	879.85	1107.9	1297.9	1468.1	1829.1
BU07R	BU07R	1.9099	3.7904	5.8727	16.865	26.31	34.761	57.22
BU08C	BU08C	1574.7	2459	3018.6	3611	4105.9	4608.9	6094.9
BU08H-A	BU08H-A	218.05	365.66	469.31	586.78	683.92	768.92	944.58
BU08H-B	BU08H-B	77.922	135.06	176.12	225.99	264.47	297.8	360.13
BU08RA	BU08RA	1145.6	1827	2344.4	2893.3	3309.2	3745.7	4583.3
BU08RB	BU08RB	1138	1760.5	2150.2	2578.1	2903.5	3345.9	4299.5
BU08RC(D)	BU08RC(D)	394.76	698.62	914.43	1151.2	1349.3	1535.7	1931.2
BU08RC(U)	BU08RC(U)	381.29	672.94	880.8	1109.8	1306.4	1486.2	1872.5
BU08SA	BU08SA	1140.2	1763.7	2157.4	2595.9	2933.8	3424.7	4423.3
BU08SB	BU08SB	1574.5	2458	3017.2	3609.6	4103.7	4608.1	6091.5
BU09C	BU09C	1372.6	2175	2704.8	3262.2	3736.3	4198.8	5521.5
BU09H-A	BU09H-A	195.73	324.7	415.36	516.44	599.87	674.75	828.72
BU09H-B	BU09H-B	66.452	104.83	132.06	165.17	189.69	211.99	249.38
BU09R(D)	BU09R(D)	1238.5	1953.7	2438.1	2983.2	3381.1	3880.8	5126
BU09R(U)	BU09R(U)	1484.5	2325.2	2859.9	3431.7	3906.7	4397.3	5837.1
BU10C	BU10C	1467.1	2361	2960.5	3582.5	4098.1	4615.2	5889.2
BU10H	BU10H	192.67	353.39	470.39	602.43	713.86	810.48	1022.9
BU10R	BU10R	1361.3	2163.4	2693	3253.6	3718.2	4189.5	5480.7
BU11H	BU11H	40.196	73.692	97.919	126.46	150.14	169.86	212.54
BU11L	BU11L	16.993	35.886	56.178	85.382	108.86	127.58	168.73
BU12H	BU12H	276.55	524.36	706.08	910.5	1083.6	1233.3	1566.6
BU13CA	BU13CA	1482.9	2393.7	3004.1	3637	4162	4688.4	5951.6
BU13CB-(E23)	BU13CB	1605.9	2657.1	3419.7	4214.1	4850.3	5496.5	6865.8

TABLE E-I-2
EXISTING CONDITIONS PEAK DISCHARGES

HMS Element	Priority Area 2 Model ID	Peak Discharge for Return Period 2	5	10	25	50	100	500
BU13CC	BU13CC	1635.1	2661.1	3434.9	4260.1	4891.6	5564.5	6988.9
BU13H-A	BU13H-A	45.266	83.731	111.39	144.93	170.44	192.61	233.24
BU13H-B	BU13H-B	85.078	136.26	172.43	216.24	249.38	278.87	330.62
BU13H-C	BU13H-C	188.04	304.86	386.35	479.93	556.26	622.97	757.1
BU13H-D	BU13H-D	56.656	93.492	119.75	152	175.82	197.31	233.77
BU13RB	BU13RB	1458.1	2358.7	2974.8	3611.3	4132.8	4657.3	5918.9
BU13RC(D)	BU13RC(D)	286.9	543.55	731.64	940.91	1118.3	1273.5	1620.7
BU13RC(U)	BU13RC(U)	276.11	523.59	705.3	909.18	1081.3	1230.7	1562.8
BU13RD(D)	BU13RD(D)	1602.5	2615.6	3369.6	4166.6	4793.1	5441.6	6843.4
BU13RD(U)	BU13RD(U)	1602.4	2633.9	3394.8	4187.5	4819.4	5465.9	6847.3
BU13S	BU13S	1635	2660.2	3433.5	4259.8	4890.6	5563.5	6988.3
BU14H	BU14H	219.18	367.23	471.33	588.11	684.76	770.47	947.77
BU15CA	BU15CA	1594.2	2640.2	3396.3	4210.3	4901.3	5584.7	7109.2
BU15CB	BU15CB	1597.5	2660.7	3418.9	4235.5	4958.7	5656.6	7232
BU15H-A	BU15H-A	164.06	284.16	369.17	470.13	552.11	620.97	762.59
BU15RA	BU15RA	1562.9	2570.3	3328.2	4140.5	4763.3	5430.7	6858.4
BU15RB	BU15RB	1576.1	2613.8	3368.5	4175.1	4856.8	5536.9	7058.6
BU15S	BU15S	1594.1	2640.1	3396.3	4210.2	4901.3	5584.8	7109.3
BU16H	BU16H	174.24	344.72	472.99	617.63	740.7	847.45	1091.3
BU17CA	BU17CA	1601.1	2714.6	3498.5	4342.6	5121.7	5846.3	7529.6
BU17CB	BU17CB	1614.8	2734.7	3526.1	4371.7	5160.5	5879.9	7585.5
BU17H-A	BU17H-A	204.83	299.02	363.08	439.6	498.21	551.27	642.17
BU17H-B	BU17H-B	143.89	240.23	308.73	390.44	455.83	511.34	621.56
BU17H-C	BU17H-C	70.736	123.23	160.59	205.73	239.69	269.63	322.71
BU17RA	BU17RA	1555.9	2617.5	3372.2	4178.2	4884.3	5574.7	7140
BU17RB	BU17RB	173.31	342.76	470.4	613.54	734.17	838.9	1079
BU17RC	BU17RC	1613.1	2730.6	3517.2	4355.8	5136.9	5851.2	7546.4
BU17S	BU17S	1612.6	2730.1	3508.6	4343.7	5076.7	5739.8	7324.3
BU18H	BU18H	78.629	150.23	202.52	262.07	312.24	355.2	450.8
BU18L	BU18L	49.59	95.994	154.29	219.93	271.31	314.33	415.01
BU19H-A	BU19H-A	503.23	755.49	926.45	1114.1	1265.3	1408.8	1677.3
BU19R	BU19R	49.454	95.708	152.66	217.63	269.07	311.07	409.29
BU20C	BU20C	1662.1	2802.9	3624.8	4419.4	5282.2	5894.7	7593.5
BU20H	BU20H	138.9	296.56	418.92	557.07	674.97	777.17	1016.5
BU20RA	BU20RA	1537.6	2606.1	3364	4152.3	4874.1	5520.4	7038.2
BU20RB	BU20RB	1650.1	2760.5	3562.3	4337.7	5183	5791.6	7454.4
BU20S	BU20S	1649.3	2752.3	3559.9	4335.1	5180	5788.1	7451.6

TABLE E-I-3
FUTURE WITHOUT PROJECT CONDITIONS PEAK DISCHARGES

HMS	ENTRIX	Peak Discharge for Return Period						
Element	Subbasin ID	2	5	10	25	50	100	500
(E9)	9	178.7	274.28	339.83	417.8	479.9	533.76	636.19
BU02C-(E8)	8	352.33	546.08	679.48	833.61	957.4	1066	1276.6
BU03C-(E21)	21	645.84	1010.6	1260.9	1529.7	1743.2	1937.2	2316.3
(E18)	18	639.16	994.92	1243.6	1501	1712.5	1908.7	2283.2
(E6)	6	238.42	335.34	401.79	482.25	539.61	595.24	676.52
BU04C-(E14)	14	1248.8	1844.8	2258.3	2670.5	2984.6	3305	3919.4
(E19)	19	1286.2	1970.7	2459.9	2939.8	3302.4	3680.7	4390.6
(E13)	13	595.59	944.6	1184.9	1458.7	1683.4	1890.9	2344
(E20)	20	2078.4	2898.5	3433.9	4061.4	4513.8	5135.5	6578.5
BU13CB-(E23)	23	2251	3440.9	4250	5109.2	5811.2	6532.1	7987.3
(E25)	25	551.29	873.95	1096.2	1341.2	1543.3	1728.6	2096.5
(E0)	0	2235.7	3417.6	4232.1	5096.7	5790.6	6531.4	7996.3
(E12)	12	2146.5	3350.9	4168.5	5063	5803.2	6603.2	8247
(E3)	3	412.94	649.41	812.54	991.87	1138.2	1273.8	1539.7
(E15)	15	463.02	728.55	905.52	1095.9	1254.4	1407.8	1705.4
(E5)	5	501.46	712.89	854.91	1022.7	1152.7	1272.3	1476.2
(E17)	17	1068	1578.4	1930.9	2364.6	2702.9	3018.4	3558.6
(E16)	16	2216.9	3478.1	4338.7	5174.8	6011.2	6705.1	8496.3

HMS	BMP	Peak Discharge for Return Period						
Element	Site ID	2	5	10	25	50	100	500
B10H	B10	501.46	712.89	854.91	1022.7	1152.7	1272.3	1476.2
B20TH	B20T	59.989	89.461	110.57	136.3	154.33	171.74	197.28
B20MSH	B20MS	9.2739	13.521	16.519	20.179	22.65	25.146	28.462
B3-1H	B3-1	142.62	218.06	269.98	331.78	380.17	422.74	500.74
B1-1H	B1-1	238.42	335.34	401.79	482.25	539.61	595.24	676.52
B3-3H	B3-3	121.8	176.44	213.85	259.01	291.19	322.01	367.73
B2-1TH	B2-1T	36.228	52.481	63.92	77.872	87.249	96.776	109.26
B2-1MSH	B2-1MS	288.39	418.37	506.86	613.41	690.84	763.71	876.01
B70H	B70	140.39	210.7	260.19	320.75	364.35	405.34	469.15
B60H	B60	329.49	486.07	592.55	718.6	817.3	905.85	1064

HMS	Priority Area 2	Peak Discharge for Return Period						
Element	Model ID	2	5	10	25	50	100	500
BU01H-A	BU01H-A	61.112	92.224	114.24	141.08	160.2	178.37	206.05
BU02C-(E8)	BU02C	352.33	546.08	679.48	833.61	957.4	1066	1276.6
BU02H	BU02H	184.87	291.1	364.28	447.91	515.64	575.68	693.18
BU02R	BU02R	177.79	273.21	338.4	416.66	478.67	532.28	633.8
BU02S	BU02S	347.33	541.84	674.04	830.97	954.28	1062.7	1272.8
BU03C-(E21)	BU03C	645.84	1010.6	1260.9	1529.7	1743.2	1937.2	2316.3
BU03H-A	BU03H-A	267.33	416.54	518.7	634	727.49	811.78	975.42
BU03RA	BU03RA	345.3	537.58	669.7	818.83	937.28	1040.9	1245.5

TABLE E-I-3
FUTURE WITHOUT PROJECT CONDITIONS PEAK DISCHARGES

HMS	Priority Area 2	Peak Discharge for Return Period						
Element	Model ID	2	5	10	25	50	100	500
BU03RB	BU03RB	643.48	1004	1252.1	1522.2	1734.8	1926.6	2304.1
BU03RC	BU03RC	639.18	995.38	1243.7	1501.2	1713.2	1909.4	2283
BU03SA	BU03SA	644.73	1006.7	1256.4	1527.3	1742	1935.1	2313.8
BU03SB	BU03SB	641.44	999.37	1248.9	1518.9	1732.4	1923.8	2300.6
BU03SC	BU03SC	639.16	994.92	1243.6	1501	1712.5	1908.7	2283.2
BU04C-(E14)	BU04C	1248.8	1844.8	2258.3	2670.5	2984.6	3305	3919.4
BU04H-A	BU04H-A	621.72	865.16	1026.1	1207.6	1350.8	1488.7	1724.3
BU04R	BU04R	636.18	990.8	1236.6	1494.4	1706.4	1902.1	2274.4
BU04S	BU04S	1243	1843.7	2255.8	2668.2	2983.1	3305.5	3918.3
BU05C	BU05C	1455.3	2122.6	2591.7	3122.8	3524.1	3968.5	4781.5
BU05H-A	BU05H-A	632.96	836.96	972.32	1134.4	1255.7	1374.6	1553.9
BU05H-B	BU05H-B	641.2	888.28	1052.3	1244.1	1393	1533.2	1768
BU05R(D)	BU05R(D)	1217.6	1837.5	2287.5	2748.7	3092.4	3465.5	4133
BU05R(U)	BU05R(U)	1120.8	1703.9	2100.6	2507.4	2824.9	3130.6	3716.5
BU06H	BU06H	54.867	82.608	101.56	123.83	141.44	157.07	185.92
BU06L	BU06L	3.1173	6.8531	19.442	32.988	45.081	54.1	116.01
BU07C	BU07C	573.55	906.86	1136.4	1403.9	1622.2	1821.2	2260.3
BU07H	BU07H	571.66	903.35	1131.6	1381	1584.3	1773.7	2144.7
BU07R	BU07R	3.1173	6.8528	19.437	32.979	45.063	54.081	115.59
BU08C	BU08C	2187.6	3041.1	3593.8	4239.3	4705.8	5340.6	6829.9
BU08H-A	BU08H-A	346.4	520.27	638.37	773.61	882	979.88	1163
BU08H-B	BU08H-B	124.91	189.29	234.56	289.58	329.77	367.05	426.89
BU08RA	BU08RA	1425.9	2076.7	2578.9	3108.6	3509.3	3955.9	4768
BU08RB	BU08RB	1395.1	1970.1	2396.4	2819.6	3169	3719.8	4567.2
BU08RC(D)	BU08RC(D)	592.49	937.85	1176	1445.9	1667.5	1873.2	2318.3
BU08RC(U)	BU08RC(U)	571.57	904.11	1133.2	1397.8	1614.3	1812	2246.6
BU08SA	BU08SA	1402.8	1973.7	2404.1	2841.2	3200.3	3806.1	4668.6
BU08SB	BU08SB	2187.3	3038.6	3591.3	4237.4	4704.5	5339	6830.8
BU09C	BU09C	1915.1	2731	3265.7	3873	4352.3	4891.4	6279.5
BU09H-A	BU09H-A	248.1	388.14	484.54	591.66	679.13	759.08	915.6
BU09H-B	BU09H-B	77.33	116.9	144.7	178.54	203.2	226.13	262.67
BU09R(D)	BU09R(D)	1695.4	2422.6	2912.9	3456.2	3886.1	4499.9	5719.2
BU09R(U)	BU09R(U)	2063.5	2879.1	3411.3	4033.9	4487.7	5109.3	6550
BU10C	BU10C	2038.5	2989.3	3607.1	4278.8	4833.6	5395.1	6793.3
BU10H	BU10H	332.15	527.07	662.12	813.22	936.63	1048.3	1269.9
BU10R	BU10R	1874	2705.2	3245.5	3847.2	4327.5	4879.1	6224.3
BU11H	BU11H	77.911	118.56	146.48	179.28	205.33	228.32	271.37
BU11L	BU11L	34.841	72.438	101.06	130.51	153.54	174.18	211.85
BU12H	BU12H	527.36	834.38	1047.2	1284.3	1478	1654.4	2003.7
BU13CA	BU13CA	2069.2	3036.6	3669.6	4353.7	4922.9	5493.9	6890.6
BU13CB-(E23)	BU13CB	2251	3440.9	4250	5109.2	5811.2	6532.1	7987.3
BU13CC	BU13CC	2242.3	3429.3	4268.9	5160.6	5844.4	6640	8135.2

TABLE E-I-3
FUTURE WITHOUT PROJECT CONDITIONS PEAK DISCHARGES

HMS	Priority Area 2	Peak Discharge for Return Period						
Element	Model ID	2	5	10	25	50	100	500
BU13H-A	BU13H-A	88.351	131.13	161.03	197.33	223.02	247.62	284.24
BU13H-B	BU13H-B	106.45	160.87	198.97	245.11	278.9	310.19	360.57
BU13H-C	BU13H-C	226.71	352.01	438.29	537.92	618.16	689.03	825.88
BU13H-D	BU13H-D	83.812	123.69	151.59	185.5	209.38	232.4	266.19
BU13RB	BU13RB	2011.6	2989.7	3626.8	4312.5	4868.9	5450.2	6829.1
BU13RC(D)	BU13RC(D)	537.47	855.33	1074.5	1316.2	1515.8	1699.6	2064.1
BU13RC(U)	BU13RC(U)	526.46	833.05	1044.6	1280.2	1473.1	1649.2	1997.2
BU13RD(D)	BU13RD(D)	2209.6	3373.3	4185.5	5048.2	5729.7	6489.4	7971
BU13RD(U)	BU13RD(U)	2229.5	3407.1	4216.5	5075.8	5771	6506.6	7972.2
BU13S	BU13S	2241.7	3427.8	4268	5160.2	5843.2	6638.7	8134.5
BU14H	BU14H	307.62	472.91	585.93	712.32	815.01	908.8	1089.3
BU15CA	BU15CA	2184.4	3382.4	4205.3	5098.8	5832	6617	8235.5
BU15CB	BU15CB	2181	3399.9	4220	5130.3	5889.8	6696.6	8347.1
BU15H-A	BU15H-A	272.69	413.8	511.28	627.18	717.2	796.96	940.75
BU15RA	BU15RA	2138	3304.7	4130	5008.9	5669.1	6433.3	7961.1
BU15RB	BU15RB	2157.5	3346.1	4160	5047.9	5770	6551.8	8160.9
BU15S	BU15S	2184.4	3382.3	4205.3	5098.8	5832	6616.9	8235.4
BU16H	BU16H	412.94	649.41	812.54	991.87	1138.2	1273.8	1539.7
BU17CA	BU17CA	2203.3	3469.4	4318.5	5261.4	6059.6	6909.7	8656.3
BU17CB	BU17CB	2225.9	3494.7	4358	5299.9	6100.3	6949.7	8723.7
BU17H-A	BU17H-A	357.27	458.3	527.14	612.36	672.08	734.03	814.63
BU17H-B	BU17H-B	252.21	370.76	452.28	550.48	623.99	691.37	802.73
BU17H-C	BU17H-C	121.71	179.78	220.44	269.88	304.54	338.09	386.86
BU17RA	BU17RA	2138.7	3340.9	4152	5045	5784	6586.3	8217.3
BU17RB	BU17RB	409.09	642.52	801.27	974.92	1119	1252.4	1514.2
BU17RC	BU17RC	2223.6	3483.7	4339.4	5271.5	6066	6907.2	8671.4
BU17S	BU17S	2223.2	3472.9	4325.4	5200.7	5931.3	6665.2	8598.6
BU18H	BU18H	310.63	417.93	488.62	570.66	634.23	695.88	795.55
BU18L	BU18L	228.58	340.71	417.8	495.85	555.11	613.66	701.28
BU19H-A	BU19H-A	587.34	878.04	1074.7	1298.2	1477.2	1640.7	1945.3
BU19R	BU19R	223.95	333.3	406.75	479.7	535.12	591.41	679.99
BU20C	BU20C	2252.5	3551.4	4430.3	5281.8	6134.4	6825.4	8717.2
BU20H	BU20H	369.34	598.77	758.56	933.09	1076.3	1209	1475.5
BU20RA	BU20RA	2116.3	3306.6	4120	4977.2	5681.2	6423.8	8074.3
BU20RB	BU20RB	2218.4	3486	4341.4	5178.2	6015.1	6707.6	8502.7
BU20S	BU20S	2216.9	3478.1	4338.7	5174.8	6011.2	6705.1	8496.3

TABLE E-I-4
FUTURE WITH PROJECT CONDITIONS PEAK DISCHARGES

HMS Element	ENTRIX Subbasin ID	Peak Discharge for Return Period 1	2	5	10	25	50	100	500
(E9)	9	72.0	88.5	140.3	173.3	207.7	233.0	257.8	298.4
BU02C-(E8)	8	208.1	263.6	403.3	498.9	604.3	686.3	759.8	913.9
BU03C-(E21)	21	442.5	559.4	866.2	1077.7	1312.1	1499.6	1664.8	1982.0
(E18)	18	440.0	556.1	859.1	1067.5	1298.8	1476.0	1641.6	1963.0
(E6)	6	31.4	44.4	86.1	115.3	139.9	160.7	175.1	201.6
BU04C-(E14)	14	932.5	1157.1	1717.5	2093.3	2512.3	2823.7	3109.4	3673.7
(E19)	19	963.1	1171.6	1781.0	2236.5	2696.5	3038.7	3381.0	4021.0
(E13)	13	464.6	595.6	944.6	1184.9	1458.7	1683.4	1890.9	2344.0
(E20)	20	1607.8	1981.1	2814.8	3316.2	3889.0	4351.5	4806.6	5979.7
BU13CB-(E23)	23	1801.2	2170.2	3374.2	4178.1	5016.9	5713.6	6416.3	7795.2
(E25)	25	431.6	551.3	874.0	1096.2	1341.2	1543.3	1728.6	2096.5
(E0)	0	1799.5	2156.4	3349.4	4158.0	5000.5	5690.3	6413.1	7794.4
(E12)	12	1740.8	2083.9	3296.1	4119.8	4999.6	5705.3	6460.1	7958.8
(E3)	3	324.9	412.9	649.4	812.5	991.9	1138.2	1273.8	1539.7
(E15)	15	359.7	463.0	728.6	905.5	1095.9	1254.4	1407.8	1705.4
(E5)	5	370.4	438.7	542.0	625.9	695.1	747.8	797.0	864.1
(E17)	17	880.7	1073.9	1568.7	1930.4	2265.4	2519.5	2760.3	3180.3
(E16)	16	1845.4	2161.0	3407.8	4253.6	5067.3	5874.2	6511.1	8143.7

HMS Element	BMP Site ID	Peak Discharge for Return Period 1	2	5	10	25	50	100	500
B10H	B10	417.8	501.5	712.9	854.9	1022.7	1152.7	1272.3	1476.2
B20TH	B20T	7.8	9.3	13.5	16.5	20.2	22.7	25.1	28.5
B20MSH	B20MS	50.2	60.0	89.5	110.6	136.3	154.3	171.7	197.3
B3-1H	B3-1	116.1	142.6	218.1	270.0	331.8	380.2	422.7	500.7
B1-1H	B1-1	202.6	238.4	335.3	401.8	482.3	539.6	595.2	676.5
B3-3H	B3-3	102.4	121.8	176.4	213.9	259.0	291.2	322.0	367.7
B2-1TH	B2-1T	30.7	36.2	52.5	63.9	77.9	87.2	96.8	109.3
B2-1MSH	B2-1MS	241.5	288.4	418.4	506.9	613.4	690.8	763.7	876.0
B70H	B70	116.7	140.4	210.7	260.2	320.8	364.4	405.3	469.2
B60H	B60	271.1	329.5	486.1	592.6	718.6	817.3	905.9	1064.0

HMS Element	Parsons Model ID	Peak Discharge for Return Period 1	2	5	10	25	50	100	500
BU01H-A	BU01H-A	50.9	61.1	92.2	114.2	141.1	160.2	178.4	206.1
BU02C-(E8)	BU02C	208.1	263.6	403.3	498.9	604.3	686.3	759.8	913.9
BU02H	BU02H	146.8	184.9	291.1	364.3	447.9	515.6	575.7	693.2
BU02R	BU02R	71.1	87.4	138.3	170.6	203.8	229.4	254.0	294.4
BU02S	BU02S	208.0	262.4	401.2	497.2	601.7	684.0	759.0	912.5
BU03C-(E21)	BU03C	442.5	559.4	866.2	1077.7	1312.1	1499.6	1664.8	1982.0
BU03H-A	BU03H-A	212.2	267.3	416.5	518.7	634.0	727.5	811.8	975.4

TABLE E-I-4
FUTURE WITH PROJECT CONDITIONS PEAK DISCHARGES

HMS	Parsons	Peak Discharge for Return Period							
Element	**Model ID**	**1**	**2**	**5**	**10**	**25**	**50**	**100**	**500**
BU03RA	BU03RA	207.6	261.5	400.1	495.7	599.7	681.5	755.5	905.3
BU03RB	BU03RB	441.5	558.3	863.1	1073.4	1305.3	1493.7	1658.4	1975.1
BU03RC	BU03RC	440.1	556.1	859.2	1067.4	1299.0	1476.4	1641.4	1962.6
BU03SA	BU03SA	442.2	558.9	864.2	1075.4	1308.7	1498.0	1663.5	1981.2
BU03SB	BU03SB	441.3	557.3	861.6	1070.1	1303.8	1491.6	1656.7	1973.0
BU03SC	BU03SC	440.0	556.1	859.1	1067.5	1298.8	1476.0	1641.6	1963.0
BU04C-(E14)	BU04C	932.5	1157.1	1717.5	2093.3	2512.3	2823.7	3109.4	3673.7
BU04H-A	BU04H-A	515.1	621.7	865.2	1026.1	1207.6	1350.8	1488.7	1724.3
BU04R	BU04R	438.4	554.5	857.0	1063.7	1294.8	1471.8	1636.5	1957.6
BU04S	BU04S	929.6	1150.9	1715.9	2091.9	2510.4	2821.3	3108.8	3671.6
BU05C	BU05C	1131.9	1351.0	1940.1	2365.3	2828.7	3182.9	3583.2	4311.6
BU05H-A	BU05H-A	541.8	633.0	837.0	972.3	1134.4	1255.7	1374.6	1553.9
BU05H-B	BU05H-B	536.3	641.2	888.3	1052.3	1244.1	1393.0	1533.2	1768.0
BU05R(D)	BU05R(D)	879.0	1095.1	1658.0	2062.8	2484.8	2800.3	3136.4	3732.2
BU05R(U)	BU05R(U)	820.6	1024.7	1561.8	1929.1	2319.2	2620.6	2901.8	3429.1
BU06H	BU06H	44.7	54.9	82.6	101.6	123.8	141.4	157.1	185.9
BU06L	BU06L	2.6	3.1	6.9	19.4	33.0	45.1	54.1	116.0
BU07C	BU07C	449.5	573.6	906.9	1136.4	1403.9	1622.2	1821.2	2260.3
BU07H	BU07H	448.1	571.7	903.4	1131.6	1381.0	1584.3	1773.7	2144.7
BU07R	BU07R	2.6	3.1	6.9	19.4	33.0	45.1	54.1	115.6
BU08C	BU08C	1694.2	2085.2	2953.9	3469.1	4060.6	4538.0	5002.4	6210.3
BU08H-A	BU08H-A	280.3	346.4	520.3	638.4	773.6	882.0	979.9	1163.0
BU08H-B	BU08H-B	103.5	124.9	189.3	234.6	289.6	329.8	367.1	426.9
BU08RA	BU08RA	1117.9	1324.2	1891.3	2314.9	2803.8	3164.6	3564.8	4289.4
BU08RB	BU08RB	1075.7	1287.1	1800.6	2190.2	2585.2	2874.9	3261.0	4094.0
BU08RC(D)	BU08RC(D)	462.4	592.5	937.9	1176.0	1445.9	1667.5	1873.2	2318.3
BU08RC(U)	BU08RC(U)	448.1	571.6	904.1	1133.2	1397.8	1614.3	1812.0	2246.6
BU08SA	BU08SA	1085.2	1296.6	1802.4	2195.7	2599.4	2898.5	3314.0	4185.3
BU08SB	BU08SB	1693.9	2085.2	2950.3	3466.2	4057.6	4535.0	5001.0	6207.7
BU09C	BU09C	1498.1	1839.3	2660.9	3176.4	3737.5	4221.8	4676.7	5764.3
BU09H-A	BU09H-A	196.0	248.1	388.1	484.5	591.7	679.1	759.1	915.6
BU09H-B	BU09H-B	64.1	77.3	116.9	144.7	178.5	203.2	226.1	262.7
BU09R(D)	BU09R(D)	1313.4	1612.1	2344.2	2796.4	3307.2	3715.5	4136.6	5235.9
BU09R(U)	BU09R(U)	1596.8	1965.9	2794.0	3290.5	3860.5	4323.3	4774.1	5951.9
BU10C	BU10C	1605.2	1957.9	2921.4	3530.0	4164.1	4712.0	5246.2	6353.0
BU10H	BU10H	261.5	332.2	527.1	662.1	813.2	936.6	1048.3	1269.9
BU10R	BU10R	1457.8	1791.0	2632.0	3151.5	3712.4	4187.7	4648.5	5734.9
BU11H	BU11H	63.3	77.9	118.6	146.5	179.3	205.3	228.3	271.4
BU11L	BU11L	26.6	34.8	72.4	101.1	130.5	153.5	174.2	211.9
BU12H	BU12H	415.2	527.4	834.4	1047.2	1284.3	1478.0	1654.4	2003.7
BU13CA	BU13CA	1629.9	1988.5	2969.0	3594.7	4243.2	4803.5	5351.3	6474.4

TABLE E-I-4
FUTURE WITH PROJECT CONDITIONS PEAK DISCHARGES

HMS	Parsons	Peak Discharge for Return Period							
Element	Model ID	1	2	5	10	25	50	100	500
BU13CB-(E23)	BU13CB	1801.2	2170.2	3374.2	4178.1	5016.9	5713.6	6416.3	7795.2
BU13CC	BU13CC	1831.3	2166.2	3360.0	4191.4	5061.4	5741.1	6514.2	7936.7
BU13H-A	BU13H-A	74.0	88.4	131.1	161.0	197.3	223.0	247.6	284.2
BU13H-B	BU13H-B	88.3	106.5	160.9	199.0	245.1	278.9	310.2	360.6
BU13H-C	BU13H-C	181.5	226.7	352.0	438.3	537.9	618.2	689.0	825.9
BU13H-D	BU13H-D	70.4	83.8	123.7	151.6	185.5	209.4	232.4	266.2
BU13RB	BU13RB	1580.5	1928.8	2919.2	3545.1	4198.0	4747.9	5292.4	6428.9
BU13RC(D)	BU13RC(D)	420.3	537.5	855.3	1074.5	1316.2	1515.8	1699.6	2064.1
BU13RC(U)	BU13RC(U)	414.1	526.5	833.1	1044.6	1280.2	1473.1	1649.2	1997.2
BU13RD(D)	BU13RD(D)	1789.7	2132.2	3304.0	4107.5	4946.5	5625.2	6361.1	7752.5
BU13RD(U)	BU13RD(U)	1791.4	2149.4	3338.8	4142.3	4979.6	5670.7	6387.9	7769.1
BU13S	BU13S	1831.2	2165.7	3358.4	4190.5	5060.1	5740.1	6511.7	7935.9
BU14H	BU14H	245.1	307.6	472.9	585.9	712.3	815.0	908.8	1089.3
BU15CA	BU15CA	1773.1	2118.5	3334.0	4167.4	5046.2	5743.4	6493.4	7965.4
BU15CB	BU15CB	1772.5	2116.2	3348.6	4179.7	5074.1	5798.1	6568.0	8070.2
BU15H-A	BU15H-A	222.6	272.7	413.8	511.3	627.2	717.2	797.0	940.8
BU15RA	BU15RA	1728.9	2062.7	3230.1	4044.6	4900.2	5554.3	6284.9	7696.4
BU15RB	BU15RB	1750.0	2093.0	3294.6	4119.4	4991.4	5677.8	6421.4	7880.4
BU15S	BU15S	1773.1	2118.5	3334.0	4167.5	5046.2	5743.5	6493.3	7965.3
BU16H	BU16H	324.9	412.9	649.4	812.5	991.9	1138.2	1273.8	1539.7
BU17CA	BU17CA	1789.4	2140.9	3415.3	4271.4	5197.9	5962.6	6768.9	8375.6
BU17CB	BU17CB	1804.9	2163.6	3440.7	4310.9	5236.4	6003.3	6809.3	8443.6
BU17H-A	BU17H-A	312.5	357.3	458.3	527.1	612.4	672.1	734.0	814.6
BU17H-B	BU17H-B	209.9	252.2	370.8	452.3	550.5	624.0	691.4	802.7
BU17H-C	BU17H-C	102.1	121.7	179.8	220.4	269.9	304.5	338.1	386.9
BU17RA	BU17RA	1735.7	2076.1	3286.1	4103.2	4981.6	5686.1	6443.2	7928.9
BU17RB	BU17RB	321.7	409.1	642.5	801.3	974.9	1119.0	1252.4	1514.2
BU17RC	BU17RC	1803.6	2161.6	3429.3	4290.1	5206.0	5966.9	6762.8	8389.2
BU17S	BU17S	1803.3	2161.2	3418.1	4274.7	5132.6	5828.5	6512.5	8283.7
BU18H	BU18H	262.0	310.6	417.9	488.6	570.7	634.2	695.9	795.6
BU18L	BU18L	172.6	228.6	340.7	417.8	495.9	555.1	613.7	701.3
BU19H-A	BU19H-A	474.8	587.3	878.0	1074.7	1298.2	1477.2	1640.7	1945.3
BU19R	BU19R	168.6	224.0	333.3	406.8	479.7	535.1	591.4	680.0
BU20C	BU20C	1874.7	2197.8	3488.6	4356.4	5191.3	6013.2	6650.3	8354.1
BU20H	BU20H	286.3	369.3	598.8	758.6	933.1	1076.3	1209.0	1475.5
BU20RA	BU20RA	1718.3	2062.0	3242.9	4045.7	4886.8	5559.7	6248.4	7723.1
BU20RB	BU20RB	1846.9	2164.0	3416.5	4256.7	5071.2	5878.3	6513.9	8147.3
BU20S	BU20S	1845.4	2161.0	3407.8	4253.6	5067.3	5874.2	6511.1	8143.7

TABLE E-I-4
FUTURE WITH PROJECT CONDITIONS PEAK DISCHARGES

HMS Element	Reservoir Site ID	Peak Discharge for Return Period (cfs) 1	2	5	10	25	50	100	500
B10S	B10S	370.4	438.7	542.0	625.9	695.1	747.8	797.0	864.1
B1-1S	B1-1S	31.4	44.4	86.1	115.3	139.9	160.7	175.1	201.6
B20D	B20D	39.6	46.8	68.6	84.1	103.1	116.4	129.2	148.0
B20D(br)	B20D(br)	10.6	13.2	20.9	26.5	33.2	38.0	42.6	49.3
B20S	B20S	0.3	0.4	0.7	0.9	1.2	1.4	1.6	2.1
B2-1D	B2-1D	181.1	216.3	313.8	380.2	460.1	518.1	572.8	651.7
B2-1D(br)	B2-1D(br)	60.4	72.1	104.6	126.7	153.4	172.7	190.9	224.4
B2-1S	B2-1S	1.2	1.6	3.4	5.1	6.7	7.9	9.1	10.6
B3-1S	B3-1S	53.1	61.9	85.0	96.1	106.9	120.6	133.8	149.6
B60S	B60S	32.0	41.7	76.2	93.5	108.8	119.4	128.6	153.3
B70S	B70S	4.1	5.0	7.8	9.8	11.8	13.1	14.0	16.3

4.0 HYDRAULIC ANALYSIS

4.1 General

One of the primary purposes of the hydraulic analysis in the Priority Area 2 study was to identify areas of potential streambank erosion. The computed velocities were also used to support the conceptual design of the streambank stabilization measures.

4.2 HEC-2 Model

The model selected in the Priority Area 2 report (Parsons, 1999) was the USACE HEC-2 Water Surface Profiles program. The computational procedure used in HEC-2 is generally known as the standard-step method. In the Priority Area 2 study, Parsons used velocity results from the detailed HEC-2 backwater model to identify reaches with existing and future streambank erosion problems. The following parameters were used to identify existing and potential streambank erosion sites: (1) reaches with 2-year peak channel velocity in excess of the maximum permissible velocity, (2) reaches with significant overbank flow during the 2-year flood, and (3) reaches with observed streambank erosion problems. Maximum permissible velocities were determined based on unprotected soils in existing natural channels for various channel linings (e.g. sand, gravel, cobble) and local soil conditions.

4.3 Streambank Erosion Potential

Based on the channel conditions defined for the maximum permissible velocities and the local soil conditions, a threshold velocity of 4.5 feet per second was used as the standard for assessing the streambank erosion potential for the primary channel systems in Butler Creek (Parsons 1998). The entire reach of Butler Creek was identified as having either moderate or severe streambank erosion potential. Potential streambank stabilization measures are described and shown in Section III Description of Recommended Plan.

For this study it was decided that the channel forming discharge would be the most appropriate flow to indicate overall channel stability and stream health. Changes in the flow, velocity, and sediment for the channel forming discharge were used in the Environmental Benefit Matrix to evaluate feature effectiveness in improving habitat scoring and are discussed in detail in Appendix F.

The channel forming discharge is the flow magnitude that, over time, applies the greatest amount of work towards shaping the channel. This is the flow that, over the long term, is the most effective at moving sediment, forming or eroding bars, changing bends and meanders, and generally doing work that results in the average morphologic characteristics of channels (Dunne and Leopold, 1978).

Numerous empirical studies of channel geometry, flow, and sediment load indicate that there are properties that are, in general, common to most channels that indicate the magnitude and frequency of the channel forming discharge. Two widely accepted methods that utilize these properties for estimating the channel forming discharge include; bank-full discharge, and effective discharge. The bank-full discharge is the maximum flow that a channel can contain within its banks; this represents a logical breakpoint between flow in the channel and flow in the floodplain. Studies have shown that for many stable streams the bank-full discharge has been found to be between the 1 and 2.5 year recurrence interval flood event. The effective discharge is the flow that transports the most sediment over the long term which typically is a moderate flood that occurs relatively frequently. The effective discharge is determined by combining the flow-frequency curve and bed material-load rating curve for a stream (Biedenharn, 2000). Similar to the bank-full discharge, the effective discharge often has a recurrence interval between 1 and 2.5 years.

Due to the highly urbanized nature of the streams located in Cobb County it was determined that bank-full flows would be difficult to determine through empirical field measurements. In many places the stream channels are unstable and the size and shape of the channel do not represent natural conditions due to development in the watershed. Because of the difficulties associated with determining the bank-full discharge and the lack of a readily available sediment rating curve, it was decided that the 2 year recurrence interval discharge would be a reasonable approximation of the channel-forming discharge. It was assumed that the two year recurrence interval event would adequately represent the channel forming discharge for Butler Creek and its tributaries in this study.

4.4 HEC-RAS Model

Four of the proposed measures fall within the Butler Creek Zone AE Special Flood Hazard Areas (SFHA). To help the City of Kennesaw and Cobb County meet their responsibilities in promulgating the requirements of the National Flood Insurance Program, an HEC-RAS model was developed to determine the effects construction of these four measures would have on the best-estimate 100-year water surface profile. The results of this analysis can be found in Butler Creek Section 206 (Ecosystem Restoration) Project, Cobb County, Georgia,100-year Flood Water Surface Elevation and Floodplain Impacts Analysis dated 15 November, 2005. An additional purpose of the model was to examine the changes in channel velocities for the main stem of Butler Creek.

The HEC-RAS model was constructed by importing the Priority Area 2 HEC-2 model into HEC-RAS and making changes to the spacing of cross-sections in the vicinity of bridge crossings where required. This represented the Existing Conditions in HEC RAS. The with-project condition was developed by adding new cross sections in the vicinity of the proposed project sites in order to improve characterization of existing flow conditions and to facilitate further modification for the with-project model. Overbank geometry was obtained graphically from the 2 foot contour interval topographic map of Cobb County. Channel geometry at these new cross sections was developed using judgment in consideration of local channel geometry and reach-scale channel slope. The multiple opening bridge routine was also specified to be used at the Highway 41 and Butler Bridge Way bridge crossings. Cross-section interpolation schemes were also adopted in order to improve the accuracy of the hydraulic solution routines. A map showing some of the cross section locations used in the HEC-RAS model can be found in Figure E-I-9.

While the RAS model used in the Floodplain Impact Analysis was setup to evaluate changes in water surface elevations due to construction of detention basins within the floodplain or floodway, it did not address changes in flow due to the detention of flow by these basins. It was therefore necessary to modify the flow regime of the with-project RAS model to reflect the changes in flow caused by each detention/retention basin. To accomplish this, a new flow data file was created in HEC-RAS that contained flow data from the HEC-HMS model discussed in section 3.1.3. A flow profile was setup for each of the seven detention/retention basins modeled previously in HEC-HMS, with flow change locations. The flow information input into the RAS model for the with-project condition is shown in Table E-I-5.

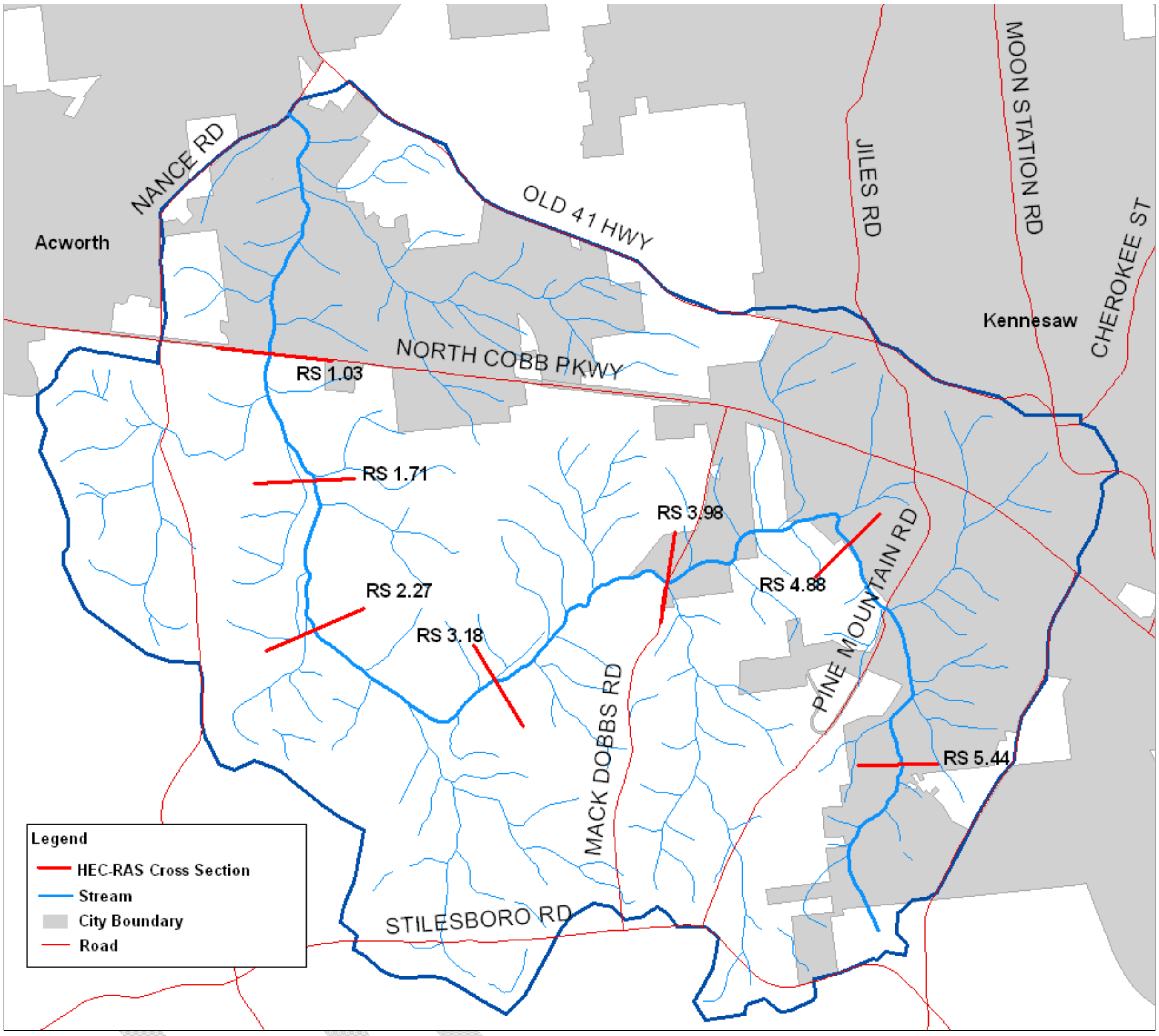


Figure E-I-9 HEC-RAS Cross Section Locations

Channel velocities at site B3-1 increased slightly as a result of the reduction of conveyance area in the main channel. The remainder of flow attenuation features did not increase channel velocities in the vicinity of the site. Channel velocities downstream of all of the flow attenuation features were decreased as a result of decreased peak flows. The flows in Table E-I-6 represent the peak 2-year discharges obtained from HEC-HMS at the corresponding river stations. Detailed output from HEC-RAS including future with project and future without project conditions can be found in attachment 2 of this appendix.

TABLE E-I-5
HEC-RAS FLOW DATA – WITH PROJECT CONDITIONS
(cfs)

RS	Future w/o	B10	B1-1	B2-1	B20	B3-1	B60	B70
5.86	347	347	347	347	347	240	347	347
5.62	641	641	641	641	641	539	641	641
5.29	639	639	639	639	639	538	639	639
5.19	1243	1243	1239	1243	1243	1169	1243	1243
5.09	1121	1121	1100	1121	1121	1053	1121	1121
4.32	1403	1403	1358	1348	1403	1397	1403	1403
4	2187	2187	2144	2135	2187	2182	2187	2187
3.83	1915	1915	1883	1877	1915	1911	1915	1915
2.63	2012	2012	1973	1969	2012	2006	2012	2012
2.33	2242	2242	2207	2203	1866	2237	2242	2242
1.73	2185	2185	2148	2145	1808	2177	2196	2177
1.5	2139	2139	2104	2101	1772	2130	2149	2132
1.07	2223	2223	2189	2186	1978	2215	2233	2217
0.52	2117	2117	2092	2085	1825	2108	2120	2110
0.02	2217	2270	2214	2214	2161	2216	2211	2206

Since the extended detention basins were designed to contain the runoff from small storms with a 2-year return period or less, the 2-year peak flow was used in the HEC-RAS analysis. It can be gathered from the HMS output data that the detention basins do not have much of an effect on higher flows such as those from a storm with a 100 year return interval, so these flows were not modeled in RAS. By setting up a separate flow profile for each proposed measure, a direct comparison could be made between with project and without project results for each proposed measure.

Table E-I-6
Sample HEC-RAS Output

Reach	River Sta	Profile	Plan	Tot. Peak Flow (cfs)	W.S. Elev (ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)
Reach-1	5.86	Future w/o	Future w/o proj	347.33	1032.69	3.87	89.83	30.13
Reach-1	5.86	B10	Future w/ proj	347.33	1032.69	3.87	89.83	30.13
Reach-1	5.86	B1-1	Future w/ proj	347.33	1032.69	3.87	89.83	30.13
Reach-1	5.86	B2-1	Future w/ proj	347.33	1032.69	3.87	89.83	30.13
Reach-1	5.86	B20	Future w/ proj	347.33	1032.69	3.87	89.83	30.13
Reach-1	5.86	B3-1	Future w/ proj	240.12	1031.58	4.05	59.22	24.88
Reach-1	5.86	B60	Future w/ proj	347.33	1032.69	3.87	89.83	30.13
Reach-1	5.86	B70	Future w/ proj	347.33	1032.69	3.87	89.83	30.13
Reach-1	5.84	Future w/o	Future w o proj	347.33	1032.47	2.99	137.04	81.49
Reach-1	5.84	B10	Future w/ proj	347.33	1032.47	2.99	137.04	81.49
Reach-1	5.84	B1-1	Future w/ proj	347.33	1032.47	2.99	137.04	81.49
Reach-1	5.84	B2-1	Future w/ proj	347.33	1032.47	2.99	137.04	81.49
Reach-1	5.84	B20	Future w/ proj	347.33	1032.47	2.99	137.04	81.49
Reach-1	5.84	B3-1	Future w/ proj	240.12	1031.2	3.17	75.7	27.83
Reach-1	5.84	B60	Future w/ proj	347.33	1032.47	2.99	137.04	81.49
Reach-1	5.84	B70	Future w/ proj	347.33	1032.47	2.99	137.04	81.49
Reach-1	5.831	Future w/o	Future w o proj	347.33	1032.36	2.43	143	100.45
Reach-1	5.831	B10	Future w/ proj	347.33	1032.36	2.43	143	100.45
Reach-1	5.831	B1-1	Future w/ proj	347.33	1032.36	2.43	143	100.45
Reach-1	5.831	B2-1	Future w/ proj	347.33	1032.36	2.43	143	100.45
Reach-1	5.831	B20	Future w/ proj	347.33	1032.36	2.43	143	100.45
Reach-1	5.831	B3-1	Future w/ proj	240.12	1031.03	2.39	100.39	61.47
Reach-1	5.831	B60	Future w/ proj	347.33	1032.36	2.43	143	100.45
Reach-1	5.831	B70	Future w/ proj	347.33	1032.36	2.43	143	100.45
Reach-1	5.8305			Culvert				
Reach-1	5.83	Future w/o	Future w o proj	347.33	1029.88	5.18	66.99	26.31
Reach-1	5.83	B10	Future w/ proj	347.33	1029.88	5.18	66.99	26.31
Reach-1	5.83	B1-1	Future w/ proj	347.33	1029.88	5.18	66.99	26.31
Reach-1	5.83	B2-1	Future w/ proj	347.33	1029.88	5.18	66.99	26.31
Reach-1	5.83	B20	Future w/ proj	347.33	1029.88	5.18	66.99	26.31
Reach-1	5.83	B3-1	Future w/ proj	240.12	1029.24	4.69	51.22	23.31
Reach-1	5.83	B60	Future w/ proj	347.33	1029.88	5.18	66.99	26.31
Reach-1	5.83	B70	Future w/ proj	347.33	1029.88	5.18	66.99	26.31

5.0 SEDIMENT MODELING

5.1 General

Sediment delivery was calculated using the Watershed Characterization System (WCS) - Sediment Tool and the default data set for Cobb County provided by the Environmental Protection Agency (EPA). WCS is a GIS-based application that is available in ArcView 3.2. WCS uses the Universal Soil Loss Equation (USLE) to estimate the erosion due to raindrop impact and shallow surface runoff. The USLE, developed by scientists W. Wischmeier and D. Smith, has been the most widely accepted and utilized soil loss equation for over 30 years. Designed as a method to predict average annual soil loss caused by sheet and rill erosion, it cannot be applied to a specific year or a specific storm. The USLE is mature technology and enhancements to it are limited by the simple equation structure.

The USLE for estimating average annual soil erosion is: A = RKLSCP

- **A** = average annual soil loss in t/a (tons per acre)
- **R** = rainfall erosivity index
- **K** = soil erodibility factor
- **LS** = topographic factor - L is for slope length & S is for slope
- **C** = cropping factor
- **P** = conservation practice factor

The USLE estimates the amount of potential erosion in a watershed, but does not yield any information about how much of that material is delivered to the stream. WCS offers 4 methods for calculating sediment delivery: distance-based, distance-and-relief-based, area-based, and WEPP-based regression methods. Discussion with technical support from EPA led to the decision that the distance-and-relief-based method would be the most suitable method to determine sediment delivery to the stream; the other methodologies were not used as part of this study and are mentioned here only for informational purposes.

For the WCS modeling process, the Butler Creek Watershed was divided into four areas: between Nance Rd and N. Cobb Pkwy, between N. Cobb Pkwy and Jim Owens Rd, between Jim Owens Rd and Pine Mountain Rd, and above Pine Mountain road. This division of areas grouped together similar topographic, soil, and landuse conditions. The topography of the headwaters of Butler Creek is much steeper than is topography near the outlet of the creek. Similarly, the landuse of the headwaters area above Pine Mountain Road is characterized by more residential and commercial development than is the area where the creek drains into Lake Acworth.

5.2 Results.

Because there was no observed data available to be used to calibrate the WCS model, it should only be used in a qualitative manner to compare different sets of conditions like existing landuse vs. future landuse conditions. The amount of sediment generated from the watershed decreases slightly with future land use conditions. This decrease is because the more urbanized land has less exposed sediment to be carried by runoff. There is not a significant change from existing to future conditions for sediment delivery because the area is already highly urbanized.

Erosion potential and sediment delivery increases as you move from the headwaters to the mouth of the creek. The land in the headwaters is heavily urbanized, leaving less open soil to be eroded and less eroded soil to be delivered to the stream. Near the mouth of Butler Creek the land is less developed with more parkland and pastures, presenting more open soil to be eroded and therefore more sediment to potentially be delivered to the stream. The results from the WCS sediment model are shown in Table E-I-7 below.

TABLE E-I-7
WCS Sediment Output Summary

Group	AREA (acres)	EROSION (tons/year)	SEDIMENT (tons/year)	UNIT EROSION (lbs/acre/yr)	UNIT SEDIMENT (lbs/acre/yr)
Existing Conditions					
Above Pine Mtn. Rd	880	3400	900	7800	2100
Above Jim Owens Rd	2769	10000	2200	7200	1600
Above Cobb Pwky	1350	3200	800	4700	1100
Above Nance Rd	990	1700	500	3400	900
Future Conditions					
Above Pine Mtn. Rd	880	3400	900	7600	2100
Above Jim Owens Rd	2769	9700	2100	7000	1500
Above Cobb Pwky	1350	2800	700	4200	1000
Above Nance Rd	990	1600	500	3300	900

A prediction of the streambank erosion rates allows for the estimation of the streambank sediment load to the total sediment load in the stream. The identified sites were visually inspected to aid in the determination of streambank erosion rates. Table E-I-8 summarizes the results of the estimated rates of streambank erosion from selected site locations.

TABLE E-I-8
Streambank Erosion Rates at Selected Sites

Streambank Erosion Rates

Project ID	Problem Area ID	Reach Location	Notes	Erosion Rate (ft/yr)	Bank Height (ft)	Erosion Reach Length	Sed. Load (tons/yr)
B1-2	15	Cobb Pkwy to Pine Mt. Rd.	Erosion somewhat stablizing w/clay, chert, gravel soil; bank has eroded approximately 3 ft.; good access from sewer easement	1.0	6.0	270.0	85.1
	32	U/S Pine Mt. Rd at confluence of two tributaries	Recent channelization work on small trib appears to be stable; no active erosion observed	N/A			--
	35		Erosion d/s Forrest Dr; banks recently armored with riprap; no active erosion observed	N/A			--
	36		Banks recently armored with riprap; no active erosion observed	N/A			--
B2-2	51	d/s Mack Dobbs Rd.	Mainstem	0.5	6.0	175.0	27.6
	95	u/s Mack Dobbs Rd	Tributary	0.5	5.0	390.0	51.2
B3-2	17	Pine Mt. Rd. to Shillings Rd.	D/S of White Oak Ct. park area; erosion at 2 bends	0.5	8.0	235.0	49.4
	25			0.5	4.0	75.0	7.9
B4-1	75	Downstream Cobb Pkwy	D/S of bridge - Erosion along outside of 2 bends	1.5	10.0	500.0	393.8
	76	Mainstem upstream Cobb Pkwy		1.0	6.0	185.0	58.3
B5-1	71	Mainstem upstream Nance Rd.		0.5	8.0	430.0	90.3
B5-2	57	Tributary near Cool Springs Dr.	310 ft total reach length	1.0	8.0	75.0	31.5
	54	Tributary upstream Nance Rd.	1160 ft total reach length	0.5	6.0	250.0	39.4
B40	77	Upstream Jim Owens Rd.	500 ft total reach length	1.0	7.0	60.0	22.1
	78			1.0	7.0	620.0	227.9
	79	R.O.W. access to towers	At bend d/s of low-water crossing	1.0	6.0	200.0	63.0
	80	Near Johnston Rd.	Erosion at 4 bends	0.5	7.0	350.0	64.3
B50	44	Jim Owens Rd to Mack Dobbs	Main Stem	0.5	6.0	190.0	29.9
	47	Jim Owens Rd to Mack Dobbs	Main Stem	0.5	6.0	315.0	49.6

Notes: Density of soil estimated to be 105 pcf.

Project site measures will reduce sediment loads in the stream. These sediment reduction benefits are quantified and included as a parameter in the Environmental Benefits Matrix. Three feature types, streambank stabilization, extended detention, and extended detention of diverted streamflow provide varying levels of benefit in reducing sediment in the stream system. Streambank stabilization is estimated to reduce existing conditions erosion levels from the site to zero due to stabilization enhancements. Extended detention sites are anticipated to reduce the sedimentation levels entering the project site by 80 %. Extended detention of diverted streamflow is expected to remove sedimentation in the system by 80 % of the ratio of the diverted flow to full streamflow that enters the site. The estimated sedimentation reduction benefits are shown for each project site in Table E-I-9 below.

TABLE E-I-9
Sediment Reduction Benefits

Project Site	Sediment Removed (tons / yr)
B3-1	0.54
BRP	1.1
B1-1	0.54
B2-1	0.54
B20	3.24
B60	2.54
B70	4.86
B10	0.54
B5-1	90.3
B5-2	70.9
B4-1	393.8
B40	157.5
B50	79.5
B2-2	78.8
B1-2	85.1
B3-2	57.3

6.0 SITE ASSESSMENT

6.1 Environmental.

An Environmental Site Assessment (ESA) of a parcel of real estate is conducted to assess the risk of contamination with petroleum products and other contaminants within the scope of the Comprehensive Environmental Response and Liability Act (CERCLA). Mr. Terry Williams of the USACE, Mobile District, Hazardous, Toxic, and Radioactive Waste (HTRW) and Environmental Support Team conducted an environmental site assessment according to ASTM E 1527-00 (Standard Practice for Environmental Site Assessments: Phase I Environmental Site Assessment Process) to determine whether hazardous, toxic, radiological substances were stored, disposed of or released to the environment that may impact the areas proposed for easement along Butler Creek in Cobb County, Georgia. The assessment consisted of reviewing topographic maps for the parcels proposed for real estate easements, Federal and state database records obtained from the Environmental Data Resources, Inc. (EDR) which incorporates databases from the US Environmental Protection Agency (USEPA) and from the Alabama Department of Environmental Management (ADEM). The intent of the document is also to identify any potential environmental contamination liabilities associated with this real property transaction.

Based on the ESA investigation and document reviews, there was no evidence that any potentially hazardous substances may have been disposed of directly on or in the subject properties for streambank enhancement along Butler Creek. The completed Environmental Site Assessment is too voluminous to include in this document but can be obtained from the USACE Mobile District office upon request.

7.0 Geotechnical

The purpose of this section is to describe the regional surface geology of the project area. No subsurface investigations were performed for the feasibility study.

The metro Atlanta region is located in the Piedmont Physiographic Province. The Piedmont is characterized by hilly terrain with exposed rock surfaces and rocky, shallow soils extending almost 1,000 miles from New York to Alabama. Elevation within the Piedmont ranges from 500 ft to 1,000 feet above sea level. Specifically in the Atlanta area, the elevation ranges from 850 feet to 1,100 feet with some topographical features with elevations 300 to 800 feet higher, such as Stone Mountain.

The rocks of the Piedmont are primarily moderate-to-high-grade metamorphics, such as gneiss, schist, amphibolites, marble and quartzite, and igneous such as granite. The granites are the result igneous intrusions, such as plutons, into the native rock. Rock exposures or outcrops in the area are surface extents of the more weather resist metamorphic or igneous rocks.
Soils of the Piedmont are primarily clay, which is the result of intense weathering of the metamorphic and igneous rock. These soils are shallow with low moisture-holding capacity and low permeability with rapid runoff after rain events. Groundwater in the Piedmont flows through faults and fractures, making it difficult to find but often locally abundant.

It was determined that a thorough geotechnical investigation would be conducted during the Plans and Specifications study phase of the NER/NED Plan.

APPENDIX E - ENGINEERING APPENDIX

BUTLER CREEK SECTION 206
ECOSYSTEM RESTORATION REPORT

SECTION II - DESCRIPTION OF PROJECT MEASURES

1.0 GENERAL

The purpose of this section is to present the assumptions and methods of analyses used to develop conceptual plans for the ecosystem and streambank restoration measures for the Butler Creek watershed. Figure EII-1 shows the locations of the potential project restoration sites developed for the Butler Creek Section 206 Aquatic Ecosystem Restoration study. Water resource problems throughout the watershed include large amounts of sediments in the streams due to increased urban runoff and areas of streambank erosion due to the increased stream flows. Potential solutions include extended detention created wetlands, detention basins, and various methods of streambank stabilization. Section III includes conceptual plan views and typical details of the project alternative measures.

2.0 ECOSYSTEM RESTORATION (BMP) MEASURES

2.1 Detention/Retention Basin Measures

2.1.1 Extended Detention Created Wetlands

Extended Detention (ED) created wetland measures were considered for four locations within the Butler Creek watershed. The project sites include B2-1, B20, B60 and B70. The selection criteria for the sites included: (1) Sites identified in the ENTRIX Problem Areas Report, (2) Adequate available area to meet design guidelines, (3) Potential water source for the selective vegetation required in the created wetlands.

The purpose of the ED created wetland areas is to detain the more frequent flood flows, create aquatic habitat by providing necessary depths and vegetative cover, remove pollutants by vegetative filtering, and remove some sediment with sediment forebays. All of the created wetland sites would be vegetated with a variety of water-tolerant vegetation. The design locations for the created wetlands were adjacent to and off the main stream, excavated in the existing overbank areas of the tributary streams. The size and design of the created wetland areas was dictated by the topography and the undeveloped space available at each site. The water source for each of the created wetlands was either from a tributary to the main stream, or from diverting a portion of the main stream flow. The wetland areas were designed to have water depths of 1 to 2 feet, with ½ foot of freeboard. Small meandering channels with depths ranging from 3 to 5 feet would be excavated through the ED wetland areas.

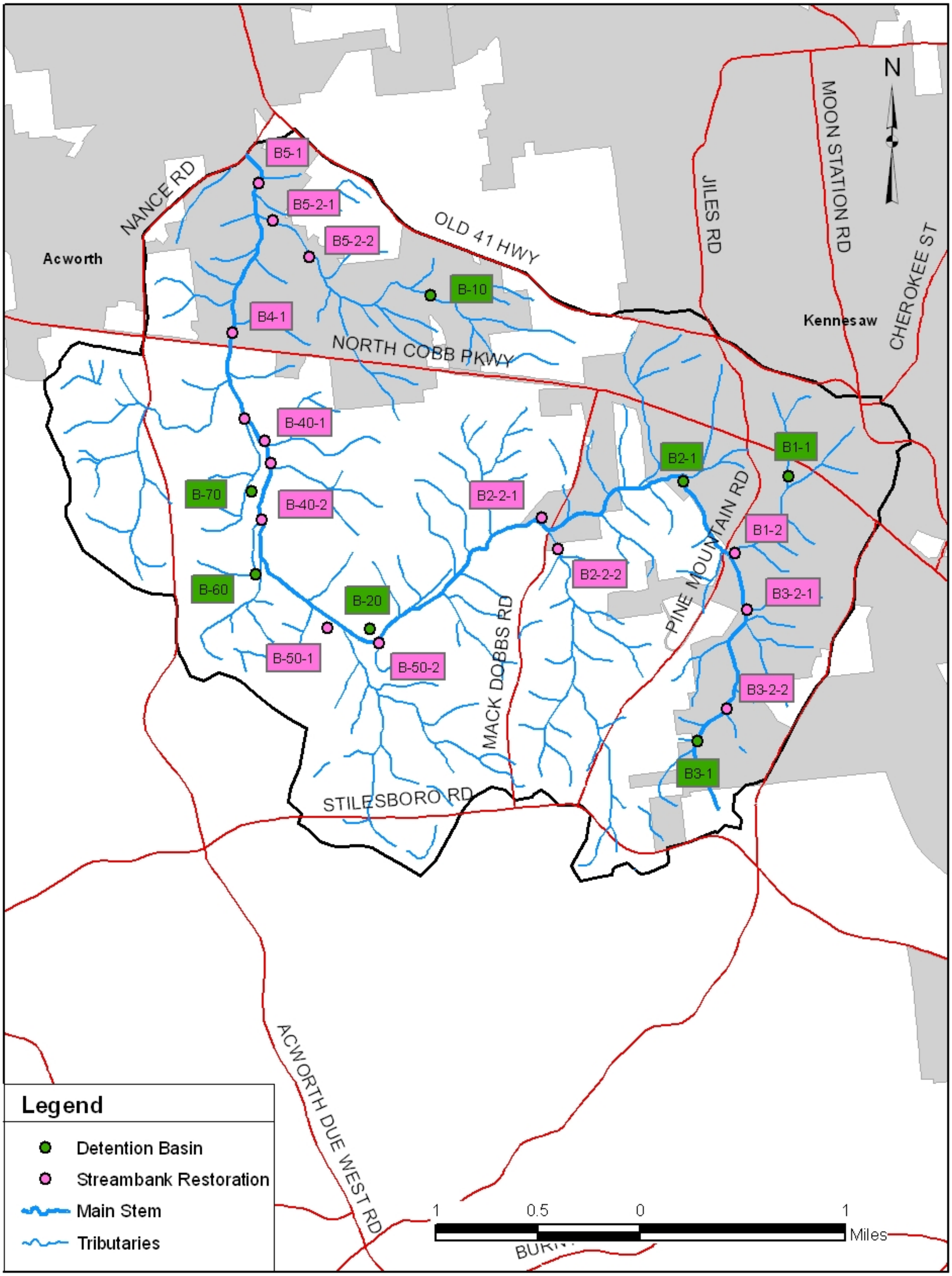


Figure EII-1 Location of Potential Project Restoration Measures

The extended detention created wetland basins were designed to contain the runoff from small storms with return periods of 2-years or less. Each detention basin was designed with an emergency spillway to handle the runoff from storms with return periods greater than 2-years and up to 10 years. These outlet structures were designed to gradually reduce basin elevations from a full, overtopping state to normal pool levels within 24 hours. The runoff from storms with return periods greater than 10 years would overflow the basins, and repairs to the containment berms or outlet structures may become necessary. Discharge estimates for the small tributaries were calculated for the 2-year through 10-year storms using the HEC-HMS model. Culvert sizes for the outlet structures were calculated using "CulvertMaster" by Haestead Methods. Figure EII-2 shows a typical outlet structure design for an ED created wetland.

2.1.2 Detention Basin Retrofits

Three detention basin retrofit measures were considered for project sites B1-1, B3-1 and B10. The purpose of the measures was to retrofit the existing basins and their outlet structures to enable detention of runoff from the 2-year frequency flows for a 24-hour period during storm events. These basins are classified as dry basins because there is little or no flow through them except during rain events. The retrofitted detention basins would also serve to reduce the water quantity impacts to existing developed areas on the downstream reaches. Dry detention basins provide limited pollutant removal benefits and are not intended for water quality treatment (Georgia Stormwater Management Manual). Retrofitting the basins and outlet structures would involve excavation and/or construction of berms to contain and direct flow toward the outlet, and stabilization or reconstruction of the outlet structure to control the rate of flow from the basin.

2.2 Streambank Stabilization Measures

The objective of the streambank restoration plan is to stabilize the streambanks where active erosion is occurring using methods appropriate for enhancing aquatic habitat in the urban setting.

2.2.1 Streambank Erosion

Systematic changes caused by urbanization in the watershed have increased the frequency and duration of the flows in the streams from stormwater runoff. Streambank erosion occurs as the channel cross section adjusts to these changes. Increased streambank erosion is one of the major causes of the degradation of the streams in the Butler watershed. Sediment loads from active streambank erosion create conditions within the stream channels that severely limit the aquatic habitat and diversity.

2.2.2 Problem Reaches

Twenty miles of Butler Creek and its tributaries were visually inspected to identify problem reaches within the watershed. The stream walks were completed under contract to ENTRIX, Inc. Sites identified as having active streambank erosion were given an erosion impact score between 1 and 10, with 10 being the most severe erosion. Sites with an erosion impact score between 8 and 10 were evaluated. At each erosion site identified, an assessment was made to include the location, approximate length of erosion, bank heights and slopes, and channel widths. Also included were general descriptions of the bankside vegetation, accessibility, and general comments.

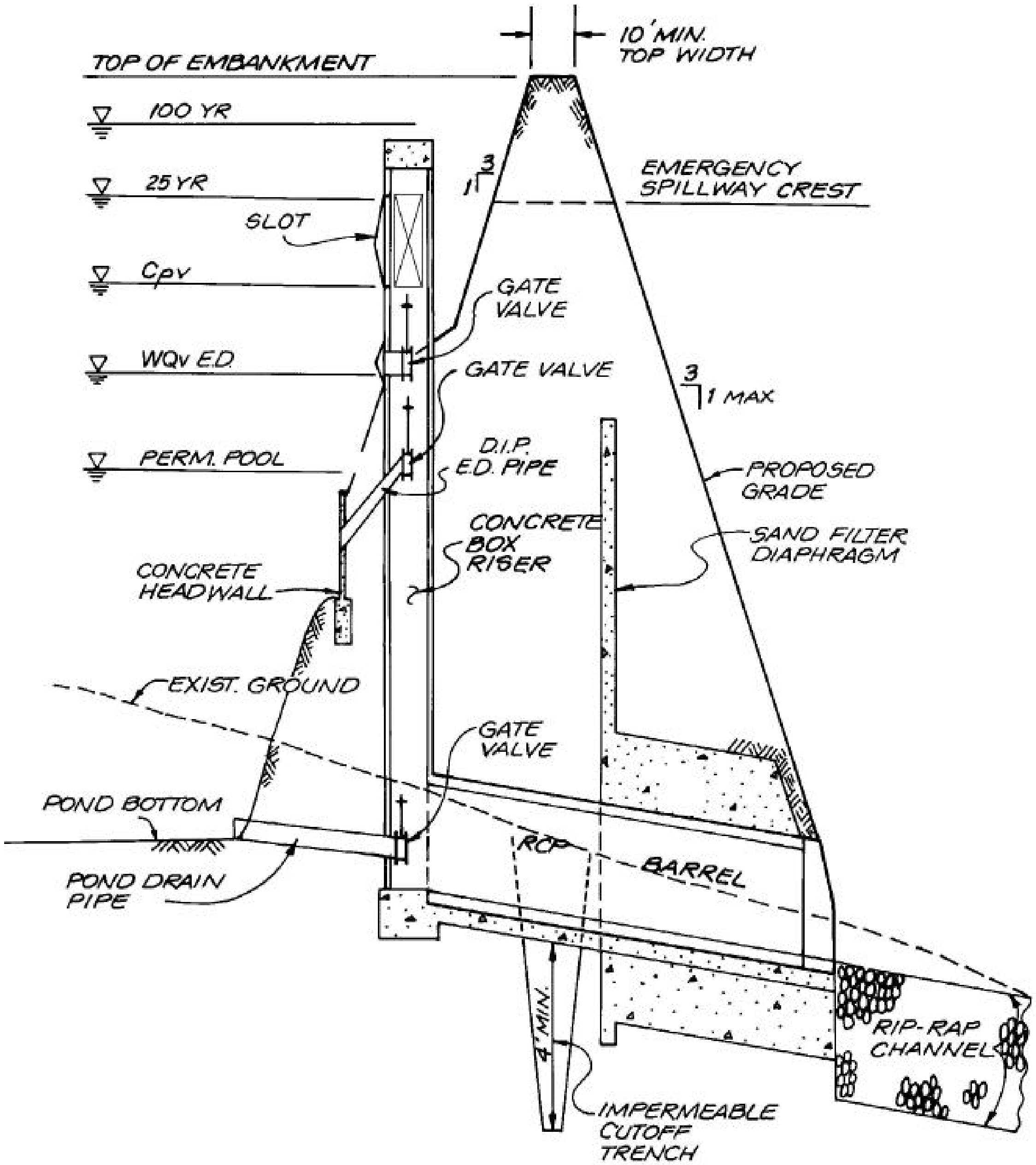


Figure E-II-2 Typical Outlet Structure Design

2.2.3 Streambank Erosion Rates

A prediction of the streambank erosion rates allows for the estimation of the streambank sediment load to the total sediment load in the stream. The identified sites were visually inspected to aid in the determination of streambank erosion rates. Erosion rates were determined by examining historical aerial photography to obtain the rate of lateral movement of the streambank. This lateral movement was measured in ft/yr and multiplied by the length of the erosion reach and bank height, as determined by field inspection, to obtain ft^3/yr. The amount of material in ft^3/yr was converted to tons/yr using a soil specific weight of $105 lbs/ft^3$.

2.2.4 Streambank Stabilization Measures

Preliminary plan designs were developed to address the erosion at each of the identified streambank erosion sites. Quantities were estimated for the development of cost estimates for each plan. The conditions of each individual site governed the selection of the stabilization method used. Descriptions of each of the streambank stabilization methods considered in this analysis are provided in sections 2.2.5 through 2.2.10. Typical views of potential measures are shown in Figures BII, Plates 1 through 4.

2.2.5 Longitudinal Peaked Stone Toe Protection.

Longitudinal peaked stone toe, LPST, is a form of stone armoring in which stone is placed at the toe of the eroded bank along the existing streambed. A typical crown elevation of the stone is between one-third and two-thirds of the top of bank height. As the toe of the bank is stabilized, the upper bank will reach a stable slope and the bank is stabilized. The stability is assisted by the establishment of a vegetated zone along the upper bank. The longitudinal stone toe allows for stabilization along a predetermined alignment. It also allows for the preservation of much of the existing vegetation on the bank slope, and encourages the growth of additional vegetation as the bank slope stabilizes (Biedenharn, 1997).

2.2.6 Cross-vanes.

The cross-vane is a low head rock grade control structure that decreases the near-bank shear stress and velocity while increasing the energy in the center of the channel. The structure establishes grade-control and reduces bank erosion while maintaining the sediment transport capacity of the stream. The cross-vane is also a stream habitat improvement structure due to an increase in bank cover, creation of holding and refuge cover, development of feeding lanes, and creation of spawning habitat (Rosgen, 2001).

2.2.7 Bendway Weirs.

A bendway weir is a low-level, upstream angled sill, attached to the outer bank of a bend and extending one quarter to one half the base flow width of the stream. Bendway weirs are usually emergent during low flows and act as spur dikes. However, they can be placed in streams with lower banks than are required for spur dikes. Bendway weirs were designed to be overtopped. Over-flowing water is redirected at a perpendicular angle to the weir. The weirs are typically angled at 5 to 20 degrees upstream, built of well-graded stone or gabions, spaced 45 to 100 feet apart, and 2 to 4 meters high. The reduction of the near bank velocity results in the deposition at the toe of the revetment along the outside of the bend. In addition, the thalweg of the channel is moved from the toe of the outer bank of the bend to the stream end of the weirs (Derrick, 1996).

2.2.8 Rootwad/Stone Toes Revetment.

Large logs with intact root wads are placed in trenches cut into the bank, such that the root wads extend beyond the bank face at the toe. The logs are overlapped and supported with stone to ensure stability, and the protruding rootwads effectively reduce flow velocities at the toe and over a range of flow elevations. A major advantage of this approach is that it reestablishes one of the natural roles of large woody debris in streams by creating a dynamic near-bank environment that traps organic material and provides colonization substrates for invertebrates and refuge habitats for fish. The logs eventually rot, resulting in a more natural bank. The revetment stabilizes the bank until woody vegetation has matured, at which time the channel can return to a more natural pattern (The Federal Interagency Stream Restoration Working Group, 1998).

2.2.9 Riparian Restoration.

Some of the streambank restoration measures include the restoration of vegetation buffer strips along the stream. The riparian restoration areas will include the establishment of willows along the upper bank of the stream channel and native vegetation within the riparian buffer. Buffer strips are known to improve water quality by buffering the impacts of adjacent land uses. Riparian buffer strips have been documented to provide shade that reduces water temperature, cause deposition of sediments, reduce nutrient loads, stabilize streambanks, reduce erosion due to runoff, and provide riparian wildlife habitat (The Federal Interagency Stream Restoration Working Group, 1998). In the urban corridors of the Butler watershed, stream buffers provide protection for the stream channel from future encroachments.

3.0 DESCRIPTION OF RECOMMENDED PLAN

3.1 GENERAL

Alternative 8 discussed in the body of the main report was selected as the recommended plan based on plan formulation and incremental analysis. Fact Sheets were developed for each of the 11 sites that make up the recommended plan. Design plates with overlain aerial photography are presented in section III to this Appendix.

Habitat restoration will directly improve aquatic and stream corridor habitat throughout both the Butler Creek and tributary reaches. Material excavated during construction and future maintenance activities would be hauled from the project area to an approved designated disposal area. Removal of riparian vegetation during these construction activities will be avoided to the extent feasible.

Riparian plantings will be a restoration component to improve the aquatic condition of the stream. Following construction, disturbed areas will be planted with native plant species to improve the fish and wildlife habitat. Soil conditions will be considered in the planting of riparian area. Plants that require long-term supplemental watering will be avoided due to the high maintenance costs and decreased potential for success.

Recommended detention ponds include a permanent pool that will provide for the settling of solids between storms and the removal of nutrients and dissolved pollutants. A littoral zone or wetland vegetation bench is designed to provide aquatic habitat and the enhancement of pollutant removal. Additional storage will be used for flood control for the larger storms.

Grade control structures are typically placed in severely unstable stream reaches. By preventing the headward migration of zones of degradation, grade control structures provide vertical stability to the stream and reduce the amount of sediment eroded from the streambed and banks. This not only protects the upstream reaches from the destabilizing effects of bed lowering, but can also minimize sedimentation problems in the downstream reaches. Grade control structures were considered for this project, but the presence of exposed bedrock throughout the Butler Creek watershed eliminated the need to artificially stabilize the stream bed.

3.2 Operation, Maintenance, Repair, Rehabilitation, and Replacement (OMRR&R) Considerations.

Based on implementation of the recommended plan and current policy and guidance, OMRR&R is the responsibility of the Sponsor. Annual maintenance responsibilities would be limited to minor activities at streambank stabilization and detention pond sites. This would involve periodic replacement of some rock and repair of the structures to the design grade and shape after significant storm events. Debris should be removed to prevent accumulations that could divert flows and cause unwanted erosion at the sites. To assure the effective stormwater treatment function of a storage facility, the permanent pool volume must be preserved. As sediment is captured over a period of time, the non-Federal sponsor will have to be able to periodically dewater the facility to mechanically remove the accumulation. Hence the control structures will be designed with gates that will allow the facility to be dewatered. Suggested operation and maintenance considerations are included in the alternative fact sheets.

3.3 Alternative Estimate Costs

The alternative estimate cost is the cost estimate associated with the level of effort required for this phase of the study. Alternative estimate costs were previously called ROM cost estimates. Alternative estimate costs were calculated based on quantity estimates developed in October 2008. The summary of costs for each proposed site can be found in Attachement 3 – Alternative Estimate Costs.

APPENDIX E – ENGINEERING APPENDIX

BUTLER CREEK SECTION 206
ECOSYSTEM RESTORATION REPORT

SECTION III - RECOMMENDED PLAN FACT SHEETS, PLAN VIEWS, AERIAL PHOTOGRAPHS AND TYPICAL MEASURE DRAWINGS

FACT SHEET

SITE: **B3-1**

SHEET REFERENCE NO: **C-1**

LOCATION: **Upstream of Schilling Chase Court**

DESIGN TYPE: **RETENTION BASIN RETROFIT PLAN**

DESIGN FEATURES: Design features include retrofitting an existing outlet structure. Riprap, plunge pool or pad, or other energy dissipater will be placed downstream of the outlet structure to prevent scouring and erosion.

The proposed detention basin outlet structure retrofit site is located near the headwaters of Butler Creek, just upstream of Schilling Chase Court. The wetland is designed to retain the 2-year return period flow from the tributary and release it over a 24-hour period. A grouted riprap emergency spillway is provided to prevent overtopping of the containment dike for flows with return periods less than a 10-year frequency. The runoff from storms with return periods greater than 10 years would overflow the basin, and repairs to the outlet structures may become necessary. The basin is intended to provide for the temporary storage of stormwater runoff to reduce downstream water quantity impacts.

O&M CONSIDERATIONS: Debris should be moved to prevent accumulations to minimize outlet clogging and to improve aesthetics following significant storm events or on an annual basis. As needed, remove sediment buildup, repair and revegetate eroded areas, perform structural repairs to inlets and outlets and mow to limit unwanted vegetation.

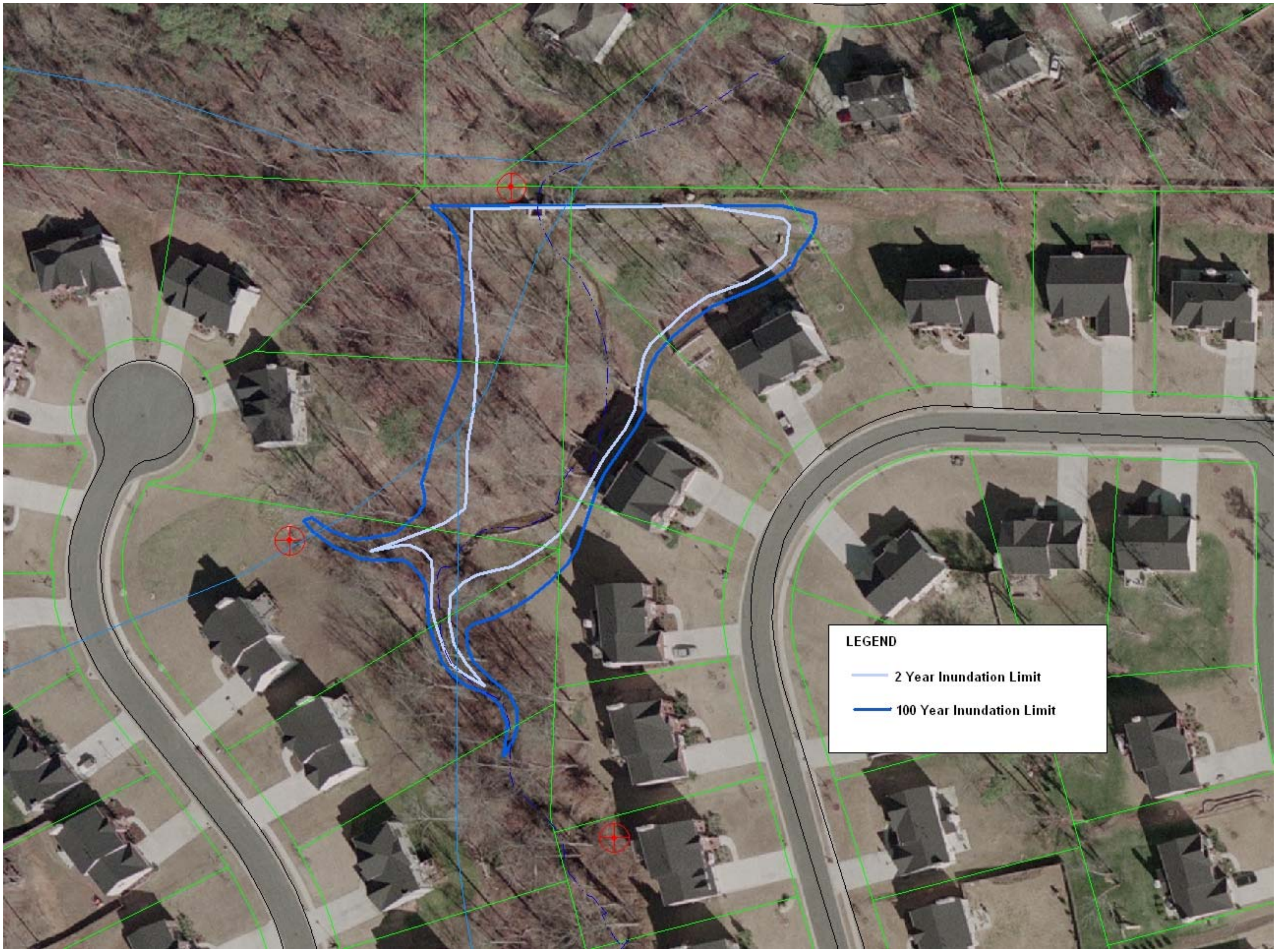


Figure E-III-1 Site B3-1 Inundation Limits

FACT SHEET

SITE: **B3-2-3**

SHEET REFERENCE NO: **C-2**

LOCATION: **Butler Ridge Park just West of Woodland Dr**

DESIGN TYPE: **Off-line Dry Detention**

DESIGN FEATURES: The 1.5 acre site is a field currently used for casual recreation. Design features include excavation and grading of the site to allow for detention of peak flows diverted from Butler Creek. A lateral diversion weir will divert flow into the site when water surfaces in the main stem of Butler Creek approach bank-full conditions. The weir will be a concrete headwall placed in a cut in the bank, parallel to stream flow, with a crest elevation just below the bankfull elevation. A containment berm constructed around the perimeter of the field will detain the diverted flow. The basin is designed to fill and overflow during high flows. The outlet structure is designed to slowly release floodwaters to fully drain the site in a 24-hour period. The site would still function as a recreational athletic field during dry conditions. Common recreation features such as back-stops and park benches could be included as part of this project feature.

O&M CONSIDERATIONS: Typical maintenance activities would include cleaning and removing debris from inlet and outlet structures and mowing the side slopes on a scheduled basis (usually monthly). Annual inspection for damage to the control structures is recommended. Repair undercut or eroded areas as needed.

FACT SHEET

SITE: **B3-2-2**

SHEET REFERENCE NO: **C-3**

LOCATION: **Near White Oak Court downstream of park footbridge**

DESIGN TYPE: **STREAMBANK STABILIZATION PLAN**

DESIGN FEATURES: The site includes 250 feet of active erosion. Design features include approximately 250 feet of channel bench with stone toe protection and native vegetation on the outside bends of both the right and left descending banks as well as approximately 0.25 acre of riparian zone restoration with native plantings on the right descending bank. Vegetation planted along the upper bank will be sufficient enough so that long-term survival rate will meet design criteria.

Channel benches will be constructed at the bankfull elevation of the existing channel and widening the channel to carry more flow. Stone toe will be used to stabilize the toe of the channel benches where velocities exceed 4.5 ft/sec. As the toe of the bank is stabilized, the upper bank will reach a stable slope and therefore be stabilized. Establishment of a riparian zone along the upper bank assists stability.

O&M CONSIDERATIONS: Annual maintenance responsibilities would involve periodic replacement of some rock and repair of the structures to the design grade and shape after significant storm events. Debris should be moved to prevent accumulations that could divert flows and cause unwanted erosion at the sites.

FACT SHEET

SITE: **B2-1**

SHEET REFERENCE NO: **C-6**

LOCATION: **Downstream of Pine Mountain Road near Pine Valley Trail and Wellcrest Drive**

DESIGN TYPE: **EXTENDED DETENTION AND STORMWATER WETLAND PLAN**

DESIGN FEATURES: Design features include the construction of an extended detention basin over the top of a stormwater wetland. Vegetation planted along the upper bank and in the riparian zone will be sufficient enough so that long-term survival rate will meet design criteria.

The design includes a 1.5 acre ED created wetland basin. A portion of the flow from Butler Creek will be diverted first through a small sediment forebay and then through the detention basin and back into the creek. The diversion channel and wetland will be excavated below the natural ground in the Butler Creek floodplain in order to divert water from the creek during low flows. A lateral diversion weir will divert flow into the site when water surfaces in the main stem of Butler Creek approach bank-full conditions. The weir will be a concrete headwall placed in a cut in the bank, parallel to stream flow, with a crest elevation just below the bankfull elevation. The design for the excavated wetland requires a containment berm along the existing sewer line. The basin is designed to fill and overflow during high flows. The outlet culvert is designed to slowly release floodwaters and return pond levels from a full, overflowing state to the normal pool elevation, with depths of 1 to 2 feet, in a 24-hour period.

O&M CONSIDERATIONS: Typical maintenance activities would include cleaning and removing debris from inlet and outlet structures and mowing the side slopes on a scheduled basis (usually monthly). Check for invasive vegetation on the wetland components on a semiannual basis. Annual inspection for damage to the control structure is recommended; signs of eutrophic conditions; signs of hydrocarbon build-up and if found remove immediately. Monitor the sediment accumulation in the wetland facility and in the forebay. Check the control gates, valves or other mechanical devices. Repair undercut or eroded areas as needed. Perform wetland plant management and harvesting if needed on an annual basis. Remove sediment from the forebay every 5 to 7 years or after 50% of the total forebay capacity has been lost. Care should be taken during pond drawdown to prevent downstream discharge of sediment, anoxic water and high flows with erosive velocities.

FACT SHEET

SITE: **B20**

SHEET REFERENCE NO: **C-9**

LOCATION: **Butler Creek floodplain**

DESIGN TYPE: **EXTENDED DETENTION STORMWATER WETLAND PLAN**

DESIGN FEATURES: Design features include extended detention over the top of a stormwater wetland. Vegetation planted along the upper bank and in the riparian zone will be sufficient enough so that long-term survival rate will meet design criteria.

The approximate 4.3 acre ED created wetland site is located in the Butler Creek floodplain off the main channel. A small intermittent tributary will be diverted through a forebay area and then into the detention area to allow the attenuation of the flows and sediment during storm events. A portion of the flow from Butler Creek will also be diverted first through a small forebay, then through the detention basin, and back into the creek. A lateral diversion weir will divert flow into the site when water surfaces in the main stem of Butler Creek approach bank-full conditions. The weir will be a concrete headwall placed in a cut in the bank, parallel to stream flow, with a crest elevation just below the bankfull elevation; the weir will not be placed deep enough to interfere with the existing sewer line. The diversion channel and wetland will be excavated below the natural ground in the Butler Creek floodplain in order to divert water from the creek during peak flows. Small, unexcavated fingers, or maintenance benches, will extend from both sides into the wetland. These fingers, left at the existing ground elevation (approximately elev. 916), serve two purposes. They will provide access into the wetland for maintenance and direct flow through the wetland in a meandering fashion to maximize travel distance and retention time. The design for the excavated wetland requires a containment berm along the main stem of Butler Creek. A spillway will allow excessive flows to safely pass through the basin and into Butler Creek. The outlet structure is designed to slowly release floodwaters and return pond levels from a full, overflowing state to the normal pool elevation, with depths of 1 to 2 feet, in a 24-hour period.

O&M CONSIDERATIONS: Typical maintenance activities would include cleaning and removing debris from inlet and outlet structures and mowing the side slopes on a scheduled basis (usually monthly). Check for invasive vegetation on the wetland components on a semiannual basis. Annual inspection for damage to the control structure is recommended; signs of eutrophic conditions; signs of hydrocarbon build-up and if found remove immediately. Monitor the sediment accumulation in the wetland facility and in the forebay. Check the control gates, valves or other mechanical devices. Repair undercut or eroded areas as needed. Perform wetland plant management and harvesting if needed on an annual basis. Remove sediment from the forebay every 5 to 7 years or after 50% of the total forebay capacity has been lost. Care should be taken during pond drawdown to prevent downstream discharge of sediment, anoxic water and high flows with erosive velocities.

FACT SHEET

SITE: **B50-2**

SHEET REFERENCE NO: **C-9**

LOCATION: **Adjacent to Site B20**

DESIGN TYPE: **STREAMBANK STABILIZATION PLAN**

DESIGN FEATURES: Design features include approximately 315 feet of longitudinal peaked stone toe protection. Vegetation planted along the upper bank will be sufficient enough so that long-term survival rate will meet design criteria.

O&M CONSIDERATIONS: Annual maintenance responsibilities would be limited to periodic replacement of some rock and repair of the structures to the design grade and shape after significant storm events. Debris should be moved to prevent accumulations that could divert flows and cause unwanted erosion at the sites.

FACT SHEET

SITE: **B50-1**

SHEET REFERENCE NO: **C-10**

LOCATION: **Adjacent to Loring Way**

DESIGN TYPE: **STREAMBANK STABILIZATION PLAN**

DESIGN FEATURES: Design features include approximately 95 feet of longitudinal stone toe protection on the right descending bank, and approximately 95 feet of bank shaping with toe protection and vegetation on the left descending bank. Vegetation planted along the upper bank will be sufficient enough so that long-term survival rate will meet design criteria.

O&M CONSIDERATIONS: Annual maintenance responsibilities would be limited to periodic replacement of some rock and repair of the structures to the design grade and shape after significant storm events. Debris should be moved to prevent accumulations that could divert flows and cause unwanted erosion at the sites.

FACT SHEET

SITE: **B40-2**

SHEET REFERENCE NO: **C-12**

LOCATION: **Parallel to Johnston Road**

DESIGN TYPE: **STREAMBANK STABILIZATION PLAN**

DESIGN FEATURES: The site includes 350 feet of active erosion. Design features include approximately 100 feet of bank shaping with stone toe protection and bank vegetation on the left descending bank and approximately 250 feet of longitudinal peaked stone toe protection on the right descending bank. Vegetation planted along the upper bank will be sufficient enough so that long-term survival rate will meet design criteria.

O&M CONSIDERATIONS: Annual maintenance responsibilities would be limited to periodic replacement of some rock and repair of the structures to the design grade and shape after significant storm events. Debris should be moved to prevent accumulations that could divert flows and cause unwanted erosion at the sites.

FACT SHEET

SITE: **B70**

SHEET REFERENCE NO: **C-13**

LOCATION: **Butler Creek floodplain adjacent to Loring Road**

DESIGN TYPE: **EXTENDED DETENTION STORMWATER WETLAND PLAN**

DESIGN FEATURES: Design features include the construction of extended detention created wetland. Vegetation planted along the upper bank and in the riparian zone will be sufficient enough so that long-term survival rate will meet design criteria.

The approximate 9 acre ED created wetland site is located in the Butler Creek floodplain off the main channel. A small intermittent tributary will be diverted through a forebay area and then into the detention area to allow the attenuation of the flows and sediment during storm events. Small, unexcavated fingers, or maintenance benches, will extend from both sides into the wetland. These fingers, left at the existing ground elevation, serve two purposes. They will provide access into the wetland for maintenance and direct flow through the wetland in a meandering fashion to maximize travel distance and retention time. The design for the excavated wetland requires a containment berm along the main stem of Butler Creek. The basin is designed to fill and overflow during high flows, but is able to contain flows with a return interval or 2 years or less without overtopping. The outlet culvert is designed to slowly release floodwaters and return pond levels from a full, overflowing state to the normal pool elevation, with depths of 1 to 2 feet, in a 24-hour period.

O&M CONSIDERATIONS: Typical maintenance activities would include cleaning and removing debris from inlet and outlet structures and mowing the side slopes on a scheduled basis (usually monthly). Check for invasive vegetation on the wetland components on a semiannual basis. Annual inspection for damage to the control structure is recommended; signs of eutrophic conditions; signs of hydrocarbon build-up and if found remove immediately. Monitor the sediment accumulation in the wetland facility and in the forebay. Check the control gates, valves or other mechanical devices. Repair undercut or eroded areas as needed. Perform wetland plant management and harvesting if needed on an annual basis. Remove sediment form the forebay every 5 to 7 years or after 50% of the total forebay capacity has been lost. Care should be taken during pond drawdown to prevent downstream discharge of sediment, anoxic water and high flows with erosive velocities.

FACT SHEET

SITE: **B40-1**

SHEET REFERENCE NO: **C-14**

LOCATION: **Parallel to Loring Road**

DESIGN TYPE: **STREAMBANK STABILIZATION PLAN**

DESIGN FEATURES: The site includes 380 feet of active erosion. Design features include the installation of a velocity dissipator on the downstream side of a culvert passing under an unnamed roadway just off Loring Road; longitudinal peaked stone toe protection along approximately 150 feet on the right descending bank just downstream of the velocity dissipator, approximately 175 feet of stone toe protection and rootwad combination structures on the right descending bank. Vegetation planted along the upper bank will be sufficient enough so that long-term survival rate will meet design criteria. Just upstream of this site, the culvert passing under the unnamed roadway will be removed and replaced with a precast concrete bridge to facilitate fish passage. See figure EII-7 for a typical drawing of this structure.

O&M CONSIDERATIONS: Annual maintenance responsibilities would be limited to periodic replacement of some rock and repair of the structures to the design grade and shape after significant storm events. Debris should be moved to prevent accumulations that could divert flows and cause unwanted erosion at the sites.

FACT SHEET

SITE: **B4-1-1**

SHEET REFERENCE NO: **C-18**

LOCATION: **Downstream of Cobb Parkway**

DESIGN TYPE: **STREAMBANK STABILIZATION PLAN**

DESIGN FEATURES: The site includes approximately 575 feet of active erosion. Design features include stone toe protection with rootwad combinations on approximately 325 feet of the left descending streambank, and 250 feet of stone toe/rootwad protection along the right descending bank. The site is immediately downstream of Cobb Parkway. Vegetation planted along the banks will be sufficient enough so that long-term survival rate will meet design criteria.

O&M CONSIDERATIONS: Annual maintenance responsibilities would be limited to periodic replacement of some rock and repair of the structures to the design grade and shape after significant storm events. Debris should be moved to prevent accumulations that could divert flows and cause unwanted erosion at the sites.

REFERENCES

Biedenharn, David S. 1997. Hydraulic Design Using Geomorphic Principles. Workshop No. 1.

Cobb County, Cities of Acworth and Kennesaw, Existing and Future Land Use, GIS

Cobb County Comprehensive Plan, 1996. As Amended, A Policy Guide 1995 - 2015

National Oceanic and Atmospheric Administration, National Weather Service, The Rainfall Frequency Atlas of the United States, TP-40, 1961

Derrick, David L., 1996. Harland Creek Innovative Bank Stabilization Demonstration Project, In 6th Annual Federal Interagency Sedimentation Conference, March 10-14, Las Vegas, Nevada.

Entrix, Ecosystem Restoration Report, Draft Problem Areas Report, Butler, Proctor, and Allatoona Creek Watersheds, Cobb County, Georgia, 2002

The Federal Interagency Stream Restoration Working Group, 1998, Stream Corridor Restoration, Principles, Processes, and Practices.

Georgia Stormwater Management Manual, 2001. Volume 2 Technical Handbook, First Edition.

Inman, Ernest J., 1995. Flood-Frequency Relations for Urban Steams in Georgia -1994 Update. U.S. Geological Survey Water-Resources Investigations Report 95-4017.

Natural Resource Conservation Service (NRCS), 1964. Soil Survey of Cobb County, Georgia. United States Department of Agriculture, Soil Conservation Service. Washington D.C.

Parsons Engineering and Science, Inc., 1999. Mayes, Sudderth and Etheredge, Inc., Final Report, Basinwide Stormwater Capital Improvement Studies, Priority Area 2, Cobb County, Georgia. Project No. SW760

Rosgen, D.L., 2001. The Cross Vein, W-Weir, and J-Hook Vein Structures, Their Description, Design and Application for Stream Stabilization and River Restoration.

ATTACHMENT 1

HEC-HMS OUTPUT

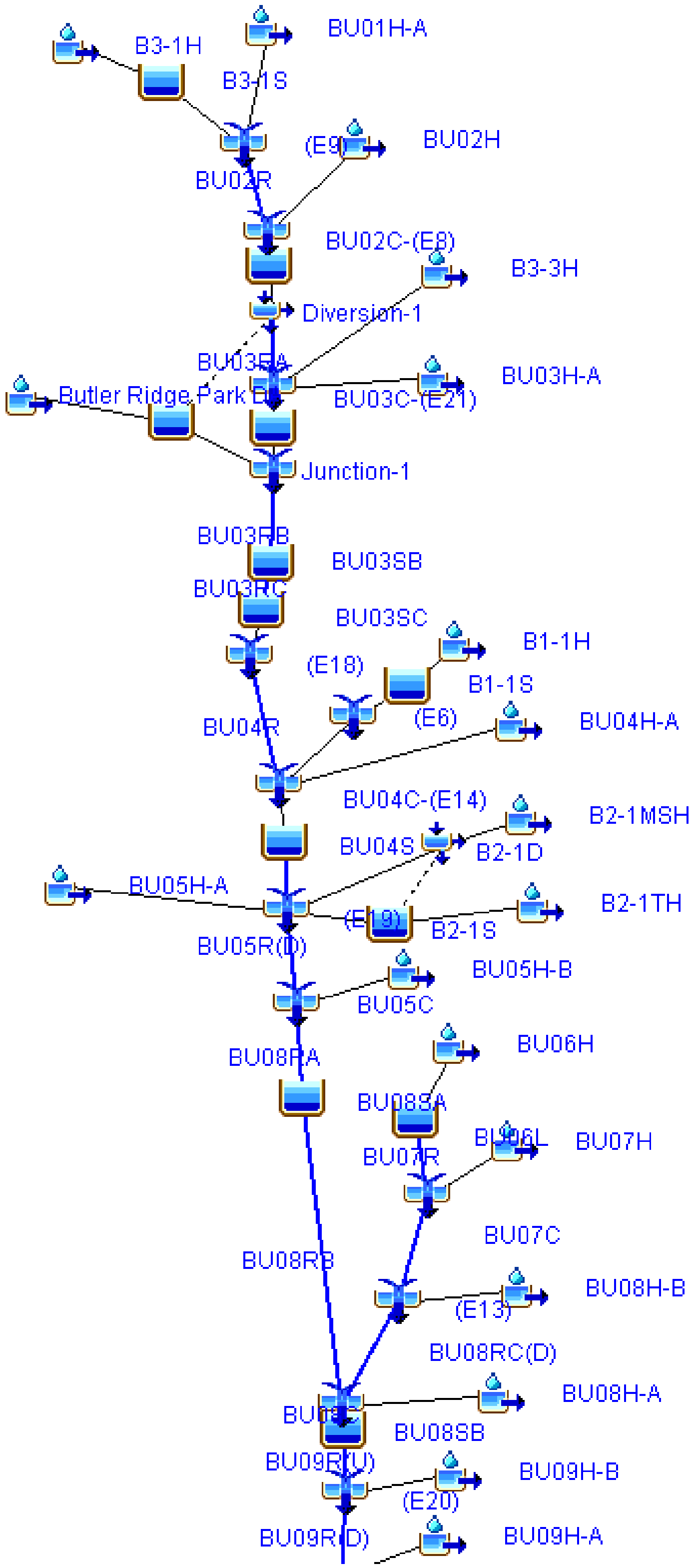


Figure E-IV-1 HEC-HMS Schematic (1 of 2)

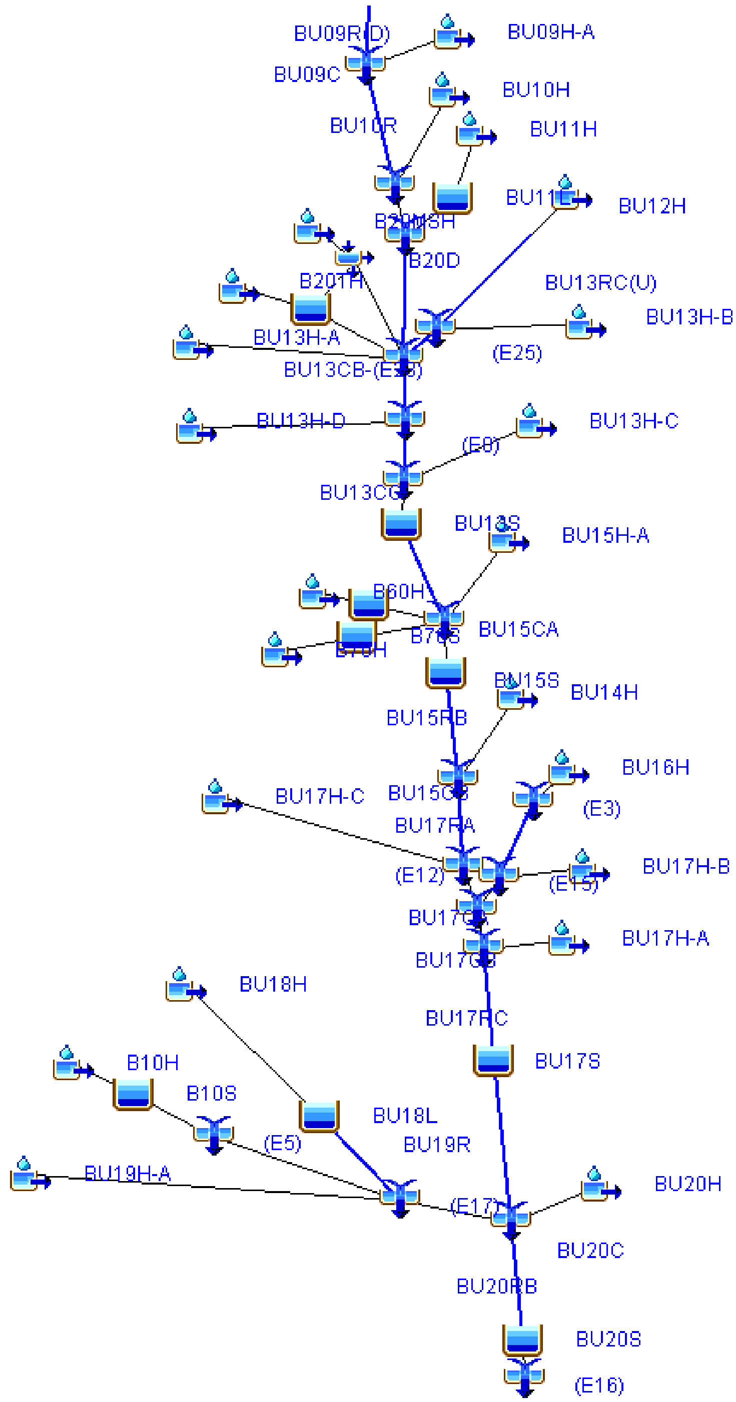


Figure E-IV-2 HEC-HMS Schematic (2 of 2)

Figure E-IV-3 Butler Creek Watershed Subbasins

TABLE E-IV-1
EXISTING CONDITIONS PEAK DISCHARGES

HMS Element	Peak Discharge (cfs) for Return Period (yrs)						
	2	**5**	**10**	**25**	**50**	**100**	**500**
(E0)	1604.3	2641.4	3406.2	4204.7	4836.1	5486.4	6867.2
(E12)	1559.8	2625.4	3384.1	4192.6	4901.4	5588.7	7162.2
(E13)	396.2	700.5	919.4	1158.9	1358.7	1546.8	1947.2
(E15)	204.7	401.5	553.3	715.7	842.0	961.0	1222.9
(E16)	1648.8	2752.2	3559.6	4335.8	5179.9	5788.0	7453.1
(E17)	704.4	1111.0	1396.8	1717.3	1979.7	2220.4	2702.3
(E18)	541.8	879.6	1115.2	1375.5	1579.5	1764.3	2139.0
(E19)	1120.2	1760.4	2246.9	2744.7	3112.5	3481.1	4205.5
(E20)	1491.7	2337.0	2877.4	3453.1	3927.7	4421.9	5861.5
(E25)	294.3	556.4	747.9	960.3	1139.8	1297.1	1647.4
(E3)	174.2	344.7	473.0	617.6	740.7	847.4	1091.3
(E5)	229.4	396.2	514.4	652.4	766.4	863.0	1065.6
(E6)	218.9	310.1	372.7	448.2	503.4	555.8	636.9
(E9)	146.0	233.6	294.2	366.1	424.5	474.1	573.1
B10H	229.4	396.2	514.4	652.4	766.4	863.0	1065.6
B1-1H	218.9	310.1	372.7	448.2	503.4	555.8	636.9
B20MSH	6.0	10.0	12.9	16.5	19.0	21.4	25.1
B20TH	39.7	67.5	87.5	111.9	129.9	146.2	173.6
B2-1MSH	196.6	313.6	393.9	489.5	563.0	627.4	742.9
B2-1TH	26.2	42.0	53.2	66.9	76.5	85.7	99.4
B3-1H	116.2	185.5	233.7	290.8	336.6	376.1	452.8
B3-3H	97.1	150.9	188.1	232.8	265.4	295.4	343.8
B60H	224.4	361.1	456.1	567.0	656.7	734.3	888.1
B70H	39.3	94.6	136.2	187.0	227.7	261.1	331.1
BU01H-A	53.1	82.8	103.8	129.4	148.2	165.5	193.7
BU02C-(E8)	298.5	482.7	610.5	757.4	876.8	981.2	1191.1
BU02H	158.9	259.8	330.0	410.5	476.3	533.9	650.6
BU02R	145.3	232.9	293.6	365.3	423.3	472.6	571.7
BU02S	295.5	478.9	606.5	755.2	874.9	979.1	1188.6
BU03C-(E21)	545.9	889.5	1130.2	1395.3	1603.9	1790.3	2165.7
BU03H-A	225.9	368.1	466.9	578.1	669.3	750.3	913.5
BU03RA	294.1	475.8	603.1	747.7	863.4	963.9	1166.2
BU03RB	544.0	885.6	1124.4	1387.6	1597.8	1782.4	2155.5
BU03RC	541.7	879.5	1115.2	1375.5	1579.2	1764.1	2139.3
BU03SA	544.8	886.8	1127.3	1391.9	1603.2	1788.2	2164.6
BU03SB	543.3	882.0	1118.3	1385.6	1596.0	1779.7	2153.1
BU03SC	541.8	879.6	1115.2	1375.5	1579.5	1764.3	2139.0
BU04C-(E14)	1082.6	1666.6	2057.8	2488.4	2804.6	3113.7	3731.8
BU04H-A	506.3	728.7	877.4	1041.6	1172.5	1298.5	1523.4
BU04R	539.7	876.4	1110.2	1371.1	1574.2	1757.5	2131.2
BU04S	1078.3	1663.4	2056.4	2486.6	2802.2	3116.0	3731.6
BU05C	1145.8	1839.3	2363.1	2912.1	3329.3	3764.9	4608.2
BU05H-A	354.5	533.6	655.3	796.4	908.8	1009.2	1196.1
BU05H-B	327.2	529.1	669.5	830.0	961.4	1076.8	1309.2
BU05R(D)	1038.3	1649.0	2087.7	2554.2	2905.5	3270.1	3952.1

TABLE E-IV-1
EXISTING CONDITIONS PEAK DISCHARGES

HMS Element	Peak Discharge (cfs) for Return Period (yrs)						
	2	5	10	25	50	100	500
BU05R(U)	978.1	1530.5	1916.2	2328.0	2645.1	2943.5	3528.9
BU06H	33.1	57.0	73.9	93.9	110.3	124.1	152.9
BU06L	1.9	3.8	5.9	16.9	26.3	34.8	57.2
BU07C	382.3	674.6	883.0	1112.2	1310.9	1492.0	1880.0
BU07H	381.3	672.5	879.8	1107.8	1297.9	1468.1	1829.0
BU07R	1.9	3.8	5.9	16.9	26.3	34.8	57.2
BU08C	1573.1	2457.9	3018.1	3610.1	4105.3	4608.8	6095.8
BU08H-A	218.0	365.6	469.3	586.7	683.9	768.9	944.5
BU08H-B	77.9	135.0	176.1	226.0	264.4	297.8	360.1
BU08RA	1143.6	1827.9	2345.5	2894.2	3309.4	3745.7	4584.1
BU08RB	1136.2	1760.6	2150.3	2578.2	2903.6	3346.1	4299.9
BU08RC(D)	394.7	698.6	914.6	1151.6	1349.2	1535.7	1931.2
BU08RC(U)	381.3	672.9	880.9	1109.7	1306.5	1486.2	1872.4
BU08SA	1138.4	1763.8	2157.4	2596.1	2933.8	3424.9	4423.9
BU08SB	1573.0	2457.0	3016.7	3608.9	4103.0	4608.0	6092.3
BU09C	1371.5	2174.3	2704.4	3261.5	3736.4	4198.7	5521.8
BU09H-A	195.7	324.7	415.4	516.4	599.9	674.8	828.7
BU09H-B	66.4	104.8	132.0	165.1	189.7	212.0	249.3
BU09R(D)	1237.0	1952.8	2437.5	2983.3	3380.8	3881.0	5126.6
BU09R(U)	1483.0	2324.2	2859.3	3431.0	3906.4	4397.6	5837.8
BU10C	1466.0	2360.8	2960.5	3582.4	4098.4	4615.6	5889.1
BU10H	192.7	353.4	470.4	602.4	713.8	810.5	1022.9
BU10R	1360.1	2162.8	2692.7	3253.1	3718.3	4189.4	5480.9
BU11H	40.2	73.7	97.9	126.4	150.1	169.9	212.5
BU11L	17.0	35.9	56.2	85.4	108.8	127.6	168.7
BU12H	276.5	524.4	706.1	910.5	1083.6	1233.3	1566.6
BU13CA	1481.8	2393.5	3004.1	3637.0	4162.5	4688.9	5951.5
BU13CB-(E23)	1605.0	2657.6	3419.6	4214.3	4851.1	5496.4	6864.5
BU13CC	1634.2	2661.6	3434.8	4260.5	4892.2	5564.8	6988.0
BU13H-A	45.3	83.7	111.4	144.9	170.4	192.6	233.2
BU13H-B	85.1	136.3	172.4	216.2	249.4	278.9	330.6
BU13H-C	188.0	304.9	386.3	479.9	556.3	623.0	757.1
BU13H-D	56.7	93.5	119.7	152.0	175.8	197.3	233.8
BU13RB	1457.0	2358.6	2974.5	3611.0	4133.2	4657.2	5918.3
BU13RC(D)	286.9	543.3	731.9	941.2	1118.2	1273.6	1620.8
BU13RC(U)	276.1	523.6	705.2	909.1	1081.5	1230.5	1562.8
BU13RD(D)	1601.6	2615.9	3369.5	4166.8	4793.6	5441.9	6842.3
BU13RD(U)	1601.4	2634.2	3394.5	4187.7	4820.0	5465.8	6846.1
BU13S	1634.1	2660.8	3433.7	4260.1	4891.2	5563.8	6987.4
BU14H	219.2	367.2	471.3	588.1	684.8	770.5	947.8
BU15CA	1593.0	2640.1	3396.4	4210.9	4901.7	5584.8	7109.8
BU15CB	1596.4	2660.7	3419.0	4236.4	4959.1	5656.8	7232.9
BU15H-A	164.1	284.2	369.2	470.1	552.1	621.0	762.6
BU15RA	1561.8	2570.2	3328.4	4141.1	4763.7	5430.7	6859.0
BU15RB	1574.9	2613.8	3368.7	4176.0	4857.3	5537.1	7059.4

TABLE E-IV-1
EXISTING CONDITIONS PEAK DISCHARGES

HMS Element	Peak Discharge (cfs) for Return Period (yrs)						
	2	5	10	25	50	100	500
BU15S	1593.0	2640.1	3396.4	4210.9	4901.8	5584.8	7109.8
BU16H	174.2	344.7	473.0	617.6	740.7	847.4	1091.3
BU17CA	1600.3	2714.7	3498.5	4343.7	5122.1	5846.3	7531.2
BU17CB	1614.0	2734.8	3526.1	4372.7	5160.9	5880.0	7587.2
BU17H-A	204.8	299.0	363.1	439.6	498.2	551.3	642.2
BU17H-B	143.9	240.2	308.7	390.4	455.8	511.3	621.5
BU17H-C	70.7	123.2	160.6	205.7	239.7	269.6	322.7
BU17RA	1555.0	2617.6	3372.1	4179.2	4884.8	5574.8	7141.3
BU17RB	173.3	342.7	470.4	613.5	734.2	838.9	1079.0
BU17RC	1612.3	2730.7	3517.2	4356.9	5137.4	5851.2	7548.2
BU17S	1611.7	2730.2	3508.6	4344.8	5077.0	5739.8	7326.0
BU18H	78.6	150.2	202.5	262.1	312.2	355.2	450.8
BU18L	49.6	96.0	154.3	219.9	271.3	314.3	415.0
BU19H-A	503.2	755.5	926.4	1114.1	1265.3	1408.8	1677.3
BU19R	49.5	95.7	152.6	217.6	269.0	311.1	409.2
BU20C	1661.6	2803.0	3624.5	4420.2	5282.1	5894.6	7595.2
BU20H	138.9	296.6	418.9	557.1	675.0	777.2	1016.5
BU20RA	1537.2	2606.3	3363.7	4153.2	4874.1	5520.3	7039.8
BU20RB	1649.6	2760.6	3562.0	4338.5	5183.0	5791.4	7455.9
BU20S	1648.8	2752.2	3559.6	4335.8	5179.9	5788.0	7453.1

TABLE E-IV-2
FUTURE WITHOUT PROJECT CONDITIONS PEAK DISCHARGES

HMS Element	Peak Discharge (cfs) for Return Period (yrs)						
	2	5	10	25	50	100	500
(E0)	2236.4	3418.3	4232.1	5097.1	5790.4	6530.6	7995.2
(E12)	2146.8	3351.3	4169.1	5063.3	5802.7	6603.3	8245.7
(E13)	595.7	944.6	1184.9	1458.9	1683.4	1890.9	2344.1
(E15)	463.0	728.6	905.6	1095.9	1254.4	1407.7	1705.0
(E16)	2216.5	3478.2	4338.8	5174.8	6010.7	6705.4	8495.5
(E17)	1067.9	1578.4	1931.1	2364.5	2703.4	3017.6	3558.4
(E18)	639.5	994.2	1242.8	1501.6	1712.7	1908.8	2282.2
(E19)	1284.8	1973.3	2460.5	2941.3	3303.1	3679.7	4390.3
(E20)	2078.1	2898.0	3432.7	4061.7	4512.5	5135.1	6579.6
(E25)	551.2	873.9	1096.1	1341.2	1543.3	1728.8	2096.4
(E3)	412.9	649.4	812.5	991.9	1138.2	1273.8	1539.7
(E5)	501.5	712.9	854.9	1022.7	1152.7	1272.3	1476.2
(E6)	238.4	335.3	401.8	482.3	539.6	595.2	676.5
(E9)	178.7	274.3	339.8	417.8	479.9	533.7	636.2
B10H	501.5	712.9	854.9	1022.7	1152.7	1272.3	1476.2
B1-1H	238.4	335.3	401.8	482.3	539.6	595.2	676.5
B20MSH	60.0	89.5	110.6	136.3	154.3	171.7	197.3

TABLE E-IV-2
FUTURE WITHOUT PROJECT CONDITIONS PEAK DISCHARGES

HMS Element	Peak Discharge (cfs) for Return Period (yrs)						
	2	5	10	25	50	100	500
B20TH	9.3	13.5	16.5	20.2	22.6	25.1	28.5
B2-1MSH	288.4	418.4	506.9	613.4	690.8	763.7	876.0
B2-1TH	36.2	52.5	63.9	77.9	87.2	96.8	109.3
B3-1H	142.6	218.1	270.0	331.8	380.2	422.7	500.7
B3-3H	121.7	176.3	213.7	258.9	291.0	321.8	367.5
B60H	329.5	486.1	592.5	718.6	817.3	905.8	1064.0
B70H	140.4	210.7	260.2	320.8	364.4	405.3	469.2
BU01H-A	61.1	92.2	114.2	141.0	160.2	178.3	206.0
BU02C-(E8)	352.3	546.1	679.5	833.6	957.4	1066.2	1276.7
BU02H	184.9	291.1	364.3	447.9	515.6	575.7	693.2
BU02R	177.8	273.2	338.4	416.6	478.6	532.3	633.8
BU02S	347.3	541.8	674.1	831.0	954.3	1062.8	1272.9
BU03C-(E21)	645.9	1010.7	1261.0	1529.9	1743.5	1937.5	2316.6
BU03H-A	267.3	416.5	518.7	634.0	727.5	811.8	975.4
BU03RA	345.3	537.6	669.7	818.9	937.3	1040.9	1245.5
BU03RB	642.8	1004.5	1252.3	1522.1	1735.2	1926.7	2303.0
BU03RC	639.6	994.2	1243.0	1501.8	1713.4	1909.6	2282.1
BU03SA	644.5	1007.0	1256.9	1527.5	1742.3	1935.3	2314.1
BU03SB	641.7	998.5	1248.4	1519.1	1732.7	1923.9	2299.5
BU03SC	639.5	994.2	1242.8	1501.6	1712.7	1908.8	2282.2
BU04C-(E14)	1249.4	1846.7	2255.1	2671.9	2985.3	3304.7	3917.9
BU04H-A	621.7	865.2	1026.1	1207.6	1350.8	1488.7	1724.3
BU04R	636.6	989.9	1235.8	1494.8	1706.8	1902.4	2273.4
BU04S	1243.6	1845.3	2252.4	2669.4	2984.2	3305.5	3916.7
BU05C	1454.3	2120.6	2592.1	3124.7	3525.6	3968.9	4782.7
BU05H-A	633.0	837.0	972.3	1134.4	1255.7	1374.6	1553.9
BU05H-B	641.2	888.3	1052.3	1244.1	1393.0	1533.2	1768.0
BU05R(D)	1216.0	1838.7	2287.9	2750.3	3094.1	3465.5	4133.7
BU05R(U)	1119.7	1706.0	2100.8	2508.5	2825.6	3129.7	3715.9
BU06H	54.9	82.6	101.6	123.8	141.4	157.1	185.9
BU06L	3.1	6.9	19.4	33.0	45.1	54.1	116.0
BU07C	573.5	906.9	1136.4	1403.9	1622.2	1821.2	2260.3
BU07H	571.7	903.3	1131.6	1381.0	1584.3	1773.7	2144.7
BU07R	3.1	6.9	19.4	33.0	45.1	54.1	115.6
BU08C	2187.3	3040.3	3592.5	4238.4	4704.2	5341.1	6831.5
BU08H-A	346.4	520.3	638.4	773.6	882.0	979.9	1163.0
BU08H-B	124.9	189.3	234.5	289.5	329.7	367.0	426.8
BU08RA	1424.8	2075.1	2579.3	3110.6	3510.8	3956.4	4769.2
BU08RB	1394.2	1969.7	2396.4	2819.9	3169.4	3720.0	4568.1
BU08RC(D)	592.5	938.2	1175.9	1445.9	1667.7	1873.2	2318.3
BU08RC(U)	571.6	904.2	1133.2	1397.9	1614.3	1812.2	2246.8
BU08SA	1402.1	1973.4	2404.0	2841.8	3200.7	3806.2	4669.3
BU08SB	2187.0	3037.9	3590.2	4236.5	4702.9	5339.5	6833.5
BU09C	1914.9	2730.8	3265.3	3872.5	4351.2	4891.2	6280.0
BU09H-A	248.1	388.1	484.5	591.7	679.1	759.1	915.6

TABLE E-IV-2
FUTURE WITHOUT PROJECT CONDITIONS PEAK DISCHARGES

HMS Element	Peak Discharge (cfs) for Return Period (yrs)						
	2	5	10	25	50	100	500
BU09H-B	77.3	116.9	144.7	178.5	203.2	226.1	262.7
BU09R(D)	1694.9	2421.8	2912.0	3456.7	3885.7	4499.7	5718.7
BU09R(U)	2063.2	2878.5	3410.1	4034.2	4486.6	5108.9	6551.1
BU10C	2038.9	2989.3	3606.9	4278.2	4832.6	5394.2	6793.3
BU10H	332.1	527.1	662.1	813.2	936.6	1048.3	1269.9
BU10R	1874.1	2704.7	3244.8	3846.9	4326.4	4879.2	6224.4
BU11H	77.9	118.6	146.5	179.3	205.3	228.3	271.4
BU11L	34.8	72.4	101.1	130.5	153.5	174.2	211.8
BU12H	527.4	834.4	1047.2	1284.3	1477.9	1654.4	2003.7
BU13CA	2069.6	3036.6	3669.6	4353.1	4921.9	5492.9	6890.6
BU13CB-(E23)	2251.8	3442.1	4249.8	5109.6	5810.4	6531.4	7985.6
BU13CC	2243.1	3430.2	4269.0	5161.0	5844.6	6639.5	8134.0
BU13H-A	88.2	130.9	160.8	197.1	222.7	247.3	283.9
BU13H-B	106.4	160.9	199.0	245.1	278.9	310.2	360.6
BU13H-C	226.7	352.0	438.3	537.9	618.2	689.0	825.9
BU13H-D	83.8	123.6	151.5	185.4	209.3	232.3	266.1
BU13RB	2011.8	2989.9	3626.3	4312.2	4867.9	5449.4	6828.7
BU13RC(D)	537.2	854.9	1074.5	1315.8	1515.7	1699.7	2064.0
BU13RC(U)	526.4	833.0	1044.5	1280.2	1473.1	1648.8	1997.2
BU13RD(D)	2210.2	3374.3	4185.5	5048.4	5729.8	6488.8	7969.9
BU13RD(U)	2230.2	3407.8	4216.6	5076.2	5770.8	6505.8	7971.1
BU13S	2242.5	3428.9	4268.0	5160.6	5843.3	6638.1	8133.3
BU14H	307.6	472.9	585.9	712.3	815.0	908.8	1089.3
BU15CA	2184.8	3382.9	4205.7	5099.3	5832.0	6617.0	8235.0
BU15CB	2181.5	3400.7	4220.3	5131.5	5889.7	6696.7	8346.8
BU15H-A	272.7	413.8	511.3	627.2	717.2	797.0	940.7
BU15RA	2138.5	3305.1	4130.4	5009.3	5669.0	6433.3	7960.6
BU15RB	2158.0	3346.9	4160.3	5049.1	5769.9	6551.9	8160.6
BU15S	2184.8	3382.8	4205.7	5099.3	5831.9	6617.0	8234.9
BU16H	412.9	649.4	812.5	991.9	1138.2	1273.8	1539.7
BU17CA	2203.7	3469.7	4319.1	5261.6	6059.0	6909.7	8654.9
BU17CB	2226.3	3495.0	4358.6	5300.1	6099.8	6949.8	8722.3
BU17H-A	357.1	458.1	526.9	612.1	671.8	733.7	814.3
BU17H-B	252.2	370.7	452.2	550.4	623.9	691.3	802.7
BU17H-C	121.7	179.8	220.4	269.9	304.5	338.1	386.9
BU17RA	2139.0	3341.3	4152.5	5045.3	5783.5	6586.4	8216.0
BU17RB	409.1	642.6	801.2	975.1	1119.1	1252.2	1513.9
BU17RC	2224.0	3484.0	4339.9	5271.7	6065.7	6907.5	8670.1
BU17S	2223.5	3473.3	4326.0	5200.8	5930.9	6665.4	8597.3
BU18H	310.6	417.9	488.6	570.7	634.2	695.9	795.6
BU18L	228.6	340.7	417.8	495.8	555.1	613.7	701.3
BU19H-A	587.3	878.0	1074.7	1298.2	1477.2	1640.7	1945.3
BU19R	223.9	333.2	406.7	479.7	535.2	591.6	679.9
BU20C	2253.7	3551.4	4430.5	5281.8	6134.0	6825.6	8716.3
BU20H	369.3	598.8	758.6	933.1	1076.3	1209.0	1475.5

TABLE E-IV-2
FUTURE WITHOUT PROJECT CONDITIONS PEAK DISCHARGES

HMS Element	Peak Discharge (cfs) for Return Period (yrs)						
	2	**5**	**10**	**25**	**50**	**100**	**500**
BU20RA	2117.6	3306.6	4120.1	4977.2	5680.8	6424.2	8073.7
BU20RB	2218.6	3486.0	4341.5	5178.1	6014.6	6707.9	8501.8
BU20S	2216.5	3478.2	4338.8	5174.8	6010.7	6705.4	8495.5

TABLE E-IV-3
FUTURE WITH ED B10 PROJECT CONDITIONS PEAK DISCHARGES

HMS Element	Peak Discharge (cfs) for Return Period (yrs)						
	2.0	**5.0**	**10.0**	**25.0**	**50.0**	**100.0**	**500.0**
(E0)	2236.4	3418.3	4232.1	5097.1	5790.4	6530.6	7995.2
(E12)	2146.8	3351.3	4169.1	5063.3	5802.7	6603.3	8245.7
(E13)	595.7	944.6	1184.9	1458.9	1683.4	1890.9	2344.1
(E15)	463.0	728.6	905.6	1095.9	1254.4	1407.7	1705.0
(E16)	2226.9	3479.1	4339.0	5175.1	6011.2	6706.0	8496.9
(E17)	1085.3	1602.8	1967.3	2411.0	2752.1	3059.8	3563.8
(E18)	639.5	994.2	1242.8	1501.6	1712.7	1908.8	2282.2
(E19)	1284.8	1973.3	2460.5	2941.3	3303.1	3679.7	4390.3
(E20)	2078.1	2898.0	3432.7	4061.7	4512.5	5135.1	6579.6
(E25)	551.2	873.9	1096.1	1341.2	1543.3	1728.8	2096.4
(E3)	412.9	649.4	812.5	991.9	1138.2	1273.8	1539.7
(E5)	495.6	705.7	846.6	1012.9	1141.8	1293.9	1478.1
(E6)	238.4	335.3	401.8	482.3	539.6	595.2	676.5
(E9)	178.7	274.3	339.8	417.8	479.9	533.7	636.2
B10H	501.5	712.9	854.9	1022.7	1152.7	1272.3	1476.2
B10S	495.6	705.7	846.6	1012.9	1141.8	1293.9	1478.1
B1-1H	238.4	335.3	401.8	482.3	539.6	595.2	676.5
B20MSH	60.0	89.5	110.6	136.3	154.3	171.7	197.3
B20TH	9.3	13.5	16.5	20.2	22.6	25.1	28.5
B2-1MSH	288.4	418.4	506.9	613.4	690.8	763.7	876.0
B2-1TH	36.2	52.5	63.9	77.9	87.2	96.8	109.3
B3-1H	142.6	218.1	270.0	331.8	380.2	422.7	500.7
B3-3H	121.7	176.3	213.7	258.9	291.0	321.8	367.5
B60H	329.5	486.1	592.5	718.6	817.3	905.8	1064.0
B70H	140.4	210.7	260.2	320.8	364.4	405.3	469.2
BU01H-A	61.1	92.2	114.2	141.0	160.2	178.3	206.0
BU02C-(E8)	352.3	546.1	679.5	833.6	957.4	1066.2	1276.7
BU02H	184.9	291.1	364.3	447.9	515.6	575.7	693.2
BU02R	177.8	273.2	338.4	416.6	478.6	532.3	633.8
BU02S	347.3	541.8	674.1	831.0	954.3	1062.8	1272.9
BU03C-(E21)	645.9	1010.7	1261.0	1529.9	1743.5	1937.5	2316.6
BU03H-A	267.3	416.5	518.7	634.0	727.5	811.8	975.4
BU03RA	345.3	537.6	669.7	818.9	937.3	1040.9	1245.5
BU03RB	642.8	1004.5	1252.3	1522.1	1735.2	1926.7	2303.0

TABLE E-IV-3 FUTURE WITH ED B10 PROJECT CONDITIONS PEAK DISCHARGES							
HMS Element	Peak Discharge (cfs) for Return Period (yrs)						
	2.0	5.0	10.0	25.0	50.0	100.0	500.0
BU03RC	639.6	994.2	1243.0	1501.8	1713.4	1909.6	2282.1
BU03SA	644.5	1007.0	1256.9	1527.5	1742.3	1935.3	2314.1
BU03SB	641.7	998.5	1248.4	1519.1	1732.7	1923.9	2299.5
BU03SC	639.5	994.2	1242.8	1501.6	1712.7	1908.8	2282.2
BU04C-(E14)	1249.4	1846.7	2255.1	2671.9	2985.3	3304.7	3917.9
BU04H-A	621.7	865.2	1026.1	1207.6	1350.8	1488.7	1724.3
BU04R	636.6	989.9	1235.8	1494.8	1706.8	1902.4	2273.4
BU04S	1243.6	1845.3	2252.4	2669.4	2984.2	3305.5	3916.7
BU05C	1454.3	2120.6	2592.1	3124.7	3525.6	3968.9	4782.7
BU05H-A	633.0	837.0	972.3	1134.4	1255.7	1374.6	1553.9
BU05H-B	641.2	888.3	1052.3	1244.1	1393.0	1533.2	1768.0
BU05R(D)	1216.0	1838.7	2287.9	2750.3	3094.1	3465.5	4133.7
BU05R(U)	1119.7	1706.0	2100.8	2508.5	2825.6	3129.7	3715.9
BU06H	54.9	82.6	101.6	123.8	141.4	157.1	185.9
BU06L	3.1	6.9	19.4	33.0	45.1	54.1	116.0
BU07C	573.5	906.9	1136.4	1403.9	1622.2	1821.2	2260.3
BU07H	571.7	903.3	1131.6	1381.0	1584.3	1773.7	2144.7
BU07R	3.1	6.9	19.4	33.0	45.1	54.1	115.6
BU08C	2187.3	3040.3	3592.5	4238.4	4704.2	5341.1	6831.5
BU08H-A	346.4	520.3	638.4	773.6	882.0	979.9	1163.0
BU08H-B	124.9	189.3	234.5	289.5	329.7	367.0	426.8
BU08RA	1424.8	2075.1	2579.3	3110.6	3510.8	3956.4	4769.2
BU08RB	1394.2	1969.7	2396.4	2819.9	3169.4	3720.0	4568.1
BU08RC(D)	592.5	938.2	1175.9	1445.9	1667.7	1873.2	2318.3
BU08RC(U)	571.6	904.2	1133.2	1397.9	1614.3	1812.2	2246.8
BU08SA	1402.1	1973.4	2404.0	2841.8	3200.7	3806.2	4669.3
BU08SB	2187.0	3037.9	3590.2	4236.5	4702.9	5339.5	6833.5
BU09C	1914.9	2730.8	3265.3	3872.5	4351.2	4891.2	6280.0
BU09H-A	248.1	388.1	484.5	591.7	679.1	759.1	915.6
BU09H-B	77.3	116.9	144.7	178.5	203.2	226.1	262.7
BU09R(D)	1694.9	2421.8	2912.0	3456.7	3885.7	4499.7	5718.7
BU09R(U)	2063.2	2878.5	3410.1	4034.2	4486.6	5108.9	6551.1
BU10C	2038.9	2989.3	3606.9	4278.2	4832.6	5394.2	6793.3
BU10H	332.1	527.1	662.1	813.2	936.6	1048.3	1269.9
BU10R	1874.1	2704.7	3244.8	3846.9	4326.4	4879.2	6224.4
BU11H	77.9	118.6	146.5	179.3	205.3	228.3	271.4
BU11L	34.8	72.4	101.1	130.5	153.5	174.2	211.8
BU12H	527.4	834.4	1047.2	1284.3	1477.9	1654.4	2003.7
BU13CA	2069.6	3036.6	3669.6	4353.1	4921.9	5492.9	6890.6
BU13CB-(E23)	2251.8	3442.1	4249.8	5109.6	5810.4	6531.4	7985.6
BU13CC	2243.1	3430.2	4269.0	5161.0	5844.6	6639.5	8134.0
BU13H-A	88.2	130.9	160.8	197.1	222.7	247.3	283.9
BU13H-B	106.4	160.9	199.0	245.1	278.9	310.2	360.6
BU13H-C	226.7	352.0	438.3	537.9	618.2	689.0	825.9
BU13H-D	83.8	123.6	151.5	185.4	209.3	232.3	266.1

TABLE E-IV-3 FUTURE WITH ED B10 PROJECT CONDITIONS PEAK DISCHARGES							
HMS Element	Peak Discharge (cfs) for Return Period (yrs)						
	2.0	5.0	10.0	25.0	50.0	100.0	500.0
BU13RB	2011.8	2989.9	3626.3	4312.2	4867.9	5449.4	6828.7
BU13RC(D)	537.2	854.9	1074.5	1315.8	1515.7	1699.7	2064.0
BU13RC(U)	526.4	833.0	1044.5	1280.2	1473.1	1648.8	1997.2
BU13RD(D)	2210.2	3374.3	4185.5	5048.4	5729.8	6488.8	7969.9
BU13RD(U)	2230.2	3407.8	4216.6	5076.2	5770.8	6505.8	7971.1
BU13S	2242.5	3428.9	4268.0	5160.6	5843.3	6638.1	8133.3
BU14H	307.6	472.9	585.9	712.3	815.0	908.8	1089.3
BU15CA	2184.8	3382.9	4205.7	5099.3	5832.0	6617.0	8235.0
BU15CB	2181.5	3400.7	4220.3	5131.5	5889.7	6696.7	8346.8
BU15H-A	272.7	413.8	511.3	627.2	717.2	797.0	940.7
BU15RA	2138.5	3305.1	4130.4	5009.3	5669.0	6433.3	7960.6
BU15RB	2158.0	3346.9	4160.3	5049.1	5769.9	6551.9	8160.6
BU15S	2184.8	3382.8	4205.7	5099.3	5831.9	6617.0	8234.9
BU16H	412.9	649.4	812.5	991.9	1138.2	1273.8	1539.7
BU17CA	2203.7	3469.7	4319.1	5261.6	6059.0	6909.7	8654.9
BU17CB	2226.3	3495.0	4358.6	5300.1	6099.8	6949.8	8722.3
BU17H-A	357.1	458.1	526.9	612.1	671.8	733.7	814.3
BU17H-B	252.2	370.7	452.2	550.4	623.9	691.3	802.7
BU17H-C	121.7	179.8	220.4	269.9	304.5	338.1	386.9
BU17RA	2139.0	3341.3	4152.5	5045.3	5783.5	6586.4	8216.0
BU17RB	409.1	642.6	801.2	975.1	1119.1	1252.2	1513.9
BU17RC	2224.0	3484.0	4339.9	5271.7	6065.7	6907.5	8670.1
BU17S	2223.5	3473.3	4326.0	5200.8	5930.9	6665.4	8597.3
BU18H	310.6	417.9	488.6	570.7	634.2	695.9	795.6
BU18L	228.6	340.7	417.8	495.8	555.1	613.7	701.3
BU19H-A	587.3	878.0	1074.7	1298.2	1477.2	1640.7	1945.3
BU19R	223.9	333.2	406.7	479.7	535.2	591.6	679.9
BU20C	2265.4	3551.7	4430.9	5282.2	6134.5	6826.2	8717.6
BU20H	369.3	598.8	758.6	933.1	1076.3	1209.0	1475.5
BU20RA	2117.6	3306.6	4120.1	4977.2	5680.8	6424.2	8073.7
BU20RB	2229.8	3486.8	4341.7	5178.4	6015.1	6708.5	8503.3
BU20S	2226.9	3479.1	4339.0	5175.1	6011.2	6706.0	8496.9

TABLE E-IV-4 FUTURE WITH ED B1-1 PROJECT CONDITIONS PEAK DISCHARGES							
HMS Element	Peak Discharge (cfs) for Return Period (yrs)						
	2	5	10	25	50	100	500
(E0)	2199.2	3394.9	4207.8	5065.3	5759.6	6494.0	7917.5
(E12)	2112.1	3320.9	4133.4	5022.1	5758.1	6545.3	8156.0
(E13)	595.7	944.6	1184.9	1458.9	1683.4	1890.9	2344.1
(E15)	463.0	728.6	905.6	1095.9	1254.4	1407.7	1705.0
(E16)	2213.5	3449.3	4302.9	5135.6	5967.9	6653.8	8427.9

TABLE E-IV-4
FUTURE WITH ED B1-1 PROJECT CONDITIONS PEAK DISCHARGES

HMS Element	Peak Discharge (cfs) for Return Period (yrs)						
	2	5	10	25	50	100	500
(E17)	1067.9	1578.4	1931.1	2364.5	2703.4	3017.6	3558.4
(E18)	639.5	994.2	1242.8	1501.6	1712.7	1908.8	2282.2
(E19)	1253.2	1909.3	2380.3	2876.2	3257.5	3646.3	4371.4
(E20)	2037.3	2870.8	3384.3	3987.3	4445.0	4961.9	6406.0
(E25)	551.2	873.9	1096.1	1341.2	1543.3	1728.8	2096.4
(E3)	412.9	649.4	812.5	991.9	1138.2	1273.8	1539.7
(E5)	501.5	712.9	854.9	1022.7	1152.7	1272.3	1476.2
(E6)	62.6	87.1	100.5	250.6	488.4	612.7	864.7
(E9)	178.7	274.3	339.8	417.8	479.9	533.7	636.2
B10H	501.5	712.9	854.9	1022.7	1152.7	1272.3	1476.2
B1-1H	238.4	335.3	401.8	482.3	539.6	595.2	676.5
B1-1S	62.6	87.1	100.5	250.6	488.4	612.7	864.7
B20MSH	60.0	89.5	110.6	136.3	154.3	171.7	197.3
B20TH	9.3	13.5	16.5	20.2	22.6	25.1	28.5
B2-1MSH	288.4	418.4	506.9	613.4	690.8	763.7	876.0
B2-1TH	36.2	52.5	63.9	77.9	87.2	96.8	109.3
B3-1H	142.6	218.1	270.0	331.8	380.2	422.7	500.7
B3-3H	121.7	176.3	213.7	258.9	291.0	321.8	367.5
B60H	329.5	486.1	592.5	718.6	817.3	905.8	1064.0
B70H	140.4	210.7	260.2	320.8	364.4	405.3	469.2
BU01H-A	61.1	92.2	114.2	141.0	160.2	178.3	206.0
BU02C-(E8)	352.3	546.1	679.5	833.6	957.4	1066.2	1276.7
BU02H	184.9	291.1	364.3	447.9	515.6	575.7	693.2
BU02R	177.8	273.2	338.4	416.6	478.6	532.3	633.8
BU02S	347.3	541.8	674.1	831.0	954.3	1062.8	1272.9
BU03C-(E21)	645.9	1010.7	1261.0	1529.9	1743.5	1937.5	2316.6
BU03H-A	267.3	416.5	518.7	634.0	727.5	811.8	975.4
BU03RA	345.3	537.6	669.7	818.9	937.3	1040.9	1245.5
BU03RB	642.8	1004.5	1252.3	1522.1	1735.2	1926.7	2303.0
BU03RC	639.6	994.2	1243.0	1501.8	1713.4	1909.6	2282.1
BU03SA	644.5	1007.0	1256.9	1527.5	1742.3	1935.3	2314.1
BU03SB	641.7	998.5	1248.4	1519.1	1732.7	1923.9	2299.5
BU03SC	639.5	994.2	1242.8	1501.6	1712.7	1908.8	2282.2
BU04C-(E14)	1245.9	1833.2	2234.0	2685.7	2990.8	3306.5	3918.3
BU04H-A	621.7	865.2	1026.1	1207.6	1350.8	1488.7	1724.3
BU04R	636.6	989.9	1235.8	1494.8	1706.8	1902.4	2273.4
BU04S	1240.0	1831.2	2232.2	2671.5	2985.6	3308.6	3922.4
BU05C	1414.9	2057.8	2508.3	2999.2	3392.6	3851.9	4682.0
BU05H-A	633.0	837.0	972.3	1134.4	1255.7	1374.6	1553.9
BU05H-B	641.2	888.3	1052.3	1244.1	1393.0	1533.2	1768.0
BU05R(D)	1172.5	1768.8	2194.3	2651.2	3006.6	3390.7	4072.7
BU05R(U)	1099.3	1669.6	2050.1	2469.6	2804.4	3113.8	3709.4
BU06H	54.9	82.6	101.6	123.8	141.4	157.1	185.9
BU06L	3.1	6.9	19.4	33.0	45.1	54.1	116.0
BU07C	573.5	906.9	1136.4	1403.9	1622.2	1821.2	2260.3

TABLE E-IV-4
FUTURE WITH ED B1-1 PROJECT CONDITIONS PEAK DISCHARGES

HMS Element	Peak Discharge (cfs) for Return Period (yrs)						
	2	5	10	25	50	100	500
BU07H	571.7	903.3	1131.6	1381.0	1584.3	1773.7	2144.7
BU07R	3.1	6.9	19.4	33.0	45.1	54.1	115.6
BU08C	2144.7	3011.2	3541.4	4161.3	4634.0	5163.6	6648.2
BU08H-A	346.4	520.3	638.4	773.6	882.0	979.9	1163.0
BU08H-B	124.9	189.3	234.5	289.5	329.7	367.0	426.8
BU08RA	1383.8	2003.4	2446.3	2969.0	3373.1	3832.3	4659.7
BU08RB	1347.9	1892.2	2302.4	2717.5	3064.2	3592.9	4464.2
BU08RC(D)	592.5	938.2	1175.9	1445.9	1667.7	1873.2	2318.3
BU08RC(U)	571.6	904.2	1133.2	1397.9	1614.3	1812.2	2246.8
BU08SA	1357.3	1895.1	2309.0	2733.8	3093.0	3670.0	4562.9
BU08SB	2144.0	3008.2	3538.9	4159.5	4632.0	5162.1	6653.6
BU09C	1883.2	2709.1	3231.0	3817.4	4303.8	4786.9	6132.8
BU09H-A	248.1	388.1	484.5	591.7	679.1	759.1	915.6
BU09H-B	77.3	116.9	144.7	178.5	203.2	226.1	262.7
BU09R(D)	1658.5	2391.8	2860.8	3393.5	3804.4	4338.5	5582.1
BU09R(U)	2022.4	2849.6	3360.4	3959.2	4416.5	4931.6	6378.2
BU10C	2002.1	2968.0	3579.8	4234.4	4789.2	5338.2	6632.1
BU10H	332.1	527.1	662.1	813.2	936.6	1048.3	1269.9
BU10R	1835.5	2679.2	3207.3	3791.9	4270.3	4768.0	6075.6
BU11H	77.9	118.6	146.5	179.3	205.3	228.3	271.4
BU11L	34.8	72.4	101.1	130.5	153.5	174.2	211.8
BU12H	527.4	834.4	1047.2	1284.3	1477.9	1654.4	2003.7
BU13CA	2032.7	3015.3	3643.5	4311.9	4880.5	5441.0	6729.4
BU13CB-(E23)	2214.1	3420.1	4227.0	5079.9	5781.3	6496.8	7911.1
BU13CC	2206.8	3405.8	4242.9	5127.6	5811.1	6601.2	8061.0
BU13H-A	88.2	130.9	160.8	197.1	222.7	247.3	283.9
BU13H-B	106.4	160.9	199.0	245.1	278.9	310.2	360.6
BU13H-C	226.7	352.0	438.3	537.9	618.2	689.0	825.9
BU13H-D	83.8	123.6	151.5	185.4	209.3	232.3	266.1
BU13RB	1972.6	2965.4	3596.4	4268.3	4824.8	5388.7	6685.2
BU13RC(D)	537.2	854.9	1074.5	1315.8	1515.7	1699.7	2064.0
BU13RC(U)	526.4	833.0	1044.5	1280.2	1473.1	1648.8	1997.2
BU13RD(D)	2173.8	3349.9	4159.1	5013.4	5695.2	6448.2	7887.7
BU13RD(U)	2192.3	3384.4	4192.0	5044.4	5740.0	6469.1	7892.6
BU13S	2206.8	3404.4	4241.7	5126.6	5809.4	6599.0	8059.4
BU14H	307.6	472.9	585.9	712.3	815.0	908.8	1089.3
BU15CA	2148.0	3354.9	4173.9	5060.1	5792.0	6566.0	8142.6
BU15CB	2145.3	3371.2	4187.6	5091.2	5848.4	6645.0	8255.3
BU15H-A	272.7	413.8	511.3	627.2	717.2	797.0	940.7
BU15RA	2102.6	3277.2	4098.6	4969.9	5629.0	6381.1	7869.1
BU15RB	2121.9	3317.4	4127.3	5007.6	5728.1	6497.9	8067.3
BU15S	2148.0	3354.9	4174.0	5060.2	5792.1	6566.0	8142.8
BU16H	412.9	649.4	812.5	991.9	1138.2	1273.8	1539.7
BU17CA	2169.0	3439.7	4284.7	5221.5	6015.8	6855.1	8567.2
BU17CB	2191.6	3465.2	4324.1	5260.0	6056.6	6895.6	8634.7

TABLE E-IV-4
FUTURE WITH ED B1-1 PROJECT CONDITIONS PEAK DISCHARGES

HMS Element	Peak Discharge (cfs) for Return Period (yrs)						
	2	5	10	25	50	100	500
BU17H-A	357.1	458.1	526.9	612.1	671.8	733.7	814.3
BU17H-B	252.2	370.7	452.2	550.4	623.9	691.3	802.7
BU17H-C	121.7	179.8	220.4	269.9	304.5	338.1	386.9
BU17RA	2104.3	3310.9	4116.7	5004.1	5738.9	6528.4	8126.3
BU17RB	409.1	642.6	801.2	975.1	1119.1	1252.2	1513.9
BU17RC	2189.4	3454.1	4304.8	5231.6	6021.1	6851.7	8584.4
BU17S	2189.0	3443.2	4290.8	5160.7	5886.4	6608.7	8511.5
BU18H	310.6	417.9	488.6	570.7	634.2	695.9	795.6
BU18L	228.6	340.7	417.8	495.8	555.1	613.7	701.3
BU19H-A	587.3	878.0	1074.7	1298.2	1477.2	1640.7	1945.3
BU19R	223.9	333.2	406.7	479.7	535.2	591.6	679.9
BU20C	2237.0	3521.8	4393.7	5241.9	6089.8	6771.8	8639.1
BU20H	369.3	598.8	758.6	933.1	1076.3	1209.0	1475.5
BU20RA	2092.1	3275.9	4082.5	4935.9	5635.3	6367.6	7995.5
BU20RB	2215.1	3457.0	4305.7	5138.9	5971.7	6656.3	8433.3
BU20S	2213.5	3449.3	4302.9	5135.6	5967.9	6653.8	8427.9

TABLE E-IV-5
FUTURE WITH ED B20 PROJECT CONDITIONS PEAK DISCHARGES

HMS Element	Peak Discharge (cfs) for Return Period (yrs)						
	2	5	10	25	50	100	500
(E0)	1842.8	2849.2	3605.7	4712.2	5644.6	6447.9	7996.2
(E12)	1779.8	2834.0	3692.1	4681.3	5587.0	6413.3	8208.0
(E13)	595.7	944.6	1184.9	1458.9	1683.4	1890.9	2344.1
(E15)	463.0	728.6	905.6	1095.9	1254.4	1407.7	1705.0
(E16)	2161.0	3183.0	3979.6	4855.9	5794.3	6475.8	8344.2
(E17)	1067.9	1578.4	1931.1	2364.5	2703.4	3017.6	3558.4
(E18)	639.5	994.2	1242.8	1501.6	1712.7	1908.8	2282.2
(E19)	1284.8	1973.3	2460.5	2941.3	3303.1	3679.7	4390.3
(E20)	2078.1	2898.0	3432.7	4061.7	4512.5	5135.1	6579.6
(E25)	551.2	873.9	1096.1	1341.2	1543.3	1728.8	2096.4
(E3)	412.9	649.4	812.5	991.9	1138.2	1273.8	1539.7
(E5)	501.5	712.9	854.9	1022.7	1152.7	1272.3	1476.2
(E6)	238.4	335.3	401.8	482.3	539.6	595.2	676.5
(E9)	178.7	274.3	339.8	417.8	479.9	533.7	636.2
B10H	501.5	712.9	854.9	1022.7	1152.7	1272.3	1476.2
B1-1H	238.4	335.3	401.8	482.3	539.6	595.2	676.5
B20D	1510.0	2292.8	2833.6	3417.1	3889.3	4451.7	5830.9
B20MSH	9.3	13.5	16.5	20.2	22.6	25.1	28.5
B20S	147.3	584.8	749.7	887.7	990.3	1016.2	1030.4
B20TH	60.0	89.5	110.6	136.3	154.3	171.7	197.3
B2-1MSH	288.4	418.4	506.9	613.4	690.8	763.7	876.0

TABLE E-IV-5
FUTURE WITH ED B20 PROJECT CONDITIONS PEAK DISCHARGES

HMS Element	Peak Discharge (cfs) for Return Period (yrs)						
	2	5	10	25	50	100	500
B2-1TH	36.2	52.5	63.9	77.9	87.2	96.8	109.3
B3-1H	142.6	218.1	270.0	331.8	380.2	422.7	500.7
B3-3H	121.7	176.3	213.7	258.9	291.0	321.8	367.5
B60H	329.5	486.1	592.5	718.6	817.3	905.8	1064.0
B70H	140.4	210.7	260.2	320.8	364.4	405.3	469.2
BU01H-A	61.1	92.2	114.2	141.0	160.2	178.3	206.0
BU02C-(E8)	352.3	546.1	679.5	833.6	957.4	1066.2	1276.7
BU02H	184.9	291.1	364.3	447.9	515.6	575.7	693.2
BU02R	177.8	273.2	338.4	416.6	478.6	532.3	633.8
BU02S	347.3	541.8	674.1	831.0	954.3	1062.8	1272.9
BU03C-(E21)	645.9	1010.7	1261.0	1529.9	1743.5	1937.5	2316.6
BU03H-A	267.3	416.5	518.7	634.0	727.5	811.8	975.4
BU03RA	345.3	537.6	669.7	818.9	937.3	1040.9	1245.5
BU03RB	642.8	1004.5	1252.3	1522.1	1735.2	1926.7	2303.0
BU03RC	639.6	994.2	1243.0	1501.8	1713.4	1909.6	2282.1
BU03SA	644.5	1007.0	1256.9	1527.5	1742.3	1935.3	2314.1
BU03SB	641.7	998.5	1248.4	1519.1	1732.7	1923.9	2299.5
BU03SC	639.5	994.2	1242.8	1501.6	1712.7	1908.8	2282.2
BU04C-(E14)	1249.4	1846.7	2255.1	2671.9	2985.3	3304.7	3917.9
BU04H-A	621.7	865.2	1026.1	1207.6	1350.8	1488.7	1724.3
BU04R	636.6	989.9	1235.8	1494.8	1706.8	1902.4	2273.4
BU04S	1243.6	1845.3	2252.4	2669.4	2984.2	3305.5	3916.7
BU05C	1454.3	2120.6	2592.1	3124.7	3525.6	3968.9	4782.7
BU05H-A	633.0	837.0	972.3	1134.4	1255.7	1374.6	1553.9
BU05H-B	641.2	888.3	1052.3	1244.1	1393.0	1533.2	1768.0
BU05R(D)	1216.0	1838.7	2287.9	2750.3	3094.1	3465.5	4133.7
BU05R(U)	1119.7	1706.0	2100.8	2508.5	2825.6	3129.7	3715.9
BU06H	54.9	82.6	101.6	123.8	141.4	157.1	185.9
BU06L	3.1	6.9	19.4	33.0	45.1	54.1	116.0
BU07C	573.5	906.9	1136.4	1403.9	1622.2	1821.2	2260.3
BU07H	571.7	903.3	1131.6	1381.0	1584.3	1773.7	2144.7
BU07R	3.1	6.9	19.4	33.0	45.1	54.1	115.6
BU08C	2187.3	3040.3	3592.5	4238.4	4704.2	5341.1	6831.5
BU08H-A	346.4	520.3	638.4	773.6	882.0	979.9	1163.0
BU08H-B	124.9	189.3	234.5	289.5	329.7	367.0	426.8
BU08RA	1424.8	2075.1	2579.3	3110.6	3510.8	3956.4	4769.2
BU08RB	1394.2	1969.7	2396.4	2819.9	3169.4	3720.0	4568.1
BU08RC(D)	592.5	938.2	1175.9	1445.9	1667.7	1873.2	2318.3
BU08RC(U)	571.6	904.2	1133.2	1397.9	1614.3	1812.2	2246.8
BU08SA	1402.1	1973.4	2404.0	2841.8	3200.7	3806.2	4669.3
BU08SB	2187.0	3037.9	3590.2	4236.5	4702.9	5339.5	6833.5
BU09C	1914.9	2730.8	3265.3	3872.5	4351.2	4891.2	6280.0
BU09H-A	248.1	388.1	484.5	591.7	679.1	759.1	915.6
BU09H-B	77.3	116.9	144.7	178.5	203.2	226.1	262.7
BU09R(D)	1694.9	2421.8	2912.0	3456.7	3885.7	4499.7	5718.7

TABLE E-IV-5
FUTURE WITH ED B20 PROJECT CONDITIONS PEAK DISCHARGES

HMS Element	Peak Discharge (cfs) for Return Period (yrs)						
	2	5	10	25	50	100	500
BU09R(U)	2063.2	2878.5	3410.1	4034.2	4486.6	5108.9	6551.1
BU10C	2038.9	2989.3	3606.9	4278.2	4832.6	5394.2	6793.3
BU10H	332.1	527.1	662.1	813.2	936.6	1048.3	1269.9
BU10R	1874.1	2704.7	3244.8	3846.9	4326.4	4879.2	6224.4
BU11H	77.9	118.6	146.5	179.3	205.3	228.3	271.4
BU11L	34.8	72.4	101.1	130.5	153.5	174.2	211.8
BU12H	527.4	834.4	1047.2	1284.3	1477.9	1654.4	2003.7
BU13CA	2069.6	3036.6	3669.6	4353.1	4921.9	5492.9	6890.6
BU13CB-(E23)	1847.6	2866.1	3672.9	4800.0	5724.5	6485.6	7986.4
BU13CC	1866.9	2877.0	3619.3	4711.9	5653.4	6502.4	8134.5
BU13H-A	88.2	130.9	160.8	197.1	222.7	247.3	283.9
BU13H-B	106.4	160.9	199.0	245.1	278.9	310.2	360.6
BU13H-C	226.7	352.0	438.3	537.9	618.2	689.0	825.9
BU13H-D	83.8	123.6	151.5	185.4	209.3	232.3	266.1
BU13RB	2011.8	2989.9	3626.3	4312.2	4867.9	5449.4	6828.7
BU13RC(D)	537.2	854.9	1074.5	1315.8	1515.7	1699.7	2064.0
BU13RC(U)	526.4	833.0	1044.5	1280.2	1473.1	1648.8	1997.2
BU13RD(D)	1830.0	2818.4	3557.6	4639.3	5553.9	6369.6	7970.6
BU13RD(U)	1835.9	2838.6	3598.1	4701.1	5626.6	6424.5	7972.1
BU13S	1866.9	2875.9	3618.9	4711.0	5651.5	6500.8	8133.8
BU14H	307.6	472.9	585.9	712.3	815.0	908.8	1089.3
BU15CA	1808.0	2845.1	3654.5	4684.6	5617.4	6441.3	8218.9
BU15CB	1808.1	2869.0	3697.5	4714.0	5665.8	6505.4	8321.8
BU15H-A	272.7	413.8	511.3	627.2	717.2	797.0	940.7
BU15RA	1762.0	2767.4	3553.6	4600.7	5464.7	6271.4	7944.1
BU15RB	1784.5	2815.2	3642.1	4655.9	5557.4	6376.3	8137.0
BU15S	1807.9	2845.1	3654.5	4684.7	5617.4	6441.3	8219.0
BU16H	412.9	649.4	812.5	991.9	1138.2	1273.8	1539.7
BU17CA	1942.1	2950.3	3818.5	4835.8	5825.2	6687.0	8610.9
BU17CB	1980.7	2975.5	3855.5	4875.0	5868.2	6724.1	8677.8
BU17H-A	357.1	458.1	526.9	612.1	671.8	733.7	814.3
BU17H-B	252.2	370.7	452.2	550.4	623.9	691.3	802.7
BU17H-C	121.7	179.8	220.4	269.9	304.5	338.1	386.9
BU17RA	1772.0	2824.1	3676.6	4664.2	5568.3	6396.4	8178.5
BU17RB	409.1	642.6	801.2	975.1	1119.1	1252.2	1513.9
BU17RC	1977.4	2970.1	3851.1	4860.0	5834.3	6684.8	8618.9
BU17S	1976.8	2969.6	3846.9	4825.2	5713.3	6461.2	8525.5
BU18H	310.6	417.9	488.6	570.7	634.2	695.9	795.6
BU18L	228.6	340.7	417.8	495.8	555.1	613.7	701.3
BU19H-A	587.3	878.0	1074.7	1298.2	1477.2	1640.7	1945.3
BU19R	223.9	333.2	406.7	479.7	535.2	591.6	679.9
BU20C	2178.5	3306.4	4087.3	4946.3	5915.5	6601.4	8569.6
BU20H	369.3	598.8	758.6	933.1	1076.3	1209.0	1475.5
BU20RA	1824.8	2865.1	3744.4	4656.6	5476.3	6219.3	7946.7
BU20RB	2162.3	3188.9	3981.6	4859.0	5798.0	6478.3	8348.0

TABLE E-IV-5 FUTURE WITH ED B20 PROJECT CONDITIONS PEAK DISCHARGES							
HMS Element	Peak Discharge (cfs) for Return Period (yrs)						
	2	5	10	25	50	100	500
BU20S	2161.0	3183.0	3979.6	4855.9	5794.3	6475.8	8344.2

TABLE E-IV-6 FUTURE WITH ED B2-1 PROJECT CONDITIONS PEAK DISCHARGES							
HMS Element	Peak Discharge (cfs) for Return Period (yrs)						
	2	5	10	25	50	100	500
(E0)	2195.2	3390.0	4204.4	5064.3	5758.6	6495.2	7936.8
(E12)	2109.0	3320.9	4137.4	5028.6	5765.5	6559.8	8186.0
(E13)	595.7	944.6	1184.9	1458.9	1683.4	1890.9	2344.1
(E15)	463.0	728.6	905.6	1095.9	1254.4	1407.7	1705.0
(E16)	2213.9	3450.4	4309.2	5144.0	5976.5	6665.5	8441.9
(E17)	1067.9	1578.4	1931.1	2364.5	2703.4	3017.6	3558.4
(E18)	639.5	994.2	1242.8	1501.6	1712.7	1908.8	2282.2
(E19)	1216.4	1908.3	2396.8	2879.0	3243.5	3620.2	4386.9
(E20)	2029.1	2867.8	3393.0	4016.7	4472.4	5038.7	6505.2
(E25)	551.2	873.9	1096.1	1341.2	1543.3	1728.8	2096.4
(E3)	412.9	649.4	812.5	991.9	1138.2	1273.8	1539.7
(E5)	501.5	712.9	854.9	1022.7	1152.7	1272.3	1476.2
(E6)	238.4	335.3	401.8	482.3	539.6	595.2	676.5
(E9)	178.7	274.3	339.8	417.8	479.9	533.7	636.2
B10H	501.5	712.9	854.9	1022.7	1152.7	1272.3	1476.2
B1-1H	238.4	335.3	401.8	482.3	539.6	595.2	676.5
B20MSH	60.0	89.5	110.6	136.3	154.3	171.7	197.3
B20TH	9.3	13.5	16.5	20.2	22.6	25.1	28.5
B2-1D	1058.2	1666.1	2087.3	2517.8	2840.1	3166.2	3782.8
B2-1MSH	288.4	418.4	506.9	613.4	690.8	763.7	876.0
B2-1S	39.0	43.3	95.5	100.0	100.0	100.0	100.0
B2-1TH	36.2	52.5	63.9	77.9	87.2	96.8	109.3
B3-1H	142.6	218.1	270.0	331.8	380.2	422.7	500.7
B3-3H	121.7	176.3	213.7	258.9	291.0	321.8	367.5
B60H	329.5	486.1	592.5	718.6	817.3	905.8	1064.0
B70H	140.4	210.7	260.2	320.8	364.4	405.3	469.2
BU01H-A	61.1	92.2	114.2	141.0	160.2	178.3	206.0
BU02C-(E8)	352.3	546.1	679.5	833.6	957.4	1066.2	1276.7
BU02H	184.9	291.1	364.3	447.9	515.6	575.7	693.2
BU02R	177.8	273.2	338.4	416.6	478.6	532.3	633.8
BU02S	347.3	541.8	674.1	831.0	954.3	1062.8	1272.9
BU03C-(E21)	645.9	1010.7	1261.0	1529.9	1743.5	1937.5	2316.6
BU03H-A	267.3	416.5	518.7	634.0	727.5	811.8	975.4
BU03RA	345.3	537.6	669.7	818.9	937.3	1040.9	1245.5
BU03RB	642.8	1004.5	1252.3	1522.1	1735.2	1926.7	2303.0
BU03RC	639.6	994.2	1243.0	1501.8	1713.4	1909.6	2282.1

TABLE E-IV-6
FUTURE WITH ED B2-1 PROJECT CONDITIONS PEAK DISCHARGES

HMS Element	Peak Discharge (cfs) for Return Period (yrs)						
	2	5	10	25	50	100	500
BU03SA	644.5	1007.0	1256.9	1527.5	1742.3	1935.3	2314.1
BU03SB	641.7	998.5	1248.4	1519.1	1732.7	1923.9	2299.5
BU03SC	639.5	994.2	1242.8	1501.6	1712.7	1908.8	2282.2
BU04C-(E14)	1249.4	1846.7	2255.1	2671.9	2985.3	3304.7	3917.9
BU04H-A	621.7	865.2	1026.1	1207.6	1350.8	1488.7	1724.3
BU04R	636.6	989.9	1235.8	1494.8	1706.8	1902.4	2273.4
BU04S	1243.6	1845.3	2252.4	2669.4	2984.2	3305.5	3916.7
BU05C	1401.2	2049.3	2526.7	3059.8	3462.7	3906.5	4748.2
BU05H-A	633.0	837.0	972.3	1134.4	1255.7	1374.6	1553.9
BU05H-B	641.2	888.3	1052.3	1244.1	1393.0	1533.2	1768.0
BU05R(D)	1145.1	1774.2	2224.5	2687.4	3033.1	3405.1	4113.7
BU05R(U)	1119.7	1706.0	2100.8	2508.5	2825.6	3129.7	3715.9
BU06H	54.9	82.6	101.6	123.8	141.4	157.1	185.9
BU06L	3.1	6.9	19.4	33.0	45.1	54.1	116.0
BU07C	573.5	906.9	1136.4	1403.9	1622.2	1821.2	2260.3
BU07H	571.7	903.3	1131.6	1381.0	1584.3	1773.7	2144.7
BU07R	3.1	6.9	19.4	33.0	45.1	54.1	115.6
BU08C	2135.6	3008.8	3551.1	4191.9	4663.9	5240.4	6753.0
BU08H-A	346.4	520.3	638.4	773.6	882.0	979.9	1163.0
BU08H-B	124.9	189.3	234.5	289.5	329.7	367.0	426.8
BU08RA	1372.9	2004.5	2513.6	3045.3	3447.7	3893.2	4731.2
BU08RB	1339.2	1912.7	2339.1	2759.4	3108.9	3640.0	4528.4
BU08RC(D)	592.5	938.2	1175.9	1445.9	1667.7	1873.2	2318.3
BU08RC(U)	571.6	904.2	1133.2	1397.9	1614.3	1812.2	2246.8
BU08SA	1347.9	1916.0	2346.4	2776.9	3139.4	3722.0	4630.4
BU08SB	2135.0	3005.7	3548.8	4190.3	4662.2	5239.4	6759.0
BU09C	1876.9	2705.3	3233.7	3833.6	4318.8	4821.8	6208.6
BU09H-A	248.1	388.1	484.5	591.7	679.1	759.1	915.6
BU09H-B	77.3	116.9	144.7	178.5	203.2	226.1	262.7
BU09R(D)	1652.9	2391.6	2874.7	3421.7	3840.4	4416.6	5657.9
BU09R(U)	2014.2	2847.3	3370.4	3989.5	4445.8	5012.0	6476.8
BU10C	1996.8	2963.2	3578.8	4241.9	4798.9	5353.7	6714.6
BU10H	332.1	527.1	662.1	813.2	936.6	1048.3	1269.9
BU10R	1830.6	2676.7	3212.9	3809.4	4289.8	4811.1	6154.2
BU11H	77.9	118.6	146.5	179.3	205.3	228.3	271.4
BU11L	34.8	72.4	101.1	130.5	153.5	174.2	211.8
BU12H	527.4	834.4	1047.2	1284.3	1477.9	1654.4	2003.7
BU13CA	2027.5	3010.5	3642.4	4317.5	4888.4	5453.6	6810.0
BU13CB-(E23)	2209.5	3414.2	4223.3	5077.5	5778.7	6496.6	7927.9
BU13CC	2202.9	3401.5	4240.5	5127.5	5810.8	6602.9	8078.1
BU13H-A	88.2	130.9	160.8	197.1	222.7	247.3	283.9
BU13H-B	106.4	160.9	199.0	245.1	278.9	310.2	360.6
BU13H-C	226.7	352.0	438.3	537.9	618.2	689.0	825.9
BU13H-D	83.8	123.6	151.5	185.4	209.3	232.3	266.1
BU13RB	1968.7	2961.9	3597.0	4276.8	4833.9	5406.7	6754.8

TABLE E-IV-6
FUTURE WITH ED B2-1 PROJECT CONDITIONS PEAK DISCHARGES

HMS Element	Peak Discharge (cfs) for Return Period (yrs)						
	2	5	10	25	50	100	500
BU13RC(D)	537.2	854.9	1074.5	1315.8	1515.7	1699.7	2064.0
BU13RC(U)	526.4	833.0	1044.5	1280.2	1473.1	1648.8	1997.2
BU13RD(D)	2170.0	3345.6	4156.7	5014.8	5696.0	6451.9	7911.0
BU13RD(U)	2188.4	3379.5	4188.9	5043.3	5739.0	6470.4	7912.3
BU13S	2203.0	3400.2	4239.4	5127.0	5809.6	6601.4	8076.8
BU14H	307.6	472.9	585.9	712.3	815.0	908.8	1089.3
BU15CA	2145.2	3352.9	4175.2	5064.4	5796.3	6575.6	8174.1
BU15CB	2142.5	3370.4	4189.5	5095.9	5853.5	6655.4	8286.1
BU15H-A	272.7	413.8	511.3	627.2	717.2	797.0	940.7
BU15RA	2099.6	3275.2	4099.9	4974.5	5633.3	6392.0	7899.7
BU15RB	2119.1	3316.6	4129.5	5013.6	5733.7	6510.3	8099.8
BU15S	2145.2	3352.9	4175.2	5064.4	5796.3	6575.7	8174.0
BU16H	412.9	649.4	812.5	991.9	1138.2	1273.8	1539.7
BU17CA	2165.9	3439.3	4287.7	5226.9	6021.7	6866.5	8594.8
BU17CB	2188.5	3464.7	4327.2	5265.3	6062.6	6906.6	8662.2
BU17H-A	357.1	458.1	526.9	612.1	671.8	733.7	814.3
BU17H-B	252.2	370.7	452.2	550.4	623.9	691.3	802.7
BU17H-C	121.7	179.8	220.4	269.9	304.5	338.1	386.9
BU17RA	2101.2	3310.8	4120.9	5010.6	5746.3	6542.9	8156.3
BU17RB	409.1	642.6	801.2	975.1	1119.1	1252.2	1513.9
BU17RC	2186.3	3453.8	4308.5	5237.1	6028.4	6863.7	8610.9
BU17S	2185.9	3443.2	4294.5	5167.4	5894.4	6623.0	8537.3
BU18H	310.6	417.9	488.6	570.7	634.2	695.9	795.6
BU18L	228.6	340.7	417.8	495.8	555.1	613.7	701.3
BU19H-A	587.3	878.0	1074.7	1298.2	1477.2	1640.7	1945.3
BU19R	223.9	333.2	406.7	479.7	535.2	591.6	679.9
BU20C	2237.4	3523.0	4399.9	5250.0	6098.7	6784.6	8656.9
BU20H	369.3	598.8	758.6	933.1	1076.3	1209.0	1475.5
BU20RA	2085.0	3277.4	4089.3	4945.0	5645.1	6382.4	8017.0
BU20RB	2215.4	3458.1	4312.0	5147.4	5980.3	6668.0	8447.8
BU20S	2213.9	3450.4	4309.2	5144.0	5976.5	6665.5	8441.9

TABLE E-IV-7
FUTURE WITH ED B3-1 PROJECT CONDITIONS PEAK DISCHARGES

HMS Element	Peak Discharge (cfs) for Return Period (yrs)						
	2	5	10	25	50	100	500
(E0)	2231.0	3413.7	4225.5	5086.2	5781.0	6517.2	7959.2
(E12)	2138.2	3343.2	4157.6	5048.4	5787.1	6576.4	8196.4
(E13)	595.7	944.6	1184.9	1458.9	1683.4	1890.9	2344.1
(E15)	463.0	728.6	905.6	1095.9	1254.4	1407.7	1705.0
(E16)	2216.0	3467.2	4323.2	5157.6	5990.8	6675.8	8450.5
(E17)	1067.9	1578.4	1931.1	2364.5	2703.4	3017.6	3558.4

TABLE E-IV-7
FUTURE WITH ED B3-1 PROJECT CONDITIONS PEAK DISCHARGES

HMS Element	Peak Discharge (cfs) for Return Period (yrs)						
	2	5	10	25	50	100	500
(E18)	538.0	828.7	1026.0	1261.8	1535.0	1762.5	2210.2
(E19)	1236.6	1859.0	2317.3	2778.6	3140.8	3506.3	4228.1
(E20)	2072.6	2893.3	3420.1	4039.5	4492.1	5036.7	6483.7
(E25)	551.2	873.9	1096.1	1341.2	1543.3	1728.8	2096.4
(E3)	412.9	649.4	812.5	991.9	1138.2	1273.8	1539.7
(E5)	501.5	712.9	854.9	1022.7	1152.7	1272.3	1476.2
(E6)	238.4	335.3	401.8	482.3	539.6	595.2	676.5
(E9)	77.4	117.7	146.1	258.2	356.3	433.1	570.3
B10H	501.5	712.9	854.9	1022.7	1152.7	1272.3	1476.2
B1-1H	238.4	335.3	401.8	482.3	539.6	595.2	676.5
B20MSH	60.0	89.5	110.6	136.3	154.3	171.7	197.3
B20TH	9.3	13.5	16.5	20.2	22.6	25.1	28.5
B2-1MSH	288.4	418.4	506.9	613.4	690.8	763.7	876.0
B2-1TH	36.2	52.5	63.9	77.9	87.2	96.8	109.3
B3-1H	142.6	218.1	270.0	331.8	380.2	422.7	500.7
B3-1S	30.1	36.3	120.3	217.3	297.5	359.5	469.7
B3-3H	121.7	176.3	213.7	258.9	291.0	321.8	367.5
B60H	329.5	486.1	592.5	718.6	817.3	905.8	1064.0
B70H	140.4	210.7	260.2	320.8	364.4	405.3	469.2
BU01H-A	61.1	92.2	114.2	141.0	160.2	178.3	206.0
BU02C-(E8)	240.2	366.8	453.8	673.3	862.9	1003.7	1256.4
BU02H	184.9	291.1	364.3	447.9	515.6	575.7	693.2
BU02R	76.1	115.5	144.9	256.1	353.3	429.7	568.1
BU02S	240.1	364.9	451.5	661.7	856.5	998.2	1252.1
BU03C-(E21)	542.3	835.2	1038.2	1272.4	1561.8	1795.0	2246.7
BU03H-A	267.3	416.5	518.7	634.0	727.5	811.8	975.4
BU03RA	239.2	363.9	450.1	651.1	830.6	966.8	1218.7
BU03RB	540.4	832.2	1033.7	1265.4	1553.7	1784.6	2232.0
BU03RC	538.1	828.5	1026.3	1261.9	1535.3	1762.5	2209.8
BU03SA	541.5	833.0	1035.6	1268.4	1559.9	1793.2	2243.4
BU03SB	539.5	831.2	1029.1	1264.3	1551.5	1781.3	2228.1
BU03SC	538.0	828.7	1026.0	1261.8	1535.0	1762.5	2210.2
BU04C-(E14)	1172.9	1726.0	2082.4	2481.3	2807.7	3095.2	3740.7
BU04H-A	621.7	865.2	1026.1	1207.6	1350.8	1488.7	1724.3
BU04R	536.3	826.4	1023.0	1260.1	1529.3	1754.9	2201.2
BU04S	1167.3	1724.1	2081.1	2479.6	2804.6	3100.8	3741.0
BU05C	1449.3	2109.7	2570.1	3069.7	3441.0	3866.8	4650.4
BU05H-A	633.0	837.0	972.3	1134.4	1255.7	1374.6	1553.9
BU05H-B	641.2	888.3	1052.3	1244.1	1393.0	1533.2	1768.0
BU05R(D)	1165.3	1746.0	2165.9	2612.9	2957.6	3325.1	4004.6
BU05R(U)	1051.2	1585.7	1942.6	2332.1	2651.6	2957.4	3578.9
BU06H	54.9	82.6	101.6	123.8	141.4	157.1	185.9
BU06L	3.1	6.9	19.4	33.0	45.1	54.1	116.0
BU07C	573.5	906.9	1136.4	1403.9	1622.2	1821.2	2260.3
BU07H	571.7	903.3	1131.6	1381.0	1584.3	1773.7	2144.7

TABLE E-IV-7
FUTURE WITH ED B3-1 PROJECT CONDITIONS PEAK DISCHARGES

HMS Element	Peak Discharge (cfs) for Return Period (yrs)						
	2	5	10	25	50	100	500
BU07R	3.1	6.9	19.4	33.0	45.1	54.1	115.6
BU08C	2181.3	3035.1	3578.9	4215.6	4683.4	5238.6	6723.1
BU08H-A	346.4	520.3	638.4	773.6	882.0	979.9	1163.0
BU08H-B	124.9	189.3	234.5	289.5	329.7	367.0	426.8
BU08RA	1419.0	2061.5	2519.9	3018.9	3402.4	3838.6	4643.4
BU08RB	1387.8	1922.3	2323.9	2734.5	3078.8	3589.8	4448.5
BU08RC(D)	592.5	938.2	1175.9	1445.9	1667.7	1873.2	2318.3
BU08RC(U)	571.6	904.2	1133.2	1397.9	1614.3	1812.2	2246.8
BU08SA	1395.9	1925.0	2330.3	2749.6	3106.1	3661.4	4543.1
BU08SB	2181.1	3032.4	3576.6	4213.6	4681.6	5238.0	6730.2
BU09C	1910.6	2727.2	3256.7	3855.8	4338.6	4838.5	6195.6
BU09H-A	248.1	388.1	484.5	591.7	679.1	759.1	915.6
BU09H-B	77.3	116.9	144.7	178.5	203.2	226.1	262.7
BU09R(D)	1689.9	2415.8	2897.8	3438.3	3855.6	4402.7	5626.4
BU09R(U)	2057.7	2873.2	3397.5	4012.0	4465.0	5009.4	6453.7
BU10C	2033.9	2985.9	3599.8	4264.5	4820.7	5373.7	6713.6
BU10H	332.1	527.1	662.1	813.2	936.6	1048.3	1269.9
BU10R	1868.6	2700.0	3235.0	3829.6	4308.8	4823.0	6137.8
BU11H	77.9	118.6	146.5	179.3	205.3	228.3	271.4
BU11L	34.8	72.4	101.1	130.5	153.5	174.2	211.8
BU12H	527.4	834.4	1047.2	1284.3	1477.9	1654.4	2003.7
BU13CA	2064.5	3033.3	3663.0	4340.1	4910.6	5474.0	6811.9
BU13CB-(E23)	2246.7	3437.8	4244.1	5099.1	5801.4	6518.7	7951.3
BU13CC	2237.6	3425.3	4261.9	5149.7	5834.2	6625.2	8099.9
BU13H-A	88.2	130.9	160.8	197.1	222.7	247.3	283.9
BU13H-B	106.4	160.9	199.0	245.1	278.9	310.2	360.6
BU13H-C	226.7	352.0	438.3	537.9	618.2	689.0	825.9
BU13H-D	83.8	123.6	151.5	185.4	209.3	232.3	266.1
BU13RB	2006.2	2985.2	3618.2	4298.1	4855.6	5425.6	6755.8
BU13RC(D)	537.2	854.9	1074.5	1315.8	1515.7	1699.7	2064.0
BU13RC(U)	526.4	833.0	1044.5	1280.2	1473.1	1648.8	1997.2
BU13RD(D)	2204.7	3369.3	4178.1	5036.7	5718.9	6473.6	7931.8
BU13RD(U)	2224.8	3403.2	4210.0	5065.2	5761.4	6492.4	7934.7
BU13S	2237.2	3423.9	4260.8	5149.1	5832.7	6623.6	8099.2
BU14H	307.6	472.9	585.9	712.3	815.0	908.8	1089.3
BU15CA	2177.5	3376.5	4196.8	5085.9	5818.8	6595.4	8188.8
BU15CB	2173.6	3393.2	4210.7	5117.3	5875.7	6674.3	8299.2
BU15H-A	272.7	413.8	511.3	627.2	717.2	797.0	940.7
BU15RA	2131.6	3298.8	4121.4	4995.7	5655.8	6411.5	7914.4
BU15RB	2150.2	3339.4	4150.7	5034.4	5755.4	6528.2	8111.9
BU15S	2177.5	3376.5	4196.8	5085.9	5818.8	6595.3	8188.8
BU16H	412.9	649.4	812.5	991.9	1138.2	1273.8	1539.7
BU17CA	2195.1	3461.7	4308.4	5247.3	6044.1	6884.6	8607.2
BU17CB	2217.7	3487.2	4347.9	5285.7	6084.8	6925.0	8674.7
BU17H-A	357.1	458.1	526.9	612.1	671.8	733.7	814.3

TABLE E-IV-7
FUTURE WITH ED B3-1 PROJECT CONDITIONS PEAK DISCHARGES

HMS Element	Peak Discharge (cfs) for Return Period (yrs)						
	2	5	10	25	50	100	500
BU17H-B	252.2	370.7	452.2	550.4	623.9	691.3	802.7
BU17H-C	121.7	179.8	220.4	269.9	304.5	338.1	386.9
BU17RA	2130.4	3333.1	4140.9	5030.4	5767.9	6559.5	8166.7
BU17RB	409.1	642.6	801.2	975.1	1119.1	1252.2	1513.9
BU17RC	2215.3	3475.9	4328.8	5257.0	6049.8	6881.4	8622.8
BU17S	2214.9	3465.2	4314.5	5186.1	5913.8	6636.7	8548.3
BU18H	310.6	417.9	488.6	570.7	634.2	695.9	795.6
BU18L	228.6	340.7	417.8	495.8	555.1	613.7	701.3
BU19H-A	587.3	878.0	1074.7	1298.2	1477.2	1640.7	1945.3
BU19R	223.9	333.2	406.7	479.7	535.2	591.6	679.9
BU20C	2245.7	3541.6	4415.8	5265.4	6114.7	6796.1	8667.0
BU20H	369.3	598.8	758.6	933.1	1076.3	1209.0	1475.5
BU20RA	2109.5	3295.8	4104.8	4959.7	5660.5	6392.4	8022.7
BU20RB	2217.6	3475.1	4326.1	5160.9	5994.6	6678.3	8456.6
BU20S	2216.0	3467.2	4323.2	5157.6	5990.8	6675.8	8450.5

TABLE E-IV-8
FUTURE WITH ED B60 PROJECT CONDITIONS PEAK DISCHARGES

HMS Element	Peak Discharge (cfs) for Return Period (yrs)						
	2	5	10	25	50	100	500
(E0)	2236.4	3418.3	4232.1	5097.1	5790.4	6530.6	7995.2
(E12)	2156.8	3359.5	4186.2	5079.7	5794.5	6597.9	8258.8
(E13)	595.7	944.6	1184.9	1458.9	1683.4	1890.9	2344.1
(E15)	463.0	728.6	905.6	1095.9	1254.4	1407.7	1705.0
(E16)	2211.3	3471.2	4327.3	5153.6	5973.8	6657.5	8433.1
(E17)	1067.9	1578.4	1931.1	2364.5	2703.4	3017.6	3558.4
(E18)	639.5	994.2	1242.8	1501.6	1712.7	1908.8	2282.2
(E19)	1284.8	1973.3	2460.5	2941.3	3303.1	3679.7	4390.3
(E20)	2078.1	2898.0	3432.7	4061.7	4512.5	5135.1	6579.6
(E25)	551.2	873.9	1096.1	1341.2	1543.3	1728.8	2096.4
(E3)	412.9	649.4	812.5	991.9	1138.2	1273.8	1539.7
(E5)	501.5	712.9	854.9	1022.7	1152.7	1272.3	1476.2
(E6)	238.4	335.3	401.8	482.3	539.6	595.2	676.5
(E9)	178.7	274.3	339.8	417.8	479.9	533.7	636.2
B10H	501.5	712.9	854.9	1022.7	1152.7	1272.3	1476.2
B1-1H	238.4	335.3	401.8	482.3	539.6	595.2	676.5
B20MSH	60.0	89.5	110.6	136.3	154.3	171.7	197.3
B20TH	9.3	13.5	16.5	20.2	22.6	25.1	28.5
B2-1MSH	288.4	418.4	506.9	613.4	690.8	763.7	876.0
B2-1TH	36.2	52.5	63.9	77.9	87.2	96.8	109.3
B3-1H	142.6	218.1	270.0	331.8	380.2	422.7	500.7
B3-3H	121.7	176.3	213.7	258.9	291.0	321.8	367.5

TABLE E-IV-8
FUTURE WITH ED B60 PROJECT CONDITIONS PEAK DISCHARGES

HMS Element	Peak Discharge (cfs) for Return Period (yrs)						
	2	5	10	25	50	100	500
B60H	329.5	486.1	592.5	718.6	817.3	905.8	1064.0
B60S	31.6	47.0	55.6	63.5	68.9	81.9	313.4
B70H	140.4	210.7	260.2	320.8	364.4	405.3	469.2
BU01H-A	61.1	92.2	114.2	141.0	160.2	178.3	206.0
BU02C-(E8)	352.3	546.1	679.5	833.6	957.4	1066.2	1276.7
BU02H	184.9	291.1	364.3	447.9	515.6	575.7	693.2
BU02R	177.8	273.2	338.4	416.6	478.6	532.3	633.8
BU02S	347.3	541.8	674.1	831.0	954.3	1062.8	1272.9
BU03C-(E21)	645.9	1010.7	1261.0	1529.9	1743.5	1937.5	2316.6
BU03H-A	267.3	416.5	518.7	634.0	727.5	811.8	975.4
BU03RA	345.3	537.6	669.7	818.9	937.3	1040.9	1245.5
BU03RB	642.8	1004.5	1252.3	1522.1	1735.2	1926.7	2303.0
BU03RC	639.6	994.2	1243.0	1501.8	1713.4	1909.6	2282.1
BU03SA	644.5	1007.0	1256.9	1527.5	1742.3	1935.3	2314.1
BU03SB	641.7	998.5	1248.4	1519.1	1732.7	1923.9	2299.5
BU03SC	639.5	994.2	1242.8	1501.6	1712.7	1908.8	2282.2
BU04C-(E14)	1249.4	1846.7	2255.1	2671.9	2985.3	3304.7	3917.9
BU04H-A	621.7	865.2	1026.1	1207.6	1350.8	1488.7	1724.3
BU04R	636.6	989.9	1235.8	1494.8	1706.8	1902.4	2273.4
BU04S	1243.6	1845.3	2252.4	2669.4	2984.2	3305.5	3916.7
BU05C	1454.3	2120.6	2592.1	3124.7	3525.6	3968.9	4782.7
BU05H-A	633.0	837.0	972.3	1134.4	1255.7	1374.6	1553.9
BU05H-B	641.2	888.3	1052.3	1244.1	1393.0	1533.2	1768.0
BU05R(D)	1216.0	1838.7	2287.9	2750.3	3094.1	3465.5	4133.7
BU05R(U)	1119.7	1706.0	2100.8	2508.5	2825.6	3129.7	3715.9
BU06H	54.9	82.6	101.6	123.8	141.4	157.1	185.9
BU06L	3.1	6.9	19.4	33.0	45.1	54.1	116.0
BU07C	573.5	906.9	1136.4	1403.9	1622.2	1821.2	2260.3
BU07H	571.7	903.3	1131.6	1381.0	1584.3	1773.7	2144.7
BU07R	3.1	6.9	19.4	33.0	45.1	54.1	115.6
BU08C	2187.3	3040.3	3592.5	4238.4	4704.2	5341.1	6831.5
BU08H-A	346.4	520.3	638.4	773.6	882.0	979.9	1163.0
BU08H-B	124.9	189.3	234.5	289.5	329.7	367.0	426.8
BU08RA	1424.8	2075.1	2579.3	3110.6	3510.8	3956.4	4769.2
BU08RB	1394.2	1969.7	2396.4	2819.9	3169.4	3720.0	4568.1
BU08RC(D)	592.5	938.2	1175.9	1445.9	1667.7	1873.2	2318.3
BU08RC(U)	571.6	904.2	1133.2	1397.9	1614.3	1812.2	2246.8
BU08SA	1402.1	1973.4	2404.0	2841.8	3200.7	3806.2	4669.3
BU08SB	2187.0	3037.9	3590.2	4236.5	4702.9	5339.5	6833.5
BU09C	1914.9	2730.8	3265.3	3872.5	4351.2	4891.2	6280.0
BU09H-A	248.1	388.1	484.5	591.7	679.1	759.1	915.6
BU09H-B	77.3	116.9	144.7	178.5	203.2	226.1	262.7
BU09R(D)	1694.9	2421.8	2912.0	3456.7	3885.7	4499.7	5718.7
BU09R(U)	2063.2	2878.5	3410.1	4034.2	4486.6	5108.9	6551.1
BU10C	2038.9	2989.3	3606.9	4278.2	4832.6	5394.2	6793.3

TABLE E-IV-8
FUTURE WITH ED B60 PROJECT CONDITIONS PEAK DISCHARGES

HMS Element	Peak Discharge (cfs) for Return Period (yrs)						
	2	5	10	25	50	100	500
BU10H	332.1	527.1	662.1	813.2	936.6	1048.3	1269.9
BU10R	1874.1	2704.7	3244.8	3846.9	4326.4	4879.2	6224.4
BU11H	77.9	118.6	146.5	179.3	205.3	228.3	271.4
BU11L	34.8	72.4	101.1	130.5	153.5	174.2	211.8
BU12H	527.4	834.4	1047.2	1284.3	1477.9	1654.4	2003.7
BU13CA	2069.6	3036.6	3669.6	4353.1	4921.9	5492.9	6890.6
BU13CB-(E23)	2251.8	3442.1	4249.8	5109.6	5810.4	6531.4	7985.6
BU13CC	2243.1	3430.2	4269.0	5161.0	5844.6	6639.5	8134.0
BU13H-A	88.2	130.9	160.8	197.1	222.7	247.3	283.9
BU13H-B	106.4	160.9	199.0	245.1	278.9	310.2	360.6
BU13H-C	226.7	352.0	438.3	537.9	618.2	689.0	825.9
BU13H-D	83.8	123.6	151.5	185.4	209.3	232.3	266.1
BU13RB	2011.8	2989.9	3626.3	4312.2	4867.9	5449.4	6828.7
BU13RC(D)	537.2	854.9	1074.5	1315.8	1515.7	1699.7	2064.0
BU13RC(U)	526.4	833.0	1044.5	1280.2	1473.1	1648.8	1997.2
BU13RD(D)	2210.2	3374.3	4185.5	5048.4	5729.8	6488.8	7969.9
BU13RD(U)	2230.2	3407.8	4216.6	5076.2	5770.8	6505.8	7971.1
BU13S	2242.5	3428.9	4268.0	5160.6	5843.3	6638.1	8133.3
BU14H	307.6	472.9	585.9	712.3	815.0	908.8	1089.3
BU15CA	2195.9	3393.1	4226.5	5121.1	5824.7	6612.0	8247.0
BU15CB	2191.9	3410.6	4240.4	5149.8	5882.0	6691.2	8359.2
BU15H-A	272.7	413.8	511.3	627.2	717.2	797.0	940.7
BU15RA	2138.5	3305.1	4130.4	5009.3	5669.0	6433.3	7960.6
BU15RB	2168.5	3356.8	4180.9	5068.9	5763.2	6547.5	8173.0
BU15S	2195.9	3393.1	4226.4	5121.0	5824.6	6612.0	8247.0
BU16H	412.9	649.4	812.5	991.9	1138.2	1273.8	1539.7
BU17CA	2213.6	3478.0	4335.3	5275.1	6050.0	6900.6	8668.0
BU17CB	2236.2	3503.3	4374.7	5313.9	6091.6	6940.6	8735.4
BU17H-A	357.1	458.1	526.9	612.1	671.8	733.7	814.3
BU17H-B	252.2	370.7	452.2	550.4	623.9	691.3	802.7
BU17H-C	121.7	179.8	220.4	269.9	304.5	338.1	386.9
BU17RA	2149.0	3349.5	4169.6	5061.7	5775.3	6581.0	8229.1
BU17RB	409.1	642.6	801.2	975.1	1119.1	1252.2	1513.9
BU17RC	2233.8	3492.0	4355.4	5284.7	6056.0	6898.2	8682.8
BU17S	2233.4	3480.9	4340.9	5209.0	5919.6	6651.1	8602.0
BU18H	310.6	417.9	488.6	570.7	634.2	695.9	795.6
BU18L	228.6	340.7	417.8	495.8	555.1	613.7	701.3
BU19H-A	587.3	878.0	1074.7	1298.2	1477.2	1640.7	1945.3
BU19R	223.9	333.2	406.7	479.7	535.2	591.6	679.9
BU20C	2255.7	3551.1	4428.9	5274.3	6109.2	6793.0	8674.0
BU20H	369.3	598.8	758.6	933.1	1076.3	1209.0	1475.5
BU20RA	2120.2	3307.0	4119.6	4971.9	5658.5	6397.8	8042.0
BU20RB	2214.6	3479.6	4330.4	5157.3	5977.8	6660.2	8439.2
BU20S	2211.3	3471.2	4327.3	5153.6	5973.8	6657.5	8433.1

TABLE E-IV-9 FUTURE WITH ED B70 PROJECT CONDITIONS PEAK DISCHARGES							
HMS Element	Peak Discharge (cfs) for Return Period (yrs)						
	2	5	10	25	50	100	500
(E0)	2236.4	3418.3	4232.1	5097.1	5790.4	6530.6	7995.2
(E12)	2140.5	3343.4	4162.0	5057.9	5793.7	6595.3	8231.1
(E13)	595.7	944.6	1184.9	1458.9	1683.4	1890.9	2344.1
(E15)	463.0	728.6	905.6	1095.9	1254.4	1407.7	1705.0
(E16)	2206.3	3467.2	4325.0	5159.7	5994.1	6685.7	8458.8
(E17)	1067.9	1578.4	1931.1	2364.5	2703.4	3017.6	3558.4
(E18)	639.5	994.2	1242.8	1501.6	1712.7	1908.8	2282.2
(E19)	1284.8	1973.3	2460.5	2941.3	3303.1	3679.7	4390.3
(E20)	2078.1	2898.0	3432.7	4061.7	4512.5	5135.1	6579.6
(E25)	551.2	873.9	1096.1	1341.2	1543.3	1728.8	2096.4
(E3)	412.9	649.4	812.5	991.9	1138.2	1273.8	1539.7
(E5)	501.5	712.9	854.9	1022.7	1152.7	1272.3	1476.2
(E6)	238.4	335.3	401.8	482.3	539.6	595.2	676.5
(E9)	178.7	274.3	339.8	417.8	479.9	533.7	636.2
B10H	501.5	712.9	854.9	1022.7	1152.7	1272.3	1476.2
B1-1H	238.4	335.3	401.8	482.3	539.6	595.2	676.5
B20MSH	60.0	89.5	110.6	136.3	154.3	171.7	197.3
B20TH	9.3	13.5	16.5	20.2	22.6	25.1	28.5
B2-1MSH	288.4	418.4	506.9	613.4	690.8	763.7	876.0
B2-1TH	36.2	52.5	63.9	77.9	87.2	96.8	109.3
B3-1H	142.6	218.1	270.0	331.8	380.2	422.7	500.7
B3-3H	121.7	176.3	213.7	258.9	291.0	321.8	367.5
B60H	329.5	486.1	592.5	718.6	817.3	905.8	1064.0
B70H	140.4	210.7	260.2	320.8	364.4	405.3	469.2
B70S	5.5	8.9	11.6	14.5	16.8	19.1	27.0
BU01H-A	61.1	92.2	114.2	141.0	160.2	178.3	206.0
BU02C-(E8)	352.3	546.1	679.5	833.6	957.4	1066.2	1276.7
BU02H	184.9	291.1	364.3	447.9	515.6	575.7	693.2
BU02R	177.8	273.2	338.4	416.6	478.6	532.3	633.8
BU02S	347.3	541.8	674.1	831.0	954.3	1062.8	1272.9
BU03C-(E21)	645.9	1010.7	1261.0	1529.9	1743.5	1937.5	2316.6
BU03H-A	267.3	416.5	518.7	634.0	727.5	811.8	975.4
BU03RA	345.3	537.6	669.7	818.9	937.3	1040.9	1245.5
BU03RB	642.8	1004.5	1252.3	1522.1	1735.2	1926.7	2303.0
BU03RC	639.6	994.2	1243.0	1501.8	1713.4	1909.6	2282.1
BU03SA	644.5	1007.0	1256.9	1527.5	1742.3	1935.3	2314.1
BU03SB	641.7	998.5	1248.4	1519.1	1732.7	1923.9	2299.5
BU03SC	639.5	994.2	1242.8	1501.6	1712.7	1908.8	2282.2
BU04C-(E14)	1249.4	1846.7	2255.1	2671.9	2985.3	3304.7	3917.9
BU04H-A	621.7	865.2	1026.1	1207.6	1350.8	1488.7	1724.3
BU04R	636.6	989.9	1235.8	1494.8	1706.8	1902.4	2273.4
BU04S	1243.6	1845.3	2252.4	2669.4	2984.2	3305.5	3916.7
BU05C	1454.3	2120.6	2592.1	3124.7	3525.6	3968.9	4782.7
BU05H-A	633.0	837.0	972.3	1134.4	1255.7	1374.6	1553.9
BU05H-B	641.2	888.3	1052.3	1244.1	1393.0	1533.2	1768.0

TABLE E-IV-9
FUTURE WITH ED B70 PROJECT CONDITIONS PEAK DISCHARGES

HMS Element	Peak Discharge (cfs) for Return Period (yrs)						
	2	5	10	25	50	100	500
BU05R(D)	1216.0	1838.7	2287.9	2750.3	3094.1	3465.5	4133.7
BU05R(U)	1119.7	1706.0	2100.8	2508.5	2825.6	3129.7	3715.9
BU06H	54.9	82.6	101.6	123.8	141.4	157.1	185.9
BU06L	3.1	6.9	19.4	33.0	45.1	54.1	116.0
BU07C	573.5	906.9	1136.4	1403.9	1622.2	1821.2	2260.3
BU07H	571.7	903.3	1131.6	1381.0	1584.3	1773.7	2144.7
BU07R	3.1	6.9	19.4	33.0	45.1	54.1	115.6
BU08C	2187.3	3040.3	3592.5	4238.4	4704.2	5341.1	6831.5
BU08H-A	346.4	520.3	638.4	773.6	882.0	979.9	1163.0
BU08H-B	124.9	189.3	234.5	289.5	329.7	367.0	426.8
BU08RA	1424.8	2075.1	2579.3	3110.6	3510.8	3956.4	4769.2
BU08RB	1394.2	1969.7	2396.4	2819.9	3169.4	3720.0	4568.1
BU08RC(D)	592.5	938.2	1175.9	1445.9	1667.7	1873.2	2318.3
BU08RC(U)	571.6	904.2	1133.2	1397.9	1614.3	1812.2	2246.8
BU08SA	1402.1	1973.4	2404.0	2841.8	3200.7	3806.2	4669.3
BU08SB	2187.0	3037.9	3590.2	4236.5	4702.9	5339.5	6833.5
BU09C	1914.9	2730.8	3265.3	3872.5	4351.2	4891.2	6280.0
BU09H-A	248.1	388.1	484.5	591.7	679.1	759.1	915.6
BU09H-B	77.3	116.9	144.7	178.5	203.2	226.1	262.7
BU09R(D)	1694.9	2421.8	2912.0	3456.7	3885.7	4499.7	5718.7
BU09R(U)	2063.2	2878.5	3410.1	4034.2	4486.6	5108.9	6551.1
BU10C	2038.9	2989.3	3606.9	4278.2	4832.6	5394.2	6793.3
BU10H	332.1	527.1	662.1	813.2	936.6	1048.3	1269.9
BU10R	1874.1	2704.7	3244.8	3846.9	4326.4	4879.2	6224.4
BU11H	77.9	118.6	146.5	179.3	205.3	228.3	271.4
BU11L	34.8	72.4	101.1	130.5	153.5	174.2	211.8
BU12H	527.4	834.4	1047.2	1284.3	1477.9	1654.4	2003.7
BU13CA	2069.6	3036.6	3669.6	4353.1	4921.9	5492.9	6890.6
BU13CB-(E23)	2251.8	3442.1	4249.8	5109.6	5810.4	6531.4	7985.6
BU13CC	2243.1	3430.2	4269.0	5161.0	5844.6	6639.5	8134.0
BU13H-A	88.2	130.9	160.8	197.1	222.7	247.3	283.9
BU13H-B	106.4	160.9	199.0	245.1	278.9	310.2	360.6
BU13H-C	226.7	352.0	438.3	537.9	618.2	689.0	825.9
BU13H-D	83.8	123.6	151.5	185.4	209.3	232.3	266.1
BU13RB	2011.8	2989.9	3626.3	4312.2	4867.9	5449.4	6828.7
BU13RC(D)	537.2	854.9	1074.5	1315.8	1515.7	1699.7	2064.0
BU13RC(U)	526.4	833.0	1044.5	1280.2	1473.1	1648.8	1997.2
BU13RD(D)	2210.2	3374.3	4185.5	5048.4	5729.8	6488.8	7969.9
BU13RD(U)	2230.2	3407.8	4216.6	5076.2	5770.8	6505.8	7971.1
BU13S	2242.5	3428.9	4268.0	5160.6	5843.3	6638.1	8133.3
BU14H	307.6	472.9	585.9	712.3	815.0	908.8	1089.3
BU15CA	2177.7	3376.5	4201.0	5095.4	5823.3	6608.9	8217.8
BU15CB	2174.9	3392.9	4215.8	5126.6	5881.0	6688.9	8330.5
BU15H-A	272.7	413.8	511.3	627.2	717.2	797.0	940.7
BU15RA	2138.5	3305.1	4130.4	5009.3	5669.0	6433.3	7960.6

TABLE E-IV-9
FUTURE WITH ED B70 PROJECT CONDITIONS PEAK DISCHARGES

HMS Element	Peak Discharge (cfs) for Return Period (yrs)						
	2	**5**	**10**	**25**	**50**	**100**	**500**
BU15RB	2151.5	3339.1	4155.8	5044.3	5761.5	6544.0	8144.3
BU15S	2177.6	3376.4	4201.0	5095.4	5823.3	6608.9	8217.7
BU16H	412.9	649.4	812.5	991.9	1138.2	1273.8	1539.7
BU17CA	2197.3	3461.8	4312.4	5256.1	6049.7	6900.9	8640.0
BU17CB	2219.9	3487.1	4351.9	5294.6	6090.8	6940.9	8707.5
BU17H-A	357.1	458.1	526.9	612.1	671.8	733.7	814.3
BU17H-B	252.2	370.7	452.2	550.4	623.9	691.3	802.7
BU17H-C	121.7	179.8	220.4	269.9	304.5	338.1	386.9
BU17RA	2132.6	3333.3	4145.4	5039.9	5774.5	6578.4	8201.4
BU17RB	409.1	642.6	801.2	975.1	1119.1	1252.2	1513.9
BU17RC	2217.6	3476.1	4332.7	5265.8	6056.1	6898.0	8655.5
BU17S	2217.2	3465.4	4318.5	5194.3	5921.1	6655.6	8580.2
BU18H	310.6	417.9	488.6	570.7	634.2	695.9	795.6
BU18L	228.6	340.7	417.8	495.8	555.1	613.7	701.3
BU19H-A	587.3	878.0	1074.7	1298.2	1477.2	1640.7	1945.3
BU19R	223.9	333.2	406.7	479.7	535.2	591.6	679.9
BU20C	2246.1	3542.1	4419.1	5270.6	6120.7	6810.7	8684.6
BU20H	369.3	598.8	758.6	933.1	1076.3	1209.0	1475.5
BU20RA	2110.0	3297.3	4108.9	4966.3	5668.3	6411.0	8046.4
BU20RB	2209.3	3475.1	4327.8	5163.1	5998.0	6688.2	8465.0
BU20S	2206.3	3467.2	4325.0	5159.7	5994.1	6685.7	8458.8

ATTACHMENT 2

HEC-RAS OUTPUT

TABLE E-V-1
HEC-RAS OUTOUT – 2 YEAR PEAK FLOWS

Reach	River Sta	Profile	Q Total (cfs)	W.S. Elev (ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)
Reach-1	5.86	Future w/o	347.33	1032.69	3.87	89.83	30.13
Reach-1	5.86	B10	347.33	1032.69	3.87	89.83	30.13
Reach-1	5.86	B1-1	347.33	1032.69	3.87	89.83	30.13
Reach-1	5.86	B2-1	347.33	1032.69	3.87	89.83	30.13
Reach-1	5.86	B20	347.33	1032.69	3.87	89.83	30.13
Reach-1	5.86	B3-1	240.12	1031.58	4.05	59.22	24.88
Reach-1	5.86	B60	347.33	1032.69	3.87	89.83	30.13
Reach-1	5.86	B70	347.33	1032.69	3.87	89.83	30.13
Reach-1	5.84	Future w/o	347.33	1032.47	2.99	137.04	81.49
Reach-1	5.84	B10	347.33	1032.47	2.99	137.04	81.49
Reach-1	5.84	B1-1	347.33	1032.47	2.99	137.04	81.49
Reach-1	5.84	B2-1	347.33	1032.47	2.99	137.04	81.49
Reach-1	5.84	B20	347.33	1032.47	2.99	137.04	81.49
Reach-1	5.84	B3-1	240.12	1031.2	3.17	75.7	27.83
Reach-1	5.84	B60	347.33	1032.47	2.99	137.04	81.49
Reach-1	5.84	B70	347.33	1032.47	2.99	137.04	81.49
Reach-1	5.831	Future w/o	347.33	1032.36	2.43	143	100.45
Reach-1	5.831	B10	347.33	1032.36	2.43	143	100.45
Reach-1	5.831	B1-1	347.33	1032.36	2.43	143	100.45
Reach-1	5.831	B2-1	347.33	1032.36	2.43	143	100.45
Reach-1	5.831	B20	347.33	1032.36	2.43	143	100.45
Reach-1	5.831	B3-1	240.12	1031.03	2.39	100.39	61.47
Reach-1	5.831	B60	347.33	1032.36	2.43	143	100.45
Reach-1	5.831	B70	347.33	1032.36	2.43	143	100.45
Reach-1	5.8305		Culvert				
Reach-1	5.83	Future w/o	347.33	1029.88	5.18	66.99	26.31
Reach-1	5.83	B10	347.33	1029.88	5.18	66.99	26.31
Reach-1	5.83	B1-1	347.33	1029.88	5.18	66.99	26.31
Reach-1	5.83	B2-1	347.33	1029.88	5.18	66.99	26.31
Reach-1	5.83	B20	347.33	1029.88	5.18	66.99	26.31
Reach-1	5.83	B3-1	240.12	1029.24	4.69	51.22	23.31
Reach-1	5.83	B60	347.33	1029.88	5.18	66.99	26.31
Reach-1	5.83	B70	347.33	1029.88	5.18	66.99	26.31
Reach-1	5.82	Future w/o	347.33	1028.84	5.47	63.47	25.67
Reach-1	5.82	B10	347.33	1028.84	5.47	63.47	25.67
Reach-1	5.82	B1-1	347.33	1028.84	5.47	63.47	25.67
Reach-1	5.82	B2-1	347.33	1028.84	5.47	63.47	25.67
Reach-1	5.82	B20	347.33	1028.84	5.47	63.47	25.67
Reach-1	5.82	B3-1	240.12	1028.2	5	47.99	22.65
Reach-1	5.82	B60	347.33	1028.84	5.47	63.47	25.67

TABLE E-V-1 HEC-RAS OUTOUT – 2 YEAR PEAK FLOWS							
Reach	**River Sta**	**Profile**	**Q Total (cfs)**	**W.S. Elev (ft)**	**Vel Chnl (ft/s)**	**Flow Area (sq ft)**	**Top Width (ft)**
Reach-1	5.82	B70	347.33	1028.84	5.47	63.47	25.67
Reach-1	5.78	Future w/o	347.33	1026.85	5.25	66.2	26.17
Reach-1	5.78	B10	347.33	1026.85	5.25	66.2	26.17
Reach-1	5.78	B1-1	347.33	1026.85	5.25	66.2	26.17
Reach-1	5.78	B2-1	347.33	1026.85	5.25	66.2	26.17
Reach-1	5.78	B20	347.33	1026.85	5.25	66.2	26.17
Reach-1	5.78	B3-1	240.12	1026.25	4.67	51.44	23.36
Reach-1	5.78	B60	347.33	1026.85	5.25	66.2	26.17
Reach-1	5.78	B70	347.33	1026.85	5.25	66.2	26.17
Reach-1	5.74	Future w/o	347.33	1025.34	4.16	83.49	37.89
Reach-1	5.74	B10	347.33	1025.34	4.16	83.49	37.89
Reach-1	5.74	B1-1	347.33	1025.34	4.16	83.49	37.89
Reach-1	5.74	B2-1	347.33	1025.34	4.16	83.49	37.89
Reach-1	5.74	B20	347.33	1025.34	4.16	83.49	37.89
Reach-1	5.74	B3-1	240.12	1024.79	3.76	63.86	32.89
Reach-1	5.74	B60	347.33	1025.34	4.16	83.49	37.89
Reach-1	5.74	B70	347.33	1025.34	4.16	83.49	37.89
Reach-1	5.7	Future w/o	347.33	1022.14	7.38	47.09	27.93
Reach-1	5.7	B10	347.33	1022.14	7.38	47.09	27.93
Reach-1	5.7	B1-1	347.33	1022.14	7.38	47.09	27.93
Reach-1	5.7	B2-1	347.33	1022.14	7.38	47.09	27.93
Reach-1	5.7	B20	347.33	1022.14	7.38	47.09	27.93
Reach-1	5.7	B3-1	240.12	1021.66	6.89	34.84	23.65
Reach-1	5.7	B60	347.33	1022.14	7.38	47.09	27.93
Reach-1	5.7	B70	347.33	1022.14	7.38	47.09	27.93
Reach-1	5.66	Future w/o	347.33	1019.53	4.39	79.07	36.82
Reach-1	5.66	B10	347.33	1019.53	4.39	79.07	36.82
Reach-1	5.66	B1-1	347.33	1019.53	4.39	79.07	36.82
Reach-1	5.66	B2-1	347.33	1019.53	4.39	79.07	36.82
Reach-1	5.66	B20	347.33	1019.53	4.39	79.07	36.82
Reach-1	5.66	B3-1	240.12	1019.08	3.78	63.55	32.81
Reach-1	5.66	B60	347.33	1019.53	4.39	79.07	36.82
Reach-1	5.66	B70	347.33	1019.53	4.39	79.07	36.82
Reach-1	5.62	Future w/o	641.16	1016.34	7.29	87.98	31.18
Reach-1	5.62	B10	641.16	1016.34	7.29	87.98	31.18
Reach-1	5.62	B1-1	641.16	1016.34	7.29	87.98	31.18
Reach-1	5.62	B2-1	641.16	1016.34	7.29	87.98	31.18
Reach-1	5.62	B20	641.16	1016.34	7.29	87.98	31.18
Reach-1	5.62	B3-1	539.25	1016.05	6.83	78.96	30.32
Reach-1	5.62	B60	641.16	1016.34	7.29	87.98	31.18
Reach-1	5.62	B70	641.16	1016.34	7.29	87.98	31.18

TABLE E-V-1 HEC-RAS OUTOUT – 2 YEAR PEAK FLOWS							
Reach	**River Sta**	**Profile**	**Q Total (cfs)**	**W.S. Elev (ft)**	**Vel Chnl (ft/s)**	**Flow Area (sq ft)**	**Top Width (ft)**
Reach-1	5.58	Future w/o	641.16	1012.82	7.34	87.38	31.12
Reach-1	5.58	B10	641.16	1012.82	7.34	87.38	31.12
Reach-1	5.58	B1-1	641.16	1012.82	7.34	87.38	31.12
Reach-1	5.58	B2-1	641.16	1012.82	7.34	87.38	31.12
Reach-1	5.58	B20	641.16	1012.82	7.34	87.38	31.12
Reach-1	5.58	B3-1	539.25	1012.47	7.04	76.57	30.08
Reach-1	5.58	B60	641.16	1012.82	7.34	87.38	31.12
Reach-1	5.58	B70	641.16	1012.82	7.34	87.38	31.12
Reach-1	5.56	Future w/o	641.16	1011.81	5.86	109.47	34.24
Reach-1	5.56	B10	641.16	1011.81	5.86	109.47	34.24
Reach-1	5.56	B1-1	641.16	1011.81	5.86	109.47	34.24
Reach-1	5.56	B2-1	641.16	1011.81	5.86	109.47	34.24
Reach-1	5.56	B20	641.16	1011.81	5.86	109.47	34.24
Reach-1	5.56	B3-1	539.25	1011.34	5.71	94.42	31.8
Reach-1	5.56	B60	641.16	1011.81	5.86	109.47	34.24
Reach-1	5.56	B70	641.16	1011.81	5.86	109.47	34.24
Reach-1	5.46	Future w/o	641.16	1007	6.54	111.89	80.76
Reach-1	5.46	B10	641.16	1007	6.54	111.89	80.76
Reach-1	5.46	B1-1	641.16	1007	6.54	111.89	80.76
Reach-1	5.46	B2-1	641.16	1007	6.54	111.89	80.76
Reach-1	5.46	B20	641.16	1007	6.54	111.89	80.76
Reach-1	5.46	B3-1	539.25	1006.77	5.89	96.16	58.3
Reach-1	5.46	B60	641.16	1007	6.54	111.89	80.76
Reach-1	5.46	B70	641.16	1007	6.54	111.89	80.76
Reach-1	5.441	Future w/o	641.16	1006.23	6.1	133.76	105.3
Reach-1	5.441	B10	641.16	1006.23	6.1	133.76	105.3
Reach-1	5.441	B1-1	641.16	1006.23	6.1	133.76	105.3
Reach-1	5.441	B2-1	641.16	1006.23	6.1	133.76	105.3
Reach-1	5.441	B20	641.16	1006.23	6.1	133.76	105.3
Reach-1	5.441	B3-1	539.25	1006.13	5.37	100.51	95.85
Reach-1	5.441	B60	641.16	1006.23	6.1	133.76	105.3
Reach-1	5.441	B70	641.16	1006.23	6.1	133.76	105.3
Reach-1	5.4405		Bridge				
Reach-1	5.44	Future w/o	641.16	1004.75	9.6	66.81	23.24
Reach-1	5.44	B10	641.16	1004.75	9.6	66.81	23.24
Reach-1	5.44	B1-1	641.16	1004.75	9.6	66.81	23.24
Reach-1	5.44	B2-1	641.16	1004.75	9.6	66.81	23.24
Reach-1	5.44	B20	641.16	1004.75	9.6	66.81	23.24
Reach-1	5.44	B3-1	539.25	1004.46	8.97	60.1	22.6
Reach-1	5.44	B60	641.16	1004.75	9.6	66.81	23.24

TABLE E-V-1 HEC-RAS OUTOUT – 2 YEAR PEAK FLOWS							
Reach	**River Sta**	**Profile**	**Q Total (cfs)**	**W.S. Elev (ft)**	**Vel Chnl (ft/s)**	**Flow Area (sq ft)**	**Top Width (ft)**
Reach-1	5.44	B70	641.16	1004.75	9.6	66.81	23.24
Reach-1	5.42	Future w/o	641.16	1004.31	4.68	148.56	84.15
Reach-1	5.42	B10	641.16	1004.31	4.68	148.56	84.15
Reach-1	5.42	B1-1	641.16	1004.31	4.68	148.56	84.15
Reach-1	5.42	B2-1	641.16	1004.31	4.68	148.56	84.15
Reach-1	5.42	B20	641.16	1004.31	4.68	148.56	84.15
Reach-1	5.42	B3-1	539.25	1003.9	4.49	120.48	49.35
Reach-1	5.42	B60	641.16	1004.31	4.68	148.56	84.15
Reach-1	5.42	B70	641.16	1004.31	4.68	148.56	84.15
Reach-1	5.41	Future w/o	641.16	1003.77	4.47	143.44	36.85
Reach-1	5.41	B10	641.16	1003.77	4.47	143.44	36.85
Reach-1	5.41	B1-1	641.16	1003.77	4.47	143.44	36.85
Reach-1	5.41	B2-1	641.16	1003.77	4.47	143.44	36.85
Reach-1	5.41	B20	641.16	1003.77	4.47	143.44	36.85
Reach-1	5.41	B3-1	539.25	1003.35	4.21	128.21	35.89
Reach-1	5.41	B60	641.16	1003.77	4.47	143.44	36.85
Reach-1	5.41	B70	641.16	1003.77	4.47	143.44	36.85
Reach-1	5.381	Future w/o	641.16	1003.05	5.45	117.56	35.2
Reach-1	5.381	B10	641.16	1003.05	5.45	117.56	35.2
Reach-1	5.381	B1-1	641.16	1003.05	5.45	117.57	35.2
Reach-1	5.381	B2-1	641.16	1003.05	5.45	117.56	35.2
Reach-1	5.381	B20	641.16	1003.05	5.45	117.56	35.2
Reach-1	5.381	B3-1	539.25	1002.62	5.26	102.6	34.21
Reach-1	5.381	B60	641.16	1003.05	5.45	117.56	35.2
Reach-1	5.381	B70	641.16	1003.05	5.45	117.56	35.2
Reach-1	5.3805		Culvert				
Reach-1	5.38	Future w/o	641.16	1002.7	6.08	105.54	34.41
Reach-1	5.38	B10	641.16	1002.7	6.08	105.54	34.41
Reach-1	5.38	B1-1	641.16	1002.7	6.08	105.54	34.41
Reach-1	5.38	B2-1	641.16	1002.7	6.08	105.54	34.41
Reach-1	5.38	B20	641.16	1002.7	6.08	105.54	34.41
Reach-1	5.38	B3-1	539.25	1002.37	5.72	94.33	33.63
Reach-1	5.38	B60	641.16	1002.7	6.08	105.54	34.41
Reach-1	5.38	B70	641.16	1002.7	6.08	105.54	34.41
Reach-1	5.36	Future w/o	641.16	1001.74	5.99	106.98	34.5
Reach-1	5.36	B10	641.16	1001.74	5.99	106.98	34.5
Reach-1	5.36	B1-1	641.16	1001.74	5.99	106.99	34.5
Reach-1	5.36	B2-1	641.16	1001.74	5.99	106.98	34.5
Reach-1	5.36	B20	641.16	1001.74	5.99	106.98	34.5
Reach-1	5.36	B3-1	539.25	1001.45	5.56	96.94	33.82

TABLE E-V-1
HEC-RAS OUTOUT – 2 YEAR PEAK FLOWS

Reach	River Sta	Profile	Q Total (cfs)	W.S. Elev (ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)
Reach-1	5.36	B60	641.16	1001.74	5.99	106.98	34.5
Reach-1	5.36	B70	641.16	1001.74	5.99	106.98	34.5
Reach-1	5.29	Future w/o	639.11	999.04	5.3	120.66	35.4
Reach-1	5.29	B10	639.11	999.04	5.3	120.66	35.4
Reach-1	5.29	B1-1	639.11	999.03	5.3	120.62	35.4
Reach-1	5.29	B2-1	639.11	999.04	5.3	120.66	35.4
Reach-1	5.29	B20	639.11	999.04	5.3	120.66	35.4
Reach-1	5.29	B3-1	537.68	998.48	5.3	101.39	34.13
Reach-1	5.29	B60	639.11	999.04	5.3	120.66	35.4
Reach-1	5.29	B70	639.11	999.04	5.3	120.66	35.4
Reach-1	5.23	Future w/o	639.11	997.93	3.96	264.59	60
Reach-1	5.23	B10	639.11	997.93	3.96	264.59	60
Reach-1	5.23	B1-1	639.11	997.93	3.96	264.43	60
Reach-1	5.23	B2-1	639.11	997.93	3.96	264.59	60
Reach-1	5.23	B20	639.11	997.93	3.96	264.59	60
Reach-1	5.23	B3-1	537.68	997.18	3.93	219.72	60
Reach-1	5.23	B60	639.11	997.93	3.96	264.59	60
Reach-1	5.23	B70	639.11	997.93	3.96	264.59	60
Reach-1	5.211	Future w/o	639.11	997.58	4.91	130.26	350.22
Reach-1	5.211	B10	639.11	997.58	4.91	130.26	350.22
Reach-1	5.211	B1-1	639.11	997.58	4.91	130.21	350.18
Reach-1	5.211	B2-1	639.11	997.58	4.91	130.26	350.22
Reach-1	5.211	B20	639.11	997.58	4.91	130.26	350.22
Reach-1	5.211	B3-1	537.68	996.89	4.56	117.92	333.71
Reach-1	5.211	B60	639.11	997.58	4.91	130.26	350.22
Reach-1	5.211	B70	639.11	997.58	4.91	130.26	350.22
Reach-1	5.2105		Culvert				
Reach-1	5.21	Future w/o	639.11	995.5	6.88	92.88	194.5
Reach-1	5.21	B10	639.11	995.5	6.88	92.88	194.5
Reach-1	5.21	B1-1	639.11	995.49	6.89	92.71	194.07
Reach-1	5.21	B2-1	639.11	995.5	6.88	92.88	194.5
Reach-1	5.21	B20	639.11	995.5	6.88	92.88	194.5
Reach-1	5.21	B3-1	537.68	995.36	5.95	90.36	188.44
Reach-1	5.21	B60	639.11	995.5	6.88	92.88	194.5
Reach-1	5.21	B70	639.11	995.5	6.88	92.88	194.5
Reach-1	5.2	Future w/o	639.11	995.69	3.66	518.2	228.49
Reach-1	5.2	B10	639.11	995.69	3.66	518.2	228.49
Reach-1	5.2	B1-1	639.11	995.68	3.67	516.17	227.85
Reach-1	5.2	B2-1	639.11	995.69	3.66	518.2	228.49
Reach-1	5.2	B20	639.11	995.69	3.66	518.2	228.49

TABLE E-V-1
HEC-RAS OUTOUT – 2 YEAR PEAK FLOWS

Reach	River Sta	Profile	Q Total (cfs)	W.S. Elev (ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)
Reach-1	5.2	B3-1	537.68	995.49	3.3	473.1	219.36
Reach-1	5.2	B60	639.11	995.69	3.66	518.2	228.49
Reach-1	5.2	B70	639.11	995.69	3.66	518.2	228.49
Reach-1	5.19	Future w/o	1242.78	995.27	6.17	635.75	318.95
Reach-1	5.19	B10	1242.78	995.27	6.17	635.75	318.95
Reach-1	5.19	B1-1	1239.05	995.26	6.17	632.8	317.84
Reach-1	5.19	B2-1	1242.78	995.27	6.17	635.75	318.95
Reach-1	5.19	B20	1242.78	995.27	6.17	635.75	318.95
Reach-1	5.19	B3-1	1168.86	995.04	6.18	575.37	240.72
Reach-1	5.19	B60	1242.78	995.27	6.17	635.75	318.95
Reach-1	5.19	B70	1242.78	995.27	6.17	635.75	318.95
Reach-1	5.18	Future w/o	1242.78	995.03	4.39	750.55	290.13
Reach-1	5.18	B10	1242.78	995.03	4.39	750.55	290.13
Reach-1	5.18	B1-1	1239.05	995.02	4.39	747.78	289.67
Reach-1	5.18	B2-1	1242.78	995.03	4.39	750.55	290.13
Reach-1	5.18	B20	1242.78	995.03	4.39	750.55	290.13
Reach-1	5.18	B3-1	1168.86	994.77	4.46	677.28	276.74
Reach-1	5.18	B60	1242.78	995.03	4.39	750.55	290.13
Reach-1	5.18	B70	1242.78	995.03	4.39	750.55	290.13
Reach-1	5.151	Future w/o	1242.78	993.45	8.44	147.25	196.66
Reach-1	5.151	B10	1242.78	993.45	8.44	147.25	196.66
Reach-1	5.151	B1-1	1239.05	993.45	8.42	147.21	196.58
Reach-1	5.151	B2-1	1242.78	993.45	8.44	147.25	196.66
Reach-1	5.151	B20	1242.78	993.45	8.44	147.25	196.66
Reach-1	5.151	B3-1	1168.86	993.21	8.35	140.04	182.79
Reach-1	5.151	B60	1242.78	993.45	8.44	147.25	196.66
Reach-1	5.151	B70	1242.78	993.45	8.44	147.25	196.66
Reach-1	5.1505		Culvert				
Reach-1	5.15	Future w/o	1242.78	993.2	7.19	361.59	182.19
Reach-1	5.15	B10	1242.78	993.2	7.19	361.59	182.19
Reach-1	5.15	B1-1	1239.05	993.2	7.17	361.7	182.22
Reach-1	5.15	B2-1	1242.78	993.2	7.19	361.59	182.19
Reach-1	5.15	B20	1242.78	993.2	7.19	361.59	182.19
Reach-1	5.15	B3-1	1168.86	993.09	7.02	341.01	175.55
Reach-1	5.15	B60	1242.78	993.2	7.19	361.59	182.19
Reach-1	5.15	B70	1242.78	993.2	7.19	361.59	182.19
Reach-1	5.14	Future w/o	1242.78	992.11	7.77	310.03	167.87
Reach-1	5.14	B10	1242.78	992.11	7.77	310.03	167.87
Reach-1	5.14	B1-1	1239.05	992.08	7.81	306.16	166.92
Reach-1	5.14	B2-1	1242.78	992.11	7.77	310.03	167.87

TABLE E-V-1 HEC-RAS OUTOUT – 2 YEAR PEAK FLOWS							
Reach	**River Sta**	**Profile**	**Q Total (cfs)**	**W.S. Elev (ft)**	**Vel Chnl (ft/s)**	**Flow Area (sq ft)**	**Top Width (ft)**
Reach-1	5.14	B20	1242.78	992.11	7.77	310.03	167.87
Reach-1	5.14	B3-1	1168.86	991.98	7.64	289.8	162.85
Reach-1	5.14	B60	1242.78	992.11	7.77	310.03	167.87
Reach-1	5.14	B70	1242.78	992.11	7.77	310.03	167.87
Reach-1	5.09	Future w/o	1120.68	989.52	7.22	296.1	164.43
Reach-1	5.09	B10	1120.68	989.52	7.22	296.1	164.43
Reach-1	5.09	B1-1	1100.22	989.49	7.17	290.96	163.15
Reach-1	5.09	B2-1	1120.68	989.52	7.22	296.1	164.43
Reach-1	5.09	B20	1120.68	989.52	7.22	296.1	164.43
Reach-1	5.09	B3-1	1052.76	989.41	7.05	278.75	160.05
Reach-1	5.09	B60	1120.68	989.52	7.22	296.1	164.43
Reach-1	5.09	B70	1120.68	989.52	7.22	296.1	164.43
Reach-1	5.04	Future w/o	1120.68	987.01	7.24	294.59	164.06
Reach-1	5.04	B10	1120.68	987.01	7.24	294.59	164.06
Reach-1	5.04	B1-1	1100.22	986.97	7.22	287.9	162.37
Reach-1	5.04	B2-1	1120.68	987.01	7.24	294.59	164.06
Reach-1	5.04	B20	1120.68	987.01	7.24	294.59	164.06
Reach-1	5.04	B3-1	1052.76	986.87	7.16	272.37	158.4
Reach-1	5.04	B60	1120.68	987.01	7.24	294.59	164.06
Reach-1	5.04	B70	1120.68	987.01	7.24	294.59	164.06
Reach-1	5.008*	Future w/o	1120.68	985.14	7.38	202.04	97.98
Reach-1	5.008*	B10	1120.68	985.14	7.38	202.04	97.98
Reach-1	5.008*	B1-1	1100.22	985.1	7.34	198.09	96.79
Reach-1	5.008*	B2-1	1120.68	985.14	7.38	202.04	97.98
Reach-1	5.008*	B20	1120.68	985.14	7.38	202.04	97.98
Reach-1	5.008*	B3-1	1052.76	985	7.23	189.06	94.01
Reach-1	5.008*	B60	1120.68	985.14	7.38	202.04	97.98
Reach-1	5.008*	B70	1120.68	985.14	7.38	202.04	97.98
Reach-1	4.976*	Future w/o	1120.68	983.42	7.01	177.39	70.29
Reach-1	4.976*	B10	1120.68	983.42	7.01	177.39	70.29
Reach-1	4.976*	B1-1	1100.22	983.38	6.95	174.7	68.8
Reach-1	4.976*	B2-1	1120.68	983.42	7.01	177.39	70.29
Reach-1	4.976*	B20	1120.68	983.42	7.01	177.39	70.29
Reach-1	4.976*	B3-1	1052.76	983.29	6.83	168.57	66.55
Reach-1	4.976*	B60	1120.68	983.42	7.01	177.39	70.29
Reach-1	4.976*	B70	1120.68	983.42	7.01	177.39	70.29
Reach-1	4.944*	Future w/o	1120.68	981.81	6.59	177.36	64.06
Reach-1	4.944*	B10	1120.68	981.81	6.59	177.36	64.06
Reach-1	4.944*	B1-1	1100.22	981.78	6.53	175.21	63.38
Reach-1	4.944*	B2-1	1120.68	981.81	6.59	177.36	64.06
Reach-1	4.944*	B20	1120.68	981.81	6.59	177.36	64.06

TABLE E-V-1
HEC-RAS OUTOUT – 2 YEAR PEAK FLOWS

Reach	River Sta	Profile	Q Total (cfs)	W.S. Elev (ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)
Reach-1	4.944*	B3-1	1052.76	981.69	6.41	169.84	61.66
Reach-1	4.944*	B60	1120.68	981.81	6.59	177.36	64.06
Reach-1	4.944*	B70	1120.68	981.81	6.59	177.36	64.06
Reach-1	4.912*	Future w/o	1120.68	980.31	6.18	185.87	67.1
Reach-1	4.912*	B10	1120.68	980.31	6.18	185.87	67.1
Reach-1	4.912*	B1-1	1100.22	980.27	6.14	183.33	66.16
Reach-1	4.912*	B2-1	1120.68	980.31	6.18	185.87	67.1
Reach-1	4.912*	B20	1120.68	980.31	6.18	185.87	67.1
Reach-1	4.912*	B3-1	1052.76	980.18	6.03	177.87	64.68
Reach-1	4.912*	B60	1120.68	980.31	6.18	185.87	67.1
Reach-1	4.912*	B70	1120.68	980.31	6.18	185.87	67.1
Reach-1	4.88	Future w/o	1120.68	979.12	5.4	217.94	80.64
Reach-1	4.88	B10	1120.68	979.12	5.4	217.94	80.64
Reach-1	4.88	B1-1	1100.22	979.08	5.36	215.16	80
Reach-1	4.88	B2-1	1120.68	979.12	5.4	217.94	80.64
Reach-1	4.88	B20	1120.68	979.12	5.4	217.94	80.64
Reach-1	4.88	B3-1	1052.76	979	5.25	208.69	78.49
Reach-1	4.88	B60	1120.68	979.12	5.4	217.94	80.64
Reach-1	4.88	B70	1120.68	979.12	5.4	217.94	80.64
Reach-1	4.85	Future w/o	1120.68	978.33	5.16	267.28	94.53
Reach-1	4.85	B10	1120.68	978.33	5.16	267.28	94.53
Reach-1	4.85	B1-1	1100.22	978.3	5.11	264.34	94.32
Reach-1	4.85	B2-1	1120.68	978.33	5.16	267.28	94.53
Reach-1	4.85	B20	1120.68	978.33	5.16	267.28	94.53
Reach-1	4.85	B3-1	1052.76	978.22	5.01	257.41	93.83
Reach-1	4.85	B60	1120.68	978.33	5.16	267.28	94.53
Reach-1	4.85	B70	1120.68	978.33	5.16	267.28	94.53
Reach-1	4.84*	Future w/o	1120.68	977.95	5.27	270.77	107.02
Reach-1	4.84*	B10	1120.68	977.95	5.27	270.77	107.02
Reach-1	4.84*	B1-1	1100.22	977.92	5.22	267.64	106.74
Reach-1	4.84*	B2-1	1120.68	977.95	5.27	270.77	107.02
Reach-1	4.84*	B20	1120.68	977.95	5.27	270.77	107.02
Reach-1	4.84*	B3-1	1052.76	977.85	5.12	260.27	106.11
Reach-1	4.84*	B60	1120.68	977.95	5.27	270.77	107.02
Reach-1	4.84*	B70	1120.68	977.95	5.27	270.77	107.02
Reach-1	4.83	Future w/o	1120.68	977.07	6.74	206.08	113.61
Reach-1	4.83	B10	1120.68	977.07	6.74	206.08	113.61
Reach-1	4.83	B1-1	1100.22	977.04	6.69	203.46	113.4
Reach-1	4.83	B2-1	1120.68	977.07	6.74	206.08	113.61
Reach-1	4.83	B20	1120.68	977.07	6.74	206.08	113.61
Reach-1	4.83	B3-1	1052.76	976.99	6.56	197.35	112.92

TABLE E-V-1 HEC-RAS OUTOUT – 2 YEAR PEAK FLOWS							
Reach	**River Sta**	**Profile**	**Q Total (cfs)**	**W.S. Elev (ft)**	**Vel Chnl (ft/s)**	**Flow Area (sq ft)**	**Top Width (ft)**
Reach-1	4.83	B60	1120.68	977.07	6.74	206.08	113.61
Reach-1	4.83	B70	1120.68	977.07	6.74	206.08	113.61
Reach-1	4.81*	Future w/o	1120.68	976.1	5.11	240.67	138.98
Reach-1	4.81*	B10	1120.68	976.1	5.11	240.67	138.98
Reach-1	4.81*	B1-1	1100.22	976.06	5.09	235.93	138.68
Reach-1	4.81*	B2-1	1120.68	976.1	5.11	240.67	138.98
Reach-1	4.81*	B20	1120.68	976.1	5.11	240.67	138.98
Reach-1	4.81*	B3-1	1052.76	975.98	5.04	224.9	137.99
Reach-1	4.81*	B60	1120.68	976.1	5.11	240.67	138.98
Reach-1	4.81*	B70	1120.68	976.1	5.11	240.67	138.98
Reach-1	4.79*	Future w/o	1120.68	975.79	3.34	363.24	163.33
Reach-1	4.79*	B10	1120.68	975.79	3.34	363.24	163.33
Reach-1	4.79*	B1-1	1100.22	975.75	3.32	356.94	161.41
Reach-1	4.79*	B2-1	1120.68	975.79	3.34	363.24	163.33
Reach-1	4.79*	B20	1120.68	975.79	3.34	363.24	163.33
Reach-1	4.79*	B3-1	1052.76	975.66	3.28	342.4	156.89
Reach-1	4.79*	B60	1120.68	975.79	3.34	363.24	163.33
Reach-1	4.79*	B70	1120.68	975.79	3.34	363.24	163.33
Reach-1	4.77	Future w/o	1120.68	975.69	2.26	541.68	190.37
Reach-1	4.77	B10	1120.68	975.69	2.26	541.68	190.37
Reach-1	4.77	B1-1	1100.22	975.65	2.24	534.17	188.95
Reach-1	4.77	B2-1	1120.68	975.69	2.26	541.68	190.37
Reach-1	4.77	B20	1120.68	975.69	2.26	541.68	190.37
Reach-1	4.77	B3-1	1052.76	975.56	2.2	516.72	185.63
Reach-1	4.77	B60	1120.68	975.69	2.26	541.68	190.37
Reach-1	4.77	B70	1120.68	975.69	2.26	541.68	190.37
Reach-1	4.75*	Future w/o	1120.68	975.59	2.37	505.36	163.92
Reach-1	4.75*	B10	1120.68	975.59	2.37	505.36	163.92
Reach-1	4.75*	B1-1	1100.22	975.55	2.35	498.89	163.75
Reach-1	4.75*	B2-1	1120.68	975.59	2.37	505.36	163.92
Reach-1	4.75*	B20	1120.68	975.59	2.37	505.36	163.92
Reach-1	4.75*	B3-1	1052.76	975.45	2.31	483.7	163.34
Reach-1	4.75*	B60	1120.68	975.59	2.37	505.36	163.92
Reach-1	4.75*	B70	1120.68	975.59	2.37	505.36	163.92
Reach-1	4.73	Future w/o	1120.68	975.46	2.54	445.69	130.82
Reach-1	4.73	B10	1120.68	975.46	2.54	445.69	130.82
Reach-1	4.73	B1-1	1100.22	975.42	2.52	440.55	130.66
Reach-1	4.73	B2-1	1120.68	975.46	2.54	445.69	130.82
Reach-1	4.73	B20	1120.68	975.46	2.54	445.69	130.82
Reach-1	4.73	B3-1	1052.76	975.32	2.47	428.5	130.29
Reach-1	4.73	B60	1120.68	975.46	2.54	445.69	130.82

TABLE E-V-1
HEC-RAS OUTOUT – 2 YEAR PEAK FLOWS

Reach	River Sta	Profile	Q Total (cfs)	W.S. Elev (ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)
Reach-1	4.73	B70	1120.68	975.46	2.54	445.69	130.82
Reach-1	4.715*	Future w/o	1120.68	975.15	3.54	326.64	130.81
Reach-1	4.715*	B10	1120.68	975.15	3.54	326.64	130.81
Reach-1	4.715*	B1-1	1100.22	975.11	3.52	321.47	130.08
Reach-1	4.715*	B2-1	1120.68	975.15	3.54	326.63	130.81
Reach-1	4.715*	B20	1120.68	975.15	3.54	326.64	130.81
Reach-1	4.715*	B3-1	1052.76	975.02	3.48	309.42	128.35
Reach-1	4.715*	B60	1120.68	975.15	3.54	326.64	130.81
Reach-1	4.715*	B70	1120.68	975.15	3.54	326.64	130.81
Reach-1	4.7	Future w/o	1120.68	973.92	6.99	160.34	59.06
Reach-1	4.7	B10	1120.68	973.92	6.99	160.34	59.06
Reach-1	4.7	B1-1	1100.22	973.89	6.95	158.28	58.64
Reach-1	4.7	B2-1	1120.68	973.92	6.99	160.34	59.06
Reach-1	4.7	B20	1120.68	973.92	6.99	160.34	59.06
Reach-1	4.7	B3-1	1052.76	973.8	6.86	153.45	57.64
Reach-1	4.7	B60	1120.68	973.92	6.99	160.34	59.06
Reach-1	4.7	B70	1120.68	973.92	6.99	160.34	59.06
Reach-1	4.68*	Future w/o	1120.68	972.74	5.68	197.16	74.59
Reach-1	4.68*	B10	1120.68	972.74	5.68	197.16	74.59
Reach-1	4.68*	B1-1	1100.22	972.7	5.66	194.24	74.07
Reach-1	4.68*	B2-1	1120.68	972.74	5.69	197.12	74.58
Reach-1	4.68*	B20	1120.68	972.74	5.68	197.16	74.59
Reach-1	4.68*	B3-1	1052.76	972.61	5.61	187.6	72.89
Reach-1	4.68*	B60	1120.68	972.74	5.68	197.16	74.59
Reach-1	4.68*	B70	1120.68	972.74	5.68	197.16	74.59
Reach-1	4.66	Future w/o	1120.68	972.44	3.47	324.51	102.34
Reach-1	4.66	B10	1120.68	972.44	3.47	324.51	102.34
Reach-1	4.66	B1-1	1100.22	972.39	3.45	320.1	101.71
Reach-1	4.66	B2-1	1120.68	972.44	3.47	324.42	102.33
Reach-1	4.66	B20	1120.68	972.44	3.47	324.51	102.34
Reach-1	4.66	B3-1	1052.76	972.3	3.4	310.12	100.28
Reach-1	4.66	B60	1120.68	972.44	3.47	324.51	102.34
Reach-1	4.66	B70	1120.68	972.44	3.47	324.51	102.34
Reach-1	4.6*	Future w/o	1120.68	971.61	3.57	318.35	99.72
Reach-1	4.6*	B10	1120.68	971.61	3.57	318.35	99.72
Reach-1	4.6*	B1-1	1100.22	971.56	3.55	313.64	98.04
Reach-1	4.6*	B2-1	1120.68	971.61	3.57	318.17	99.65
Reach-1	4.6*	B20	1120.68	971.61	3.57	318.35	99.72
Reach-1	4.6*	B3-1	1052.76	971.46	3.49	303.4	94.3
Reach-1	4.6*	B60	1120.68	971.61	3.57	318.35	99.72
Reach-1	4.6*	B70	1120.68	971.61	3.57	318.35	99.72

TABLE E-V-1
HEC-RAS OUTOUT – 2 YEAR PEAK FLOWS

Reach	River Sta	Profile	Q Total (cfs)	W.S. Elev (ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)
Reach-1	4.54*	Future w/o	1120.68	970.82	3.79	311.79	112.37
Reach-1	4.54*	B10	1120.68	970.82	3.79	311.79	112.37
Reach-1	4.54*	B1-1	1100.22	970.77	3.76	306.09	110.66
Reach-1	4.54*	B2-1	1120.68	970.82	3.79	311.34	112.24
Reach-1	4.54*	B20	1120.68	970.82	3.79	311.79	112.37
Reach-1	4.54*	B3-1	1052.76	970.66	3.7	294.33	107.03
Reach-1	4.54*	B60	1120.68	970.82	3.79	311.79	112.37
Reach-1	4.54*	B70	1120.68	970.82	3.79	311.79	112.37
Reach-1	4.48*	Future w/o	1120.68	969.94	4.29	298.02	128.18
Reach-1	4.48*	B10	1120.68	969.94	4.29	298.02	128.18
Reach-1	4.48*	B1-1	1100.22	969.88	4.26	291.08	124.99
Reach-1	4.48*	B2-1	1120.68	969.93	4.29	296.86	127.6
Reach-1	4.48*	B20	1120.68	969.94	4.29	298.02	128.18
Reach-1	4.48*	B3-1	1052.76	969.78	4.18	278.69	120.47
Reach-1	4.48*	B60	1120.68	969.94	4.29	298.02	128.18
Reach-1	4.48*	B70	1120.68	969.94	4.29	298.02	128.18
Reach-1	4.42	Future w/o	1120.68	968.19	6.35	185.98	84.2
Reach-1	4.42	B10	1120.68	968.19	6.35	185.98	84.2
Reach-1	4.42	B1-1	1100.22	968.14	6.33	181.22	78.24
Reach-1	4.42	B2-1	1120.68	968.15	6.42	182.42	79.78
Reach-1	4.42	B20	1120.68	968.19	6.35	185.98	84.2
Reach-1	4.42	B3-1	1052.76	968.12	6.08	179.9	76.5
Reach-1	4.42	B60	1120.68	968.19	6.35	185.98	84.2
Reach-1	4.42	B70	1120.68	968.19	6.35	185.98	84.2
Reach-1	4.32	Future w/o	1402.67	963.44	7.1	197.51	50.06
Reach-1	4.32	B10	1402.67	963.44	7.1	197.51	50.06
Reach-1	4.32	B1-1	1357.69	963.33	7.07	192.09	49.61
Reach-1	4.32	B2-1	1348.25	963.31	7.06	190.94	49.52
Reach-1	4.32	B20	1402.67	963.44	7.1	197.51	50.06
Reach-1	4.32	B3-1	1396.53	963.42	7.1	196.78	49.99
Reach-1	4.32	B60	1402.67	963.44	7.1	197.51	50.06
Reach-1	4.32	B70	1402.67	963.44	7.1	197.51	50.06
Reach-1	4.18	Future w/o	1402.67	961.41	4.07	363.79	77.88
Reach-1	4.18	B10	1402.67	961.41	4.07	363.79	77.88
Reach-1	4.18	B1-1	1357.69	961.29	4.02	354.52	75.93
Reach-1	4.18	B2-1	1348.25	961.27	4.01	352.83	75.57
Reach-1	4.18	B20	1402.67	961.41	4.07	363.79	77.88
Reach-1	4.18	B3-1	1396.53	961.39	4.07	362.37	77.59
Reach-1	4.18	B60	1402.67	961.41	4.07	363.79	77.88
Reach-1	4.18	B70	1402.67	961.41	4.07	363.79	77.88

TABLE E-V-1
HEC-RAS OUTOUT – 2 YEAR PEAK FLOWS

Reach	River Sta	Profile	Q Total (cfs)	W.S. Elev (ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)
Reach-1	4.161	Future w/o	1402.67	961.39	3.6	634.84	396.38
Reach-1	4.161	B10	1402.67	961.39	3.6	634.84	396.38
Reach-1	4.161	B1-1	1357.69	961.26	3.58	599.68	390.49
Reach-1	4.161	B2-1	1348.25	961.24	3.57	593.25	389.4
Reach-1	4.161	B20	1402.67	961.39	3.6	634.84	396.38
Reach-1	4.161	B3-1	1396.53	961.37	3.6	629.5	395.49
Reach-1	4.161	B60	1402.67	961.39	3.6	634.84	396.38
Reach-1	4.161	B70	1402.67	961.39	3.6	634.84	396.38
Reach-1	4.1605		Mult Open				
Reach-1	4.16	Future w/o	1402.67	959.94	4.69	299.26	129.33
Reach-1	4.16	B10	1402.67	959.94	4.69	299.26	129.33
Reach-1	4.16	B1-1	1357.69	959.82	4.61	294.4	98.96
Reach-1	4.16	B2-1	1348.25	959.8	4.6	293.37	92.54
Reach-1	4.16	B20	1402.67	959.94	4.69	299.26	129.33
Reach-1	4.16	B3-1	1396.53	959.92	4.68	298.62	125.3
Reach-1	4.16	B60	1402.67	959.94	4.69	299.26	129.33
Reach-1	4.16	B70	1402.67	959.94	4.69	299.26	129.33
Reach-1	4.15	Future w/o	1402.67	959.82	4.75	308.12	98.61
Reach-1	4.15	B10	1402.67	959.82	4.75	308.12	98.61
Reach-1	4.15	B1-1	1357.69	959.71	4.68	298.56	68.54
Reach-1	4.15	B2-1	1348.25	959.68	4.67	296.95	66.44
Reach-1	4.15	B20	1402.67	959.82	4.75	308.12	98.61
Reach-1	4.15	B3-1	1396.53	959.8	4.74	306.65	94.61
Reach-1	4.15	B60	1402.67	959.82	4.75	308.12	98.61
Reach-1	4.15	B70	1402.67	959.82	4.75	308.12	98.61
Reach-1	4	Future w/o	2187.22	955.31	8.39	260.76	40.87
Reach-1	4	B10	2187.22	955.31	8.39	260.76	40.87
Reach-1	4	B1-1	2144.21	955.24	8.31	258.02	40.51
Reach-1	4	B2-1	2135.33	955.23	8.29	257.44	40.49
Reach-1	4	B20	2187.22	955.31	8.39	260.76	40.87
Reach-1	4	B3-1	2181.52	955.3	8.38	260.4	40.61
Reach-1	4	B60	2187.22	955.31	8.39	260.76	40.87
Reach-1	4	B70	2187.22	955.31	8.39	260.76	40.87
Reach-1	3.981	Future w/o	2187.22	955.11	7.44	294.07	96.91
Reach-1	3.981	B10	2187.22	955.11	7.44	294.07	96.91
Reach-1	3.981	B1-1	2144.21	955.05	7.36	291.34	79.77
Reach-1	3.981	B2-1	2135.33	955.03	7.34	290.77	76.18
Reach-1	3.981	B20	2187.22	955.11	7.44	294.07	96.91
Reach-1	3.981	B3-1	2181.52	955.1	7.43	293.71	94.65
Reach-1	3.981	B60	2187.22	955.11	7.44	294.07	96.91
Reach-1	3.981	B70	2187.22	955.11	7.44	294.07	96.91

TABLE E-V-1 HEC-RAS OUTOUT – 2 YEAR PEAK FLOWS							
Reach	**River Sta**	**Profile**	**Q Total (cfs)**	**W.S. Elev (ft)**	**Vel Chnl (ft/s)**	**Flow Area (sq ft)**	**Top Width (ft)**
Reach-1	3.9805		Bridge				
Reach-1	3.98	Future w/o	2187.22	955.11	7.44	294.04	96.7
Reach-1	3.98	B10	2187.22	955.11	7.44	294.04	96.7
Reach-1	3.98	B1-1	2144.21	955.05	7.36	291.3	79.56
Reach-1	3.98	B2-1	2135.33	955.03	7.34	290.73	75.97
Reach-1	3.98	B20	2187.22	955.11	7.44	294.04	96.7
Reach-1	3.98	B3-1	2181.52	955.1	7.43	293.68	94.44
Reach-1	3.98	B60	2187.22	955.11	7.44	294.04	96.7
Reach-1	3.98	B70	2187.22	955.11	7.44	294.04	96.7
Reach-1	3.97	Future w/o	2187.22	954.17	9.45	295.75	84.91
Reach-1	3.97	B10	2187.22	954.17	9.45	295.75	84.91
Reach-1	3.97	B1-1	2144.21	954.12	9.35	291.43	84.05
Reach-1	3.97	B2-1	2135.33	954.11	9.33	290.52	83.86
Reach-1	3.97	B20	2187.22	954.17	9.45	295.75	84.91
Reach-1	3.97	B3-1	2181.52	954.16	9.44	295.16	84.79
Reach-1	3.97	B60	2187.22	954.17	9.45	295.75	84.91
Reach-1	3.97	B70	2187.22	954.17	9.45	295.75	84.91
Reach-1	3.83	Future w/o	1915.12	947.01	8.44	620.06	336.72
Reach-1	3.83	B10	1915.12	947.01	8.44	620.06	336.72
Reach-1	3.83	B1-1	1883.35	946.98	8.41	609.96	335.94
Reach-1	3.83	B2-1	1876.93	946.97	8.4	607.98	335.78
Reach-1	3.83	B20	1915.12	947.01	8.44	620.06	336.72
Reach-1	3.83	B3-1	1910.89	947	8.43	618.77	336.62
Reach-1	3.83	B60	1915.12	947.01	8.44	620.06	336.72
Reach-1	3.83	B70	1915.12	947.01	8.44	620.06	336.72
Reach-1	3.68	Future w/o	1915.12	940.96	6.96	776.37	348.65
Reach-1	3.68	B10	1915.12	940.96	6.96	776.37	348.65
Reach-1	3.68	B1-1	1883.35	940.93	6.94	764.49	347.76
Reach-1	3.68	B2-1	1876.93	940.92	6.93	762.05	347.58
Reach-1	3.68	B20	1915.12	940.96	6.96	776.37	348.65
Reach-1	3.68	B3-1	1910.89	940.96	6.95	774.75	348.53
Reach-1	3.68	B60	1915.12	940.96	6.96	776.37	348.65
Reach-1	3.68	B70	1915.12	940.96	6.96	776.37	348.65
Reach-1	3.53	Future w/o	1915.12	933.88	8.93	577.85	333.43
Reach-1	3.53	B10	1915.12	933.88	8.93	577.85	333.43
Reach-1	3.53	B1-1	1883.35	933.85	8.89	569.11	332.74
Reach-1	3.53	B2-1	1876.93	933.85	8.88	567.28	332.6
Reach-1	3.53	B20	1915.12	933.88	8.93	577.85	333.43
Reach-1	3.53	B3-1	1910.89	933.88	8.93	576.71	333.34
Reach-1	3.53	B60	1915.12	933.88	8.93	577.85	333.43

TABLE E-V-1 HEC-RAS OUTOUT – 2 YEAR PEAK FLOWS							
Reach	**River Sta**	**Profile**	**Q Total (cfs)**	**W.S. Elev (ft)**	**Vel Chnl (ft/s)**	**Flow Area (sq ft)**	**Top Width (ft)**
Reach-1	3.53	B70	1915.12	933.88	8.93	577.85	333.43
Reach-1	3.38	Future w/o	1915.12	929.75	3.92	1445.19	399.89
Reach-1	3.38	B10	1915.12	929.75	3.92	1445.19	399.89
Reach-1	3.38	B1-1	1883.35	929.7	3.9	1426.5	398.52
Reach-1	3.38	B2-1	1876.93	929.69	3.9	1422.68	398.24
Reach-1	3.38	B20	1915.12	929.75	3.92	1445.19	399.89
Reach-1	3.38	B3-1	1910.89	929.74	3.92	1442.72	399.71
Reach-1	3.38	B60	1915.12	929.75	3.92	1445.19	399.89
Reach-1	3.38	B70	1915.12	929.75	3.92	1445.19	399.89
Reach-1	3.355*	Future w/o	1915.12	929.46	4.12	1348.7	384.07
Reach-1	3.355*	B10	1915.12	929.46	4.12	1348.7	384.07
Reach-1	3.355*	B1-1	1883.35	929.41	4.1	1330.71	383.43
Reach-1	3.355*	B2-1	1876.93	929.4	4.1	1327.06	383.13
Reach-1	3.355*	B20	1915.12	929.46	4.12	1348.7	384.07
Reach-1	3.355*	B3-1	1910.89	929.45	4.12	1346.33	383.98
Reach-1	3.355*	B60	1915.12	929.46	4.12	1348.7	384.07
Reach-1	3.355*	B70	1915.12	929.46	4.12	1348.7	384.07
Reach-1	3.33*	Future w/o	1915.12	929.15	4.3	1251.58	364.73
Reach-1	3.33*	B10	1915.12	929.15	4.3	1251.58	364.73
Reach-1	3.33*	B1-1	1883.35	929.1	4.28	1234.57	364.04
Reach-1	3.33*	B2-1	1876.93	929.09	4.28	1231.1	363.9
Reach-1	3.33*	B20	1915.12	929.15	4.3	1251.58	364.73
Reach-1	3.33*	B3-1	1910.89	929.14	4.3	1249.33	364.64
Reach-1	3.33*	B60	1915.12	929.15	4.3	1251.58	364.73
Reach-1	3.33*	B70	1915.12	929.15	4.3	1251.58	364.73
Reach-1	3.305*	Future w/o	1915.12	928.81	4.5	1152.56	346.29
Reach-1	3.305*	B10	1915.12	928.81	4.5	1152.56	346.29
Reach-1	3.305*	B1-1	1883.35	928.76	4.48	1136.58	345.51
Reach-1	3.305*	B2-1	1876.93	928.75	4.48	1133.34	345.35
Reach-1	3.305*	B20	1915.12	928.81	4.5	1152.56	346.29
Reach-1	3.305*	B3-1	1910.89	928.8	4.5	1150.47	346.19
Reach-1	3.305*	B60	1915.12	928.81	4.5	1152.56	346.29
Reach-1	3.305*	B70	1915.12	928.81	4.5	1152.56	346.29
Reach-1	3.28*	Future w/o	1915.12	928.44	4.72	1052.88	329.44
Reach-1	3.28*	B10	1915.12	928.44	4.72	1052.88	329.44
Reach-1	3.28*	B1-1	1883.35	928.4	4.7	1037.98	328.56
Reach-1	3.28*	B2-1	1876.93	928.39	4.7	1034.95	328.38
Reach-1	3.28*	B20	1915.12	928.44	4.72	1052.88	329.44
Reach-1	3.28*	B3-1	1910.89	928.44	4.72	1050.93	329.32
Reach-1	3.28*	B60	1915.12	928.44	4.72	1052.88	329.44
Reach-1	3.28*	B70	1915.12	928.44	4.72	1052.88	329.44

TABLE E-V-1 HEC-RAS OUTOUT – 2 YEAR PEAK FLOWS								
Reach	**River Sta**	**Profile**	**Q Total (cfs)**	**W.S. Elev (ft)**	**Vel Chnl (ft/s)**	**Flow Area (sq ft)**	**Top Width (ft)**
Reach-1	3.255*	Future w/o	1915.12	928.03	5	949.29	314.94
Reach-1	3.255*	B10	1915.12	928.03	5	949.29	314.94
Reach-1	3.255*	B1-1	1883.35	927.99	4.97	935.49	313.91
Reach-1	3.255*	B2-1	1876.93	927.98	4.97	932.69	313.7
Reach-1	3.255*	B20	1915.12	928.03	5	949.29	314.94
Reach-1	3.255*	B3-1	1910.89	928.02	4.99	947.48	314.81
Reach-1	3.255*	B60	1915.12	928.03	5	949.29	314.94
Reach-1	3.255*	B70	1915.12	928.03	5	949.29	314.94
Reach-1	3.23*	Future w/o	1915.12	927.55	5.34	842.69	305.24
Reach-1	3.23*	B10	1915.12	927.55	5.34	842.69	305.24
Reach-1	3.23*	B1-1	1883.35	927.51	5.31	830.05	303.96
Reach-1	3.23*	B2-1	1876.93	927.5	5.3	827.47	303.7
Reach-1	3.23*	B20	1915.12	927.55	5.34	842.69	305.24
Reach-1	3.23*	B3-1	1910.89	927.55	5.34	841.03	305.08
Reach-1	3.23*	B60	1915.12	927.55	5.34	842.69	305.24
Reach-1	3.23*	B70	1915.12	927.55	5.34	842.69	305.24
Reach-1	3.205*	Future w/o	1915.12	926.95	5.84	728.31	307.82
Reach-1	3.205*	B10	1915.12	926.95	5.84	728.31	307.82
Reach-1	3.205*	B1-1	1883.35	926.91	5.8	716.88	306.02
Reach-1	3.205*	B2-1	1876.93	926.91	5.8	714.55	305.66
Reach-1	3.205*	B20	1915.12	926.95	5.84	728.31	307.82
Reach-1	3.205*	B3-1	1910.89	926.95	5.84	726.81	307.59
Reach-1	3.205*	B60	1915.12	926.95	5.84	728.31	307.82
Reach-1	3.205*	B70	1915.12	926.95	5.84	728.31	307.82
Reach-1	3.18	Future w/o	1915.12	926.06	6.79	604.44	384.44
Reach-1	3.18	B10	1915.12	926.06	6.79	604.44	384.44
Reach-1	3.18	B1-1	1883.35	926.02	6.77	588.95	383.49
Reach-1	3.18	B2-1	1876.93	926.01	6.77	585.79	383.29
Reach-1	3.18	B20	1915.12	926.06	6.79	604.44	384.44
Reach-1	3.18	B3-1	1910.89	926.06	6.79	602.4	384.31
Reach-1	3.18	B60	1915.12	926.06	6.79	604.44	384.44
Reach-1	3.18	B70	1915.12	926.06	6.79	604.44	384.44
Reach-1	3.152*	Future w/o	1915.12	925.2	6.85	547.61	367.29
Reach-1	3.152*	B10	1915.12	925.2	6.85	547.61	367.29
Reach-1	3.152*	B1-1	1883.35	925.16	6.82	532.98	361.38
Reach-1	3.152*	B2-1	1876.93	925.15	6.82	530	360.17
Reach-1	3.152*	B20	1915.12	925.2	6.85	547.61	367.29
Reach-1	3.152*	B3-1	1910.89	925.2	6.85	545.66	366.51
Reach-1	3.152*	B60	1915.12	925.2	6.85	547.61	367.29
Reach-1	3.152*	B70	1915.12	925.2	6.85	547.61	367.29

TABLE E-V-1
HEC-RAS OUTOUT – 2 YEAR PEAK FLOWS

Reach	River Sta	Profile	Q Total (cfs)	W.S. Elev (ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)
Reach-1	3.124*	Future w/o	1915.12	924.32	6.91	488.63	358.53
Reach-1	3.124*	B10	1915.12	924.32	6.91	488.63	358.53
Reach-1	3.124*	B1-1	1883.35	924.27	6.9	471.26	352.1
Reach-1	3.124*	B2-1	1876.93	924.26	6.9	467.72	350.77
Reach-1	3.124*	B20	1915.12	924.32	6.91	488.63	358.53
Reach-1	3.124*	B3-1	1910.89	924.31	6.91	486.31	357.67
Reach-1	3.124*	B60	1915.12	924.32	6.91	488.63	358.53
Reach-1	3.124*	B70	1915.12	924.32	6.91	488.63	358.53
Reach-1	3.096*	Future w/o	1915.12	923.32	7.17	382.17	319.51
Reach-1	3.096*	B10	1915.12	923.32	7.17	382.17	319.51
Reach-1	3.096*	B1-1	1883.35	923.26	7.15	365.89	302.26
Reach-1	3.096*	B2-1	1876.93	923.25	7.14	362.81	298.88
Reach-1	3.096*	B20	1915.12	923.32	7.17	382.17	319.51
Reach-1	3.096*	B3-1	1910.89	923.31	7.17	379.9	317.16
Reach-1	3.096*	B60	1915.12	923.32	7.17	382.17	319.51
Reach-1	3.096*	B70	1915.12	923.32	7.17	382.17	319.51
Reach-1	3.068*	Future w/o	1915.12	922.41	6.97	329.71	101.19
Reach-1	3.068*	B10	1915.12	922.41	6.97	329.71	101.19
Reach-1	3.068*	B1-1	1883.35	922.35	6.92	324.47	99.87
Reach-1	3.068*	B2-1	1876.93	922.34	6.91	323.49	99.63
Reach-1	3.068*	B20	1915.12	922.41	6.97	329.71	101.19
Reach-1	3.068*	B3-1	1910.89	922.4	6.96	328.97	101
Reach-1	3.068*	B60	1915.12	922.41	6.97	329.71	101.19
Reach-1	3.068*	B70	1915.12	922.41	6.97	329.71	101.19
Reach-1	3.04	Future w/o	1915.12	921.59	6.62	347.1	100.84
Reach-1	3.04	B10	1915.12	921.59	6.62	347.1	100.84
Reach-1	3.04	B1-1	1883.35	921.54	6.58	341.69	99.63
Reach-1	3.04	B2-1	1876.93	921.53	6.57	340.77	99.42
Reach-1	3.04	B20	1915.12	921.59	6.62	347.1	100.84
Reach-1	3.04	B3-1	1910.89	921.59	6.61	346.3	100.66
Reach-1	3.04	B60	1915.12	921.59	6.62	347.1	100.84
Reach-1	3.04	B70	1915.12	921.59	6.62	347.1	100.84
Reach-1	3.016*	Future w/o	1915.12	920.86	6.7	358.72	126.94
Reach-1	3.016*	B10	1915.12	920.86	6.7	358.72	126.94
Reach-1	3.016*	B1-1	1883.35	920.83	6.61	354.6	118.3
Reach-1	3.016*	B2-1	1876.93	920.82	6.6	353.61	118.02
Reach-1	3.016*	B20	1915.12	920.86	6.7	358.72	126.94
Reach-1	3.016*	B3-1	1910.89	920.86	6.68	358.24	124.69
Reach-1	3.016*	B60	1915.12	920.86	6.7	358.72	126.94
Reach-1	3.016*	B70	1915.12	920.86	6.7	358.72	126.94
Reach-1	2.992*	Future w/o	1915.12	920.09	6.84	390.59	248.31

TABLE E-V-1 HEC-RAS OUTOUT – 2 YEAR PEAK FLOWS							
Reach	**River Sta**	**Profile**	**Q Total (cfs)**	**W.S. Elev (ft)**	**Vel Chnl (ft/s)**	**Flow Area (sq ft)**	**Top Width (ft)**
Reach-1	2.992*	B10	1915.12	920.09	6.84	390.59	248.31
Reach-1	2.992*	B1-1	1883.35	920.05	6.78	381.51	237.02
Reach-1	2.992*	B2-1	1876.93	920.04	6.77	379.71	234.72
Reach-1	2.992*	B20	1915.12	920.09	6.84	390.59	248.31
Reach-1	2.992*	B3-1	1910.89	920.08	6.83	389.36	246.82
Reach-1	2.992*	B60	1915.12	920.09	6.84	390.59	248.31
Reach-1	2.992*	B70	1915.12	920.09	6.84	390.59	248.31
Reach-1	2.968*	Future w/o	1915.12	919.34	6.78	447.97	306.45
Reach-1	2.968*	B10	1915.12	919.34	6.78	447.97	306.45
Reach-1	2.968*	B1-1	1883.35	919.3	6.74	437.18	299.09
Reach-1	2.968*	B2-1	1876.93	919.29	6.73	435.03	297.6
Reach-1	2.968*	B20	1915.12	919.34	6.78	447.97	306.45
Reach-1	2.968*	B3-1	1910.89	919.33	6.78	446.53	305.48
Reach-1	2.968*	B60	1915.12	919.34	6.78	447.97	306.45
Reach-1	2.968*	B70	1915.12	919.34	6.78	447.97	306.45
Reach-1	2.944*	Future w/o	1915.12	918.64	6.56	533	353.85
Reach-1	2.944*	B10	1915.12	918.64	6.56	533	353.85
Reach-1	2.944*	B1-1	1883.35	918.6	6.52	520.4	348.09
Reach-1	2.944*	B2-1	1876.93	918.6	6.51	517.88	346.92
Reach-1	2.944*	B20	1915.12	918.64	6.56	533	353.85
Reach-1	2.944*	B3-1	1910.89	918.63	6.55	531.32	353.08
Reach-1	2.944*	B60	1915.12	918.64	6.56	533	353.85
Reach-1	2.944*	B70	1915.12	918.64	6.56	533	353.85
Reach-1	2.92	Future w/o	1915.12	918.12	5.87	702.03	404.02
Reach-1	2.92	B10	1915.12	918.12	5.87	702.03	404.02
Reach-1	2.92	B1-1	1883.35	918.08	5.87	684.95	402.43
Reach-1	2.92	B2-1	1876.93	918.07	5.86	681.49	402.1
Reach-1	2.92	B20	1915.12	918.12	5.87	702.03	404.02
Reach-1	2.92	B3-1	1910.89	918.11	5.87	699.77	403.81
Reach-1	2.92	B60	1915.12	918.12	5.87	702.03	404.02
Reach-1	2.92	B70	1915.12	918.12	5.87	702.03	404.02
Reach-1	2.894*	Future w/o	1915.12	917.45	6.02	582.31	297.98
Reach-1	2.894*	B10	1915.12	917.45	6.02	582.31	297.98
Reach-1	2.894*	B1-1	1883.35	917.41	5.99	570.23	295.38
Reach-1	2.894*	B2-1	1876.93	917.4	5.99	567.8	294.85
Reach-1	2.894*	B20	1915.12	917.45	6.02	582.31	297.98
Reach-1	2.894*	B3-1	1910.89	917.45	6.02	580.71	297.64
Reach-1	2.894*	B60	1915.12	917.45	6.02	582.31	297.98
Reach-1	2.894*	B70	1915.12	917.45	6.02	582.31	297.98
Reach-1	2.868*	Future w/o	1915.12	916.83	5.94	547.32	268.79
Reach-1	2.868*	B10	1915.12	916.83	5.94	547.32	268.79

TABLE E-V-1 HEC-RAS OUTOUT – 2 YEAR PEAK FLOWS							
Reach	**River Sta**	**Profile**	**Q Total (cfs)**	**W.S. Elev (ft)**	**Vel Chnl (ft/s)**	**Flow Area (sq ft)**	**Top Width (ft)**
Reach-1	2.868*	B1-1	1883.35	916.79	5.9	536.45	266.92
Reach-1	2.868*	B2-1	1876.93	916.78	5.9	534.27	266.55
Reach-1	2.868*	B20	1915.12	916.83	5.94	547.32	268.79
Reach-1	2.868*	B3-1	1910.89	916.83	5.93	545.88	268.54
Reach-1	2.868*	B60	1915.12	916.83	5.94	547.32	268.79
Reach-1	2.868*	B70	1915.12	916.83	5.94	547.32	268.79
Reach-1	2.842*	Future w/o	1915.12	916.27	5.73	540.03	257.69
Reach-1	2.842*	B10	1915.12	916.27	5.73	540.03	257.69
Reach-1	2.842*	B1-1	1883.35	916.23	5.7	529.89	256.21
Reach-1	2.842*	B2-1	1876.93	916.22	5.69	527.84	255.92
Reach-1	2.842*	B20	1915.12	916.27	5.73	540.03	257.69
Reach-1	2.842*	B3-1	1910.89	916.26	5.73	538.68	257.49
Reach-1	2.842*	B60	1915.12	916.27	5.73	540.03	257.69
Reach-1	2.842*	B70	1915.12	916.27	5.73	540.03	257.69
Reach-1	2.816*	Future w/o	1915.12	915.79	5.41	556.35	254.29
Reach-1	2.816*	B10	1915.12	915.79	5.41	556.35	254.29
Reach-1	2.816*	B1-1	1883.35	915.75	5.37	546.92	253.09
Reach-1	2.816*	B2-1	1876.93	915.74	5.37	545.02	252.84
Reach-1	2.816*	B20	1915.12	915.79	5.41	556.35	254.29
Reach-1	2.816*	B3-1	1910.89	915.78	5.41	555.09	254.13
Reach-1	2.816*	B60	1915.12	915.79	5.41	556.35	254.29
Reach-1	2.816*	B70	1915.12	915.79	5.41	556.35	254.29
Reach-1	2.79	Future w/o	1915.12	915.41	4.99	600.67	256.07
Reach-1	2.79	B10	1915.12	915.41	4.99	600.67	256.07
Reach-1	2.79	B1-1	1883.35	915.37	4.94	592.01	255.08
Reach-1	2.79	B2-1	1876.93	915.37	4.94	590.25	254.88
Reach-1	2.79	B20	1915.12	915.41	4.99	600.67	256.07
Reach-1	2.79	B3-1	1910.89	915.4	4.98	599.51	255.94
Reach-1	2.79	B60	1915.12	915.41	4.99	600.67	256.07
Reach-1	2.79	B70	1915.12	915.41	4.99	600.67	256.07
Reach-1	2.76333*	Future w/o	1915.12	914.92	5.41	660.69	310.33
Reach-1	2.76333*	B10	1915.12	914.92	5.41	660.69	310.33
Reach-1	2.76333*	B1-1	1883.35	914.9	5.36	651.55	309.05
Reach-1	2.76333*	B2-1	1876.93	914.89	5.35	649.7	308.79
Reach-1	2.76333*	B20	1915.12	914.92	5.41	660.69	310.33
Reach-1	2.76333*	B3-1	1910.89	914.92	5.4	659.48	310.16
Reach-1	2.76333*	B60	1915.12	914.92	5.41	660.69	310.33
Reach-1	2.76333*	B70	1915.12	914.92	5.41	660.69	310.33
Reach-1	2.73666*	Future w/o	1915.12	914.28	6.03	712.42	394.5
Reach-1	2.73666*	B10	1915.12	914.28	6.03	712.42	394.5
Reach-1	2.73666*	B1-1	1883.35	914.26	5.97	703.92	392.81

TABLE E-V-1
HEC-RAS OUTOUT – 2 YEAR PEAK FLOWS

Reach	River Sta	Profile	Q Total (cfs)	W.S. Elev (ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)
Reach-1	2.73666*	B2-1	1876.93	914.26	5.96	702.24	392.47
Reach-1	2.73666*	B20	1915.12	914.28	6.03	712.4	394.5
Reach-1	2.73666*	B3-1	1910.89	914.28	6.02	711.27	394.27
Reach-1	2.73666*	B60	1915.12	914.28	6.03	712.42	394.5
Reach-1	2.73666*	B70	1915.12	914.28	6.03	712.42	394.5
Reach-1	2.71	Future w/o	1915.12	913.33	7	750.11	505.58
Reach-1	2.71	B10	1915.12	913.33	7	750.11	505.58
Reach-1	2.71	B1-1	1883.35	913.28	7.04	727.78	502.55
Reach-1	2.71	B2-1	1876.93	913.27	7.04	723.12	501.91
Reach-1	2.71	B20	1915.12	913.33	7	750.24	505.59
Reach-1	2.71	B3-1	1910.89	913.32	7.01	747.18	505.18
Reach-1	2.71	B60	1915.12	913.33	7	750.11	505.58
Reach-1	2.71	B70	1915.12	913.33	7	750.11	505.58
Reach-1	2.68333*	Future w/o	1915.12	910.56	10.33	244.02	99.49
Reach-1	2.68333*	B10	1915.12	910.56	10.33	244.02	99.49
Reach-1	2.68333*	B1-1	1883.35	910.51	10.3	238.98	97.99
Reach-1	2.68333*	B2-1	1876.93	910.5	10.3	238.04	97.71
Reach-1	2.68333*	B20	1915.12	910.56	10.34	243.95	99.47
Reach-1	2.68333*	B3-1	1910.89	910.55	10.33	243.34	99.29
Reach-1	2.68333*	B60	1915.12	910.56	10.33	244.02	99.49
Reach-1	2.68333*	B70	1915.12	910.56	10.33	244.02	99.49
Reach-1	2.65666*	Future w/o	1915.12	909.46	7.75	369.76	103.28
Reach-1	2.65666*	B10	1915.12	909.46	7.75	369.76	103.28
Reach-1	2.65666*	B1-1	1883.35	909.41	7.71	364.57	102.51
Reach-1	2.65666*	B2-1	1876.93	909.41	7.69	364.13	102.44
Reach-1	2.65666*	B20	1915.12	909.45	7.76	369.21	103.2
Reach-1	2.65666*	B3-1	1910.89	909.45	7.75	369.02	103.17
Reach-1	2.65666*	B60	1915.12	909.46	7.75	369.76	103.28
Reach-1	2.65666*	B70	1915.12	909.46	7.75	369.76	103.28
Reach-1	2.63	Future w/o	2011.66	909.15	5.52	726.05	310.81
Reach-1	2.63	B10	2011.66	909.15	5.52	726.05	310.81
Reach-1	2.63	B1-1	1973.23	909.1	5.48	710.3	310.14
Reach-1	2.63	B2-1	1969.29	909.1	5.48	708.67	310.07
Reach-1	2.63	B20	2011.66	909.14	5.53	723.64	310.71
Reach-1	2.63	B3-1	2006.24	909.14	5.52	723.85	310.72
Reach-1	2.63	B60	2011.66	909.15	5.52	726.05	310.81
Reach-1	2.63	B70	2011.66	909.15	5.52	726.05	310.81
Reach-1	2.555*	Future w/o	2011.66	907.88	5.68	776.69	412.97
Reach-1	2.555*	B10	2011.66	907.88	5.68	776.69	412.97
Reach-1	2.555*	B1-1	1973.23	907.83	5.65	755.51	412.09
Reach-1	2.555*	B2-1	1969.29	907.82	5.65	753.3	412

TABLE E-V-1 HEC-RAS OUTOUT – 2 YEAR PEAK FLOWS							
Reach	**River Sta**	**Profile**	**Q Total (cfs)**	**W.S. Elev (ft)**	**Vel Chnl (ft/s)**	**Flow Area (sq ft)**	**Top Width (ft)**
Reach-1	2.555*	B20	2011.66	907.84	5.75	759.99	412.28
Reach-1	2.555*	B3-1	2006.24	907.87	5.68	773.69	412.85
Reach-1	2.555*	B60	2011.66	907.88	5.68	776.69	412.97
Reach-1	2.555*	B70	2011.66	907.88	5.68	776.69	412.97
Reach-1	2.48*	Future w/o	2011.66	906.68	5.52	895.42	471.58
Reach-1	2.48*	B10	2011.66	906.68	5.52	895.42	471.58
Reach-1	2.48*	B1-1	1973.23	906.62	5.51	868.22	464.51
Reach-1	2.48*	B2-1	1969.29	906.61	5.51	865.33	463.75
Reach-1	2.48*	B20	2011.66	906.46	5.9	794.52	444.79
Reach-1	2.48*	B3-1	2006.24	906.67	5.52	891.51	470.57
Reach-1	2.48*	B60	2011.66	906.68	5.52	895.42	471.58
Reach-1	2.48*	B70	2011.66	906.68	5.52	895.42	471.58
Reach-1	2.405*	Future w/o	2011.66	905.9	4.42	1322.9	555.19
Reach-1	2.405*	B10	2011.66	905.9	4.42	1322.9	555.19
Reach-1	2.405*	B1-1	1973.23	905.83	4.43	1284.15	548.13
Reach-1	2.405*	B2-1	1969.29	905.82	4.43	1279.9	547.35
Reach-1	2.405*	B20	2011.66	905.2	5.49	959.01	484.84
Reach-1	2.405*	B3-1	2006.24	905.89	4.42	1317.28	554.18
Reach-1	2.405*	B60	2011.66	905.9	4.42	1322.9	555.19
Reach-1	2.405*	B70	2011.66	905.9	4.42	1322.9	555.19
Reach-1	2.33	Future w/o	2241.85	905.49	3.4	2130.21	671.26
Reach-1	2.33	B10	2241.85	905.49	3.4	2130.21	671.26
Reach-1	2.33	B1-1	2207.06	905.41	3.41	2076.92	663.87
Reach-1	2.33	B2-1	2203.21	905.4	3.42	2071.05	663.05
Reach-1	2.33	B20	1866.26	904.61	3.62	1575.24	589.78
Reach-1	2.33	B3-1	2236.79	905.47	3.4	2122.47	670.19
Reach-1	2.33	B60	2241.85	905.49	3.4	2130.21	671.26
Reach-1	2.33	B70	2241.85	905.49	3.4	2130.21	671.26
Reach-1	2.311	Future w/o	2241.85	904.22	8.02	279.58	553.93
Reach-1	2.311	B10	2241.85	904.22	8.02	279.58	553.93
Reach-1	2.311	B1-1	2207.06	904.16	7.97	277.03	548.18
Reach-1	2.311	B2-1	2203.21	904.15	7.96	276.75	547.55
Reach-1	2.311	B20	1866.26	903.55	7.4	252.25	484.76
Reach-1	2.311	B3-1	2236.79	904.21	8.01	279.22	553.11
Reach-1	2.311	B60	2241.85	904.22	8.02	279.58	553.93
Reach-1	2.311	B70	2241.85	904.22	8.02	279.58	553.93
Reach-1	2.3105		Culvert				
Reach-1	2.31	Future w/o	2241.85	903.14	9.5	236.02	440.7
Reach-1	2.31	B10	2241.85	903.14	9.5	236.02	440.7
Reach-1	2.31	B1-1	2207.06	903.11	9.4	234.76	437.24

TABLE E-V-1 HEC-RAS OUTOUT – 2 YEAR PEAK FLOWS							
Reach	**River Sta**	**Profile**	**Q Total (cfs)**	**W.S. Elev (ft)**	**Vel Chnl (ft/s)**	**Flow Area (sq ft)**	**Top Width (ft)**
Reach-1	2.31	B2-1	2203.21	903.1	9.39	234.62	436.85
Reach-1	2.31	B20	1866.26	902.77	8.42	221.58	400.78
Reach-1	2.31	B3-1	2236.79	903.13	9.48	235.84	440.22
Reach-1	2.31	B60	2241.85	903.14	9.5	236.02	440.7
Reach-1	2.31	B70	2241.85	903.14	9.5	236.02	440.7
Reach-1	2.3	Future w/o	2241.85	903.23	6.84	854.24	450.06
Reach-1	2.3	B10	2241.85	903.23	6.84	854.24	450.06
Reach-1	2.3	B1-1	2207.06	903.18	6.85	831.88	444.66
Reach-1	2.3	B2-1	2203.21	903.17	6.85	829.44	444.06
Reach-1	2.3	B20	1866.26	902.67	6.95	621.2	390.11
Reach-1	2.3	B3-1	2236.79	903.22	6.84	851.08	449.3
Reach-1	2.3	B60	2241.85	903.23	6.84	854.24	450.06
Reach-1	2.3	B70	2241.85	903.23	6.84	854.24	450.06
Reach-1	2.27	Future w/o	2241.85	903.14	4.38	583.88	181.44
Reach-1	2.27	B10	2241.85	903.14	4.38	583.88	181.44
Reach-1	2.27	B1-1	2207.06	903.1	4.34	576.19	178.96
Reach-1	2.27	B2-1	2203.21	903.09	4.34	575.36	178.69
Reach-1	2.27	B20	1866.26	902.67	3.97	505.03	154.07
Reach-1	2.27	B3-1	2236.79	903.13	4.37	582.79	181.1
Reach-1	2.27	B60	2241.85	903.14	4.38	583.88	181.44
Reach-1	2.27	B70	2241.85	903.14	4.38	583.88	181.44
Reach-1	2.25*	Future w/o	2241.85	902.93	4.44	656.57	235.1
Reach-1	2.25*	B10	2241.85	902.93	4.44	656.57	235.1
Reach-1	2.25*	B1-1	2207.06	902.89	4.41	646.63	233.5
Reach-1	2.25*	B2-1	2203.21	902.88	4.41	645.56	233.33
Reach-1	2.25*	B20	1866.26	902.47	4.07	551.9	217.71
Reach-1	2.25*	B3-1	2236.79	902.92	4.44	655.18	234.88
Reach-1	2.25*	B60	2241.85	902.93	4.44	656.57	235.1
Reach-1	2.25*	B70	2241.85	902.93	4.44	656.57	235.1
Reach-1	2.23*	Future w/o	2241.85	902.71	4.46	744.75	270.33
Reach-1	2.23*	B10	2241.85	902.71	4.46	744.75	270.33
Reach-1	2.23*	B1-1	2207.06	902.67	4.43	733.35	269.01
Reach-1	2.23*	B2-1	2203.21	902.66	4.43	732.13	268.88
Reach-1	2.23*	B20	1866.26	902.25	4.14	624.12	257.52
Reach-1	2.23*	B3-1	2236.79	902.7	4.46	743.17	270.15
Reach-1	2.23*	B60	2241.85	902.71	4.46	744.75	270.33
Reach-1	2.23*	B70	2241.85	902.71	4.46	744.75	270.33
Reach-1	2.21	Future w/o	2241.85	902.47	4.44	843.11	307.92
Reach-1	2.21	B10	2241.85	902.47	4.44	843.11	307.92
Reach-1	2.21	B1-1	2207.06	902.43	4.42	829.99	306.16
Reach-1	2.21	B2-1	2203.21	902.43	4.41	828.61	305.97

TABLE E-V-1
HEC-RAS OUTOUT – 2 YEAR PEAK FLOWS

Reach	River Sta	Profile	Q Total (cfs)	W.S. Elev (ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)
Reach-1	2.21	B20	1866.26	902.02	4.16	706.89	289.06
Reach-1	2.21	B3-1	2236.79	902.47	4.43	841.3	307.68
Reach-1	2.21	B60	2241.85	902.47	4.44	843.11	307.92
Reach-1	2.21	B70	2241.85	902.47	4.44	843.11	307.92
Reach-1	2.1875*	Future w/o	2241.85	902.15	4.74	848.26	316.81
Reach-1	2.1875*	B10	2241.85	902.15	4.74	848.26	316.81
Reach-1	2.1875*	B1-1	2207.06	902.11	4.72	834.68	314.45
Reach-1	2.1875*	B2-1	2203.21	902.1	4.72	833.26	314.2
Reach-1	2.1875*	B20	1866.26	901.7	4.44	711.32	292.19
Reach-1	2.1875*	B3-1	2236.79	902.14	4.74	846.42	316.49
Reach-1	2.1875*	B60	2241.85	902.15	4.74	848.26	316.81
Reach-1	2.1875*	B70	2241.85	902.15	4.74	848.26	316.81
Reach-1	2.165*	Future w/o	2241.85	901.78	5.18	842.84	337.78
Reach-1	2.165*	B10	2241.85	901.78	5.18	842.84	337.78
Reach-1	2.165*	B1-1	2207.06	901.73	5.16	828.13	334.18
Reach-1	2.165*	B2-1	2203.21	901.73	5.16	826.62	333.81
Reach-1	2.165*	B20	1866.26	901.34	4.85	702.37	301.66
Reach-1	2.165*	B3-1	2236.79	901.77	5.18	840.9	337.31
Reach-1	2.165*	B60	2241.85	901.78	5.18	842.86	337.79
Reach-1	2.165*	B70	2241.85	901.78	5.18	842.84	337.78
Reach-1	2.1425*	Future w/o	2241.85	901.31	5.83	815.83	347.77
Reach-1	2.1425*	B10	2241.85	901.31	5.83	815.83	347.77
Reach-1	2.1425*	B1-1	2207.06	901.26	5.82	799	345.85
Reach-1	2.1425*	B2-1	2203.21	901.26	5.82	797.35	345.66
Reach-1	2.1425*	B20	1866.26	900.86	5.54	664.13	325.33
Reach-1	2.1425*	B3-1	2236.79	901.3	5.83	813.75	347.53
Reach-1	2.1425*	B60	2241.85	901.31	5.83	815.89	347.78
Reach-1	2.1425*	B70	2241.85	901.31	5.83	815.85	347.77
Reach-1	2.12	Future w/o	2241.85	899.48	10.07	397.77	206
Reach-1	2.12	B10	2241.85	899.48	10.07	397.77	206
Reach-1	2.12	B1-1	2207.06	899.48	9.94	396.38	205.72
Reach-1	2.12	B2-1	2203.21	899.48	9.93	395.84	205.61
Reach-1	2.12	B20	1866.26	899.09	9.57	320.07	189.87
Reach-1	2.12	B3-1	2236.79	899.48	10.06	396.94	205.83
Reach-1	2.12	B60	2241.85	899.48	10.07	397.68	205.98
Reach-1	2.12	B70	2241.85	899.48	10.07	397.76	206
Reach-1	2.1	Future w/o	2241.85	898.66	6.95	530.5	345.35
Reach-1	2.1	B10	2241.85	898.66	6.95	530.5	345.35
Reach-1	2.1	B1-1	2207.06	898.62	6.92	517.63	343.35
Reach-1	2.1	B2-1	2203.21	898.62	6.91	516.21	343.13
Reach-1	2.1	B20	1866.26	898.23	6.51	385.51	322.1

TABLE E-V-1 HEC-RAS OUTOUT – 2 YEAR PEAK FLOWS							
Reach	**River Sta**	**Profile**	**Q Total (cfs)**	**W.S. Elev (ft)**	**Vel Chnl (ft/s)**	**Flow Area (sq ft)**	**Top Width (ft)**
Reach-1	2.1	B3-1	2236.79	898.66	6.95	528.64	345.06
Reach-1	2.1	B60	2241.85	898.66	6.95	530.52	345.35
Reach-1	2.1	B70	2241.85	898.66	6.95	530.52	345.35
Reach-1	2.04666*	Future w/o	2241.85	896.98	6.81	636.34	389.94
Reach-1	2.04666*	B10	2241.85	896.98	6.81	636.34	389.94
Reach-1	2.04666*	B1-1	2207.06	896.94	6.78	622.02	387.23
Reach-1	2.04666*	B2-1	2203.21	896.93	6.78	620.41	386.93
Reach-1	2.04666*	B20	1866.26	896.54	6.47	474.81	358.23
Reach-1	2.04666*	B3-1	2236.79	896.97	6.81	634.25	389.54
Reach-1	2.04666*	B60	2241.85	896.98	6.81	636.32	389.93
Reach-1	2.04666*	B70	2241.85	896.98	6.81	636.32	389.93
Reach-1	1.99333*	Future w/o	2241.85	894.79	7.68	577.03	424.33
Reach-1	1.99333*	B10	2241.85	894.79	7.68	577.03	424.33
Reach-1	1.99333*	B1-1	2207.06	894.77	7.63	565.66	422.4
Reach-1	1.99333*	B2-1	2203.21	894.76	7.63	564.45	422.2
Reach-1	1.99333*	B20	1866.26	894.49	7.1	452.01	402.63
Reach-1	1.99333*	B3-1	2236.79	894.79	7.67	575.4	424.06
Reach-1	1.99333*	B60	2241.85	894.79	7.68	577.06	424.34
Reach-1	1.99333*	B70	2241.85	894.79	7.68	577.06	424.34
Reach-1	1.94	Future w/o	2241.85	893.37	5.9	1076.18	589.72
Reach-1	1.94	B10	2241.85	893.37	5.9	1076.18	589.72
Reach-1	1.94	B1-1	2207.06	893.33	5.9	1054.68	588.31
Reach-1	1.94	B2-1	2203.21	893.33	5.9	1051.99	588.14
Reach-1	1.94	B20	1866.26	892.96	5.85	838.64	573.96
Reach-1	1.94	B3-1	2236.79	893.37	5.9	1072.87	589.51
Reach-1	1.94	B60	2241.85	893.37	5.9	1075.97	589.71
Reach-1	1.94	B70	2241.85	893.37	5.9	1075.97	589.71
Reach-1	1.92	Future w/o	2241.85	892.99	5.1	896.49	582.7
Reach-1	1.92	B10	2241.85	892.99	5.1	896.49	582.7
Reach-1	1.92	B1-1	2207.06	892.95	5.1	872.66	581.22
Reach-1	1.92	B2-1	2203.21	892.95	5.1	869.5	581.03
Reach-1	1.92	B20	1866.26	892.53	5.12	632.8	566.17
Reach-1	1.92	B3-1	2236.79	892.99	5.1	892.72	582.46
Reach-1	1.92	B60	2241.85	892.99	5.1	896.17	582.68
Reach-1	1.92	B70	2241.85	892.99	5.1	896.14	582.67
Reach-1	1.87666*	Future w/o	2241.85	891.67	6.17	497.39	173.42
Reach-1	1.87666*	B10	2241.85	891.67	6.17	497.39	173.42
Reach-1	1.87666*	B1-1	2207.06	891.63	6.13	490.46	172.55
Reach-1	1.87666*	B2-1	2203.21	891.62	6.13	489.02	172.37
Reach-1	1.87666*	B20	1866.26	891.21	5.78	420.51	163.44
Reach-1	1.87666*	B3-1	2236.79	891.66	6.17	495.98	173.25

TABLE E-V-1 HEC-RAS OUTOUT – 2 YEAR PEAK FLOWS							
Reach	**River Sta**	**Profile**	**Q Total (cfs)**	**W.S. Elev (ft)**	**Vel Chnl (ft/s)**	**Flow Area (sq ft)**	**Top Width (ft)**
Reach-1	1.87666*	B60	2241.85	891.67	6.17	497	173.37
Reach-1	1.87666*	B70	2241.85	891.67	6.17	496.9	173.36
Reach-1	1.83333*	Future w/o	2241.85	890.46	6.28	588.54	195.35
Reach-1	1.83333*	B10	2241.85	890.46	6.28	588.54	195.35
Reach-1	1.83333*	B1-1	2207.06	890.42	6.24	580.78	194.59
Reach-1	1.83333*	B2-1	2203.21	890.41	6.26	577.61	194.29
Reach-1	1.83333*	B20	1866.26	889.99	5.91	498.92	186.44
Reach-1	1.83333*	B3-1	2236.79	890.45	6.28	586.44	195.15
Reach-1	1.83333*	B60	2241.85	890.46	6.28	587.65	195.26
Reach-1	1.83333*	B70	2241.85	890.46	6.29	587.18	195.22
Reach-1	1.79	Future w/o	2241.85	889.62	5.67	812.31	223.41
Reach-1	1.79	B10	2241.85	889.62	5.67	812.31	223.41
Reach-1	1.79	B1-1	2207.06	889.58	5.63	804.26	222.82
Reach-1	1.79	B2-1	2203.21	889.55	5.66	797.46	222.32
Reach-1	1.79	B20	1866.26	889.17	5.26	712.74	215.97
Reach-1	1.79	B3-1	2236.79	889.6	5.68	808.7	223.15
Reach-1	1.79	B60	2241.85	889.61	5.68	810.06	223.25
Reach-1	1.79	B70	2241.85	889.6	5.69	808.86	223.16
Reach-1	1.76*	Future w/o	2241.85	889.4	3.81	1031.64	298.46
Reach-1	1.76*	B10	2241.85	889.4	3.81	1031.64	298.46
Reach-1	1.76*	B1-1	2207.06	889.37	3.78	1021.16	297.46
Reach-1	1.76*	B2-1	2203.21	889.33	3.81	1010.45	296.44
Reach-1	1.76*	B20	1866.26	888.95	3.53	899.7	286.02
Reach-1	1.76*	B3-1	2236.79	889.39	3.82	1026.16	297.94
Reach-1	1.76*	B60	2241.85	889.39	3.82	1027.99	298.11
Reach-1	1.76*	B70	2241.85	889.38	3.83	1026.07	297.93
Reach-1	1.73	Future w/o	2184.52	889.28	2.81	1276.91	388
Reach-1	1.73	B10	2184.52	889.28	2.81	1276.91	388
Reach-1	1.73	B1-1	2148.22	889.24	2.79	1263.65	386.77
Reach-1	1.73	B2-1	2145.29	889.2	2.81	1248.28	385.34
Reach-1	1.73	B20	1807.69	888.83	2.59	1106.04	371.81
Reach-1	1.73	B3-1	2177.46	889.26	2.81	1269.36	387.3
Reach-1	1.73	B60	2195.62	889.26	2.83	1270.92	387.45
Reach-1	1.73	B70	2177.37	889.26	2.81	1269.32	387.3
Reach-1	1.711	Future w/o	2184.52	888.63	6.5	793.56	405.62
Reach-1	1.711	B10	2184.52	888.63	6.5	793.56	405.62
Reach-1	1.711	B1-1	2148.22	888.6	6.46	781.54	404.64
Reach-1	1.711	B2-1	2145.29	888.51	6.65	745.69	401.71
Reach-1	1.711	B20	1807.69	888.14	6.35	600.9	389.64
Reach-1	1.711	B3-1	2177.46	888.59	6.56	779.39	404.47
Reach-1	1.711	B60	2195.62	888.57	6.65	772.9	403.94

TABLE E-V-1 HEC-RAS OUTOUT – 2 YEAR PEAK FLOWS							
Reach	**River Sta**	**Profile**	**Q Total (cfs)**	**W.S. Elev (ft)**	**Vel Chnl (ft/s)**	**Flow Area (sq ft)**	**Top Width (ft)**
Reach-1	1.711	B70	2177.37	888.59	6.56	779.34	404.46
Reach-1	1.7105		Culvert				
Reach-1	1.71	Future w/o	2184.52	888.52	6.73	751.77	402.21
Reach-1	1.71	B10	2184.52	888.52	6.73	751.77	402.21
Reach-1	1.71	B1-1	2148.22	888.49	6.7	737.06	401
Reach-1	1.71	B2-1	2145.29	888.48	6.7	735.94	400.91
Reach-1	1.71	B20	1807.69	888.13	6.37	597.46	389.35
Reach-1	1.71	B3-1	2177.46	888.52	6.73	748.9	401.97
Reach-1	1.71	B60	2195.62	888.53	6.74	756.09	402.56
Reach-1	1.71	B70	2177.37	888.52	6.73	748.97	401.98
Reach-1	1.7	Future w/o	2184.52	888.44	5.62	1075.23	547.94
Reach-1	1.7	B10	2184.52	888.44	5.62	1075.23	547.94
Reach-1	1.7	B1-1	2148.22	888.4	5.6	1054.79	546.37
Reach-1	1.7	B2-1	2145.29	888.4	5.6	1053.22	546.25
Reach-1	1.7	B20	1807.69	888.04	5.41	866.98	456.31
Reach-1	1.7	B3-1	2177.46	888.43	5.62	1071.25	547.64
Reach-1	1.7	B60	2195.62	888.45	5.62	1081.22	548.41
Reach-1	1.7	B70	2177.37	888.43	5.61	1071.35	547.65
Reach-1	1.65	Future w/o	2184.52	887.44	5.63	1072.29	547.72
Reach-1	1.65	B10	2184.52	887.44	5.63	1072.29	547.72
Reach-1	1.65	B1-1	2148.22	887.39	5.63	1047.33	545.79
Reach-1	1.65	B2-1	2145.29	887.39	5.63	1045.16	545.62
Reach-1	1.65	B20	1807.69	886.92	5.67	813.15	426.78
Reach-1	1.65	B3-1	2177.46	887.43	5.63	1066.67	547.28
Reach-1	1.65	B60	2195.62	887.45	5.63	1079.75	548.29
Reach-1	1.65	B70	2177.37	887.43	5.63	1067.61	547.36
Reach-1	1.5	Future w/o	2138.66	883.95	5.92	386.88	110.98
Reach-1	1.5	B10	2138.66	883.95	5.92	386.88	110.98
Reach-1	1.5	B1-1	2104.39	883.9	5.88	381.1	108.14
Reach-1	1.5	B2-1	2101.28	883.9	5.88	380.58	107.88
Reach-1	1.5	B20	1771.9	883.32	5.54	326.29	83.26
Reach-1	1.5	B3-1	2130.21	883.94	5.91	385.45	110.29
Reach-1	1.5	B60	2148.8	883.97	5.93	388.62	111.82
Reach-1	1.5	B70	2132.38	883.94	5.91	385.82	110.47
Reach-1	1.35	Future w/o	2138.66	880.63	5.94	384.35	109.75
Reach-1	1.35	B10	2138.66	880.63	5.94	384.35	109.75
Reach-1	1.35	B1-1	2104.39	880.58	5.91	378.48	106.82
Reach-1	1.35	B2-1	2101.28	880.57	5.9	377.96	106.56
Reach-1	1.35	B20	1771.9	880	5.56	324.24	82.34
Reach-1	1.35	B3-1	2130.21	880.62	5.93	382.9	109.03

TABLE E-V-1 HEC-RAS OUTOUT – 2 YEAR PEAK FLOWS							
Reach	**River Sta**	**Profile**	**Q Total (cfs)**	**W.S. Elev (ft)**	**Vel Chnl (ft/s)**	**Flow Area (sq ft)**	**Top Width (ft)**
Reach-1	1.35	B60	2148.8	880.65	5.95	386.11	110.61
Reach-1	1.35	B70	2132.38	880.62	5.94	383.27	109.21
Reach-1	1.2	Future w/o	2138.66	877.83	5.43	445.56	136.56
Reach-1	1.2	B10	2138.66	877.83	5.42	445.96	136.71
Reach-1	1.2	B1-1	2104.39	877.78	5.39	438.89	133.9
Reach-1	1.2	B2-1	2101.28	877.77	5.38	438.38	133.69
Reach-1	1.2	B20	1771.9	877.39	4.87	391.47	113.19
Reach-1	1.2	B3-1	2130.21	877.82	5.42	443.91	135.9
Reach-1	1.2	B60	2148.8	877.84	5.44	447.66	137.39
Reach-1	1.2	B70	2132.38	877.82	5.42	444.28	136.05
Reach-1	1.07	Future w/o	2223.24	872.21	9.9	224.56	55.75
Reach-1	1.07	B10	2223.24	872.21	9.92	224.04	55.71
Reach-1	1.07	B1-1	2189.13	872.15	9.9	221.21	55.48
Reach-1	1.07	B2-1	2186.02	872.15	9.9	220.77	55.45
Reach-1	1.07	B20	1977.94	871.73	9.97	198.31	53.58
Reach-1	1.07	B3-1	2214.74	872.2	9.9	223.7	55.68
Reach-1	1.07	B60	2233.29	872.23	9.91	225.39	55.82
Reach-1	1.07	B70	2216.99	872.2	9.9	224.02	55.71
Reach-1	1.031	Future w/o	2223.24	872.33	6.41	346.68	384.66
Reach-1	1.031	B10	2223.24	872.32	6.42	346.27	382.15
Reach-1	1.031	B1-1	2189.13	872.27	6.36	344.02	368.49
Reach-1	1.031	B2-1	2186.02	872.27	6.36	343.66	366.28
Reach-1	1.031	B20	1977.94	871.88	6.1	324.42	279.17
Reach-1	1.031	B3-1	2214.74	872.31	6.4	345.95	380.24
Reach-1	1.031	B60	2233.29	872.34	6.43	347.39	389
Reach-1	1.031	B70	2216.99	872.32	6.4	346.21	381.84
Reach-1	1.0305		Mult Open				
Reach-1	1.03	Future w/o	2223.24	871.82	6.91	321.52	276.03
Reach-1	1.03	B10	2223.24	871.81	6.93	321.02	275.49
Reach-1	1.03	B1-1	2189.13	871.78	6.85	319.43	273.76
Reach-1	1.03	B2-1	2186.02	871.77	6.85	319.09	273.4
Reach-1	1.03	B20	1977.94	871.45	6.53	302.69	255.64
Reach-1	1.03	B3-1	2214.74	871.81	6.9	320.92	275.38
Reach-1	1.03	B60	2233.29	871.83	6.93	322.05	276.61
Reach-1	1.03	B70	2216.99	871.82	6.9	321.16	275.64
Reach-1	1.02	Future w/o	2223.24	871.89	5.45	818.76	279.86
Reach-1	1.02	B10	2223.24	871.88	5.46	815.79	279.29
Reach-1	1.02	B1-1	2189.13	871.85	5.42	805.7	277.32
Reach-1	1.02	B2-1	2186.02	871.84	5.42	803.67	276.93
Reach-1	1.02	B20	1977.94	871.48	5.34	707.16	257.37

TABLE E-V-1 HEC-RAS OUTOUT – 2 YEAR PEAK FLOWS							
Reach	**River Sta**	**Profile**	**Q Total (cfs)**	**W.S. Elev (ft)**	**Vel Chnl (ft/s)**	**Flow Area (sq ft)**	**Top Width (ft)**
Reach-1	1.02	B3-1	2214.74	871.88	5.44	815.02	279.14
Reach-1	1.02	B60	2233.29	871.91	5.46	822.12	280.51
Reach-1	1.02	B70	2216.99	871.89	5.44	816.5	279.43
Reach-1	0.52	Future w/o	2117.3	862.79	6.62	738.99	311.36
Reach-1	0.52	B10	2117.3	862.81	6.58	745.34	312.69
Reach-1	0.52	B1-1	2091.99	862.76	6.59	730.05	309.48
Reach-1	0.52	B2-1	2084.91	862.75	6.58	727.71	308.99
Reach-1	0.52	B20	1825.22	862.44	6.24	633.31	288.4
Reach-1	0.52	B3-1	2108.21	862.78	6.61	735.84	310.7
Reach-1	0.52	B60	2119.59	862.79	6.62	738.99	311.36
Reach-1	0.52	B70	2109.72	862.78	6.61	735.01	310.53
Reach-1	0.02	Future w/o	2216.8	856.46	4.17	1069.46	376.81
Reach-1	0.02	B10	2269.78	856.55	4.19	1104.28	386.37
Reach-1	0.02	B1-1	2213.9	856.46	4.17	1067.71	376.32
Reach-1	0.02	B2-1	2214.23	856.46	4.17	1067.92	376.38
Reach-1	0.02	B20	2161	856.36	4.15	1032.76	366.46
Reach-1	0.02	B3-1	2216.36	856.46	4.17	1069.27	376.76
Reach-1	0.02	B60	2210.53	856.45	4.17	1065.46	375.7
Reach-1	0.02	B70	2205.85	856.44	4.17	1062.58	374.89
Reach-1	0.012	Future w/o	2216.8	855.93	5.73	387.09	73.97
Reach-1	0.012	B10	2269.78	856.02	5.77	393.15	73.98
Reach-1	0.012	B1-1	2213.9	855.93	5.72	386.79	73.97
Reach-1	0.012	B2-1	2214.23	855.93	5.72	386.82	73.97
Reach-1	0.012	B20	2161	855.84	5.68	380.45	73.97
Reach-1	0.012	B3-1	2216.36	855.93	5.73	387.06	73.97
Reach-1	0.012	B60	2210.53	855.93	5.72	386.39	73.97
Reach-1	0.012	B70	2205.85	855.92	5.72	385.89	73.97
Reach-1	0.0105		Bridge				
Reach-1	0.009	Future w/o	2216.8	855.19	6.68	331.77	72.61
Reach-1	0.009	B10	2269.78	855.27	6.72	337.67	72.96
Reach-1	0.009	B1-1	2213.9	855.19	6.68	331.5	72.6
Reach-1	0.009	B2-1	2214.23	855.19	6.68	331.54	72.6
Reach-1	0.009	B20	2161	855.1	6.64	325.5	72.25
Reach-1	0.009	B3-1	2216.36	855.19	6.68	331.78	72.61
Reach-1	0.009	B60	2210.53	855.18	6.68	331.07	72.57
Reach-1	0.009	B70	2205.85	855.17	6.67	330.6	72.55
Reach-1	0	Future w/o	2216.8	855.07	5.61	639.42	247
Reach-1	0	B10	2269.78	855.15	5.65	660.29	254.31
Reach-1	0	B1-1	2213.9	855.07	5.61	638.29	246.6
Reach-1	0	B2-1	2214.23	855.07	5.61	638.41	246.64

TABLE E-V-1 HEC-RAS OUTOUT – 2 YEAR PEAK FLOWS							
Reach	**River Sta**	**Profile**	**Q Total (cfs)**	**W.S. Elev (ft)**	**Vel Chnl (ft/s)**	**Flow Area (sq ft)**	**Top Width (ft)**
Reach-1	0	B20	2161	854.98	5.56	617.66	239.15
Reach-1	0	B3-1	2216.36	855.07	5.61	639.26	246.94
Reach-1	0	B60	2210.53	855.06	5.61	636.97	246.13
Reach-1	0	B70	2205.85	855.05	5.6	635.14	245.48

ATTACHMENT 3

Alternative Estimate Costs

Butler Creek Watershed
Aquatic Ecosystem Restoration
Detailed Project Report

Environmental Appendix

August 2011

US Army Corps of Engineers
Mobile District

Contents

Figures

Tables

1. Introduction

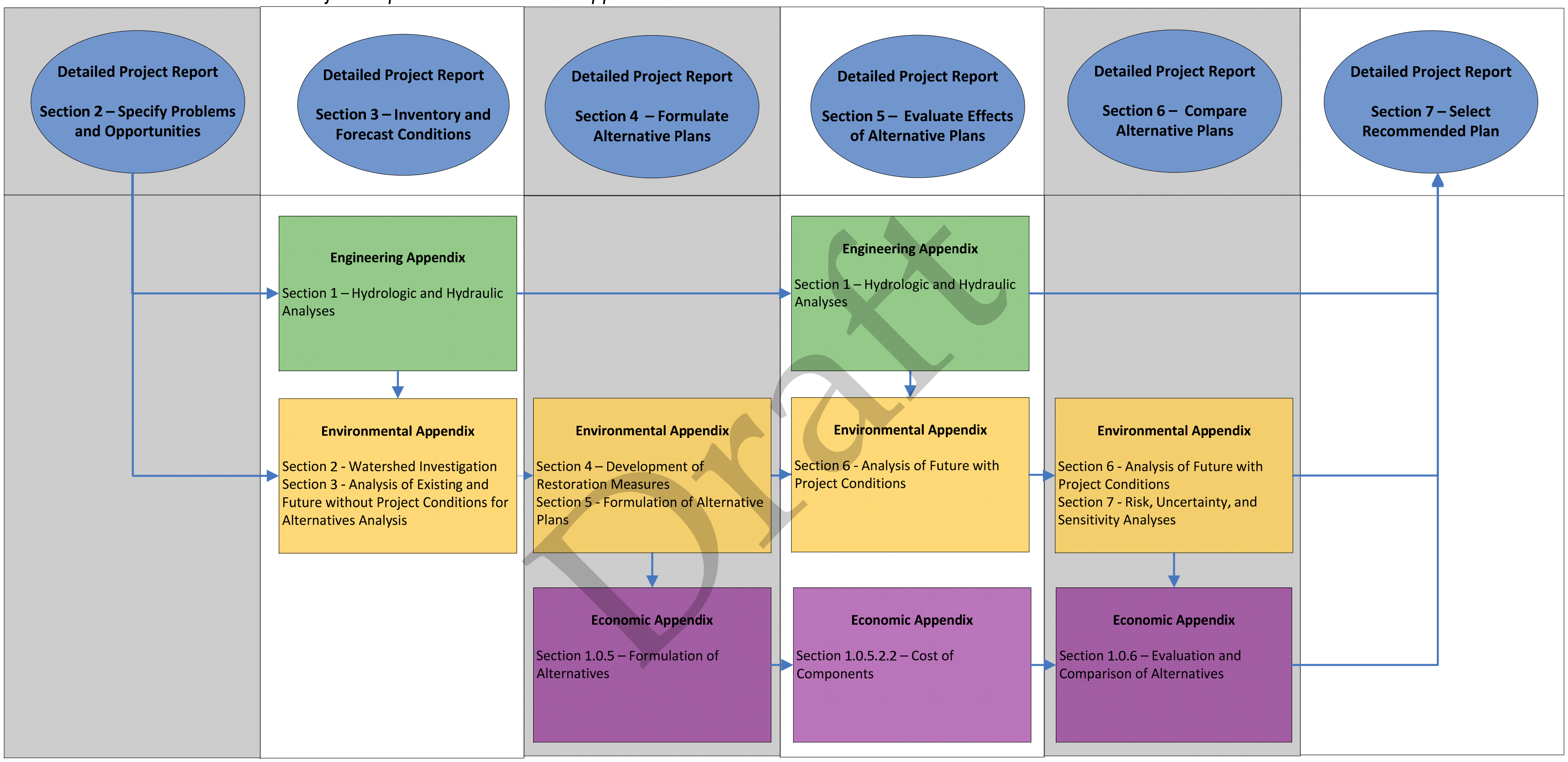
1.1 Background

Through a partnership between the U.S. Army Corps of Engineers (USACE) and Cobb County, Georgia, a plan was developed to restore the aquatic ecosystem of the Butler Creek watershed under Section 206 of the Water Resources Development Act of 1996 (WRDA 96), as amended. This continuing authority program was authorized by Congress "to carry out ecosystem restoration and protection projects if determined that such projects will improve environmental quality, are in the public interest, and are cost-effective" (Public Law 104-303). The *Butler Creek Watershed Aquatic Ecosystem Restoration Detailed Project Report* (Detailed Project Report) was developed to identify, evaluate, and recommend to decision makers an appropriate, coordinated, and implementable solution to the identified water resources problems and opportunities in the Butler Creek watershed. The Detailed Project Report is aligned with requirements for funding under the Continuing Authorities Program (CAP), as outlined in Engineering Regulation 1105-2-100 (Planning Guidance Notebook). The USACE objective in federal ecosystem restoration planning (one of the primary missions of the Civil Works program) is increase the net quantity and/or quality of ecosystem resources.

1.2 Organization

The Detailed Project Report describes a study to identify aquatic habitat problems in the Butler Creek watershed and recommend the most cost-effective strategy for aquatic ecosystem restoration. This study incorporates a systematic approach that follows the six-step planning process outlined in the *Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies* (P&G), adopted by the Water Resource Council and required for all federal water resource projects. The six planning steps are presented in Figure 1-1 and are outlined, for the Butler Creek watershed, in the Detailed Project Report. This Environmental Appendix is associated with Steps 2 through 5, as shown in Figure 1-1. The Environmental Appendix uses information from the Engineering Appendix to: (1) inventory and forecast conditions, (2) formulate alternative plans, and (3) evaluate the effects of alternative plans. This information is then used in the Economics Appendix to recommend a cost-effective aquatic ecosystem restoration alternative for the Butler Creek watershed. The Detailed Project Report provides an overall discussion of these steps and the resulting Tentatively Selected Plan.

FIGURE 1-1
Organization of the Detailed Project Report Appendices in Relation to the Six Planning Steps
Butler Creek Watershed Detailed Project Report – Environmental Appendix



2. Watershed Investigation

To document existing (2010) conditions in the watershed, physical conditions of stream channels and adjacent riparian ecosystems as well as aquatic biological communities were assessed at various representative locations in the study area. Existing conditions provided a strong indication of the status of aquatic communities in Butler Creek and were used to identify areas that would benefit most from aquatic ecosystem restoration efforts. Data evaluated as part of the existing conditions assessment include: long-term water quality data, fish community assessments, benthic macroinvertebrate assessments, stream assessments, and physical habitat assessments.

2.1 Location

The study area for this Detailed Project Report includes the Butler Creek watershed, which is located in the Etowah River basin in northwestern Cobb County, Georgia, and drains into Lake Acworth (Figure 2-1). Lake Acworth is a subimpoundment of Lake Allatoona, a federally managed multi-use reservoir. The Etowah River basin is part of the larger Coosa River basin. The Coosa River flows through Alabama, becoming the Alabama River as it joins with the Tallapoosa River. The Alabama-Coosa-Tallapoosa Rivers basin (ACT basin) flows into the Gulf of Mexico.

The mainstem of Butler Creek is approximately 6 miles long, and the Butler Creek watershed encompasses 6,016 total acres (9.4 square miles) (Figure 2-2). Topography in the Butler Creek watershed ranges from 1,100 feet above mean sea level (msl) in the headwaters to 850 feet above msl, where the stream enters the backwaters of Lake Acworth. The summer pool elevation for Lake Allatoona is 840 feet and the winter pool elevation is 823 feet. Butler Creek and its watershed are located entirely within Cobb County, which is located in the northern portion of the Piedmont physiographic province. The watershed includes portions of the Cities of Kennesaw and Acworth and unincorporated areas of Cobb County, with the headwaters being the most developed portion of the watershed.

2.2 Prior Studies

Prior reports/studies associated with the Butler Creek watershed outline aquatic habitat and other environmental problems in the watershed and in the larger Lake Allatoona watershed. In particular, long-term monitoring by Cobb County and coordination with the U.S. Fish and Wildlife Service (USFWS) has been ongoing to better understand any potential impacts to the federally protected Cherokee darter (*Etheostoma scotti*), which has known populations in the Butler Creek watershed. These studies, as well as historical data for the watershed, were evaluated as part of this study. Other prior studies evaluated are summarized below.

2.2.1 2002/2004 Studies of Butler, Proctor, and Allatoona Creek Watersheds

In 2002, a report was prepared to summarize field assessments in the Butler, Proctor, and Allatoona creek watersheds (Entrix, 2002a and 2002b). Entrix, the environmental consulting firm that conducted the stream walks and identified problem areas in 2002, summarized the preliminary efforts that were conducted as part of this study. The report described problems, opportunities, planning objectives, methods for watershed investigations, and recommended locations for specific restoration measures throughout the streams. Following the completion of Entrix (2002b), restoration measures were subsequently used by the Butler Creek watershed Project Delivery Team (PDT) to formulate and evaluate logical restoration alternatives, as discussed in this Detailed Project Report. These preliminary efforts have been documented and updated as part of this Detailed Project Report.

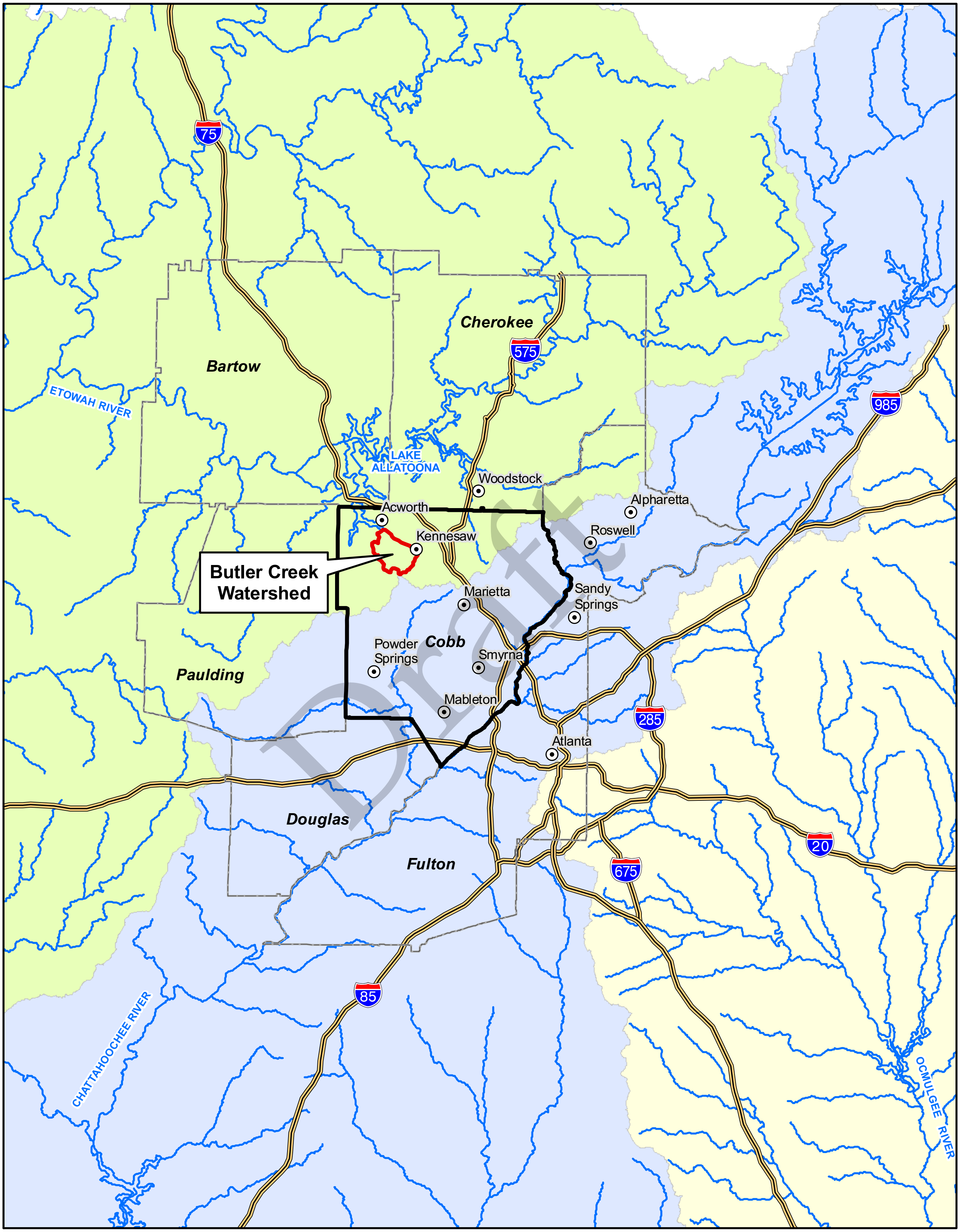
2.2.2 2002 Fish Community and Habitat Assessments in Butler, Proctor, and Allatoona Creek Watersheds

Between April and July 2002, Byron Freeman and staff at the University of Georgia Institute of Ecology conducted fish community and habitat surveys at 9 locations in the Butler Creek watershed, 4 in the Proctor Creek watershed, and 10 in the Allatoona Creek watershed. The primary purposes of the study were to assess the species assemblages in these watersheds, with particular consideration to the Cherokee darter, and to assess the species assemblages and habitat conditions at potential restoration areas identified by Entrix in 2002. Each of the watersheds demonstrated a likely loss of species since the 1950s, with the Butler Creek watershed having the least diversity and being the most dominated by tolerant species (Freeman et al., 2003). Cherokee darters were prevalent in all three watersheds; though Butler Creek contained no other darter species or sculpins (*Cottus*), indicative of poor water quality or habitat conditions. All three watershed showed signs of degradation and poor fish diversity, with the likely cause of degradation being urbanization and associated stressors, such as sedimentation and altered hydrology. Restoration measures aimed at improving fish diversity and promoting recovery of the Cherokee darter were recommended, such as culvert replacement, retrofitting of stormwater controls, streambank stabilization, and realignment of channelized stream segments.

2.2.3 2004/2009 Total Maximum Daily Loads

The Georgia Environmental Protection Division (GAEPD) of the Georgia Department of Natural Resources (GADNR) identifies segments of state streams in Georgia's Integrated 305(b)/303(d) List of Waters in accordance with Section 305(b) of the Clean Water Act. Six miles of Butler Creek, from its headwaters to Lake Acworth, are identified in the draft 2010 Integrated 305(b)/303(d) List of Waters as not supporting the designated "fishing" water use classification due to violations of fecal coliform standards and biological criteria for fish bioassessments. The violation of fecal coliform standards represents at least a 10 percent exceedance of geometric mean criteria in at least one year of data (GAEPD, 2010). The fish bioassessment listing is based on fish Index of Biotic Integrity (IBI) scores rated "poor" or very poor." The potential cause of both fecal coliform and fish bioassessment violations is cited as urban runoff (GAEPD, 2010).

For streams not supporting a designated use, GAEPD develops a Total Maximum Daily Load (TMDL), or an estimate of the amount of a pollutant that can be introduced to a stream without causing the stream to violate its designated use. A TMDL for fecal coliform in the mainstem of Butler Creek was developed in 2004 and identifies an estimated 55 percent reduction in fecal coliform yields to in the stream to meet its designated use (GAEPD, 2004). To address impacted biological communities, a TMDL focusing on sediment as the



City
Interstate
River/Stream
Butler Creek Watershed
Cobb County Boundary
Surrounding County
Altamaha River Basin
Apalachicola Chattahooche Flint River Basin
Alabama Coosa Tallapoosa River Basin

0 5 10 Miles

FIGURE 2-1
River Basin Map
Butler Creek Watershed DPR - Environmental Appendix

CH2MHILL

\\GALILEO\PROJ\BUTLERCREEK\MAPFILES\LOCATIONMAP.MXD JMINIX 5/24/2010 16:17:34

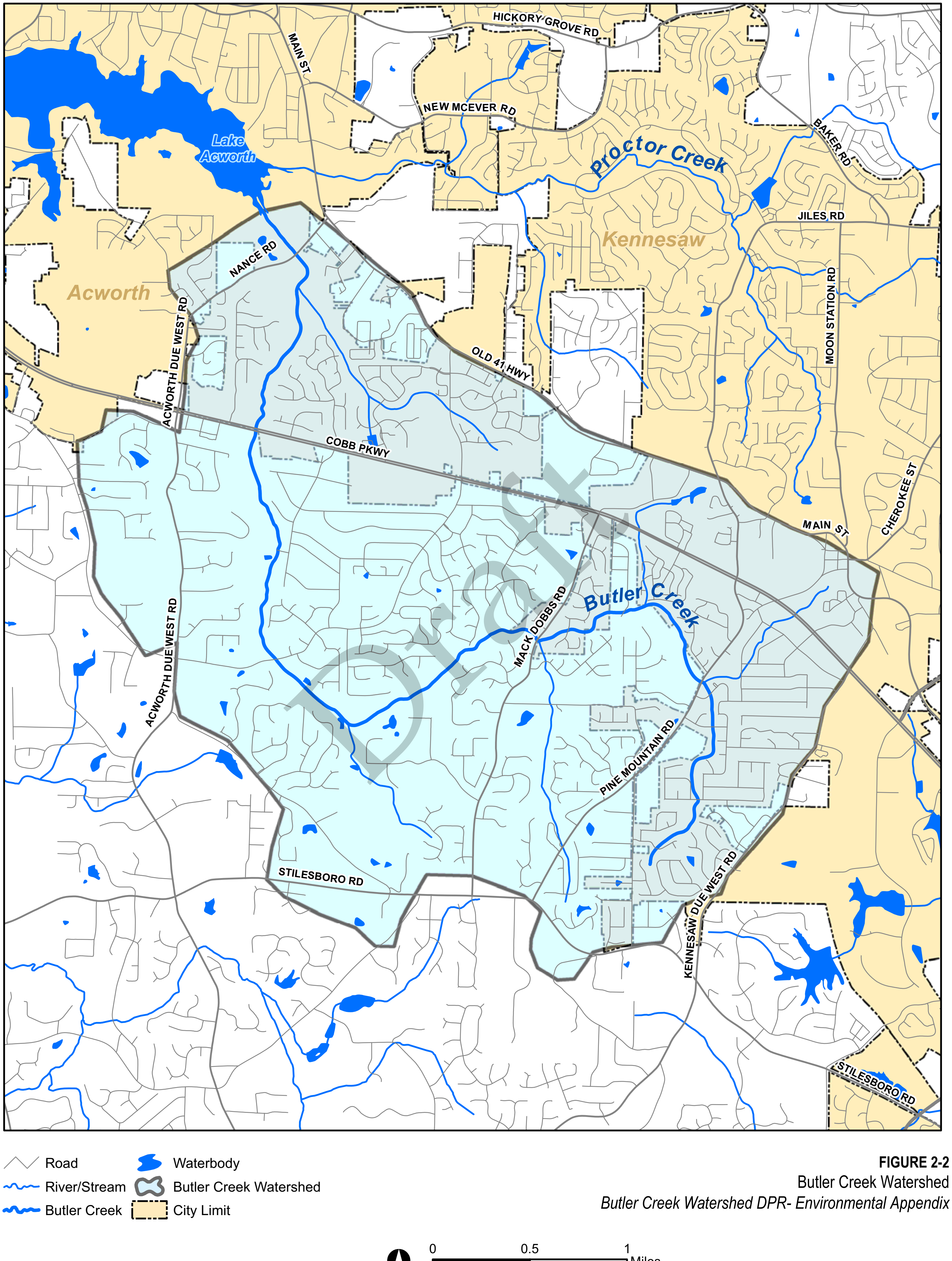


FIGURE 2-2
Butler Creek Watershed
Butler Creek Watershed DPR- Environmental Appendix

CH2MHILL

\\GALILEO\PROJ\BUTLERCREEK\MAPFILES\WATERSHED.MXD JMINIX 5/24/2010 16:05:49

measurable pollutant of concern was developed for 49 segments of the Coosa River Basin, including Butler Creek (GAEPD, 2009). The biological TMDL identifies the most common cause of degraded fish communities as a lack of habitat due to stream sedimentation, and the TMDL is therefore focused on addressing sediment loading to streams. The Butler Creek TMDL identifies an estimated allowable sediment load of 480 tons per year to the stream, indicating a 63 percent reduction of current sediment loading to meet the stream's designated use. Management practices to limit sediment loading are presented in the TMDL report, including implementation of proper erosion and sedimentation control plans for land disturbance activities, compliance with National Pollutant Discharge Elimination System (NPDES) permits, and mitigation and prevention of stream bank erosion due to an increase in stream flow and velocity caused by urban runoff (GAEPD, 2009).

In 2006, a TMDL Implementation Plan was developed to address fecal coliform in tributaries to Lake Allatoona, including Butler Creek. The Plan identifies a set of regulatory and voluntary management activities to improve watershed conditions with the goal of achieving water quality standards in the stream. Cobb County Water System (CCWS) has worked with GAEPD to develop a list of potential sources of impairment, and urban nonpoint source runoff was identified as the primary source of impairment. Management actions were identified cooperatively by CCWS, the Metropolitan North Georgia Water Planning District (MNGWPD), and the cities of Kennesaw and Acworth. Implementation of activities is being coordinated through NPDES Phase I municipal separate storm sewer system (MS4) permits, including water quality monitoring and screening of stormwater outfalls, septic tanks, and stream sewer crossings.

2.2.4 2002–2010 Cobb County Watershed Assessment and Protection Plan

In 2002, Cobb County prepared a Countywide Watershed Assessment (WSA) to develop a better understanding of impacts to waterways and strategies for protecting water quality and habitat. Data collected for the WSA indicated degraded aquatic ecosystems throughout the County. Based on degraded conditions, the Cobb County Water System (CCWS) developed a Countywide Watershed Protection Plan (WPP). The WPP was developed in accordance with NPDES permit requirements and includes ongoing implementation of watershed management strategies (CCWS, 2002). GAEPD approved the WPP in 2003. The Etowah River basin, including the Butler Creek watershed, is considered a priority watershed for the purpose of focusing funding and efforts. Priority watersheds are those where the USEPA and state partners have agreed to focus mutual resources to protect and restore waters. Therefore, Cobb County prioritizes this river basin in its WPP implementation strategies.

The Cobb County WPP identifies sedimentation, loss of instream habitat, and channelization as key factors adversely affecting aquatic biological communities. Objectives of the WPP include: 1) eliminating watershed pollutant sources, 2) preventing further nonpoint source pollution, and 3) providing public education on watershed management strategies. Since development of the WPP, Cobb County has remained committed to the WPP objectives, with ongoing long-term water quality and biological monitoring, implementation of watershed improvement projects, enforcement of protective stormwater ordinances, and ongoing public education efforts. Annual reporting under this plan documents the ongoing monitoring of Butler Creek and its aquatic communities, including the Cherokee darter.

2.2.5 2005 Piedmont Ecoregion Fish Sampling

Fish sampling conducted by the GADNR Wildlife Resources Division at 378 sites throughout the Piedmont ecoregion in North Georgia shows that more than 50 percent of the streams sampled have fish communities characterized as poor or very poor, based on the widely accepted scoring criteria developed by Karr to assess the health of aquatic communities based on attributes of the fish population (GADNR, 2005).

2.2.6 Endangered Species Act Section 7 Consultation with USFWS

In September 2005, USACE–Mobile requested formal consultation with USFWS under Section 7 of the Endangered Species Act for proposed aquatic ecosystem restoration plans in the Butler Creek watershed and associated potential impacts to the Cherokee darter population. Previous sampling has identified Cherokee darter populations in Butler Creek and also in Allatoona and Proctor creeks, upstream of Lake Allatoona. After continued coordination among the agencies, USFWS issued its biological opinion in February 2007. After changes to the Tentatively Selected Plan were made, USFWS issued an updated FWCA Report in February 2011. The report indicated that the USFWS "supports the proposed restoration plan, as designed, provided final specifications for…detention ponds do not significantly affect creek flows." Consultation under the Endangered Species Act was reinitiated on February 2, 2011, and updated biological opinion was submitted on May 20, 2011.

The final biological opinion is that "the action, as proposed, is not likely to jeopardize the continued existence of the Cherokee darter and may provide considerable benefit to the Butler Creek population." The USFWS determined that restoration activities in the Butler Creek watershed would have adverse, short-term impacts to the Cherokee darter (increased turbidity, mortality, or both, or injury caused by large equipment operating in the stream channel), but could have both positive and negative long-term impacts. The USFWS stated that the positive long-term benefits of restoration activities would outweigh any adverse impacts based on the proposed location in an urban, degraded watershed. The USFWS recommended mitigation measures to limit direct and indirect impacts to the Cherokee darter, including: minimizing sedimentation in the action area; installing structures to minimize erosion and dissipate stream velocity; avoiding spawning areas; minimizing construction duration; and implementing a post-construction monitoring plan.

2.2.7 Etowah Aquatic Habitat Conservation Plan

The Etowah Aquatic Habitat Conservation Plan (HCP), which has been underway since 2002, is a voluntary, cooperative effort between cities and counties located in the Georgia portion of the Etowah River Basin, including Butler Creek. The Etowah River watershed is home to three endemic species of fish, including the federally protected Cherokee darter, which has known populations in the Butler Creek watershed, as well as the amber darter (*Percina antesella*) and federally protected Etowah darter (*Etheostoma etowahae*). The goal of the HCP is to develop a comprehensive regional habitat conservation plan to aid local governments in the development of ordinances and policies that protect aquatic habitat, including that of federally protected fishes in the watershed. It will also serve as a cost-sharing mechanism for the communities to cooperatively implement habitat conservation strategies. The Habitat Conservation Plan establishes Priority Areas of the Etowah River basin and applies stricter stormwater management requirements in Priority Areas 1 and 2. The Butler Creek watershed is included in the Habitat Conservation Plan Priority Area 2, which supports the Cherokee darter, as well as habitat immediately upstream from Priority Area 1, which supports the Etowah and amber darters as well.

Cobb County and the cities of Acworth and Kennesaw, which are partially located in the Butler Creek watershed, have entered an agreement for implementation of the HCP. As such, these communities will adopt additional protective ordinances identified in the HCP. The southern portion of the Lake Allatoona watershed, including Butler Creek, was categorized as a Priority 2 watershed, and therefore a watershed runoff limit was established. The runoff limit for the Lake Allatoona watershed requires that any new development must manage runoff to mimic more natural conditions of land with less than 5 percent impervious cover.

As a result of the HCP, USFWS will grant each community an incidental take permit (ITP) for development actions within its jurisdiction. This would create a more streamlined and efficient process for the local communities while at the same time establishing a comprehensive plan to protect aquatic habitats in this biologically diverse and unique watershed. This plan and its associated environmental assessment were published in the Federal Register for public review and comment in 2009, and the plan is now under final review by the USFWS. Twelve local governments have submitted their requests for incidental take permits. If the permit applications are approved by USFWS, each local government must then implement the actions identified in the HCP.

2.3 Land Use

Land use is a primary influence on watersheds, and existing and projected future land use data are commonly used to evaluate and forecast watershed conditions. Land use data can be used to characterize potential sources of contaminants from nonpoint source pollutants to aquatic ecosystems. Additionally, more intensive land uses, such as high-density residential and industrial, which are highly impervious, can identify areas of increased nonpoint source pollution. A discussion of historical, existing, and projected future land use in the Butler Creek watershed is provided below.

TABLE 2-1
Existing (2009) Land Use in the Butler Creek Watershed
Butler Creek Watershed Detailed Project Report – Environmental Appendix

Land Use Category	Percent of Watershed
Residential	74.7%
Forest	8.5%
Commercial	7.7%
Parks/Cemeteries/Golf Course	4.0%
Transitional	2.3%
Institutional	2.0%
Agriculture	0.8%
Other (Transportation/Communications/ Utilities, Reservoirs)	<1%
Total	100

Source: Atlanta Regional Commission (2009)

2.3.1 Historical and Existing Land Use (2009)

The population in Cobb County has more than doubled over the last three decades. According to the US Census Bureau, the population estimates for the County increased by 50 percent between 1980 (roughly 300,000 people) and 1990 (roughly 450,000 people). The population in the County increased to approximately 600,000 by the year 2000 and to roughly 700,000 by July 2008. Development within the Butler Creek watershed has experienced similar growth patterns as the County as a whole, with land shifting from low density residential and agricultural land use to higher density residential and commercial/industrial uses over the past 30 years. This change in land use has resulted in habitat degradation in Butler Creek, its tributaries, and riparian stream buffers.

Table 2-1 shows land use data for Butler Creek watershed, based on the Atlanta Regional Commission's (ARC's) LandPro 2009 Geographic Information System (GIS) database for the 20-county Atlanta region. Land use types in the Butler Creek watershed were combined to form the six categories shown in Table 2-1 and in Figure 2-3. As shown, the watershed is developed with limited areas remaining undisturbed by development. The dominant land use in the Butler Creek watershed is residential (74.7 percent), with the next largest percentages being forest (8.5 percent) and commercial (7.7 percent). The southern portion of the watershed (upstream portion) is dominated by residential areas, while the Highway 41 corridor (in the downstream portion) is surrounded by commercial and transitional uses (Figure 2-3).

2.3.2 Future Land Use (2030)

While the pre-1990's agricultural impacts to the watershed (primarily related to sediment, animal waste, pesticides, herbicides, and fertilizer) have declined. Legacy sediments were deposited in stream corridors, continuing to affect stream stability. The legacy sediment combined with the increase in population, associated with more intensive land uses, and the increase in impervious surfaces have ultimately increased the amount of nonpoint source pollution delivered to streams. As the population in the County continues to grow, land use changes will occur to accommodate a larger population and population density. Projected future land use plans, based on the Cobb County 2030 Comprehensive Plan, are shown in Figure 2-4. Land use plans indicate a continued dominance of suburban residential and urban land uses in the Butler Creek watershed (Cobb County Development Agency, 2008). Although relatively little change in land use is projected in the Butler Creek watershed compared to other portions of Cobb County, the existing developed residential and commercial / industrial areas and the associated hydrologic conditions, will continue to have adverse impacts to the watershed if restoration measures are not implemented.

Cobb County, as well as the cities of Acworth and Kennesaw, follows required stormwater management guidelines; however, watersheds are not likely to improve due to historical land uses without the implementation of restoration projects to enhance these guidelines. Restoration measures would be enhanced by requirements for stormwater management that the County follows as documented in their *Watershed Protection Plan* and in compliance with the MNGWPD's *District-wide Watershed Management Plan* (2003, updated 2009). GAEPD enforces these requirements as part of Cobb County's NPDES discharge permits and the Phase I MS4 permit, through public education and outreach; public participation/ involvement; illicit discharge detection and elimination; pre- and post-construction stormwater control according to the *Georgia Stormwater Management Manual* (ARC et al., 2001); and pollution prevention and good housekeeping. The implications of land use types on potential pollution to streams are discussed in the following subsection.

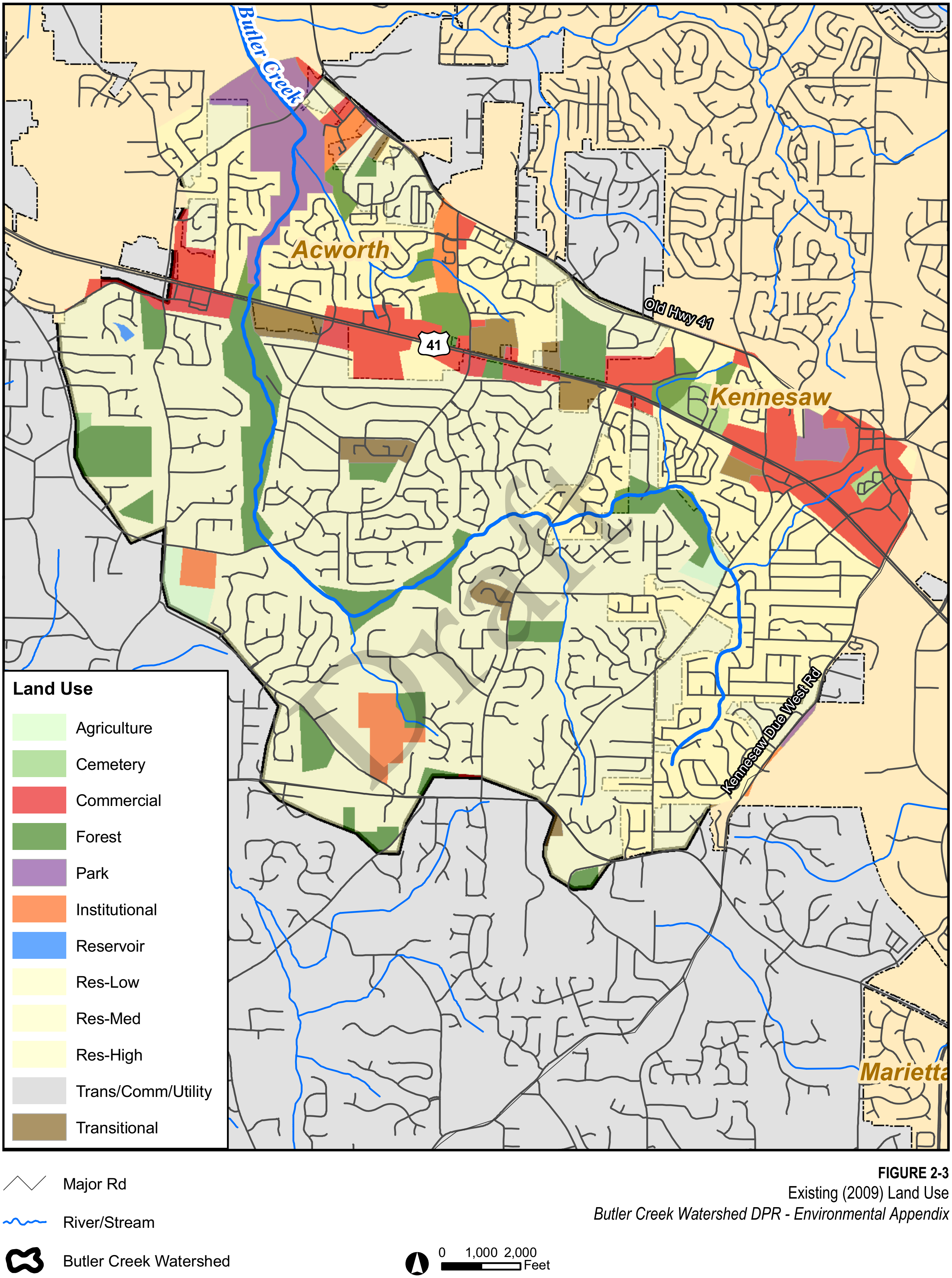


FIGURE 2-3
Existing (2009) Land Use
Butler Creek Watershed DPR - Environmental Appendix

Source: Atlanta Regional Commission, 2009

CH2MHILL

\\GALILEO\PROJ\BUTLERCREEK\MAPFILES\LANDUSE.MXD JMINIX 7/29/2010 10:46:31

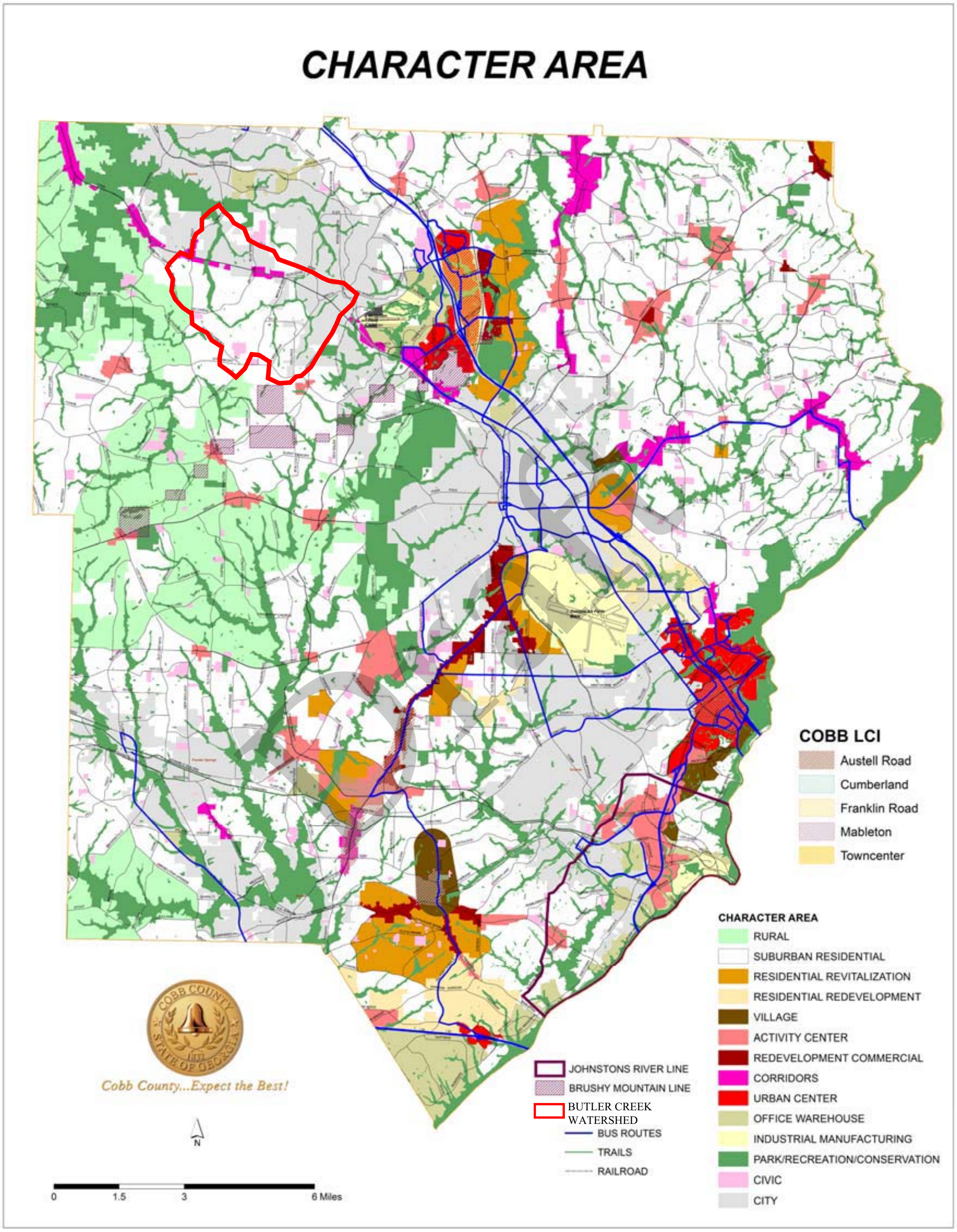


FIGURE 2-4
Projected Future (2030) Land Use (from Cobb County Development Agency, 2008)
Butler Creek Watershed DPR - Environmental Appendix

2.4 Pollution Sources

Aquatic habitat and ecosystem integrity in the watershed are affected by both point and nonpoint sources of pollutants. *Point sources* are identifiable, fixed locations (such as pipe outfalls) where pollutants are discharged. *Nonpoint sources* are those that cannot be traced to a specific location, such as stormwater runoff. Potential pollutant sources identified in the Butler Creek watershed are shown on Figure 2-5 and summarized below. The majority of the potential pollution sources are located along the Highway 41 corridor and in the City of Kennesaw. Of the 15 potential pollution sources identified, 14 are located in one of these areas (Figure 2-5).

2.4.1 Potential Point Sources

Treated Wastewater Dischargers: The Cobb County – Northwest Water Reclamation Facility (WRF) is located in the Butler Creek watershed and operates under an NPDES permit to discharge a monthly average of 8.0 million gallons per day (mgd) effluent (treated wastewater). However, the Northwest WRF discharge is to Lake Allatoona, and therefore potential pollutants originating from the Northwest WRF are not expected to affect conditions in the Butler Creek watershed.

Toxic Release Inventory (TRI)/Resource Conservation and Recovery Information System (RCRIS) Sites: There are 15 RCRIS facilities and no TRI facilities within the Butler Creek watershed. These facilities are used to store, release, and/or transfer toxic chemicals or hazardous waste. While there is no evidence of these facilities contributing contaminants of concern to the watershed, they are included in the assessment of potential pollutants since these facilities store, release, and/or transfer toxic chemicals and/or hazardous waste. Examples of RCRIS facilities in the Butler Creek watershed include Home Depot, various fuel and auto parts stores, and various dry cleaners. A comprehensive search of environmental records, including 43 federal databases, 21 state and local databases, and 5 tribal databases, was conducted for the Tentatively Selected Plan, as part of this study. These results are included in Appendix J to the Detailed Project Report.

Industrial/Commercial: As indicated by the land use data presented in Table 2-1, industrial and commercial development encompasses 8 percent of the Butler Creek watershed area. However, the watershed currently contains no industrial sites that operate under NPDES permits for stormwater or wastewater discharges. Industries identified in the Phase I Environmental Site Assessment (ESA) of the Tentatively Selected Plan include: fuel stations, dry cleaners, an outfitter's store, a plant nursery, and a high school. No leaking underground storage tanks were identified in the Phase I ESA.

Landfills: The Butler Creek watershed does not contain any landfills.

2.4.2 Potential Non-Point Sources

Stormwater Runoff from Non-stabilized Sites: Land clearing and development have occurred as part of urbanization in the Butler Creek watershed. If sediment and erosion control practices are not applied correctly during land disturbance, nonpoint source pollution can result. Inadequate erosion control measures may contribute large quantities of sediment to the stream channel. As previously noted, Cobb County, as well as the cities of Acworth and Kennesaw, follows proper stormwater management guidelines; however stormwater runoff is still affecting the watershed due to due to historical land uses and channel alterations. Evidence of stormwater runoff is discussed in Section 5.1 – Identification of Problem Sites.

Stormwater Runoff from Stabilized Sites: Due to the highly developed nature of the Butler Creek watershed, stormwater runoff over impervious surfaces can carry significant loads of pollutants into the stream channel. These include animal waste, vegetative matter, sediment, pesticides, herbicides, fertilizer, and trace metals from urban materials such as roofing materials, flashing, galvanized pipes, brake linings, and tires. In addition, atmospheric pollutants can be deposited on impervious surfaces and delivered to the stream.

Bank Erosion: Impervious areas in the Butler Creek watershed decrease the infiltration and storage capacity of the soils in the watershed. This results in an increase in the volume and the velocity of stormwater runoff that is delivered to stream channels. This increase in runoff volume and velocity erodes stream channels and banks and adds to sediment loading in the stream. As noted in the discussion of streamwalks conducted for the development of alternative plans (see Section 5.1), channel erosion was observed throughout the Butler Creek watershed. The active erosion of stream banks has the potential to embed substrates used by fish and macroinvertebrate species for spawning and cover. Bank erosion also leads to a loss in streambank vegetation, reducing the availability and diversity of food sources for aquatic species.

2.5 Water Quality Monitoring (1987 – 2008)

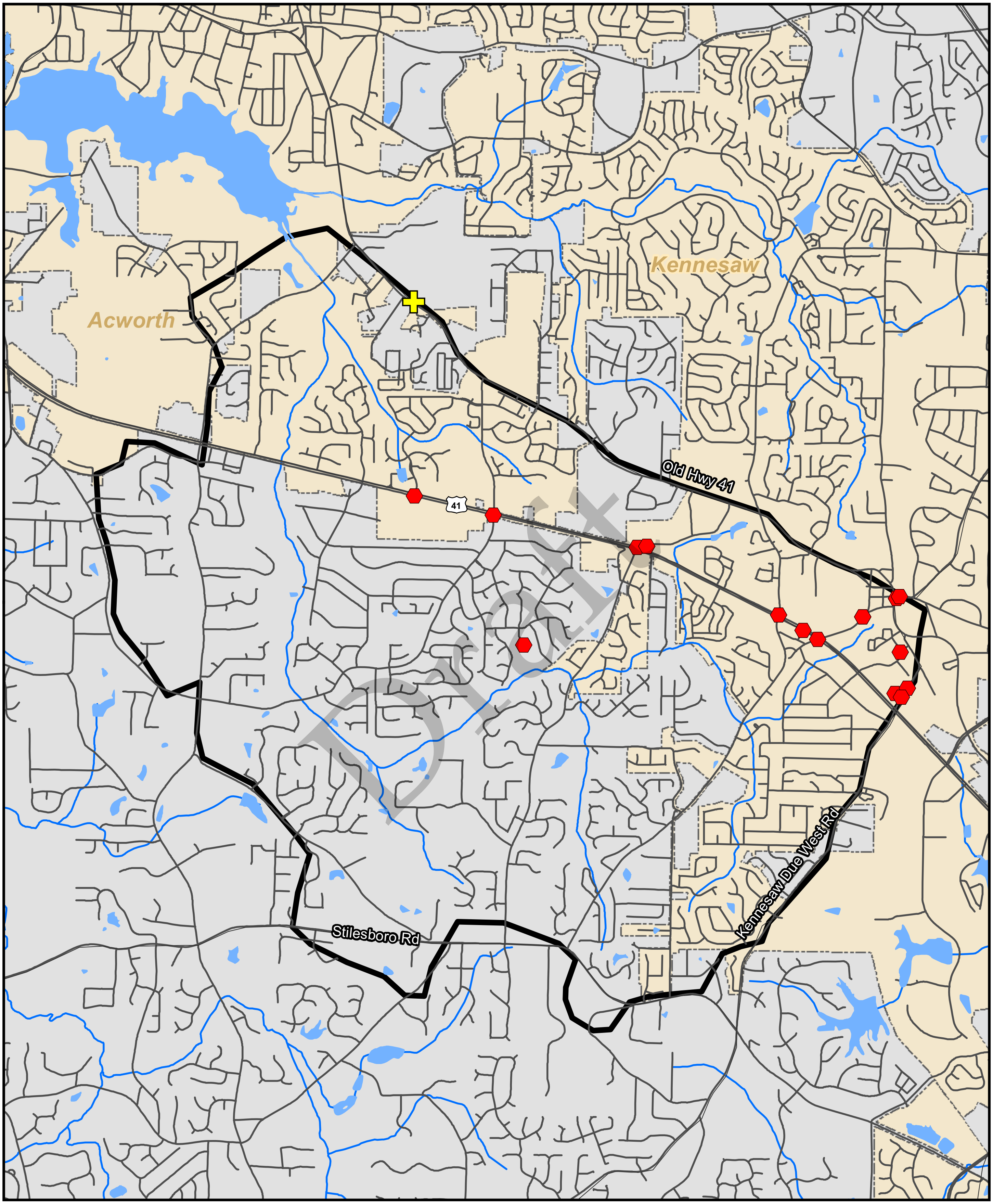
The Cobb County Water System (CCWS) collects quarterly water quality data in five Water Reclamation Facility (WRF) service areas across the County as part of their Cobb County Stream Monitoring Program (CCSMP). Of the 92 stations that are sampled for water quality, CCWS monitors six stations on Butler Creek (Table 2-2, Figure 2-6). For the purpose of establishing historical water quality in the Butler Creek watershed, data collected approximately quarterly between 1987and 2008 were evaluated. Key water quality parameters are discussed in this section, including dissolved oxygen (DO), pH, conductivity, turbidity, total suspended solids (TSS), fecal coliform, and nitrate-nitrite. Other parameters that were monitored for the CCSMP included biochemical oxygen demand, dissolved organic carbon, total Kjeldahl nitrogen, total phosphorus, cadmium, chromium, copper, lead, and mercury.

TABLE 2-2
CCWS Long-term Monitoring Stations on Butler Creek
Butler Creek Watershed Detailed Project Report – Environmental Appendix

Station ID	Location
BT1	Tributary to Butler Creek at Pine Mountain Road
BT2	Butler Creek at Mack Dobbs Road
BT3	Butler Creek at Jim Owens Road
BT4	Butler Creek at Nance Road
BTA	Tributary to Butler Creek at Fowler Road
BTB	Butler Creek at Pine Mountain Road

Dissolved Oxygen

Georgia water quality standards for DO are based on the type of fish the stream supports. The standard for waters supporting warm-water fish species, such as those in the Butler Creek watershed, is a daily average of 5.0 milligrams per liter (mg/L) and no less than 4.0 mg/L at all times. As shown in Figure 2-7, yearly average DO levels in the Butler Creek watershed have been greater than 6 mg/L since 1987. In general, DO concentrations have



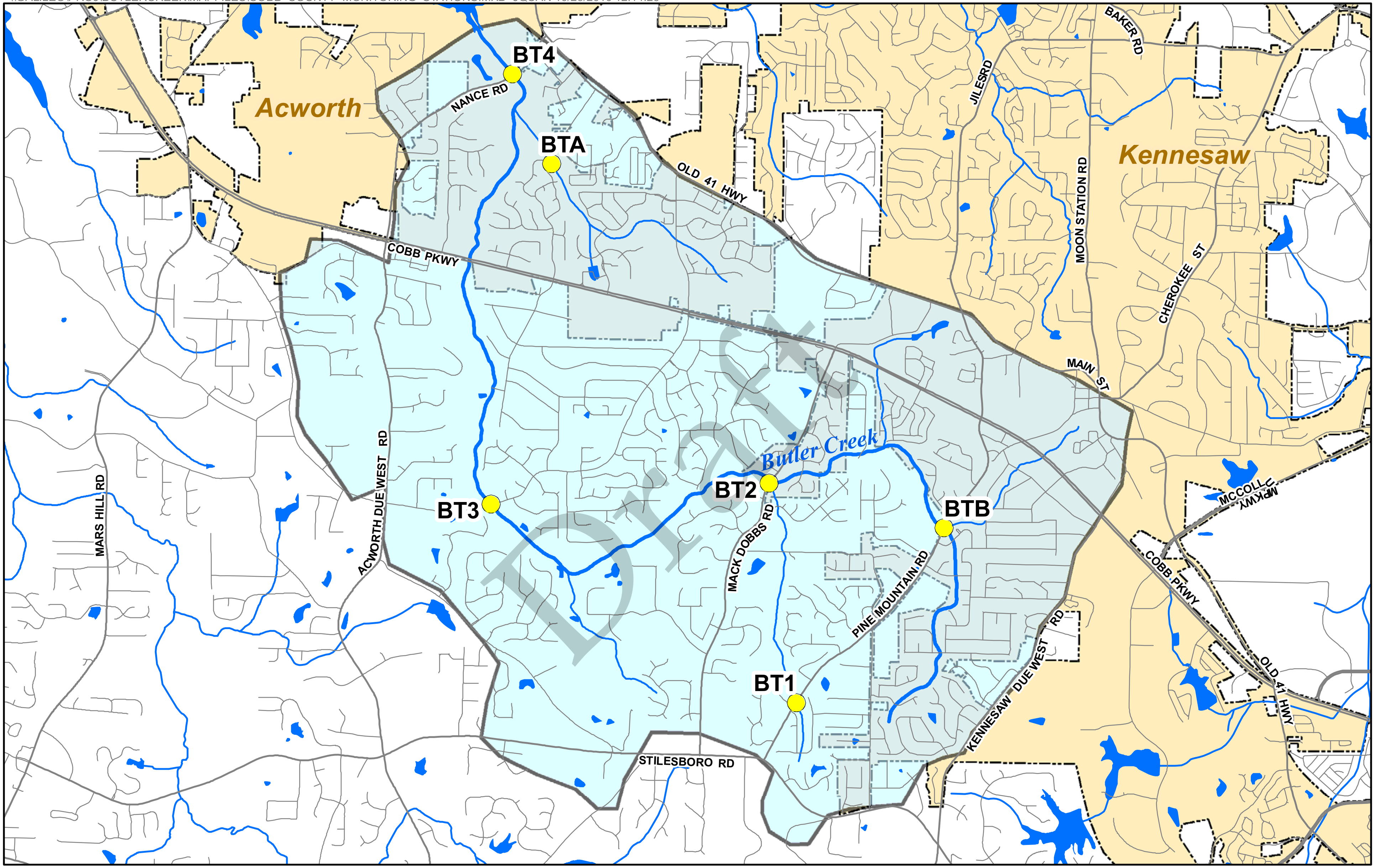
PCS
RCRA
River / Stream
Major Rd
Waterbody
Butler Creek Watershed
City Limit

0 1,000 2,000
Feet

FIGURE 2-5
Potential Pollution Sources
Butler Creek Watershed DPR - Environmental Appendix

CH2MHILL

\\GALILEO\PROJ\BUTLERCREEK\MAPFILES\COBB_COUNTY_MONITORING_STATIONS.MXD JQUAN 10/26/2010 12:14:26



Monitoring Station
Major Road
Road
River/Stream
Butler Creek
Waterbody
Butler Creek Watershed
City Limit

0 0.5 1 Miles

FIGURE 2-6
CCWA Monitoring Stations
Butler Creek Watershed DPR - Environmental Appendix

CH2MHILL

fluctuated between approximately 6 mg/L (during warmer weather) and 12 mg/L (during colder weather), with levels at Jim Owens Road (BT3) being relatively high and levels at Pine Mountain Road (BT1/BTB) being relatively low. Individual DO concentrations were less than 4 mg/L at three sites (Jim Owens Road [BT3], Nance Road [BT4], Pine Mountain Road [BT1]) during a severe regional drought in August 2007; all other samples have met the instantaneous criterion. Average levels of DO in 1994 were relatively low; though it should be noted that only one sample event occurred during this year, in June. The reason for this is unknown, and it appears to have been an isolated event, as this trend has not continued.

pH

The State standard for pH is 6.00 to 8.50 standard units (GADNR, 2009). pH values at the Butler Creek sampling stations were consistently within the state standard (see Figure 2-8). As can be expected in a uniform water body, pH levels increase from the smallest drainage area site (BT1) to the largest drainage area site (BT4), as the concentration of dissolved hydrogen ions is expected to be smaller (higher pH) with more water volume (larger drainage area), assuming no additional sources are introduced. This suggests that there are no major point or nonpoint contributors to high or low pH levels within Butler Creek. During the June 1994 sample event, pH levels were relatively high, at the same time that DO levels were low.

Conductivity

At present, there are no State standards for conductivity; however, the USEPA has indicated that general levels of conductivity for freshwater between 150 and 500 µS/cm can support healthy fish and macroinvertebrate communities (USEPA, 1997). Average conductivity levels from historical monitoring data ranged between 101 µS/cm (at Mac Dobbs Road [BT2]) to 129 µS/cm (at Pine Mountain Road [BTB]), slightly below the recommended level. However, these levels are commonly observed in urban streams in the metropolitan Atlanta area and do not indicate a water quality concern.

Turbidity

High turbidity levels often indicate upstream erosion problems associated with construction sites, unstable stream banks, excessive nutrients, and/or urban runoff, and thus turbidity is important to monitor in highly urbanized areas with commercial activities and residential growth. While there is no State standard for turbidity, Laenen and Dunnette (1997) suggest 30 nephelometric turbidity units (NTUs) as a point above which the potential for water quality degradation exists. Turbidity was generally below 30 NTU, with the exception of three sampling events, in March 1987, June 1986, and February 1997, with a maximum value of 97 mg/L at Mack Dobbs Road (BT2). However, as shown in Figure 2-9, turbidity levels have declined throughout the watershed since 1997, likely due to the most current construction stormwater management strategies implemented by the County in the early 2000's.

Total Suspended Solids

Levels of TSS can be influenced by natural sources (such as silt captured in runoff) or human sources such as construction sites and urban and agricultural land uses. In a water body, high TSS is often associated with higher concentrations of bacteria, nutrients, pesticides, and metals in the water. Consistent with turbidity data, TSS concentrations have decreased since 1997, and levels at Pine Mountain Road (BT1) were generally the lowest among the stations (Figure 2-10). Overall, TSS concentrations do not indicate a water quality concern.

Fecal Coliform

GADNR has established a fecal coliform criterion of a geometric mean (4 samples collected over a 30-day period) less than 1,000 colonies (col.)/100 milliliters (mL) and an individual sample less than 4,000 col./100 mL, for the months of November through April. During the months of May through October, when most recreational activities are expected to occur, the State criterion is a geometric mean less than 200 col./100 mL (GADNR, 2009). While geometric mean data are not available, these levels can be used for comparison to average levels, shown in Figure 2-11.

Average fecal coliform concentrations have consistently been higher at Pine Mountain Road (BT1) since sampling began in 1987. The highest levels overall were recorded in 1987 at BT1, on two occasions (24,000 col./100 mL in March 1987 and 11,000 col./100 mL in May 1987). Overall, average levels have decreased throughout the watershed since 2000. Elevated levels

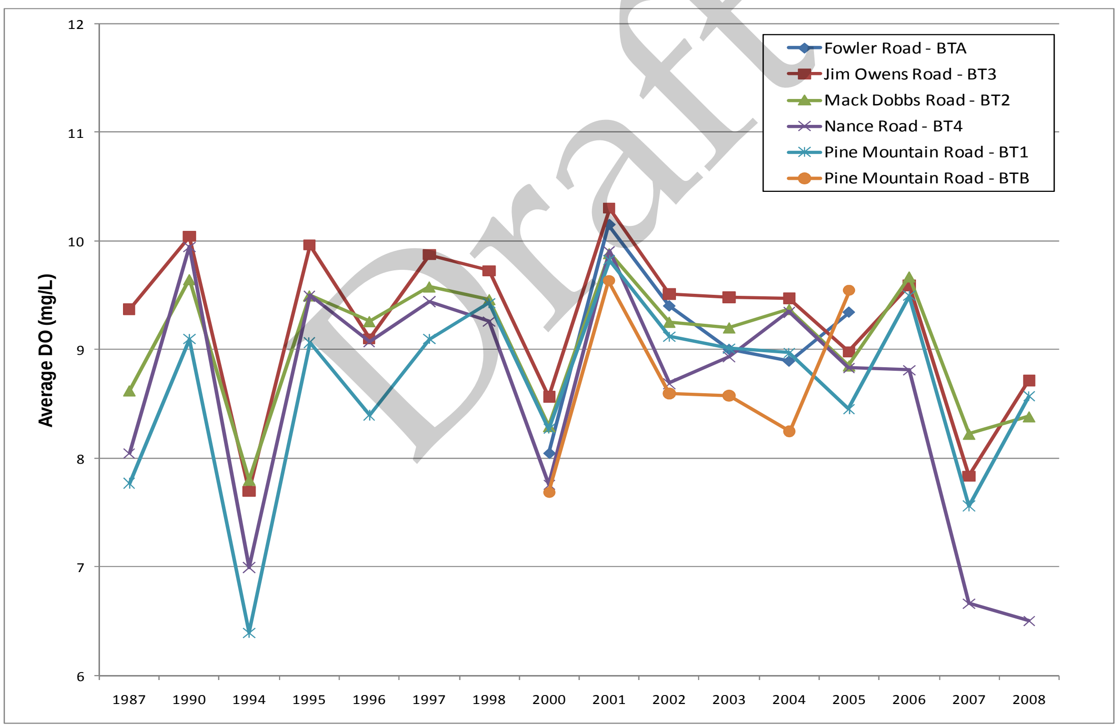


FIGURE 2-7
Yearly Average Dissolved Oxygen (1987-2008)
Butler Creek Watershed Detailed Project Report – Environmental Appendix

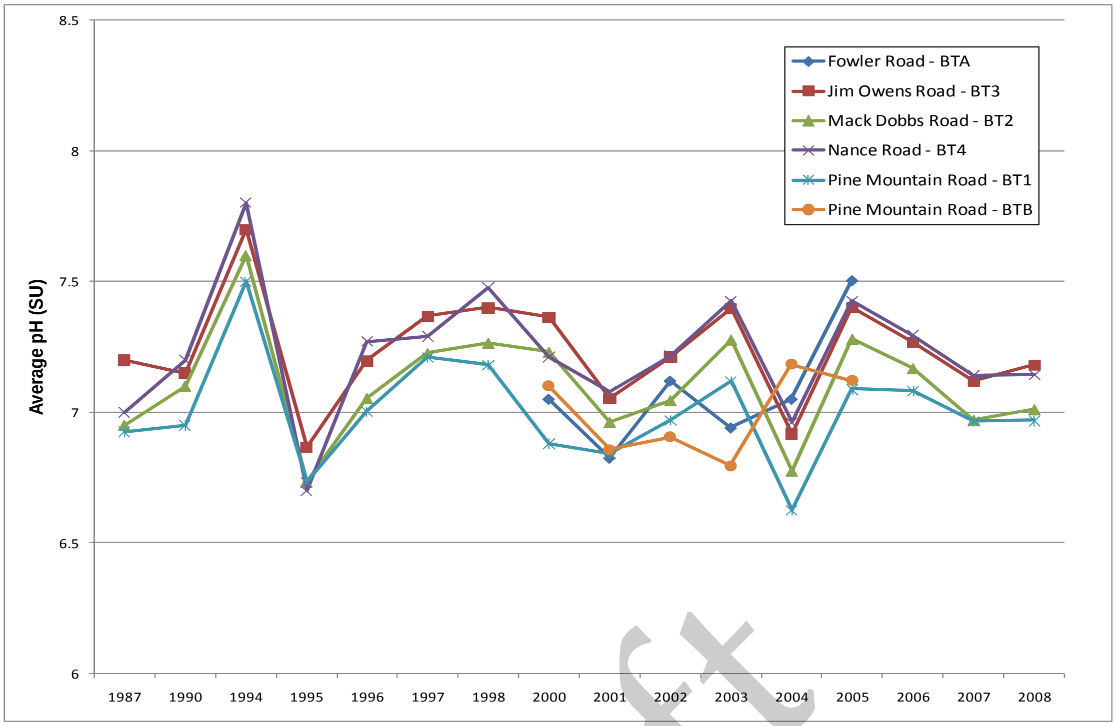


FIGURE 2-8
Yearly Average pH (1987-2008)
Butler Creek Watershed Detailed Project Report – Environmental Appendix

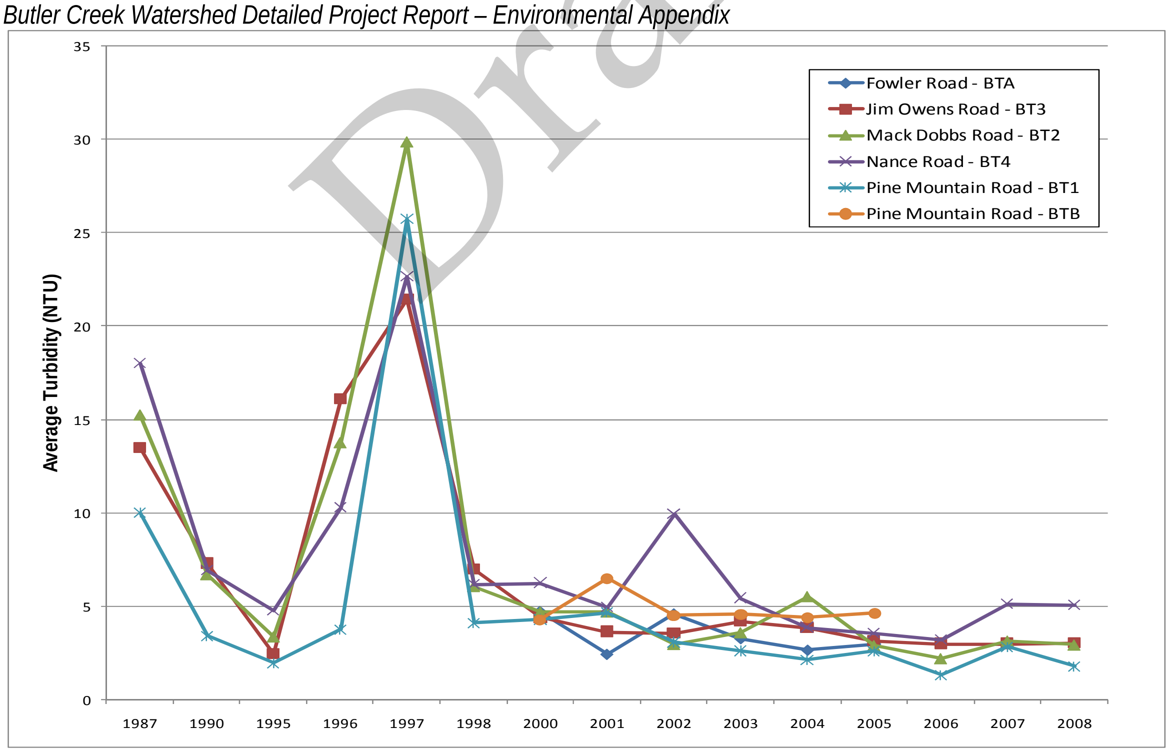


FIGURE 2-9
Yearly Average Turbidity (1987-2008)
Butler Creek Watershed Detailed Project Report – Environmental Appendix

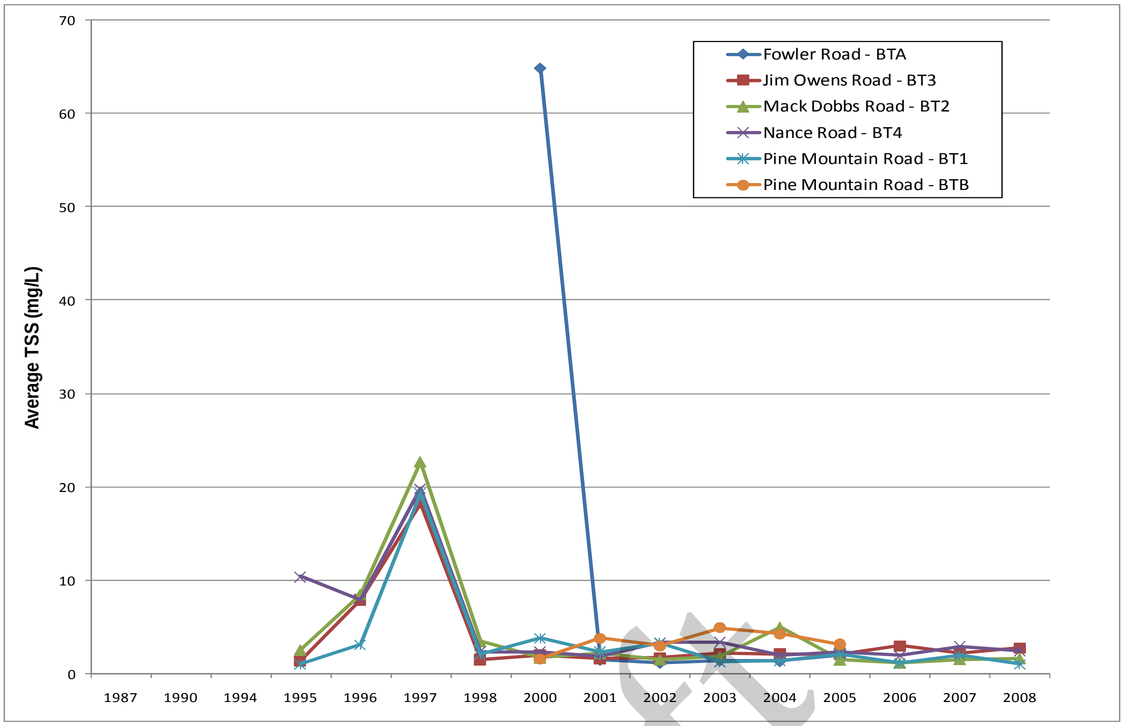


FIGURE 2-10
Yearly Average Total Suspended Solids (1995-2008)
Butler Creek Watershed Detailed Project Report – Environmental Appendix

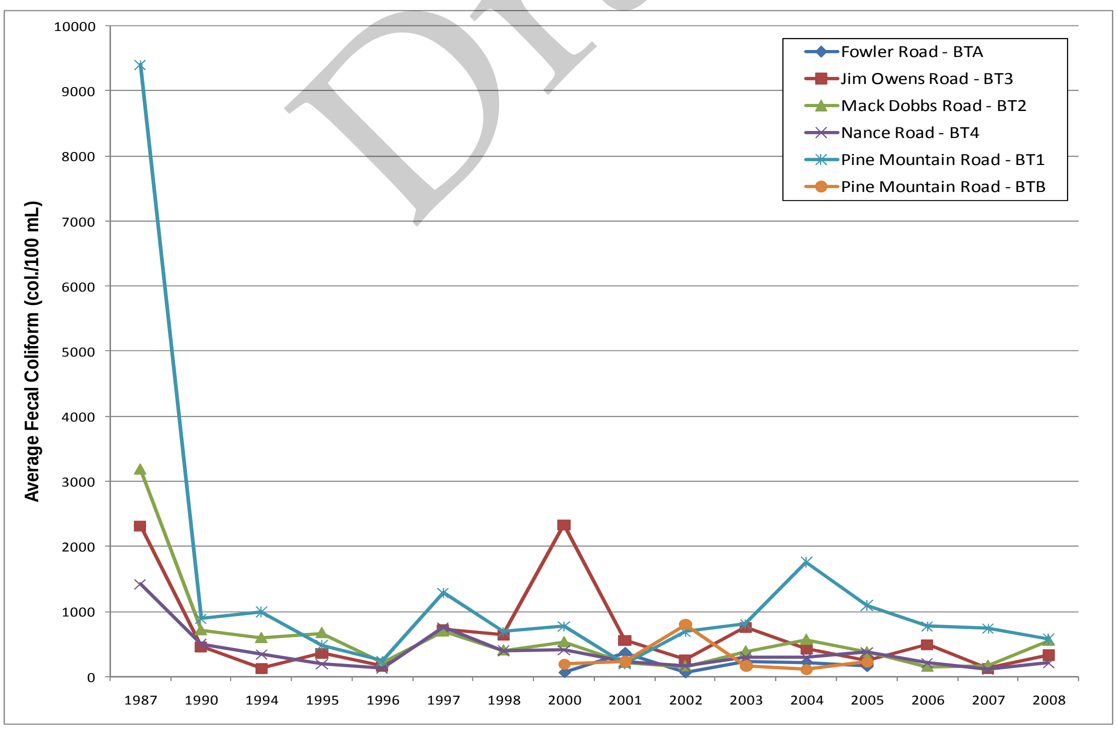


FIGURE 2-11
Yearly Average Fecal Coliform (1987-2008)
Butler Creek Watershed Detailed Project Report – Environmental Appendix

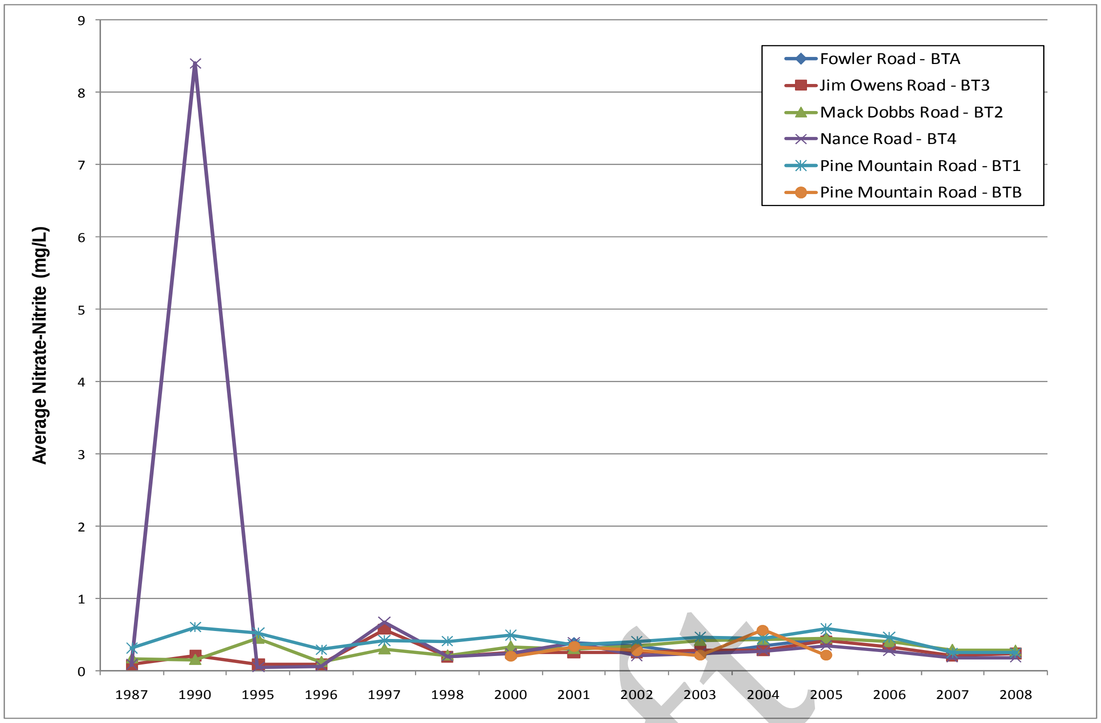


FIGURE 2-12
Yearly Average Nitrate-Nitrite (1987-2008)
Butler Creek Watershed Detailed Project Report – Environmental Appendix

prior to this may be attributed to wet-weather sampling, high construction periods, a lack of stormwater controls, and/or other environmental factors. Overall, concentrations of fecal coliform are consistent with the ubiquitous nature of fecal coliform in both developed and undeveloped watersheds.

Nitrate-Nitrite

Elevated nitrate-nitrite in surface waters can lead to excessive growth of aquatic plants, which can affect turbidity and dissolved oxygen levels in streams, and in turn affect aquatic biota. In 2000, the USEPA reported that in the Piedmont ecoregion, which includes the service area watersheds, more than 95 percent of 1,215 collected samples had nitrate/nitrite values lower than 3.26 mg/L (USEPA, 2000b). Since there are no State standards for nutrients in Georgia, this value can be compared to data collected for this study, providing a reference or background value for average nitrate/nitrite concentrations in the region. As shown in Figure 2-12, levels of nitrate-nitrite in the Butler Creek watershed have generally measured below 1 mg/L, indicating no water quality concern. Relatively high levels in 1997 correspond with elevated levels of fecal coliform, TSS, and turbidity during that time period.

2.6 Fish Community Assessments (2003 – 2009)

CCWS conducts fish sampling at selected locations throughout the County, including Butler Creek at Jim Owens Road (BT3, Figure 2-6), on a 5-year cycle. Sampling is conducted between early April and mid-October and follows the most recent Standard Operating

Procedures provided by GADNR. The IBI (Karr et al., 1986) is used to evaluate the health of the fish communities at each sampling station. IBI scores are calculated based on rating 13 metrics of fish community structure in five broad categories: species richness, species composition, trophic function, species abundance, and physical condition. The final IBI scores are used to determine the overall qualitative conditions of the fish communities, ranging from "excellent" to "very poor."

Figure 2-13 provides the 2003 fish community assessment data for Butler Creek at Jim Owens Road (BT3), as well as results from other Cobb County stations also located in the Coosa River basin (Allatoona Creek at Midway Road [AL1], Little Allatoona Creek at Pitner Road [LAL3], and Proctor Creek at Baker Road [PC1]). Additionally, Figure 2-13 includes results from data collected by CH2M HILL in 2009 in the Allatoona Creek (ALC-1 through ALC-5) and Proctor Creek (PRC-1 through PRC-4) watersheds, as part of other aquatic ecosystem restoration studies. The results are shown in order of increasing drainage area, for comparison of stations of similar size. As shown, fish communities in the Coosa River basin in Cobb County have historically scored at most 30 points, and are categorized as either "poor" (scores 26 through 32) or "very poor" (scores less than 24) according to GADNR qualitative categories (2005). The 2003 score for Butler Creek at Jim Owens Road was comparable to other stations in the Coosa River basin, indicating a degraded fish community.

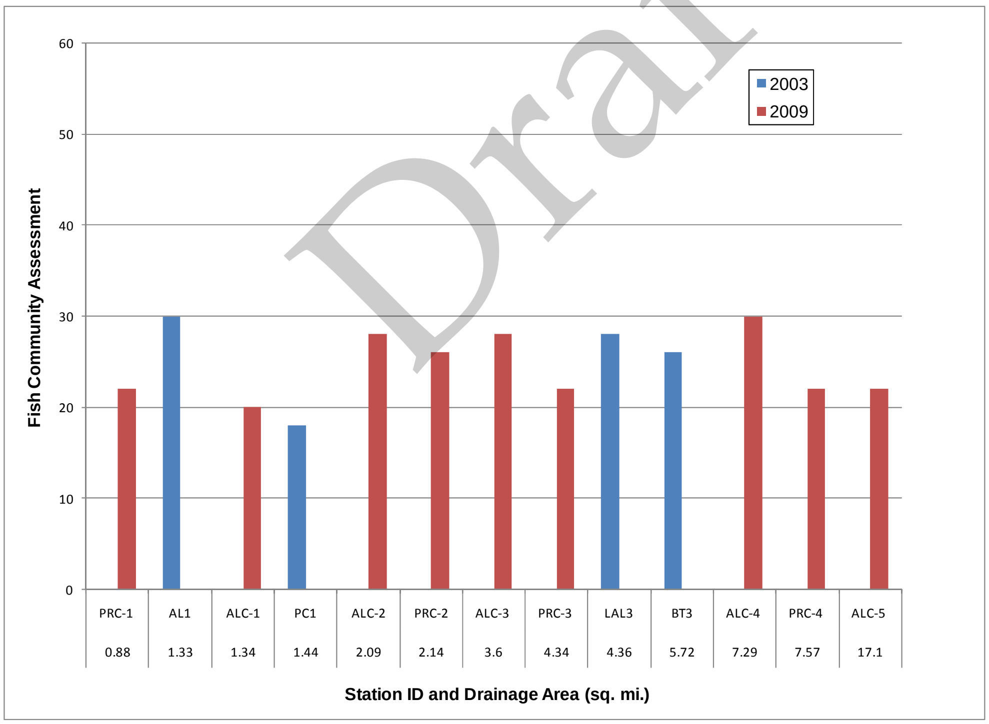


FIGURE 2-13
Fish Community Assessment Data in the Coosa River Basin in Cobb County
Butler Creek Watershed Detailed Project Report – Environmental Appendix

2.7 Macroinvertebrate Community Assessments (2003 – 2010)

CCWS conducts benthic macroinvertebrate sampling and analysis at selected locations throughout the County, including Butler Creek at Jim Owens Road (BT3, Figure 2-6), on an approximately biannual basis. Figure 2-14 shows the metric calculations for benthic macroinvertebrate data collected by CCWS from 2003 through 2008, in accordance with the *Standard Operating Procedures for Conducting Macroinvertebrate Biological Assessment of Wadeable Streams in Georgia, Standard Operating Procedures* (GADNR, 2007). Figure 2-14 also includes results from 2010 sampling, by CH2M HILL, in the Allatoona Creek (ALC-1 through ALC-5) and Proctor Creek (PRC-1 through PRC-4) watersheds for other aquatic ecosystem restoration studies.

Benthic macroinvertebrate samples were identified to the lowest taxonomic level practical, and a benthic macroinvertebrate index (BMI) score was calculated based on five metric categories specific to the Southern Inner Piedmont (45a) sub-ecoregion of Georgia. This assessment was consistent with USEPA’s RBPs (Barbour et al., 1999), and involved collecting samples from the various habitats for analysis and data evaluation. Each metric category represents a different component of community structure and/or function and provides a measure of biotic integrity. Corresponding qualitative ratings are currently unavailable, according to GAEPD; however, it should be noted that each metric is scored out of 100 points, allowing for comparison among sites. The macroinvertebrate index scores for Butler Creek at Jim Owens Road ranged from 36 (in 2008) to 59 (in 2003 and 2006). The scores suggest degradation of aquatic habitat and biota in the study area. Scores in the Butler Creek watershed have historically been lower than those in Allatoona Creek, and the most recent Butler Creek score in 2008 shows a substantial decline from previous sampling years (Figure 2-14).

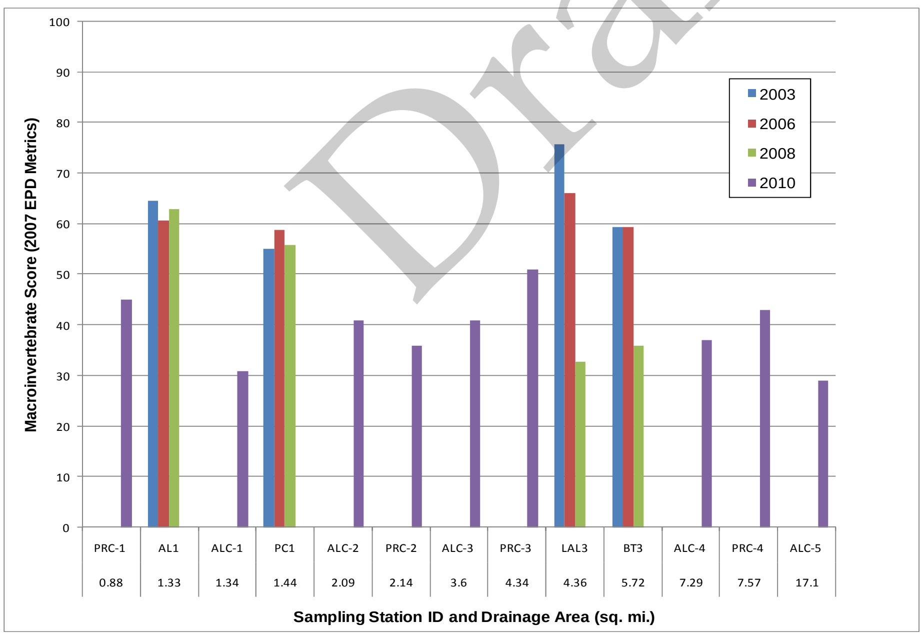


FIGURE 2-14
Benthic Macroinvertebrate Assessment Data in the Coosa River Basin in Cobb County
Butler Creek Watershed Detailed Project Report – Environmental Appendix

2.8 Physical Habitat Assessments (2000 – 2010)

Figure 2-15 shows the results of physical habitat assessments conducted CCWS (at AL1, PC1, LAL3, and BT3) between 2000 and 2009 and those conducted by CH2M HILL (at ALC and PRC station IDs) in 2010. Physical habitat assessments were conducted using protocols and worksheets provided in the most current GADNR SOPs. The procedures include an evaluation of the local watershed, channel substrates, stream width, and general habitat quality conditions. The GADNR habitat assessment forms provide qualitative categories for each metric that can be applied to overall habitat scores. A score between 0 and 50 points (out of a possible 100 points) is considered "poor," between 51 and 100 points is "marginal," between 101 and 150 points is "suboptimal," and higher than 150 points is "optimal."

As shown in Figure 2-15, physical habitat scores at PC1 and BT3, which were assessed during more than one sampling year, show no major change over time. Additionally, there are no apparent trends based on drainage area. Of the physical habitat assessments conducted, all have scored in the "suboptimal" qualitative category, with the exception of Little Allatoona Creek at Pitner Road (LAL3), which scored in the upper range of the "marginal" category. The habitat assessment score for Butler Creek at Jim Owens Road (BT3) was 138 points in 2005 and 140 points in 2006. In 2001, GADNR measured a physical habitat assessment score of 86.2 at Nance Road on Butler Creek, as part of the TMDL analysis for impacted biota (GAEPD, 2009). It should be noted that physical habitat assessments conducted in 2010 were, on average, lower than most conducted prior, but still primarily in the suboptimal category. While the dataset is not sufficiently robust to establish trends over time, the habitat assessment scores suggest that physical habitat in the basin is currently only somewhat degraded. However, over time, localized areas of excessive erosion and incised channel conditions will likely result in continued degradation.

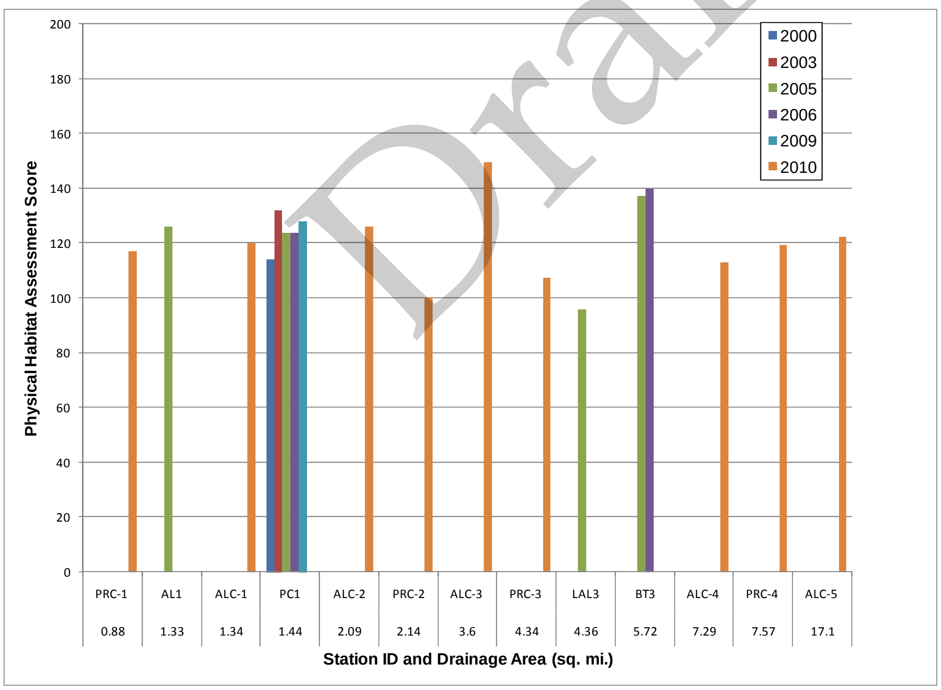


FIGURE 2-15
Physical Habitat Assessment Data in the Coosa River Basin in Cobb County
Butler Creek Watershed Detailed Project Report – Environmental Appendix

3. Analysis of Existing and Future without Project Conditions for Alternatives Analysis

Section 2 details existing conditions in the Butler Creek watershed, based on available data at the time the Detailed Project Report was developed (2010). However, quantification of aquatic habitat and ecosystem conditions, for alternatives analysis, was completed by the PDT in 2004. While the following section provides the 2004 basis for the alternatives analysis, the watershed investigation in Section 2 demonstrates that the need for aquatic ecosystem restoration in the Butler Creek watershed still exists. The following section details the methods used to quantify existing and future without project conditions, in accordance with requirements for evaluating federal aquatic ecosystem restoration projects.

3.1 Quantification of Existing Conditions for Alternatives Analysis

3.1.1 Physical Habitat-Based Approach

In 2004, the PDT assessed various methods for evaluating the net quantity and/or quality of ecosystem resources in the Butler Creek watershed, to quantify changes to instream habitat and aquatic ecosystems. Methods considered included a physical habitat-based approach, assessing various physical habitat characteristics, and a hydrogeomorphic approach, which defines and quantifies a list of specific measureable functions provided by the ecosystem. Ultimately, USACE-Mobile, in consultation with the USACE-South Atlantic Division and USFWS, developed a physical habitat-based approach to qualitatively evaluate environmental benefits associated with the aquatic ecosystem restoration measures and alternatives. The approach involves developing a matrix of physical stream characteristics and assigning a score for each site, based on conditions relative to a reference reach. This method has been accepted for use in Georgia, and has been widely used throughout the U.S. (Newton, et al, 1998, Sommerville and Pruitt 2004). It should be noted that the Ecosystem Restoration Model (ERM) was developed in 2007 by an interagency team including USACE, EPA, USFWS, and GADNR as a more refined quantitative method for determining environmental benefits of aquatic ecosystem restoration projects in north Georgia watersheds in the metro-Atlanta area. However, this model was developed after the quantification of existing, future without project, and future with project conditions in the Butler Creek watershed had been quantified in 2004. The extensive resources that would be required to re-evaluate field sites, collect and analyze additional data, and conduct additional alternatives analyses made changing the evaluation method unfeasible for this Detailed Project Report.

USACE adapted the GADNR physical habitat assessment forms to determine environmental benefits for the proposed project in the Butler Creek watershed. Various physical habitat metrics were scored using previous data collected during the 2002 stream assessment (detailed in Section 2). A reference reach was selected to compare other points along Butler Creek and its tributaries. The reference reach (at waypoint 43) was chosen based on its physical characteristics as a relatively high-quality reach of Butler Creek that could be comparatively used to demonstrate improvements in stream function associated with small fish species in the Georgia Piedmont and especially with the Cherokee darter. Likewise, the characteristics of the reach and the metric scoring for the site indicated that it would have relatively better habitat for other aquatic life including native plants and invertebrates. The reference reach had sloping banks with little evident erosion, little streambed incision, a higher degree of cobble and gravel substrate, less sand and sediment deposition, and a greater degree of undisturbed natural vegetation when compared to other sites in Butler Creek.

3.1.2 Calculating Habitat Units and Assumptions

The following assumptions were made to quantify existing ecological resources and aquatic habitat:

- The physical habitat assessment conducted in 2002 at waypoint 43 was used as a reference reach to represent a high-quality stream ecosystem.
- In comparison to waypoint 43, the physical habitat availability and diversity throughout the remainder of the Butler Creek watershed is, generally, 50 percent lower.
- The same physical habitat score can be applied at any of the problem sites in the watershed to represent existing conditions.
- Based on field observations discussed in Section 2 and modeling results summarized in this section, project area is an important factor in predicting the level of future degradation expected at any given problem site due to future increases in discharge, velocity, and sediment loading.

Based on these assumptions, habitat units were used to quantify and compare ecological benefits for existing conditions, future without project conditions, and future with project conditions, where,

habitat units = physical habitat score × project area.

3.1.3 Results

The physical habitat assessment results for the reference reach (waypoint 43) and the representative existing conditions in the Butler Creek watershed are shown in Table 3-1. Based on GADNR qualitative categories, the reference reach is considered “optimal;” overall conditions in the watershed are considered “marginal,” by comparison. These physical habitat assessment scores are the basis for calculating the habitat units at a given location. For example, assuming the project area at waypoint 43 is equal to 2 acres, the habitat units at that location are equal to 310 (155×2). If physical habitat at waypoint 43 were to become as degraded as the remainder of the watershed (existing conditions score), the habitat units at that location would be equal to 154 (77×2). The net habitat units (156, or 310-154) would then be used to quantify the change in ecological resources at waypoint 43. The calculation of net habitat units will be more relevant in the alternatives analysis process.

TABLE 3-1
Physical Habitat Assessment Scores – Existing Conditions
Butler Creek Watershed Detailed Project Report – Environmental Appendix

Physical Habitat Parameter	Reference Reach (Waypoint 43)	Butler Creek Watershed
Epifaunal Substrate / In-stream Cover	16	8
Embeddedness	17	8
Velocity/Depth Regimes	15	7
Channel Alteration	15	7
Sediment Deposition	16	8
Frequency of Riffles	17	8
Channel Flow Status	13	7
Bank Vegetative Protection	15	9
Bank Stability	15	8
Riparian Vegetative Zone	16	7
Total Physical Habitat Assessment Score	**155**	**77**
Qualitative Category	Optimal	Marginal

3.2 Quantification of Future without Project Conditions for Alternatives Analysis

3.2.1 Approach to Predict Future without Project Conditions

For future without project conditions, the PDT developed an overall habitat assessment score for the Butler Creek watershed, analogous to the "existing conditions" score presented in Table 3-1. The future without project habitat assessment score was determined based on a comparison of existing and future conditions estimated by hydrologic and hydraulic (H&H) modeling. The use of H&H models to predict future stream velocities, discharge rates, and sediment loads is important in estimating future watershed and instream conditions. As land in North Georgia continues to undergo development, altered flow patterns, like those resulting from urbanization, lead to increased stream degradation, and the increase in impervious surfaces intensifies the number and strength of flood events. These altered flow and flood patterns, which contribute to a decline in biological health, can be predicted using appropriate models. In addition, models can estimate the degree of sedimentation that will result from changes in land use and stormwater runoff due to growth and development.

Commonly used and well-accepted H&H models, including Hydrologic Engineering Center (HEC)-2 Water Surface Profiles program, the Watershed Characterization System (WCS) program, and Hydrologic Engineering Center Hydrologic Modeling System (HEC-HMS), were used to quantify existing and future conditions of the Butler Creek watershed. Three key factors which have the potential to influence aquatic ecological integrity were modeled, including (1) discharge, (2) channel velocity, and (3) sediment delivery. The H&H modeling methodology and results are detailed in Appendix E (Engineering Appendix) of the Detailed Project Report, and a discussion of the environmental analysis of future without project conditions is provided below.

Discharge

The hydrologic study for Butler Creek was conducted to determine peak stream flows, or peak discharges, of various frequency storm events, under existing and future conditions. HEC-HMS models for existing conditions and future without project conditions were developed using data provided by Cobb County, the City of Acworth and the City of Kennesaw for current (1999) and projected future (2030) land use data, respectively. The land use datasets were utilized by the HEC-HMS models to account for changes in impervious cover and corresponding runoff lag times.

Figure 3-1 illustrates the modeled 2-year peak discharge, at various locations on the mainstem of Butler Creek, under existing and future without project conditions. The increase in impervious area in the future land use dataset is influences the modeled increase in peak flows from the existing conditions model (Figure 3-1). As shown in Figure 3-1, the increase in peak discharge is expected to be greater for stream locations with larger drainage areas. For example, the 2-year peak discharge at Cobb Parkway is expected to increase by approximately 1700 cubic feet per second (cfs), based on future land use changes, while the 2-year peak discharge at Pine Mountain Road, in the headwaters, is expected to increase by approximately 100 cfs. This supports the assumption that the effects of flow, a driving factor of habitat quality and availability, are magnified in downstream reaches of the watershed.

Channel Velocity

Velocity results from the detailed HEC-2 backwater model (Figure 3-2) were used to identify reaches with existing and future stream bank erosion. The following locations were identified as problem locations: (1) reaches with 2-year peak channel velocity in excess of the maximum permissible velocity, (2) reaches with significant overbank flow during the 2-year flood, and (3) reaches with observed stream bank erosion problems. Maximum permissible velocities were determined based on unprotected soils in existing natural channels for various channel linings (e.g. sand, gravel, or cobble) and local soil conditions. Based on the channel conditions defined for the maximum permissible velocities and the local soil conditions, a threshold velocity of 4.5 feet per second was used as the standard for assessing the stream bank erosion potential for the primary channel systems in Butler Creek (Parsons 1998). The entire reach of Butler Creek was identified as having either moderate or severe stream bank erosion potential, based on a consistent velocities above 4.5 feet per second (Figure 3-2). The hydraulic model results support the need for stream bank restoration measures throughout much of the watershed, with exceedances of the 4.5 feet per second threshold spread evenly throughout the mainstem of Butler Creek (Figure 3-2). Table E-V-1 in Attachment 2 to the Engineering Appendix (Appendix E of the Detailed Project Report) provides the peak flow, channel velocity, and water surface elevation under future without project conditions and future with project conditions.

Sediment Delivery

Sediment delivery was calculated using the Watershed Characterization System (WCS) - Sediment Tool and the default data set for Cobb County provided by the Environmental Protection Agency (EPA). WCS uses the Universal Soil Loss Equation (USLE) to estimate the erosion due to raindrop impact and shallow surface runoff. Based on modeled results for existing and future without project conditions, the amount of sediment generated from the watershed remains roughly consistent with future land use conditions (Figure 3-3). A slight

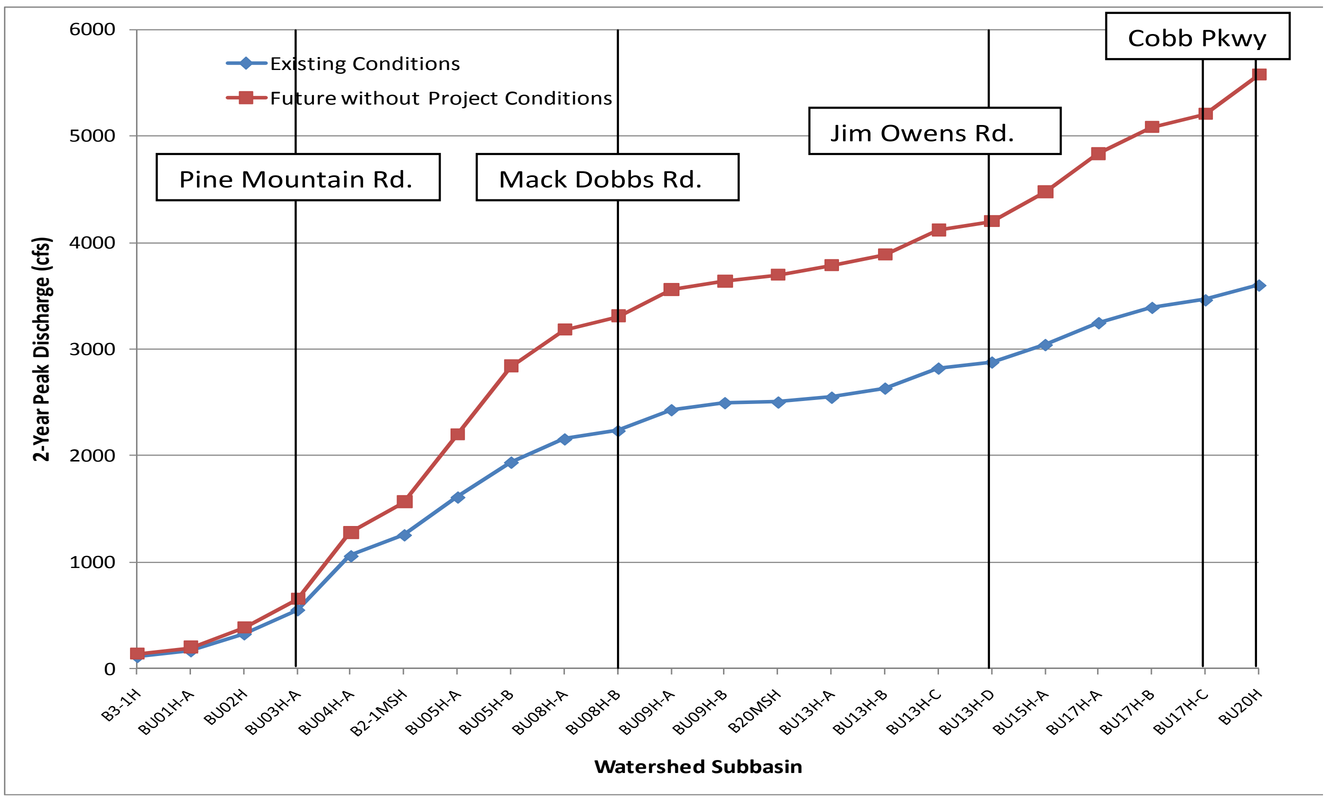


FIGURE 3-1
2-Year Peak Discharge Profile Under Existing and Future without Project Conditions
Butler Creek Watershed Detailed Project Report – Environmental Appendix

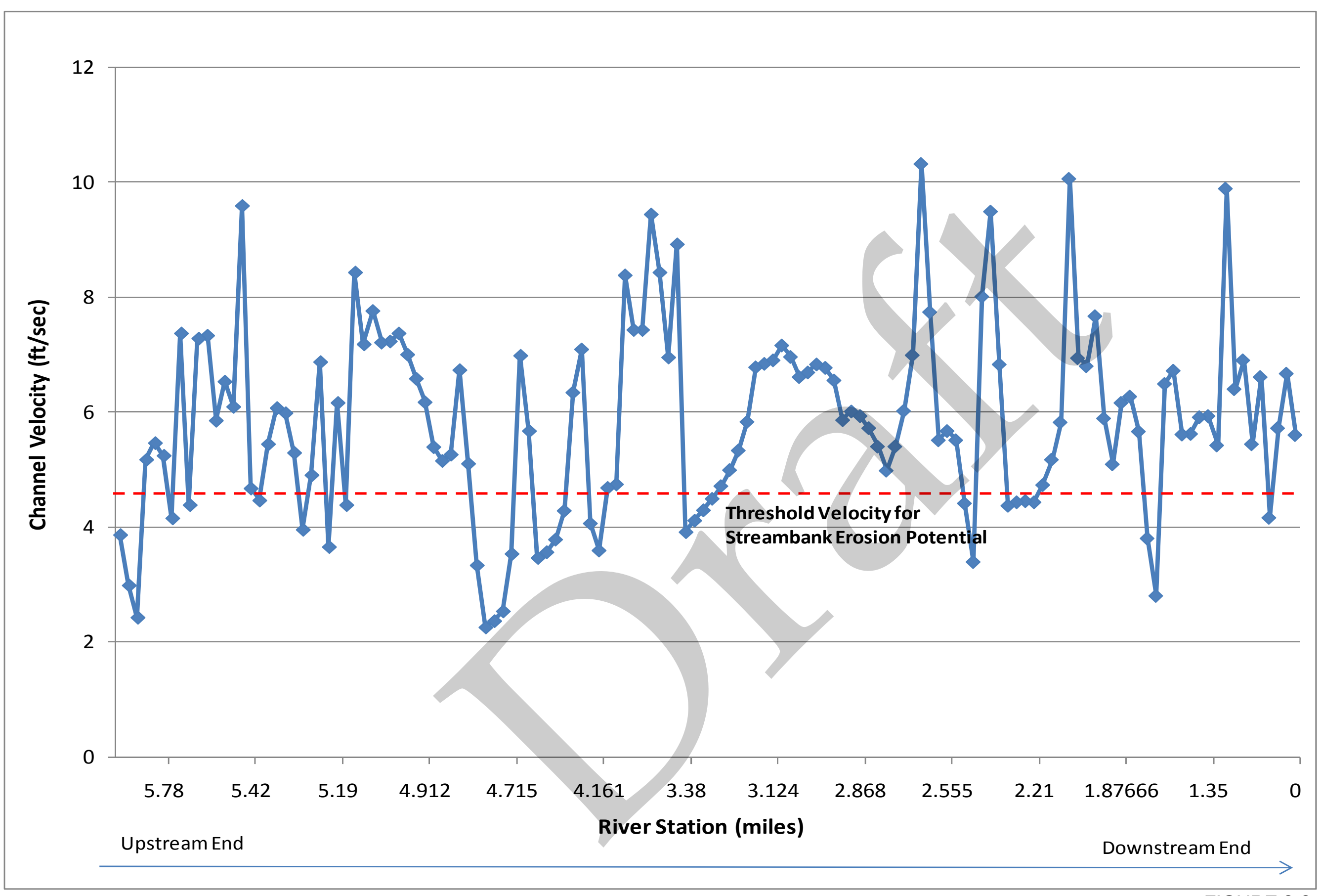


FIGURE 3-2
Velocity Profile Under Future without Project Conditions
Butler Creek Watershed Detailed Project Report – Environmental Appendix

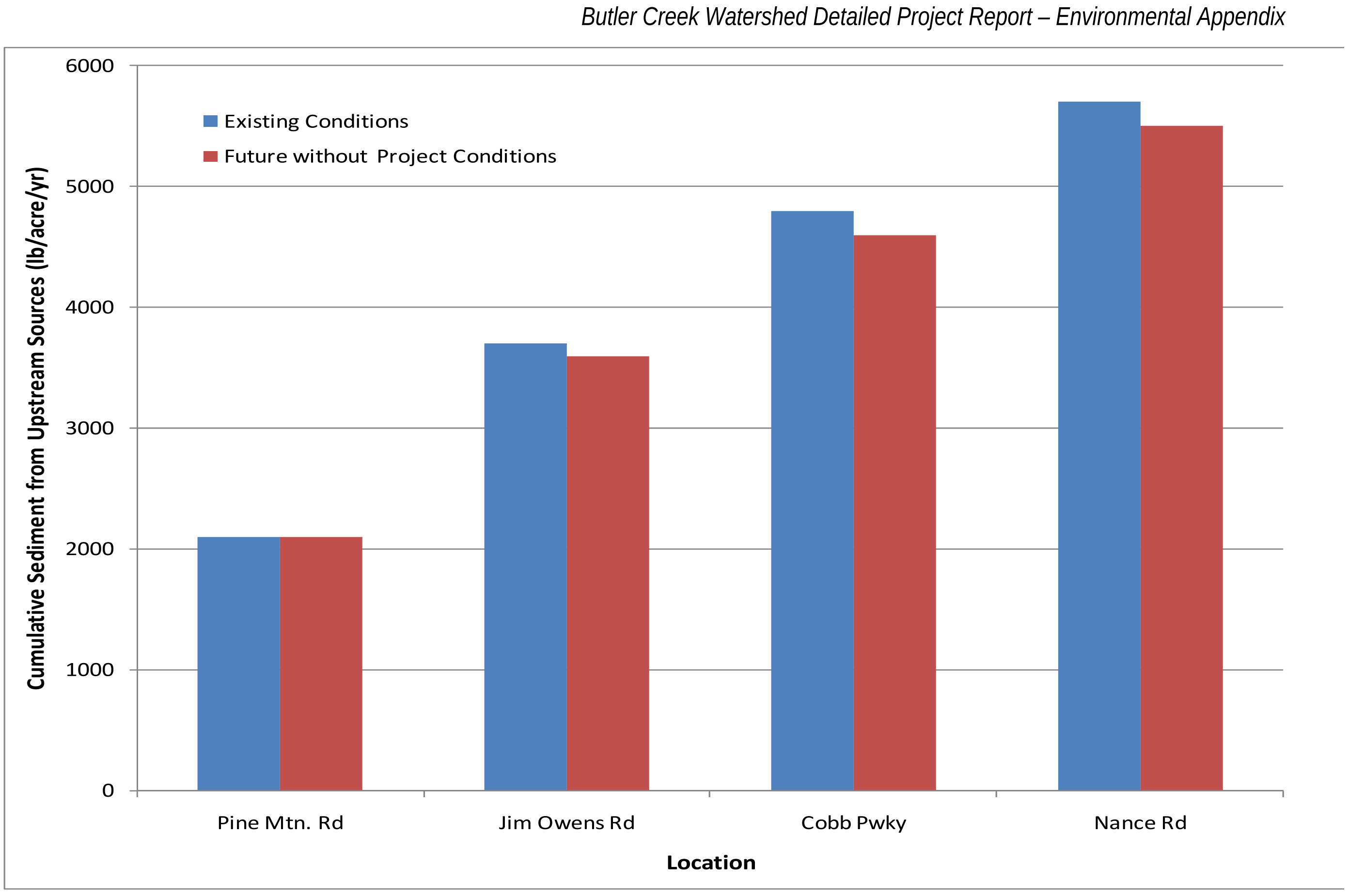


FIGURE 3-3
Sediment Yield Under Existing and Future without Project Conditions
Butler Creek Watershed Detailed Project Report – Environmental Appendix

future decrease is due to an increase in more urbanized land with less exposed sediment available to be carried by stormwater runoff. As shown, erosion potential and sediment delivery are lowest in the headwaters and higher as the stream flows to Lake Allatoona (Figure 3-3). The land in the headwaters is heavily urbanized, leaving less open soil to be eroded and less eroded soil to be delivered to the stream; whereas land near Lake Allatoona is less developed with more parkland and pastures, presenting more open soil to be eroded and therefore more sediment to potentially be delivered to the stream. Table E-I-7 in Appendix E to the Detailed Project Report provides the sediment delivery output under existing and future without project conditions at selected locations throughout the watershed.

3.2.2 Calculating Future without Project Habitat Units and Assumptions

The following assumptions were made to quantify future without project ecological resources and aquatic habitat:

- The physical habitat assessment score projected for existing conditions was used as a baseline for future without project conditions.
- In comparison to existing conditions, the physical habitat availability and diversity throughout the rest of the Butler Creek watershed is predicted to be generally at least 50 percent lower, based on the results of the H&H modeling.
- Based on model results, flow is the major contributor to degraded stream habitat throughout the Butler Creek watershed, and parameters inextricably related to flow (sedimentation, channel flow status, velocity/depth regime, frequency of riffles, and embeddedness) are expected to decline by more than 50 percent under future without project conditions.
- The future without project physical habitat score will be applied at all of the potential alternative locations.
- The use of project area as a multiplier for the expected physical habitat score at any one location weights the habitat unit scores, so that impacts in larger project areas are magnified; this accounts for the increased effects of flow and sediment expected as project area increases.
- The net habitat units (difference between future without project habitat units and future with project habitat units) can be used as a quantification of ecological lift for the alternatives analysis.

Based on these assumptions, habitat units were used to quantify and compare ecological benefits for existing conditions, future without project conditions, and future with project conditions, where,

habitat units = physical habitat score × project area.

3.2.3 Results

Based on the assumptions above and the H&H model results, an overall composite score was developed for the Butler Creek watershed under future without project conditions. The scores for each metric were projected based on a comparison to existing conditions for that metric (Table 3-1) as well as the H&H model results. The physical habitat assessment results for the reference reach, existing conditions, and future without project conditions are shown in Table 3-2. Based on GADNR qualitative categories, predicted future physical habitat will be "poor." In line with the example given in Section 3.1.3, the net habitat units at the 2-acre drainage point, assuming a change from existing to future without project conditions would be equal to 94 ([77×2] – [30×2]). The physical habitat score of 30 (future without project conditions) will be used to develop the net habitat units for each restoration alternative, and is equivalent to the physical habitat score of the No Action Alternative.

TABLE 3-2
Physical Habitat Assessment Scores – Existing and Future without Project Conditions
Butler Creek Watershed Detailed Project Report – Environmental Appendix

Parameter	Reference Reach	Butler Creek Watershed	
	Existing Conditions	**Existing Conditions**	**Future without Project Conditions**
Epifaunal Substrate / In-stream Cover	16	8	4
Embeddedness	17	8	2
Velocity/Depth Regimes	15	7	3
Channel Alteration	15	7	5
Sediment Deposition	16	8	2
Frequency of Riffles	17	8	2
Channel Flow Status	13	7	3
Bank Vegetative Protection	15	9	3
Bank Stability	15	8	3
Riparian Vegetative Zone	16	7	3
Total	155	77	30
Qualitative Category	Optimal	Marginal	Poor

4. Development of Restoration Measures

Plan formulation is the process of developing an array of plans that meet the planning objectives and avoid planning constraints. Plan formulation should involve input from agencies, stakeholders, citizens, the USACE, and the nonfederal sponsor. Alternative plans were comprised of structural and nonstructural components, called restoration measures, and are developed to the extent that they could be realistically evaluated and compared in terms of meeting planning objectives (Planning Manual, 1996). Alternative plans were formulated to meet the planning objectives and avoid planning constraints specified in Chapter 2. The formulation of alternative plans involved: (1) identifying restoration measures that could meet the planning objectives and avoid planning constraints; (2) identifying problem sites in the watershed that would benefit from restoration; and (3) formulating alternatives using the restoration measures to address problem sites. Using these steps, 107 single-site alternatives were developed for the Butler Creek watershed. Chapter 5 (Evaluating Alternative Plans) of the Detailed Project Report evaluates combinations of these alternatives, and the No Action Alternative.

4.1 Identification of Restoration Measures

Before formulating alternative plans, a full array of restoration measures was identified to facilitate a sustainable and holistic approach to addressing watershed problems. Thirty-nine potential restoration measures were identified to address problems in freshwater, riverine ecosystems and to formulate alternatives (Table 4-1). These measures established a list of options that could be included in aquatic ecosystem restoration alternatives, and include both structural and nonstructural elements as defined below. The measures were divided into 4 structural categories (instream, streambanks, riparian, and flow attenuation) and 1 nonstructural category, as shown in Table 4-1 and described in subsequent sections.

- Structural restoration measures required onsite construction, and may involve installation of features within the streambed (instream), along the streambanks, or within the stream riparian ecosystem. Riparian ecosystem measures may involve vegetative restoration or flow attenuation features designed to reduce peak stormwater discharges to the stream. Each potential structural measure considered for the watershed is described in detail below.
- Nonstructural measures included activities, programs, ordinances, or policies aimed at protecting watersheds and streams from activities that may cause adverse impacts. These measures did not involve construction-related activities, but rather established programs or policies that promote protection and preservation of the physical stream conditions and overall ecosystem integrity. Nonstructural measures may involve removal of litter and invasive plant species, public education programs, and scheduled stream inspections or monitoring programs.

Table 4-1 summarizes structural and nonstructural restoration measures considered in the alternative formulation process. The 39 potential restoration measures are detailed below.

TABLE 4-1
Potential Restoration Measures for Alternative Plans
Butler Creek Watershed Aquatic Ecosystem Restoration Detailed Project Report

Structural				
Instream	**Streambanks**	**Riparian**	**Flow Attenuation**	**Nonstructural**
Engineered riffle	Adjust stream meanders (add bends)	Cattle exclusion fencing	Extended wet detention basin	Adoption of protective stormwater ordinances [a]
J-hook	Create bankfull bench	Invasive plant species management	Extended dry detention basin	Enforcement of protective ordinances [a]
Cross vane	Bank grading	Riparian planting (native hardwoods)	Outlet control structure	Litter cleanup in stream corridors [a]
Debris jam removal	Bank stabilization matting	Riparian planting (seeding and mulching)	Outlet control structure retrofit	Public educational components: interpretive signage, trails, boardwalks, benches [a]
Culvert replacement	Streambank planting		Detention basin expansion	Ongoing invasive plant species management [a]
Stone toe protection	Riprap		Created wetlands	Post-construction stormwater management [a]
Boulders	Rootwad		Aquatic vegetation planting	Construction site inspection program [a]
Pool/Step pool			Micropool	Preservation of greenspace [a]
Log sill			Sediment forebay	Long-term stream monitoring [a]
			Pilot channel	

[a] Note that all applicable measures were considered, including those being implemented by the nonfederal sponsor separate from this project (Section 1.7, Nonfederal Sponsor Ongoing Projects and Programs).

4.1.1 Structural Restoration Measures

4.1.1.1 Instream Measures

Instream restoration measures would be installed along the streambed (below bankfull elevation) to adjust or stabilize the stream profile, provide improved habitat conditions, or establish flow regimes to better support aquatic ecosystem communities. These measures included various structures that provide refuge and spawning habitats for aquatic species. The placement of instream restoration measures, especially in areas with a homogeneous habitat structure, would provide a greater habitat diversity, which, in turn, promotes ecosystem resiliency and species diversity. Instream restoration measures implemented within or upstream of an area of concern would provide benefits at the associated area of concern.

Engineered Riffles

Riffles are important stream features for several reasons. They provide streambed stability, provide suitable habitat for aquatic and macroinvertebrate communities, and provide grade control for creating or maintaining a stable channel gradient. Considering riffles as an instream restoration measure, there are several varieties of riffle types from which to choose. Low-gradient linear riffles are suitable to maintain a gentle stream profile, while also establishing habitat enhancement. For steeper stream reaches, Newberry riffles or rock ramps are better suited. These structures can effectively provide grade control within moderate to steep gradient streams, while also providing adequate fish passage and habitat features. In the Butler Creek watershed, the stream channel has been degraded due to sedimentation, resulting in decreased frequency and diversity of riffles. As a result, engineered riffles were a valid restoration measure in the Butler Creek watershed.

J-hooks

J-hooks are named for their J-shape and typically consist of stone or logs. They are usually placed along channel meanders (up to the bankfull elevation), and are intended to keep erosive flows away from streambanks. Together with cross vanes, J-hooks can be used to establish channel grade control and to help form riffle/pool sequences that promote instream habitats critical for maintaining species diversity. Aquatic habitat diversity provided by riffle/pool sequences was scarce, and peak instream flow velocities have increased in the Butler Creek watershed. J-hooks were a valid restoration measure in this watershed to carry forward in the planning process.

Cross Vanes

Similar to J-hooks, cross vanes typically consist of stone or logs. They are U-shaped structures that can be placed in the channel (up to the bankfull elevation) to keep erosive flows off stream banks, establish grade control, and form riffle/pool sequences. Cross vanes typically are placed along straight channel reaches and can be used to effectively create and maintain a stable channel gradient. By helping to form riffle/pool sequences, this measure creates a diversity of instream habitats critical for maintaining species diversity and for creating and maintaining a stable channel gradient. While cross vanes would serve the same purpose as engineered riffles and log sills, each of these measures were selected for further evaluation since the stream type, hydrology, soils, and surrounding land use may dictate which measure would be more effective in a single location.

Debris Jam Removal

Streams with altered hydrology and altered sediment transport regimes often experience excessive erosion and carry large material or debris downstream. Debris jams are created when fallen trees and other debris accumulate and obstruct flow. This situation adversely affects natural channel conditions, not only resulting in local degradation of habitat conditions, but also causing sedimentation/embeddedness of the upstream channel, obstruction to fish passage, and downstream channel scour and erosion. Debris jam removal was a valid restoration measure and was considered where these conditions persist.

Culvert Replacement

Culverts are constructed at set elevations, but stream channels over time evolve and often change elevation, especially in degraded streams. Replacing a culvert at a different elevation can reconnect upstream and downstream stream reaches during base flow conditions, removing a fish passage barrier especially for smaller species. Culvert type and installation method are important considerations for this measure. Bottomless or buried culverts maintain connectivity of stream substrate, further improving fish mobility. During the Butler Creek stream assessments, many culvert maintenance issues were identified, including culverts needing replacement. For this reason, culvert replacement is an appropriate restoration measure to move forward in the planning process.

Stone Toe Protection

Streambank erosion often is due to excessive flow and stress at the toe of slope. Erosion and undercutting at the toe of slope can lead to sloughing of the streambanks and ultimately sedimentation of habitats. Stone toe protection measures may be installed to alleviate stresses and stabilize this critical point of the channel section. Stone toe protection techniques range from simply placing riprap along the toe of slope, to more elaborate measures such as longitudinal peaked stone toe protection. These measures include planting woody vegetation such as willows within the interstitial spaces between the stones. This reduces the introduction of sediment from eroded stream banks to stream habitat. This measure would be suitable for spot repairs of eroded stream bank or for longer reaches of eroded channel such as runs and outer bends. In the Butler Creek watershed, eroded streambanks are contributing sediment load to the channel and affecting aquatic habitats; thus, this would be an appropriate restoration measure.

Boulders

Boulders may be placed within the stream channel for multiple purposes. They may serve to provide streambank stability by deflecting erosive flow, but they might also provide cover and spawning areas for fish and benthic macroinvertebrate species. Boulder is typically placed along the outer bend toe of slope for bank stability purposes, but they might also be placed along inside bends or within pools to provide habitat enhancement and cover. In the Butler Creek watershed, the diversity of aquatic habitats has been degraded by changes in hydrology. For this reason, the placement of boulders was carried forward as an appropriate restoration measure for consideration in this watershed.

Pool / Step Pool

Pools are instream features that promote diversity of flow regimes by establishing deep, slow flow conditions (suitable habitat for various aquatic species). Depending upon the depth, pools can also provide shade and cooler conditions that further support aquatic diversity. Steps pools are instream restoration measures that can be used to create or maintain stable channel profile, especially in high gradient reaches where other low-gradient grade control features (such as cross vanes or engineered riffles) may not be applicable. Step pools enhance instream habitat by providing cover and spawning areas for fish and benthic macroinvertebrate species. With degradation in the Butler Creek watershed limiting aquatic habitat and species diversity, the use of step pools as a restoration measure was valid.

Log Sill

Log sills may be used as grade control structures (in similar fashion as engineered riffles and cross vanes), but their use is more applicable to low-gradient reaches where the required vertical drop across the structure is at or below 6 inches. Similar to the other grade control structures, log sills may be used to create or maintain a stable channel profile. Instream logs also provide suitable habitat for several aquatic and macroinvertebrate species. Log sills, as well as other grade control restoration measures, were appropriate for consideration in the Butler Creek watershed to address channel stability and affected aquatic habitat.

4.1.1.2 Streambank Restoration Measures

Streambank restoration measures included features that can be constructed along the streambank (between bankfull elevation and top of bank), stabilizing the banks by placement of structural or vegetative reinforcement. Selecting the appropriate streambank restoration measure is dependent upon the severity of the erosion, flow velocities, soil types, bank height and steepness, and stream alignment (degree of meandering). The various streambank restoration measures available for consideration are described below.

Adjust Stream Meander (Add Bends)

Adding meanders to a straightened stream segment can reduce instream velocity and return the flow regime to a more natural pattern. This measure is applicable to longer reaches of straightened stream segments and is one of the more intensive restoration measures from a construction standpoint. Increasing the sinuosity of a channel improves the diversity of riffle/pool habitat for aquatic ecosystems and reduces instream channel velocities by decreasing channel slope and promoting attenuation of peak flows. Both a reduction in riffle/pool habitat and increases in instream flow velocities are present in the Butler Creek watershed. For these reasons, the adjustment of stream meanders is deemed a suitable restoration measure.

Create Bankfull Bench

Construction of channel bankfull bench (or floodplain bench) increases the capacity of a stream to carry larger flow events and reduces erosive forces that affect instream habitats. This restoration measure is suitable for incised channel reaches with little or no connection to the floodplain. Channel benching includes excavation of benches without disturbing the streambed, and results include improved streambank stability, improved sediment transport, and return of the stream hydrograph to a more natural condition. This measure promotes enhancement and maintenance of instream habitats by reducing erosive forces and sediment sources. Because the Butler Creek watershed exhibits a flashy hydrograph, an altered stream hydrology, and streambank instability, the creation of bankfull benches is a valid restoration measure for consideration within the watershed.

Bank Grading

Bank grading is an applicable restoration measures in areas experiencing bank erosion and instability. Laying back steep banks can aid in the return of streamflow patterns to a natural state and minimize impacts associated with flashy streamflow. Grading and stabilizing of eroded banks reduces instream sedimentation sources and supports the return of streamflow patterns to a more natural state. This restoration measure is being carried forward to consider in areas of the Butler Creek watershed exhibiting extensive stream bank erosion and instability, which contribute sediment loading to the stream channel and affect aquatic habitats. This restoration measure is valid in light of the flashy hydrograph of the watershed.

Bank Stabilization Matting

Bank stabilization reduces soil loss, which leads to instream sedimentation and substrate embeddedness. This measure includes implementing practices structural in nature where failing banks threaten private property or public infrastructure and may be employed when available space or highly erosive flows are a constraint. A common factor along most degrading streams is the erosion of streambanks especially along outer bends and the introduction of sediment to stream habitat from this erosion. This approach typically reduces the bank slope so that it is less susceptible to the erosive force of storms.

To enhance bank stabilization efforts, several types of matting or geotextile protection can be considered. Available options range for simple jute matting, to more structural geotextile/geo-grid products. Selection of the appropriate stabilization product is based upon the severity of the condition and erosive forces that are encountered. In the Butler Creek watershed, increased stream velocities have contributed to bank instability. This restoration measure, the use of bank stabilization matting, is appropriate for use in this watershed.

Streambank Planting

Vegetative planting of streambanks is important to enhance stability and to provide cover, refuge, and food supply to aquatic communities. This measure may be used in combination with bank grading or bank stabilization matting to improves the overall effectiveness of these stabilization measures. Through vegetative planting, a root matrix is established within the upper soil layer which helps bind soils and protect against soil loss/erosion. Streambank instability and lack of vegetation are identified problems in the Butler Creek watershed. The use of vegetative planting on streambanks is a valid approach to carry forward in the planning process.

Riprap

Riprap is one of the most common measures used to stabilize streambanks. This measure involves bank grading and reshaping before placing riprap boulders to stabilize the streambank. Filter fabric typically (although not always) is placed along the graded bank before placing riprap. The voids between riprap boulders sometimes are planted with woody vegetation, or sometimes grouted to prevent movement of the stones and further enhance stability. Riprap stabilization protects the banks against erosive flows and provides some refuge for aquatic communities but does not provide effective shading or food supply compared to more natural techniques that incorporate streambank vegetation. In the Butler Creek watershed, streambank instability is contributing to the degradation of aquatic habitats. For this reason, riprap is a valid restoration measure, but with limitations.

Root Wad

Root wads are a streambank protection technique that provides immediate streambank stabilization, protects the toe-of-slope, and provides excellent fish habitat, especially for juveniles. They provide toe support for bank revegetation techniques and collect sediment and debris that will enhance bank stability over time. Root wads are installed by excavating into the streambank deep enough to accommodate an 8- to 10-foot tree bole (tree tops should be removed, leaving the trunks at least 10 feet long with root fans attached). Optional header and footer logs may be installed and pinned in place using rebar to help stabilize root wads into the bank. With instream habitat degraded in the Butler Creek watershed, root wads can improve bank stability and create aquatic habitat. For these reasons, root wad is considered a valid restoration measure.

4.1.1.3 Riparian Restoration Measures

Riparian restoration measures include features that can be constructed immediately outside the channel section but within the stream's riparian ecosystem. These measures are related primarily to establishment of effective native riparian vegetation (including hardwoods, shrubs, and seeding), but also include invasive plant species management measures.

Cattle Exclusion Fencing

Cattle use streams as a water source and for refuge during hot weather, and they often trample streambanks in the process, degrading streambank stability and establishment of natural woody vegetation. This measure removes that impact, allowing streambanks to stabilize and woody vegetation to grow. Another benefit of cattle fencing is the reduction of bacteriological loading to the stream. Many areas in north Georgia, which are or have been predominantly agricultural and undeveloped, have been affected by livestock entering the stream. However, this measure was evaluated as being not applicable to the Butler Creek watershed due to the absence of agricultural land uses.

Invasive Plant Species Management

Wetlands and stream buffers can be enhanced with the management of exotic and invasive plant species, and replacement with native vegetation. Removal of invasive plant species improves riparian aquatic ecosystem conditions and increases bank stability by (1) allowing native species to populate, (2) providing improved woody vegetation for bank stability, (3) establishing diversity of vegetative cover, (4) increasing available food sources for aquatic and riparian communities, and (5) providing improved stream buffer shading and refuge.

Selective removal of vegetation most often is used to control invasive plant species that dominate the stream channel and stream terraces. Mechanical removal is another method, but it is not often recommended for streambanks unless used in conjunction with grading or other stabilization methods. Methods using regulated chemicals approved for invasive plant species management, including broadcast and spot treatments, must be carefully considered when working near streams. Buffer areas disturbed during other enhancement and alteration activities associated with restoration should be replanted with native vegetation. In the Butler Creek watershed, streams would benefit from an increase in available food sources, shading, and other benefits of a native riparian area. Removal of invasive plant species would improve the riparian area, making this restoration measure appropriate to carry forward in the planning process.

Riparian Planting (Native Hardwoods)

Planting native trees or other woody vegetation in riparian zones (especially those that have been impacted or cleared) is intended to improve riparian aquatic ecosystems. The benefits of this measure include shading the stream, providing habitat and shelter with root masses and woody debris, leaf litter as a food source to organisms, and reduction of bank erosion and sediment loading to the stream. Riparian planting can be used alone in areas identified during stream walks or used following other land-disturbing measures such grading or benching streambanks. This measure may not be very effective in the short term (while woody vegetation is being established), but it is effective over the long term by adding stability and protection to a stream channel and its aquatic habitats. This measure should be considered along stream reaches affected by disturbance of the riparian corridor. Such reaches have been identified in the Butler Creek watershed. For this reason, riparian planting is considered a valid, long-term restoration measure.

Riparian Planting (Seeding and Mulching)

In addition to planting native trees and hardwoods within riparian zones, seeding and mulching are also important to provide immediate protection. Shrubs, grasses, and other plantings typically establish more quickly than the larger woody vegetation, and help establish an immediate source of cover and protection within the buffer. Riparian planting with seeding and mulching results in many of the same benefits listed above related to native hardwoods, and so is carried forward for the same reasons.

4.1.1.4 Flow Attenuation Restoration Measures

Flow attenuation restoration measures include features that can be constructed adjacent to the stream, but within the riparian ecosystem. They are intended to mitigate hydrologic impacts to the stream by attenuating peak stormwater discharges. These measures are strategically placed to capture runoff, provide stormwater storage (through pond or basin excavation), and regulate/reduce peak discharge releases to the stream. When designed properly, these measures can effectively improve both stream and riparian habitat communities in a number of ways. In accordance with the Section 206 authority, flow attenuation measures for aquatic ecosystem restoration should primarily address instream flows, as opposed to stormwater runoff. A brief description of potential flow attenuation restoration measures, with a focus on reducing instream peak flows, is provided below.

Extended Wet Detention Basin

An extended dry detention basin is an excavated surface storage facility designed to collect and temporarily store stormwater runoff, and release it at a reduced rate. An extended wet detention basin is generally deeper than either extended dry detention basins or created wetlands, and is designed to maintain a permanent pool. This measure helps restore natural flow regimes by attenuating peak flows through stormwater capture, storage, and regulated release. Similar to both extended dry detention basins and created wetlands, extended wet detention basins can help protection downstream channel integrity, stability, and habitat through peak flow attenuation. In the Butler Creek watershed, the natural flow regime has been altered and frequent, high-intensity peak flows were common. An extended wet detention basin would address this identified problem and was a valid restoration measure.

Extended Dry Detention Basin

Similar to the extended wet detention basin described above, an extended dry detention basin is an excavated surface storage facility designed to collect and temporarily store stormwater runoff, and release it at a reduced rate. An extended dry detention basin is designed to drain completely following a storm. Its primary purpose typically is flood control, but basins can effectively attenuate peak flows from any size storm and protect downstream channels and habitats. The attenuation of peak flows is necessary to restore natural flow regimes that have been modified by changes to surrounding land use. Extended dry detention basins serve a purpose similar to other flow attenuation structures (extended wet detention basins and created wetlands), but each is selected for further evaluation in the Butler Creek watershed since the hydrology, soils, and surrounding land use may dictate which measure would be more effective in a single location.

Outlet Control Structure

Outlet control structures are stormwater devices used to regulate flow (discharge) from a stormwater storage basin, including extended dry/wet detention basins and created wetlands. Outlet control structures typically are concrete structures (round or rectangular riser structures having formed notches and weirs) but might include stone structures such as stone spillways. Outlet control structures often incorporate multiple stage openings to regulate discharge for various recurring storms. These structures also often incorporate the use of trash racks, debris screens, or sediment filters to enhance operational performance. An outlet control structure was considered a valid restoration measure to address the altered hydrology and specifically, the increases in peak events in the Butler Creek watershed.

Outlet Control Structure Retrofit

This measure includes retrofitting or modifying an outlet control structure to adjust/enhance operational performance. Typical outlet control structure retrofits might include reduction in weir or orifice openings, adjustments to control elevations, modifications to the outlet control structure discharge pipe, and installation of a trash rack, debris shield, or sediment filter. Minor retrofitting of an outlet control structure might significantly improve its performance by reducing flow released to the receiving stream. This restoration measure was appropriate for carrying forward in the planning process, as it addresses altered hydrology in the watershed, similar to installation of a new outlet control structure.

Detention Basin Expansion

Expansion of a detention basin may also be a feasible flow attenuation measure. Basin expansion might be accomplished vertically by increasing depth, laterally by expanding the footprint, or by adjusting the side slope angle to allow for increased storage capacity. Expansion of a detention basin directly improves its efficiency through increase storage volumes and reduced discharge to the receiving stream. Reduction in peak flow releases to the stream helps to minimize hydrologic alterations within the watershed and restore natural flow regimes. In the Butler Creek watershed, altered hydrology and increased peak flows limit aquatic habitat diversity. Detention basin expansion is an appropriate restoration measure for these reasons.

Created Wetlands

The creation of riparian wetlands can attenuate peak stormwater discharges to the stream by providing capture and storage of stormwater runoff, and regulating its release back to the stream. Wetland construction within the riparian corridor helps to restore natural flow regimes by decreasing the velocity and volume of stormwater runoff and providing protection of downstream channels and habitat. Other beneficial functions of riparian wetlands include (1) providing habitat for aquatic organisms by establishment of necessary depths and vegetative cover, (2) removing pollutants through vegetative filtering, and (3) improving water quality through sediment removal (see also "sediment forebay" below). These functions provide associated benefits to aquatic ecosystems. Created wetlands are carried forward in the planning process to address altered instream hydrology for the same reasons as detention ponds and outlet control structure and their retrofits.

Aquatic Vegetation Planting

Aquatic vegetation planted within wetland areas or extended wet detention basins help to stabilize these features and minimize impacts related to peak flows, such as the potential for channelization. Establishing aquatic vegetation will also reduce the potential for erosion and sedimentation throughout the facility. As an associated benefit, aquatic vegetation provides both a food source and habitat for riparian organisms that inhabit the riparian wetland or extended wet detention basin. Vegetation also promotes nutrient uptake and overall water quality improvement. All these functions benefit the receiving stream in term of water quality improvement. In conjunction with flow attenuation measures, aquatic vegetation planting is an appropriate measure to carry forward to address the altered hydrology in the Butler Creek watershed.

Micropool

A micropool is a measure that can be incorporated into the design of a created wetland or an extended wet or dry detention basin. The micropool typically is shallow and permanently inundated. Its function is to reduce re-suspension of sediment and to guard against vegetation encroachments toward the outlet control structure. The micropool can be planted with wetland vegetation, but it should be deep enough at the outlet control structure pipe to discourage vegetative encroachments that could cause clogging. In the Butler Creek watershed, altered hydrology and peak volumes are identified problems. A micropool used in conjunction with other flow attenuation devices is a valid restoration measure.

Sediment Forebay

The sediment forebay is a measure associated with created wetland and extended wet or dry detention basins. When used, this measure can enhance sediment reduction by trapping larger particles near the inlet of the pond. If possible, the forebay should include a permanent pool to minimize the potential for scour and re-suspension of sediment. Sediment forebays should be designed with ease of maintenance, facilitating periodic scheduled sediment removal. A sediment forebay, in conjunction with a flow attenuation device, is a feasible restoration measure for the same reasons given for other detention enhancements.

Pilot Channel

A pilot channel is a surface conveyance used within created wetlands and extended wet or dry detention basins to convey low flows through those facilities. Because flows are concentrated under low-flow conditions, flow traveling through such facilities can be erosive and cause erosion and sedimentation within the basin. By concentrating low flows through a pilot channel, the channel can be designed and stabilized to withstand the flow with causing adverse erosion and sedimentation. A pilot channel is a valid restoration measure, when used to enhance the functionality of other flow attenuation measures, for consideration in the Butler Creek watershed. The watershed exhibits altered hydrology and increases in peak volumes.

4.1.2 Nonstructural Restoration Measures

Non-structural restoration measures include activities, programs, ordinances, or policies aimed at protecting streams and riparian ecosystems from activities that might cause adverse impacts. These measures do not involve construction-related activities, but rather establish programs or policies that promote protection and preservation of the physical stream conditions and overall ecosystem integrity. Each of the non-structural measures identified would promote the sustainability of aquatic ecosystem restoration in the Butler Creek watershed; however, Cobb County would implement the measures as part of its ongoing watershed management program (Section 1.7, Nonfederal Sponsor Ongoing Projects and Programs). While each of these measures is removed from further consideration, a description of the measures is provided to summarize activities that the non-federal sponsor could undertake to enhance and protect the benefits of aquatic ecosystem restoration in the Butler Creek watershed.

Adoption of Protective Stormwater Ordinances

Adoption of stormwater ordinances, such as those developed by the Metropolitan North Georgia Water Planning District, promotes stream restoration through establishment of stormwater management regulations. Adoption, implementation, and enforcement responsibilities fall onto municipalities and local jurisdictions. Federal- and state-mandated programs, such as NPDES permitting, now apply to construction activities as well as communities that fall under Phase 1 and Phase 2 regulations. Such programs are effective in terms of establishing standards for land use and development, as well as establishing programs to monitor streams and stormwater discharges. Municipalities can also adopt development standards related to stormwater management, such as those provided in the *Georgia Stormwater Management Manual*.

Enforcement of Protective Ordinances

Protective ordinances may be related to stream buffer protection, greenway preservation, development standards, construction standards, and other activities. Ongoing enforcement of these ordinances can ultimately protect streams, stream buffers, and the benefits they provide to aquatic ecosystems. Enforcement of protective ordinances and public education concerning the benefits of stream buffers work together to preserve continuous reaches of stream buffers, which are critical to stream stability and the avoidance of degradation from impacts related to development. Enforcement is the responsibility of local governments, which must plan and dedicate resources for this effort to be effective.

Litter Cleanup in Stream Corridors

Another nonstructural measure that can be used to promote environmental awareness, ecosystem protection, and stream restoration are scheduled stream walks and cleanup activities. These programs would be sponsored by municipalities or various civic organizations, and are usually focused on a specific segment of stream known to be affected by excessive litter and debris. Such events require planning and promotion, but if well-organized can very effectively improve affected streams.

Public Educational Components: Interpretive Signage, Trails, Boardwalks, Benches

Public educational components can be implemented with other structural restoration measures to convey and demonstrate environmental stewardship principals related to stormwater management and protection of streams and rivers. Interpretive signage, mulch trails, boardwalks, or benches may be incorporated, where appropriate, into a restoration design. Educational programs can target a variety of citizen groups (including schools and civic organizations) and may use a vast array of resources to deliver pertinent information. Available sources that can be used to disseminate of information include newspapers and publications, media broadcasts, mailing of brochures, and various other sources.

Ongoing Invasive Plant Species Management

Some municipalities have implemented management programs to control the propagation of invasive plant species present within stream corridors. This nonstructural measure requires either dedication of in-house resources or an annual contract/budget to programmatically target and remove invasive plant species on a regular schedule.

Post-construction Stormwater Management

Post-construction stormwater management includes implementation of a program to review design plans and inspect completed construction sites and developments to observe functionality of the constructed stormwater management facilities. This activity would help identify any necessary modifications to the operation or maintenance of features, such as outlet structures, detention ponds, and other stormwater infrastructure. This nonstructural measure may serve as an early warning/preventative maintenance system to identify and address potential adverse conditions before they develop further or worsen.

Construction Site Inspection Program

Stormwater runoff from improperly managed and controlled construction sites can be detrimental to the overall health of the receiving streams. Insufficient sediment and erosion control measures at construction sites can result in high concentrations of TSS in stormwater runoff and downstream sedimentation. A construction site inspection program, in conjunction with erosion and sedimentation control ordinances, can be an effective nonstructural measure to prevent such occurrences.

Preservation of Greenspace

In addition to enforcement of stream buffers, designating and preserving greenway corridors can further protect streams by extending setbacks and limiting disturbance within an established distance from the stream. Preservation of greenspace further protects the stream corridor from impacts related to clearing, encroachments, or unauthorized activities.

Long-Term Stream Monitoring

Monitoring programs can help to identify conditions that may be adversely affecting streams, or have potential to cause adverse impacts. Identification of debris jams, severe bank erosion or worsening conditions, changes in stream alignment and stability, unauthorized clearing or encroachments, and other developing situations might be detected through scheduled monitoring. In this way, monitoring can be a means of early detection of developing problems, which might be quickly addressed or prevented before conditions worsen.

4.2 Evaluation and Screening of Restoration Measures

The restoration measures identified in Table 4-1 were evaluated and screened based on the following factors:

- Potential to meet the Butler Creek watershed planning objectives and avoid planning constraints
- Necessary groupings of restoration measures

Based on this screening and evaluation, detailed below, all potential restoration measures to improve aquatic ecosystems in the Butler Creek watershed were selected to be included in the formulation of alternative plans. No restoration measures were screened out based on this process.

4.2.1 Screening of Restoration Measures based on Plan Objectives

Restoration measures were evaluated based on their applicability to the Butler Creek watershed objectives and opportunities. These restoration measures that could address each identified opportunity are summarized in Table 4-2 and organized based on the aquatic ecosystem restoration opportunities developed within the Detailed Project Report. Comparing aquatic ecosystem restoration opportunities with the potential restoration measures listed in Table 4-1, each of the potential structural restoration measures identified remains viable for consideration in formulation of alternative plans. Further, although the non-structural programs and activities listed in Table 4-1 do not directly address specific aquatic ecosystem restoration opportunities for the Butler Creek watershed, these programs could directly enhance these opportunities for aquatic ecosystem restoration.

4.2.2 Evaluation of Restoration Measure Combinations

After potential restoration measures were screened to identify those that can address problems in the watershed, the dependence and compatibility of different restoration measures was evaluated. Combining some restoration measures may be necessary for a sustainable result (**Measures that Must be Combined**). Other measures cannot be effectively combined (**Measures that are Mutually Exclusive**), and still others have a sustainable result when implemented in combination or independently (**Measures that Can be Combined**). To formulate alternatives that were logical and focused, combinations of potential restoration measures were categorized into one of these three potential categories (summarized in Tables 4-3 through 4-7 and detailed below). This information was used to formulate alternative plans.

TABLE 4-2
Ecosystem Opportunities and Potential Restoration Measures
Butler Creek Watershed Aquatic Ecosystem Restoration Detailed Project Report

Ecosystem Restoration Opportunity	Potential Restoration Measures	
To protect the Cherokee darter population by increasing the frequency and quality of riffle/pool habitats in the watershed.	• Engineered riffle • J-hook • Cross vane • Rootwad	• Pool/step pool • Log sill • All nonstructural measures
To restore native, intolerant aquatic species and increase species richness/evenness in the watershed.	• Engineered riffle • J-hook • Cross vane • Pool/step pool	• Log sill • Root wad • Boulders • All nonstructural measures
To restore natural flow regimes to a practicable extent and reconnect the stream to the floodplain to dissipate peak flow velocities, which increases the quality of instream and riparian habitats.	• Debris jam removal • Culvert replacement • Adjust stream meanders • Create bankfull bench • Bank grading • Extended wet detention basin • Extended dry detention basin • Outlet control structure	• Outlet control structure retrofit • Existing detention basin expansion • Created wetland • Aquatic vegetation planting • Micropool • Sediment forebay • Pilot channel • All nonstructural measures
To reduce sedimentation and prevent further habitat embeddedness by improving bank stability and enhancing vegetated riparian ecosystems.	• Bank stabilization using geotextile mattress • Stone toe protection • Bank grading • Invasive plant species management	• Riparian planting (native hardwoods; seeding and mulching) • Vegetative planting of streambanks • Riprap • All nonstructural measures

4.2.2.1 Measures That Must Be Combined

Restoration measures that must be combined included those that, without use in combination with one or more other measures, were not considered to be sustainable. Table 4-3 summarizes measures that must be combined with one or more other measures to obtain benefit and provides an explanation for the measure combinations.

4.2.2.2 Measures That Are Mutually Exclusive

Mutually exclusive measures included those that serve the same purpose, as well as those that could not be combined in a single location. Table 4-4 lists restoration measures that would be included in the Butler Creek alternatives analysis and that are mutually exclusive. Measures that were mutually exclusive would be independently evaluated for a single location, but based on materials and requirements, they could be combined into a restoration alternative.

TABLE 4-3
Restoration Measures that Must be Combined
Butler Creek Watershed Aquatic Ecosystem Restoration Detailed Project Report

Primary Measure	Complementary Measures	Explanation
Streambank Restoration Measures		
Stream meander (add bends)	Bank grading, bank stabilization matting or riprap, and streambank planting	Stream meandering requires bank grading to reshape the stream; this measure would not be implemented without the subsequent stabilization and planting of the streambanks (that are created from the stream meander measure) to mitigate the bank grading and assure sustainability of the meanders.
Create bankfull bench	Bank grading, bank stabilization matting or riprap, and streambank planting	Creating a bankfull bench requires bank grading to reshape the banks. This measure would not be implemented without the subsequent stabilization and planting of the streambanks to mitigate bank grading and ensure sustainability of the bankfull bench.
Bank grading	Bank stabilization matting or riprap, and streambank planting	Bank grading would be implemented either to create a bankfull bench or to meander the stream. This measure would not be implemented without the subsequent stabilization and planting of the streambanks to mitigate the bank grading.
Bank stabilization matting	Streambank planting	Bank stabilization matting requires streambank planting to maintain streambank stability after the stabilization materials have biodegraded.
Riparian Restoration Measures		
Invasive plant species management	Riparian planting (native hardwoods and seeding and mulching)	Invasive plant species management would require the subsequent planting of cleared areas to allow for benefits of riparian restoration measures.
Flow Attenuation Restoration Measures		
Extended wet detention basin	Outlet control structure and aquatic vegetation planting	Extended wet detention basins must include an outlet control structure and aquatic vegetation to function as a flow attenuation measure.
Extended dry detention basin	Outlet control structure	Extended dry detention basins must include an outlet control structure to function as a flow attenuation measure.
Created wetlands	Outlet control structure and aquatic vegetation planting	Created wetlands must include an outlet control structure and aquatic vegetation to function as a flow attenuation measure.
Outlet control structure	Extended wet detention basin, created wetlands, extended dry detention basin, or detention basin expansion	Outlet control structures must be constructed within a detention basin (new or existing) to function as a flow attenuation measure.
Aquatic vegetation planting	Extended wet detention basin or created wetlands	Aquatic vegetation could be planted only in an area that is intended to remain wet (wet detention basin or created wetlands) in order to be maintained.
Micropool	Extended wet detention basin, created wetlands, extended dry detention basin, or detention basin expansion	A micropool can enhance the benefits of a flow attenuation measure but can be constructed only within a detention basin (new or existing) or created wetlands.

TABLE 4-3
Restoration Measures that Must be Combined
Butler Creek Watershed Aquatic Ecosystem Restoration Detailed Project Report

Primary Measure	Complementary Measures	Explanation
Sediment forebay	Extended wet detention basin, created wetlands, extended dry detention basin, or detention basin expansion	A sediment forebay can enhance the benefits of a flow attenuation measure but can be constructed only within a detention basin (new or existing) or created wetlands.
Pilot channel	Extended wet detention basin, created wetlands, extended dry detention basin, or detention basin expansion	A pilot channel can enhance the benefits of a flow attenuation measure, but it can be constructed only within a detention basin (new or existing) or created wetlands.

TABLE 4-4
Restoration Measures that are Mutually Exclusive
Butler Creek Watershed Aquatic Ecosystem Restoration Detailed Project Report

Mutually Exclusive Measures	Explanation
Instream Restoration Measures	
Cross vane Log sill Engineered riffle	These measures are all implemented to achieve grade control and to construct riffle/pool sequences. Only one would be required at a single location.
Flow Attenuation Restoration Measures	
Extended wet detention basin Extended dry detention basin Created wetland Detention basin expansion	Only one of these measures could be constructed/implemented in a single location, although the measures could be combined into an alternative.
Outlet control structure retrofit Outlet control structure	Only one of these measures would be implemented, based on whether a detention basin is being constructed or an existing basin is being retrofitted.
Outlet control structure retrofit Extended dry detention basin Extended wet detention basin Created wetlands	An outlet control structure retrofit would not be included with the construction of new detention basins or created wetlands, since there would be no existing outlet control structure.
Aquatic vegetation planting Extended dry detention basin	Aquatic vegetation would not be planted in an extended dry detention pond, since the pond will not sustain this type of vegetation.

4.2.2.3 Measures That Can Be Combined

Combining measures was an important consideration during alternative plan formulation, since many measures are more effective when used in series with other measures. As an example, use of multiple instream measures such as cross vanes, pools, J-hooks and engineered riffle help to maximize restoration efforts by establishing desired riffle/pool sequences. Categories of restoration measures (instream, streambank, riparian, and flow attenuation) also provide benefits that enhance and sustain each other. The previous

TABLE 4-5
Combinations of Instream Restoration Measures
Butler Creek Watershed Aquatic Ecosystem Restoration Detailed Project Report

Primary Measure \ Complementary Measures	Log sill	Engineered riffle	Cross vane	J-hook	Debris jam removal	Culvert replacement	Pool/Step pool	Boulders	Stone toe protection
Log sill		M/E	M/E	C	C	C	C	C	C
Engineered riffle	M/E		M/E	C	C	C	C	C	C
Cross vane	M/E	M/E		C	C	C	C	C	C
J-hook	C	C	C		C	C	C	C	C
Debris jam removal	C	C	C	C		C	C	C	C
Culvert replacement	C	C	C	C	C		C	C	C
Pool/Step pool	C	C	C	C	C	C		C	C
Boulders	C	C	C	C	C	C	C		C
Stone toe protection	C	C	C	C	C	C	C	C	

C – can be combined
M/C – must be combined
M/E – mutually exclusive

TABLE 4-6
Combinations of Streambank and Riparian Restoration Measures
Butler Creek Watershed Aquatic Ecosystem Restoration Detailed Project Report

Primary Measure \ Complementary Measures	Adjust stream meander (add bends)	Creation of bankfull bench	Bank grading	Bank stabilization matting	Riprap	Streambank planting	Rootwad	Invasive plant species removal	Riparian planting (native hardwoods)	Riparian planting (seeding/ mulching)
Adjust stream meander (add bends)		C	M/C	M/C (with at least one)		M/C	C	C	C	C
Creation of bankfull bench	C		M/C	M/C (with at least one)		M/C	C	C	C	C
Bank grading	C	C		M/C (with at least one)		M/C	C	C	C	C
Bank stabilization matting	C	C	C		C	M/C	C	C	C	C
Riprap	C	C	C	C		C	C	C	C	C
Streambank planting	C	C	C	C	C		C	C	C	C
Rootwad	C	C	C	C	C	C		C	C	C
Invasive species removal	C	C	C	C	C	C	C		M/C	M/C
Riparian planting (native hardwoods)	C	C	C	C	C	C	C	C		C
Riparian planting (seeding/mulching)	C	C	C	C	C	C	C	C	C	

C – can be combined
M/C – must be combined
M/E – mutually exclusive

TABLE 4-7
Combinations of Flow Attenuation Restoration Measures
Butler Creek Watershed Aquatic Ecosystem Restoration Detailed Project Report

Primary Measure \ Complementary Measures	Extended wet detention basin	Created wetlands	Extended dry detention basin	Detention basin expansion	Outlet control structure	Outlet control structure retrofit	Aquatic vegetation planting	Micropool	Sediment forebay	Pilot channel
Extended wet detention basin		M/E	M/E	M/E	M/C	M/E	M/C	C	C	C
Created wetlands	M/E		M/E	M/E	M/C	M/E	M/C	C	C	C
Extended dry detention basin	M/E	M/E		M/E	M/C	M/E	M/E	C	C	C
Detention basin expansion	M/E	M/E	M/E		C	C	C	C	C	C
Outlet control structure	M/C (with at least one)					M/E	C	C	C	C
Outlet control structure retrofit	M/E	M/E	M/E	C	M/E		C	C	C	C
Aquatic vegetation planting	M/C (with at least one)		M/E	C	C	C		C	C	C
Micropool	M/C (with at least one)				C	C	C		C	C
Sediment forebay	M/C (with at least one)				C	C	C	C		C
Pilot channel	M/C (with at least one)				C	C	C	C	C	

C – can be combined
M/C – must be combined
M/E – mutually exclusive

sections identified restoration measures that must be combined or are mutually exclusive. Any remaining combinations contained individual measures that were identified as applicable to the Butler Creek aquatic ecosystem project, and therefore can be combined in a single alternative. Tables 4-5 through 4-7 summarize the compatibility of the restoration measures identified in Section 4.1 (Identification of Restoration Measures). Combinations of these measures will be included in the formulation of alternative plans and were further evaluated in the economics analysis of the final array of alternative.

5. Formulation of Alternative Plans

Following the identification and screening of restoration measures, the next step in formulating alternative plans was to identify locations in the watershed with the greatest potential to provide habitat improvement, with the implementation of these restoration measures. Alternative formulation included applying measures to these problem areas to develop plans, combining plans into additional alternatives, and screening alternatives to keep those most likely to solve the problems. This process involved further reviews of: (1) the restoration measures identified as having the potential to meet the planning objectives; (2) site-specific problems and opportunities in the Butler Creek watershed; and (3) restoration measures appropriate for each problem site. The alternative formulation process resulted in 107 single-site restoration alternatives, all possible combinations of the 107 alternatives, and the No Action Alternative. Steps followed to formulate alternatives are outlined below.

5.1 Identification of Problem Sites

In February 2002, Entrix, Inc., under contract with USACE–Mobile, conducted stream assessments in the Butler Creek watershed to identify problems that contribute to degraded habitat conditions. The stream assessments included the mainstem of Butler Creek and tributaries. Roughly 20 stream miles were walked by the field crew, resulting in a total of 131 waypoints to document both problems and reaches with adequate habitat. Of the 131 waypoints, 107 were formulated as the single-site alternatives mentioned above. These 107 waypoints were classified with habitat degradation due to at least one of the following categories:

- Bank erosion
- Incised or widening channel morphology
- Debris dam
- Dumping/trash
- Excessive sedimentation
- Foul odor
- Reduced riparian zone
- Erosion control
- Hydrologic alteration
- Impervious area
- Land clearing/construction
- Storm drain
- Other problems

While some waypoints were associated with localized problems that did not extend downstream, other waypoints occurred in a series that suggested more severe problems extending throughout a reach. These extended reaches with severe problems were identified as being important factors to address when developing a watershed-wide aquatic ecosystem restoration plan. Entrix (2002b) defined five of these extended reaches in the Butler Creek watershed as problem areas (Figure 5-1; Table 5-1). Three of the five reaches occurred in the headwaters of Butler Creek and tributaries, upstream of Mack Dobbs Road. The two additional problem areas were just upstream and downstream of Cobb Parkway in the downstream part of the watershed. No extended reaches or problem areas were located in the central part of the watershed. As such, a reference reach was selected in the central part of the watershed at Waypoint 43, upstream of Jim Owens Road.

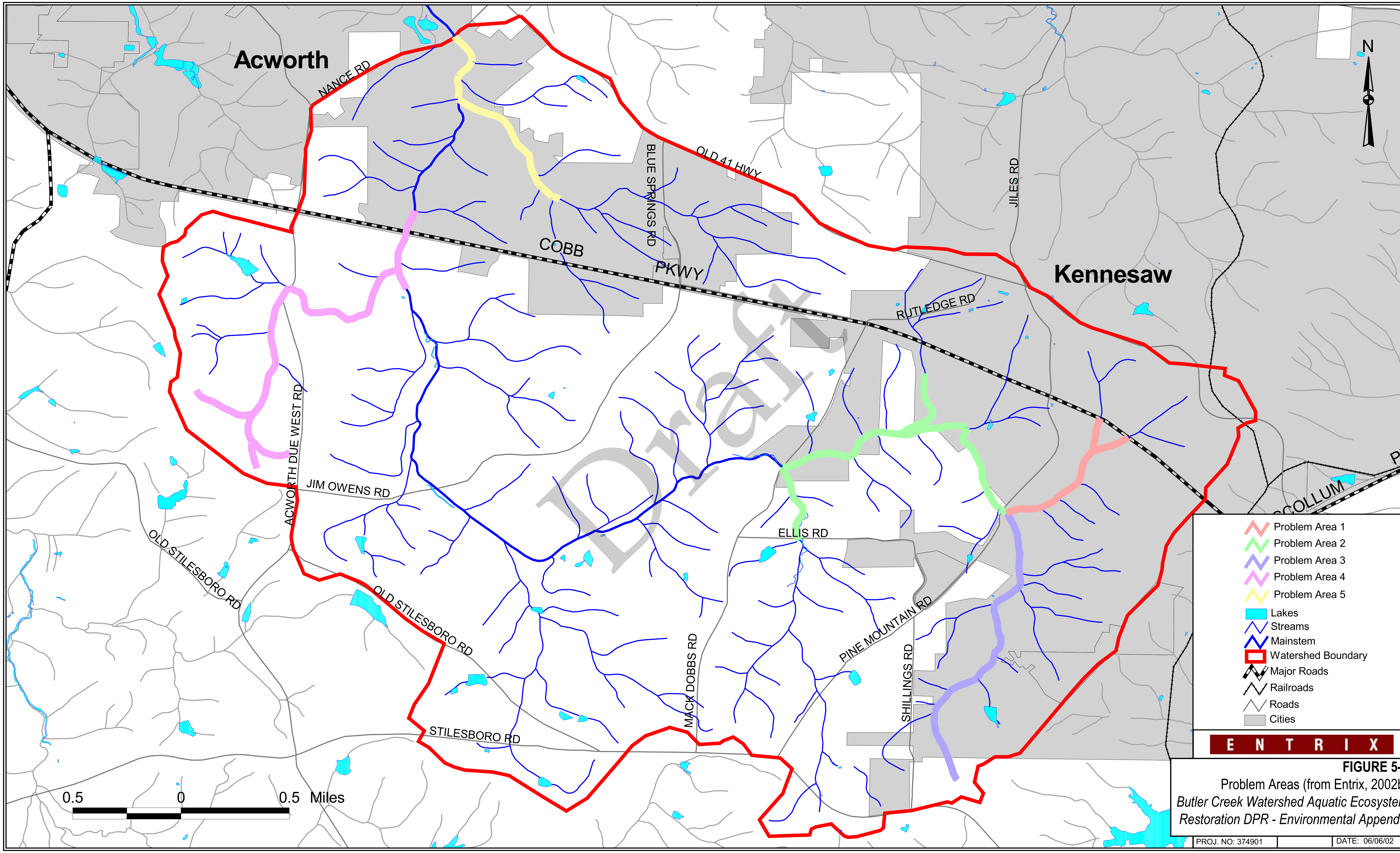
Active Bank Erosion and Excessive Sedimentation: Active bank erosion was observed along a majority of the stream segments (75 out of 131 waypoints). This condition results in a loss of habitats along the streambank and embeddedness, which occurs when excessive sediment covers benthic habitats used for spawning and cover. In most cases, the most significant active erosion was occurring along the outside bends of meandering stream segments, where the energy from high stream flows is the greatest. The outer bends tend to absorb high velocity flow, often directed at an angle almost perpendicular to the alignment of the stream bank. The streambanks at these locations actively erode to some degree with each storm event, increasing sediment loads to downstream areas. This occurrence is supported by the stream assessment results, where excessive sedimentation was observed in areas downstream from reaches with severe bank erosion.

Channel Alterations: Additionally, changes to the natural channel morphology (both incised and widening channels) were observed throughout much of the watershed (47 out of 131 waypoints). Changes to the natural stream shape and floodplain has adverse impacts on aquatic ecosystems, especially those more sensitive to environmental changes. Additionally, changes to the natural hydrology can increase streambank erosion and sedimentation through increased flow and channel velocity.

Inadequate Riparian Ecosystems: Inadequate riparian ecosystems were observed at 32 of the 131 waypoints. Condition of vegetation on streambanks and surrounding riparian zones is important to preventing bank erosion, attenuating intense peak flows, as well as providing cover, refuge, and food supply to aquatic communities.

5.2 Alternative Plans

The alternative plans developed for the Butler Creek watershed included the No Action Alternative and the 107 single-site alternatives in Table 5-2. Alternative screening and reformulation are detailed in Chapter 5 of the Detailed Project Report. Restoration measures were applied to each of the 107 problem sites to develop 107 single-site alternatives. Figure 5-2 shows the location of the developed alternatives, and Table 5-2 summarizes the nature of the problems, as well as the appropriate restoration measures to address them.



Acworth
Kennesaw
NANCE RD
OLD 41 HWY
BLUE SPRINGS RD
COBB
PKWY
JILES RD
RUTLEDGE RD
ACWORTH DUE WEST RD
JIM OWENS RD
OLD STILESBORO RD
OLD STILESBORO RD
ELLIS RD
PINE MOUNTAIN RD
MACK DOBBS RD
SHILLINGS RD
STILESBORO RD
MCCOLLUM
PKWY
Draft
N
0.5
0
0.5
Miles
Problem Area 1
Problem Area 2
Problem Area 3
Problem Area 4
Problem Area 5
Lakes
Streams
Mainstem
Watershed Boundary
Major Roads
Railroads
Roads
Cities
ENTRIX
FIGURE 5-1
Problem Areas (from Entrix, 2002b)
Butler Creek Watershed Aquatic Ecosystem
Restoration DPR - Environmental Appendix
PROJ. NO: 374901
DATE: 06/06/02

TABLE 5-1
Problem Area Descriptions (Entrix, 2002)
Butler Creek Watershed Aquatic Ecosystem Restoration Detailed Project Report

Headwaters of Butler Creek Watershed (upstream of Mack Dobbs Road)

Problem Area 1

- Relatively high stream gradient that contributed to good physical habitat in isolated places
- This reach was in the poorest overall condition
- At the confluence between this reach and the southern tributary, the banks were eroded and the riparian zone on the left bank was reduced.
- Upstream of this point there were two bridge crossings over the creek within 250 feet of each other, where the stream was piped through single 60 inch corrugated metal pipes, substantial sedimentation, bank erosion, and channel widening was associated with both crossings.
- A debris dam on the downstream side of the lower bridge crossing contributed to additional stream bank erosion.
- Immediately downstream of the upper bridge crossing, the left bank was eroded in close proximity to the foundation of a home.
- Upstream of the upper bridge crossing, the topography was very steep immediately adjacent to the stream. The banks were eroded, sometimes to a height of 20 feet. Additionally, a sewer line in danger of collapse was observed here. The inner PVC pipe was exposed at a joint in the outer iron pipe.
- Downstream of Cobb Parkway, the stream split into two secondary tributaries, with substantial bank erosion, sedimentation, and channel incision occurring on both tributaries. On the eastern tributary, several large (about 60 inch) corrugated pipes were found in the stream. Immediately downstream of Cobb Parkway, there was a strong petroleum and grease odor.

The problems in this reach originated from the high flows from extensive development occurring around Cobb Parkway. The steep gradient in the stream and the surrounding land use altered the hydrology and contributed to increased bank erosion. In this reach, there were several stormwater drains that contributed to the altered hydrology. During the stream walks, a homeowner (near Butler Creek Road) complained of his lawn flooding in recent years, another indication of the altered hydrology that contributes to increased flooding in the watershed. The three bridge crossings in the older neighborhood development and the associated reduced riparian zone also contributed to the problems.

Problem Area 2

- The stream bank eroded substantially at the confluence of Butler Creek and the third order tributary. The bank area between the two streams, upstream of the confluence, was eroding and will soon collapse delivering a substantial load of sediment to the stream.
- In Butler Creek, bank erosion was present throughout, with isolated areas of sedimentation, channel incision, and channel widening.
- Bank erosion, ranging from minor to severe, was the main problem noted from Mack Dobbs Road upstream to the midpoint of the mainstem portion of this problem area.
- Above this point, there was more severe bank erosion, enlarged sand bars, channel incision, and channel widening. In this reach there were several large (36 inch diameter) storm drains that drained a residential development and a mobile home park. Additionally, the mobile homes in the park were placed close (<25 feet) to the stream banks in several places. There were concrete flumes draining under two of the mobile homes that discharged into the stream. There was also a noticeable amount of trash in the stream.
- Upstream of the mobile home park, where the stream makes the sharp bend to the southwest, there was a large (36 inch diameter) storm drain on the left bank side of the stream. There was a large amount of sediment near this drain and localized erosion around the head-wall.
- Further upstream, bank erosion and sedimentation decreased, but the channel was incised and widened in places.
- The problems observed on the third order tributary draining from the south included severe localized bank erosion and some channel widening. Upstream of the confluence with Butler Creek, the stream flowed through a 36 inch diameter corrugated metal pipe under a driveway. Upstream of the driveway bank erosion became more severe, as the banks were actively eroding. There was a new (<5 years old) housing development on the left bank side with lawns maintained to the stream bank. There was also a bridge crossing for a neighborhood street (three 7-foot × 7-foot box culverts) and a large storm drain collecting storm water from the neighborhood. Upstream of the culvert there was a pipe crossing the stream elevated approximately 1 foot above the water, resulting in formation of a debris dam.
- The quality of the reach improved dramatically upstream as there was a large bedrock area serving to prevent further upstream erosion (i.e. head-cutting).
- The second order tributary draining from the north had good habitat quality at the confluence with Butler Creek. The channel had not incised or widened, the banks were not substantially eroded, and sedimentation was minor. Conditions degraded upstream as the stream flowed between two streets within the mobile home park. Noted problems included bank erosion, channel incision, and sedimentation. The channel appeared straightened in this area and was lined with riprap, mobile homes were positioned very near the stream bank. Upstream of the straightened section, the surrounding topography was steep and the left bank side of the stream was eroded up to 30 feet high. There were multiple storm drain inputs (24 and 36 inch) and two bridge crossings where the stream was piped through 60 inch corrugated metal pipes. Upstream of the mobile home park, stream habitat conditions improved as a result of a large wetland.

Problem Area 3

- This stream reach extended throughout older residential areas (>20 years old) in the downstream reaches and newer residential areas (<10 years old) in the upstream reaches. The overall riparian ecosystem was in very poor condition. There were five bridge crossings associated with the different neighborhood streets as well as several storm drain inputs. The downstream reach from Butler Creek Rd to the confluence with the northern headwater tributary contained a substantial amount of bank erosion with minor sedimentation, incision, and widening.
- Bank erosion, channel incision and widening, and enlarged sand/gravel bars were noted in this reach. The stream was beginning to re-form a new floodplain in the incised channel. Segments of this reach with good quality habitat were associated with exposed bedrock in the stream. These segments had low banks, minor bank erosion, and minor sedimentation. In areas where the riparian zone was severely reduced, severe bank erosion, channel widening, and sedimentation was observed.
- Upstream of Summit Wood Dr, there was a debris dam that contributed to sedimentation. Within one residential area, a large concrete wall was constructed across the stream channel. The structure appeared to have once been used to detain storm water, but is no longer used for any detention function. A plunge pool was formed on the downstream side of the wall, causing active erosion on the left bank. Substantial bank erosion continued in scattered locations up to a small pond at the terminus of the stream. The pond was filled with sediment, decreasing the pond's effectiveness.

Downstream Portion of Butler Creek Watershed (near Cobb Parkway)

Problem Area 4

- Immediately downstream of Cobb Pkwy bank erosion and enlarged point bars occurred along a large meander bend. Stormwater runoff from Cobb Pkwy and off-road recreational vehicle activity contributed to bank erosion and sedimentation in the stream.
- There was a large section of bedrock shoals located upstream of Cobb Pkwy with substantial bank erosion immediately downstream of the large shoals. The stream channel was straight, and the large shoal area prevented the stream from actively incising and in response the stream channel has widened considerably near the shoals resulting in active bank erosion. The large change in slope and straight channel below the shoals enhance the erosional processes already taking place.
- The tributary was incised at the confluence with Butler Creek and there was a plume of sediment located in Butler Creek from the tributary channel incision.
- Downstream of Acworth Due West Rd, there was severe bank erosion, excessive sedimentation, incision, and widening. Three debris dams contributed to upstream sedimentation. The riparian ecosystem was inadequate with multiple stormdrains from neighborhoods.
- The stream was piped through a 36 inch diameter corrugated metal pipe under Acworth Due West Rd. The culvert appeared to be undersized and scoured a deep pool on the downstream side.
- Upstream of Acworth Due West Rd, the stream turned sharply and flowed through a new housing development. At this location, sedimentation was noted and the channel was incised. There were also a series of debris dams that caused upstream blockage of sand and silt.
- Upstream of the new development, the riparian ecosystem was forested and the banks were not as eroded, but sedimentation was very heavy. There were indications that land clearing activities were eminent and sediment monitoring stations were set up in the stream. Land clearing activities were observed in the tributary, for a large housing development. A dry pond was located on the upstream side of a new street, and could serve to contain increased flows as construction of homes continues in the area.

Problem Area 5

- The stream hydrology in Butler Creek from Nance Rd to just downstream of the tributary was affected by Lake Acworth, which slows stream velocities and causes sediment deposition. As a result there was substantial sedimentation. Several feet of sand occurred in the channel, and a large sand bar was on the right bank just upstream of the tributary. Bank erosion was minimal to moderate due to several factors including the stabilization provided by the forested riparian area, no storm drain inputs, and a Cobb County/USACE easement running along the stream.
- The third order tributary that enters Butler Creek upstream of Nance Road was heavily incised at the confluence with Butler Creek. The stream made a series of tight meander bends, and was actively incising to reach the elevation of Butler Creek. The banks were undergoing substantial erosion and the channel bed contained abundant fine sediment up to two feet deep. There was also a debris dam in this reach, which added to the sedimentation problems.
- Approximately 200 ft upstream of the confluence was a utility road crossing where the channel bed had been lined with riprap for about 50 feet creating a steep grade control. The riprap prevented the deeply incised stream channel from head cutting up the tributary and had stabilized the channel upstream of the utility crossing. Upstream of the utility crossing, channel conditions improved steadily in the upstream direction, but the riparian zone was reduced by a new housing development (<5 years old). Several storm drain (36 inch diameter) inputs from the neighborhood contributed to localized bank erosion and sedimentation.
- Upstream, there was a newer housing development (<3 years old) on the right bank. Multiple storm drain inputs contributed to localized bank erosion and sedimentation in this location as well.
- Further upstream, land-clearing activities occurred and a new bridge crossing was constructed. Riparian zone was of poor quality on both sides. Upstream of this new development, habitat conditions continued to improve; however, there were more new (<5 years old) housing developments in place and more land that was marked to be cleared.

TABLE 5-2
Single-site Alternatives (adapted from Entrix, 2002a)
Butler Creek Watershed Detailed Project Report

Waypoint/ Alternative ID	Aquatic Habitat Problem(s)	Applied Restoration Measure(s)
1	40% bank erosion	Bank stabilization matting, streambank planting, bank grading
2	80% bank erosion	Bank stabilization matting, streambank planting, bank grading
3	40% bank erosion	Bank stabilization matting, streambank planting
4	60% bank erosion	Bank stabilization matting, streambank planting
5	40% bank erosion, excessive sedimentation, land clearing/construction	Bank stabilization matting, streambank planting
6	Excessive sedimentation	Dry extended detention pond, wet extended detention pond
7	10% bank erosion, excessive sedimentation, inadequate riparian buffer	Bank stabilization matting, streambank planting, dry extended detention pond, wet extended detention pond, riparian planting (native hardwoods), riparian planting (seeding/mulching)
8	Incised channel, widening channel	Bank grading, dry extended detention pond, wet extended detention pond
9	10% bank erosion, widening channel, excessive sedimentation, inadequate riparian buffer	Bank stabilization matting, streambank planting, bank grading
10	10% bank erosion, incised channel, widening channel, excessive sedimentation	Outlet control structure
11	Excessive sedimentation, land clearing/construction, inadequate riparian buffer	Bank stabilization matting, streambank planting
15	100% bank erosion, incised channel, widening channel, excessive sedimentation, inadequate riparian buffer, hydrologic alteration	Bank stabilization matting, streambank planting, riparian planting (native hardwoods), riparian planting (seeding/mulching)
16	40% bank erosion, incised channel, widening channel, inadequate riparian buffer, hydrologic alteration	Bank stabilization matting, streambank planting, riparian planting (native hardwoods), riparian planting (seeding/mulching)
17	90% bank erosion, incised channel, widening channel, excessive sedimentation, hydrologic alteration	Bank stabilization matting, streambank planting, bank grading,
20	40% bank erosion, hydrologic alteration	Bank stabilization matting, streambank planting, created wetland, dry extended detention pond, wet extended detention pond
21	40% bank erosion, hydrologic alteration	Bank stabilization matting, streambank planting
22	90% bank erosion, widening channel, inadequate riparian buffer, hydrologic alteration	Bank stabilization matting, streambank planting

TABLE 5-2
Single-site Alternatives (adapted from Entrix, 2002a)
Butler Creek Watershed Detailed Project Report

Waypoint/ Alternative ID	Aquatic Habitat Problem(s)	Applied Restoration Measure(s)
23	40% bank erosion, excessive sedimentation, inadequate riparian buffer, hydrologic alteration	Bank stabilization matting, streambank planting, riparian planting (native hardwoods), riparian planting (seeding/mulching)
25	100% bank erosion, widening channel, debris dam, excessive sedimentation, hydrologic alteration	Bank stabilization matting, streambank planting
26	Inadequate riparian buffer	Bank stabilization matting, streambank planting
27	40% bank erosion, widening channel, hydrologic alteration	Bank stabilization matting, streambank planting, outlet control structure
28	40% bank erosion, widening channel, hydrologic alteration	Created wetland, dry extended detention pond
29	90% bank erosion, hydrologic alteration	Bank stabilization matting, streambank planting, outlet control structure
30	90% bank erosion, inadequate riparian buffer, hydrologic alteration	Bank stabilization matting, streambank planting
31	70% bank erosion, widening channel, excessive sedimentation, hydrologic alteration	Bank stabilization matting, streambank planting, bank grading
32	90% bank erosion, inadequate riparian buffer, hydrologic alteration	Bank stabilization matting, streambank planting
34	Widening channel, debris dam, excessive sedimentation, hydrologic alteration	Outlet control structure
35	100% bank erosion, widening channel, excessive sedimentation, inadequate riparian buffer, hydrologic alteration	Bank stabilization matting, streambank planting, outlet control structure
36	100% bank erosion, excessive sedimentation, hydrologic alteration	Bank stabilization matting, streambank planting
37	Other problem(s) identified	Bank stabilization matting, streambank planting
38	10% bank erosion, hydrologic alteration	Bank stabilization matting, streambank planting
39	40% bank erosion, widening channel, excessive sedimentation, hydrologic alteration	Bank stabilization matting, streambank planting
40	100% bank erosion, incised channel, widening channel, excessive sedimentation, inadequate riparian buffer, hydrologic alteration	Outlet control structure
44	90% bank erosion, excessive sedimentation, hydrologic alteration	Bank stabilization matting, streambank planting, bank grading

TABLE 5-2
Single-site Alternatives (adapted from Entrix, 2002a)
Butler Creek Watershed Detailed Project Report

Waypoint/ Alternative ID	Aquatic Habitat Problem(s)	Applied Restoration Measure(s)
45	Widening channel, excessive sedimentation, hydrologic alteration	Created wetlands
46	Debris dam, excessive sedimentation, hydrologic alteration	Bank stabilization matting, streambank planting
47	90% bank erosion, excessive sedimentation, hydrologic alteration	Bank stabilization matting, streambank planting
48	10% bank erosion, excessive sedimentation, inadequate riparian buffer, hydrologic alteration	Bank stabilization matting, streambank planting, riparian planting (native hardwoods), riparian planting (seeding/mulching)
49	100% bank erosion, debris dam, excessive sedimentation, hydrologic alteration	Bank stabilization matting, streambank planting, bank grading
50	90% bank erosion, widening channel, inadequate riparian buffer, hydrologic alteration	Bank stabilization matting, streambank planting, riparian planting (native hardwoods), riparian planting (seeding/mulching)
51	80% bank erosion, widening channel, inadequate riparian buffer, hydrologic alteration	Bank stabilization matting, streambank planting, riparian planting (native hardwoods), riparian planting (seeding/mulching)
53	Other problem(s) identified	
54	100% bank erosion, incised channel, debris dam, excessive sedimentation, hydrologic alteration	Bank stabilization matting, streambank planting, outlet control structure
55	Other problem(s) identified	Outlet control structure
56	Debris dam, excessive sedimentation, hydrologic alteration	Bank stabilization matting, streambank planting
57	40% bank erosion, incised channel, widening channel, excessive sedimentation, inadequate riparian buffer, hydrologic	Bank stabilization matting, streambank planting, created wetland, dry extended detention pond, wet extended detention pond, riparian planting (native
58	Excessive sedimentation, hydrologic alteration	Dry extended detention pond, wet extended detention pond, outlet control structure
59	70% bank erosion, debris dam, excessive sedimentation, inadequate riparian buffer, hydrologic alteration	Bank stabilization matting, streambank planting,
60	30% bank erosion, inadequate riparian buffer, hydrologic alteration	Bank stabilization matting, streambank planting, outlet control structure
62	30% bank erosion, debris dam, hydrologic alteration	Bank stabilization matting, streambank planting
63	Debris dam, hydrologic alteration	Bank stabilization matting, streambank planting

TABLE 5-2
Single-site Alternatives (adapted from Entrix, 2002a)
Butler Creek Watershed Detailed Project Report

Waypoint/ Alternative ID	Aquatic Habitat Problem(s)	Applied Restoration Measure(s)
65	80% bank erosion, incised channel, excessive sedimentation, hydrologic alteration	Bank stabilization matting, streambank planting, outlet control structure
66	100% bank erosion, incised channel, inadequate riparian buffer, hydrologic alteration	Bank stabilization matting, streambank planting, riparian planting (native hardwoods), riparian planting (seeding/mulching)
68	Excessive sedimentation, hydrologic alteration	Bank stabilization matting, streambank planting
69	Incised channel, hydrologic alteration	Bank stabilization matting, streambank planting
71	80% bank erosion, excessive sedimentation, hydrologic alteration	Bank stabilization matting, streambank planting
73	80% bank erosion, widening channel, excessive sedimentation, land clearing/construction, hydrologic alteration	Bank stabilization matting, streambank planting
74	90% bank erosion, hydrologic alteration	Bank stabilization matting, streambank planting, dry extended detention pond
75	100% bank erosion, widening channel, debris dam, excessive sedimentation, hydrologic alteration	Dry extended detention pond, outlet control structure
76	100% bank erosion, widening channel, hydrologic alteration	Bank stabilization matting, streambank planting, created wetland
77	100% bank erosion, hydrologic alteration	Bank stabilization matting, streambank planting
78	100% bank erosion, excessive sedimentation, hydrologic alteration	Created wetlands
79	100% bank erosion, excessive sedimentation, hydrologic alteration	Outlet control structure
80	100% bank erosion, widening channel, inadequate riparian buffer, hydrologic alteration	Bank stabilization matting, streambank planting, bank grading
81	90% bank erosion, widening channel, hydrologic alteration	Bank stabilization matting, streambank planting, outlet control structure
82	Incised channel	
83	90% bank erosion, incised channel, debris dam, excessive sedimentation, hydrologic alteration	Bank grading
84	90% bank erosion, incised channel, widening channel, excessive sedimentation, hydrologic alteration	Bank stabilization matting, streambank planting, created wetland,

TABLE 5-2
Single-site Alternatives (adapted from Entrix, 2002a)
Butler Creek Watershed Detailed Project Report

Waypoint/ Alternative ID	Aquatic Habitat Problem(s)	Applied Restoration Measure(s)
85	60% bank erosion, incised channel, widening channel, excessive sedimentation, inadequate riparian buffer, hydrologic alteration	Bank stabilization matting, streambank planting, riparian planting (native hardwoods), riparian planting (seeding/mulching)
86	30% bank erosion, hydrologic alteration	Bank stabilization matting, streambank planting, outlet control structure
87	Excessive sedimentation, hydrologic alteration	Created wetland, dry extended detention pond, wet extended detention pond
88	Incised channel, debris dam, excessive sedimentation, hydrologic alteration	Bank stabilization matting, streambank planting
89	Incised channel, debris dam, excessive sedimentation, hydrologic alteration	Bank stabilization matting, streambank planting
91	70% bank erosion, incised channel, debris dam, excessive sedimentation, hydrologic alteration	Bank stabilization matting, streambank planting
92	Excessive sedimentation, land clearing/construction, hydrologic alteration	Wet extended detention pond
93	Excessive sedimentation, land clearing/construction, hydrologic alteration	Bank stabilization matting, streambank planting
94	40% bank erosion, widening channel, hydrologic alteration	Bank stabilization matting, streambank planting, outlet control structure
95	90% bank erosion, hydrologic alteration	Bank stabilization matting, streambank planting,
96	30% bank erosion, debris dam, inadequate riparian buffer, hydrologic alteration	Created wetland, dry extended detention pond, wet extended detention pond, riparian planting (native hardwoods), riparian planting (seeding/mulching), outlet control structure
97	Other problem(s) identified	
98	10% bank erosion, debris dam, hydrologic alteration	Bank stabilization matting, streambank planting, outlet control structure
99	90% bank erosion, hydrologic alteration	Bank stabilization matting, streambank planting,
100	70% bank erosion, inadequate riparian buffer, hydrologic alteration	Bank stabilization matting, streambank planting, dry extended detention pond, riparian planting (native hardwoods), riparian planting (seeding/mulching), outlet control structure
101	40% bank erosion, hydrologic alteration	Bank stabilization matting, streambank planting, bank grading,
102	60% bank erosion, incised channel, widening channel, hydrologic alteration	Bank stabilization matting, streambank planting, outlet control structure

TABLE 5-2
Single-site Alternatives (adapted from Entrix, 2002a)
Butler Creek Watershed Detailed Project Report

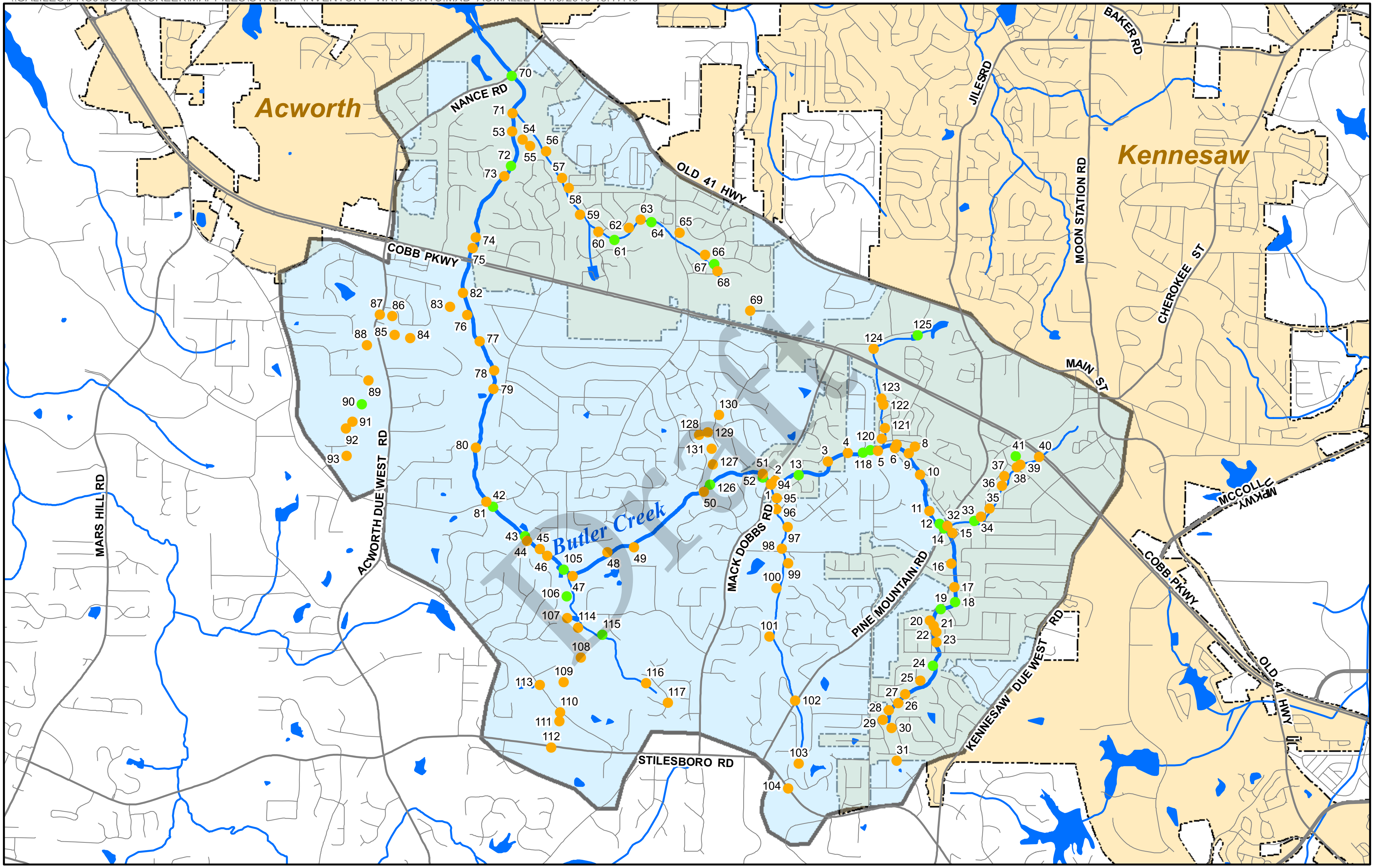
Waypoint/ Alternative ID	Aquatic Habitat Problem(s)	Applied Restoration Measure(s)
103	Excessive sedimentation, land clearing/construction, inadequate riparian buffer, hydrologic alteration	Bank stabilization matting, streambank planting
104	Excessive sedimentation, land clearing/construction, inadequate riparian buffer, hydrologic alteration	Riparian planting (native hardwoods), riparian planting (seeding/mulching), outlet control structure
107	100% bank erosion, incised channel, excessive sedimentation, inadequate riparian buffer, hydrologic alteration	Bank stabilization matting, streambank planting, outlet control structure
108	100% bank erosion, incised channel, debris dam, hydrologic alteration	Bank stabilization matting, streambank planting,
109	10% bank erosion, incised channel, widening channel, hydrologic alteration	Outlet control structure
110	Debris dam, excessive sedimentation, inadequate riparian buffer, hydrologic alteration	Outlet control structure
111	40% bank erosion, incised channel, hydrologic alteration	Bank stabilization matting, streambank planting,
112	90% bank erosion, incised channel, excessive sedimentation, hydrologic alteration	Bank stabilization matting, streambank planting, outlet control structure
113	Other problem(s) identified	Bank stabilization matting, streambank planting
114	Other problem(s) identified	Bank stabilization matting, streambank planting
116	90% bank erosion, incised channel, excessive sedimentation, hydrologic alteration	Outlet control structure
117	90% bank erosion, incised channel, hydrologic alteration	Outlet control structure
120	60% bank erosion, incised channel, excessive sedimentation, inadequate riparian buffer, hydrologic alteration	Bank stabilization matting, streambank planting, outlet control structure
121	100% bank erosion, excessive sedimentation, inadequate riparian buffer, hydrologic alteration	Bank stabilization matting, streambank planting, outlet control structure
122	40% bank erosion, excessive sedimentation, inadequate riparian buffer, hydrologic alteration	Bank stabilization matting, streambank planting, outlet control structure
123	Other problem(s) identified	Created wetland
124	Incised channel, hydrologic alteration	Bank stabilization matting, streambank planting
127	Excessive sedimentation, land clearing/construction	Bank stabilization matting, streambank planting

TABLE 5-2
Single-site Alternatives (adapted from Entrix, 2002a)
Butler Creek Watershed Detailed Project Report

Waypoint/ Alternative ID	Aquatic Habitat Problem(s)	Applied Restoration Measure(s)
128	70% bank erosion, incised channel, inadequate riparian buffer, hydrologic alteration	Bank stabilization matting, streambank planting, riparian planting (native hardwoods), riparian planting (seeding/mulching)
129	70% bank erosion	Bank stabilization matting, streambank planting, riparian planting (native hardwoods), riparian planting (seeding/mulching)
130	Other problem(s) identified	Bank stabilization matting, streambank planting
131	Inadequate riparian buffer, hydrologic alteration	Riparian planting (native hardwoods), riparian planting (seeding/mulching)

Adapted from Entrix, 2002a and 2002b

\\GALILEO\PROJ\BUTLERCREEK\MAPFILES\STREAM_INVENTORY_WAYPOINTS.MXD AOMALLEY 11/5/2010 15:17:49



Waypoint without Identified Problem

Potential Restoration Alternative

Major Road

Road

River/Stream

Butler Creek

Waterbody

Butler Creek Watershed

City Limit

0 0.5 1 Miles

FIGURE 5-2

107 Single-site Alternatives

Butler Creek Watershed Aquatic Ecosystem Restoration DPR - Environmental Appendix

CH2MHILL

Restoration alternatives for the Butler Creek watershed were developed by applying the restoration measures at 107 problem sites that were identified during the 2002 field assessment. The problems in Butler Creek varied by severity (such as amount of sedimentation in a given area) and extent (distance along the stream). However, they were similar in type, where most stream reaches were channelized with degraded habitat because of sedimentation and a limited riparian ecosystem. As a result, the project delivery team formulated one alternative plan to address each individual problem site. Measures were selected and combined to address the specific problems observed. Other measures were eliminated if they did not specifically address the problem, were less effective than the selected measures, did not meet the planning objectives, or could not be implemented because of site constraints. During formulation, the project delivery team considered many combinations of measures to address problems, avoid constraints, and meet the planning objectives. However, only one set of measures was ultimately selected to address the problems at each site.

For instream measures, log sills were not used for grade control in any alternative plans, because other instream measures were deemed more appropriate for channel conditions and for redirecting flow to the center of the stream. Although log sills are well-suited for smaller stream systems experiencing some degree of incising, the project delivery team determined that a more robust method of grade control (such as engineered riffles) would be more appropriate for stream profile stabilization and to address the more severe incising conditions observed at problem sites. Bank stabilization measures were selected based on observed conditions, with measures including bank grading, matting, or planting used instead of riprap (or other bank hardening approaches) where possible. Riparian measures (if selected) were selected as appropriate to enhance disturbed riparian ecosystem conditions.

Flow attenuation measures applied to alternatives included retrofit of an existing outlet control structure, extended dry detention ponds, and created wetlands, depending on the existing hydrology. The new detention basins and created wetlands often included micropools, pilot channels, and aquatic vegetation. Outlet control structure retrofits were selected when channel protection volume could not be achieved with the current outlet control structure configuration. Basin expansion was selected as a measure when the pond could be expanded (deepened or expanded laterally) given current site use, conditions, and constraints.

5.3 Screening Alternative Plans

Before conducting detailed evaluations of environmental benefits and costs for each alternative plan, the 107 single-site alternative plans (excluding the No Action Alternative) were screened to identify those that would sustainably meet the planning study objectives by addressing the most severe areas of habitat loss in the watershed with the greatest potential for future habitat improvement. In 2004, the screening process was conducted by the USACE-Mobile to verify the most severe problems prior to moving forward with plan formulation. Stream assessment data from 2002 was used to screen out correctable problem sites and carry forward those sites with the worst existing conditions. The screening process resulted in screening out 75 single-site alternatives. The remaining alternatives, including 21 stream locations with severe bank erosion and 11 flow attenuation locations, are shown on Figure 5-3. The screening process is detailed below.

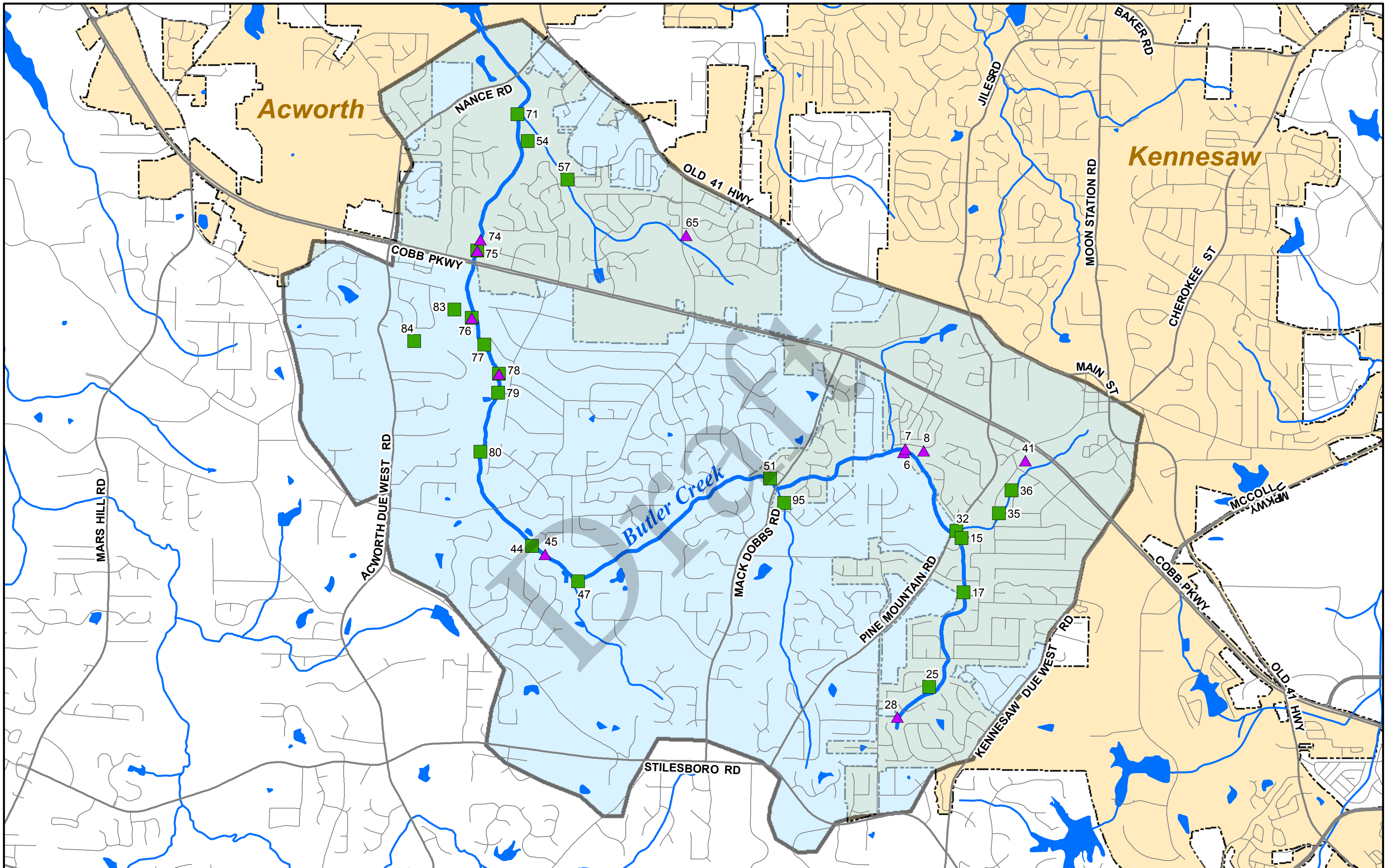
As part of the first step in the screening process, the most severe problems were identified as the 39 (out of 131) problem sites with streambanks greater than 80 percent eroded (see Table 5-2). The percent eroded was quantified during the 2002 field assessments based on the approximate percentage of bare surface area on a streambank at each waypoint. Based on field observations, stream banks with erosion greater or equal to 80 percent were identified as those that had characteristics of severe degradation. While stream banks with a lower percentage of bank erosion had bare areas, existing vegetation in other areas was stabilizing stream banks, leading to a natural recovery to a more stable bank configuration, and preventing further degradation. However, banks with 80 percent erosion or more were associated with stream reaches with more widespread bank failure and vertical, unstable banks, where there was not enough vegetation to prevent further damage. The project delivery team determined that other problem areas were less impacted, where the stream channel had the potential to recover some stability in the future.

The project delivery team determined that other problem areas were determined to be less impacted, where the stream channel had the potential to recover some stability in the future. At these 39 locations, additional measurements were collected in 2004 to determine the approximate length of eroded banks, bank heights and slopes, and channel width. As a secondary screening of severity, measurements were used to calculate streambank erosion rates and sediment loading. In addition to these 39 locations, 5 additional waypoints located near one of these severe bank erosion locations were also re-evaluated by the project delivery team (that is, 44 waypoints total). Through these updated assessments, it was noted that 18 of the 44 waypoints have improved through actions taken by the adjacent property owners, or otherwise stabilized over time through natural processes. In contrast, 21 of the 44 waypoints remained in similar or worse condition. These 21 waypoints were screened in 2004 as the most degraded reaches with opportunities for restoration (Table 5-3).

TABLE 5-3
32 Single-site Alternatives Carried Forward for Alternative Formulation (Entrix, 2002a)
Butler Creek Watershed Aquatic Ecosystem Restoration Detailed Project Report

	Stream Problem Site Description				**Potential Flow Attenuation Recommendation**			
Waypoint	Incised Channel	Bank Erosion	Buffer Degradation	Stormwater Inflow	Created Wetland	Extended Dry Detention	Extended Wet Detention	Off-Channel Detention
6						X	X	X
7						X	X	
8						X	X	
15		X	X					
17	X	X						
25		X						
28						X	X	
32		X						
34				X				
35		X		X				
36		X						
41					X	X	X	
44	X	X						
45								X
47		X						
51		X	X					
54		X						
57		X	X	X				
58				X				
71		X						
74						X		
75				X		X		
76		X			X			X
77		X						
78								X
79				X				
80	X	X						
83	X							
84		X			X			
Total Sites		**21**				**11**		

Source: Entrix, 2002.



Screened Bank Erosion Waypoint
Screened Riparian Waypoint
Major Road
Road
River/Stream
Butler Creek
Waterbody
Butler Creek Watershed
City Limit

0 0.5 1 Miles

FIGURE 5-3
32 Screened Single-site Alternatives
Butler Creek Watershed Aquatic Ecosystem Restoration

\\GALILEO\PROJ\BUTLERCREEK\MAPFILES\SCREENED_BANK_RIPARIAN_WAYPOINTS.MXD AOMALLEY 11/8/2010 13:56:44

CH2MHILL

While most of the 21 waypoints were within the original 5 problem areas identified in 2002 (see Figure 5-1), 7 waypoints were outside of the original 5 problem areas: waypoints 44, 45, 47, 77 – 80. These 7 waypoints represented areas of stream bank erosion that may not have been the most severe; however, these areas had available land in adjacent riparian areas where peak flows could potentially be attenuated upstream of the severe bank erosion locations (waypoints 77 – 80) and upstream of the least degraded reach in the watershed (44, 45, 47). While these waypoints would not be considered the most severe problems in the watershed, the location make them important to consider in alternative plan formulation for flow attenuation to protect the most pristine downstream habitats and restoration.

In addition to the 21 waypoints discussed above, waypoints were also screened in 2004 as potential flow attenuation sites, based on location in the watershed, available land located near stream locations which is affected by high peak flows and channel velocities. Peak flow attenuation waypoints identified in 2002 were eliminated if they lacked sufficient storage volume capacity and/or adequate connectivity to the floodplain. Of the originally identified peak flow attenuation waypoints, 11 were carried forward for alternative plan formulation (Table 5-3).

5.4 Reformulation of Alternative Plans

Due to budgetary constraints, the plan formulation process for Butler Creek has extended over 8 years. As a result, evaluation techniques and stream conditions have changed since the problem sites were developed and evaluated in 2002 and 2004. While alternative plans were originally formulated in 2002 (see Section 4.3, Developing Alternative Plans), the plan formulation process was not carried forward to complete the study until 2010. In 2004, the single-site alternatives screened in the previous section were formulated into 17 alternatives. In 2010, the project delivery team conducted a site visit to re-evaluate the field conditions prior to completing the Detailed Project Report. As a result, the 17 alternatives developed in 2004 were updated and reformulated to 12 alternatives in 2010. The 12 alternatives were then reformulated to 10 alternatives, by combining 2 stream restoration alternatives with flow attenuation alternatives to ensure completeness of the final alternatives. Each reformulation step is discussed separately below.

5.4.1 Reformulation to Seventeen Alternatives

The Butler Creek watershed is influenced by changes in land use and impervious cover, as well as channel morphology, which have led to more intense peak flows and high-energy velocities, increased bank erosion, and channel incising and widening. Modeling results support this finding, where future flows are predicted to increase, high-energy velocities will occur in many reaches, and sediment loads will be greater from the downstream portions of the watershed. As a result, logical alternatives were formulated to address stream and riparian restoration, as well as peak flow attenuation. Stream and riparian restoration generally improve aquatic habitats by enhancing specialized habitats, food sources, refuge, and shading; however, they do not have a significant influence on reducing peak flows, unless the stream is reconnected to the floodplain. Peak flows can influence downstream channel integrity, stability, and habitat. Thus, peak flow attenuation alternatives were considered to be an important part of formulating a comprehensive set of alternatives to address watershed problems.

As outlined in Section 5.1 (Screening Alternative Plans), stream assessment data from 2002 and 2004, supported by hydrologic and hydraulic model results, were used to screen out correctable alternatives and identify those with the worst existing conditions to be carried forward for analysis. These included 21 stream alternatives and 11 flow attenuation alternatives (Table 5-1). However, to ensure that efforts were focused on logical and complete restoration alternatives to address problems in the watershed, each alternative plan was formulated to provide sustainable ecological benefit when separately implemented. Therefore, the 32 single-site alternatives were reformulated to develop 17 combination alternatives (consisting of groups of single-site alternatives). The 17 alternatives consisted of 10 combinations of single-site stream alternatives (Figure 5-4) and 7 combinations of single-site flow attenuation alternatives (Figure 5-5). The single-site alternative(s) included in each of the 17 reformulated alternatives are provided in Table 5-4 and Figures 5-4 and 5-5.

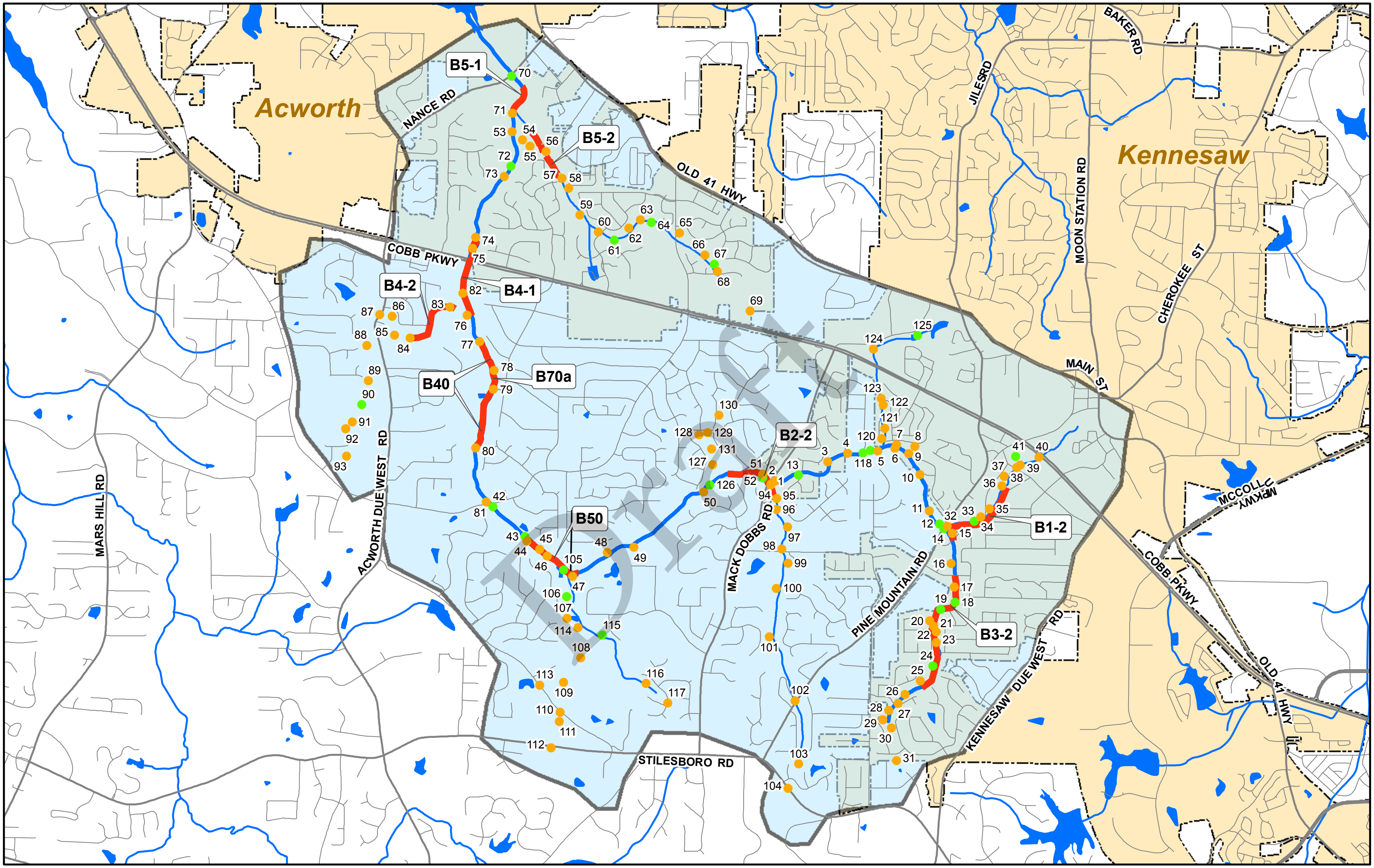
TABLE 5-4
Reformulation to 17 Alternatives (2004)
Butler Creek Watershed Aquatic Ecosystem Restoration Detailed Project Report

Alternative ID	Single-site Alternative(s) Included
Stream Restoration Alternatives	
B1-2	15, 32, 35, 36
B2-2	1, 2, 51
B3-2	17, 20, 21, 22, 23, 25
B4-1	74, 75, 76, 82
B4-2	83, 84
B5-1	71
B5-2	54, 56, 57
B40	77, 78, 80
B50	44, 45, 46, 47
B70a	79
Flow Attenuation Alternatives	
B1-1	41
B2-1	6, 7, 8
B3-1	28
B10	66
B20	46, 47, 48
B60	81
B70	79

5.4.2 Reformulation to Twelve Alternatives

In 2010, the project delivery team conducted a site visit to re-evaluate the field conditions prior to completing the Detailed Project Report. As a result, the 17 alternatives developed in 2004 were updated and reformulated to 12 alternatives. The rationale for alternative changes, additions, and removals is summarized in Table 5-5. The 12 alternatives resulting from evaluation and reformulation are shown on Figure 5-6.

Based on the 2010 field assessment, several of the 10 stream restoration alternatives were modified to either extend or reduce the extent of stream restoration. In addition, four potential stream restoration alternatives were eliminated from further consideration because either the municipality or the property owner had taken action to stabilize the banks or vegetative cover had naturally stabilized the bank since the 2004 alternative formulation. In 2010, additional field evaluations of the 8 peak flow attenuation alternatives were also conducted. Two alternatives (B10 and B2-1) were eliminated, and Alternative B3-2-3 was added as a flow attenuation measure due to impacts from the severe flooding in September 2009 in Cobb County. After this reformulation, a total of 6 stream restoration alternatives and 6 peak flow attenuation alternatives remained for further evaluation and consideration. These alternatives are summarized in Table 5-6.



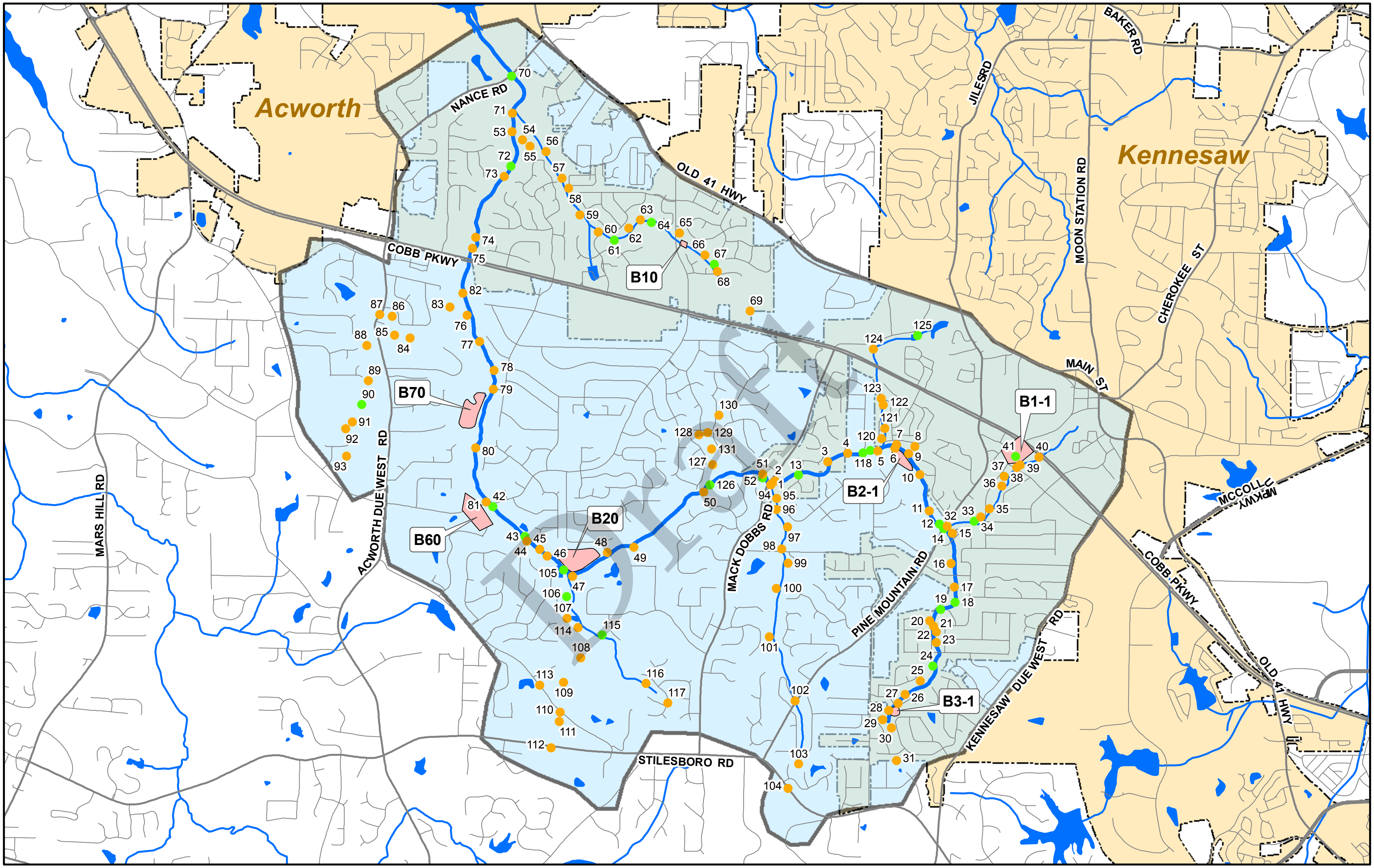
Waypoint without Identified Problem
Waypoint with Identified Problem
Stream Restoration Alternatives
Major Road
Road
River/Stream
Butler Creek
Waterbody
Butler Creek Watershed
City Limit

0 0.5 1 Miles

FIGURE 5-4
10 Reformulated Stream Restoration Alternatives
Butler Creek Watershed Aquatic Ecosystem Restoration

CH2MHILL

\\GALILEO\PROJ\BUTLERCREEK\MAPFILES\RESTORATION_ALTERNATIVES_2002.MXD AOMALLEY 11/5/2010 16:18:10



Waypoint without Identified Problem
Waypoint with Identified Problem
Major Road
Road
River/Stream
Butler Creek
Waterbody
Butler Creek Watershed
Flow Attenuation Alternative
City Limit

0 0.5 1 Miles

FIGURE 5-5
7 Reformulated Flow Attenuation Alternatives
Butler Creek Watershed Aquatic Ecosystem Restoration

CH2MHILL

\\GALILEO\PROJ\BUTLERCREEK\MAPFILES\POTENTIAL_FLOW_ATTENUATION_ALTERNATIVES_2004.MXD AOMALLEY 11/5/2010 17:23:12

TABLE 5-5
Reformulation to 12 Alternatives (2010)
Butler Creek Watershed Aquatic Ecosystem Restoration Detailed Project Report

2004 Alternative ID	2010 Change	Rationale for Change
Stream Restoration Alternatives		
B1-2 (15, 32, 35, 36)	Eliminated	Cobb County took action to stabilize the banks with rip-rap where active erosion was occurring
B2-2 (51, 95)	Altered	The portion upstream of Mack Dobbs Rd. was eliminated from the array of possible features due to new residential development that have created access and constructability issues. Also, the existing stream buffer is providing significant visual and sound barrier protection for the residents. Other portions were eliminated because the streambank has stabilized and erosion is no longer problematic.
B3-2 (17, 35)	Altered	Cobb County took action to stabilize the banks where active erosion was occurring. The debris dams that were observed on previous field visits have been removed either by the local municipality or natural processes. Intervention is no longer needed. Natural vegetation has stabilized the reach/site of active erosion.
B4-1 (75, 76)	Altered	The upstream portion of B4-1 – South of Cobb Parkway - was removed due to an outcropping of bedrock that acts to stabilize the channel bed and streambanks.
B4-2 (88, 84)	Eliminated	Vegetative cover has naturally stabilized the bank, eliminating the need for intervention.
B5-1 (71)	Eliminated	Reach has shown no change in the stream alignment and appears to be stable. The reach is heavily influence by backwater effects from Lake Acworth and erosion does not appear to be actively occurring.
B5-2 (54, 57)	Eliminated	A natural riffle / pool complex was observed in a recent field visit. Bedrock outcroppings and thick vegetative cover indicate that channel stabilization measures are no longer needed.
B40 (77, 78, 80)	Altered	Portions removed due to natural stabilization.
B50 (44, 47)	Altered	Portion removed because the site has naturally developed an adequate riparian zone and as a result, the thick vegetation has stabilized the eroding streambank.
B70a (79)	No change	
Flow Attenuation Alternatives		
B1-1 (41)	Eliminated	Due to the construction of a private business in the footprint of the proposed feature. The building, parking lot, and stormwater catchment of the business take up a sizable portion of the feature footprint, making constructing the feature no longer feasible.
B2-1 (6, 7, 8)	No change	
B3-1 (28)	No change	

TABLE 5-5
Reformulation to 12 Alternatives (2010)
Butler Creek Watershed Aquatic Ecosystem Restoration Detailed Project Report

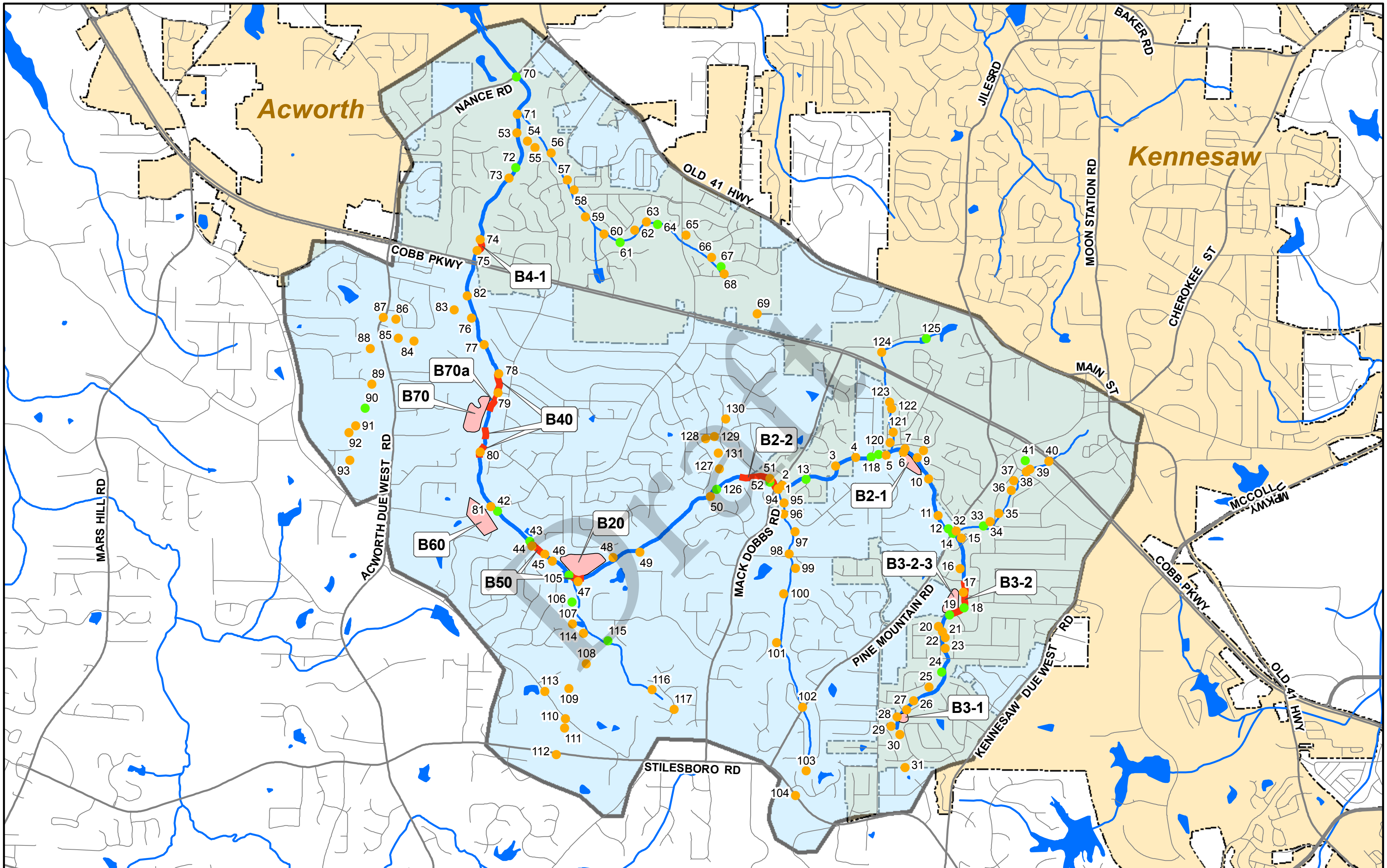
2004 Alternative ID	2010 Change	Rationale for Change
B10 (65)	Eliminated	After a reevaluation of effectiveness of retrofitting the existing outlet structure. After the most recent site visit, more detailed information regarding the dimensions and characteristics of the existing structure was obtained. An analysis of this information indicated that the structure is already operating at capacity for the design flow (2 year discharge). Modifying the structure to attenuate more flow would require a larger footprint for the associated pool behind the detention structure. It was decided by the project delivery team that the additional real estate needed would make this feature prohibitively expensive for only modest benefit.
B20 (45)	No change	
B60 (81)	No change	
B70 (74, 75, 76, 78)	No change	
N/A	Added B3-2-3 (17, 18, 19)	New location added based on impacts from the severe flooding in September 2009 in Cobb County

TABLE 5-6
Summary of 12 Restoration Alternatives Developed in 2010
Butler Creek Aquatic Watershed Ecosystem Restoration Detailed Project Report

Alternative ID (Single-site Alternative ID)	Description
Stream Restoration Alternatives	
B2-2 (51)	Includes about 500 linear feet of stone toe protection, bank grading, rootwad placement, and native vegetation plantings, located at Mack Dobbs Road and Caylor Circle.
B3-2 (17, 18, 19)	Includes 250 linear feet of constructed channel bench with stone toe protection, near White Oak Court. Native vegetation would be planted on both banks along with plantings in 0.25 acre of riparian zone on the right descending bank. Stone toe would be used where water velocities exceed 4.5 cubic feet per second. Roughly 300 cubic yards of onsite material would be excavated below the ordinary high water line and 100 cubic yards of riprap placed in the channel.
B4-1 (75	Includes stone toe protection with rootwad combinations on roughly 325 feet of the left descending streambank, and 250 feet of stone toe/rootwad protection along the right descending bank, downstream of Cobb Parkway. Vegetation would be planted in disturbed areas along the banks. Roughly 500 cubic yards of riprap would be placed below the ordinary high water line.
B40 (77, 78, 80)	Includes two areas adjacent to Alternative B70, parallel to Loring and Johnston Roads. One area has 100 feet of bank shaping with stone toe protection and bank vegetation on the left descending bank and roughly 250 feet of stone toe protection/rootwad installation on the right descending bank. Vegetation would be planted along the upper banks to stabilize active erosion. The other area has longitudinal peaked stone toe protection along roughly 150 feet on the right descending bank, just downstream of a culvert, and about 175 feet of stone toe protection and rootwad combination structures on the right descending bank. Vegetation

TABLE 5-6
Summary of 12 Restoration Alternatives Developed in 2010
Butler Creek Aquatic Watershed Ecosystem Restoration Detailed Project Report

Alternative ID (Single-site Alternative ID)	Description
	would be planted in disturbed areas along the banks. Roughly 300 cubic yards of riprap would be placed below the ordinary high water line.
B50 (44, 47)	Includes two streambank protection areas between Alternative B20 and Loring Way. Includes 315 feet of longitudinal stone toe bank protection with vegetation along both upper banks across from Alternative B20 and nearer to Loring Way, 95 feet of longitudinal stone toe bank protection on the left descending bank, and 95 feet of bank shaping and stone toe bank protection on the right descending bank. Roughly 250 cubic yards of riprap would be placed below the ordinary high water line.
B70a (79)	Includes the construction of a pre-cast concrete bridge in Butler Creek at the entry to Alternative B70, which would replace a deteriorating low water crossing. Primary objective of alternative would be to remove obstructions to upstream fish passage.
Flow Attenuation Alternatives	
B2-1 (6, 7, 8)	Includes a 1.5-acre extended detention created wetland, downstream of Pine Mountain Road, near Pine Valley Trail and Wellcrest Drive. The design includes constructed meanders to maximize travel distance and retention time. The outlet culvert is designed to release floodwater slowly from an overflowing state to normal pool elevation in a 24-hour period.
B3-1 (28)	Involves rebuilding an outlet control structure along with downstream riprap placement for energy dissipation located upstream of Schilling Chase Court. Would prevent scouring and erosion.
B20 (45)	Involves creating a 4.3-acre extended detention created wetland in the floodplain. The wetland would include multiple “benches” to provide wildlife habitat. Design includes constructed meanders to maximize travel distance and retention time. Outlet culvert is designed to slowly release floodwater from an overflowing state to normal pool elevation in a 24-hour period.
B60 (81)	Includes a 5-acre wetland detention pond downstream of Alternative B40.
B70 (78, 79,80)	Creation of 7.8 acres of extended planted wetland detention basin, offline from the main channel of Butler Creek, in the Butler Creek floodplain adjacent to Loring Road. The basin would have unexcavated fingers or benches extending into the basin that would provide a meandering flow through the system, as well as provide maintenance access. The outlet culvert is designed to slowly release floodwater from an overflowing state to normal pool elevation in a 24-hour period. Roughly 1.2 acres of the area is wetland that would be excavated or filled.
B3-2-3 (17, 18, 19)	Includes construction of a 0.5-acre offline dry detention area, at Butler Ridge Park just west of Woodland Drive and White Oak Court. A berm would hold floodwaters, which would be released slowly over a 24-hour period following rain storms.



Waypoint without Identified Problem
Waypoint with Identified Problem
Major Road
Road
River/Stream
Butler Creek
Waterbody
Butler Creek Watershed
Flow Attenuation Alternative
City Limit

0 0.5 1 Miles

FIGURE 5-6
Final Reformulated Alternatives
Butler Creek Watershed Aquatic Ecosystem Restoration

\\GALILEO\PROJ\BUTLERCREEK\MAPFILES\POTENTIAL_FLOW_ATTENUATION_ALTERNATIVES_2010.MXD AOMALLEY 11/5/2010 17:23:41

CH2MHILL

5.4.3 Reformulation to Ten Alternatives

The success of a single stream restoration alternative was assumed to be enhanced by nearby flow attenuation alternatives. Before comparing alternative plans, two of the stream restoration alternative plans were combined with adjacent, upstream flow attenuation alternatives, assuming that the success of the stream restoration alternatives would be tied to implementation of the flow attenuation alternative. This assumption is supported by modeling results, which indicate that intense peak flows and velocity have an adverse effect on instream habitat and stability, particularly in downstream locations. Specifically, habitat improvements for stream restoration Alternative B50 were enhanced by the presence of flow attenuation Alternative B20; likewise, habitat improvements at stream restoration Alternatives B4-1 and B70a were enhanced by flow attenuation Alternative B70. This final reformulation resulted in 10 final alternatives:

- 3 stream restoration alternatives (B2-2, B3-2, and B40),
- 4 flow attenuation alternatives (B2-1, B3-1, B60, and B3-2-3),
- 2 combination alternatives (combination of B70 [flow attenuation], B70a [bridge replacement], and B4-1 [stream restoration] and combination of B20 [flow attenuation] and B50 [stream restoration])
- No Action Alternative

These alternatives constitute the final reformulated alternative plans. These alternatives are detailed in the following section and every possible combination of these alternatives is evaluated in the remainder of this document. The possible combinations of alternatives (512 combinations) were established by the IWR Plan, which will be detailed in Section 5.3.2 (Efficiency).

5.4.4 Final Reformulated Alternatives for Evaluation of Alternative Plans

The final alternatives included in the evaluation detailed in the remainder of this document are described below. The restoration measures were assigned to the alternatives when they were originally developed (see Section 4.3.2, Alternative Plans); however the narratives below include a discussion of how the project delivery team applied measures to address problems. Recall, the problems in Butler Creek varied by severity (such as amount of sedimentation in a given area) and extent (distance along the stream). However, they were similar in type, where most stream reaches were channelized with degraded habitat because of sedimentation and a limited riparian ecosystem. As a result, the project delivery team formulated one alternative plan to address each individual problem site. Measures were selected and combined to address the specific problems observed. Other measures were eliminated if they did not specifically address the problem, were less effective than the selected measures, did not meet the planning objectives, or could not be implemented because of site constraints. During formulation, the project delivery team considered many combinations of measures to address problems, avoid constraints, and meet the planning objectives. However, only one set of measures was ultimately selected to address the problems at each site.

No Action Alternative

The No Action Alternative represents the option of not implementing any restoration measures in the watershed. It provided a baseline for comparison of the potential impacts of the proposed action. If no action was to be taken, it was expected that the Butler Creek watershed would continue to degrade as additional development occurred, and it was likely that water quality, fish communities, and benthic macroinvertebrate communities would continue to decline.

Alternative B3-1

Alternative B3-1 involves retrofitting an existing outlet control structure, located upstream Schilling Chase Court. The alternative is located near the headwaters of Butler Creek and is designed to provide temporary storage of stormwater runoff to reduce downstream channel impacts. In addition to retrofitting the existing outlet control structure, to meet current design standards, riprap would be placed instream, downstream of the detention basin outlet, to provide energy dissipation and to prevent scouring and erosion. Riprap was selected to restore the eroded banks and to protect the streambanks and riparian ecosystem from continued degradation.

Instream Measures:	*Bank Stabilization Measures:*	*Riparian Measures:*	*Flow Attenuation Measures:*
None selected	Riprap	None selected	Outlet control structure retrofit

Alternatives B50 and B20 (Combination Alternative)

This combination alternative includes Alternatives B50 and B20. Instream habitat improvements at stream restoration Alternative B50 was assumed to be enhanced by the presence of flow attenuation Alternative B20 (see Section 5.4.3, Reformulation to Ten Alternatives).

Alternative B50 includes two streambank restoration areas between Alternative B20 and Loring Way. Adjacent to the location of Alternative B20, restoration measures include 315 feet of longitudinal stone toe bank protection with vegetation along the upper bank. Vegetation planted along the upper bank would be sufficient enough so that long-term survival rate would meet design criteria. The second stream reach, located near Loring Way, would include approximately 95 feet of longitudinal stone toe protection on the right descending bank, and approximately 95 feet of bank shaping with toe protection and vegetation on the left descending bank. No riparian measures were selected for Alternative B50 because the riparian ecosystem is intact, with mature woody vegetation along both sides of the stream. To address channel widening and incising, stone toe protection was selected for grade control and to deflect flow from eroded banks. In addition, the bank stabilization measures listed below were selected to restore the eroded banks and to protect the existing streambanks and riparian ecosystem from continued degradation. No riparian measures were selected for this alternative, because the riparian ecosystem is intact with mature woody vegetation along both sides of the stream.

Alternative B20 involves the construction of an extended detention basin on top of a created wetland. The alternative is located near Jim Owens Road. The approximate 4.3-acre extended detention created wetland site is located in the Butler Creek floodplain off the main channel. A small intermittent tributary would be diverted through a forebay area and then into the detention area to allow the attenuation of the flows and sediment during storm events. A portion of the flow from Butler Creek would also be diverted first through a small forebay, then through the detention basin, and back into the creek. A lateral diversion weir would divert flow into the site when water surfaces in the main stem of Butler Creek approach bankfull conditions. The diversion channel and wetland would be excavated below the natural ground in the Butler Creek floodplain in order to divert water from the creek during peak flows. Small, unexcavated fingers, or maintenance benches, would extend from both sides into the wetland. Design includes constructed meanders to maximize travel distance and retention time. Outlet culvert is designed to slowly release floodwater from an overflowing state to normal pool elevation in a 24-hour period.

Instream Measures:	*Bank Stabilization Measures:*	*Riparian Measures:*	*Flow Attenuation Measures:*
Stone toe protection	Riprap	None selected	Extended wet detention basin
	Rootwad		Created wetland
	Streambank planting		Micropool
	Bank grading		Pilot channel
	Bank stabilization matting		Aquatic vegetation planting
			Sediment forebay
			Outlet control structure

Alternative B2-1

Alternative B2-1 involves construction of an extended detention basin (with sediment forebay) on top of a stormwater wetland. The wetland/detention basin would be 1.5-acres in area, located downstream of Pine Mountain Road, near Pine Valley Trail and Wellcrest Drive. A portion of Butler Creek flow would be re-routed through the sediment forebay and then through the basin. Conceptual design includes a constructed pilot channel, designed to meander and maximize travel distance and retention time. The outlet control structure would be designed to release floodwater slowly from an overflowing state to normal pool elevation in a 24-hour period. The diversion channel and wetland would be excavated below the natural ground in the Butler Creek floodplain in order to divert water from the creek during low flows. A lateral diversion weir would divert flow into the site when water surfaces in the main stem of Butler Creek approach bankfull conditions. The weir would be a concrete headwall placed in a cut in the bank, parallel to stream flow, with a crest elevation just below the bankfull elevation. The design for the excavated wetland requires a containment berm along the existing sewer line. The basin is designed to fill and overflow during high flows. The outlet culvert is designed to slowly release floodwaters and return pond levels from a full, overflowing state to the normal pool elevation, with depths of 1 to 2 feet, in a 24-hour period.

Instream Measures:	*Bank Stabilization Measures:*	*Riparian Measures:*	*Flow Attenuation Measures:*
None selected	None selected	None selected	Extended wet detention basin
			Created wetland
			Pilot channel
			Aquatic vegetation planting
			Sediment forebay
			Outlet control structure

Alternative B3-2

Alternative B3-2 is a stream restoration near White Oak Court, just downstream of Butler Ridge Park (Alternative B3-2-3). Under existing conditions, a 250-foot segment of stream is actively eroding. Design would include 250 linear feet of channel bench, constructed at the bankfull elevation of the existing channel. Bank grading would widen the channel to carry a greater volume of flow. Native vegetation would be planted on both banks along with plantings in 0.25 acre of riparian zone on the right descending bank. Stone toe protection would be used where water velocities exceed 4.5 cubic feet per second. Onsite material would be excavated below the ordinary high water line, and riprap would be used for bank stabilization. As the toe of the bank is stabilized, the upper bank would reach a stable slope and therefore be stabilized. Establishment of a riparian zone along the upper bank assists stability.

Instream Measures:	*Bank Stabilization Measures:*	*Riparian Measures:*	*Flow Attenuation Measures:*
Stone toe protection	Streambank planting Bank grading Create bankfull bench Riprap	Riparian planting (seeding and mulching) Riparian planting (native hardwoods) Invasive plant species control	None selected

Alternative B2-2

Alternative B2-2 includes about 500 linear feet of stream restoration, including stone toe protection, bank grading, streambank planting, and rootwad placement, near Mack Dobbs Road and Caylor Circle. In addition, the bank stabilization and riparian ecosystem enhancement measures (including invasive plant species management) listed below were selected to restore the eroded banks and to protect the existing streambanks and riparian ecosystem from continued degradation. The riparian buffer zone would be enhanced with native hardwood plantings throughout approximately 0.2 acres. To address channel widening and incising, stone toe protection was selected for grade control and to deflect flow from eroded banks. In addition, the bank stabilization and riparian measures listed below were selected to restore the eroded banks and to protect the existing streambanks and riparian ecosystem from continued degradation.

Instream Measures:	*Bank Stabilization Measures:*	*Riparian Measures:*	*Flow Attenuation Measures:*
Stone toe protection	Rootwad Streambank planting	Riparian planting (seeding and mulching) Riparian planting (native hardwoods) Invasive plant species management	None Selected

Alternatives B70, B70a, and B4-1 (Combination Alternative)

This combination alternative includes Alternatives B70, B70a, and B4-1. Instream habitat improvements at stream restoration Alternatives B4-1 and B70a were assumed to be enhanced by flow attenuation Alternative B70 (see Section 5.2.3).

Alternative B4-1 includes stone toe protection with rootwad combinations on roughly 325 feet of the left descending streambank, and 250 feet of stone toe/rootwad protection along the right descending bank, downstream of Cobb Parkway. Vegetation would be planted in disturbed areas along the banks. Roughly 1,000 cubic yards of riprap would be placed below the ordinary high water line.

Alternative B70 includes a creation of 7.8 acres of extended detention created wetlands, in the Butler Creek floodplain adjacent to Loring Road. The basin would have unexcavated fingers or benches extending into the basin that would provide a meandering flow through the system, as well as provide maintenance access. The outlet culvert would slowly release floodwater from an overflowing state to normal pool elevation in a 24-hour period. Roughly 1.2 acres of adjacent land is currently a wetland that would be excavated or filled.

Alternative B70a includes the construction of a pre-cast concrete bridge in Butler Creek at the entry to Alternative B70, which would replace a deteriorating low water crossing. Primary objective of alternative would be to remove obstructions to upstream fish passage.

Instream Measures:	*Bank Stabilization Measures:*	*Riparian Measures:*	*Flow Attenuation Measures:*
Stone toe protection	Riprap		Extended wet detention basin
Culvert replacement	Rootwad	None selected	Created wetland
	Streambank planting		Micropool
	Bank grading		Pilot channel
			Aquatic vegetation planting
			Sediment forebay
			Outlet control structure

Alternative B60

Alternative B60 includes a 5-acre wetland detention pond downstream of Alternative B40. Based on H & H model results for peak discharge reductions, the following flow attenuation measures are necessary to sustainably address problems in this location, reduce sedimentation, and restore aquatic ecosystems. No riparian measures were selected for this alternative, because the riparian ecosystem is intact with mature woody vegetation along both sides of the stream.

Instream Measures:	*Bank Stabilization Measures:*	*Riparian Measures:*	*Flow Attenuation Measures:*
None selected	None selected	None selected	Extended wet detention basin Created wetland Micropool Pilot channel Aquatic vegetation planting Sediment forebay Outlet control structure

Alternative B3-2-3

Alternative B3-2-3 involves construction of a 0.5-acre extended dry detention basin, at Butler Ridge Park just west of Woodland Drive and White Oak Court. The 1.5 acre site is a field currently used for casual recreation. Design features include excavation and grading of the site to allow for detention of peak flows diverted from Butler Creek. A lateral diversion weir would divert flow into the site when water surfaces in the main stem of Butler Creek approach bankfull conditions. The weir would be a concrete headwall placed in a cut in the bank, parallel to stream flow, with a crest elevation just below the bankfull elevation. A containment berm constructed around the perimeter of the field would detain the diverted flow. The basin is designed to fill and overflow during high flows. The outlet structure is designed to slowly release floodwaters to fully drain the site in a 24-hour period. The site would still function as a recreational athletic field during dry conditions. Common recreation features such as back-stops and park benches could be included as part of this project feature. An existing culvert, on the upstream end of the proposed detention pond, would be replaced as part of the alternative design.

Instream Measures:	*Bank Stabilization Measures:*	*Riparian Measures:*	*Flow Attenuation Measures:*
Culvert replacement	None selected	None selected	Extended dry detention basin Outlet control structure

Alternative B40

Alternative B40 includes two areas, parallel to Loring and Johnston Roads.
Along Johnston Road, there was 350 feet of active erosion. Design features include approximately 100 feet of bank shaping with stone toe protection and bank vegetation on the left descending bank and approximately 250 feet of longitudinal peaked stone toe protection on the right descending bank. Vegetation planted along the upper bank will be sufficient enough so that long-term survival rate will meet design criteria. Along Loring Road, there is 380 feet of active erosion. Design features include the installation of a velocity dissipator on the downstream side of a culvert passing under an unnamed roadway just off Loring Road; longitudinal peaked stone toe protection along approximately 150 feet on the right descending bank just downstream of the velocity dissipator, another approximately 175 feet of stone toe protection and rootwad combination structures on the right descending bank downstream. No riparian measures were selected for this alternative, because the riparian ecosystem is intact with mature woody vegetation along both sides of the stream.

Instream Measures:	*Bank Stabilization Measures:*	*Riparian Measures:*	*Flow Attenuation Measures:*
Stone toe protection	Bank grading Streambank planting Rootwads Riprap	None selected	None selected

6. Analysis of Future with Project Conditions

The analysis of future with project conditions is associated with the effectiveness criterion for federal water resources projects. Effectiveness of an alternative is "the extent to which an alternative plan alleviates the specified problems and achieves the specified opportunities" (P&G Section VI.1.6.2(c)(2)). It is associated with the plan's contribution to solving the planning problems and meeting plan objectives. Effectiveness should be considered during the screening of alternatives as well as evaluation of alternatives (Planning Manual, 1996). During the screening process (Section 5.1), effectiveness was evaluated based on the conditions at the alternative location, to identify alternatives that had limited potential to improve habitat and contribute to plan objectives. During the evaluation process, discussed in the following section, a more rigorous approach was used to quantify the effectiveness of reformulated alternatives, in terms of meeting the plan objectives.

6.1 Approach to Predict Future with Project Conditions

Each alternative's benefit to aquatic habitat was evaluated in terms of the amount of potential improvement the alternative may have on fish and benthic macroinvertebrate communities, as well as physical habitat diversity and availability. Physical habitat assessment scores, for each alternative, were predicted based on existing physical habitat conditions (Section 3), modeled future without project conditions (Section 3), and modeled future with project conditions (presented below). Each of the 10 physical habitat parameters was evaluated in terms of its expected response to the changes in peak discharge, channel velocity, and sediment delivery that have been modeled with project implementation (Appendix E).

Hydrologic and hydraulic models developed for future without project conditions (Section 3) were altered to account for implementation of flow attenuation alternatives, where discharge and channel velocity were estimated under future with project conditions. Since modeled future without project channel velocities indicate the need for stream restoration measures throughout the watershed, the localized effects of the stream restoration alternatives were assumed to be equivalent and were not modeled. However, while the physical habitat scores predicted for the stream restoration alternatives do not vary much, the project area multiplier in the calculation of habitat units distinguishes the individual alternatives and accounts for the fact that the impacts of stream restoration on the watershed as a whole are primarily dependent on the location of the alternative. A brief summary of model results, for analysis of flow attenuation measures, is provided below.

6.1.1 Peak Discharge

The hydrologic study was performed to investigate the effectiveness of proposed measures to reduce the future condition flows within the watershed. Peak discharge, under future conditions with a flow attenuation alternative, was estimated by updating the future without project model to include flow attenuation measures. These alternatives were modeled prior to the 2010 changes to alternatives and consisted of four newly created flow attenuation structures and three retrofits to existing outlet control structures. To evaluate the independent effects of each of these basins, seven separate basin models were created in HEC-HMS. Each alternative was added as a reservoir component in HEC-HMS, with appropriate elevation-storage and storage-discharge functions assigned. This method of modeling each detention basin separately allowed for the evaluation of the change in flow caused by each basin.

Figure 6-1 demonstrates the 2-year peak discharge in the mainstem of Butler Creek, under future without project and future with project conditions. Since the extended detention basins were designed to contain the runoff from small storms with a 2-year return period or less, the 2-year peak flow was used in the HEC-RAS analysis. As shown, the modeled flow reductions are not significant and do show much variance among alternatives. However, these reductions do not represent true conditions that have been field assessed for flow attenuation measures, such as created wetlands and extended detention basins. These values are therefore used as a comparison of alternatives instead of an evaluation of actual changes. For example, model results suggest that reduced peak discharges from Alternative B20 are greater than other alternatives, which will be accounted for in the physical habitat score prediction (Figure 6-1). Likewise, Alternative B3-1 demonstrates a reduction in peak discharges in the upstream portion of the watershed but has little effect on downstream conditions, which is considered when predicting its physical habitat score.

6.1.2 Channel Velocity

The future with project HEC-RAS model was developed by altering the future without project HEC-2 model with cross sections from the 2004 stream assessment in the vicinity of the proposed flow attenuation alternative sites, in order to improve characterization of existing flow conditions and to facilitate further modification for the with-project model. Overbank geometry was obtained graphically from the 2 foot contour interval topographic map of Cobb County. Channel geometry at these new cross sections was developed using judgment in consideration of local channel geometry and reach-scale channel slope. Cross-section interpolation schemes were also adopted in order to improve the accuracy of the hydraulic solution routines. Modeled channel velocity, under future without project and future with project results are shown in Figure 6-2. Similar to peak discharge results, modeled channel velocity does not show a significant variation from future with project conditions and is used only as a comparison between alternatives. Also similar to peak discharge results, Alternatives B20 and B3-1 are shown to have the greatest impact of channel velocity reduction in their respective areas of the watershed.

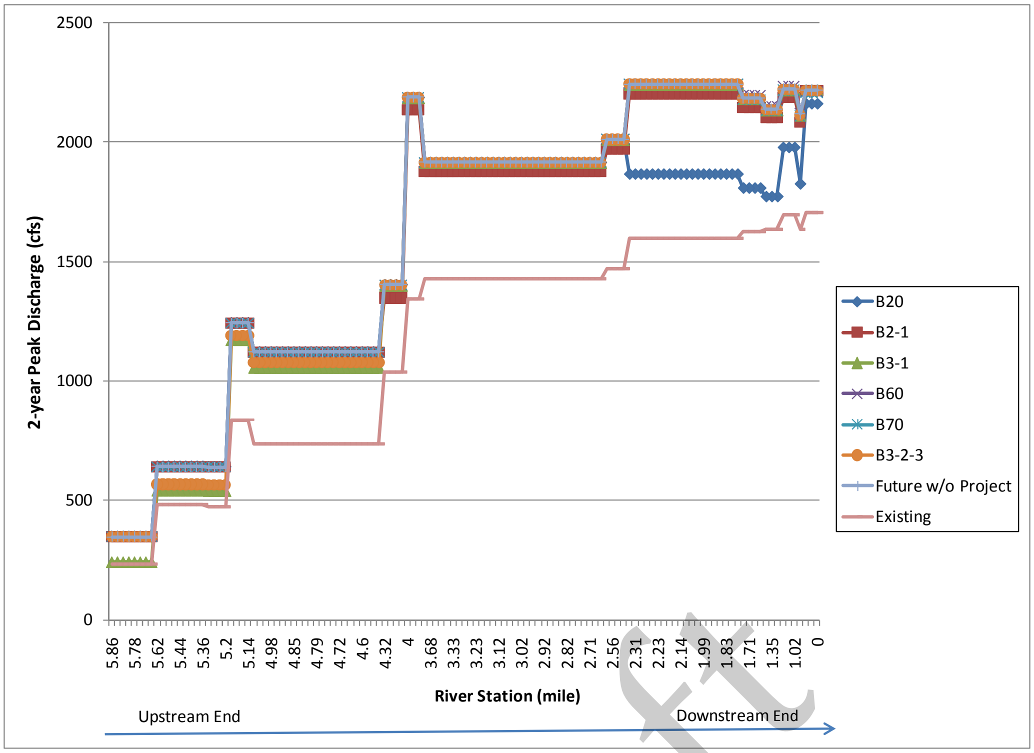


FIGURE 6-1
2-Year Peak Discharge Profile Under Future without Project and Future with Project Conditions
Butler Creek Watershed Detailed Project Report – Environmental Appendix

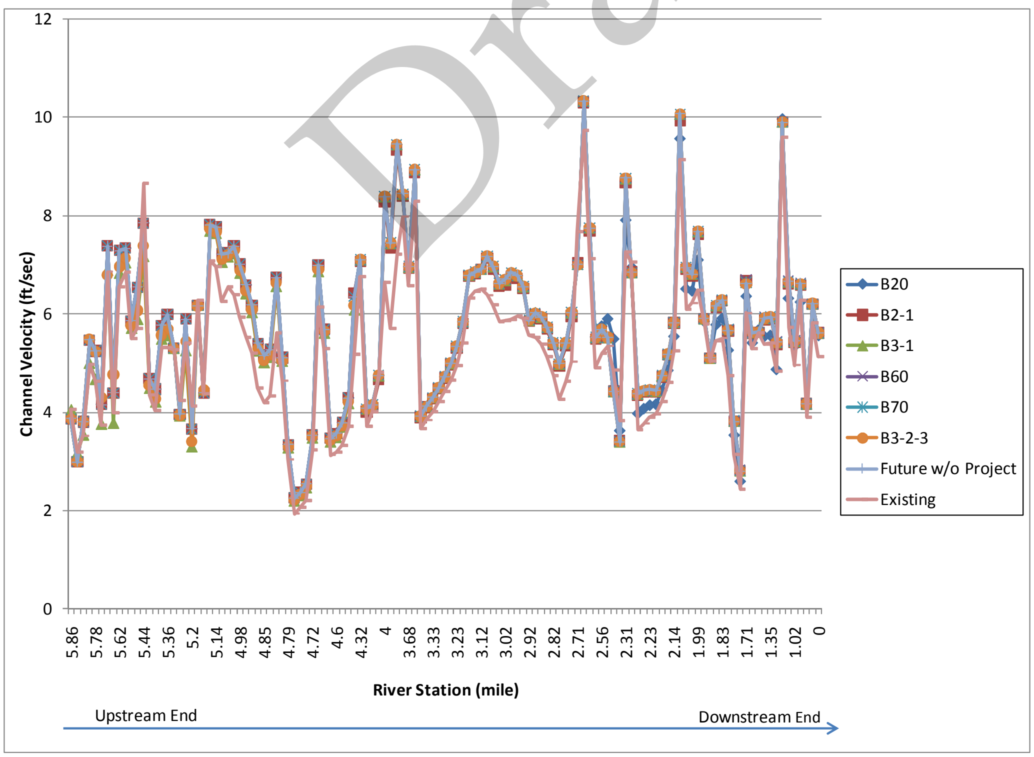


FIGURE 6-2
Velocity Profile Under Future without Project and Future with Project Conditions
Butler Creek Watershed Detailed Project Report – Environmental Appendix

6.1.3 Sediment

A prediction of the streambank erosion rates allows for the estimation of the streambank sediment load to the total sediment load in the stream. The potential alternatives were field-inspected to aid in the determination of streambank erosion rates. Three feature types, streambank stabilization, extended detention, and extended detention of diverted streamflow provide varying levels of benefit in reducing sediment in the stream system. Streambank stabilization is estimated to reduce existing conditions erosion levels from the site to zero due to stabilization enhancements. Extended detention sites are anticipated to reduce the sedimentation levels entering the project site by 80 percent. Extended detention of diverted streamflow is expected to remove sedimentation in the system by 80 percent of the ratio of the diverted flow to full streamflow that enters the site. The estimated sedimentation reduction benefits for each alternative are shown in Table 6-1.

TABLE 6-1
Estimated Sediment Reduction for Alternatives
Butler Creek Watershed Aquatic Ecosystem Restoration Detailed Project Report

Alternative ID	Estimated Sediment Reduction (tons/year)
Stream Restoration Alternatives	
B4-1	393.8
B40	157.5
B50	79.5
B2-2	78.8
B3-2	57.3
Flow Attenuation Alternatives	
B2-1	0.5
B20	3.2
B60	2.5
B70	4.9
B3-1	0.5
B3-2-3	1.1

6.1.4 Assumptions for Calculation of Habitat Units

Based on a review of modeled output, and on knowledge of the alternative locations and expected benefits, the following assumptions were made to quantify future with-project ecological resources and aquatic habitat:

- The relative difference in physical habitat assessment score from future with and without project conditions, for each flow attenuation alternative, is based on modeled peak discharge and channel velocity.
- Because of model limitations, modeled flow attenuation alternatives do not show significant changes; therefore, the future with-project physical habitat assessment scores do not vary much and the effects of the alternatives are based largely on the contributing project area.
- Since channel velocities indicate the need for stream restoration measures throughout the watershed, and the localized impacts of the stream restoration should always result in an "optimal" physical habitat score at that location, the physical habitat assessment scores are not expected to vary significantly among alternatives.
- Based on model results for discharge, velocity, and sediment delivery, the impacts of stream restoration alternatives on the watershed as a whole depend primarily on the location of the alternative, which will be accounted for with the project area multiplier.
- Alternative B70a is intended to reduce barriers to fish passage. This alternative would not improve upstream habitat when implemented individually, but it can be combined with other stream restoration measures to improve fish access to upstream aquatic

habitats. As a result, Alternative B70a is not expected to have as much of a positive improvement on the watershed as other stream restoration measures; therefore the multiplier used to calculate net habitat units for this alternative was selected as number smaller than the project area.

- The future with-project physical habitat score will be applied at the potential alternative locations.
- Net habitat units (the difference between future without- and with-project habitat units) can be used to quantify ecological lift for the alternatives analysis.

Based on these assumptions, net habitat units were used to quantify and compare ecological benefits for existing conditions, future without- project conditions, and future with-project conditions, where, habitat units = physical habitat score × project area.

6.2 Net Habitat Units for Reformulated Alternatives

Table 6-2 lists the predicted physical habitat assessment score for each Butler Creek watershed restoration alternative. As shown, the stream restoration alternatives are all expected to have an “optimal” physical habitat score, at the location of the alternative, with the exception of B70a, which is expected to be “suboptimal.” The physical habitat scores for flow attenuation alternatives were predicted based on relative modeled outputs and on the size and location in the watershed. Physical habitat scores for alternatives ranged from 116 points (B3-1, B70a) to 150 (B2-2, B4-1, B40). Table 6-2 also lists the habitat units of each alternative, calculated as the physical habitat score multiplied by the project area, and the net habitat units, or the difference between future without-project habitat units, at that location, and the future with-project habitat units. Recall that the net habitat units provided by each combination alternatives is assumed to be the sum of the net habitat units for each of its alternative parts.

TABLE 6-2
Physical Habitat Scores, Habitat Units, and Net Habitat Units for Alternatives Analysis
Butler Creek Watershed Aquatic Ecosystem Restoration Detailed Project Report

Alternative	Project Area (acres)	Existing		Future without Project		Future with Project			
		Physical Habitat Score	Habita t Units	Physical Habitat Score	Habitat Units	Physical Habitat Score	Habita t Units	Net HU (from future without)	Net HU (from existin g)
No Action	N/A	77	N/A	30	N/A	30	N/A	0	N/A
Flow Attenuation Alternatives									
B3-2-3	2.02	77	156	30	60.6	145	293	232	137
B3-1	2.75	77	212	30	82.5	116	319	237	107
B2-1	4.41	77	340	30	132.3	136	600	467	260
B60	4.71	77	363	30	141.3	137	645	504	283
B70	10	77	770	30	300	142	1420	1120	650
B20	11.48	77	884	30	344.4	143	1642	1297	758

Streambank Restoration Alternatives									
B70-a	0.15[a]	77	12	30	4.5	116	17	13	6
B2-2	0.65	77	50	30	19.5	150	98	78	47
B3-2	0.9	77	69	30	27	149	134	107	65
B50	1.72	77	132	30	51.6	145	249	198	117
B4-1	3.55	77	273	30	106.5	150	533	426	259
B40	5.17	77	398	30	155.1	150	776	620	377
Combination Alternatives									
B50 & B20	13.2	77	1016	30	396	143	1891	1495	875
B70, B70a, & and B4-1	13.7	77	1055	30	411	144	1970	1559	915

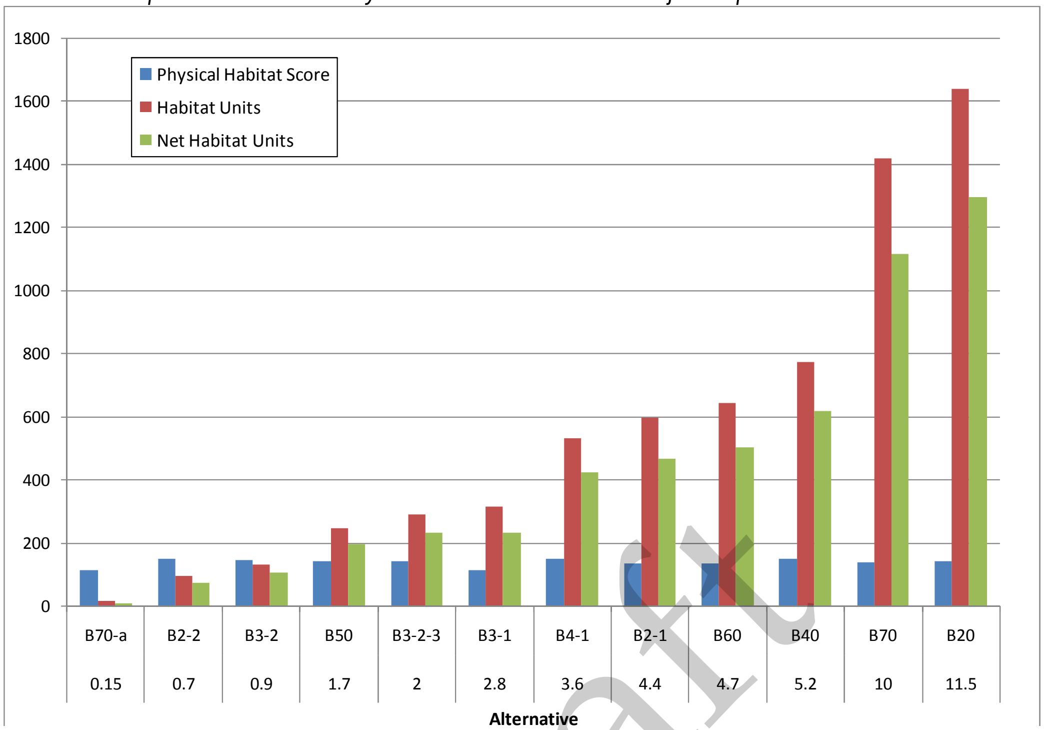
N/A – not applicable. The habitat units of the No Action Alternative vary depending on which project the comparison is being made. The No Action physical habitat score should be combined by the project area to determine the No Action conditions for that specific comparison.

[a] 0.15 is used as the multiplier for B70a, instead of its project area, since the alternative was designed to improve fish passage, not to provide overall watershed habitat benefits.

6.3 Summary

Figure 6-3 graphically represents the physical habitat score, habitat units, and net habitat units for each alternative. While physical habitat scores do not vary greatly among alternatives, the benefits of each alternative are enhanced as the project area of the alternative increases. The purpose of evaluating the effectiveness of each alternative is to quantify the anticipated aquatic habitat and ecosystem benefits and to use these benefits to further the evaluation of alternatives, in terms of efficiency, completeness, and acceptability. As previously mentioned, effectiveness of an alternative can be described as how well the alternative plan solves planning problems and meets the objectives. Each alternative would provide a certain amount of net habitat benefit to the aquatic ecosystem of Butler Creek, however, the alternatives with a greater project area would provide the greatest overall habitat benefit. As shown in Figure 6-3-7, each alternative would provide some degree of habitat improvement, meaning the net habitat units for each would be greater than under future without-project conditions. However, to evaluate the alternatives fully, the net habitat units must be evaluated with respect to the project cost. The cost effectiveness/incremental cost analysis (CE/ICA) is discussed in the following section.

FIGURE 6-3
Predicted Physical Habitat Score and Habitat Units (Future with-Project Conditions) and Net Habitat Units
Butler Creek Aquatic Watershed Ecosystem Restoration Detailed Project Report



7. Risk, Uncertainty, and Sensitivity Analyses

7.1 Potential Environmental Risks

Risk is inherent to water resources planning and aquatic ecosystem restoration projects, and must be defined to the extent practical throughout the planning process. Characterizing risk and uncertainty early in the planning process allows time to develop adaptive management and contingency plans to promptly address unforeseen conditions. Alternatives formulated for the Butler Creek watershed aquatic ecosystem restoration study were developed with these risks in mind, and risks were taken into consideration during the alternative selection process.

With regard to environmental impacts, potential risks to be considered when developing and comparing aquatic ecosystem restoration measures and alternatives include:

- risk of project failure,
- risk of ecosystem damage,
- natural disaster or catastrophic event, and
- residual risk.

These risks are described in more detail below, including a brief discussion of planning efforts established to minimize risks and potential impacts to the extent practical. Section 7 of the Detailed Project Report provides the Risk Management Plan, Monitoring Plan, and Long-Term Management Strategy that were prepared in response to the risks and uncertainties identified, and to establish plans to mitigate potential adverse effects.

7.1.1 Risk of Project Failure

The risks associated with project failure may include (1) site-specific failure of one or more of the restoration measures implemented within a project reach (may be either structural or non-structural failure) or (2) overall project success failure should monitoring results suggest that aquatic ecosystem restoration is not satisfactorily meeting the goals and objectives developed during Planning Step 2. Project failure may result from many factors, including failure to implement the Tentatively Selected Plan (such as if real estate acquisition does not occur), poor implementation of the Tentatively Selected Plan, or mischaracterization of existing conditions resulting in the selection of restoration measures that do not sufficiently address problems.

The Plans provided in Section 7 of the Detailed Project Report outline strategies to address project failure, including the following mitigation actions:

- conducting scheduled site inspections on a regular basis to identify developing problems (if any)
- establishing an annual maintenance budget to repair any observed project damage
- maintaining construction access, should equipment entry be necessary to repair or replace materials

- implementing post-construction monitoring plan to track the success of established aquatic ecosystem restoration goals and objectives

7.1.2 Risk of Ecosystem Damage

As is typical for stream restoration projects, there is risk of initially causing some degree of damage to the local ecosystem before restoration measures fully take effect and conditions begin to improve. Ecosystem damages (including localized increases in turbidity and suspended sediment, initial/continued degradation of aquatic communities, or initial lack of physical habitat improvement) might result from construction activities necessary to install certain in-stream measures, or from grading activities necessary to re-shape the channel section to a more stable long-term condition. Further, a period of time will be required following construction to allow aquatic communities to re-establish themselves within the project area, and for vegetative measures to be established to provide habitat and stream stability benefits. Initial adverse impacts to the ecosystem such as those described above are expected to reverse upon construction completion, and conditions will begin to improve (risk reduced) as benefits from the completed aquatic ecosystem restoration measures begin to take effect.

Should initial ecosystem damage be observed during construction, such conditions will be noted and appropriate measures taken, prior to construction completion, to minimize such damages. Any continued ecosystem damages observed following construction completion will be noted through post-construction monitoring. Post-construction biological monitoring will be scheduled for the first and third years following construction completion. The Risk Management Plan describes regularly scheduled activities aimed at identifying potential ecosystem damage through construction observation and scheduled post-construction monitoring. This plan also describes measures that should be taken should ecosystem damage be observed, as well as responsibilities for implementation of corrective actions.

7.1.3 Natural Disaster or Catastrophic Event

USACE-Mobile and Cobb County acknowledge the potential for natural disasters (e.g., flood, tornado, wildfire, drought, etc.) or other catastrophic events (e.g., vandalism, encroachment) to negatively impact project success. Both entities are aware that any such events will require action to address the event. The likelihood of an event such as a hurricane-related storm event causing excessive flooding and streambank erosion is uncertain; however, it is recognized that northern Georgia is subject to these weather events. At the other extreme, drought may limit instream baseflows and reduce the chances of successful establishment of vegetation. Risk associated with environmental conditions and its inherent uncertainty is similar among all project alternatives.

Should a natural disaster or catastrophic event take place prior to construction but following design altering the site conditions, during construction, or within the first three years following construction completion, USACE-Mobile and Cobb County will collaborate to develop a mutually agreeable course of action to mitigate any adverse impacts caused by the event. This risk can be addressed, and the cost necessary to implement corrective action will be based on the federal (65 percent)/non-federal (35 percent) cost-share basis. Should a natural disaster or catastrophic event take place following the 3-year post-construction period, then any required corrective action would be the responsibility of the non-federal sponsor.

7.1.4 Residual Risks

By utilizing natural channel design techniques and re-establishing natural processes as part of the aquatic ecosystem restoration plan, minimal long-term management or maintenance beyond the 3-year post-construction monitoring period is anticipated. However, some degree of risk and uncertainty is inherent to the planning and implementation of any aquatic ecosystem restoration project. These risks and uncertainties should be characterized, to the extent possible, early-on in the planning process such that adaptive management and contingency plans can be established to promptly address unforeseen conditions. Ecosystem damages (if any) noted during this time will be addressed by USACE-Mobile and Cobb County in a mutually agreeable, collaborative effort. Any ecosystem damage occurring beyond the 3-year post-construction monitoring period will be considered "residual risk." Residual risks (including prolonged or excessive maintenance or repairs) are possible, although unexpected, following project completion. One way to assess the likelihood of this risk is by implementing a post-construction monitoring plan (see Appendix I to the Detailed Project Report). The procedures to address these residual risks will be developed and outlined in an Adaptive Management and Contingency Plan and a Long-Term Management and Maintenance Plan. Addressing residual risks will be the responsibility of the non-federal sponsor.

7.2 Environmental Uncertainties

Similar to the potential environmental risks described above, environmental uncertainties are also inherent to water resources and aquatic ecosystem restoration projects. Uncertainties are primarily related to the variability of environmental conditions, including climate, land use, and hydrology, as well as the accuracy and consistency of data collection techniques. The uncertainties discussed below include:

- Physical performance
- Future environmental conditions (land use, meteorological conditions, etc.)
- Accuracy of data collection and analysis techniques

7.2.1 Physical Performance

Each of the alternatives formulated for Butler Creek watershed aquatic ecosystem restoration was evaluated based on predicted future benefits (quantified by habitat units), through processes described previously and utilizing the IWR Planning Suite. The predicted benefits were used to establish specific performance standards for the Recommended Plan, as identified in Section 1 of the Detailed Project Report. Although "actual" performance is expected to closely follow "predicted" performance, intermediate and long-term success could either lag behind or exceed predicted results. This uncertainty of physical performance must be considered throughout the planning process, including during alternative formulation, alternative plan selection, and Recommended Plan implementation.

7.2.2 Future Environmental Conditions

Projected future environmental conditions were based on the Cobb County Comprehensive Plan, and specifically the future land use plan that has been adopted (Cobb County, 2008).

However, land use changes and development in the watershed may not follow these patterns, which would affect the accuracy of the model results as well as the accuracy of the potential change in biological metrics that was projected for the habitat units. Cobb County zoning and development ordinances will provide assurances to restoration benefits; however, local impacts to the watershed may differ from the assumptions developed for modeling purposes. The effectiveness of Cobb County's development ordinances also adds some uncertainty to the future watershed conditions developed in the modeling. In particular, this effectiveness could affect assumptions related to hydrology changes in the watershed, especially peak flows and velocities.

At a more local scale, upstream conditions may impact the ability of a restoration alternative to meet its success criteria. Stream physical habitat conditions on property outside the limits of a project reach may degrade due to localized conditions such as bank erosion, leading to mass wasting of a streambank and sediment loading to the channel. Meteorological changes altering the long-term water cycle such as changes in precipitation and air temperature may influence stream base flows and other physical habitat characteristics within the watershed. These changes are slow to occur over time; however, over the 50-year planning period, these changes may be significant enough to influence the potential success of aquatic ecosystem restoration.

Environmental risks and uncertainties at each potential site are being addressed by conducting Phase I and Phase II environmental site assessments. Considerations include previous land uses and the potential for any site contamination which could affect the health of aquatic ecosystems and safety of construction.

7.2.3 Accuracy of Data Collection and Analysis Techniques

The projection of future habitat assessment scores, which form the basis for selection of the Tentatively Selected Plan for Butler Creek, relies on evaluation of historical data and on current data collection and analysis. The habitat assessment data provides some degree of uncertainty, due to the subjective nature of some assessments as well as the consistency of the sampling team from year to year. In order to reduce the uncertainty from the data collection and analysis, habitat assessments based on the GAEPD Standard Operating Procedures (SOPs) have been used for each year which data was analyzed, and data was evaluated for similar levels of effort and sampling season. In addition, one habitat score was developed based on a reference reach to represent each of various restoration scenarios, including existing conditions, and future without project conditions. This assumption may reduce any artificial differences observed when comparing future with project conditions. However, the data collection and analysis is expected to provide some uncertainty in the prediction of future habitat assessment scores.

7.3 Sensitivity Analysis

A sensitivity analysis is provided to account the variability in predicted habitat units and to establish a range of uncertainty in the predicted values. Although extensive modeling and analysis were conducted to predict habitat units scores, subjectivity in applying judgment to the scoring process and unforeseen changes in environmental conditions contribute to uncertainty in actual scores. It was assumed that uncertainty in the future score prediction was less than 50 percent of the projected change from future without project conditions, with unique future without project conditions habitat units scores based on habitat assessment score and contributing watershed area determined for each alternative. Variability in projected benefits for each of the alternatives is similar in terms of percent deviation from the predicted values. Therefore, overall variability increases as predicted benefits increase. Figure 7-1 represents the range of the risk of uncertainty that can be expected for projected future habitat units scores for each alternative selected for further environmental analysis.

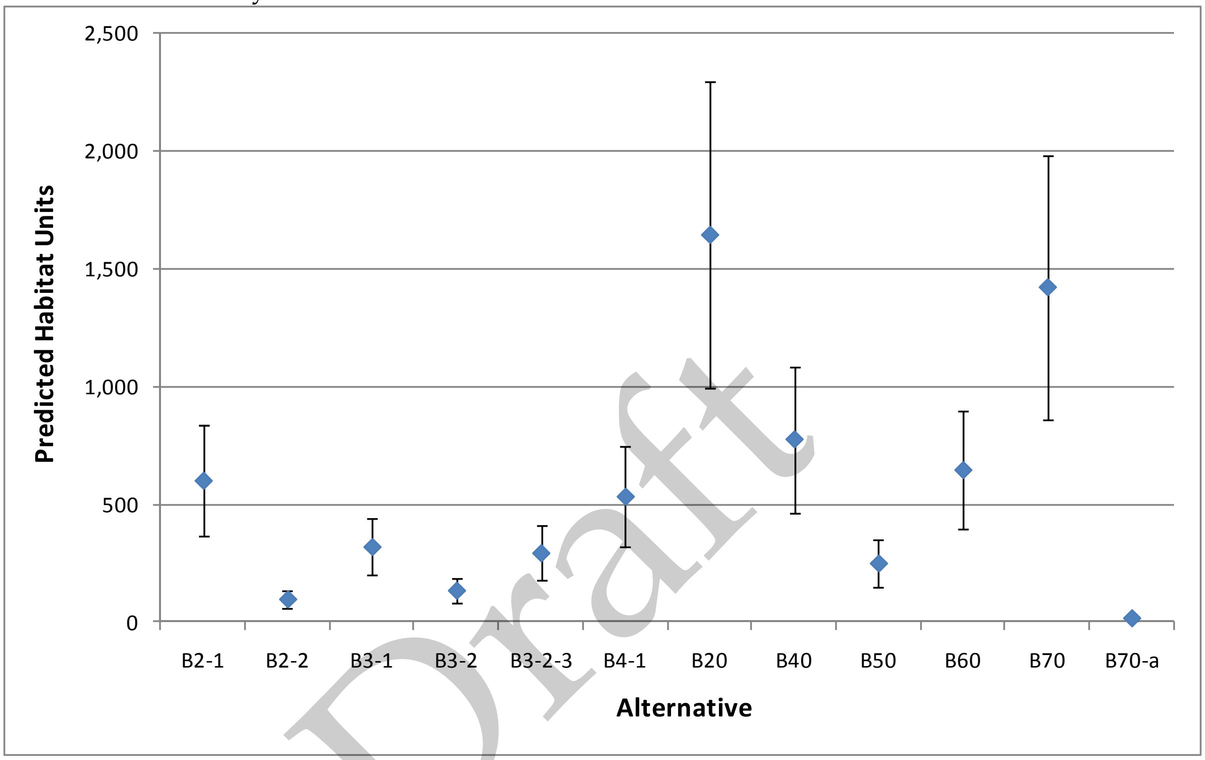


FIGURE 7-1
Range of Uncertainty Analysis in the Prediction of Habitat Units
Butler Creek Watershed Detailed Project Report – Environmental Appendix

Risks and uncertainties are associated with the implementation of any aquatic ecosystem restoration project in the Butler Creek watershed. While many of the risks are low as they can be mitigated to some extent during the planning and implementation phases of a project, risks may affect the ability of a restoration project to meet planning objectives. Uncertainties may also affect the ability of a restoration project to meet its planning objectives.

8. References

Atlanta Regional Commission (ARC), AMEC Earth and Environmental, Center for Watershed Protection, Debo and Associates, and Jordan Jones, and Goulding. 2001. *Georgia Stormwater Management Manual*, Volumes 1 and 2. First Edition – August 2001.

Barbour, M. T., K. J. Gerritsen, B. D. Snyder, and J. B. Stribling. 1999. *Rapid Bioassessment Protocols for Use in Streams and Wadeable Rivers: Benthic Macroinvertebrates and Fish, Second Edition*. EPA 841-B-98-002. U.S. Environmental Protection Agency Office of Water. Washington DC.

Cobb County Development Agency. 2008. Mapping Our Future: 2030 Comprehensive Plan Community Agenda. Adopted July 23, 2007; revised January 15, 2008.

Cobb County Water System (CCWS). 2009. Cobb County Watershed Protection Plan Biennial Report April 2005 through March 2007.

Cobb County Water System (CCWS). 2007. Cobb County Watershed Protection Plan Biennial Report April 2003 through March 2005.

Cobb County Water System (CCWS). 2002. *Cobb County Watershed Protection Plan.*

Entrix, Inc. 2002a. *Ecosystem Restoration Report – Problem Areas Report, Butler, Proctor, and Allatoona Creek Watersheds, Cobb County, Georgia*. Prepared for the U.S. Army Corps of Engineers Mobile District.

Entrix, Inc. 2002b. *Ecosystem Restoration Report – Planning Objectives and Restoration Measures, Butler, Proctor, and Allatoona Creek Watersheds, Cobb County, Georgia*. Prepared for the U.S. Army Corps of Engineers Mobile District.

Freeman, Byron J., Seth Wenger, Jane Rogers, and Megan Hagler. 2003. Fish Community Analysis of Allatoona, Butler, and Proctor Creek Watersheds, Etowah River Basin, Cobb County, Georgia. University of Georgia Institute of Ecology. Prepared for U.S. Army Corps of Engineers-Mobile District and Entrix, Inc.

Georgia Department of Natural Resources (GADNR). 2005. *Standard Operating Procedures for Conducting Biomonitoring on Fish Communities in Wadeable Streams of Georgia*. Wildlife Resources Division, Fisheries Management Section.

Georgia Department of Natural Resources (GADNR). 2007. *Standard Operating Procedures for Macroinvertebrate Biological Assessment of Wadeable Streams in Georgia*. Environmental Protection Division, Watershed Protection Branch, Atlanta, Georgia.

Georgia Department of Natural Resources (GADNR). 2009. *Total Maximum Daily Load Evaluation for Forty-Nine Stream Segments in the Coosa River Basin for Sediment (Biota Impacted)*. Submitted to USEPA, Region 4. January 2009.

Georgia Environmental Protection Division (GAEPD). 2004. Total Maximum Daily Load Evaluation for Fifty-Eight Stream Segments in the Coosa River Basin for Fecal Coliform Submitted to USEPA, Region 4. January 2004.

Georgia Environmental Protection Division (GAEPD). 2009. *Draft Total Maximum Daily Load Evaluation for Two Segments of Lake Allatoona in the Coosa River Basin for Chlorophyll a*. Submitted to USEPA, Region 4.

Georgia Environmental Protection Division (GAEPD). 2010. *Draft State 305(b)/303(d) List of Waters.* Georgia Department of Natural Resources Environmental Protection Division, Atlanta.

Karr, J. R., K. D. Fausch, P. L. Angermeier, P. R. Yant, and I. J. Schlosser. 1986. *Assessing Biological Integrity in Running Waters, a Method and Its Rationale.* Illinois Natural History Survey Special Publication 5.

Laenen, A., and D. Dunnette. 1997. *River Quality: Dynamics and Restoration*. Lewis Publishers. Boca Raton, FL.

Newton, B., et al. 1998. Stream Visual Assessment Protocol. Natural Resources Conservation Service, National Water and Climate Center, Portland Oregon (Technical Note 99-1).

Trawick, Dean, Matthew Lang, Inez Bergerson, and Maria Chin. Butler Creek Aquatic Ecosystem Restoration Project. Proceedings of the 2005 Georgia Water Resources Conference, held April 25–27, 2005, at The University of Georgia. Athens, Georgia.

U.S. Army Corps of Engineers (USACE). 2000. *Planning Guidance Notebook*. Engineering Regulation No. 1105-2-100. CECE-P- Headquarters, Civil Works, Planning and Policy Division. Washington, D.C.

U.S. Army Corps of Engineers (USACE). 2001. *Preliminary Restoration Plan, Aquatic Ecosystem Restoration Project, Butler Creek Watershed, Georgia.* Atlanta, Georgia.

U.S. Environmental Protection Agency, Office of Water. 1997*. Volunteer Stream Monitoring: A Methods Manual*. EPA 841-B-97-003. Washington DC.

U.S. Environmental Protection Agency. 2000. *Ambient Water Quality Criteria Recommendations – Rivers and Streams in Nutrient Ecoregion IX*. EPA 822-B-00-019. Washington, D.C.

U.S. Fish and Wildlife Service (USFWS). 2009. Etowah Aquatic Habitat Conservation Plan.

U.S. Fish and Wildlife Service (USFWS). 2007. Biological opinion for the USACE's proposed ecosystem restoration plan for Butler Creek, Cobb County, on the federally threatened Cherokee darter. Signed February 13, 2007.

Water Resources Development Act of 1996. Section 206. Public Law 104–303. October 12, 1996.

Appendix G
Economic Appendix

U.S. ARMY CORPS OF ENGINEERS

Butler Creek Ecosystem Restoration Study

Draft Economic Appendix

4/30/2011

Draft Economic Appendix

Table of Contents

<u>List of Tables</u>

1.0 Butler Creek Watershed Ecosystem Restoration: Cost Effectiveness and Incremental Cost Analysis

This section describes the economic evaluation of proposed ecosystem restoration measures within the Butler Creek watershed.

1.0.1. Study Area

Figure 1.0-1 shows the location of the Butler Creek watershed in relation to the State of Georgia and Cobb County. The Butler Creek watershed is a portion of the Cobb County Priority Area 2 watershed. Butler Creek, located in northwest Georgia, is a tributary to Lake Acworth, a sub-impoundment of Lake Allatoona and has a total drainage area of 9.4 square miles. The total study area is 6,016 acres.

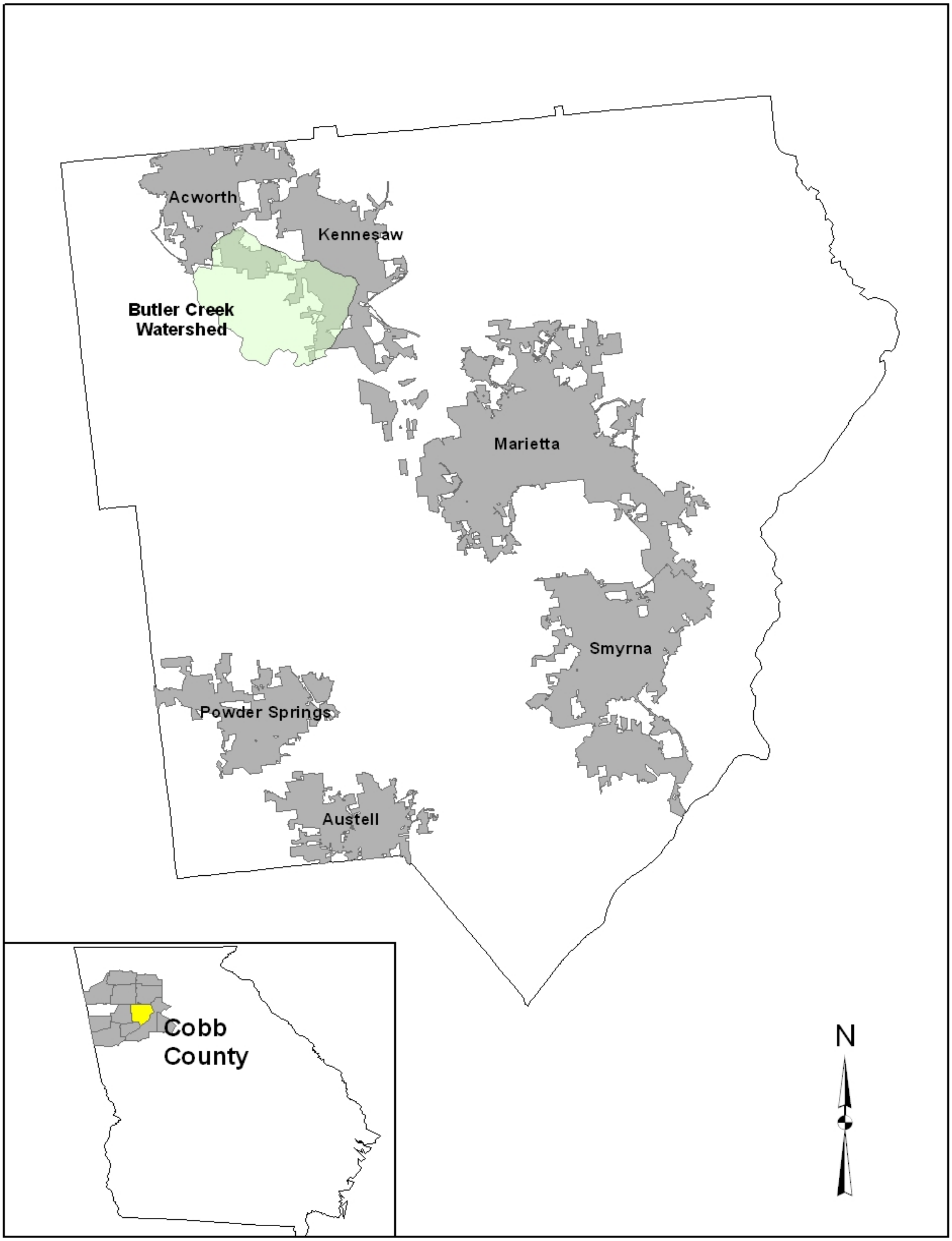


Figure 1.0-1. Butler Creek Ecosystem Restoration Study Area

1.0.2. Problems

After several site surveys the PDT identified several problems in the Butler Creek watershed:

- Scarcity of riffle/pool habitats critical to the Cherokee darter(*Etheostoma scotti*), a federally threatened species, and for othersensitive aquatic species
- 303(d) listing for impacted fish communities
- Decline in native, intolerant fish, and macroinvertebrate species
- Hydrologic channel impacts including a limited connection to thefloodplain and more intense peak instream flow velocities, which result in decreased habitat use for native, sensitive fish andmacroinvertebrate species
- A high degree of instream sedimentation and substrate embeddedness, which is reducing the availability and quality of instream habitat

1.0.3. Objectives

The following objectives were developed for this ecosystem restoration study:

- To create sustainable riffle/pool habitats at 8 locations throughout the watershed
- Restore stream habitats to support diverse fish communities in Butler Creek
- Restore native, intolerant aquatic species and increase species richness/evenness in the watershed
- Restore natural flow regimes to a practicable extent and reconnect the stream to the floodplain to dissipate peak flow velocities, which increases the quality of instream and riparian habitat
- Reduce embedded habitat by improving bank stability and limiting sedimentation from riparian areas

1.0.4. Opportunities

Potential solutions include extended detention-created wetlands, detention basins, and various methods of streambank stabilization specifically:

- To create sustainable riffle/pool habitats at 8 locations throughout the watershed
- To delist Butler Creek for impacted fish communities.
- To increase the richness and evenness of native fish and benthic macroinvertebrates by adding at least 3 species at 3 restored locations in the watershed over the next 25 years
- Develop retention basins, detention ponds, or riparian wetlands at 8 locations throughout the watershed, in order to restore floodplain function and rehabilitate altered flow regimes
- To implement stream channel restoration measures, including both stream stabilization and grade control across approximately 3,500 feet throughout the watershed

1.05. Formulation of Alternatives

1.0.5.1. Ecosystem Restoration Management Measures

There are a total of 10 proposed restoration management measures for this study listed in Table 1.0-1. Management measures are defined as the building blocks of alternatives to meet the planning objectives. Measures included extended detention created wetlands, detention basin retrofits, and streambank stabilization measures. Figure 1.0-3 gives the project sites for the potential measures with respect to the study area. Figure 1.0-2 displays the locations of the project sites of the potential ecosystem restoration measures.

Table 1.0-1.
Ecosystem Restoration Management Measures

Potential Ecosystem Restoration Measures	Description
No Action	No Action
B2-1, B20, B60, B70, B70-A,B3-2-3	Extended Detention Created Wetlands
B3-1	Detention Basin Retrofits
B3-2, B2-2, B50, B40, B4-1,	Streambank Stabilization Measures

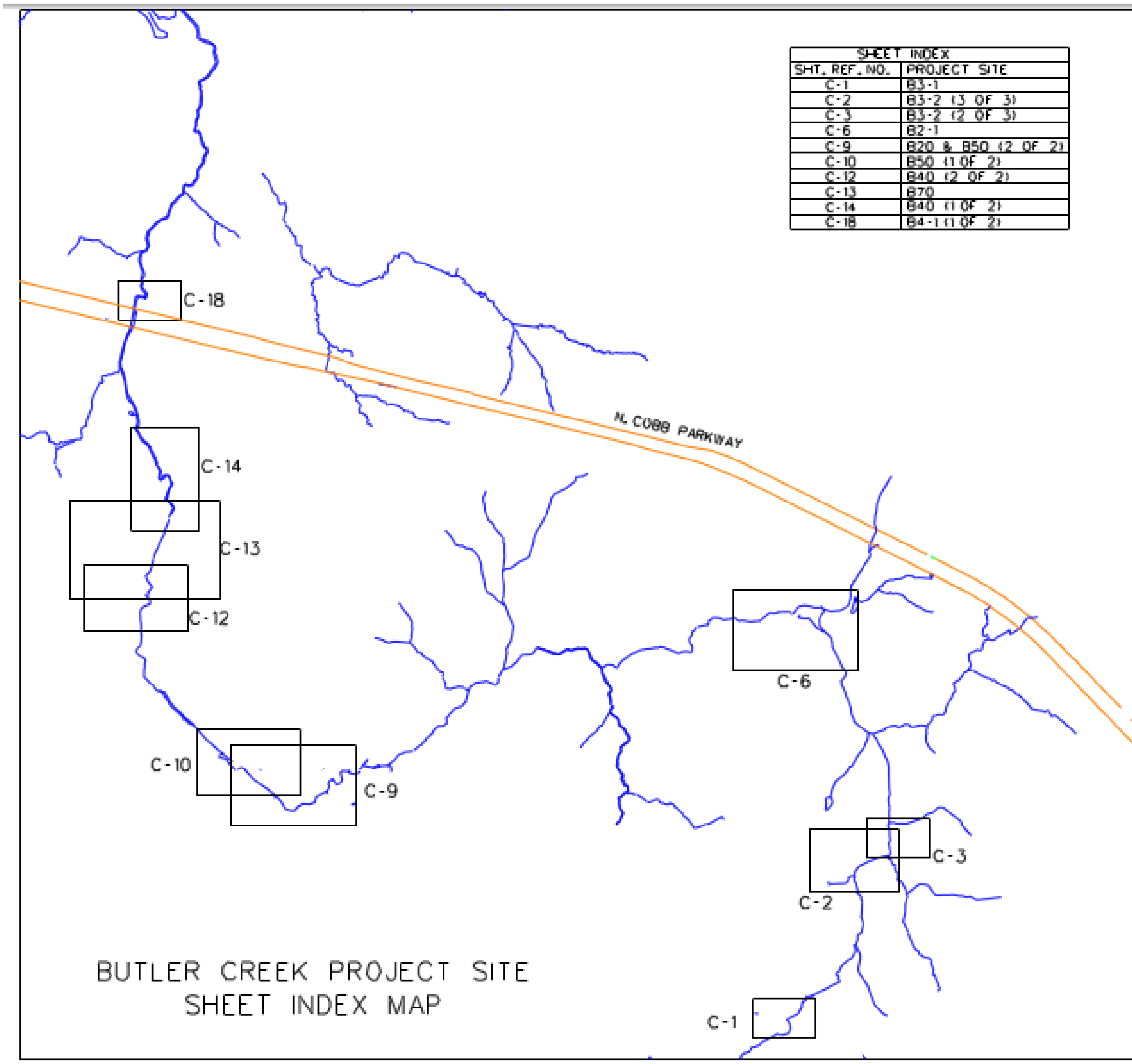


Figure 1.0-2 Project site locations of restoration measures

1.0.5.1.1. Extended Detention Created Wetlands

Extended Detention (ED) created wetland measures are considered at four locations within the Butler Creek watershed. The potential project ecosystem restoration measures include B2-1, B20, B60, B70, and B 3-2-3. B70-A is a bridge that will be used as passage for the Darter fish. It is included in this management measure group because B70 has a dependent relationship with it.

The purpose of the ED created wetland areas is to detain the more frequent flood flows, create aquatic habitat by providing necessary depths and vegetative cover, remove pollutants by vegetative filtering, and remove some sediment with sediment forebays.

The extended detention basins are designed to contain the runoff from small storms with return periods of 2-years or less. Each detention basin is designed with an emergency spillway to handle the runoff from storms with return periods greater than 2-years and up to 10 years. These outlet structures were designed to gradually reduce basin elevations from a full, overtopping state to normal pool levels within 24 hours. The runoff from storms with return periods greater than 10 years would overflow the basins, and repairs to the containment berms or outlet structures may become necessary.

1.0.5.1.2. Detention Basin Retrofits

Detention basin retrofit measures are considered at one location within the Butler Creek Watershed. The potential project ecosystem restoration measure include:B3-1. The purpose of this measure is to retrofit the existing basins and their outlet structures to enable detention of runoff from the 2-year frequency flows for a 24-hour period during storm events. These basins are classified as dry basins because there is little or no flow through them except during rain events. The retrofitted detention basins would also serve to reduce the water quantity impacts to existing developed areas on the downstream reaches. Dry detention basins provide limited pollutant removal benefits and are not intended for water quality treatment (Georgia Stormwater Management Manual). Retrofitting the basins and outlet structures would involve excavation and/or construction of berms to contain and direct flow toward the outlet, and stabilization or reconstruction of the outlet structure to control the rate of flow from the basin.

1.0.5.1.3. Streambank Stabilization Measures

The objective of the streambank restoration plan is to stabilize the streambanks where active erosion is occurring using methods appropriate for enhancing aquatic habitat in the urban setting. The potential project ecosystem restoration measures include B3-2, B2-2, B50, B40, B4-1.

Systematic changes caused by urbanization in the watershed have increased the frequency and duration of the flows in the streams from stormwater runoff. Streambank erosion occurs as the channel cross section adjusts to these changes. Increased streambank erosion is one of the major causes of the degradation of the streams in the Butler watershed. Sediment loads from active streambank erosion create conditions within the stream channels that severely limit the aquatic habitat and diversity.

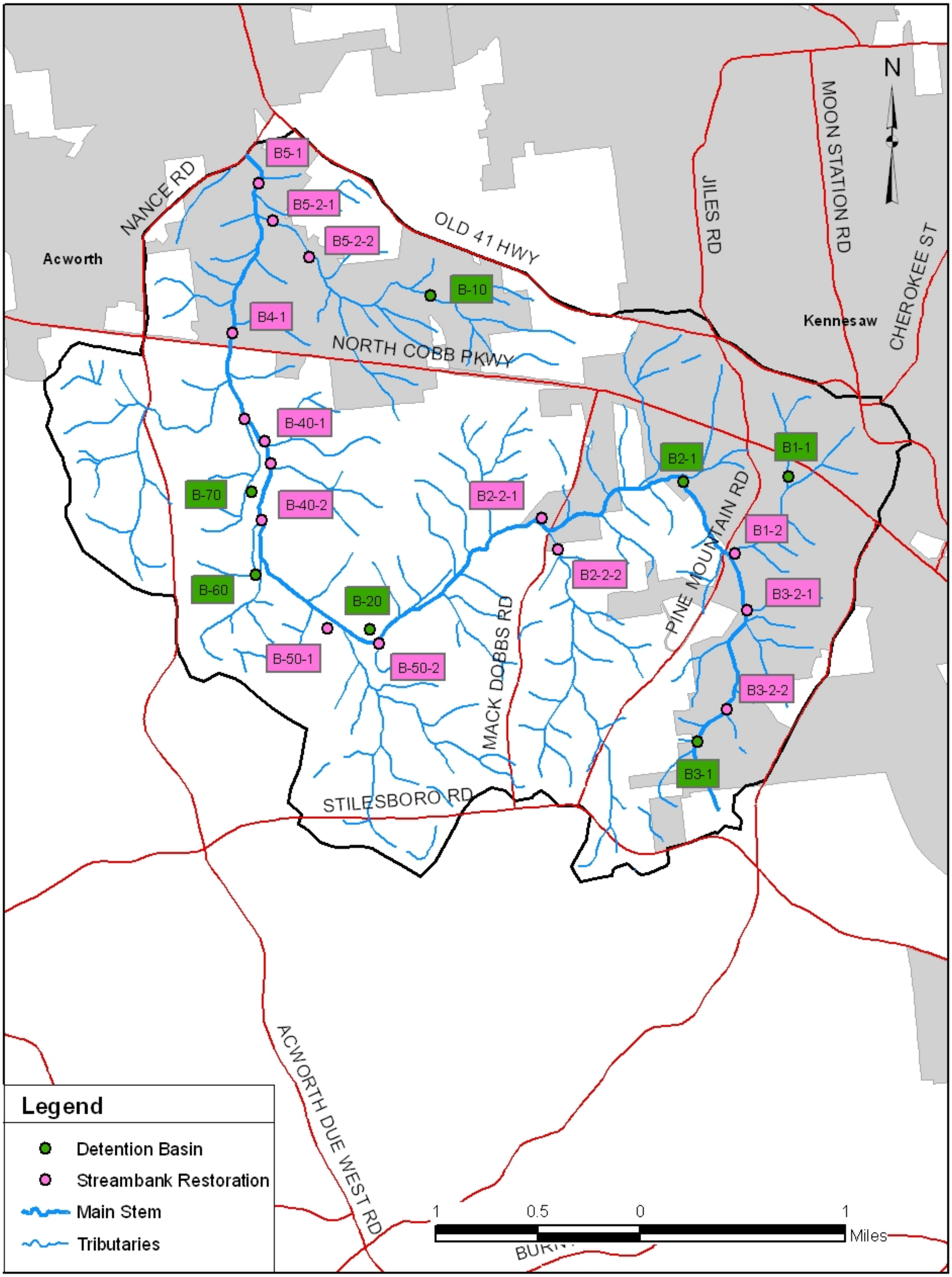


Figure 1.0-3: Location of Potential Project Restoration Measures

1.0.5.2. Ecosystem Restoration Components

Components are defined as one or more management measures. Since streambank stabilization long-term success relies on a nearby ED created wetland or detention basin retrofit, some streambank stabilization management measures were combined with an ED created wetland or detention basin retrofit management measure within a similar location along the watershed. For example, long-term success for streambank stabilization for sites B40 and B50 depend upon the presence of the B20 ED created wetland. Also, streambank stabilization for site B4-1 is dependent upon the B70 ED created wetland and the B70 ED created wetland is dependent upon the B70-A Bridge. As a result, the 13 management measures, now become 10 components. Table 1.0-2 displays each ecosystem restoration component.

Table 1.0-2.
Ecosystem Restoration Components

Component	Description
1	No Action
2	B3-1 Retro
3	B50SB+B20Det
4	B2-1 Det
5	B3-2SB
6	B2-2SB
7	B70Det+B70-ABridge+B4-1SB
8	B60 Det
9	B3-2-3
10	B40

1.0.5.2.1. Benefits of Components

Benefits are measured in terms of Average Annual Habitat Units (AAHU). The habitat assessment protocol, which provides a basic level of stream health evaluation that is based on physical conditions within the assessment area, Hydrologic Engineering Center Hydrologic Modeling System (HEC-HMS), HEC-2, and Watershed Characterization System Sediment Tool Extension were used to develop habitat scores. Habitat scores for each component are multiplied by the acres they affect to determine the Average Annual Habitat Units (AAHU) for each component. Table 1.0-3 shows the AAHUs for each component. The AAHU's for the no action zone were not calculated at the watershed level. The With Out Project Condition (WOPC) AAHU's were calculated for each area and then was compared to the With Project condition (WPC) The Net AAHU reflects the lift from the WOPC to the WPC. Refer to the Environmental Appendix for more detail.

Table 1.0-3.
AAHUs of Components

Component	Description	AAHUs	Net AAHU
1	No Action	0	0
2	B3-1 Retro	319	236.5
3	B50SB+B20Det	1891	1495
4	B2-1 Det	600	467
5	B3-2SB	134	107
6	B2-2SB	98	78
7	B70Det+B70-ABridge+B4-1SB	1970	1559
8	B60 Det	645	504
9	B3-2-3	293	232.3
10	B40	776	620

1.0.5.2.2. Costs of Components

The total first cost of construction includes construction costs, a contingency cost of 20 percent, lands and damages cost, Planning, Engineering and Design (PED) costs of 10 percent and a Construction Management cost of 6%.

The first cost plus Interest During Construction (IDC) equals the total investment cost. The construction time used for calculating IDC for EDs and retrofits are estimated at six months and streambank restoration is estimated at nine months.

The total investment cost is amortized at the Fiscal Year (FY) 2011 Federal discount rate of 4.125 percent over a 50-year economic period of analysis to calculate the Average Annual Investment Cost (AAIC). Average Annual O&M (AAO&M) costs were present valued and amortized at an interest rate of 4.125 percent over a 50-year economic period of analysis. The sum of the AAIC and AAO&M cost equals the Average Annual Costs (AAC).

For each component, the first costs of construction, IDC, investment cost, AAIC, AAO&M, cost and AAC are presented in Table 1.0-4

Refer to the Engineering Appendix for more details.

Table 1.0-4.
Costs of Components

(Fiscal Year 2008 Prices and Interest Rate (4.125%) over a 50 Year Economic Period of Analysis)

COMPONENTS	DESCRIPTION	FIRST COST	IDC	INVESTMENT COST	AAIC	AAO&M	AAC
1	No Action	$0	$0	$0	$0	$0	$0
2	B3-1 Retro	$47,000	$400	$47,400	$2,000	$2,200	$4,200
3	B50SB+B20Det	$929,000	$8,200	$937,200	$45,000	$9,102	$54,102
4	B2-1 Det	$250,000	$2,100	$252,100	$12,000	$5,712	$17,712
5	B3-2SB	$66,000	$800	$66,800	$3,000	$1,841	$4,841
6	B2-2SB	$96,000	$1,300	$97,300	$5,000	$1,940	$6,940
7	B70Det+B70-ABridge+B4-1SB	$1,485,000	$14,300	$1,499,300	$71,000	$9,211	$80,211
8	B60 Det	$525,000	$4,500	$529,500	$25,000	$6,013	$31,013
9	B3-2-3	$142,000	$200	$142,200	$7,000	$3,786	$10,786
10	B40	$226,000	$3,100	$229,100	$11,000	$1,993	$12,993

1.0.6. Evaluation and Comparison of Alternatives

1.0.6.1. Overview

Cost Effectiveness and Incremental Cost Analyses (CE/ICA) evaluate alternative plans for ecosystem restoration to assist decision makers in selecting a National Ecosystem Restoration (NER) plan. The process ensures the NER plan meets the planning objectives and constraints while meeting tests of completeness, acceptability, efficiency, and effectiveness.

1.0.6.2. Procedural Guidelines

This analysis is based on and follows guidance from the US Army Corps of Engineers Institute for Water Resources publication, Evaluation of Environmental Investment Procedures Manual, Interim: Cost Effectiveness and Incremental Analyses, May 1995, IWR Report #95-R-1 and Cost Effectiveness Analysis for Environmental Planning: Nine Easy Steps, October 1994, IWR Report 94-PS-2.

1.0.6.3 CE/ICA

Given the AAC and AAHUs of each component, the Institute for Water Resources' Planning Suite Model which generates the CE/ICA was used to determine the sequencing of the components and development of the final alternatives. The Cost-Effective Analysis evaluates the effectiveness of each alternative and determines which alternatives are cost-effective or the least costly for a given level of output. Essentially for a given output, no other alternative is less costly and no other alternative has a higher level of output for a lower cost. The Incremental Cost Analysis evaluates the efficiency of the cost-effective alternatives to determine which alternatives are Best Buy alternatives.

The Period of Analysis for the study was 50 years. Costs are stated in 2008 dollars and the FY 2011 federal discount rate of 4.125% was used for amortization purposes.

An alternative is an action that utilizes one or more components. All combinations of the 10 potential ecosystem restoration components created 512 different alternatives. Fourty-three of these alternatives were cost effective. Ten were "Best Buy" alternatives. The first "Best Buy" alternative is the component with the least incremental AAC per AAHU. The second "Best Buy" alternative includes the first "Best Buy" alternative plus the next component that has the least incremental AAC per NetAAHU. This pattern continues until the last "Best Buy" alternative is identified. The last "Best Buy" alternative always includes all the components. The figure below shows the full array of possible alternatives including non-cost-effective, cost- effective and best buy plans.

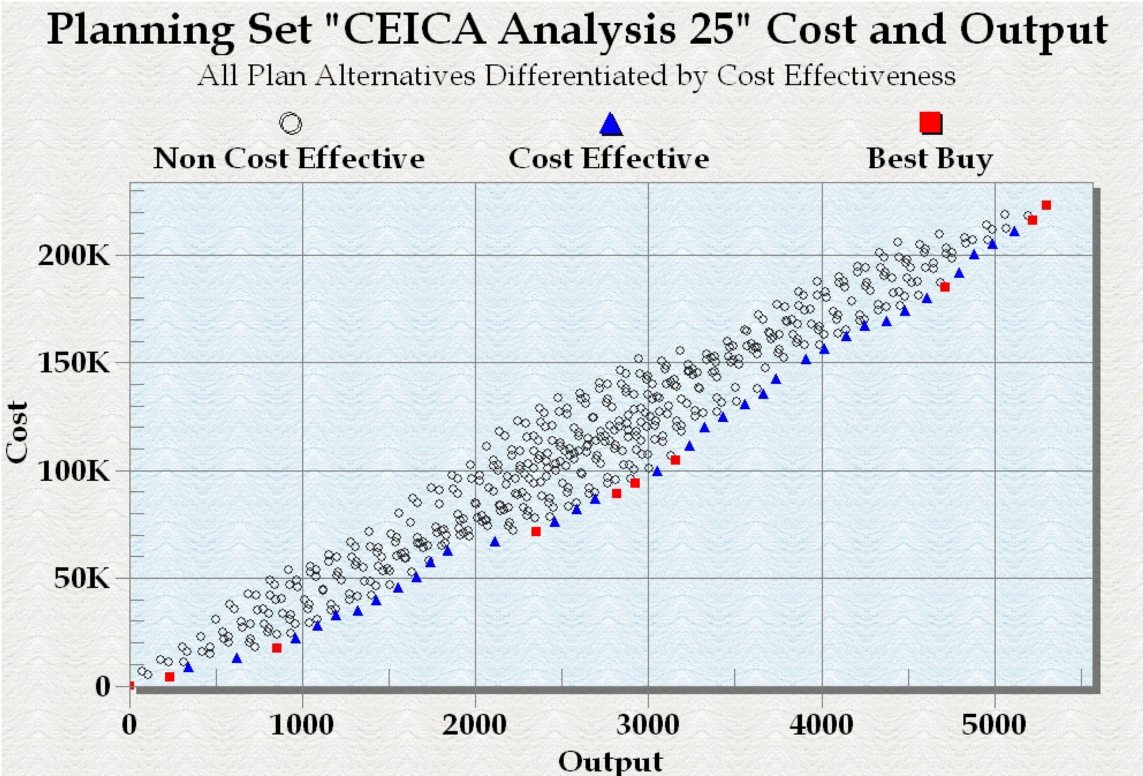


Figure 1.0-3

Table 1.0-5. illustrates the AAHUs of each alternative as a result of combining the component to form alternatives. The alternatives displayed are the final array of alternatives that were identified as "Best Buys"

Table 1.0-5.
AAHUs of Alternatives

ALTERNATIVES	DESCRIPTION	AAHU	Net AAHU
1	No Action	0	0
2	+B3-1 Retro	319	236.5
3	+B40	1095	620
4	+B50SB+B20Det	2986	1495
5	+B2-1	3586	467
6	+B3-2SB	3720	107
7	+B3-2-3	4013	232.3
8	+B70Det+B70-ABridge+B4-1SB	5983	1559
9	+B60 Det	6628	504
10	+B2-2SB	6726	78

As shown in Table 1.0-6, in combining ecosystem restoration components to form alternatives, cost from the prior alternative is added to the next alternative.

Table 1.0-6.
Costs of Alternatives

(Fiscal Year 2008 Prices and FY 2011 Interest Rate (4.125%) over a 50 Year Economic Period of Analysis)

ALTERNATIVES	DESCRIPTION	FIRST COST	IDC	INVESTMENT COST	AAIC	AAO&M	AAC
1	No Action	$0	$0	$0	$0	$0	$0
2	+B3-1 Retro	$47,000	$400	$47,400	$2,000	$2,200	$4,200
3	+B40	$273,000	$2,400	$275,400	$13,000	$4,200	$17,200
4	+B50SB+B20Det	$1,202,000	$11,700	$1,213,700	$58,000	$13,300	$71,295
5	+B2-1	$1,452,000	$13,800	$1,465,800	$70,000	$19,000	$89,007
6	+B3-2SB	$1,518,000	$14,600	$1,532,600	$73,000	$20,800	$93,848
7	+B3-2-3	$1,660,000	$14,800	$1,674,800	$80,000	$24,600	$104,635
8	+B70Det+B70-ABridge+B4-1SB	$3,145,000	$29,100	$3,174,100	$151,000	$33,846	$184,846
9	+B60 Det	$3,670,000	$33,600	$3,703,600	$176,000	$39,859	$215,859
10	+B2-2SB	$3,766,000	$34,900	$3,800,900	$181,000	$41,799	$222,799

In order to determine the cost effectiveness of each alternative, the list of alternatives is ordered so that they are listed in increasing order of their outputs (AAHU).

To determine if an alternative is cost effective, economically inefficient alternatives must first be identified and eliminated. An economically inefficient alternative is an alternative that cost more for the same level of benefit. Since each alternative produces a different level of AAHU, alternatives are not eliminated for the reason of economic inefficiency.

Lastly, economically ineffective alternatives are identified and eliminated to determine which alternatives are cost effective. An economically ineffective alternative is an alternative that cost more than the subsequent alternative but produces less benefit than that subsequent alternative.

To determine which of the cost effective alternatives are "best buy" alternatives, an iterative analysis is conducted that calculates average costs, identifies an alternative with the lowest average cost, eliminates alternatives with levels of output less than this alternative and advances levels of output greater than the lowest average level of output to the next step. So once the first iteration establishes the lowest average cost level of output, the next iteration is conducted with the previous step's lowest average cost level of output as the zero level of output. This process is repeated until the final level of output is identified as the lowest average cost level of output. The final result is a series of alternatives with the lowest average cost for additional output. From this series of alternatives, an incremental cost analysis is performed.

An incremental cost is the difference in cost between two solutions by the difference in output between the same two solutions. The word "incremental" means "additional". What is being measured is the additional AAC for an additional AAHU between alternatives ranked in ascending order of output. For example, the additional AAC is $4,200 and the additional AAHU is 236.5 from the "No Action" alternative to Alternative 2 (B3-1Retrofit). This results in an incremental AAC per NetAAHU of $17.76 for each of the first 236.5 AAHUs. To determine which "best buy" alternative to select, the question of "Is it worth it?" must be answered by the decision makers. Is the additional cost of the next alternative worth its additional output? Or in other words, for the next "best buy" alternative's additional output is it worth the additional AAC per AAHU?

Table 1.0-7 displays the incremental AAC per AAHU for each "Best Buy" alternative. Figure 1.0-3 displays Incremental AAC per AAHU for each level of output.

Table 1.0-7.
Best Buy Alternatives

ALTERNATIVES	DESCRIPTION	AAC	AAHU	INCREMENTAL AAC	INCREMENTAL Net AAHU	INCREMENTAL AAC per AAHU
1	No Action	$0	0	$0	0	$0.00
2	+B3-1 Retro	$4,200	319	$4,200	236.5	$17.76
3	+B40	$17,200	1095	$13,000	620	$20.97
4	+B50SB+B20Det	$71,295	2986	$54,095	1495	$36.18
5	+B2-1	$89,007	3586	$17,712	467	$37.93
6	+B3-2SB	$93,848	3720	$4,841	107	$45.24
7	+B3-2-3	$104,635	4013	$10,786	232.3	$46.43
8	+B70Det+B70-ABridge+B4-1SB	$184,846	5983	$80,211	1559	$51.45
9	+B60 Det	$215,859	6628	$31,013	504	$61.53
10	+B2-2SB	$222,799	6726	$6,940	78	$88.98

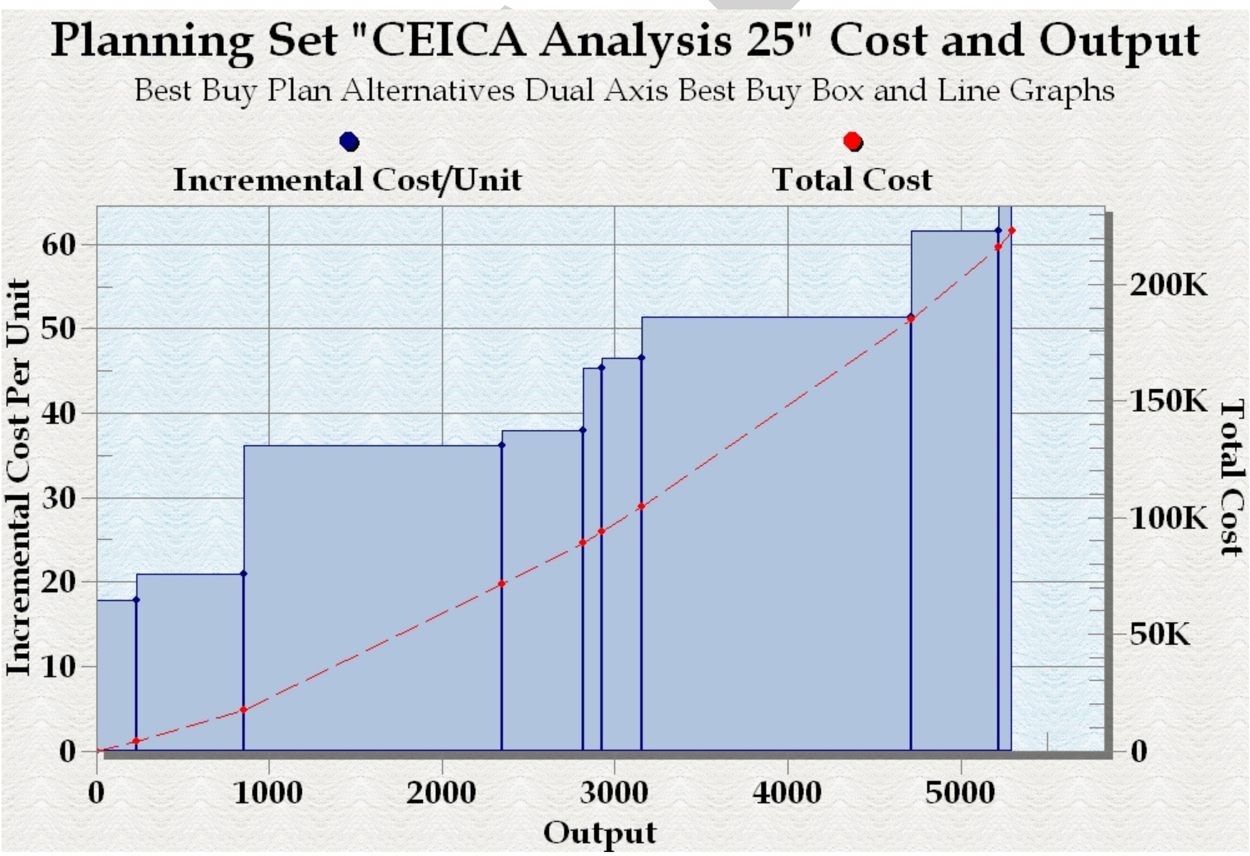


Figure 1.0-4. Display of Best Buy Alternatives for the Butler Creek Ecosystem Restoration.

1.0.7 Tentatively Selected Plan

This study began with an array 38 potenital project sites which were screened based on the ability to meet the engineering requirements and meet the project opportunites and objectives. Before the CE/ICA was used to evaluate the measures the measure array was narrowed down to 10 measures, including the “No Action” alternative. A total of 512 alternatives were generated and 43 were cost-effective. The final array of Best Buy plans consisted of 10 alternatives. Best Buy 8 was identified as the tentatively selected plan based on its ability to meet the project objectives, cost feasibility considering both the sponsor and the authority limits, as well as providing a sufficient amount of ecosystem benefits at an acceptable cost.

Appendix H
Cost Engineering Appendix

**** TOTAL PROJECT COST SUMMARY ****

PROJECT: Butler Creek Watershed Aquatic Ecosystem Restoration Project
LOCATION: Cobb County, Georgia

DISTRICT: Mobile
POC: CHIEF, COST ENGINEERING, [redacted]
PREPARED: 5/9/2011

This Estimate reflects the scope and schedule in report; Butler Creek Watershed Aquatic Ecosystem Restoration Project Feasibility Report - Cost Engineering Appendix and Engineering Appendix

Program Year (Budget EC): 2012
Effective Price Level Date: 1 OCT 11

WBS NUMBER	Civil Works Feature & Sub-Feature Description	COST ($K)	CNTG ($K)	CNTG (%)	BASE COST TOTAL ($K)	ESC (%)	COST ($K)	CNTG ($K)	FIRST COST TOTAL ($K)	FULLY FUNDED PROJECT ESTIMATE Spent Thru: 18-Apr-11 ($K)		COST ($K)	CNTG ($K)	FULL ($K)
A	*B*	*C*	*D*	*E*	*F*	*G*	*H*	*I*	*J*	*K*	*L*	*M*	*N*	*O*
15	FLOODWAY CONTROL & DIVERSION STF	$2,461	$591	24%	$3,052	0.7%	$2,478	$595	**$3,072**			$2,603	$625	$3,228
	CONSTRUCTION ESTIMATE TOTALS:	$2,461	$591		**$3,052**	0.7%	$2,478	$595	**$3,072**			$2,603	$625	$3,228
01	LANDS AND DAMAGES	$368	$92	25%	$460	0.7%	$371	$93	$463			$375	$94	$468
30	PLANNING, ENGINEERING & DESIGN	$322	$77	24%	$399	0.5%	$324	$78	**$401**	1,157		$339	$81	$1,577
31	CONSTRUCTION MANAGEMENT	$222	$53	24%	$275	0.5%	$223	$54	**$277**			$248	$60	$307
	PROJECT COST TOTALS:	$3,373	$813	24%	**$4,186**	0.6%	$3,395	$818	**$4,213**	1,157		$3,564	$859	$5,581

ESTIMATED FEDERAL COST:	65%	**$3,627**
ESTIMATED NON-FEDERAL COST:	35%	**$1,953**
ESTIMATED TOTAL PROJECT COST:		**$5,581**

O&M OUTSIDE OF TOTAL PROJECT COST:

**** TOTAL PROJECT COST SUMMARY ****

**** CONTRACT COST SUMMARY ****

PROJECT: Butler Creek Watershed Aquatic Ecosystem Restoration Project
LOCATION: Cobb County, Georgia
This Estimate reflects the scope and schedule in report; Butler Creek Watershed Aquatic Ecosystem Restoration Project Feasibility Report - Cost Engineering Appendix and Engineering Appendix

DISTRICT: Mobile
POC: CHIEF, COST ENGINEERING, [redacted]
PREPARED: 5/9/2011

Estimate Prepared: 18-Apr-11
Effective Price Level: 18-Apr-11

Program Year (Budget EC): 2012
Effective Price Level Date: 1 OCT 11

		RISK BASED								FULLY FUNDED PROJECT ESTIMATE				
WBS NUMBER	Civil Works Feature & Sub-Feature Description	COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	ESC (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	Mid-Point Date	ESC (%)	COST ($K)	CNTG ($K)	FULL ($K)
A	*B*	*C*	*D*	*E*	*F*	*G*	*H*	*I*	*J*	*P*	*L*	*M*	*N*	*O*
	PHASE 1													
15	FLOODWAY CONTROL & DIVERSION STF	$449	$108	24%	$557	0.7%	$452	$108	$561	2013Q4	2.8%	$465	$111	$576
	CONSTRUCTION ESTIMATE TOTALS:	$449	$108	24%	**$557**		$452	$108	$561			$465	$111	$576
01	LANDS AND DAMAGES	$111	$28	25%	$139	0.7%	$112	$28	$140	2012Q4	1.1%	$113	$28	$141
30	PLANNING, ENGINEERING & DESIGN													
1.0%	Project Management	$4	$1	24%	$5	0.5%	$4	$1	$5	2012Q4	1.7%	$4	$1	$5
1.0%	Planning & Environmental Compliance	$4	$1	24%	$5	0.5%	$4	$1	$5	2012Q4	1.7%	$4	$1	$5
4.0%	Engineering & Design	$18	$4	24%	$22	0.5%	$18	$4	$22	2012Q4	1.7%	$18	$4	$23
1.0%	Engineering Tech Review ITR & VE	$4	$1	24%	$5	0.5%	$4	$1	$5	2012Q4	1.7%	$4	$1	$5
1.0%	Contracting & Reprographics	$4	$1	24%	$5	0.5%	$4	$1	$5	2012Q4	1.7%	$4	$1	$5
3.0%	Engineering During Construction	$13	$3	24%	$16	0.5%	$13	$3	$16	2013Q4	5.4%	$14	$3	$17
1.0%	Planning During Construction	$4	$1	24%	$5	0.5%	$4	$1	$5	2013Q4	5.4%	$4	$1	$5
1.0%	Project Operations	$4	$1	24%	$5	0.5%	$4	$1	$5	2012Q4	1.7%	$4	$1	$5
31	CONSTRUCTION MANAGEMENT													
6.0%	Construction Management	$27	$6	24%	$33	0.5%	$27	$7	$34	2013Q4	5.4%	$29	$7	$35
1.5%	Project Operation:	$7	$2	24%	$9	0.5%	$7	$2	$9	2013Q4	5.4%	$7	$2	$9
1.5%	Project Management	$7	$2	24%	$9	0.5%	$7	$2	$9	2013Q4	5.4%	$7	$2	$9
	CONTRACT COST TOTALS:	$656	$159		**$815**		$660	$160	$820			$678	$164	**$842**

**** TOTAL PROJECT COST SUMMARY ****

**** CONTRACT COST SUMMARY ****

PROJECT: Butler Creek Watershed Aquatic Ecosystem Restoration Project
LOCATION: Cobb County, Georgia
This Estimate reflects the scope and schedule in report; Butler Creek Watershed Aquatic Ecosystem Restoration Project Feasibility Report - Cost Engineering Appendix and Engineering Appendix

DISTRICT: Mobile
POC: CHIEF, COST ENGINEERING, [redacted]
PREPARED: 5/9/2011

Estimate Prepared: 18-Apr-11
Effective Price Level: 18-Apr-11

Program Year (Budget EC): 2012
Effective Price Level Date: 1 OCT 11

FULLY FUNDED PROJECT ESTIMATE

WBS NUMBER A	Civil Works Feature & Sub-Feature Description B	COST ($K) C	CNTG ($K) D	CNTG (%) E	TOTAL ($K) F	ESC (%) G	COST ($K) H	CNTG ($K) I	TOTAL ($K) J	Mid-Point Date P	ESC (%) L	COST ($K) M	CNTG ($K) N	FULL ($K) O
	PHASE 2													
15	FLOODWAY CONTROL & DIVERSION STF	$850	$204	24%	$1,054	0.7%	$856	$205	$1,061	2014Q4	4.6%	$895	$215	$1,109
	CONSTRUCTION ESTIMATE TOTALS:	$850	$204	24%	**$1,054**		$856	$205	$1,061			$895	$215	$1,109
01	LANDS AND DAMAGES	$115	$29	25%	$143	0.7%	$115	$29	$144	2012Q4	1.1%	$117	$29	$146
30	PLANNING, ENGINEERING & DESIGN													
1.0%	Project Management	$9	$2	24%	$11	0.5%	$9	$2	$11	2012Q4	1.7%	$9	$2	$11
1.0%	Planning & Environmental Compliance	$9	$2	24%	$11	0.5%	$9	$2	$11	2012Q4	1.7%	$9	$2	$11
4.0%	Engineering & Design	$34	$8	24%	$42	0.5%	$34	$8	$42	2012Q4	1.7%	$35	$8	$43
1.0%	Engineering Tech Review ITR & VE	$9	$2	24%	$11	0.5%	$9	$2	$11	2012Q4	1.7%	$9	$2	$11
1.0%	Contracting & Reprographics	$9	$2	24%	$11	0.5%	$9	$2	$11	2012Q4	1.7%	$9	$2	$11
3.0%	Engineering During Construction	$26	$6	24%	$32	0.5%	$26	$6	$32	2014Q4	9.9%	$29	$7	$36
1.0%	Planning During Construction	$9	$2	24%	$11	0.5%	$9	$2	$11	2014Q4	9.9%	$10	$2	$12
1.0%	Project Operations	$9	$2	24%	$11	0.5%	$9	$2	$11	2012Q4	1.7%	$9	$2	$11
31	CONSTRUCTION MANAGEMENT													
6.0%	Construction Management	$51	$12	24%	$63	0.5%	$51	$12	$64	2014Q4	9.9%	$56	$14	$70
1.5%	Project Operation:	$13	$3	24%	$16	0.5%	$13	$3	$16	2014Q4	9.9%	$14	$3	$18
1.5%	Project Management	$13	$3	24%	$16	0.5%	$13	$3	$16	2014Q4	9.9%	$14	$3	$18
	CONTRACT COST TOTALS:	$1,156	$278		**$1,434**		$1,163	$280	$1,443			$1,216	$293	**$1,509**

**** TOTAL PROJECT COST SUMMARY ****

PROJECT: Butler Creek Watershed Aquatic Ecosystem Restoration Project
LOCATION: Cobb County, Georgia
This Estimate reflects the scope and schedule in report; Butler Creek Watershed Aquatic Ecosystem Restoration Project Feasibility Report - Cost Engineering Appendix and Engineering Appendix

DISTRICT: Mobile
POC: CHIEF, COST ENGINEERING, [redacted]
PREPARED: 5/9/2011

Estimate Prepared: 18-Apr-11
Effective Price Level: 18-Apr-11

Program Year (Budget EC): 2012
Effective Price Level Date: 1 OCT 11

FULLY FUNDED PROJECT ESTIMATE

WBS NUMBER A	Civil Works Feature & Sub-Feature Description B	COST ($K) C	CNTG ($K) D	CNTG (%) E	TOTAL ($K) F	ESC (%) G	COST ($K) H	CNTG ($K) I	TOTAL ($K) J	Mid-Point Date P	ESC (%) L	COST ($K) M	CNTG ($K) N	FULL ($K) O
	PHASE 3													
15	FLOODWAY CONTROL & DIVERSION STF	$1,162	$279	24%	$1,441	0.7%	$1,170	$281	$1,451	2015Q4	6.3%	$1,244	$299	$1,543
	CONSTRUCTION ESTIMATE TOTALS:	$1,162	$279	24%	**$1,441**		$1,170	$281	$1,451			$1,244	$299	$1,543
01	LANDS AND DAMAGES	$143	$36	25%	$178	0.7%	$144	$36	$179	2012Q4	1.1%	$145	$36	$181
30	PLANNING, ENGINEERING & DESIGN													
1.0%	Project Management	$12	$3	24%	$15	0.5%	$12	$3	$15	2012Q4	1.7%	$12	$3	$15
1.0%	Planning & Environmental Compliance	$12	$3	24%	$15	0.5%	$12	$3	$15	2012Q4	1.7%	$12	$3	$15
4.0%	Engineering & Design	$46	$11	24%	$57	0.5%	$46	$11	$57	2012Q4	1.7%	$47	$11	$58
1.0%	Engineering Tech Review ITR & VE	$12	$3	24%	$15	0.5%	$12	$3	$15	2012Q4	1.7%	$12	$3	$15
1.0%	Contracting & Reprographics	$12	$3	24%	$15	0.5%	$12	$3	$15	2012Q4	1.7%	$12	$3	$15
3.0%	Engineering During Construction	$35	$8	24%	$43	0.5%	$35	$8	$44	2015Q4	14.3%	$40	$10	$50
1.0%	Planning During Construction	$12	$3	24%	$15	0.5%	$12	$3	$15	2015Q4	14.3%	$14	$3	$17
1.0%	Project Operations	$12	$3	24%	$15	0.5%	$12	$3	$15	2012Q4	1.7%	$12	$3	$15
31	CONSTRUCTION MANAGEMENT													
6.0%	Construction Management	$70	$17	24%	$87	0.5%	$70	$17	$87	2015Q4	14.3%	$80	$19	$100
1.5%	Project Operation:	$17	$4	24%	$21	0.5%	$17	$4	$21	2015Q4	14.3%	$20	$5	$24
1.5%	Project Management	$17	$4	24%	$21	0.5%	$17	$4	$21	2015Q4	14.3%	$20	$5	$24
	CONTRACT COST TOTALS:	$1,562	$376		**$1,938**		$1,572	$379	$1,950			$1,671	$402	**$2,073**

Appendix H, Attachment 1

Total Project Cost Summary Spreadsheet

**** TOTAL PROJECT COST SUMMARY ****

PROJECT: Butler Creek Watershed Aquatic Ecosystem Restoration Project
LOCATION: Cobb County, Georgia

DISTRICT: Mobile
PREPARED: 5/9/2011
POC: CHIEF, COST ENGINEERING, [redacted]

This Estimate reflects the scope and schedule in report; Butler Creek Watershed Aquatic Ecosystem Restoration Project Feasibility Report - Cost Engineering Appendix and Engineering Appendix

						Program Year (Budget EC): 2012								
						Effective Price Level Date: 1 OCT 11				FULLY FUNDED PROJECT ESTIMATE				
					BASE COST				**FIRST COST**	Spent Thru:				
WBS	Civil Works	COST	CNTG	CNTG	TOTAL	ESC	COST	CNTG	**TOTAL**	18-Apr-11		COST	CNTG	FULL
NUMBER	Feature & Sub-Feature Description	($K)	($K)	(%)	($K)	(%)	($K)	($K)	**($K)**	($K)		($K)	($K)	($K)
A	*B*	*C*	*D*	*E*	*F*	*G*	*H*	*I*	*J*	*K*	*L*	*M*	*N*	*O*
15	FLOODWAY CONTROL & DIVERSION STF	$2,461	$591	24%	$3,052	0.7%	$2,478	$595	**$3,072**			$2,603	$625	$3,228
	CONSTRUCTION ESTIMATE TOTALS:	$2,461	$591		**$3,052**	0.7%	$2,478	$595	**$3,072**			$2,603	$625	$3,228
01	LANDS AND DAMAGES	$368	$92	25%	$460	0.7%	$371	$93	$463			$375	$94	$468
30	PLANNING, ENGINEERING & DESIGN	$322	$77	24%	$399	0.5%	$324	$78	**$401**	1,157		$339	$81	$1,577
31	CONSTRUCTION MANAGEMENT	$222	$53	24%	$275	0.5%	$223	$54	**$277**			$248	$60	$307
	PROJECT COST TOTALS:	$3,373	$813	24%	**$4,186**	0.6%	$3,395	$818	**$4,213**	1,157		$3,564	$859	$5,581

[redacted]

ESTIMATED FEDERAL COST:	65%	**$3,627**
ESTIMATED NON-FEDERAL COST:	35%	**$1,953**
ESTIMATED TOTAL PROJECT COST:		**$5,581**

O&M OUTSIDE OF TOTAL PROJECT COST:

**** TOTAL PROJECT COST SUMMARY ****

**** CONTRACT COST SUMMARY ****

PROJECT: Butler Creek Watershed Aquatic Ecosystem Restoration Project
LOCATION: Cobb County, Georgia
This Estimate reflects the scope and schedule in report; Butler Creek Watershed Aquatic Ecosystem Restoration Project Feasibility Report - Cost Engineering Appendix and Engineering Appendix

DISTRICT: Mobile
POC: CHIEF, COST ENGINEERING, [redacted]
PREPARED: 5/9/2011

Estimate Prepared: 18-Apr-11
Effective Price Level: 18-Apr-11

Program Year (Budget EC): 2012
Effective Price Level Date: 1 OCT 11

				RISK BASED						FULLY FUNDED PROJECT ESTIMATE				
WBS NUMBER	Civil Works Feature & Sub-Feature Description	COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	ESC (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	Mid-Point Date	ESC (%)	COST ($K)	CNTG ($K)	FULL ($K)
A	*B*	*C*	*D*	*E*	*F*	*G*	*H*	*I*	*J*	*P*	*L*	*M*	*N*	*O*
	PHASE 1													
15	FLOODWAY CONTROL & DIVERSION STF	$449	$108	24%	$557	0.7%	$452	$108	$561	2013Q4	2.8%	$465	$111	$576
	CONSTRUCTION ESTIMATE TOTALS:	$449	$108	24%	**$557**		$452	$108	$561			$465	$111	$576
01	LANDS AND DAMAGES	$111	$28	25%	$139	0.7%	$112	$28	$140	2012Q4	1.1%	$113	$28	$141
30	PLANNING, ENGINEERING & DESIGN													
1.0%	Project Management	$4	$1	24%	$5	0.5%	$4	$1	$5	2012Q4	1.7%	$4	$1	$5
1.0%	Planning & Environmental Compliance	$4	$1	24%	$5	0.5%	$4	$1	$5	2012Q4	1.7%	$4	$1	$5
4.0%	Engineering & Design	$18	$4	24%	$22	0.5%	$18	$4	$22	2012Q4	1.7%	$18	$4	$23
1.0%	Engineering Tech Review ITR & VE	$4	$1	24%	$5	0.5%	$4	$1	$5	2012Q4	1.7%	$4	$1	$5
1.0%	Contracting & Reprographics	$4	$1	24%	$5	0.5%	$4	$1	$5	2012Q4	1.7%	$4	$1	$5
3.0%	Engineering During Construction	$13	$3	24%	$16	0.5%	$13	$3	$16	2013Q4	5.4%	$14	$3	$17
1.0%	Planning During Construction	$4	$1	24%	$5	0.5%	$4	$1	$5	2013Q4	5.4%	$4	$1	$5
1.0%	Project Operations	$4	$1	24%	$5	0.5%	$4	$1	$5	2012Q4	1.7%	$4	$1	$5
31	CONSTRUCTION MANAGEMENT													
6.0%	Construction Management	$27	$6	24%	$33	0.5%	$27	$7	$34	2013Q4	5.4%	$29	$7	$35
1.5%	Project Operation:	$7	$2	24%	$9	0.5%	$7	$2	$9	2013Q4	5.4%	$7	$2	$9
1.5%	Project Management	$7	$2	24%	$9	0.5%	$7	$2	$9	2013Q4	5.4%	$7	$2	$9
	CONTRACT COST TOTALS:	$656	$159		**$815**		$660	$160	$820			$678	$164	**$842**

**** TOTAL PROJECT COST SUMMARY ****

**** CONTRACT COST SUMMARY ****

PROJECT: Butler Creek Watershed Aquatic Ecosystem Restoration Project
LOCATION: Cobb County, Georgia
This Estimate reflects the scope and schedule in report; Butler Creek Watershed Aquatic Ecosystem Restoration Project Feasibility Report - Cost Engineering Appendix and Engineering Appendix

DISTRICT: Mobile
POC: CHIEF, COST ENGINEERING, [redacted]
PREPARED: 5/9/2011

Estimate Prepared: 18-Apr-11
Effective Price Level: 18-Apr-11

Program Year (Budget EC): 2012
Effective Price Level Date: 1 OCT 11

FULLY FUNDED PROJECT ESTIMATE

WBS NUMBER	Civil Works Feature & Sub-Feature Description	COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	ESC (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	Mid-Point Date	ESC (%)	COST ($K)	CNTG ($K)	FULL ($K)
A	*B*	*C*	*D*	*E*	*F*	*G*	*H*	*I*	*J*	*P*	*L*	*M*	*N*	*O*
	PHASE 2													
15	FLOODWAY CONTROL & DIVERSION STF	$850	$204	24%	$1,054	0.7%	$856	$205	$1,061	2014Q4	4.6%	$895	$215	$1,109
	CONSTRUCTION ESTIMATE TOTALS:	$850	$204	24%	**$1,054**		$856	$205	$1,061			$895	$215	$1,109
01	LANDS AND DAMAGES	$115	$29	25%	$143	0.7%	$115	$29	$144	2012Q4	1.1%	$117	$29	$146
30	PLANNING, ENGINEERING & DESIGN													
1.0%	Project Management	$9	$2	24%	$11	0.5%	$9	$2	$11	2012Q4	1.7%	$9	$2	$11
1.0%	Planning & Environmental Compliance	$9	$2	24%	$11	0.5%	$9	$2	$11	2012Q4	1.7%	$9	$2	$11
4.0%	Engineering & Design	$34	$8	24%	$42	0.5%	$34	$8	$42	2012Q4	1.7%	$35	$8	$43
1.0%	Engineering Tech Review ITR & VE	$9	$2	24%	$11	0.5%	$9	$2	$11	2012Q4	1.7%	$9	$2	$11
1.0%	Contracting & Reprographics	$9	$2	24%	$11	0.5%	$9	$2	$11	2012Q4	1.7%	$9	$2	$11
3.0%	Engineering During Construction	$26	$6	24%	$32	0.5%	$26	$6	$32	2014Q4	9.9%	$29	$7	$36
1.0%	Planning During Construction	$9	$2	24%	$11	0.5%	$9	$2	$11	2014Q4	9.9%	$10	$2	$12
1.0%	Project Operations	$9	$2	24%	$11	0.5%	$9	$2	$11	2012Q4	1.7%	$9	$2	$11
31	CONSTRUCTION MANAGEMENT													
6.0%	Construction Management	$51	$12	24%	$63	0.5%	$51	$12	$64	2014Q4	9.9%	$56	$14	$70
1.5%	Project Operation:	$13	$3	24%	$16	0.5%	$13	$3	$16	2014Q4	9.9%	$14	$3	$18
1.5%	Project Management	$13	$3	24%	$16	0.5%	$13	$3	$16	2014Q4	9.9%	$14	$3	$18
	CONTRACT COST TOTALS:	$1,156	$278		**$1,434**		$1,163	$280	$1,443			$1,216	$293	**$1,509**

**** TOTAL PROJECT COST SUMMARY ****

PROJECT: Butler Creek Watershed Aquatic Ecosystem Restoration Project
DISTRICT: Mobile
PREPARED: 5/9/2011
LOCATION: Cobb County, Georgia
POC: CHIEF, COST ENGINEERING, [redacted]
This Estimate reflects the scope and schedule in report; Butler Creek Watershed Aquatic Ecosystem Restoration Project Feasibility Report - Cost Engineering Appendix and Engineering Appendix

Estimate Prepared: 18-Apr-11
Effective Price Level: 18-Apr-11

Program Year (Budget EC): 2012
Effective Price Level Date: 1 OCT 11

FULLY FUNDED PROJECT ESTIMATE

WBS NUMBER	Civil Works Feature & Sub-Feature Description	COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	ESC (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	Mid-Point Date	ESC (%)	COST ($K)	CNTG ($K)	FULL ($K)
A	***B***	***C***	***D***	***E***	***F***	***G***	***H***	***I***	***J***	***P***	***L***	***M***	***N***	***O***
	PHASE 3													
15	FLOODWAY CONTROL & DIVERSION STF	$1,162	$279	24%	$1,441	0.7%	$1,170	$281	$1,451	2015Q4	6.3%	$1,244	$299	$1,543
	CONSTRUCTION ESTIMATE TOTALS:	$1,162	$279	24%	**$1,441**		$1,170	$281	$1,451			$1,244	$299	$1,543
01	LANDS AND DAMAGES	$143	$36	25%	$178	0.7%	$144	$36	$179	2012Q4	1.1%	$145	$36	$181
30	PLANNING, ENGINEERING & DESIGN													
1.0%	Project Management	$12	$3	24%	$15	0.5%	$12	$3	$15	2012Q4	1.7%	$12	$3	$15
1.0%	Planning & Environmental Compliance	$12	$3	24%	$15	0.5%	$12	$3	$15	2012Q4	1.7%	$12	$3	$15
4.0%	Engineering & Design	$46	$11	24%	$57	0.5%	$46	$11	$57	2012Q4	1.7%	$47	$11	$58
1.0%	Engineering Tech Review ITR & VE	$12	$3	24%	$15	0.5%	$12	$3	$15	2012Q4	1.7%	$12	$3	$15
1.0%	Contracting & Reprographics	$12	$3	24%	$15	0.5%	$12	$3	$15	2012Q4	1.7%	$12	$3	$15
3.0%	Engineering During Construction	$35	$8	24%	$43	0.5%	$35	$8	$44	2015Q4	14.3%	$40	$10	$50
1.0%	Planning During Construction	$12	$3	24%	$15	0.5%	$12	$3	$15	2015Q4	14.3%	$14	$3	$17
1.0%	Project Operations	$12	$3	24%	$15	0.5%	$12	$3	$15	2012Q4	1.7%	$12	$3	$15
31	CONSTRUCTION MANAGEMENT													
6.0%	Construction Management	$70	$17	24%	$87	0.5%	$70	$17	$87	2015Q4	14.3%	$80	$19	$100
1.5%	Project Operation:	$17	$4	24%	$21	0.5%	$17	$4	$21	2015Q4	14.3%	$20	$5	$24
1.5%	Project Management	$17	$4	24%	$21	0.5%	$17	$4	$21	2015Q4	14.3%	$20	$5	$24
	CONTRACT COST TOTALS:	$1,562	$376		**$1,938**		$1,572	$379	$1,950			$1,671	$402	**$2,073**

Appendix H, Attachment 2
MCACES Basis of Estimate

Butler Creek Ecosystem Restoration

Cobb County, Georgia

BASIS OF ESTIMATE

CH2MHILL

Project Name:	Butler Creek Watershed Section 206 Ecosystem Restoration
Class Estimate:	Class 3
Requested By:	[redacted]
Estimated By:	[redacted]
Estimator Phone:	678.530.4544
Estimate Date:	May 13, 2011

[redacted]
ESTIMATOR

Purpose of Estimate

The purpose of this Engineer's Estimate for Project Cost is to establish an Engineer's opinion of probable cost for construction of Tentatively Selected Plan at the preliminary design stage.

General Project Description

The U.S. Army Corps of Engineers (USACE) Mobile District has proposed an aquatic ecosystem restoration project under Section 206 of the Water Resources Development Act of 1996, as amended. The Tentatively Selected Plan is best buy alternative 8, which includes the alternative sites summarized in Table 1.

TABLE 1
Proposed Butler Creek Restoration Alternative

Alternative	Location/Access	Alternative Type	Alternative Description
B2-1	Wellcrest Drive	Extend Detention & Stormwater Wetland	Rerouting of portion of Butler Creek flow, at bankfull conditions, through a sediment forebay and into 1.5-acre extended detention created wetland basin
B3-1	Shillings Chase Court	Retention Basin Retrofit	Retrofit of an existing outlet control structure
B3-2	White Oak Court	Streambank Stabilization	Channel bench and toe protection along ~250 ft; native plantings in 0.25 acres of riparian zone
B3-2-3	Butler Ridge Park	Dry Extended Detention Pond	1.5-acre site to be converted to extended dry detention for attenuation of peak flows
B4-1	North of Cobb Parkway	Streambank Stabilization	Stone toe protection and rootwad combination along ~325 ft on left bank and ~250 ft on right bank
B20	Sewer easement from Jim Owens Road	Extend Detention & Stormwater Wetland	Rerouting of intermittent tributary and portion of Butler Creek flow, during storm events, through a sediment forebay and into 4.3-acre extended detention created wetland
B40 (1 of 2)	Loring Way and Loring Road	Streambank Stabilization	Installation of a velocity dissipator; stone toe protection along ~325 ft on right bank (in 2 segments)
B40 (2 of 2)	Sewer easement near Johnston Road	Streambank Stabilization	Bank shaping, stone toe protection, and vegetation along ~100 ft on left bank; ~250 ft of longitudinal peaked stone toe protection on right bank; vegetation of upper left and right banks

TABLE 1
Proposed Butler Creek Restoration Alternative

Alternative	Location/Access	Alternative Type	Alternative Description
B50	Sewer easement from Jim Owens Road	Streambank Stabilization	Near Loring Way: Stone protection along ~95 ft of longitudinal toe on right bank; ~95 feet of bank shaping, stone toe protection, and vegetation on left bank Near B20: Stone toe protection across ~315 feet
B70 & B70a	Loring Road	Extend Detention & Stormwater Wetland	Rerouting of intermittent tributary through a sediment forebay and into 9-acre extended detention created wetland and concrete bridge to facilitate fish passage

Overall Costs

Table 2 provides a summary of the rounded breakdown of construction costs. See attached breakdown for additional details.

TABLE 2
Summary of Rounded Construction Costs by Phase

Alternative	Contract Cost
Phase 1	
Flow Attenuation	
B2-1	$229,000
B3-1	$69,000
B3-2-3	$96,000
Streambank Stabilization	
B3-2	$55,000
Phase 1 Total	**$449,000**
Phase 2	
Flow Attenuation	
B20	$788,000
Streambank Stabilization	
B50	$62,000
Phase 2 Total	**$850,000**
Phase 3	
Flow Attenuation	
B70	$673,000
Streambank Stabilization	
B4-1	$314,000
B40	$175,000
Phase 3 Total	**$1,162,000**
Tentatively Selected Plan	**$2,461,000**

*** Per USACE-Mobile the above cost includes no escalation, design contingency, owner contingency, or SIOH.**

Markups Phase

The following typical contractor markups were applied to the Cost Estimate:

Owner Markups

Sales Tax	6%
Contingency	0%
SIOH	0%

Contractors Markups

JOOH	10%
HOOH	8%
Profit	8%
Bond	1.09%
Design Contingency	0%

Subcontractor Markups

Sub HOOH	12%
Sub JOOH	8%
Sub Profit	8%

Contingency and Escalation

There is no contingency or escalation provided in this basis of estimate. Contingency and escalation for the project are included in the Total Project Cost Summary spreadsheet (Attachment 1 to the Cost Engineering Appendix). Contingency was calculated using the 35% CWE Contingency Analysis for projects less than $40 million (Attachment 3 to the Cost Engineering Appendix). Escalation was calculated using the Total Project Cost Summary Spreadsheet (Attachment 1 to the Cost Engineering Appendix). Escalation calculation sheets are also provided as an attachment to this basis of estimate for computation of escalation over the next 5 years

Estimate Classification

This cost estimate prepared is considered a class 3 Budget Level as defined by the ASTM E2516. It is considered accurate to +20% to -30%.

The cost estimates shown, which include any resulting conclusions on project financial or economic feasibility or funding requirements, have been prepared for guidance in project evaluation and implementation from the information available at the time of the estimate. The final costs of the project and resulting feasibility will depend on actual labor and material costs, competitive market conditions, actual site conditions, final project scope, implementation schedule, continuity of personnel and engineering, and other variable factors. Therefore, the final project costs will vary from the estimate presented here. Because of these factors, project feasibility, benefit/cost ratios, risks, and funding needs must be carefully reviewed prior to making specific financial decisions or establishing project budgets to help ensure proper project evaluation and adequate funding.

Cost Resources

The following is a list of the various cost resources used in the development of the cost estimate.

- R.S. Means as published in 2008 MII Cost Library
- R.S. Means *Site Work and Landscape Cost Data*, 29th edition, 2010
- Mechanical Contractors Association - Labor Manual
- National Electrical Contractors Association - Labor Unit Manual (NECA)
- CH2M HILL Historical Data
- Estimator Judgment
- MII Labor & Equipment Libraries
- Labor unit pricing based on the Davis Bacon wage rates for Cobb county, GA, revision date 10/22/2010.

Estimate Methodology

This cost estimate is considered a bottom rolled up type estimate with detailed cost items and breakdown of Labor, Materials and Equipment. The estimate may include allowance cost and dollars per SF cost for certain components of the estimate.

Major Assumptions

The estimate is based on the assumption the work will be done on a competitive bid basis and the contractor will have a reasonable amount of time to complete the work, with a reasonable project schedule, no overtime, constructed under a single contract, without liquidated damages. This estimate should be evaluated for market changes after 90 days of the issue date.

It is assumed that the construction contract will be executed in 3 phases, each phase having a duration of approximately 175 days.

General Site Work Assumptions:

1. Construction access to all project sites will be available from a combination of public right-of-way, existing sanitary sewer easement, or newly acquired construction access easements (with costs for easements included under Account 01 – Lands and Damages). Land acquisition costs included within this estimate are based on recent (2010) real estate appraisals completed by USACE - Mobile.
2. Construction quantities and conceptual designs provided by USACE-Mobile were used as a basis of this estimate. Conceptual design plates are included as part of the Cost Appendix.
3. Unit prices used within this estimate were derived from a variety of sources, but checked for consistency with available unit pricing from recent and local construction projects consisting of similar construction elements and features.
4. The cost estimate is considered to be a class 3 budget level estimate as defined by ASTM E2516, and is considered accurate to +20% to -30%. There is no contingency or escalation included in this estimate.

Mobilization/Demobilization:

1. Anticipated construction equipment is indicated in the mobilization folder, with equipment expected to include dozers, loaders, excavators and dump trucks.
2. Time is included in this task for the project manager (above time normally considered under JOOH) to oversee loading and unloading of equipment, establishment of staging areas, site entrances and security, construction access roads, maintenance of traffic, signage, and coordination with local/adjacent property owners.

Clearing and Grubbing:

1. Clearing and grubbing includes removal of trees (up to 6-inch diameter), stumps and shrubs necessary to access the site, and remove existing vegetation from the existing streambanks within the limits of the proposed restoration.

2. Materials cleared from the project site will be loaded into dump trucks and transported to an approved dump/landfill.
3. Costs included for clearing (per acre) are based on recent bids, with consideration given to existing site conditions and density/size of vegetation to be removed. Clearing and grubbing costs generally range from less than $1000 per acre to $5000 per acre, depending upon conditions.

Earthwork and Grading:

1. For stream restoration sites, required grading is limited to that portion of the existing stream banks proposed to be reshaped and stabilized using turf matrix and willow stakes. Slopes generally do not exceed 2:1 (horizontal to vertical) with banks averaging approximately 4 to 8 feet in height. Grading will be achieved using a combination of backhoe and hand labor. Only minor earthwork is required, as banks will be reshaped using existing on-site material.
2. Streambanks that have been cleared and re-graded will be stabilized using a combination of geotextile fabric, seed and willow stakes. Additional bank stabilization measures will include placement of rip rap, rootwads, and longitudinal peaked stone toe protection.
3. Earthwork quantities have been calculated from the conceptual design drawings and include separate quantities/costs for material to the excavated and hauled off-site, material excavated that may remain on-site, and material hauled to the site and placed as fill.

Riprap and Stone:

1. Riprap will be a combination of GDOT Type 1 and Type 3 riprap, with unit pricing based on a cubic yard basis.
2. Stone used to stabilize stream restoration sites (longitudinal peaked stone toe protection) is also estimated on a cubic yard basis, assuming the no grading will be required prior to placement.
3. This estimate assumes that the contractor is paid for the volume of stone purchased, brought to the site, and installed. Measurement and payment is assumed to be by truck volume, not as measured in place.

Vegetation and Riparian Restoration:

1. Riparian buffers will be established using a combination of native hardwood plantings; including trees, shrubs, and seedlings.
2. Unit prices for riparian restoration are based largely on recent bid prices (per acre) for riparian restoration of similar type, species, and density proposed.
3. Unit prices for willow posts (stream restoration sites) were derived from average bid prices for recent projects located within the region.

Fencing:

1. Silt fencing is assumed to be type C silt fence, with unit prices per linear foot including wooden posts and trenching in of the fabric at the base of the silt fence. Costs also include maintenance and removal of temporary fencing.

2. Chain link fencing is assumed to be 6 feet in height, with quantities based of fencing the perimeter of flow attenuation sites.

Structures and Piping:

1. Flow attenuation sites will include some piping to facilitate flow diversion to, and regulated discharge from the stormwater storage basins. Piping is assumed to be corrugated metal pipe, with the discharge regulated using a corrugated metal pipe riser.
2. Pipe end treatments (headwalls or flared end sections) will be provided, and costs for such are included as part of the linear foot cost estimated for pipe installation. Unit prices for piping further include excavation, bedding, and backfill.
3. The outlet control structure for site B3-1 is a concrete weir, replacing the existing weir. The existing weir has undermined and the opening for flow is too large to provide stormwater attenuation. Demolition and removal of the existing concrete weir is proposed.
4. Site B-70 includes demolition and removal of an existing concrete culvert, and replacement with a bridge to facilitate fish passage. Costs for culvert removal and replacement with a bridge are provided, including costs associated with concrete bridge abutments.

Articulated Concrete Matting:

1. Articulated concrete matting is used for stream restoration site B2-1. The matting is assumed to be 6 inches in thickness. Unit pricing (per square yard) includes materials and delivery cost, as well as labor and equipment cost for installation.

Rootwads:

1. Materials for rootwads and footer logs will be obtained from on-site trees, and are assumed to be approximately 10" to 12" in diameter.
2. Pricing of rootwads was derived primarily using available unit price bids for similar work within the region (prices ranging from $1000 to $1500 per rootwad, installed).

Excluded Costs

The cost estimate excludes the following costs:

- Non-construction or soft costs for design, services during construction, legal and owner administration costs.
- Material Adjustment allowances above and beyond what is included at the time of the cost estimate.

Reference Documents

Construction quantities and conceptual design plans were provided by USACE-Mobile.

Butler Creek

Scope and Description of Alternative B2-1:
Rerouting of intermittent tributary through a sediment forebay and into 1.5-acre extended detention created wetland basin and construction include: clear and grubbing, earth fill, excavation off site and on site, 24" CMP, 30" CMP riser with appurtenances, seeding and mulching, wetland planting, articulated concrete mat, rip rap, and fencing.

Scope and Description of Alternative B3-1:
Retrofit of an existing OCS, construction includes temporary access roads, demolition and concrete outlet

Scope and Description of Alternative B3-2-3:
Diversion structure from Butler Creek to channel water above baseflow into detention pond, construction includes: clear and grubbing, earth fill, excavation off site and on site, 18" CMP, 30" CMP riser with appurtenances, seeding and mulching and rip rap.

Scope and Description of Alternative B3-2:
Channel bench and toe protection along ~250 ft; native plantings in 0.25 acres of riparian zone, construction includes: access road, site work, logitudinal peaked stone toe, bank shaping excavation, willow post planting, grassing and environment protection

Scope and Description of Alternative B20:
Rerouting of intermittent tributary through a sediment forebay and into 4.3-acre extended detention created wetland, construction includes: clear and grubbing, earth fill, excavation off site and on site, 42" CMP, 30" CMP riser with appurtenances, seeding and mulching, wetland planting, rip rap, and fencing.

Scope and Description of Alternative B50:
Stone protection of ~95 ft of longitudinal toe on right bank and ~95 feet of bank shaping, toe protection, and vegetation on left bank, construction includes: access roads, site work, filter fabic, longitudinal peaked stone toe, grassing, willow post planting and environement protection

Scope and Description of Alternative B70:
Rerouting of intermittent tributary through a sediment forebay and into 9-acre extended detention created wetland and concrete bridge to facilitate fish passage, construction includes: clear and grubbing, earth fill, excavation off site and on site, demolition of existing structure, precast concrete bridge, concrete abutment, 42" CMP, 30" CMP riser with appurtenances, seeding and mulching, wetland planting, rip rap, and fencing.

Scope and Description of Alternative B4-1:
Stone toe protection and rootwad combination along ~270 ft on right streambank and ~210 ft on left streambank, construction includes: access road, site work, logitudinal peaked stone toe, rootwad structure, willow post planting, grassing and environment protection

Scope and Description of Alternative B40:
Installation of a velocity dissipator; stone toe protection along ~150 ft on right bank; ~450 ft of stone toe protection and rootwad combination structures on right bank and 280 ft on left bank; two cross vanes within a 400-ft reach downstream of stone toe/rootwad; vegetation of upper banks. Bank shaping, stone toe protection, and vegetation along ~150 ft on left bank; ~250 ft of longitudinal peaked stone toe protection on right bank; vegetation of upper left and right banks, construction includes: access roads, site work, bank shaping excavation, filter fabric, longitudinal peaked stone toe, rip rap 18" velocity dissipator, rootwad structure, grassing, willow post planting and environement protection

Estimated by	[redacted]
Designed by	
Prepared by	[redacted]
Preparation Date	4/18/2011
Effective Date of Pricing	4/18/2011
Estimated Construction Time	525 Days

For Official Use Only.

Designed by

Estimated by
[redacted]

Prepared by
[redacted]

Design Document
Document Date 4/15/2011
District Mobile
Contact [redacted]
Budget Year 2011
UOM System Original

Direct Costs
LaborCost
EQCost
MatlCost
SubBidCost

Timeline/Currency
Preparation Date 4/18/2011
Escalation Date 4/18/2011
Eff. Pricing Date 4/18/2011
Estimated Duration 525 Day(s)

Currency US dollars
Exchange Rate 1.000000

Costbook CB08EB: MII English Cost Book 2008

Labor LNS2009: Up to Date per Cobb County, GA - Davis Bacon Wage Rate (10-22-2010)

Labor Rates
LaborCost1
LaborCost2
LaborCost3
LaborCost4

Equipment EP07R03: MII Equipment Region 3r 2007
Note: Up to dat as of 4-18-2011

03 SOUTHEAST	
Sales Tax	6.00
Working Hours per Year	1,530
Labor Adjustment Factor	0.83
Cost of Money	5.25
Cost of Money Discount	25.00
Tire Recap Cost Factor	1.50
Tire Recap Wear Factor	1.80
Tire Repair Factor	0.15
Equipment Cost Factor	1.00
Standby Depreciation Factor	0.50

Fuel	
Electricity	0.090
Gas	3.610
Diesel Off-Road	3.890
Diesel On-Road	3.890

Shipping Rates	
Over 0 CWT	10.26
Over 240 CWT	9.59
Over 300 CWT	8.41
Over 400 CWT	7.64
Over 500 CWT	4.49
Over 700 CWT	4.36
Over 800 CWT	4.99

Date	Author	Note
4/15/2011	General Site Work Assumptions:	1. The estimate is based on the assumption the work will be done on a competitive bid basis and the contractor will have a reasonable amount of time to complete the work, with a reasonable project schedule, no overtime, constructed under a single contract, without liquidated damages. This estimate should be evaluated for market changes after 90 days of the issue date.
4/15/2011		2. It is assumed that the construction contract will be executed in 3 phases, each phase having a duration of approximately 175 days.
4/15/2011		3. Construction access to all project sites will be available from a combination of public right-of-way, existing sanitary sewer easement, or newly acquired construction access easements (with costs for easements included under Account 01 - Lands and Damages). Land acquisition costs included within this estimate are based on recent (2010) real estate appraisals completed by USACE - Mobile.
4/15/2011		4. Construction quantities and conceptual designs provided by USACE-Mobile were used as a basis of this estimate. Conceptual design plates are included as part of the Cost Appendix.
4/15/2011		5. Unit prices used within this estimate were derived from a variety of sources, but checked for consistency with available unit pricing from recent and local construction projects consisting of similar construction elements and features.
4/15/2011		6. The cost estimate is considered to be a class 3 budget level estimate as defined by ASTM E2516, and is considered accurate to +20% to -30%. There is no contingency or escalation included in this estimate
4/15/2011	Mobilization/Demobilization:	1. Anticipated construction equipment is indicated in the mobilization folder, with equipment expected to include dozers, loaders, excavators and dump trucks.
4/15/2011		2. Time is included in this task for the project manager (above time normally considered under JOOH) to oversee loading and unloading of equipment, establishment of staging areas, site entrances and security, construction access roads, maintenance of traffic, signage, and coordination with local/adjacent property owners.
4/15/2011	Clearing and Grubbing:	1. Clearing and grubbing includes removal of trees (up to 6-inch diameter), stumps and shrubs necessary to access the site, and remove existing vegetation from the existing streambanks within the limits of the proposed restoration.
4/15/2011		2. Materials cleared from the project site will be loaded into dump trucks and transported to an approved dump/landfill.
4/15/2011		3. Costs included for clearing (per acre) are based on recent bids, with consideration given to existing site conditions and density/size of vegetation to be removed. Clearing and grubbing costs generally range from less than $1000 per acre to $5000 per acre, depending upon conditions.
4/15/2011	Earthwork and Grading:	1. For stream restoration sites, required grading is limited to that portion of the existing stream banks proposed to be reshaped and stabilized using turf matrix and willow stakes. Slopes generally do not exceed 2:1 (horizontal to vertical) with banks averaging approximately 4 to 8 feet in height. Grading will be achieved using a combination of backhoe and hand labor. Only minor earthwork is required, as banks will be reshaped using existing on-site material.
4/15/2011		2. Streambanks that have been cleared and re-graded will be stabilized using a combination of geotextile fabric, seed and willow stakes. Additional bank stabilization measures will include placement of rip rap, rootwads, and longitudinal peaked stone toe protection.
4/15/2011		3. Earthwork quantities have been calculated from the conceptual design drawings and include separate quantities/costs for material to the excavated and hauled off-site, material excavated that may remain on-site, and material hauled to the site and placed as fill.
4/15/2011	Riprap and Stone:	1. Riprap will be a combination of GDOT Type 1 and Type 3 riprap, with unit pricing based on a cubic yard basis
4/15/2011		2. Stone used to stabilize stream restoration sites (longitudinal peaked stone toe protection) is also estimated on a cubic yard basis, assuming the no grading will be required prior to placement.
4/15/2011		3. This estimate assumes that the contractor is paid for the volume of stone purchased, brought to the site, and installed. Measurement and payment is assumed to be by truck volume, not as measured in place.
4/15/2011	Vegetation and Riparian Restoration	1. Riparian buffers will be established using a combination of native hardwood plantings; including trees, shrubs, and seedlings.

Date	Author	Note
4/15/2011		2. Unit prices for riparian restoration are based largely on recent bid prices (per acre) for riparian restoration of similar type, species, and density proposed.
4/15/2011		3. Unit prices for willow posts (stream restoration sites) were derived from average bid prices for recent projects located within the region
4/15/2011	Fencing:	1. Silt fencing is assumed to be type C silt fence, with unit prices per linear foot including wooden posts and trenching in of the fabric at the base of the silt fence. Costs also include maintenance and removal of temporary fencing.
4/15/2011		2. Chain link fencing is assumed to be 6 feet in height, with quantities based of fencing the perimeter of flow attenuation sites.
4/15/2011	Structures and Piping:	1. Flow attenuation sites will include some piping to facilitate flow diversion to, and regulated discharge from the stormwater storage basins. Piping is assumed to be corrugated metal pipe, with the discharge regulated using a corrugated metal pipe riser.
4/15/2011		2. Pipe end treatments (headwalls or flared end sections) will be provided, and costs for such are included as part of the linear foot cost estimated for pipe installation. Unit prices for piping further include excavation, bedding, and backfill.
4/15/2011		3. The outlet control structure for site B3-1 is a concrete weir, replacing the existing weir. The existing weir has undermined and the opening for flow is too large to provide stormwater attenuation. Demolition and removal of the existing concrete weir is proposed.
4/15/2011		4. Site B-70 includes demolition and removal of an existing concrete culvert, and replacement with a bridge to facilitate fish passage. Costs for culvert removal and replacement with a bridge are provided, including costs associated with concrete bridge abutments.
4/15/2011	Articulated Concrete Matting:	Articulated concrete matting is used for stream restoration site B2-1. The matting is assumed to be 6 inches in thickness. Unit pricing (per square yard) includes materials and delivery cost, as well as labor and equipment cost for installation
4/15/2011	Rootwads:	1. Materials for rootwads and footer logs will be obtained from on-site trees, and are assumed to be approximately 10" to 12" in diameter.
4/15/2011		2. Pricing of rootwads was derived primarily using available unit price bids for similar work within the region (prices ranging from $1000 to $1500 per rootwad, installed).

Description	Quantity	UOM	ContractCost	Escalation	Contingency	SIOH	ProjectCost
Summary Report			**3,372,899.76**	**0.00**	**0.00**	**0.00**	**3,372,899.76**
Account 01 - Lands and Damages	**1.0**	**EA**	**368,000.00**	**0.00**	**0.00**	**0.00**	**368,000.00**
Account 15 - Floodway Control & Diversion Structure	**1.0**	**EA**	**2,460,899.76**	**0.00**	**0.00**	**0.00**	**2,460,899.76**
Phase 1	**1.0**	**EA**	**449,107.57**	**0.00**	**0.00**	**0.00**	**449,107.57**
Flow Attenuation	**3.0**	**EA**	**393,739.10**	**0.00**	**0.00**	**0.00**	**393,739.10**
Streambank Stabilization	**1.0**	**EA**	**55,368.47**	**0.00**	**0.00**	**0.00**	**55,368.47**
Phase 2	**1.0**	**EA**	**850,234.13**	**0.00**	**0.00**	**0.00**	**850,234.13**
Flow Attenuation	**1.0**	**EA**	**787,840.13**	**0.00**	**0.00**	**0.00**	**787,840.13**
Streambank Stabilization	**1.0**	**EA**	**62,394.01**	**0.00**	**0.00**	**0.00**	**62,394.01**
Phase 3	**1.0**	**EA**	**1,161,558.06**	**0.00**	**0.00**	**0.00**	**1,161,558.06**
Flow Attenuation	**1.0**	**EA**	**672,876.72**	**0.00**	**0.00**	**0.00**	**672,876.72**
Streambank Stabilization	**2.0**	**EA**	**488,681.35**	**0.00**	**0.00**	**0.00**	**488,681.35**
Account 30 - Planning, Engineering and Design	**1.0**	**EA**	**322,000.00**	**0.00**	**0.00**	**0.00**	**322,000.00**
Account 31 - Construction Management	**1.0**	**EA**	**222,000.00**	**0.00**	**0.00**	**0.00**	**222,000.00**

Appendix H, Attachment 3

CWE Risk/Contingency Analysis

Butler Creek Watershed Aquatic Ecosystem Restoration Project - PROJECT < $40M

35% CWE Contingency Analysis

Instructions:

General note: Blue text indicates items to be populated by the user.

Calculations worksheet:

1. Create the **Item** list based on appropriately selected items from the estimate's Work Breakdown Structure (WBS).
   Note that the last item in the list accounts for all WBS items not specifically selected for analysis.
   Up to 14 Items can be entered on the appropriate numbered lines without changing the formulas and structure of this workbook.

2. Enter the corresponding **Contract Cost** for the WBS Items.

3. Explain the basis for each of the Selected Work Breakdown Structure Items in the **Basis** column.

WBS Risk Matrix worksheet:

1. Evaluate the impact of the Typical Risk Elements on the Selected Work Breakdown Structure Items on a scale from 0-5, 0 being the lowest and 5 being the highest.

2. Determine, if appropriate, a maximum contingency threshold for each of the Items and enter into the corresponding cells in **row 24**.
   For convienence, if a common threshold is used, change only the value in cell **E24.**
   Enter 100% in E24 if limiting of the calculated contingency is not desired.

Butler Creek Watershed Aquatic Ecosystem Restoration Project - PROJECT < $40M
35% CWE Contingency Analysis

	Term	Definition
Terminology	Risk Analysis ER 1110-2-1302, 15 Sep 08, page 19	a. Cost risk analysis is the process of identifying and measuring the cost impact of project uncertainties on the estimated TPC. It shall be accomplished as a joint analysis between the cost engineer and the designers or appropriate PDT members that have specific knowledge and expertise on all possible project risks. (1) PDTs are required to prepare a formal cost risk analysis for all decision documents requiring Congressional authorization for projects exceeding $40 million (TPC)(see appendix B). Where cost risk analysis is required, it is anticipated that the cost risk analysis will be performed once the recommended plan is identified prior to the alternative formulation briefing milestone.
	Typical Risk Elements	Factors that can introduce risk to items listed in the Selected Work Breakdown Structure Items. The ones listed are the most typical for Civil Works Projects. These Risk Elements should be reviewed and established for each project.
	Selected Work Breakdown Structure Items	These are items from the estimate's Work Breakdown Structure, either broad or detailed, that are believed to contain some risk. The cost estimator defines the Work Breakdown Structure. It is recommended that the PDT select the appropriate Selected Work Breakdown Structure Items and considers all Features. Focus should be placed on the items with the significant risks. Appropriately identifying the Selected Work Breakdown Structure Items will lead to a more confident development of contingency.
Typical Risk Elements	Project Scope	• Project accomplish intent? • Level of detail in design? • Investigations remain to finalize design? • Designer confidence in scope of work? • What are assumptions made? • Opportunities for scope to change (materials, details, etc.) during design?
	Acquisition Strategy	• Established contracting plan - unclear? • Accelerated schedule or harsh weather schedule? • 8a - Small Business contractor likely? • Design-build?
	Construction Complexity	• Project constructible? • Unique methods of construction? • Special construction equipment?
	Volatile Commodities	• Materials or equipment subject to fluctuation?
	Quantities	• Level of confidence in the quantities? • Possibility for increase in quantities? • Appropriate method used to calculate quantities? • Enough information to calculate the quantities? • Calculated quantities check between designer and cost estimator?
	Fabrication & Project Installed Equipment	• Unusual parts, material or equipment be manufactured and/or installed? • Confidence in supplier's ability to produce equipment? • Confidence in contractor's ability to install equipment?
	Cost Estimating Method	• Reliability of quotes or Cost Book? • Assumptions made and affect on cost estimate? • Confidence of crews and production rates? • Site accessibility, delays? • Prime & Subcontractors appropriately identified? • Markups reasonable?
	External Project Risks	• Political influences and affect on project? • Adverse weather affect project? • What can impact project schedule? • Changes to project schedule affect quality?

Butler Creek Watershed Aquatic Ecosystem Restoration Project - PROJECT < $40M

35% CWE Contingency Analysis

Risk Level	Description
0	No Risk
1	Neglible
2	Marginal
3	Significant
4	Critical
5	Crisis

Selected Work Breakdown Structure Items

Typical Risk Elements

	Mobilization - Flow Attenuation Measures	Mobilization - Stream Restoration	Excavation - Flow Attenuation Measures	Excavation/Bank shaping- streams	Longitudinal Peak Stone Toe - bypass technique	Site Work - Stream Restoration	Clearing and Grubbing	Rootwads	Vegetation/Plantings/ Seeding/Mulching	0	0	0	0	Remaining Items
Project Scope	-	-	-	-	-	-	-	2	-					1
Acquisition Strategy	-	-	-	-	-	-	-	-	-					-
Construction Complexity	2	2	3	3	3	3	3	3	2					1
Volatile Commodities	-	-	-	-	-	-	-	-	-					1
Quantities	-	-	-	2	2	-	2	3	2					1
Fabrication & Project Installed Equipment	-	-	-	-	-	-	-	-	-					-
Cost Estimating Method	2	2	2	2	1	-	-	-	2					1
External Project Risks	-	-	2	2	4	3	3	-	4					2

Evaluate the impact of the Typical Risk Element on the Selected Work Breakdown Structure Item on a scale from 0-5, 0 being the lowest and 5 being the highest.

Summation	4	4	7	9	10	6	8	8	10	0	0	0	0	7
Weighted Summation	10	10	17.5	22.5	25	15	20	20	25	0	0	0	0	17.5
Weighted Average	1.25	1.25	2.19	2.81	3.13	1.88	2.50	2.50	3.13	0.00	0.00	0.00	0.00	2.19
Calculated Contingency	12.5%	12.5%	21.9%	28.1%	31.3%	18.8%	25.0%	25.0%	31.3%	0.0%	0.0%	0.0%	0.0%	21.9%
Maximum Allowable Contingency	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
Suggested Contingency	12.5%	12.5%	21.9%	28.1%	31.3%	18.8%	25.0%	25.0%	31.3%	0.0%	0.0%	0.0%	0.0%	21.9%

Butler Creek Watershed Aquatic Ecosystem Restoration Project - PROJECT < $40M
35% CWE Contingency Analysis

WBS	Item	Contract Cost	Contingency %	Basis	Contingency	Total
15	**Mobilization - Flow Attenuation Measures**	**$ 110,220**	12.5%	Erosion control, tracking of mud, wet materials	$ 13,777.46	$ 123,997.12
					$ -	$ -
15	**Mobilization - Stream Restoration**	**$ 45,714**	12.5%	Access to stream; steep stream slopes	$ 5,714.20	$ 51,427.76
					$ -	$ -
15	**Excavation - Flow Attenuation Measures**	**$ 666,369**	21.9%	Potential for rocks and roots to impact complexity; wet material	$ 145,768.24	$ 812,137.32
					$ -	$ -
15	**Excavation/Bank shaping- streams**	**$ 22,428**	28.1%	Potential for rocks and roots to impact complexity; wet material	$ 6,307.81	$ 28,735.59
					$ -	$ -
15	**Longitudinal Peak Stone Toe - bypass technique**	**$ 178,442**	31.3%	Need for bypass unknown; depending on flow conditions, the complexity of bypassing flow to install LPST may increase	$ 55,763.09	$ 234,204.99
					$ -	$ -
15	**Site Work - Stream Restoration**	**$ 56,194**	18.8%	Potential for rocks and roots to impact complexity	$ 10,536.34	$ 66,730.14
					$ -	$ -
15	**Clearing and Grubbing**	**$ 46,886**	25.0%	Potential for rocks and roots to impact complexity	$ 11,721.59	$ 58,607.93
					$ -	$ -
15	**Rootwads**	**$ 207,232**	25.0%	Rootwads may not be available onsite and would have to be brought in; bank condit	$ 51,808.11	$ 259,040.55
					$ -	$ -
15	**Vegetation/Plantings/Seeding/Mulching**	**$ 343,837**	31.3%	Depending on weather conditions, the timeline for plantings may vary. The success	$ 107,449.18	$ 451,286.56
			0.0%		$ -	$ -
			0.0%		$ -	$ -
			0.0%		$ -	$ -
			0.0%		$ -	$ -
	Remaining Items 32%	**$ 783,578**	21.9%	General contingency amount used for these perceived low risk items.	$ 171,407.65	$ 954,985.47
	Total Construction Estimate	$ 2,460,900			Total: $ 580,254	Total: $ 3,041,153

Weighted Contingency = **23.58%**

$ 226,000.00

Appendix I

Pre- and Post-construction Monitoring Plan

Draft Report

Butler Creek Watershed Aquatic Ecosystem Restoration Monitoring Plan

US Army Corps of Engineers
Mobile District

August 2011

Contents

Tables

Figures

1. Introduction

1.1 Monitoring Requirements

This monitoring plan was developed to evaluate the performance of all ecosystem restoration components developed as part of the Tentatively Selected Plan for Butler Creek. Monitoring is appropriate to verify that the ecosystem restoration objectives (as established in Section 2) are being achieved, to identify if adjustments for unforeseen circumstances are needed, and to determine if changes to structures or their operation, or to management techniques, are required. Because the Tentatively Selected Plan for Butler Creek includes stream restoration and extended detention features within the riparian floodplain, this monitoring plan includes monitoring requirements both biological (for stream restoration) and hydrologic (for extended detention). The monitoring plan was developed such that the specific objectives identified for each stream restoration and extended detention component of the Tentatively Selected Plan can be evaluated.

Three monitoring events are scheduled at each recommended site. Preconstruction monitoring will be conducted at each sampling station, in accordance with Ecosystem Response Model protocols. Post-construction monitoring will be conducted biannually at the pre-determined locations. The biological and hydrologic monitoring requirements, sampling stations, and schedule are described below. The technical approach and performance standards are described in subsequent sections.

1.1.1 Biological Monitoring Requirements

Biological monitoring will be conducted to evaluate the performance of the stream restoration components of the Tentatively Selected Plan for Butler Creek, including stream restoration Sites 2-2, 3-2, 4-1, 5-1, 5-2, 40, and 50. Pre- and post-construction biological monitoring will include assessments of physical habitat and fish and benthic macroinvertebrate communities. Monitoring will follow the technical methods and approach described in Section 2.1 and will be conducted within the stream reach identified for restoration (see also Section 1.2, Sampling Stations). Section 1.3 contains the schedule for biological monitoring.

1.1.2 Hydrologic Monitoring Requirements

Hydrologic monitoring will be conducted to evaluate the performance of the extended detention components of the Tentatively Selected Plan (Sites 2-1, 3-1, 3-2-3, 20, and 70). Each area will be monitored to document high water marks and to estimate the storage volumes used and peak flow reduction achieved through extended detention. Pre- and post-construction hydrologic monitoring will include field measurements taken near outlet structures to verify the peak water surface elevation occurring within each basin in response to a qualifying rainfall event. The data will then be used to calculate peak flow reduction using methods described in Section 2.2. Section 1.3 contains a schedule for hydrologic monitoring.

1.2 Sampling Stations

The Tentatively Selected Plan identifies 10 sites for ecosystem restoration within the Butler Creek watershed (Figure 1-1). Sites B2-2, B3-2, B4-1, B40, and B50 involve stream restoration along Butler Creek. Sites B2-1, B3-1, B3-2-3, B20, and B70 involve detention pond or created wetland installations and retrofits. This monitoring plan establishes sampling stations in proximity to each of these project sites. Monitoring station locations are shown on Figures 1-2 through 1-10, and are described below in Table 1-1. Pre- and post construction biological monitoring will be conducted at all stream restoration sites, while hydrologic monitoring will be conducted at each of the detention pond and created wetland sites. Description and photographs of each monitoring station are provided below.

TABLE 1-1
Monitoring Station Descriptions
Butler Creek Watershed Monitoring Plan

Station ID	Stream	Location	Monitoring Required
B2-1	Butler Creek	End of Wellcrest Drive	Hydrologic
B2-2	Butler Creek; Tributary to Butler Creek	Mack Dobbs Road, accessed from bridge; Private Drive on Mack Dobbs Road	Biological
B3-1	Tributary to Butler Creek	Shillings Chase Court	Hydrologic
B3-2	Butler Creek	End of White Oak Court	Biological
B3-2-3	Butler Creek	End of Woodland Place	Hydrologic
B4-1	Butler Creek	North of Cobb Parkway, accessed from gravel road near guardrail	Biological
B20	Butler Creek	Sewer easement from Jim Owens Road	Hydrologic
B40	Butler Creek	Loring Way blocked off, so accessed from the sewer easement crossing Loring Drive; sewer easement near Johnston Road	Biological
B50	Butler Creek	Sewer easement from Jim Owens Road	Biological
B70	Butler Creek	Loring Road, accessed from a dirt road with a paved, culvert bridge crossing over Butler Creek	Hydrologic

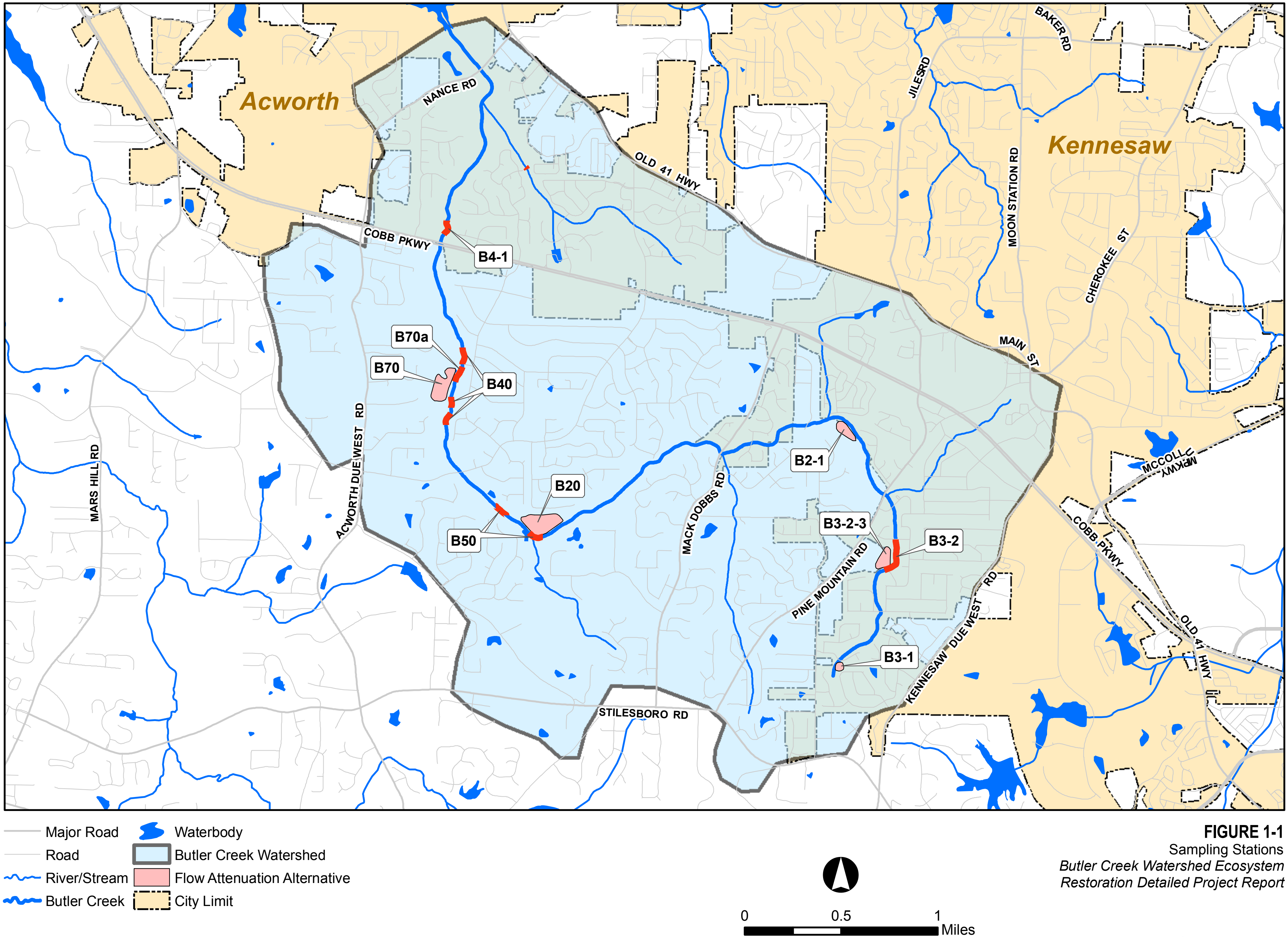


FIGURE 1-1
Sampling Stations
Butler Creek Watershed Ecosystem
Restoration Detailed Project Report

CH2MHILL

\\GALILEO\PROJ\BUTLERCREEK\MAPFILES\TENATIVELY_SELECTED_PLAN.MXD AOMALLEY 11/9/2010 14:20:43

1.2.1 Station B2-1

Station B2-1 (Figure 1-2) is located near the end of Wellcrest Drive. Proposed modifications include rerouting an intermittent tributary through a sediment forebay into an extended detention created wetland.

1.2.2 Station B2-2

Part of Station B2-2 (Figure 1-3) is located along the mainstem of Butler Creek near Mack Dobbs Road. The remainder is on a small tributary to Butler Creek along a private drive joining Mack Dobbs Road. Proposed modifications include stone toe/rootwad combination along the mainstem of Butler Creek, along with restoration of riparian buffer. Proposed modifications along the tributary to Butler Creek include bench cutting with toe protection and planting woody vegetation.

1.2.3 Station B3-1

Station B3-1 (Figure 1-4) is located near Shillings Chase Court. Proposed modifications include retrofitting the existing outlet control structure at the site.

FIGURE 1-2
Station B2-1
Butler Creek Watershed Monitoring Plan

FIGURE 1-3
Station B2-2
Butler Creek Watershed Monitoring Plan

FIGURE 1-4
Station B3-1
Butler Creek Watershed Monitoring Plan

1.2.4 Station B3-2

Station B3-2 (Figure 1-5) is located along the mainstem of Butler Creek near the end of White Oak Court. Proposed modifications at this site include channel bench and toe protection installation, along with native plantings in the riparian zone.

1.2.5 Station B3-2-3

Station B3-2-3 (Figure 1-6) is located near the end of Woodland Place. Proposed modifications include a flow diversion structure to channel water exceeding the baseflow into a new detention pond.

1.2.6 Station B4-1

Station B4-1 (Figure 1-7) is located along the mainstem of Butler Creek north of Cobb Parkway. Proposed modifications include stone toe protection and rootwad installation along both banks.

FIGURE 1-5
Station B3-2
Butler Creek Watershed Monitoring Plan

FIGURE 1-6
Station B3-2-3
Butler Creek Watershed Monitoring Plan

FIGURE 1-7
Station B4-1
Butler Creek Watershed Monitoring Plan

1.2.7 Station B20

Station B20 is located along a sewer easement near Jim Owens Road. Proposed modifications include rerouting of an intermittent tributary through a sediment forebay and into an extended detention created wetland.

1.2.8 Station B40

Station B40 (Figure 1-8) is located along the mainstem of Butler Creek, with part of the site near Loring Drive and another part near Johnston Road. Proposed modifications include installing a velocity dissipater, stone toe protection, rootwads, and cross vanes, along with bank shaping and vegetation of upper banks.

FIGURE 1-8
Station B40
Butler Creek Watershed Monitoring Plan

1.2.9 Station B50

Station B50 (Figure 1-9) is located along the mainstem of Butler Creek near a sewer easement from Jim Owens Road. Proposed modifications at this site include installation bank protection and toe protection, along with vegetation of upper banks.

FIGURE 1-9
B50
Butler Creek Watershed Monitoring Plan

1.2.10 Station B70

Station B70 (Figure 1-10) is located near Loring Road. Proposed modifications include rerouting of an intermittent tributary through a sediment forebay and into an extended detention created wetland. Figure 1-10 shows the site for Station B70.

FIGURE 1-10
B70
Butler Creek Watershed Monitoring Plan

1.3 Monitoring Schedule

Physical habitat assessment and benthic macroinvertebrate sampling will be conducted at each stream restoration site between mid-September and the end of February, with pre-construction monitoring beginning in 2011. Fish sampling at stream restoration sites will be conducted between early-April and mid-October, with preconstruction sampling occurring in 2011–2012. Post-construction monitoring will be conducted biannually after construction.

Hydrologic monitoring will follow the technical approach described in Section 2.2 at each extended detention area and created wetland listed above. Hydrologic monitoring may take place at any time of the year but is dependent upon the occurrence of a qualifying rainfall event, as defined in Section 2.2. Similar to biological monitoring, at least one preconstruction and two post-construction monitoring events are required. Post-construction monitoring will be the responsibility of the nonfederal sponsor.

2. Technical Approach

2.1 Biological Monitoring Methods

The approach to biological monitoring of Butler Creek is based on the concept that ecosystem health can be measured in terms of the composition, structure, and function of resident biotic communities. At least two aquatic biologists familiar with the most current GADNR sampling and data analysis protocols will conduct the biological monitoring. Sampling and data analysis will follow current GADNR Standard Operating Procedures (SOPs) and include physical habitat assessments, benthic macroinvertebrate community assessments, and fish sampling. Fish sampling will be conducted during one event. Macroinvertebrate sampling and physical habitat assessments will be conducted on another occasion, in accordance with respective GADNR-recommended sampling periods. One preconstruction and two post-construction monitoring events are scheduled at each station.

2.1.1 Physical Habitat Assessment

Physical habitat assessments will be conducted at the seven stream restoration sampling stations (Table 1-1) following procedures outlined in *Standard Operating Procedures: Macroinvertebrate Biological Assessment of Wadeable Streams* (GADNR, 2007). The assessment involves rating ten parameters to evaluate substrates, habitat availability, riparian corridors and streambank conditions. The Georgia Environmental Protection Division (GAEPD) has developed alternate protocols for riffle/run–prevalent systems, usually found in high-gradient conditions, and glide/pool prevalent systems, usually found in low-gradient conditions (Table 2-1). According to the SOP, distinction between riffle/run and glide/pool protocols depend on the location of sample site within the state (i.e., most high gradient streams are located above the Fall Line), the presence or absence of riffles, and professional judgment. Based on guidance communicated at the GAEPD Macroinvertebrate Biological Assessment Workshop (August 2008), a riffle/run prevalent system is now defined as "any stream which includes an audible riffle that breaks the water's surface." The field team will assess each sampling station to determine which protocols to follow based on recent GAEPD guidance.

Roughly 200 meters of stream will be walked to evaluate the physical habitat at each station. The area used for the habitat assessment will include the reach to be sampled for benthic macroinvertebrates and fish. For QA/QC purposes, two qualified team members will individually evaluate 10 physical habitat assessment parameters (Table 2-1), following field sheets provided in the SOP, and the results will be averaged. If the total habitat scores deviate by 30 or more points, then the team members will review their judgment together. If agreement on the scores cannot be reached, the field team leader will make the final decision. A total habitat score will be calculated by summing the average scores of each parameter, with the highest possible total score being 200 points.

According to the SOP, physical habitat scores are no longer compared to reference reach scores to develop a qualitative assessment, as in previous SOPs (that is, qualitative assessments such as "comparable to reference" or "dissimilar to reference").

TABLE 2-1
Habitat Assessment Parameters for Riffle/Run and Glide/Pool Systems
Butler Creek Watershed Monitoring Plan

Parameter	Parameter Description
Riffle/Run Prevalent System	
Epifaunal substrate/instream cover	Measures availability of actual substrates available as refugia or feeding sites or sites for spawning and nursery functions for aquatic organisms.
Embeddedness	Measures the degree to which cobbles, boulders, and other rock substrate are surrounded by fine sediment.
Velocity/depth combinations	Measures a stream's characteristic velocity/depth regime.
Channel alteration	Measures large-scale alteration of instream habitat that affects stream sinuosity and causes scouring.
Sediment deposition	Relates to the amount of sediment that has accumulated and the changes that have occurred to the stream bottom as a result of deposition.
Frequency of riffles	Estimates the frequency or occurrence of riffles as a measure of sinuosity.
Channel flow status	The degree to which the channel is filled with water during base or average annual flow periods.
Bank vegetative protection	Measures the amount of the stream bank that is covered by vegetation.
Bank stability	Measures the existence of, or the potential for, detachment of soil from the upper and lower stream banks and its movement into the stream.
Riparian vegetative zone	Measures the width of natural vegetation from the edge of the upper streambank out through the floodplain.
Glide/Pool Prevalent System	
Bottom substrate/available cover	Measures availability of actual substrates available as refugia or feeding sites, or sites for spawning and nursery functions for aquatic organisms.
Pool substrate characterization	Evaluates the type and condition of bottom substrates found in pools.
Pool variability	Rates overall mixture of pool types according to size and depth thus accommodating a diverse aquatic community consisting of various species and age classes.
Channel alteration	See above.
Sediment deposition	See above.
Channel sinuosity	Measure of meandering or sinuosity, based on an estimated run-to-bend ratio, which quantifies the diversity of habitat and fauna, and the ability of the stream to remain stable during storm surges.
Channel flow status	See above.
Bank vegetative protection	See above.
Bank stability	See above.
Riparian vegetative zone width	See above.

However, individual metric scores are categorized into one of four qualitative condition categories: poor, marginal, suboptimal, and optimal. Scores between 0 and 25 percent of the highest score are considered Poor, between 26 and 50 percent marginal, between 51 and 75 percent suboptimal, and higher than 75 percent optimal. These qualitative condition categories will be used when interpreting results to evaluate conditions at each station and to make comparisons among stations.

Stream stability will be evaluated at each monitoring station using both parameters from the habitat assessment and the Rosgen bank erosion hazard index and near bank stress procedures (Rosgen, 2006). Stability and erosion potential will be evaluated to assess the overall channel stability at each cross-section. Because each restoration project has its own critical values, the values that determine the geomorphic threshold for a particular stream must be determined on a case-by-case basis. Adjustments that do not exceed the critical values may be attributed to changes within or along the channel that signal increased stability, such as added vegetation on the banks.

2.1.2 Benthic Macroinvertebrate Sampling

Benthic macroinvertebrates will be sampled at each stream restoration station between mid-September and the end of February, following qualitative techniques described in *Standard Operating Procedures: Macroinvertebrate Biological Assessment of Wadeable Streams.* This assessment is a multi-habitat approach that maximizes efficiency of field work and analysis. It is consistent with USEPA's rapid bioassessment protocols (RBPs [Barbour, et al., 1999]) and involves obtaining samples collected from the various habitats for analysis and data evaluation. Multi-habitat assemblages provide the broad-based information necessary to make the best assessment of biotic integrity as it relates to stream conditions.

Field Methods. Sampling will be conducted over a 100-meter reach, at least 100 meters upstream of any road crossing when possible. The number of jabs or kicks to be collected from each habitat type will depend on the determination of the stream system (riffle/run- or glide/pool- prevalent) (Table 2-2). The major habitat types at each site—undercut banks, rocks, vegetation, sand, riffles, runs, and pools—and the proportion of each habitat type sampled will be recorded on the field sheets. Sampling will be conducted downstream to upstream, at 20 different locations in the reach, by jabbing a D-frame net into the habitat or using a kick net to kick a sample from a habitat type. One team member will be responsible for the D-frame sampling (jabs). The other will be track the number of jabs, compile the material in a sieve bucket, check large debris for organisms, and elutriate the sieve bucket to reduce the silt content. The organisms collected will be bagged, preserved in 10 percent formalin, and shipped to a laboratory certified to conduct macroinvertebrate identification. In situ measurements of dissolved oxygen, temperature, pH, and specific conductance will be made during the macroinvertebrate sampling to document adverse water chemistry parameters that might affect the aquatic communities.

TABLE 2-2
Benthic Macroinvertebrate Protocols for Riffle/Run and Glide/Pool Streams
Butler Creek Watershed Monitoring Plan

Habitat	Number of Jabs or Kicks
Riffle/Run Streams	
Fast riffle	3
Slow riffle	3
Woody debris/snags	5
Undercut banks/root mats	3
Coarse particulate organic matter / leaf packs	3
Sand or bottom substrate	3
Macrophytes (if any)	3
Glide/Pool Streams	
Woody debris/snags	8
Undercut banks/root mats	6
Coarse particulate organic matter / leaf packs	3
Sand or bottom substrate	3
Macrophytes (if any)	3

Source: GADNR (2007)

Sampling techniques for each habitat type are summarized below.

Riffle Kick Net. Riffle kick net samples will be collected from both fast and slow riffles in riffle/run stream systems. A 1-square-meter riffle area will be disturbed using kicks, and organisms will be collected in the kick net. This technique is intended primarily to collect species that require highly oxygenated waters such as those in the Ephemeroptera, Plecoptera, and Trichoptera orders. If six riffle areas are not present, allocated kicks will be redistributed among the remaining habitats.

Woody Debris and Snags. Woody debris/snags samples include the collection of organisms found in and on rocks or logs. These habitat types will be washed, scraped into buckets, and poured through a 500-micron net. This technique is used for collecting small organisms from species in the family Chironomidae, Baetidae, and Hydroptilidae as well as Oligochaetes and other scrapers/grazers.

Undercut Banks and Root Mats. The undercut banks/root mats samples will be collected from three different bank areas, including mud banks and root mats when available. Bank samples are particularly important for collection of species that prefer low-current environments.

Coarse Particulate Organic Matter and Leaf Packs. Sampling of coarse particulate organic matter and leaf packs will consist of collecting clumps of leaves, small sticks, and parts of logs. Most material will be collected from rocks or snags and will not include new leaf fall. Leaf packs are important for collecting shredder organisms, such as species in the orders Plecoptera and Trichoptera.

Sand or Bottom Substrate. Three sand kick samples will be collected with a fine-mesh (500-micron) net bag or kick net. The bag or net will be held open near the substrate while sandy habitats just upstream are vigorously agitated. This technique is especially useful for collecting small organisms, such as species in the family Chironomidae, that inhabit sandy substrates.

Macrophytes. Submerged, floating, or emergent vegetation often occurs along the shore zone and in channel beds. Samples will be collected by dragging a sweep net in an upstream direction through the vegetation if present. If macrophytes are not present, the allocated sample jabs will not be redistributed, as with the other techniques.

Data Analysis. Macroinvertebrates will be identified to lowest possible taxonomic level and enumerated by an entomologist certified to conduct macroinvertebrate assessments. Data analysis techniques will follow the procedures described in the SOP, which include an evaluation of multiple metrics according to the subecoregion in which the sample was collected. Each metric category represents a different component of community structure or function and provides a measure of biotic integrity. Results will be entered into spreadsheets provided by GADNR that calculate a multi-metric benthic macroinvertebrate index score. Each individual metric will be scored on a 100-point scale, and the final score will be an average of the metric scores. Reference conditions are inherent in the formulas used to calculate the metric scores. Qualitative condition categories based on the benthic macroinvertebrate index are pending with GADNR. Until GADNR makes further information available, data analysis will include a comparison of scores among stations and an evaluation of the percentage of the highest possible score for each sampling station.

2.1.3 Fish Sampling

Fish sampling will be conducted between early April and mid-October in accordance with *Standard Operating Procedures for Conducting Biomonitoring on Fish Communities in Wadeable Streams of Georgia* (GADNR, 2005) and RBP V (Plafkin et al., 1989; Barbour et al., 2000). The methodology, detailed below, involves a fish community survey using standard field techniques, species identification, enumeration, specimen external examination, and assignment of ratings to a variety of fish community attributes (metrics), which are summed to obtain an overall measure of biotic integrity.

Field Methods. Fish will be sampled at the seven stream restoration stations (Table 1-1). Backpack electrofishing will be used to sample representative habitats in each sample reach, including riffles, runs, and pools. Electrofishing may be supplemented by seining under appropriate conditions, and the unit sampling effort (the minutes spent electrofishing) will be comparable among stations. Since the Cherokee darter, a federal-listed "threatened" species, is present in the watershed, caution will be used with electrofishing and seining operations to avoid causing harm to the Cherokee darter. A scientific fish collection permit from the U.S. Fish and Wildlife Service will be obtained before sampling. GADNR (2005) recommends sampling reaches equal to 35 times the mean standard width to decrease variability in IBI scores. Fish sampling will progress upstream, so as not to disturb sediments and decrease visibility, and team members will be careful not to walk through the sampling area before sampling. A trained biologist will operate the shocker. Another team member will help capture stunned fish, carry a live bucket for all captured fish, and maintain multiple live tanks (coolers) on the bank by changing the water frequently. Sampling team members assisting in fish sampling will use proper protective equipment, such as waders and rubber gloves.

After electrofishing is completed, the lead fisheries biologist will select areas in which to use a minnow seine, which is particularly effective in collecting darters, minnows, and other smaller fish generally not as vulnerable to backpack electrofishing. Two seining methods will be used: kick sets and downstream haul bets. For kick sets, the minnow seine will be set perpendicular to the current so that the lead line of the seine is situated on the bottom of the stream. Two field members will hold the net, and a third will kick and disturb the substrate causing fish to move downstream, away from the disturbance and into the net. The downstream haul net requires two field members to sweep the net downstream, through runs and pools, slightly faster than the current, keeping the lead line close to the bottom. The net will be either lifted midstream or hauled on to the bank when possible.

After sampling is complete, fish will be identified and enumerated in the field to the greatest extent practical, with some voucher specimens being preserved in 10 percent formalin for laboratory confirmation of species identification. All other specimens (including all Cherokee darter specimens) will be released live at the collection site. Extreme care will be taken to ensure that no Cherokee darter specimens are harmed during the identification effort, and that no Cherokee darter specimens are preserved. A data sheet that includes size, weight, and external anomalies of the species collected will be completed at each station, along with detailed notes on habitat and surrounding watershed conditions. In addition, in situ measurements of dissolved oxygen, temperature, pH, and specific conductance will be made during the fish sampling to document any adverse water chemistry parameters that might affect the aquatic communities.

Data Analysis. The index of biotic integrity (Karr et al., 1986) will be used to evaluate the health of the fish communities at each sampling station. The index, which is used as the model for EPA's RBP (Barbour et al., 1999; and Plafkin et al., 1989), integrates a broad range of fish community attributes into an assessment of stream biotic integrity. The methodology involves species identification, enumeration, and external examination of the collected fish; and assignment of ratings to various fish community attributes (metrics), which are summed to obtain an overall measure of biotic integrity. Scores will be calculated based on rating 13 metrics of fish community structure in 5 broad categories: species richness, species composition, trophic function, species abundance, and physical condition. The index of biotic integrity assumes that each metric correlates either positively or negatively with increased stream degradation. The 13 metrics integrate attributes of the entire fish community that are differentially sensitive to various levels of stream perturbation. These metrics were modified from Karr et al. (1986) and are used by the GADNR in its fish sampling protocols. The final scores will be used to determine the overall qualitative conditions of the fish communities, ranging from excellent to very poor.

2.1.4 Sampling Equipment

Table 2-3 lists the sampling equipment required for the biological sampling.

2.2 Hydrologic Monitoring Methods

Hydrologic monitoring will be conducted for each extended detention basin and created wetland listed above. The approach to hydrologic monitoring of these sites combines field observations and measurement of peak water surface elevations (stage) resulting for a qualifying rainfall event, and estimation of storage volume and peak flow reduction. These elements of the approach are described in the sections below. Figure 1-1 shows the locations for hydrologic monitoring.

2.2.1 Qualifying Rainfall Event

For purposes of defining a qualifying rainfall event for this monitoring plan and evaluating the performance of each extended detention cell, field measurement and analysis may be conducted following any rainfall event exceeding 0.5 inch within a 24-hour period. Determination of rainfall depth will be based upon data from local rain gauges near the monitoring stations.

TABLE 2-3
Biological Sampling Equipment
Butler Creek Watershed Monitoring Plan

Sampling Equipment	Quantity	Sampling Equipment	Quantity
Fish Sampling		***General Equipment***	
Backpack electroshocker	1	Collection permit	1
Shocker wand	1	Ice	
Shocker tail	1	Chain-of-custody forms	6
Extra battery for shocker	1	FedEx shipping forms	3
Empty cooler	1	Custody seals	6
Aquarium bubblers	2	Camera	1
Rubber gloves	2 pair	Memory card	1
Fish collection nets (dip nets)	2	Packing tape (rolls)	2
Seine net (10 by 6 feet)	1	Analyte-free water (1-gallon containers)	2
5-gallon bucket	2	Ziploc freezer bags (1-gallon, 20 per box)	2
1-gallon plastic jar	1/station	Ziploc freezer bags (2-gallon, 20 per box)	2
Data sheets	1/station	Paper towels (rolls)	2
Pliers	1	Latex gloves (box)	1
Plastic ruler	2	Phone list	1

TABLE 2-3
Biological Sampling Equipment
Butler Creek Watershed Monitoring Plan

Sampling Equipment	Quantity
Benthic Macroinvertebrate Sampling	
500-micron D-frame nets	2
500-micron kick net	1
Sieve bucket	2
Sorting pans and plastic trays	4
Formalin (1-gallon containers)	3
Scrub brush	2
Tweezers	4
Winterized gloves	2
Empty coolers	6
Habitat assessment data sheets	2
Squirt bottles	2
In Situ Water Quality Monitoring	
Meter for in situ measurements	1
Sampling plans	1
Field safety instruction	1
Tree tags	6
Vermiculite	2 bags
Personal Equipment	
Rain gear	
Hat	
Gloves	
Rubber boots	
Sunblock	
Pens (waterproof ink), pencils	
Field sheets	
Compass/global positioning system unit	
Field notebook	
Thermos	
Waders, hip boots	
Potable water	1 gallon

2.2.2 Field Observations and Measurements

Within 24 hours following a qualifying rainfall event, personnel qualified and experienced in observation and measurement of high water marks will visit each site listed above and document observed peak water surface elevations within each cell. The peak stage will be measured relative to the control elevations for each extended detention cell. Measurements will be made near the outlet structures for each cell, but may be verified at any point along the detention cell perimeter that shows clear evidence of the high water mark.

2.2.3 Estimation of Storage Volume and Peak Flow Reduction

Estimation of the storage volume provided by each extended detention basin or created wetland will be made from a simple mathematical calculation using the pond surface area multiplied by the vertical difference between measured peak stage and normal control elevation for each cell. This calculation will provide an estimate of the maximum storage volume used within each detention cell for attenuation of peak discharge along Butler Creek.

Peak flow reduction will then be estimated using HEC-HMS modeling software. HEC-HMS is used to estimate peak runoff in response to rainfall but also may be used to estimate the affects of storage volume within the watershed and upstream of the point of analysis. Two points of analysis are required for each site: one located along Butler Creek immediately downstream of the outlet structure discharge for the flow attenuation feature, the other along Butler Creek immediately downstream of the discharge for the flow attenuation feature.

For each analysis point described above, HEC-HMS will be developed to estimate peak runoff from the effective drainage basin, inputting known watershed characteristics such as basin size, land use, flow paths, and time of concentration. Predicted peak discharge from the model will be compared to available USGS gauge data for comparison and calibration. Once the model is calibrated for the rainfall depth associated with the monitoring event, the calculated storage volume will be input to estimate peak flow attenuation (reduction) achieved by the extended detention cells.

2.3 Chain-of-Custody and Shipping (for Biological Monitoring)

Any sampling and analytical program must follow a system for sample control from collection to data reporting. This includes tracing the possession and handling of samples from the time of collection through analysis and final disposition. The documentation of the sample history is referred to as the "chain-of-custody" (COC). A sample is considered to be in a person's custody if it is in the person's physical possession, in view of the person after he or she has taken possession, secured by that person so that no one can tamper with the sample, or in a designated secure area. The following section details the COC system that will be followed as part of biological monitoring.

2.3.1 Chain-of-Custody Record

To establish the documentation necessary to trace sample possession from the time of collection, a COC record, which can be obtained from the laboratory, will be completed for every sample event. To maintain the COC record, every person who has custody of the sample at any time will sign, date, and note the time on the COC record. Samples will not be left unattended unless placed in a secured and sealed container with the COC record inside the container.

The COC record will include special instructions for the laboratory to follow, such as composite preparation or clean metal analysis, which will be consistent with the contract. If discrepancies are identified, the field team leader will inform the project manager before the samples are analyzed. The following special instructions will be included on the COC forms:

- **Benthic Macroinvertebrates—**Identify samples to the lowest taxonomic level possible, and complete the Georgia RBP assessment for the metrics listed in the contract.

2.3.2 Sample Labeling and Shipment

Benthic macroinvertebrate samples will be placed in a zip-seal bag and preserved with 10 percent formalin after collection at each station. For each benthic macroinvertebrate sample, the following information will be marked on the outside of the bag:

- Field team leader name
- Butler Creek (BC)
- CH2M HILL/USACE
- Date
- Station number
- Station identifier

A labeled tag will be inserted into the benthic macroinvertebrate sample with the same information. Water-proof paper will be used to prepare the tag, and the labels on both bags and tags will be marked with indelible ink. After the samples have been labeled and preserved, they will be double-bagged with a 1-gallon zip-seal bag and then a 2-gallon bag. The outer bag will then be sealed with duct tape.

Benthic macroinvertebrate samples will be stored in coolers and remain in the custody of the field team leader until the cooler is full or ready for shipment. Coolers prepared for shipping will be packed to minimize movement of samples and will include vermiculite in case of leakage. Each shipping container will contain a COC form with the analytical directions for the laboratory. Benthic macroinvertebrate samples will be shipped to the laboratory within 5 days of collection.

2.3.3 Custody Seals

Custody seals are used to detect tampering with samples, from collection to the time of analysis. When samples are packed for shipping, custody seals will be placed across the latch and across the lid opening of the coolers to confirm that they arrive at the laboratory unopened. The custody seal placed across the lid opening will be secured with strapping tape. The tape will be placed over the custody seal and wrapped completely around the cooler so that it remains closed during shipping.

3. Performance Standards

Identification of performance standards is critical to documenting achievement of improvements in ecosystem health with regard to established objectives corresponding to implementation of ecosystem restoration measures. As noted, biological monitoring and hydrologic monitoring are part of the Tentatively Selected Plan for Butler Creek. An overview of tracking methods used during each type of monitoring is presented below, along with associated objectives from Section 2 of the feasibility report.

3.1 Biological Monitoring

Physical habitat monitoring is used to track changes that occur as a result of stream enhancement. Potential habitat improvement is determined during conceptual planning to estimate the near-term and long-term expected changes after the project. The habitat assessment SOPs published by GAEPD (2007) will be used to determine the habitat score of the prerestoration condition and at a suitable reference site to estimate the expected condition for the ecoregion. Successful habitat improvement is measured as an increase in habitat score after restoration. Success for fish and benthic macroinvertebrate communities is based on baseline condition scores and includes a specific percent increase during each monitoring event (see Table 3-1).

TABLE 3-1
Monitoring Requirements and Performance Standards
Butler Creek Watershed Monitoring Plan

Monitoring Requirement	Performance Standards (Objectives)
Biological Monitoring	
Physical habitat assessment	Create sustainable riffle/pool habitats in impacted stream reaches by constructing instream habitat features.
	Use rock/grade control, at locations in the Tentatively Selected Plan, to provide for an adequate frequency of riffles (76 to 100 percent of reach covered by riffles) and diverse velocity/depth regimes (fast-shallow, fast-deep, slow-shallow, and slow-deep).
	Reduce bank erosion at the Tentatively Selected Plan locations by one physical habitat condition category after 5 years.
	Implement stream channel restoration measures, including both stream stabilization and grade control, in highly degraded areas of the watershed.
Fish community assessment	Increase the species richness and evenness of native fish in the watershed by 5 percent over the next 5 years.
Benthic macroinvertebrates	Increase the species richness and evenness of native benthic macroinvertebrates in the watershed by 5 percent over the next 5 years.
Hydrologic Modeling	
Flow attenuation	Reduce peak flows by at least 5 percent by implementing flow attenuation measures, such as the creation of riparian wetlands in the floodplain or retrofits to existing detention ponds.

3.2 Hydrologic Monitoring

Hydrologic monitoring is used to track changes in flow attenuation that occur as a result of implementation of peak flow attenuation improvements. Existing flow attenuation capability will be established during preconstruction monitoring, and post-construction monitoring will be used to document the additional degree of flow attenuation provided at various peak flow events through implementation of the Tentatively Selected Plan. Table 3-1 lists the success criteria for flow attenuation feature installations and modifications.

3.3 Contingencies and Responsibilities

Cobb County would be responsible for 35 percent of all project costs, including acquisition, administration, development, management and maintenance, long-term monitoring, and remedial measures. If the success criteria described in this monitoring plan and the performance standards are not met at monitoring milestones (biannual sampling events), Cobb County would undertake remedial actions to correct the problem. If the results from a monitoring event show that significant problems have developed, USACE would be notified and, after consultation with the USACE and Cobb County, appropriate remedial actions would be taken.

In the context of this project, success is defined as the fulfillment of ecosystem restoration objectives in accordance with the overall project objectives. Table 3-1 lists the restoration success criteria for Butler Creek. Success with regard to each criterion will be determined through monitoring.

4. References

Barbour, M. T., J. Gerritsen, B. D., Snyder and J. B. Stribling. 2000. *Rapid Bioassessment Protocols for Use in Streams and Rivers: Periphyton, Benthic Macroinvertebrates, and Fish.* U.S. Environmental Protection Agency, Assessment and Watershed Protection Division, EPA/841-B-99-002.

Georgia Environmental Protection Division (GAEPD). 2008. S*tate 305(b)/303(d) List, January 2008.* Georgia Department of Natural Resources Environmental Protection Division, Atlanta.

Georgia Department of Natural Resources (GADNR). 2005. *Standard Operating Procedures for Conducting Biomonitoring on Fish Communities in the Piedmont Ecoregion of Georgia*. Wildlife Resources Division, Fisheries Section.

Georgia Department of Natural Resources. 2007. *Standard Operating Procedures: Freshwater Macroinvertebrate Biological Assessment*. Environmental Protection Division. 2007.

Karr, J. R., and D. R. Dudley. 1981. *Ecological Perspective on Water Quality Goals*. Environmental Management 5:55-68.

Plafkin, J. L., M. T. Barbour, K. D. Porter, S. K. Gross, and R. M. Hughes. 1989. *Rapid Bioassessment Protocols for use in Streams and Rivers: Benthic Macroinvertebrates and Fish*. U.S. Environmental Protection Agency, Assessment and Watershed Protection Division, EPA/440/4-89/001.

Rosgen, D. 2006. *Watershed Assessment of River Stability and Sediment Supply*. Wildland Hydrology, Fort Collins, Colorado.

Appendix J

HTRW Report/Phase I Environmental Site Assessment

Draft Report

Phase I Environmental Site Assessment

Butler Creek Site
Cobb County, Georgia

US Army Corps
of Engineers
Mobile District

August 2011

Contents

Contents, Continued

Contents, Continued

Contents, Continued

Acronyms and Abbreviations

AST	aboveground storage tank
ASTM	American Society for Testing and Materials
CCWS	Cobb County Water System
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act of 1980
CFR	Code of Federal Regulations
ERNS	Emergency Response Notification System
EDR®	Environmental Data Resources, Inc.
EDR® radius report	EDR® Radius Report™ with GeoCheck® Report
EPA	U.S. Environmental Protection Agency
ESA	environmental site assessment
FEMA	Federal Emergency Management Agency
GADNR	Georgia Department of Natural Resources
GAEPD	Georgia Environmental Protection Division
LUST	leaking underground storage tank
NFA	no further action
NPDES	National Pollutant Discharge Elimination System
NPL	National Priorities List
NRCS	Natural Resources Conservation Service
OCS	outlet control structure
PCBs	polychlorinated biphenyls
Practice	Code of Federal Regulations (CFR) Section 312.10 and the American Society for Testing and Materials (ASTM) 1527-05
RCRA	Resource Conservation and Recovery Act of 1976
REC	recognized environmental condition
USACE	U.S Army Corps of Engineers

USGS	U.S. Geological Survey
UST	underground storage tank

1.0 Executive Summary

1.1 Background

A Phase I Environmental Site Assessment (ESA) was authorized for completion by CH2M HILL of 15 alternative sites within the Butler Creek watershed, which is located in the Etowah River Basin in northwestern Cobb County. The U.S. Army Corps of Engineers (USACE) Mobile District has proposed an aquatic ecosystem restoration project under Section 206 of the Water Resources Development Act of 1996, as amended. The proposed restoration for the 15 alternative sites is listed in Table 1-1. Figure 1-1 shows the location of the watershed in Georgia, and Figure 1-2 provides a closer view of the Butler Creek watershed.

TABLE 1-1
Proposed Butler Creek Restoration Projects
Phase I Environmental Site Assessment – Butler Creek, Georgia, Site

Alternative	Location/Access	Proposed Restoration Type	Proposed Restoration Features
B2-1	Wellcrest Drive	Extend Detention & Stormwater Wetland	Rerouting of portion of Butler Creek flow, at bankfull conditions, through a sediment forebay and into 1.5-acre extended detention created wetland basin
B2-2 (1 of 2)	Mack Dobbs Road	Streambank Stabilization	Combination of stone toe protection and rootwad placement along approximately 150feet on right bank; restoration of ~245 feet of riparian buffer
B2-2 (2 of 2)	Private Drive on Mack Dobbs Road	Streambank Stabilization	Bench cut with toe protections along ~390 feet of right streambank; vegetation with willows and native trees
B3-1	Shillings Chase Court	Retention Basin Retrofit	Retrofit of an existing outlet control structure
B3-2	White Oak Court	Streambank Stabilization	Channel bench and toe protection along ~250 ft; native plantings in 0.25 acres of riparian zone
B3-2-3	Butler Ridge Park	Dry Extended Detention Pond	1.5-acre site to be converted to extended dry detention for attenuation of peak flows
B4-1	North of Cobb Parkway	Streambank Stabilization	Stone toe protection and rootwad combination along ~325 ft on left bank and ~250 ft on right bank
B5-1	Sewer easement from Nance Road	Streambank Stabilization	Placement of j-hooks along 200 linear feet of right bank (approx. 5 required), and combination of stone toe protection

			and rootwad placement 150 linear feet on both banks
B5-2	Sewer easement from Nance Road	Streambank Stabilization	Placement of rock grade control structures intermittently along approximately 1000 linear feet of tributary (approximately 8 structures required), and spot stabilization through reshaping banks, matting, and vegetative stabilization.
B20	Sewer easement from Jim Owens Road	Extend Detention & Stormwater Wetland	Rerouting of intermittent tributary and portion of Butler Creek flow, during storm events, through a sediment forebay and into 4.3-acre extended detention created wetland
B40 (1 of 2)	Loring Way and Loring Road	Streambank Stabilization	Installation of a velocity dissipator; stone toe protection along ~325 ft on right bank (in 2 segments)
B40 (2 of 2)	Sewer easement near Johnston Road	Streambank Stabilization	Bank shaping, stone toe protection, and vegetation along ~100 ft on left bank; ~250 ft of longitudinal peaked stone toe protection on right bank; vegetation of upper left and right banks
B50 (1 of 2)	Sewer easement from Jim Owens Road	Streambank Stabilization	Protection of ~315 feet of longitudinal toe of streambank; vegetation of upper banks
B50 (2 of 2)	Sewer easement from Jim Owens Road	Streambank Stabilization	Stone protection of ~95 feet of longitudinal toe on right bank and ~95 feet of bank shaping, toe protection, and vegetation on left bank
B70 & B70a	Loring Road	Extend Detention & Stormwater Wetland	Rerouting of intermittent tributary through a sediment forebay and into 9-acre extended detention created wetland and concrete bridge to facilitate fish passage

1.2 Summary of Work Performed

The ESA consisted of a walking and driving reconnaissance, a records review, a review of historical maps and photographs, and interviews. The ESA was conducted in conformance with the Code of Federal Regulations (CFR) Section 312.10 and the American Society for Testing and Materials (ASTM) E1527-05 (Practice). Exceptions to the Practice include the following:

- Interviews with the previous owners were not performed. Interview questionnaires were mailed to the current property owners listed in Section 4.5.
- Aerial photographs at 5-year intervals were not reviewed because they were unavailable at that interval. No aerial photographs were obtained from 1944 through 1954, 1956 through 1959, 1961 through 1965, 1967 through 1971, 1973 through 1985, 1987 through 1992, and 1994 through 2010.

- City directory information was reviewed only for the years spanning 1968 through 1997. Business directories and city directories, including city, cross reference, and telephone directories were reviewed, if available, for approximate 5-year intervals. No information was found for the subject properties or surrounding properties; the results indicated that the subject properties were not listed in the resource search.

The purpose of the Phase I ESA was to identify, to the extent feasible, recognized environmental conditions (RECs), which are defined as follows:

> The presence or likely presence of any hazardous substances or petroleum products on a property under conditions that indicate an existing release, a past release, or a material threat of a release of any hazardous substances or petroleum products into structures on the property or into the ground, groundwater, or surface water of the property.

The subject properties are located in Cobb County, Georgia. See Table 1-1 for access to Alternative sites.

1.3 Summary of Results

This ESA is summarized as follows:

- The walking and driving reconnaissance on 10 June 2010 indicated that the subject properties are unoccupied stream segments and open field areas.
- Alternatives B2-2, B3-2, B4-1, B5-1, B5-2, B40, and B50, are sections of Butler Creek or associated tributaries and include the creek bed and a 50-foot buffer on both banks. Alternative B2-1 includes a section of a Butler Creek tributary and the surrounding floodplain area. Alternatives B3-2-3, B20, and B70 are open field and wooded areas adjacent to Butler Creek tributaries. Alternative B70 includes an open field area adjacent to two radio towers and associated structures. Two transformers were also observed within the site. Finally, Alternative B3-1 is a manmade structure located in the stream channel of a Butler Creek tributary.
- The subject properties are surrounded by residential areas.
- The Environmental Data Resources, Inc., Radius Map and GeoCheck® Reports (EDR® radius reports) (2010a and 2010b) indicates that one sewage spill occurred within the subject properties or Butler Creek.
- The EDR® radius reports (2010a and 2010b) indicate that several regulated properties (properties identified in the federal, state and local database searches) were within the 0.5-mile search radii outside the subject properties (additional sites located outside the 0.5-mile radius are listed in Appendix C):
  - Four spill incidents identified in the SPILLS database
  - Four facilities indentified in the Resource Conservation and Recovery Act of 1976 (RCRA)-NonGen database
  - Four leaking underground storage tanks (USTs) identified in the Leaking Underground Storage Tank (LUST) database

  - Three drycleaner facilities identified in the DRYCLEANERS database
  - Eight identified aboveground storage tanks (ASTs) or USTs currently in use
  - Three orphan sites
- ESA questionnaires regarding the environmental condition of the properties were mailed to the residents and owners adjoining and surrounding the subject properties.
- The findings of this Phase I ESA reveal evidence of a historical recognized environmental condition (REC) on the subject property Alternative B50.

Available data, the EDR® radius reports (2010a and 2010b) and windshield surveys of adjacent and surrounding properties are not sufficient to conclude whether the adjoining residential properties have impacted the subject properties. However, at the time of this report, there was no evidence of releases on the adjacent properties that have had an environmental impact on the subject properties.

This assessment revealed evidence of a historic REC. In 2000, an overflowing manhole released raw sewage and other unknown materials into Butler Creek at Alternative B50. The overflow was caused by a heavy grease clog in the sewer line. The incident report indicated similar releases have occurred at this location in the past. The released material was not sampled, so any potential hazardous constituents are unknown. The grease build up in the pipe was also not sampled, and whether the grease is petroleum-based or cooking waste is unknown. The grease may have been released to Butler Creek during the overflow. No soil or sediment analytical data was readily available within the study area. Lacking analytical data, there was no identified direct evidence that the sediments and bank soils have been environmentally impacted. No evidence of the release was observed at Alternative B50 during the site reconnaissance. CCWS coordinated with fat, oil, and grease users in the area and the problem was resolved. No additional spills have occurred.

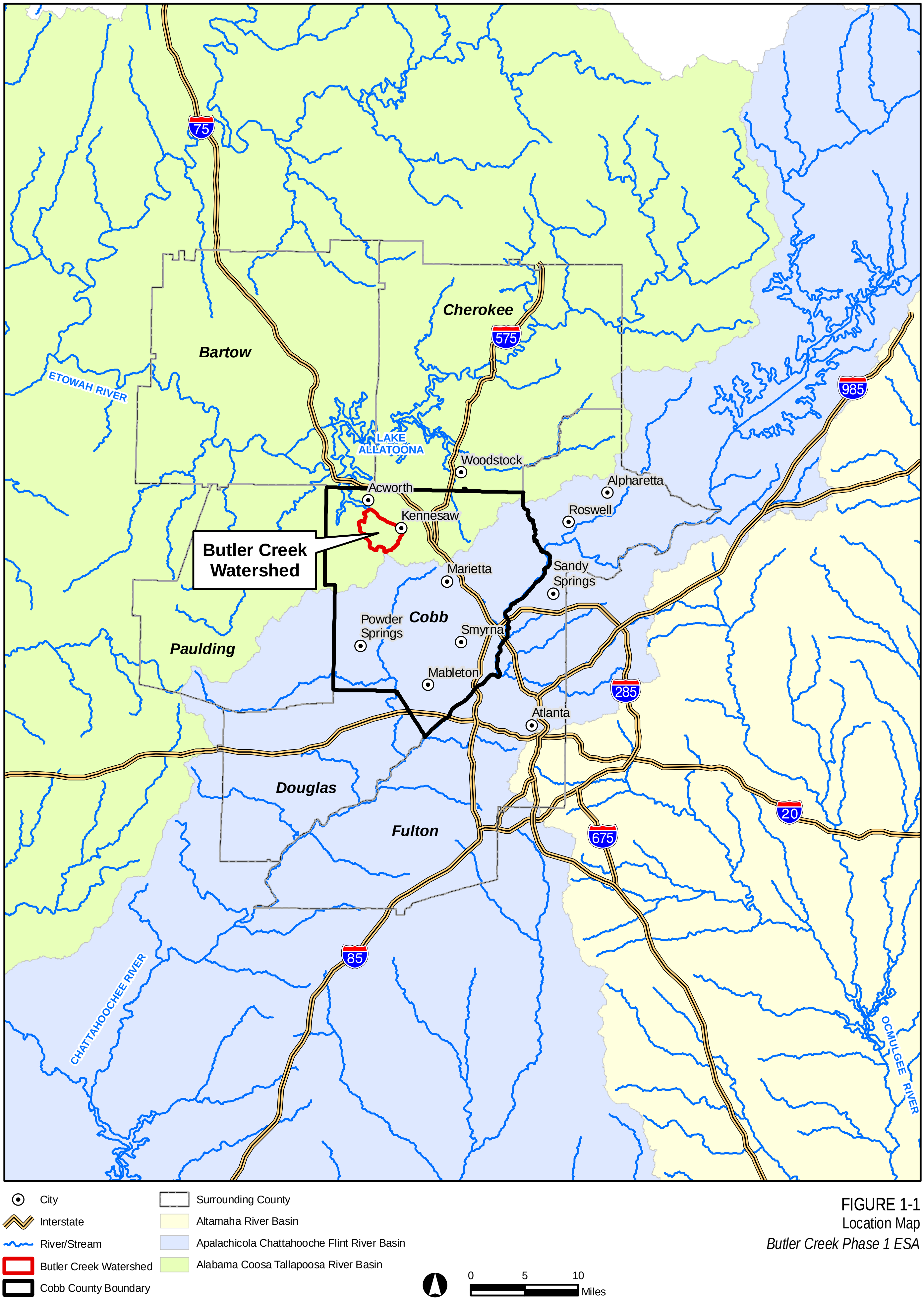


FIGURE 1-1
Location Map
Butler Creek Phase 1 ESA

CH2MHILL

\\GALILEO\PROJ\BUTLERCREEK\MAPFILES\LOCATIONMAP.MXD JMINIX 5/24/2010 16:17:34

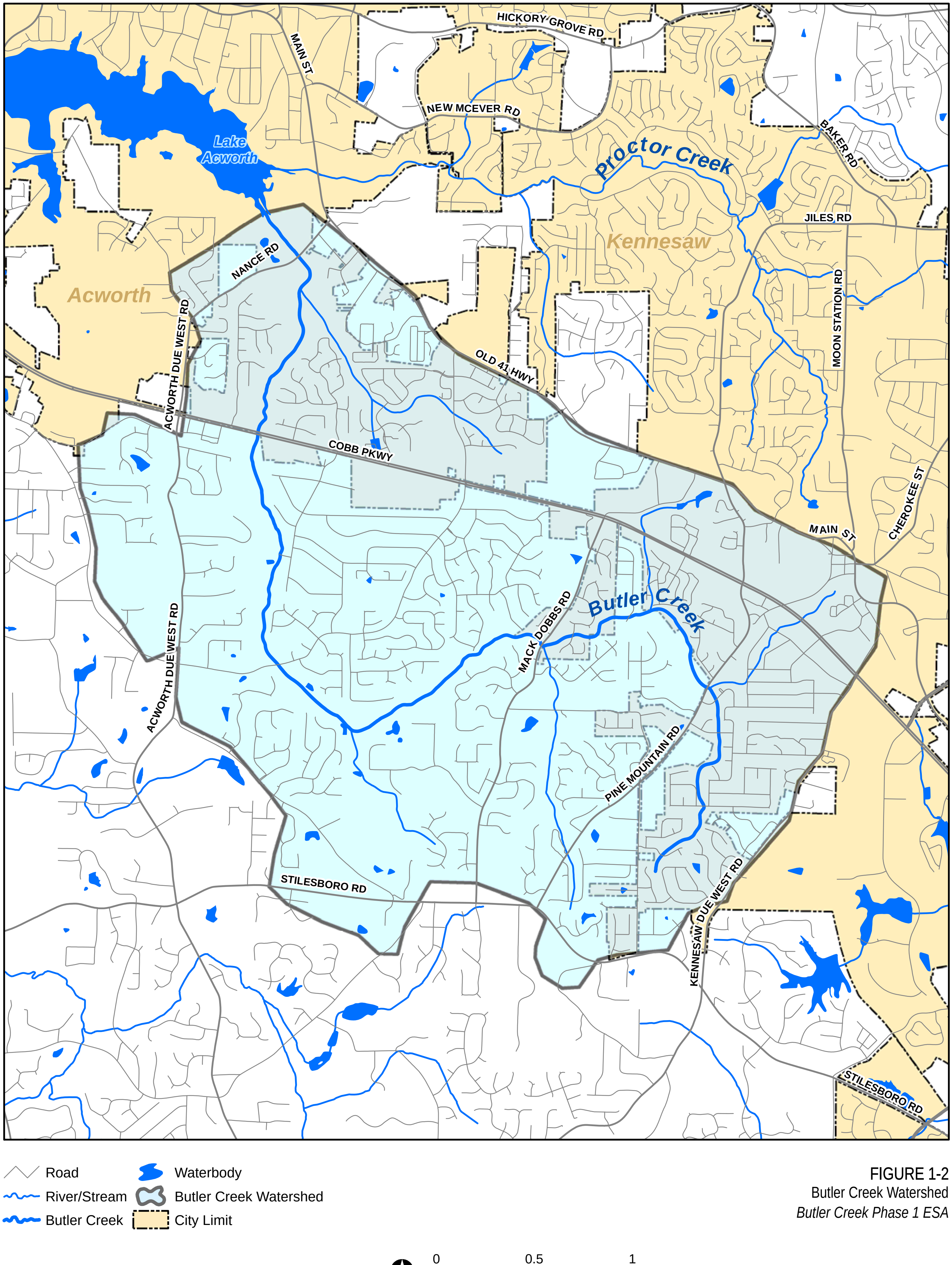


FIGURE 1-2
Butler Creek Watershed
Butler Creek Phase 1 ESA

2.0 Introduction

2.1 Purpose

CH2M HILL conducted a Phase I ESA of the 15 subject properties shown on Figures 2-1 through 2-11. The USACE Mobile District has proposed an aquatic ecosystem restoration project under Section 206 of the Water Resources Development Act of 1996, as amended. The proposed restoration for the 15 sites is listed in Table 1-1.

The purpose of the Phase I ESA was to identify, to the extent feasible, RECs in accordance with the Practice. As defined in the Practice, a REC means the following:

> The presence or likely presence of any hazardous substances or petroleum products on a property under conditions that indicate an existing release, a past release, or a material threat of a release of any hazardous substances or petroleum products into structures on the property or into the ground, groundwater, or surface water of the property. The term includes hazardous substances or petroleum products even under conditions in compliance with laws. The term is not intended to include de minimis conditions that generally do not present a threat to human health or the environment and that generally would not be the subject of an enforcement action if brought to the attention of appropriate governmental agencies.

2.2 Detailed Scope of Service

CH2M HILL's scope of services, performed in accordance with the Practice, consisted of the following primary components:

- **Walking and Driving Reconnaissance**. CH2M HILL performed a property survey to check for visible evidence of hazardous materials handling, storage, or disposal, and other potential contaminants or practices that might have affected the subject properties. No samples were collected or analyzed as part of the scope of services. The property survey was performed on 10 June 2010 by CH2M HILL.
- **Records Review**. Properties within the designated ASTM radii were evaluated for potential impacts to the subject properties. This evaluation was limited to the following:
  - Evidence of environmental conditions on adjacent properties was based on readily observable conditions from the subject property and publicly accessed roadways (CH2M HILL did not physically enter neighboring properties)
  - Data that were reasonably ascertainable from federal, state, and local regulatory agency files using EDR® databases as the source of information
- **Review of Historical Maps and Photographs**. A list of historical maps, records, reports, and photographs is presented in Section 5.0. These items were reviewed to help identify

current and historically documented environmental conditions that may have impacted the subject properties.

- **Interviews**. An ESA questionnaire was mailed to the owners of the subject properties.

CH2M HILL conducted the Phase I ESA in a manner consistent with accepted environmental site assessment practices and believes that the information contained in this report is true and correct, within the limitations and exceptions described in Section 2.4. All findings, opinions, and conclusions stated in this report are derived from facts and circumstances as they existed during the property survey on 10 June 2010; however, they are not necessarily indicative of future conditions or operating practices at the subject properties.

2.3 Significant Assumptions

Significant assumptions made as part of identifying RECs based on the records review, property reconnaissance, and interviews are discussed in this report. In accordance with the Practice, information collected from these and other sources was assumed to be correct and has not been independently verified by CH2M HILL.

2.4 Limitations and Exceptions

The Phase I ESA was performed in accordance with the Practice and is limited to the practices set forth in the standard. Exceptions to the Practice include the following data gaps:

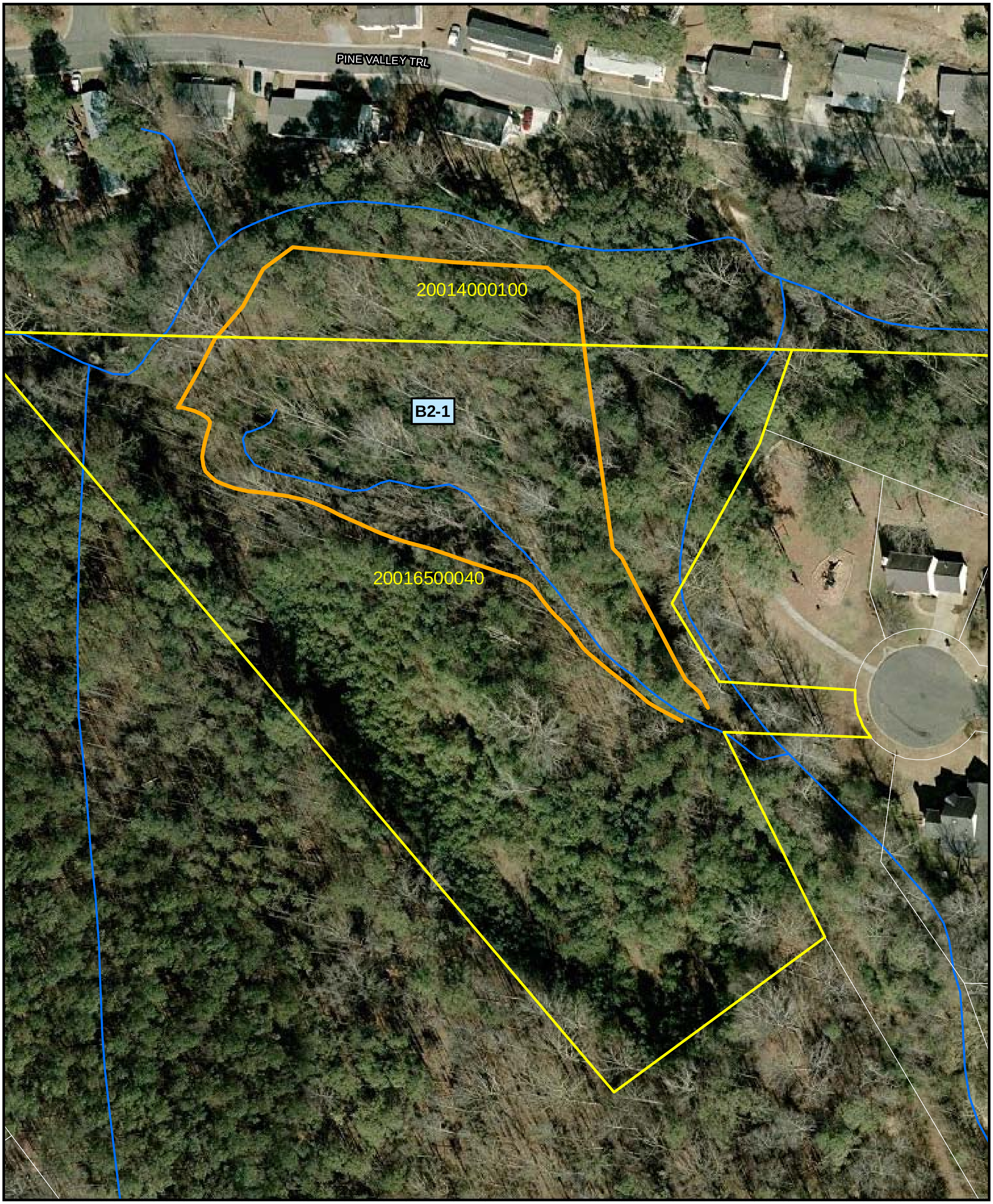
- Interviews with the previous owners were not performed. Interview questionnaires were mailed to the current property owners listed in Section 4.5.
- Aerial photographs at 5-year intervals were not reviewed because they were unavailable at that interval. No aerial photographs were obtained from 1944 through 1954, 1956 through 1959, 1961 through 1965, 1967 through 1971, 1973 through 1985, 1987 through 1992, and 1994 through 2004.
- City directory information was reviewed only for the years spanning 1968 through 1997. Business directories and city directories, including city, cross reference, and telephone directories were reviewed, if available, for approximate 5-year intervals. No information was found for the subject properties or surrounding properties; the results indicated that the subject properties were not listed in the resource search.

2.5 Special Terms and Conditions

There are no special terms and conditions for these subject properties.

2.6 User Reliance

This report was prepared for the exclusive use of USACE Mobile District for specific application to the subject properties. No warranty, expressed or implied, is made. There are no beneficiaries of this report other than USACE Mobile District, and no other person or entity is to rely on this report without written consent of CH2M HILL and a written agreement limiting CH2M HILL's liability.



River / Stream

Parcels Within Project Footprint

Project Footprint

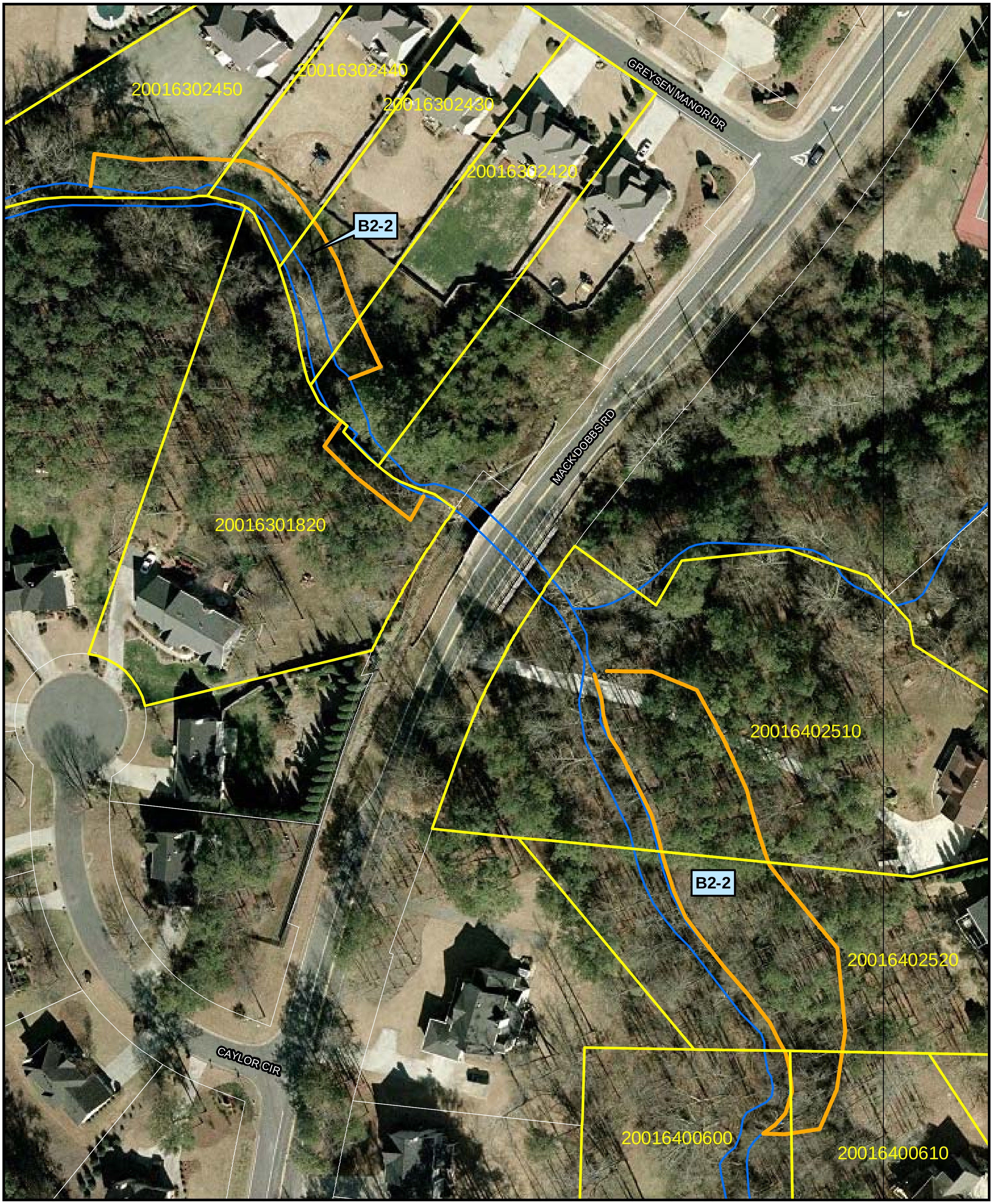
Parcels

0 50 100 Feet

FIGURE 2-1
Alternative B2-1
Butler Creek Phase 1 ESA

CH2MHILL

\\GALILEO\PROJ\BUTLERCREEK\MAPFILES\PARCELS.MXD JMINIX 6/3/2010 12:04:36



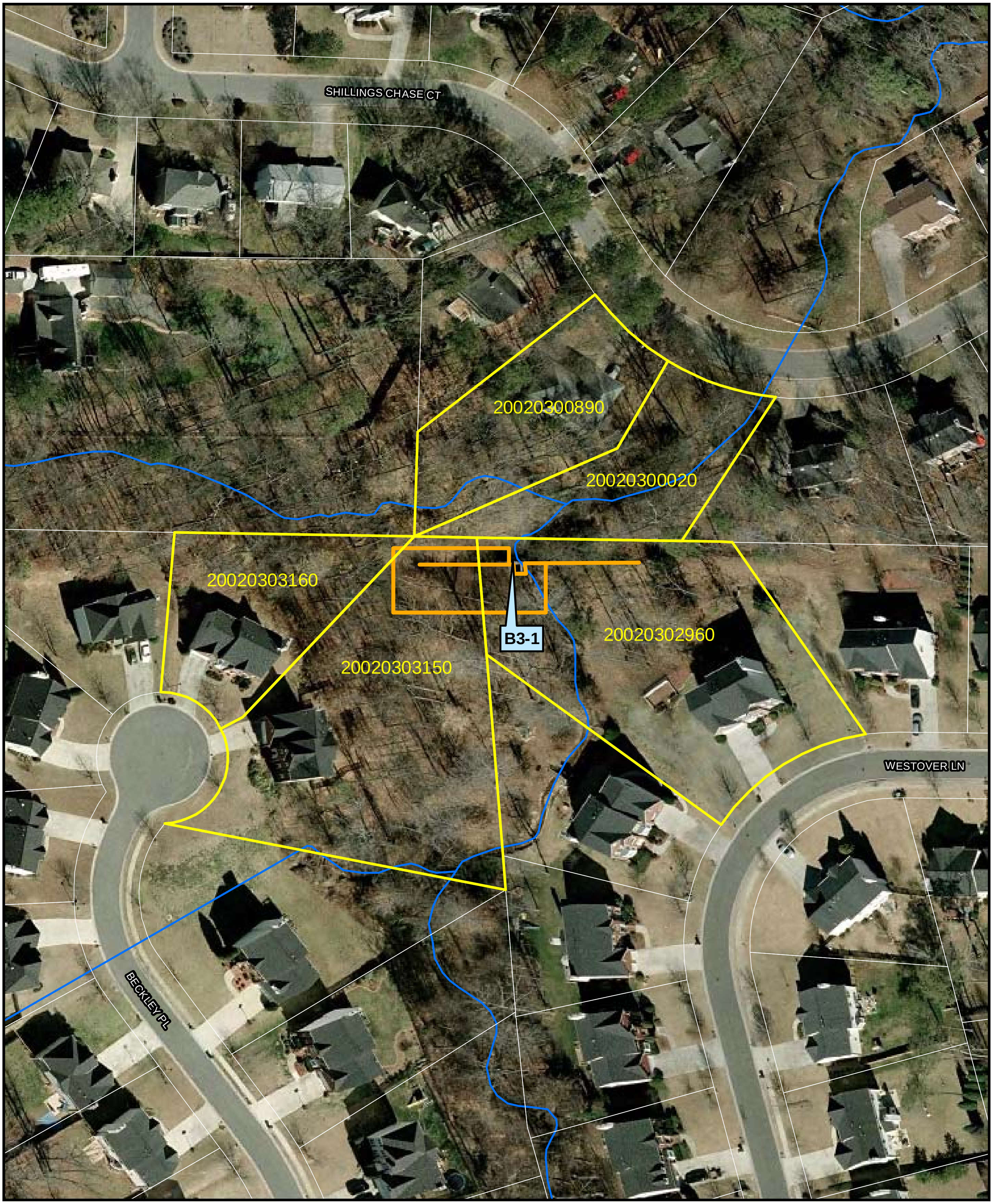
River / Stream
Parcels Within Project Footprint
Project Footprint
Parcels

0 50 100 Feet

FIGURE 2-2
Alternative B2-2
Butler Creek Phase 1 ESA

CH2MHILL

\\GALILEO\PROJ\BUTLERCREEK\MAPFILES\PARCELS.MXD JMINIX 6/3/2010 12:04:36



River / Stream

Parcels Within Project Footprint

Project Footprint

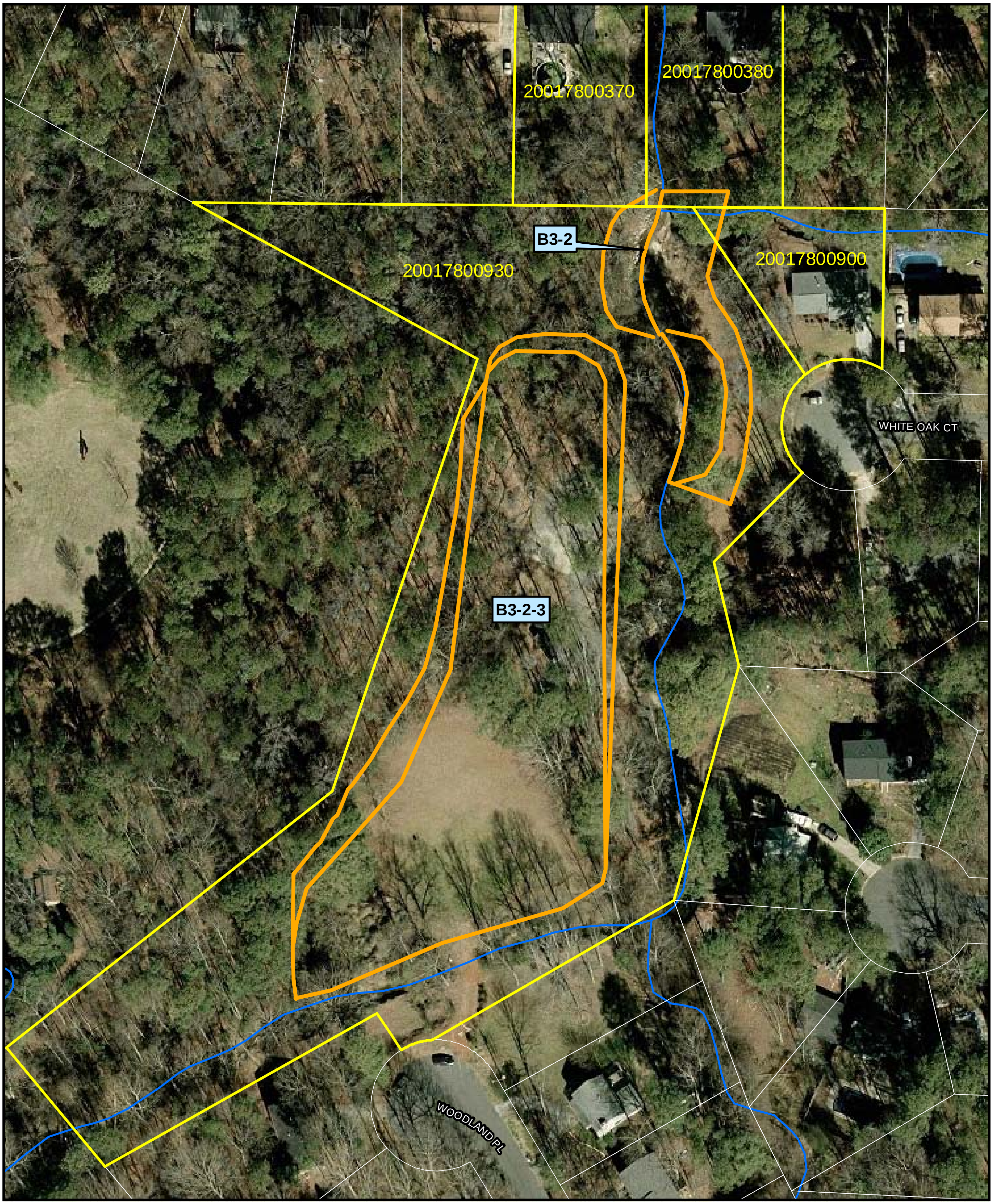
Parcels

0 50 100 Feet

FIGURE 2-3
Alternative B3-1
Butler Creek Phase 1 ESA

CH2MHILL

\\GALILEO\PROJ\BUTLERCREEK\MAPFILES\PARCELS.MXD JMINIX 6/3/2010 12:04:36



River / Stream

Parcels Within Project Footprint

Project Footprint

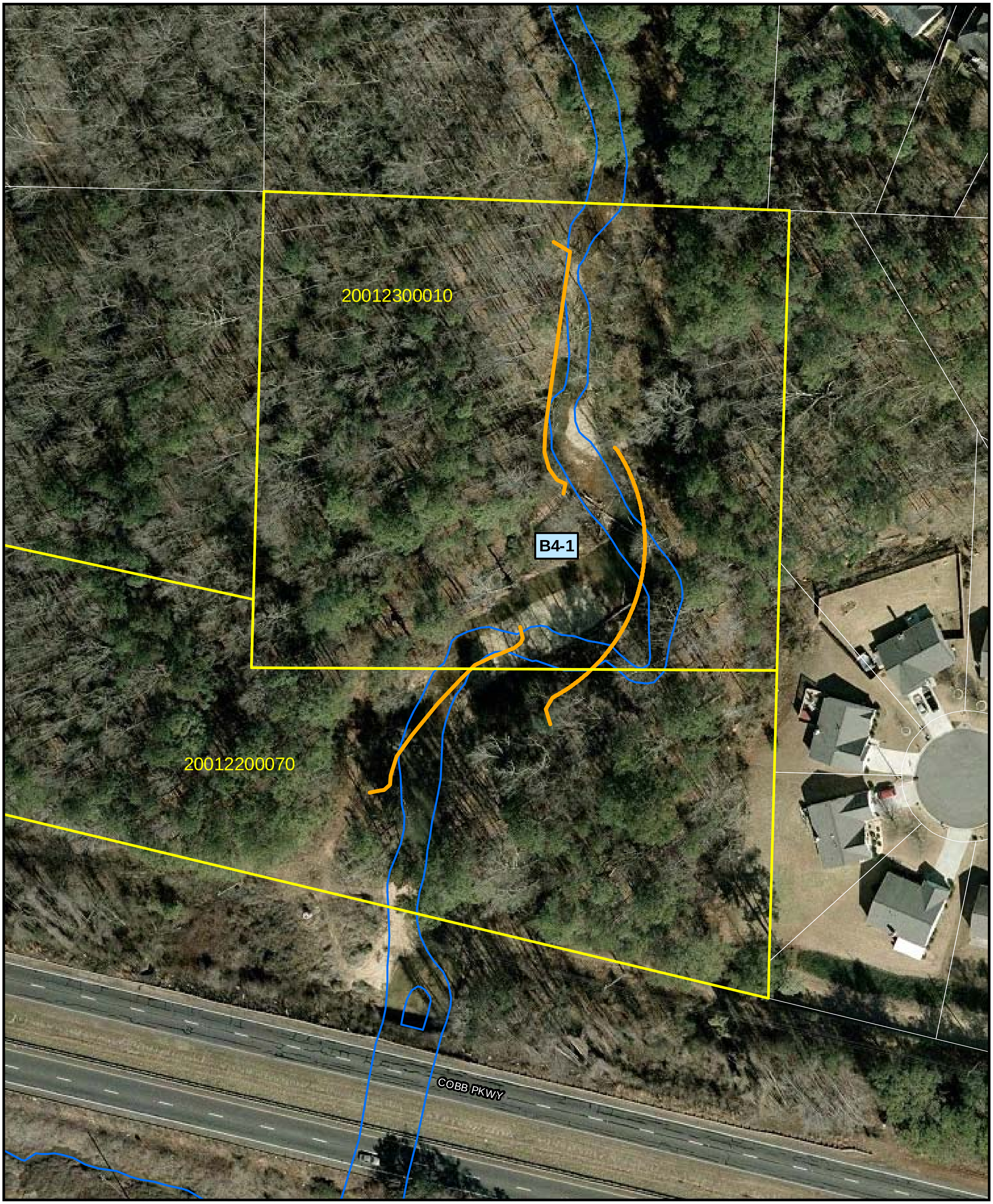
Parcels

0 50 100 Feet

FIGURE 2-4
Alternative B3-2 and B3-2-3
Butler Creek Phase 1 ESA

CH2MHILL

\\GALILEO\PROJ\BUTLERCREEK\MAPFILES\PARCELS.MXD JMINIX 6/3/2010 12:04:36



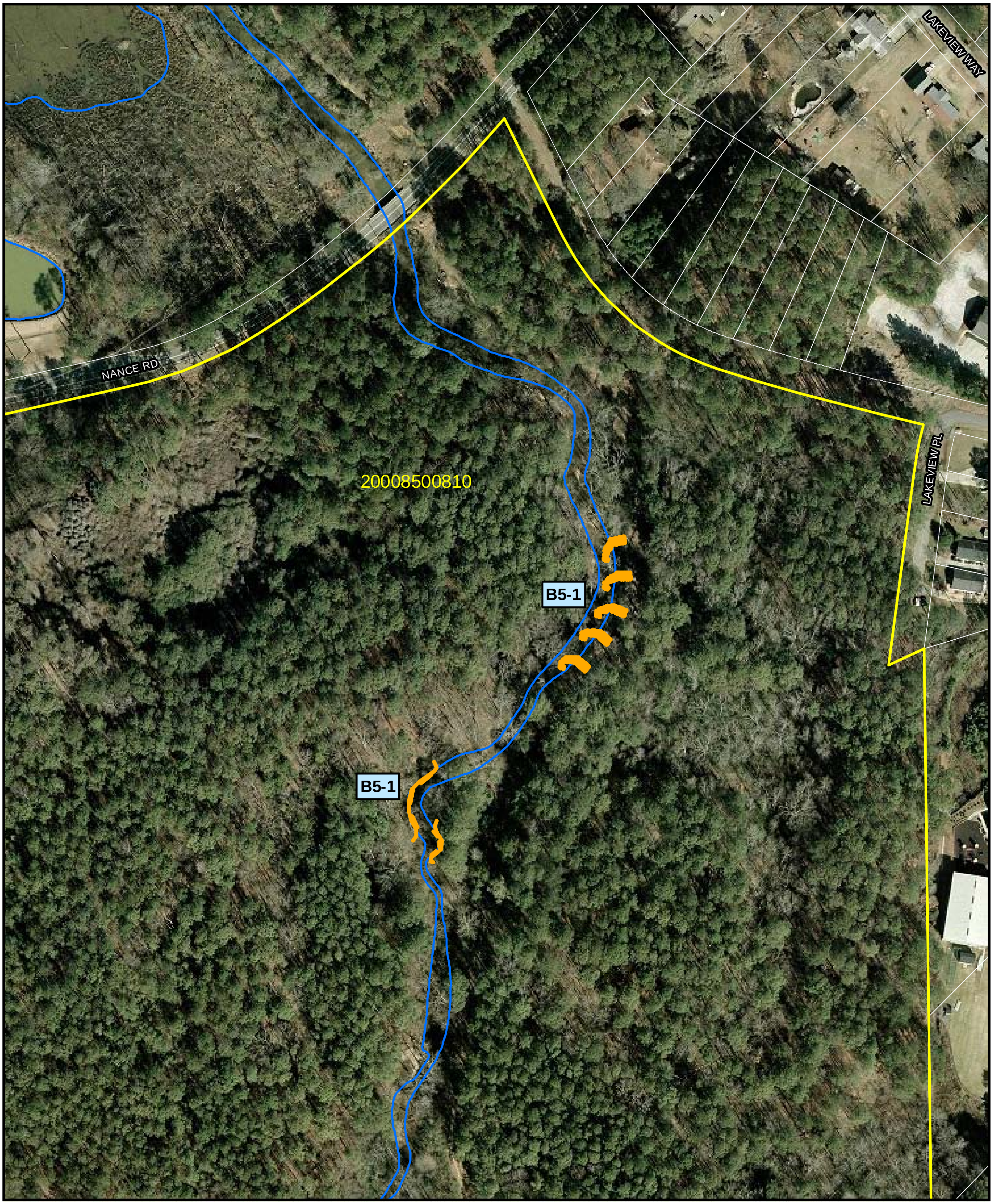
River / Stream
Parcels Within Project Footprint
Project Footprint
Parcels

0 50 100
Feet

FIGURE 2-5
Alternative B4-1
Butler Creek Phase 1 ESA

CH2MHILL

\\GALILEO\PROJ\BUTLERCREEK\MAPFILES\PARCELS.MXD JMINIX 6/3/2010 12:04:36



River / Stream

Parcels Within Project Footprint

Project Footprint

Parcels

0 50 100
Feet

FIGURE 2-6
Alternative B5-1
Butler Creek Phase 1 ESA

CH2MHILL

\\GALILEO\PROJ\BUTLERCREEK\MAPFILES\PARCELS.MXD JMINIX 6/3/2010 12:04:36

River / Stream
Parcels Within Project Footprint
Project Footprint
Parcels

0 50 100
Feet

FIGURE 2-7
Alternative B5-2
Butler Creek Phase 1 ESA

\\GALILEO\PROJ\BUTLERCREEK\MAPFILES\PARCELS.MXD JMINIX 6/3/2010 12:04:36

CH2MHILL

River / Stream

Parcels Within Project Footprint

Project Footprint

Parcels

0 50 100 Feet

FIGURE 2-8
Alternative B20 and B50(2of2)
Butler Creek Phase 1 ESA

CH2MHILL

\\GALILEO\PROJ\BUTLERCREEK\MAPFILES\PARCELS.MXD JMINIX 6/3/2010 12:04:36

River / Stream

Parcels Within Project Footprint

Project Footprint

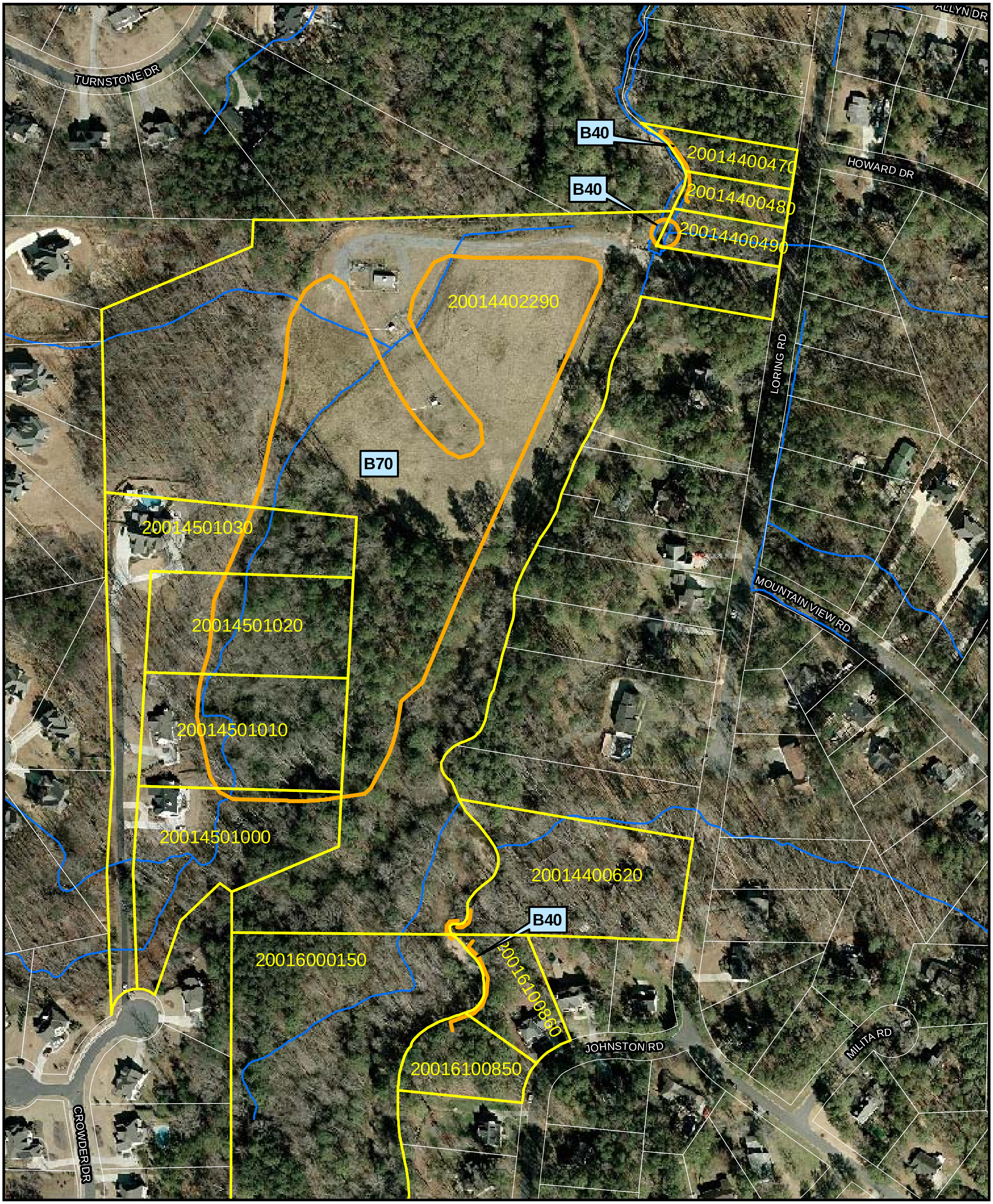
Parcels

0 50 100 Feet

FIGURE 2-9
Alternative B50(1of2)
Butler Creek Phase 1 ESA

CH2MHILL

\\GALILEO\PROJ\BUTLERCREEK\MAPFILES\PARCELS.MXD JMINIX 6/3/2010 12:04:36



River / Stream
Parcels Within Project Footprint
Project Footprint
Parcels

0 50 100 Feet

FIGURE 2-10
Alternative B40 and B70
Butler Creek Phase 1 ESA

CH2MHILL

\\GALILEO\PROJ\BUTLERCREEK\MAPFILES\PARCELS.MXD JMINIX 6/3/2010 12:04:36

3.0 Site Description

3.1 Location and Legal Description

The subject properties, Alternatives B2-2, B3-2, B4-1, B5-1, B5-2, B40, and B50 (Appendix A, Photographs 1-12) are sections of Butler Creek or associated tributaries and include the creek bed and a 50-foot buffer on both banks. Alternative B2-1 (Appendix A, Photographs 13 and 14) includes a section of a Butler Creek tributary and the surrounding floodplain area. Alternatives B3-2-3, B20, and B70 (Appendix A, Photographs 15 and 16) are open field and wooded areas adjacent to Butler Creek tributaries. Finally, Alternative B3-1 (Appendix A, Photograph 17) is a manmade structure located in the stream channel of a Butler Creek tributary.

3.2 Subject Property and Vicinity General Characteristics

The subject properties are located in the City of Kennesaw, Georgia. Kennesaw is located in northwest Cobb County within the Piedmont region of Georgia. The City of Kennesaw is within the Atlanta metropolitan area and includes predominantly residential and commercial land use areas. Residential neighborhoods surrounded the subject properties and commercial shopping malls are found along Cobb Parkway, which transects the Butler Creek watershed.

3.3 Current Use of the Subject Property

All the alternative sites are unoccupied stream sections or areas surrounded by residential neighborhoods and parks.

3.4 Descriptions of Structures, Roads, Other Improvements on the Subject Property

The site access and visual observations for each of the alternatives is reported in Table 3-1.

TABLE 3-1
Site Visit Observations
Phase I Environmental Site Assessment – Butler Creek, Georgia, Site

Alternative	Location/Access	Site Visit Observations
B2-1	End of Wellcrest Drive	Several sewer manholes. Straight, non-flowing tributary stream with low eroded banks. A destroyed shed was observed within the tributary stream (Appendix A, Photograph 18). The remaining area was wooded and no additional structures were observed.

TABLE 3-1
Site Visit Observations
Phase I Environmental Site Assessment – Butler Creek, Georgia, Site

Alternative	Location/Access	Site Visit Observations
B2-2 (1 of 2)	Mack Dobbs Road, accessed from bridge	Residential properties surround the alternative site (Butler Creek). Mowed grasses and thin tree line on right bank. Forested buffer on left bank. Cobble beds in stream bed and some riprap.
B2-2 (2 of 2)	Private Drive on Mack Dobbs Road	Small tributary to Butler Creek. Wooded riparian area. No additional structures observed.
B3-1	Shillings Chase Court	Small tributary stream flowed through a concrete manmade structure located behind two residential dwellings. A sewer manhole was observed near the structure. The remaining area was wooded and no additional structures were found.
B3-2	End of White Oak Court	A collapsed foot bridge was observed in Butler Creek (Appendix A, Photograph 19). A closed park area was located on the left bank. A thin wooded riparian area surrounded the creek.
B3-2-3	End of Woodland Place	Includes a large open field and the closed park area noted in B3-2. A small gravel drive and culvert provide access to the site from Woodland Place (Appendix A, Photograph 20).
B4-1	North of Cobb Parkway, accessed from gravel road near guardrail	Main stem of Butler Creek. Existing riprap stone wall with sewer manhole on right bank (Appendix A, Photograph 21). Eroded banks and gravel beds in stream channel. The riparian area was wooded and no additional structures were observed.
B5-1	Sewer easement from Nance Road	Tributary to Butler Creek. Sewer right-of-way and manholes directly adjacent to site on right bank. One manhole was observed on the left bank. Wooded riparian area and no additional structures were observed.
B5-2	Sewer easement from Nance Road	Tributary to Butler Creek. Sewer right-of-way and manholes directly adjacent to site on right bank. Residential areas directly adjacent to stream on both banks. One residence on left bank is pumping water from the stream to supply small pond (Appendix A, Photographs 22 and 23). Wooded riparian area and no other structures were observed.
B20	Sewer easement from Jim Owens Road	Main stem of Butler Creek. Wooded area. No structures or other observations to report.
B40 (1 of 2)	Loring Way blocked off, so accessed from	Main stem of Butler Creek. Large rock bed in stream. Riprap downstream where the sewer

TABLE 3-1
Site Visit Observations
Phase I Environmental Site Assessment – Butler Creek, Georgia, Site

Alternative	Location/Access	Site Visit Observations
	the sewer easement crossing Loring Drive	easement crosses the creek. Wooded riparian area.
B40 (2 of 2)	Sewer easement near Johnston Road	Main stem of Butler Creek. Stream forms s-shape. Wooded riparian area. No additional observations.
B50 (1 of 2)	Sewer easement from Jim Owens Road	Main stem of Butler Creek. Sewer easement directly adjacent to stream on right bank. Stream forms s-shape. Wooded riparian area. No additional observations.
B50 (2 of 2)	Sewer easement from Jim Owens Road	Main stem of Butler Creek. Sewer easement directly adjacent to stream on right bank. Fallen trees observed in the stream. Eroded banks. Wooded riparian area. No additional observations.
B70	Loring Road, accessed from a dirt road with a paved, culvert bridge crossing over Butler Creek	Main stem of Butler Creek. Two radio towers and associated small building with electrical boxes were observed directly adjacent to subject property (Appendix A, Photograph 24). Sewer easement observed along east side of subject property. Two transformers were observed along the north boundary. (Appendix A, Photograph 25).

No other improvements were observed on the subject properties.

3.5 Current Uses of Adjoining Properties

The surrounding land use for the subject properties is generally characterized as residential or forested lands. The Cobb County sewer easement was adjacent to several of the subject properties, including Alternatives B4-1, B5-1, B5-2, B20, B40, B50, and B70. Two radio towers and an associated fenced-in building was observed in the property adjacent to Alternative B70.

On 10 June 2010, CH2M HILL performed a windshield and walk-through survey of properties adjacent to the subject properties. The adjacent properties were not entered; however, no ASTs or drums were observed. Transformers were observed in the property adjacent to Alternative B70.

4.0 USACE-provided Information

4.1 Title Records

No chain-of-title information has been provided to or acquired by CH2M HILL during this Phase I ESA.

4.2 Environmental Liens or Activity and Use Limitations

An environmental liens and use of limitations search was performed for the subject properties through the Georgia Superior Court Clerks' Cooperative Authority database web site http://www.gsccca.org/search/Lien/. A lien exists for the property owned by Kazim Sayedzada at 4112 Crowder Drive, Kennesaw, GA 30152; however, it is unknown whether this is an environmental lien.

4.3 Commonly Known or Reasonably Ascertainable Information

Other than information available through a search of environmental databases, Cobb County records, and limited interviews, no additional information on the subject properties or adjacent properties was reasonably obtainable for inclusion in this evaluation.

4.4 Valuation Reduction for Environmental Issues

No valuation reduction information has been provided to or acquired by CH2M HILL during this Phase I ESA.

4.5 Owner, Property Manager, and Occupant Information

The subject properties in question are stream segments and floodplain areas owned by the following individuals:

[redacted]

[redacted]

4.6 Reason for Performing Phase I ESA

The Phase I ESA was performed as part of a property transaction to identify potential RECs prior to a possible lease-to-purchase agreement of the subject properties by the nonfederal sponsor.

4.7 Other

No other information was provided to or reviewed by CH2M HILL as part of this Phase I ESA.

5.0 Records Review

5.1 Federal, State, and Tribal Environmental Records Review

An environmental records search was performed by EDR® and provided in the EDR® radius reports (2010a and 2010b; see Appendix B). The following federal records and databases were searched as prescribed in the Practice minimum search distances:

- National Priorities List (NPL)
- Proposed NPL
- Delisted NPL
- Federal Superfund Liens (NPL LIENS)
- Comprehensive Environmental Response, Compensation, and Liability Information System (CERCLIS)
- Federal Facility Site Information Listing (FEDERAL FACILITY)
- CERCLIS NFARP--No Further Remedial Action Planned
- Correction Action Report (CORRACTS)
- Resource Conservation and Recovery Act Information (RCRA-TSDF)
- Resource Conservation and Recovery Act Information (RCRA-LQG)
- Resource Conservation and Recovery Act Information (RCRA-SQG)
- Resource Conservation and Recovery Act Information (RCRA-CESQG)
- Resource Conservation and Recovery Act Information (RCRA-NonGen)
- Emergency Response Notification System (ERNS)
- Hazardous Material Information Reporting Systems (HMIRS)
- Engineering Controls Sites List
- Sites with Institutional Controls
- Spills information (SPILLS)
- Incident and Accident Data (DOT OPS)
- Department of Defense Sites (DOD)
- Formerly Used Defense Sites (FUDS)
- A Listing of Brownfields Sites (US BROWNFIELDS)

- Superfund (CERCLA) Consent Decrees (CONSENT)
- Records of Decisions (ROD)
- Uranium Mill Tailing Sites (UMTRA)
- Toxic Chemical Release Inventory System (TRIS)
- Toxic Substances Control Act (TSCA)
- Federal Insecticide, Fungicide, and Rodenticide Act and Toxic Substances Control Act Tracking System (FTTS)
- FIFRA/TSCA Tracking System Administrative Case Listing (HIST FTTS)
- Section 7 Tracking Systems (SSTS)
- Integrated Compliance Information Systems (ICIS)
- Radiation Information Database (RADINFO)
- PCB Activity Database System (PADS)
- Material Licensing Tracking System (MLTS)
- Mines Master Index File (MINES)
- Facility Index System/Facility Registry System (FINDS)
- RCRA Administrative Action Tracking System (RAATS)
- NPDES Wastewater Permit List (NPDES)
- Coal Ash Disposal Site Listing (COAL ASH)
- Sleam-Electric Plan Operation Data (COAL ASH DOE)
- PCB Transformer Registration Database (PCB TRANSFORMER)
- Coal Combustion Residues Surface Impoundments List (COAL ASH EPA)

The following state and local records and databases were searched:

- Hazardous Site Inventory (SHWS)
- Georgia Non-Hazardous Site Inventory (GA NON-HSI)
- Drycleaner Database (DRYCLEANERS)
- State Coalition for Remediation of Drycleaners Listing (SCRD DRYCLEANERS)
- Solid Waste Disposal Facilities (SWF/LF)
- CERCLA Lien Information (LIENS 2)
- Brownfields Public Record List (BROWNFIELDS)
- Public Record List (INST CONTROL)
- Voluntary Cleanup Program Site (VIC)
- Open Dump Inventory (ODI)
- Torres Martinez Reservation Illegal Dump Site Locations (DEBRIS REGION 9)
- Historical Landfills (HIST LF)

- Clandestine Drug Labs (US CDL)
- Delisted Hazardous Site Inventory Listing (DEL SHWS)
- National Clandestine Laboratory Register (US HIST CDL)
- Current Emissions Inventory Data (AIRS)
- Tier 2 Chemical Inventory Reports (TIER 2)
- GADNR Underground Storage Tank Database (UST)
- GADNR Aboveground Storage Tank Database (AST)
- Underground Storage Tank Listing (FEMA UST)
- Land Use Control Information System (LUCIS)

The following tribal records and databases were searched:

- Indian Reservation (INDIAN RESERV)
- Leaking Underground Storage Tanks on Indian Land (INDIAN LUST)
- Underground Storage Tanks on Indian Land (INDIAN UST)
- Voluntary Cleanup Priority Listing (INDIAN VCP)

5.1.1 Subject Property

One state federal record was found for subject property Alternative B50. A sewage spill to Butler Creek was reported at 3909 Sharpel Lane, Kennesaw, GA 30152 (located directly adjacent to Alternative B50) on April 8, 2000. An overflowing manhole released approximately 80 gallons of raw sewage and other unknown materials into Butler Creek. Heavy grease build up caused a clog in the pipe and the release from the manhole. The line was flushed with 100 gallons of water. The incident report indicated that similar clogs have occurred in the past at this location. Cobb County Water System (CCWS) planned to camera into the pipe to determine the cause of the grease build up (CCWS, 2000).

The released material was not sampled, so any potential hazardous constituents are unknown. The grease build up in the pipe was also not sampled, and whether the grease is petroleum-based or cooking waste is unknown. The grease may have been released to Butler Creek during the overflow. No evidence of the release was observed at Alternative B50 during the site reconnaissance. CCWS coordinated with fat, oil, and grease users in the area and the problem was resolved. No additional spills have occurred.

5.1.2 Surrounding Properties

The environmental records for surrounding properties found within a 0.5-mile radius of the subject properties are listed in Table 5-1. Spills or releases to Butler Creek outside of the radius search were not evaluated in this report.

TABLE 5-1
Environmental Records for Surrounding Properties
Phase I Environmental Site Assessment – Butler Creek, Georgia, Site

Name/Type of Property	Address	Distance and Direction from Nearest Subject Property	Database	Remarks/Status

TABLE 5-1
Environmental Records for Surrounding Properties
Phase I Environmental Site Assessment – Butler Creek, Georgia, Site

Name/Type of Property	Address	Distance and Direction from Nearest Subject Property	Database	Remarks/Status
[redacted]	[redacted]	0.5 mile southwest of B4-1	RCRA-NonGen, FINDS	Non generator of hazardous materials, historically CESQG
[redacted]	[redacted]	0.24 mile west of B2-2	SPILLS	12/14/1992, unknown material
[redacted]	[redacted]	0.28 miles west of B2-2	RCRA-NonGen, FINDS	Non generator of hazardous materials, historically small quantity generator, no violations
[redacted]	[redacted]	0.45 mile west of B3-2 and B3-2-3	SPILLS	11/27/1992, unknown material
[redacted]	[redacted]	0.14 mile south of B-50 and B-20	SPILLS	Painting company dumping paint waste into tributary to Butler Creek
[redacted]	[redacted]	0.2 mile south of B2-2	SPILLS	06/20/2000, sewage spill to Butler Creek
[redacted]	[redacted]	0.5 mile northeast of B2-1	LUST, UST	LUST – NFA 3/2/2001 (3) 10,000-gallon gas USTS, currently in use
[redacted]	[redacted]	0.4 mile northeast of B2-1	LUST, UST	LUST – NFA 5/17/1991 (1) Diesel UST, removed 8/21/98
[redacted]	[redacted]	0.56 mile north of B2-1	RCRA-NonGen, FINDS	Currently non generator of hazardous materials, historically small quantity generator of ignitable wastes, no violations
[redacted]	[redacted]	0.87 mile northwest of B2-2	DRYCLEANERS	No reported violations

TABLE 5-1
Environmental Records for Surrounding Properties
Phase I Environmental Site Assessment – Butler Creek, Georgia, Site

Name/Type of Property	Address	Distance and Direction from Nearest Subject Property	Database	Remarks/Status
[redacted]	[redacted]	0.77 mile northwest of B2-2	AST	1 AST, unknown capacity
[redacted]	[redacted]	0.88 mile northwest of B2-2	LUST, UST, RCRA-NonGen, FINDS, AST	LUST – NFA 10/30/91 (2) 10,000-gallon gas USTs, removed 1/13/90 5,000-gallon gas UST, removed 1/13/90 550-gallon used oil UST, removed 1/13/90 (3) 10,000-gallon gas USTs and (1) 1,000-gallon used oil UST; currently in use Historically CESQG of ignitable wastes, wastes with pH less than 2, and benzene; no violations AST – 20 tanks with unknown capacity
[redacted]	[redacted]	0.9 mile northwest of B2-2	FINDS, LUST, UST	LUST – NFA 4/7/95
[redacted]	[redacted]	0.4 mile northeast of B2-1	DRYCLEANERS	No reported violations
[redacted]	[redacted]	0.81 mile northeast of B40 and B70	DRYCLEANERS	No reported violations
[redacted]	[redacted]	0.8 mile northwest of B2-2	FINDS, UST	(2) 14,000-gallon gas USTs and (2) 7,000-gallon gas USTs; currently in use

TABLE 5-1
Environmental Records for Surrounding Properties
Phase I Environmental Site Assessment – Butler Creek, Georgia, Site

Name/Type of Property	Address	Distance and Direction from Nearest Subject Property	Database	Remarks/Status
[redacted]	[redacted]	0.85 mile northwest of B2-2	AST	24 tanks, unknown capacity
[redacted]	[redacted]	1.04 miles east of B5-1 and B5-2	UST	550-gallon used oil UST; removed 6/17/99
[redacted]	[redacted]	0.36 mile west of B4-1	FINDS, UST	(2) 10,000-gallon gas USTs and (1) 10,000-gallon diesel UST; currently in use
[redacted]	[redacted]	0.3 mile northeast of B5-2	UST	(1) 10,000-gallon gas and (2) 8,000-gallon gas and diesel USTs; all currently in use
				(1) 1,000-gallon kerosene; temporarily out of use
[redacted]	[redacted]	1 mile east of B5-1 and B5-2	UST	(1) 7,000-gallon and (1) 4,000-gallon gas USTs; removed 8/17/92
				(1) 11,000-gallon gas UST; permanently out of use
[redacted]	[redacted]	0.35 mile north of B5-1	FINDS, LUST, UST	LUST – NFA 5/23/95

Notes:
AST = Aboveground Storage Tank database
CESQG = Resource Conservation and Recovery Act (RCRA) – Conditionally Exempt Small Quantity Generators
DRYCLEANERS = List of drycleaners in the state
FINDS = Facility Index System/Facility Registry System
LUST = Leaking Underground Storage Tank Incident Reports
NFA = no further action
RCRA-NonGen = Resource Conservation and Recovery Act (RCRA) (Non-generators do not presently generate hazardous waste.)
SPILLS = Releases of hazardous substances to the environment
UST = Underground Storage Tank database

Table A-1 in Appendix C lists additional properties identified in the EDR® radius reports (2010a and 2010b) located more than 0.5 mile from the subject properties.

5.1.2.1 Orphan Properties

The information about orphan properties provided in Table 5-3 was found during the records search.

TABLE 5-3
Orphan Properties
Phase I Environmental Site Assessment – Butler Creek, Georgia, Site

Operator	Database
American Manufacturing Co	FINDS, AIRS
Cobb County Northwest WRF	FINDS, UST, LUST
Bayer Corporation	FINDS, RCRA-NonGen

Notes:
AIRS = Aerometric Information Retrieval System
FINDS = Facility Index System/Facility Registry System
LUST = Leaking Underground Storage Tank Incident Reports
RCRA-NonGen = Resource Conservation and Recovery Act (RCRA) – Non-Generators do not presently generate hazardous waste
UST = Underground Storage Tank database

CH2M HILL mapped all orphan sites listed in the EDR® radius reports (2010a and 2010b) using Google Earth. The American Manufacturing Co and Bayer Corporation were located outside of the established ASTM radii search distances. The Cobb County Northwest WRF is located less than 0.5 miles from Alternative B5-1. According to the GAEPD, the two leaking USTs onsite were closed and a No Further Action was issued in June 2005.

5.2 Physical Setting Source(s)

Five U.S. Geological Survey (USGS) 7.5-minute series Acworth, a 15-minute series Acworth quadrangle topographic map, and a 30-minute series Acworth quadrangle topographic map that included the subject properties were reviewed. The subject properties, including Butler Creek and the surrounding floodplain area, are relatively flat. The general direction of topographic slope is north-northwest.

5.2.1 Historical Use Information on the Subject Property

5.2.1.1 Topographic Maps

The following historical topographic maps were provided by EDR® (2010c and 2010d) and reviewed by CH2M HILL:

- 1896 Series 30 Acworth quadrangle
- 1909 Series 15 Acworth quadrangle
- 1956 Series 7.5 Acworth quadrangle
- 1968 Series 7.5 Acworth quadrangle
- 1972 Series 7.5 Acworth quadrangle
- 1985 Series 7.5 Acworth quadrangle
- 1992 Series 7.5 Acworth quadrangle

These USGS topographic maps indicate there are no structures on the subject properties.

The EDR® Historical Topographic Map Report is provided in Appendix D.

5.2.1.2 Aerial Photographs

The following aerial photographs were provided by EDR® (2010e and 2010f) and reviewed by CH2M HILL:

- 1943, scale: 1 inch = 476 feet
- 1955, scale: 1 inch = 476 feet
- 1960, scale: 1 inch = 476 feet
- 1966, scale: 1 inch = 476 feet
- 1972, scale: 1 inch = 476 feet
- 1986, scale: 1 inch = 950 feet
- 1993, scale: 1 inch = 950 feet

The aerial photographs are summarized as follows:

- **1943 through 1972 Photographs:** The aerial photographs show farm lands and no residential neighborhoods in the areas surrounding the subject properties. Open farm lands with little tree cover were prevalent in the early aerials. However, the area was predominantly forested in the 1966 and 1972 photographs. No structures were noted on or directly adjacent to the subject properties at each of the proposed alternative stream improvement locations.
- **1986 and 1993 Photographs:** Several residential areas are shown on both aerials. In the 1986 photos, the area north of Cobb Parkway surrounding Alternatives B4-1, B5-1, and B5-2 is undeveloped and forested. However, the land has been cleared for residential neighborhoods in the 1993 photographs. The land surrounding Alternatives B2-2, B3-1, and B3-2-3 was cleared in 1986, and some of the neighborhoods had been built as evidenced on the 1993 aerial. The residential neighborhoods surrounding Alternatives B2-1, B20, and B50 also appeared in the 1993 aerials. The radio tower area adjacent to Alternatives B40 and B70 appears in the 1993 aerial. No structures were noted on or directly adjacent to the subject properties at each of the proposed alternative stream improvement locations.
- **2005 and 2006 Photographs:** These two aerial photographs picture only the Alternative B10 area, which has been removed from the report. These two aerials are not included in the Appendix.

The EDR® Aerial Photo Decade Package is provided in Appendix D.

5.2.1.3 City Directories

City directory information (EDR®, 2010g) was reviewed; the subject properties were not listed. For the years spanning 1968 through 1997, business directories and city directories, including city, cross reference, and telephone directories were reviewed, when available, for approximately 5-year intervals. No information was found for the subject properties. The surrounding properties were primarily residential with the exception of several businesses listed on Cobb Parkway.

5.3 Non-scope Considerations

5.3.1 Asbestos-containing Building Materials

An open concrete structure is present at Alternative B3-1. However, asbestos-containing material is not likely to occur on the property.

5.3.2 Radon

No enclosed buildings are currently present on the subject properties; therefore radon levels are not likely to affect the properties.

5.3.3 Lead-based Paint

No painted buildings, structures, or other improvements are located on the subject properties; therefore, it is highly unlikely that lead-based paint is present.

5.3.4 Lead in Drinking Water

Currently, the subject properties have no potable water supply.

5.3.5 Polychlorinated Biphenyls

Two transformers, potentially containing polychlorinated biphenyls (PCBs), were observed on subject property Alternative B70 during the reconnaissance survey (Appendix A, Photograph 26). No equipment potentially containing PCBs was found on the remaining subject properties.

5.3.6 Regulatory Compliance

The subject properties are not covered by the National Pollutant Discharge Elimination System (NPDES) requirements; therefore, the subject property does not have an NPDES permit and have not been inspected for compliance with NPDES regulations.

5.3.7 Industrial Hygiene

No industrial activity is located on the subject properties.

5.3.8 Health and Safety

No industrial activity is located on the subject properties.

5.3.9 Indoor Air Quality

No enclosed buildings were identified on the subject properties; only remnants of a former building are present. Therefore, no inquiry into indoor air quality was necessary.

5.3.10 Pesticides and Herbicides

No storage or production of listed biological agents, pesticides and/or herbicides were reported or documented to have occurred at the subject properties.

5.3.11 Mold

An open concrete structure is present at Alternative B3-1; however, mold was not observed during the reconnaissance survey.

5.4 Historical Use Information on Adjoining Properties

No historical use information, beyond review of the topographic maps and aerial photographs discussed above, of the adjoining properties was available through the records search.

6.0 Site Reconnaissance

On 10 June 2010, CH2M HILL personnel performed a visual reconnaissance of surface conditions at the subject properties.

6.1 Methodology and Limiting Conditions

A walking reconnaissance was conducted to survey the subject properties visually, and to identify historical and current RECs on the subject properties. The methodology used was a perimeter boundary reconnaissance, visually looking north, south, east, and west from the three corner points (northwest, southwest, and east) of the subject properties and property boundary (north, south, and west) midpoints, occasionally walking onto the subject properties. Photographs taken during the survey are included in Appendix A. No limiting conditions were encountered during the walking reconnaissance of the subject properties.

6.2 General Site Setting

The subject properties are located in a setting consisting of residential and commercial uses.

6.2.1 Topography

The subject properties are either floodplain areas or stream sections of Butler Creek and associated tributaries. Therefore, the topography is relatively flat at all the subject properties.

6.2.2 Surface Water Hydrology

All the subject properties are within the Butler Creek watershed. The Butler Creek Watershed is located in northwestern Cobb County, Georgia in the Coosa River Basin. Butler Creek drains into Lake Allatoona.

The Georgia Department of Natural Resources (GAEPD) is required, under Section 303(d) of the Clean Water Act, to identify water bodies for which effluent limitations are not stringent enough to achieve water quality standards and water body uses. Segments of Butler Creek, including the subject properties, are listed for not supporting the “fishing” water use classification and for violating fecal coliform standards (GAEPD, 2010).

6.2.3 Soils/Soil Condition

Toccoa soils are found at Alternatives B2-2 (1 of 2), B4-1, B5-1, B40 (both sections), and B50 (both sections) (Natural Resources Conservation Service [NRCS], 2010a). The soils on Alternatives B3-2 and B5-2 consist of Toccoa soils and Cartecay soils, and only Cartecay soils occur at Alternative B3-1. The Alternative B20 location includes both Toccoa soils and Cartecay silt loam, silty variant soils. Gwinnett clay loam (10 to 15 percent slopes, severely eroded) and Toccoa soils are present at Alternative B2-2 (2 of 2). Finally, Cartecay soils are the predominant soils present at Alternatives B2-1, B3-2-3, and B70 in addition to Madison and Pacolet soils (15 to 25 percent slopes, eroded), Pacolet sandy loam (10 to 15 percent slopes), and Altavista silt loam soils (occasionally flooded), respectively (NRCS, 2010a).

According to the NRCS, all the soils on the subject properties predominantly consist of sandy loam, loam, sandy clay loam, clay loam, and clay granular materials. The Altavista and Toccoa soils are considered moderately well drained, and both Cartecay soils are somewhat poorly drained (NRCS, 2010b, 2010c, 2010d, and 2010e). The remaining soil types present on the subject properties are classified as well drained (NRCS, 2010f, 2010g, 2010h, and 2010i).

6.2.4 Floodplains

According to available Federal Emergency Management Agency (FEMA) flood zone maps, all the Alternative properties are within classified flood areas (FEMA, 2008a, 2008b, and 2008c). These subject properties are either sections of Butler Creek or associated tributaries or open fields within the floodplain. These areas would be expected to flood with heavy precipitation conditions.

6.3 Exterior Observations

The exterior of the subject properties were visually surveyed. The following are observations from the survey:

- The subject properties were predominantly surrounded by residential neighborhoods.
- The sewer system right-of-way parallels or crosses the stream channel at most of the subject properties.
- A closed community park was observed at the Alternatives B3-2 and B3-2-3 locations. A former footbridge in the park had also collapsed into the stream channel. The Alternative B3-2-3 location was also accessible from a gravel road with a culvert bridge.
- Alternative B70 included an open field area with two radio towers and an associated structure present on the adjacent property. The area was accessible from a dirt road with a paved culvert bridge.
- No visible evidence of spills, leaks, or releases of hazardous materials or petroleum products was observed on the subject properties during the survey.

6.4 Interior Observations

The stream flowed through an open, unpainted concrete structure at Alternative B3-1.

7.0 Interviews

ESA questionnaires were mailed to the property owners listed in Table 7-1. Properties and parcel IDs are shown on Figures 2-1 through 2-11.

TABLE 7-1
Property Owners
Phase I Environmental Site Assessment – Butler Creek, Georgia, Site

Parcel ID	Alternative Site	Owner	Mailing Address
[redacted]			

TABLE 7-1
Property Owners
Phase I Environmental Site Assessment – Butler Creek, Georgia, Site

Parcel ID	Alternative Site	Owner	Mailing Address
[redacted]			

Responses were received from:

[redacted]

According to the responses, property owners have used spot pesticide and herbicide treatments on adjacent residential lawns. However, no additional investigation is deemed necessary and, overall, no potential environmental constraints were found on these properties.

8.0 Findings

The findings of this Phase I ESA are as follows:

- The subject properties are located within the Butler Creek watershed area.
- Environmental questionnaires were mailed to the surrounding properties owners, and the responses received indicated no additional environmental restraints.
- The records search and walking reconnaissance indicated no visible RECs at the subject properties.
- The historical aerial photographs show gradual residential development surrounding the subject properties.
- A review of the EDR® radius reports (2010a and 2010b) indicated that 1 sewage spill occurred within the subject properties along Butler Creek and 22 additional regulated properties or incidents occur within a 0.5-mile search radius. Table 8-1 describes the type and number of sites within the search radii.
- The five LUSTs within the radii were NFA status.
- Three orphan sites were listed in the EDR® radius reports (2010a and 2010b). These sites were mapped using Google Earth. The American Manufacturing Co and Bayer Corporation were located outside of the established ASTM radii search distances. The Cobb County Northwest WRF is located less than 0.5 miles from Alternative B5-1. However, according to the GAEPD, the two leaking USTs onsite were closed and a No Further Action was issued in June 2005.

TABLE 8-1
Properties in the Search Radii including the Subject Properties
Phase I Environmental Site Assessment – Butler Creek, Georgia, Site

Database	Number of Sites
LUSTs	5
SPILLS	4
RCRA NonGen	4
Drycleaners	3
AST/UST	8
Orphan Sites	3

Notes:
AST = Aboveground Storage Tank database
LUST = Leaking Underground Storage Tank Incident Reports
RCRA-NonGen = Resource Conservation and Recovery Act (RCRA) – Non-Generators do not presently generate hazardous waste
SPILLS = Releases of hazardous substances to the environment
UST = Underground Storage Tank database

9.0 Opinion

The properties, based on the data collected in this report, appear to be suitable for the implementation of an aquatic ecosystem restoration project, under Section 206 of the Water Resources Development Act of 1996, as amended.

10.0 Conclusions

CH2M HILL performed a Phase I Environmental Assessment in conformance with the scope and limitations of the ASTM E1527-05 of 15 subject properties within the Butler Creek watershed. Any exceptions to, or deletions from, this Practice are described in Section 11 of this report. This assessment has revealed evidence of a historic recognized environmental condition in connection with subject property Alternative B50. In 2000, an overflowing manhole released raw sewage and other unknown materials into Butler Creek at Alternative B50. The overflow was caused by a heavy grease clog in the sewer line. The incident report indicated similar releases have occurred at this location in the past. The released material was not sampled, so any potential hazardous constituents are unknown. The grease build up in the pipe was also not sampled, and whether the grease is petroleum-based or cooking waste is unknown. The grease may have been released to Butler Creek during the overflow. No soil or sediment analytical data was readily available within the study area. Lacking analytical data, there was no identified direct evidence that the sediments and bank soils have been environmentally impacted. No evidence of the release was observed at Alternative B50 during the site reconnaissance. The identified REC does not appear to limit the USACE intended property use to restore the creek banks and limit further erosion of the banks.

Several regulated properties exist within the ASTM-established radii of the subject properties. A windshield survey of the regulated properties and a records review indicate that any findings on surrounding regulated properties appear to have been assessed by the appropriate agency and are either closed or in the process of remediation.

11.0 Deviations and Data Gaps

The Phase I ESA was performed in accordance with the Practice and is limited to the practices set forth in the standard. Exceptions to the Practice include the following:

- Interviews with the previous owners were not performed.
- Aerial photographs at 5-year intervals were not reviewed because they were unavailable at that interval. No aerial photographs were obtained from 1944 through 1954, 1956 through 1959, 1961 through 1965, 1967 through 1971, 1973 through 1985, 1987 through 1992, and 1994 through 2010.
- City directory information was reviewed only for the years spanning 1968 through 1997. Business directories and city directories, including city, cross reference, and telephone directories were reviewed, if available, for approximate 5-year intervals. No information was found for the subject properties or surrounding properties; the results indicated that the subject properties were not listed in the resource search.
- The Phase I ESA User deviated from the standard by not considering the relationship between the negotiated price of the property to the fair market value of the property.

12.0 Additional Services

No additional services outside the scope of work were provided.

13.0 References

Cobb County Water System (CCWS). 2000. Caller Log Detail – Sharpel Lane Kennesaw, Georgia.

Environmental Data Resources, Inc. (EDR®). 2010a. EDR® Radius Map and GeoCheck® Butler Creek 1. 9 June 2010.

Environmental Data Resources, Inc. (EDR®). 2010b. EDR® Radius Map and GeoCheck® Butler Creek 2. 9 June 2010.

Environmental Data Resources, Inc. (EDR®). 2010c. EDR® Historical Topographic Map Report. Butler Creek 1. 9 June 2010.

Environmental Data Resources, Inc. (EDR®). 2010d. EDR® Historical Topographic Map Report. Butler Creek 2. 9 June 2010.

Environmental Data Resources, Inc. (EDR®). 2010e. EDR® Historical Aerial Photo Map Report. Butler Creek 1. 9 June 2010.

Environmental Data Resources, Inc. (EDR®). 2010f. EDR® Historical Aerial Photo Map Report. Butler Creek 2. 9 June 2010.

Environmental Data Resources, Inc. (EDR®). 2010g. EDR City Directory Abstract. Butler Creek. 9 June 2010.

Federal Emergency Management Agency (FEMA). 2008a. Flood Insurance Rate Map Community Panel Number 13067C0019G. Revised December 16, 2008.

Federal Emergency Management Agency (FEMA). 2008b. Flood Insurance Rate Map Community Panel Number 13067C0016G. Revised December 16, 2008.

Federal Emergency Management Agency (FEMA). 2008c. Flood Insurance Rate Map Community Panel Number 13067C0018G. Revised December 16, 2008.

Georgia Department of Natural Resources (GADNR). 1999. Protected Animals of Georgia.

Georgia Department of Natural Resources (GADNR). 2008a. Locations of Special Concern Animals, Plants and Natural Communities in Cobb County, Georgia. http://georgiawildlife.dnr.state.ga.us/content/specieslocationbycounty.asp?lstCounty=Cobb, accessed June 23, 2010.

Georgia Department of Natural Resources (GADNR). 2008b. Special Concern Animal Species in Georgia. http://georgiawildlife.dnr.state.ga.us/content/specialconcernanimals.asp, accessed May 19, 2010.

Georgia Department of Natural Resources (GADNR). 2008c. Special Concern Plant Species in Georgia. http://georgiawildlife.dnr.state.ga.us/content/specialconcernplants.asp, accessed May 19, 2010.

Georgia Environmental Protection Division (GAEPD). 2010. Draft 2010 Integrated 305(b)/303(d) Listed Streams. http://www.gaepd.org/Documents/305b.html, accessed May 21, 2010.

Natural Resources Conservation Service (NRCS). 2010a. Websoil Survey 2.2 – Subject properties. http://websoilsurvey.nrcs.usda.gov/app/WebSoilSurvey.aspx, accessed June15, 2010.

Natural Resources Conservation Service (NRCS). 2010b. Websoil Survey 2.2 - Cobb County, Georgia - AL—Altavista silt loam, occasionally flooded. http://websoilsurvey.nrcs.usda.gov/app/WebSoilSurvey.aspx, accessed June 15, 2010.

Natural Resources Conservation Service (NRCS). 2010c. Websoil Survey 2.2 – Cobb County, Georgia – Cw — Cartecay silt loam, silty variant. http://websoilsurvey.nrcs.usda.gov/app/WebSoilSurvey.aspx, accessed June 15, 2010.

Natural Resources Conservation Service (NRCS). 2010d. Websoil Survey 2.2 – Cobb County, Georgia – Cah— Cartecay soils. http://websoilsurvey.nrcs.usda.gov/app/WebSoilSurvey.aspx, accessed June 15, 2010.

Natural Resources Conservation Service (NRCS). 2010e. Websoil Survey 2.2 – Cobb County, Georgia – Toc — Toccoa soils. http://websoilsurvey.nrcs.usda.gov/app/WebSoilSurvey.aspx, accessed June 15, 2010.

Natural Resources Conservation Service (NRCS). 2010f. Websoil Survey 2.2 – Cobb County, Georgia – GgB2 — Gwinnett loam, 2 to 6 percent slopes, eroded. http://websoilsurvey.nrcs.usda.gov/app/WebSoilSurvey.aspx, accessed June 15, 2010.

Natural Resources Conservation Service (NRCS). 2010g. Websoil Survey 2.2 – Cobb County, Georgia – GeD3 — Gwinnett clay loam, 10 to 15 percent slopes, severely eroded. http://websoilsurvey.nrcs.usda.gov/app/WebSoilSurvey.aspx, accessed June 15, 2010.

Natural Resources Conservation Service (NRCS). 2010h. Websoil Survey 2.2 – Cobb County, Georgia – MsE2 — Madison and Pacolet soils, 15 to 25 percent slopes, eroded. http://websoilsurvey.nrcs.usda.gov/app/WebSoilSurvey.aspx, accessed June 15, 2010.

Natural Resources Conservation Service (NRCS). 2010i. Websoil Survey 2.2 – Cobb County, Georgia – PfD —Pacolet sandy loam, 10 to 15 percent slopes. http://websoilsurvey.nrcs.usda.gov/app/WebSoilSurvey.aspx, accessed June 15, 2010.

14.0 Signature of Environmental Professional

I declare that, to the best of my professional knowledge and belief, I meet the definition of Environmental Professional as defined in 40 CFR 312.10. I have specific qualifications (see Section 15) based on education, training, and experience to assess the nature, history, and setting of the subject properties. This investigation is in general conformance with the standards and practices set forth in 40 CFR 312.

[redacted]

[redacted]

15.0 Qualifications of Environmental Professionals

Resumes of the Environmental Professionals involved in the preparation of this report are located in Appendix E and include the following:

- [redacted]
- [redacted]

Appendix A
Site Photographs

Photograph 1 – Alternative B2-1 (1 of 2)

Photograph 2 – Alternative B2-1 (2 of 2)

Photograph 3 – Alternative B3-2

Photograph 4 – Alternative B4-1 looking upstream towards Cobb Parkway

Photograph 5 – Alternative B4-1 looking downstream with rip-rap wall on the right bank

Photograph 6 – Alternative B5-1 (section closer to Nance Road)

Photograph 7 – Alternative B5-1

Photograph 8 – Alternative B5-2

Photograph 9 – Alternative B40 (1 of 2)

Photograph 10 – Alternative B40 (2 of 2)

Photograph 11 – Alternative B50 (1 of 2)

Photograph 12 – Alternative B50 (2 of 2)

Photograph 13 – Alternative B2-1 (stream channel)

Photograph 14 – Alternative B2-1 (forested area with sewer manholes)

Photograph 15 – Alternative B3-2-3

Photograph 16 – Alternative B70 (open field area)

Photograph 17 – Alternative B3-1 manmade structure

Photograph 18 – Destroyed shed found at Alternative B2-1

Photograph 19 – Collapsed footbridge at Alternative B3-2

Photograph 20 – Gravel drive and culvert at Alternative B3-2-3

Photograph 21 – Rip-rap wall with sewer manhole at Alternative B4-1

Photograph 22 – Intake pump to adjacent pond at Alternative B5-2

Photograph 23- Residential pond directly adjacent to stream at Alternative B5-2

Photograph 24 – Two radio towers and associated structure adjacent to Alternative B70

Photograph 25 – Paved culvert bridge access to Alternative B70

Photograph 26 – Transformers observed at Alternative B70

Appendix B
EDR Radius ™ Map Reports with Geocheck

The EDR Radius TM Map Report with GeoCheck is included on the CD insert

Appendix C
Additional Properties Identified in the EDR® Radius Map Reports

Appendix D
Historical Aerial Photographs and Topographic Maps

The Historic Aerial Photographs and Topographic Maps are included on the CD insert

Appendix E
Qualifications of Environmental Professionals

[redacted]

Education

- Bachelor of Science, Chemistry, Wayne State University, 1992
- Post-Bachelors Certificate, Hazardous Materials Management, Wayne State University, 1993

Professional Training

- OSHA 40-Hour HAZWOPER training, 1998; annual 8-hour refresher courses
- AAI and Liability: Prepare, Preserve, and Protect Seminar, 2006

Distinguishing Qualifications

More than 13 years experience with CH2M HILL focusing on environmental site assessments and remediation projects.

Relevant Experience

Mr. Brose is a project manager and an environmental scientist in CH2M HILL's Atlanta, Georgia, office. He has 14 years experience in Phase I and Phase II Environmental Site Assessments (ESAs); environmental baseline surveys (EBSs);Environmental Condition of Property (ECP)reports; and site characterization and remediation projects.

Recent Representative Projects

Project Manager, USACE, 2010-present. Conducting 18 ECPs for the Defense Logistics Agency various naval warehouse sites.

Project Manager, USACE, 2009-2010. Conducted four ECPs for the Defense Logistics Agency Wynn sites.

Project Manager, USACE, 2009. Conducted four ECPs for the Defense Logistics Agency warehouses.

Lead Environmental Scientist, USACE, Homestead, Florida, 2009. Conducted an ECP report for Special Operations Command South on a 95-acre parcel.

Lead Environmental Scientist, AFCEE, 2008-2009. Conducted four EBSs for the privatization of military family housing.

Task Manager, US Army Corps of Engineers, 2008-2009. Conducted 14 Phase I ESAs for the US Customs and Border Protection.

Project Manager, Confidential Client, 2007. Performed a Phase I ESA at a chemical plant in Atlanta, Georgia in accordance with ASTM E1527-05 guidelines.

Task Manager, Manta FOL, Ecuador, 2007. Conducted an EBS at the US Air Force forward operating location in Manta, Ecuador.

Task Manager, Curaçao FOL, Curaçao, Netherland Antilles, 2007. Conducted an EBS at the US Air Force forward operating location in Curaçao, Netherland Antilles.

Project Manager, MARTA, 2006-2007. Assessed four separate properties in accordance with all appropriate inquiry (AAI) guidelines in Atlanta, Georgia.

Lead Environmental Scientist, Eglin AFB, Florida, 2006. Conducted two EBSs on parcels on Eglin AFB being leased to the city of Mary Esther, Florida and Gulf Power.

Project Manager, MARTA, 2006-2010. Managed the remediation of diesel releases at two MARTA bus maintenance facilities in Atlanta, Georgia using dual phase fluid extraction technology.

Lead Environmental Scientist, FPL Energy, 2005. Performed a Phase I ESA covering 36 square miles of property with over 100 property owners for a placement of wind turbines near Abilene, Texas.

Project Manager, Confidential Client, 2000-2007. Managed the site characterization and remediation of five petroleum pipeline releases in Alabama, Georgia, and Mississippi.

[redacted]

Education

- MS, Agricultural Engineering, Colorado State University, 1983
- BS, Agricultural Engineering, Colorado State University, 1980

Active Registrations

- P.E. (Civil Engineer): CO, TX

Relevant Experience

David Stieb, PE, has 23 years of experience with the firm and 2 years previous experience with other firms. Mr. Stieb specializes in water and wastewater conveyance systems, environmental evaluation of property for transfer, and site remediation. He has acted as Project Manager and Senior design Engineer for Hazardous Waste Site Remediation System Design, Utility System evaluations, and environmental Assessment of Property for transfer.

Representative Projects

Task Manager- Lead Engineer: Phase II, Phase III,and Phase IV Environmental Baseline Surveys (EBS) and Findings of Suitability to Transfer (FOST) for the 1,500-acre former Naval Complex, Charleston, SC. Previous property uses included residential, commercial, warehouse, heavy industrial, nuclear submarine maintenance, and ammo storage. Directed a staff of eight personnel in performing ASTM Phase I environmental assessments as well as portions of deed transfer documents (FOST). Duties included providing assistance to Navy legal staff on transfer issues associated with the environmental condition of the property in addition to the assessments and FOST documents. CH2M HILL developed a style for reporting the findings that is assisting the Navy in transferring the property in parcels while meeting the American Society for Testing and Materials (ASTM), the Department of Defense (DoD) Base Realignment and Closure (BRAC), and regulatory requirements.

Project Manager and Assistant Project Manager for performing ASTM Phase I to lease Kelly AFB property being privatized. Directed a staff of up to six personnel in performing ASTM Phase I environmental assessments for leasing approximately 2,000 acres of the former Kelly AFB. Previous property uses included residential, commercial, warehouse areas, and heavy industrial. CH2M HILL developed a style for reporting the findings that is assisting the Air Force in transferring the property in parcels while meeting the ASTM, DoD BRAC, and regulatory requirements.

Task Manager for ASTM Phase I evaluations of the airfield at Arnold AFB. Work at Arnold AFB included documenting environmental condition of the area around the closed airstrip at Arnold Air Force Base, Tullahoma, Tennesse. The airfield was being reopened and new construction of hangers was proposed for a joint use, civilian and military, facility. Mr. Stieb directed the staff performing the work and performed senior review.

Task Manager for ASTM Phase I evaluations of utilities, Fort Hood, TX. Work at Fort Hood was to support utilities privatization study to evaluate selling utility infrastructure. Directed the staff performing the work and performed senior review.

Assistant Project Manager and Senior Engineer on an ASTM Phase II effort to support transfer of property from the U. S. Air Force to the city of San Antonio. Responsibilities included identification of historic property use, directing field investigations to assess the environmental condition of identified facilities on a 4,000-acre complex, preparation of reports, negotiations with regulators, and support to Air Force legal staff on transfer issues associated with the environmental condition of the property.

Senior Engineer for ASTM Phase I evaluations of former Army Maintenance Depot in Baton Rouge, La. Responsibilities included establishing project team goals, objectives, and evaluation criteria. Also was the Quality Assurance/Quality Control (QA/QC) Engineer (performed senior review) of project deliverables.

Senior Engineer for ASTM Phase I evaluations for the Military Family Housing Privatization at Fort Belvoir, Va. Responsibilities included establishing project team goals, objectives, and evaluation criteria. Also was the QA/QC Engineer (performed senior review) of project deliverables.

Senior Engineer for ASTM Phase I evaluations for the Hawian Air National Guard at Hickham Air Force Base, HI. Responsibilities included establishing project team goals, objectives, and evaluation criteria. Also was the QA/QC Engineer (performed senior review) of project deliverables.

Senior Engineer for ASTM Phase I evaluations for 63 US Army Reserve Facilities closed under BRAC. The work was performed under contract with the US Army Corps of Engineers, Louisville District. Responsibilities included establishing project team goals, objectives, and evaluation criteria. Also was the QA/QC Engineer (performed senior review) of project deliverables.

Senior Engineer for ASTM Phase I evaluations for the Kansas Air National Guard at McConnell Air Force Base, KS. Responsibilities included establishing project team goals, objectives, and evaluation criteria. Also was the QA/QC Engineer (performed senior review) of project deliverables.

Senior Engineer for ASTM Phase I evaluations for the County of Santa Rosa, FL Responsibilities included data evaluation, report preparation, and assigning property environmental classifications to establish the future land use.

Project Manager and Senior Engineer: Experience includes Project Manager for the evaluation of an Industrial Wastewater Collection System for Kelly AFB, Texas. Project included identification and inventory of the system, identification of cross-connections with sanitary and storm sewer systems, recommendations for system repairs, recommendations for disconnection of cross-connections, and recommendations of abandonment options.

Project Engineer: Experience includes the assessment, evaluation, and development of construction cost estimates to repair or replace potable water distribution systems and wastewater collections systems for the United States Air Force in support of the Air Forces's Utility Investment Program initiative. Mr. Stieb has performed system assessments, determined system condition, prepared 5-year construction investment plans, and prepared Government Form 1391 Construction costs for the investment plan to achieve functioning utility systems meeting current utility system standards.

Project Engineer: Experience includes the assessment and inventorying of potable water distribution systems, wastewater collections systems, natural gas distribution systems, and electrical distribution systems in support of DoD's Utility Privatization Initiative.

Project Engineer: Design Engineer for a hydraulic containment system covering 250 acres for the UPRR, Laramie Tie Plant. He investigated, evaluated, and designed a groundwater containment system consisting of over 10,000 linear feet of drainlines, a 200-gpm treatment plant, and a monitoring and sampling network to evaluate system effectiveness. The facility was located on the banks of the Laramie River and had three bedrock units and an alluvial aquifer all producing groundwater which needed controlled and treated. In addition to the drainlines the system include a 2-mile long soil-bentonite wall to limit inflow, three bedrock recovery wells, and approximately 50 monitoring wells to evaluate system effectiveness.

Project Engineer: Design experience includes the design and operation of shallow alluvial contaminant recovery pilot systems. The design involved recovering contaminants in sands and gravels utilizing below ground drainlines and aboveground treatment facilities. The system also used recharge of the treated water to enhance the recovery of contaminants. His experience includes construction management and quality assurance for Union Pacific Railroad during construction of the water control system and the soil bentonite cutoff wall.

Lead Engineer, Free Product Recovery of Creosote Oil from Shallow Subsurface. Performed the initial field investigations to characterize the subsurface and map the distribution of free product in the subsurface. The free product was located primarily at the base of the shallow alluvial aquifer with stringers extending along preferential bedding planes into the lower bedrock units. He established the design criteria that was used to recover the free product from the shallow alluvium over approximately a 100-acre site in 7 modules. Criteria included development of a dual drainline recovery system with injection of treated water to enhance product recovery. Over 2 million gallons were recovered, treated, and sent to a railroad tie treating facility for reuse. Other duties included design, construction manager, and operations manager of two pilot systems and the first two modular units.

Project Manager for Pilot Oil Recovery Program at Chevron, Port Arthur Refinery. Responsibilities included directing field investigations on an approximtely 4,000-acre refining complex to characterize subsurface conditions. Designed, implemented, and directed operations of three pilot oil recovery systems. He was involved in preparation of the initial framework for demonstrating impractability of free product recovery from the tight clay soils present at the refinery.The occurence of recoverable free oil in the high plasticity clays was primarily through secondary features including desication cracks, former solution channels, and along formation discontinuity planes.

Project Engineer: Performed various onsite remediation tasks in California, Colorado, Idaho, Texas, and Wyoming**.** Responsibilities have varied from performing the field investigations, including interpretation of results, to preparing rpeorts for submittal to regulatory agencies. He has been on the negotiation team with the regulators on several of the projects. Additional responsibilities include the preparation of proposals and subcontract documents.

Appendix L
Real Estate Plan

REAL ESTATE PLAN

FOR

BUTLER CREEK SECTION 206

AQUATIC ECOSYSTEM RESTORATION PROJECT

COBB COUNTY, GEORGIA

US Army Corps of Engineers
Mobile District

March 2011

BUTLER CREEK, GA

SECTION 206, AQUATIC ECOSYSTEM RESTORATION PROJECT

REAL ESTATE PLAN

TABLE OF CONTENTS

1. THE REAL ESTATE PLAN

The Real Estate Plan (REP) identifies and describes the lands, easements, and rights-of-way required for the construction, operation and maintenance of the proposed Butler Creek, Section 206, Aquatic Ecosystem Restoration Project. This REP is tentative in nature and is to be used for planning purposes only in order to support the plan formulation and implementation of the proposed project. Although this report is written based on specific data research prepared by the Project Delivery Team (PDT), modifications to the proposed plan could occur during the review phase thus changing the final acquisition areas and/or administrative and land costs. Furthermore, due to the nature of this study, the level of detail provided herein is understood to be equivalent to the main report.

2. AUTHORITY

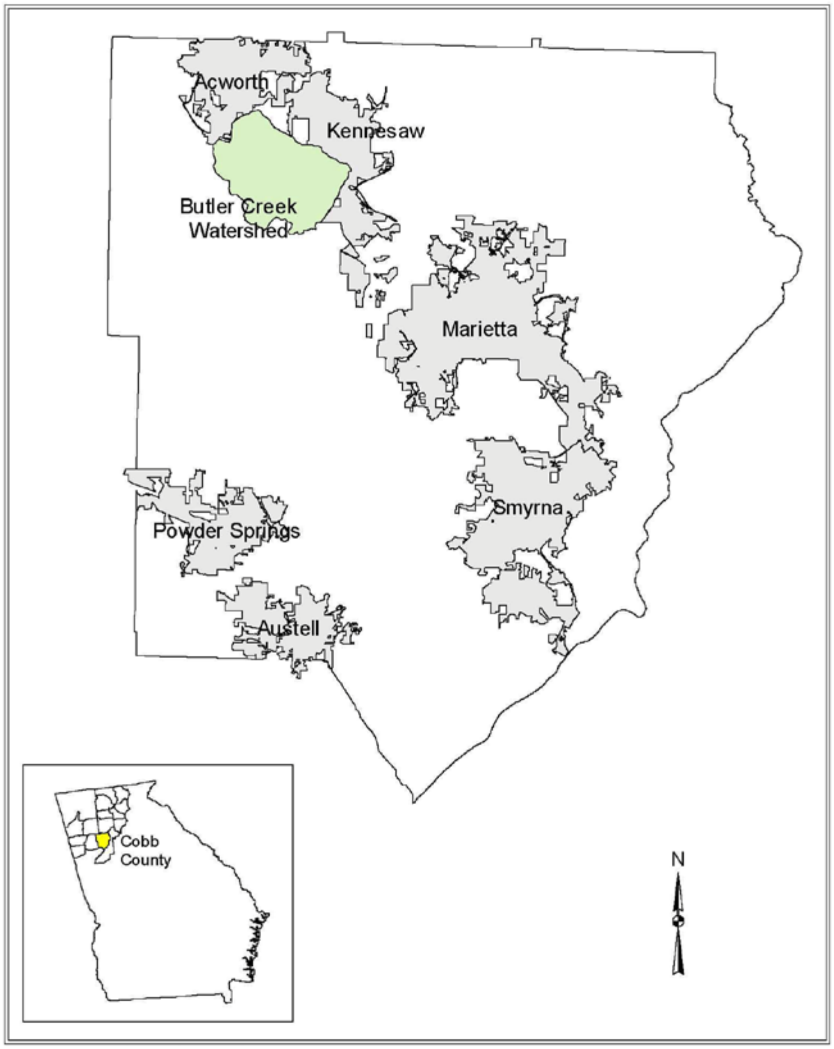
Water Resources Development Act of 1996 (WRDA), Section 206, Aquatic Ecosystem Restoration provision authorizes the Secretary of the Army to carry out aquatic ecosystem restoration and protection projects if it is determined that the project 1) will improve the quality of the environment and is in the public interest; and 2) is cost effective. Projects funded using this authority must be for restoration of aquatic ecosystem structure and function. No relationship to an existing Corps project is required. Not more than $5,000,000.00 in Federal funds may be expended for a project undertaken pursuant to this authority. The non-Federal share will be 35 percent of the total implementation costs, including provisions of all LERRDs, post-feasibility design, plans and specifications, materials and construction, and 100 percent of any OMRR&R costs in accordance with the decision document and the Project Partnership Agreement (PPA). The entire sponsor share may be work-in-kind, including plans and specifications, materials, and project construction. However, if the value of the Non-Federal Sponsor's (NFS) contributions is less than 35 percent of the total project costs, the NFS must make a cash payment so that its contributions equal 35 percent of total project costs (See ER 1105-2-100, Appendix F, Amendment #2).

3. PROJECT DESCRIPTION

The study area includes the 6,000 acre Butler Creek Watershed that is a tributary to Lake Acworth, a sub-impoundment of Lake Allatoona. The various project sites identified herein are located in Cobb County in the northwest portion of the State of Georgia. Cobb County encompasses approximately 340.2 square miles and is bordered on the south and east by Fulton County and on the northwest by Bartow County. Cobb County contains a number of municipalities including Marietta (County Seat), Acworth, Austell, Kennesaw, Smyrna and Powder Springs.

The study area, as shown in Figure 3-1, is within the political boundaries of Cobb County, GA. The Cobb County Water System, located at 660 South Cobb Drive, Marietta, GA 30060, is the Non-Federal Sponsor (NFS) for the proposed project.

Figure 3-1 – Vicinity Map of Study Area



The Cobb County Watershed is located in the northwest portion of the county. The majority of the study area is intensely developed with residential, commercial and industrial development, including most of the City of Acworth and the western portions of the City of Kennesaw. This area of Cobb County is experiencing dramatic land use conversions from historic undeveloped rural lands to intense residential uses in response to the urban sprawl of the Atlanta Metropolitan Region. With development comes an increase in the volume of stormwater runoff and the peak discharges that must be stored and/or conveyed by the existing stormwater facilities. This results in increased sediment and accelerated erosion. In turn, this contributes to the degradation of the water quality, aquatic habitat, and recreational resources. A number of impervious surfaces that exist in the project area have contributed to flash flooding in streams, consequently causing erosion and sediment flow downstream which has changed the character of the impacted stream environments. The project proposes measures to reduce the flash flooding thereby reducing sediment flow and impacts to the system as a whole. These measures will help to restore the stream to more natural conditions and channel dimensions. To insure proper features were used in this study, the PDT instituted a number of Best Management Practices (BMPs). These are techniques used to control storm water runoff, sediment control, and soil stabilization, as well as management decisions to prevent or reduce nonpoint source pollution. The Environmental Protection Agency (EPA) defines a BMP as a "technique, measure or structural control that is used for a given set of conditions to manage the quantity and improve the quality of storm water runoff in the most cost-effective manner."

Material excavated during construction and future maintenance activities would be hauled from the project area to an approved designated disposal area. Removal of riparian vegetation during these construction activities will be avoided to the extent feasible. Habitat restoration will directly improve aquatic and stream corridor habitat throughout both the creek and tributary reaches. The stone weir cross-vanes would prevent further degradation of the tributaries and Butler Creek and would improve the habitat quality of the stream for various fish species and benthic organisms. Riparian plantings will be a restoration component to improve the aquatic condition of the stream.

Following construction, disturbed areas will be planted with native plant species to improve the fisheries and wildlife habitat. Soil conditions will be considered in the planting of riparian area. Plants that require long-term supplemental watering will be avoided due to the high maintenance costs and decreased potential for success. Recommended detention ponds include a permanent pool that will provide for the settling of solids between storms and the removal of nutrients and dissolved pollutants. A littoral zone or wetland vegetation bench is designed to provide aquatic habitat and the enhancement of pollutant removal. Additional storage will be used for flood control for the larger storms. Grade control structures are typically placed in severely unstable stream reaches. By preventing the headward migration of zones of degradation, grade control structures provide vertical stability to the stream and reduce the amount of sediment eroded from the streambed and banks. This not only protects the upstream reaches from the destabilizing effects of bed lowering, but can also minimize sedimentation problems in the downstream reaches. Upstream tributary locations will be considered in the placement of grade control structures in an effort to minimize cost and prevent migration of channel degradation on both the mainstream reach as well as the tributary.

The tentatively selected plan was chosen based on plan formulation and incremental analysis. After this evaluation and formulation process, the proposed plan resulted in 11 project sites containing various restoration measures depending on the need for each particular site. Table 3.2 provides a list of each project site #, feature type, a latitude and longitude point, and the estimated total acreage, including access and staging areas.

Table 3.2

	Project Site #	Feature	Sheet Ref. #	Latitude	Longitude	Total Acreage
1	B3-1	Det.Basin Retrofit	C-1	34.00139	84.63287	0.225
2	B3-2-3 (3 of 3)	Dry Detention	C-2	34.0090222	84.6279166	1.8
3	B3-2-2 (2 of 3)	Streambank Stab.	C-3	34.009	84.62739	0.4
4	B2-1	Wetland	C-6	34.01949	84.6313	1.8
5	B20	Wetland	C-9	34.01074	84.65967	10.2
6	B50-2 (2 of 2)	Streambank Stab.	C-9	34.01074	84.65967	0.4
7	B50-1 (1 of 2)	Streambank Stab.	C-10	34.01264	84.66246	0.37
8	B-40 (2 of 2)	Streambank Stab.	C-12	34.01974	84.66791	0.58
9	B70	Wetland	C-13	34.02387	84.66643	10.42
10	B-40 (1 of 2)	Streambank Stab.	C-14	34.02387	84.66643	0.55
11	B4-1 (1 of 2)	Streambank Stab.	C-18	34.03395	84.60817	1.01
	Total:					**27.76**

4. REAL ESTATE ACQUISITION

The requirements for lands, easements, rights-of-way and relocations, and disposal/borrow areas (LERRDs) should include the rights to construct, operate, maintain, repair, replace, rehabilitate, and patrol channel improvement and ecosystem restoration works, including streambank stabilizations, detention basin retrofits, dry detention ponds, and extended stormwater wetlands within the various project sites.

Based on the design drawings overlaid with property boundary lines (attached as Exhibits B-1 through B-10) there are a total of 11 project sites. Of these proposed 11 project sites, it is estimated that a total of 26 parcels will be impacted for the purpose of construction of restoration features, staging areas, and access. This correlates to an approximate total of 27.76 acres to be acquired.

There are 6 sites proposed for streambank stabilizations (typical 50' widths) and 1 basin retrofit that fall along and within the banks of Butler Creek. It is recommended that the streambank restoration sites be acquired through the standard Bank Stabilization Easement as cited in Section 15 herein. This easement estate is appropriate for these feature types that are located within the banks of the stream and/or within the riparian buffer zone adjoining the banks of the stream.

Regarding those sites proposed for extended storm water wetlands or dry detention basins (Sites B3-2-3, B2-1, B20, and B70) it is recommended that these be acquired in fee or through the previously approved non-standard Environmental Restoration Easement.

The proposed non-standard Environmental Restoration Easement is restrictive in that the encumbered areas cannot be used for any buildings or structures by the property owners, and the easements include the right by the sponsor to remove and /or plant trees and vegetation, excavate or cut the land and dredge, and place dredged or other materials on the site. In addition, the easement allows the right to construct environmental restoration works, which includes the construction of weirs, sills, and other works for the impoundment of water and/or the restoration of fish and other aquatic habitat (See Section 15 herein for complete estate language).

In addition to the land rights needed for the proposed sites, there are also LERRD requirements detailed herein for perpetual access to the sites and temporary staging areas for initial construction purposes. All proposed road easements are not expected to exceed 25' in width. In addition, it should be noted that a great deal of consideration was put into identifying the location of the access and staging areas in order to avoid disruption of local businesses and residents, but still meet the needs of the proposed project. As a result, many of the planned access routes follow existing roads currently being used by county personnel for sewer line maintenance.

It is anticipated that materials excavated during construction will be used for fill where needed or disposed of at a county landfill. If additional fill is required, it will be obtained from a commercial source. Fill obtained from a commercial source is considered a construction cost and would not be credited as part of the LERRD.

Of the two main types of features proposed for this project, the streambank stabilization features are located in undeveloped areas of currently minimal use in and along the banks of Butler Creek. These sites, as listed in Table 3.1, require minimal acreage and are typically less intrusive on the parent tract. All of the streambank stabilization sites are located within the FEMA 100-year Flood Hazard Area (Zone AE) as described in Cobb County's stream buffer classification index. According to FEMA, Zone AE is an area subject to inundation by the 1-percent-annual-chance flood event. Furthermore, the easements proposed for streambank stabilizations will be located within an existing 50-foot stream buffer classification that includes a 25-foot impervious buffer. It should be noted that this buffer zone does not provide expressed land rights to construct these features, but it does prohibit the underlying fee owner from development.

The remaining 4 sites proposed under this project are detention features. Due to the acreage size and potential easement imposition that would be placed on these 4 sites, it is anticipated that fee simple acquisition may be necessary. These sites are described in more detail below:

1. Site B-3-2-3 (3 of 3) is designed as a multiple use dry detention basin enveloping approximately 1.7 acres of Butler Ridge Park. This park is assessed to the City of Kennesaw as public park lands for the use of surrounding residents. O&M access is to be acquired through a perpetual road easement containing 0.05 acres. This access road will commence at the Woodland Place right-of-way and run northward to the detention basin. The temporary work area easement for construction staging will also be placed within the park boundaries for a period not to exceed 3 years and also contains approximately 0.05 acres.

2. Site B2-1 is designed as an extended detention and stormwater wetland basin containing approximately 1.4 acres. This site is located on privately-owned undeveloped parcel west of Wellcrest Drive. This parcel appears to be set aside for future residential development. O&M access is to be acquired through a perpetual road easement containing approximately 0.28 acres. This access road will commence at the Wellcrest Drive cul-de-sac right-of-way and run westward across Butler Creek to the proposed wetland basin. The location for the temporary work area easement for staging is situated directly north and adjacent to the proposed access route. This site is currently a neighborhood park vested to the City of Kennesaw, further identified as PIN: 2001-6502350. The staging area is expected to encompass approximately 0.12 acres.

3. Site B-20 is designed as an extended detention and stormwater wetland basin containing approximately 10.15 acres. The basin feature will impact 3 private landowners and 1 parcel owned by the Stilesboro Homeowners Association. The wetland basin is situated in the rear of these parcels which adjoins Butler Creek and an existing sewer line. The developed lots impacted by the western most end of the basin could be acquired via the ecosystem restoration easement due to the current land use and existing sewer line easements crossing said parcels. The majority of the basin acreage impacts two developed parcels (identified as PIN: 2001-810150 and 2001-8100390).

   O&M access begins at Jim Owens Road and runs southeastwardly along an existing roadway that runs parallel with a sewer line. According to the NFS, the access road is currently being used for ingress and egress and is the planned access route for the proposed feature. A temporary work area easement for construction staging will be required and is located on PIN 2001-8202880. This staging site adjoins the existing access road at the extreme rear of this parcel.

4. Site B-70 is designed as an extended detention and stormwater wetland basin containing approximately 10.00 acres. The basin feature will impact 5 properties zoned as residential. The majority of the basin will be located on PIN 2001-4402290 which is vested to Prieto Broadcasting Inc. Due to the required size of this basin, more than half of this 17.9 acre parent tract will be impacted. Access to this parcel is an existing roadway running westward from Loring Road. A perpetual road easement containing 0.15 acres will need to be acquired over this existing roadway to provide ingress and egress to the basin. An additional roadway runs in a northerly direction from Jim Owens Road and is directly parallel with an existing sewer line. According to the NFS, this road way is currently being used as an access route for stormwater and sewer line maintenance.

Table 4-1

[redacted]

[redacted]

5. UTILITY RELOCATION

There are no known utility relocations within the LER required for the proposed project.

6. EXISTING PROJECTS

There are no existing Federal projects that lie fully or partially within the LER required for the proposed project. However, Cobb County, GA has begun an aggressive program to acquire floodplain land along major waterways. For instance, an acquisition of 265 acres of floodplain land in north/central Cobb County provided Noonday Creek a very large buffer of 300-400 feet through much of its length.

7. ENVIRONMENTAL IMPACTS & HAZARDOUS, TOXIC, RADIOACTIVE WASTE (HTRW)

Construction of the proposed project is not expected to cause adverse environmental impacts. However, upon completion of the Alternative Formulation Briefing (AFB) process, the National Environmental Policy Act (NEPA) portion of the combined report will be formalized into the combined NEPA document. Several key components of the NEPA document have essentially been completed as part of the planning process to date and are incorporated into this study report. The NEPA document will be completed concurrently with the study report. All relevant issues typically addressed in the NEPA process will be included in the final report.

A Phase I Environmental Site Assessment (ESA) and HTRW report was completed for the subject properties located within the Butler Creek watershed area. This assessment included site reconnaissance on 10 June 2010 that indicated no visible Recognized Environmental Conditions (RECs) upon the subject properties. Environmental questionnaires were mailed to surrounding property owners and those responses received revealed no additional environmental restraints. Historical aerial photographs portray only gradual residential development surrounding the subject properties. In addition, research was conducted via the use of environmental databases to pinpoint possible environmental or HTRW conditions on the subject or adjacent properties.

The final opinion, as further documented in the Environmental Appendix to the main study report, reveals the subject properties to be suitable for the implementation of an aquatic ecosystem restoration project, under Section 206 of the Water Resources Development Act of 1996, as amended.

8. NON-FEDERAL SPONSOR RESPONSIBILITES AND CAPABILITIES

The Cobb County Water System is the Non-Federal Sponsor (NFS) for the proposed project. The NFS has the responsibility to acquire all real estate interests required for the project. The NFS shall accomplish all alterations and relocations of facilities, structures and improvements, if any, determined by the government to be necessary for construction of the project.

Title to any acquired real estate will be retained by the NFS and will not be conveyed to the United States Government. The government will require access rights be provided by the NFS for entry to the project. Prior to advertisement of any construction contract, the NFS shall furnish to the government an Authorization for Entry for Construction (Exhibit "C") to all lands, easements and rights-of-way, as necessary. The NFS will also furnish to the government evidence supporting their legal authority to grant rights-of-way to such lands. Based on State of Georgia law, the NFS has quick take authority which is an expedited version of condemnation that allows the local government to file a complaint in circuit court and gain immediate title to the property.

The NFS shall comply with applicable provisions of the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970, Public Law 91-646, approved 2 January 1971, and amended by Title IV of the Surface Transportation Uniform Relocation Assistance Act of 1987, Public Law 100-17, effective 2 April 1989, in acquiring real estate interests for the proposed project, and inform all affected persons of applicable benefits, policies, and procedures in connection with said Act(s).

An Assessment of Non-Federal Sponsor's Real Estate Acquisition was provided to the NFS on 9 September 2010. Said assessment was acknowledged by the NFS on 29 October 2010 as shown in Exhibit "D" attached hereto.

The NFS is entitled to receive credits against its share of project costs for the value of lands it provides and the value of any relocation that may be required for the project. The value of the real property interests will also include the documented incidental costs of acquiring such interests, as determined by the Government to be reasonable. Credit for sponsor owned lands that may have been acquired more than 5 years from the effective date of the PPA will not include incidental costs. Credit for real property owned by the sponsor at the effective date of the PPA will be based on the fair market value of the land at that time. For land acquired after the effective date of the PPA, credit will be based on the fair market value at time of acquisition and administrative costs will be based on actual documented costs submitted by the sponsor.

9. GOVERNMENT OWNED PROPERTY

A portion of Site B4-1 will impact a 3.2 acre parcel of land currently owned in fee by the United States of America and assessed to the U.S. Army Corps of Engineers. A portion of this parcel (approximately 0.35 acres) will be required for the proposed streambank stabilization within and along the banks of Butler Creek which traverses this parcel. In addition, 0.18 acres are required for perpetual access to said construction site. The perimeter of this parcel is highlighted in red as shown in Figure 9-1.

Circa 1950, this parcel of land was acquired by USACE from the Estate of S.L. Richards, identified as Segment G, Tract No. G – 628, Allatoona Lake Project. This tract is currently being managed by USACE. Negotiations will be conducted between the NFS and USACE as to the easement conveyance necessary to implement the streambank stabilization and perpetual ingress and egress requirements.

Figure 9-1

10. HISTORICAL SIGNIFICANCE

At this time, there are no known significant cultural resources in the proposed project area. However, to comply with Section 106 of the National Historic Preservation Act, the restoration feature locations that comprise the selected feature formulation(s) that will be carried forward must be investigated for archaeological resources or documented as to why no archaeological survey was conducted. If an archaeological site is encountered during the Phase I investigation, sufficient work shall be conducted so as to definitively determine the site's National Register of Historic Places eligibility. Sites determined eligible for the NRHP will be avoided, or, if not possible, mitigated in accordance with 36 CFR 800.

11. MINERAL RIGHTS

There are no mineral activities or rights to be acquired within the scope of the proposed project.

12. PUBLIC LAW 91-646 RELOCATION ASSISTANCE BENEFITS

Public Law 91-646, Uniform Relocation Assistance provides entitlement for various payments associated with federal participation in acquisition of real property. Title II makes provision for relocation expenses for displaced persons, and Title III provides for reimbursement of certain expenses incidental to transfer of property. Currently, there is no expectation for relocation benefits based on the project footprints.

13. ATTITUDE OF PROPERTY OWNERS

There are no known objections to the proposed project.

14. ACQUISITION SCHEDULE

The NFS has indicated that their in-house staff is not currently sufficient to acquire the proposed real estate interests required for the project. However, Cobb County's real estate department can provide oversight and obtain experienced contract support to perform the necessary acquisition of fee and/or easement real estate interests required for the proposed project. It is projected that acquisitions will take approximately 12 months, and can begin when final plans and specs have been completed and the Project Partnership Agreement (PPA) has been executed. The NFS, USACE Project Manager and Real Estate Technical Manager will formulate the milestone schedule upon project approval to allow adequate time to complete the real estate acquisition to meet the advertisement for construction date.

15. ESTATES FOR PROPOSED PROJECT

a) <u>FEE</u>: A fee simple estate is provided herein to account for those sites where an easement would cause an unwarranted burden on the underlying fee owner thereby creating an uneconomic remnant.

The fee simple title to (the land described in Schedule A) (Tracts Nos.) Subject, however, to existing easements for public roads and highways, public utilities, railroads and pipelines. [1]

---

[1] Where an outstanding interest in the subsurface mineral estate is part of a block ownership which is to be excluded from the taking in accordance with paragraph 5-289 (2), the following clause will be added: "excepting and excluding from the taking all interests in the (coal) (oil and gas) which are outstanding in parties other than the surface owners and all appurtenant rights for the exploration, development and removal of said (coal) (oil and gas) so excluded."

b) **<u>BANK PROTECTION EASEMENT:</u>** This standard easement is recommended for the proposed streambank restoration sites along Butler Creek.

A perpetual and assignable easement and right-of-way in, on, over and across the land hereinafter described for the location, construction, operation, maintenance, alteration, repair, rehabilitation and replacement of a bank protection works, and for the placement of stone, riprap and other materials for the protection of the bank against erosion; together with the continuing right to trim, cut, fell, remove and dispose therefrom all trees, underbrush, obstructions, and other vegetation; and to remove and dispose of structures or obstructions within the limits of the right-of-way; and to place thereon dredged, excavated or other fill material, to shape and grade said land to desired slopes and contour, and to prevent erosion by structural and vegetative methods and to do any other work necessary and incident to the project; together with the right of ingress and egress for such work; reserving, however, to the landowners, their heirs and assigns, all such rights and privileges as may be used without interfering with or abridging the rights and easement hereby acquired; subject, however to existing easements for public roads and highways, public utilities, railroads and pipelines.

c) **<u>ENVIRONMENTAL RESTORATION EASEMENT</u>:** The following non-standard estate is recommended for approval for use on the subject project, in accordance with ER 405-1-12, paragraph 12-10 c. which states:

Where there is no corresponding standard estate for the interest to be required, or where changes to the corresponding standard estate (or previously approved non-standard estate) are desired, a non-standard estate must be drafted and approved. The District Chief of Real Estate may approve non-standard estates if they serve the intended project purpose, substantially conform with and do not materially deviate from the corresponding standard estate contained in Chapter 5, and do not increase the costs nor potential liability of the Government. Changing an estate from easement to fee, or vice versa, or altering an estate so as to affect project purposes, is not within the scope of the District's approval authority. For all non-standard estates not within the scope of District's approval authority, approval may be obtained either by placing the body of the nonstandard estate in the Real Estate Plan (REP) of a feasibility report or other study decision document that is approved by HQUSACE, or by request for approval forwarded prior to use of such estate through Division to HQUSACE (ATTN: CERE-A) for appropriate coordination, review, and final determination.

As discussed with the Project Deliver Team (PDT), a determination has been made that said non-standard easement could meet the requirements for certain dry detention basins or wetland creation sites in lieu of fee acquisition. This same estate was also recommended and approved by Mobile District for the ISIS Aquatic Ecosystem Restoration Project.

This non-standard Environmental Restoration Easement estate is derived from the standard Channel Improvement Easement adding the words "*to construct weirs,* *sills and other works for the impoundment of water and/or the restoration of fish and aquatic habitat*" to the body of the easement. In addition, the title of said non-standard easement was revised to mirror the type of project being implemented. This estate serves the intended project purpose, substantially conform with and does not materially deviate from the corresponding standard estate contained in Chapter 5, and does not increase the costs nor potential liability of the Government. As such, approval of this non-standard estate is specifically requested herein as allowed under ER 405-1-12, paragraph 12-10 c.

A perpetual and assignable right and easement to construct, operate, and maintain environmental restoration works on, over and across (the land described in Schedule A) (Tracts Nos.), for <u>Butler Creek Aquatic Ecosystem Restoration Project</u>, for the purposes as authorized by the Act of Congress, including the right to clear, cut, fell, remove and dispose of any and all timber, trees, underbrush, buildings, improvements and/or other obstructions therefrom; to excavate, dredge, cut away, and remove any or all of said land; to plant trees, shrubs, grasses, and aquatic vegetation; to construct weirs, sills and other works for the impoundment of water and/or the restoration of fish and aquatic habitat; and for such other purposes as may be required in connection with said work of restoration; reserving, however, to the owners, their heirs and assigns, all such rights and privileges as may be used without interfering with or abridging the rights and easement hereby acquired; provided however, the owners, their heirs and assigns, shall not cut, remove or disturb in any manner, any trees, plants or vegetation planted in connection herewith; subject, however, to existing easements for public roads and highways, public utilities, railroads and pipelines.

The Grantee, its authorized representative or assigns shall have the continuing right of ingress and egress to and over said easement area for the purpose of inspecting said easement area to determine the Grantor's, their personal representatives, heirs, successors, and assigns, lessees, agents, and licensees compliance with the restrictions set out above.

d) <u>TEMPORARY WORK AREA EASEMENT:</u> The standard Temporary Work Area Easement will be used for those sites identified as staging areas for construction.

A temporary easement and right-of-way in, on, over and across (the land described in Schedule A) (Tracts Nos. _____, _____ and _____), for a period not to exceed ___________________, beginning with date possession of the land is granted to the United States, for use by the United States, its representatives, agents, and contractors as a (borrow area) (work area), including the right to (borrow and/or deposit fill, spoil and waste material thereon) (move, store and remove equipment and supplies, and erect and remove temporary structures on the land and to perform any other work necessary and incident to the construction of the <u>Butler Creek Aquatic Ecosystem Restoration Project</u>, together with the right to trim, cut, fell and remove therefrom all trees, underbrush, obstructions, and any other vegetation, structures, or obstacles within the limits of the right-of-way; reserving, however, to the landowners, their heirs and assigns, all such *rights and privileges as may be used without interfering with or abridging the rights and easement hereby acquired; subject, however, to existing easements for public roads and highways, public utilities, railroads and pipelines.*

e) <u>ROAD EASEMENT:</u> Due to the Operation and Maintenance (O&M) requirements expected after construction of these restoration measures, the standard road easement is recommended for the future access to the project sites.

A perpetual and assignable easement and right-of-way in, on, over and across (the land described in Schedule A) (Tracts Nos. _____, _____ and _____), for the location, construction, operation, maintenance, alteration replacement of (a) road(s) and appurtenances thereto; together with the right to trim, cut, fell and remove therefrom all trees, underbrush, obstructions and other vegetation, structures, or obstacles within the limits of the right-of-way; subject, however, to existing easements for public roads and highways, public utilities, railroads and pipelines.

16. REAL ESTATE ESTIMATE

A Gross Appraisal was prepared by USACE-SAM-RE-P staff appraiser, effective date of 25 July 2010, to determine an approximate fair market value of lands required for the proposed project. The gross appraisal was subsequently reviewed by USACE-SAJ on 19 October 2010 for conformance to Uniform Standards of Professional Appraisal Practice (USPAP), USACE Appraisal Guidelines, including EC 405, Chapters 1-4, proper methodology, formatting and the supportability of valid conclusions.

The land values contained in this report were determined using data from public records, and from interviews with local professionals. The sales of comparable properties that are used in the valuation represent the best available comparisons in terms of physical proximity, location, access, and highest and best use. A number of bona fide vacant land sales for each property type were compiled to offer reasonable support for unit land values to be used in calculating aggregate real estate costs for the project.

An important factor in determining values for streambank stabilization sites within buffer zones is that these ordinances limit development activities within the buffer areas, thereby lessening the impact of the proposed easements and project improvements. As such, the value will be less than a total take since these areas generally serve as drainage and buffer zones for the sites in the before and will be buffers and drainage for the sites in the after. The easement areas can still be used to satisfy green area/open space and/or buffer zone requirements.

The estimated real estate costs include the land cost and federal and non-federal administrative costs. Due to the restrictive nature of the proposed Ecosystem Restoration Easement, some sites are valued as a high percentage of the fee value of the land. However, depending on land class and other site specific information, the estimated values can be inconsistent thus fluctuating below the fee value.

Administrative costs are those costs incurred for verifying ownership of lands, surveys/mapping and legal descriptions, certification of those lands required for project purposes, tract appraisals, title insurance/legal opinions, negotiations, analysis or other requirements that may be necessary during Planning, Engineering and Design (PED) phase. A 25% contingency is applied to the estimated total for these items. Table 16-1 is the Baseline Cost Estimate for Real Estate (BCERE) for the proposed project.

The cost estimate for all Federal and non-Federal real estate activities necessary for implementation of the project after completion of the feasibility study for land acquisition, construction, LERRD, and other items are coded as delineated in the Cost Work Breakdown Structure (CWBS). This real estate cost estimate is then incorporated into the Total Current Working Estimate utilizing the Microcomputer Aided Cost Engineering System (MCACES). The Chart of Accounts at Table 16-2 shows the CWBS for real estate activities inclusive of all proposed sites.

Table 16-1
Real Estate Baseline Cost Estimate Summary

a. Lands and Improvements					
					380,000.00
				subtotal	380,000.00
b. Mineral Rights					0
c. Damages					0
d. P.L. 91-646 Relocation costs					0
e. Administrative Cost (Incl. 25% Contingency)					80,000
	Relocation	Acquisition	Total		
Federal	0	20,000	20,000		
Non-Fed	0	60,000	60,000		
	0	80,000	80,000		
Sub-Total					460,000.00
(25% Contingency incl. under item a and e)					
TOTAL					460,000.00
ROUNDED					**460,000.00**

Table 16-2
Chart of Accounts

01A	PROJECT PLANNING	FEDERAL	NON-FEDERAL	TOTALS
	Other			
	Project Cooperation Agreement			
01AX	Contingencies (25%)			
	Subtotal			
01B	LANDS AND DAMAGES/PERMITS			
01B40	Acquisition/Review of NFS	16,000		16,000
01B20	Acquisition by NFS		48,000	48,000
01BX	Contingencies (25%)	4,000	12,000	20,000
	Subtotal	20,000	60,000	80,000
01F	PL 91-646 ASSISTANCE		N/A	N/A
01F20	By NFS		N/A	N/A
01FX	Contingencies (25%)		N/A	N/A
	Subtotal		N/A	N/A
01R	REAL ESTATE LAND PAYMENTS			
01R1B	Land Payments by NFS		302,200	302,200
01R2B	PL91-646 Relocation Payment by NFS		N/A	N/A
01R2D	Review of NFS	N/A		N/A
01RX	Contingencies (25%)	0	77,800	77,800
	Subtotal	20,000	440,000	460,000
	TOTALS	**0**	**440,000**	**460,000**
	ROUNDED			**460,000.00**

17. NAVIGATIONAL SERVITUDE

The Federal Navigational Servitude doctrine arises from two related components: navigation power which is derived from the commerce clause of the U.S. Constitution giving Congress regulatory power over navigable waters; and navigation servitude which provides that certain private property may be taken, without compensation to the landowner, if the taking is necessary to exercise the navigation power. Private ownership of land below navigable or tidal waters is acquired and held subject to the dominant public right of navigation. This dominant public right may be exercised by Congress without giving rise to a compensable taking. Exercise of Federal Navigational Servitude is not applicable to the subject project as the focus of this project is for ecosystem restoration rather than for commerce related purposes.

18. INDUCED FLOODING

Site B3-1 is the only site with the potential for induced flooding. This site is located upstream of Shilling Chase Court in Westover Subdivision, Unit 1. The construction footprint is located within an existing detention basin outlet structure on Parcel Identification Number (PIN) 2002-0303150 and 2002-0302960. The design feature includes retrofitting this existing outlet structure which will slowly release floodwaters and return pond levels from a full, overflowing state to a dry surface, in a 24-hour period. This basin is intended to provide for the temporary storage of storm water runoff to reduce downstream water quantity impacts. Riprap, plunge pool or pad, or other energy dissipater will be placed downstream of the outlet structure to prevent scouring and erosion.

Due to the fact that this site has an existing flood control structure and flooding of this area has occurred historically, a taking does not appear to be justified because there is no expectation for an increase in the inundation limits. The designed intent of this retrofit is not to increase the current maximum inundation limits, but to provide flow attenuation for more frequently occurring events. As shown in Figure 18.1, the dark blue line indicates the peak elevations for the existing 100-year inundation limit (1075.1' contour) and the white line indicating the existing 2-year limit (1073.5' contour). Consequently, no flooding will occur as a result of this project past these existing contour lines, nor will any habitable structures be impacted. If it is revealed that the sponsor's existing easement in this area is not suitable and additional acquisition of LER should occur due to the backing of water, then a Physical Takings Analysis will be performed by USACE. This analysis will present a reasoned conclusion, backed by case law, as to whether the induced flooding is significant enough to rise to the level of taking for which just compensation is owed to the fee owner.

Figure 18-1 – Site B3-1

The Operation and Maintenance (O&M) requirements for Site B3-1 include the continued removal of debris to prevent accumulations to minimize outlet clogging and to improve aesthetics following significant storm events or on an annual basis. In addition, O&M responsibilities include the removal of sediment buildup, repair and re-vegetate eroded areas, perform structural repairs to inlets/outlets, and mow to limit unwanted vegetation. As a result of these O&M responsibilities, a 20' perpetual road easement is required for ingress and egress to the site. This road easement will run southwesterly from a point beginning at the r/w of Shillings Chase Ct and traverse a non-buildable lot identified as PIN 2002-030002. During initial retrofitting of this outlet structure, a temporary work area easement for staging purposes will also be required. This staging area will be located on PIN 2002-0303150 and run for a period not to exceed 3 years.

19. APPLICATION OF ZONING ORDINANCES

Currently, there is no expectation of the NFS enacting zoning ordinances in lieu of, or to facilitate, land acquisition in connection with the proposed project.

After a cursory review of Cobb County's existing stormwater management initiatives as they impact real estate requirements, it was noted that the State of Georgia and the Cobb County Water System, in conjunction with the Cobb County Board of Commissioners has worked to implement and enforce stream buffer ordinances. Accordingly, these stream buffers are a minimum 50-foot wide buffers including a 25-foot impervious buffer that are now required for all streams. This buffer can increase to as much as 200 feet depending on the contributing drainage area. Upon further review of Cobb County's Stream Protection regulations, which is based on State law, it is noted that the State of Georgia owns the flowing water within the stream. However, the adjoining fee landowner owns the waterbottoms and banks subject to the applicable buffer zone ordinances in and around said stream or creek.

20. EXHIBITS/FIGURES/TABLES

- **a. Exhibit "A" – Overview Map of Butler Creek Watershed**
- **b. Exhibit "B" – Butler Creek Project Sites - Sheet Index Map**
- **c. Exhibit "B-1" – Site B3-1 / Sheet C-1**
- **d. Exhibit "B-2" – Site B3-2-3 (3 of 3) / Sheet C-2**
- **e. Exhibit "B-3" – Site B3-2-2 (2 of 3) / Sheet C-3**
- **f. Exhibit "B-4" – Site B2-1 / Sheet C-6**
- **g. Exhibit "B-5" – Site B20 & B50-2 (2 of 2) / Sheet C-9**
- **h. Exhibit "B-6" – Site B50-1 (1 of 2) / Sheet C-10**
- **i. Exhibit "B-7" – Site B40 (2 of 2) / Sheet C-12**
- **j. Exhibit "B-8" – Site B70 / Sheet C-13**
- **k. Exhibit "B-9" – Site B40 (1 of 2) / Sheet C-14**
- **l. Exhibit "B-10" – Site B4-1 (1 of 2) / Sheet C-18**
- **m. Exhibit "C" – Authorization for Entry for Construction**
- **n. Exhibit "D" – Assessment of NFS RE Acquisition Capability**
- **o. Exhibit "E" - Formal Risk Notification Letter to NFS**
- **p. Figure 3-1 - Study Area Vicinity**

q. Table 3-2 – Summary list of Sites w/ total acreage per site
r. Table 4-1 – Summary list of impacted parcels and acreage breakout
s. Figure 9-1 – Government-Owned Property – Site 4-1 (1 of 2) Tax Map
t. Table 16-1 –Baseline Cost Estimate for Real Estate (BCERE)
u. Table 16-2 – Chart of Accounts
v. Figure 18-1 – Induced Flooding – Site B3-1 Tax & Contour Map

EXHIBIT "A"

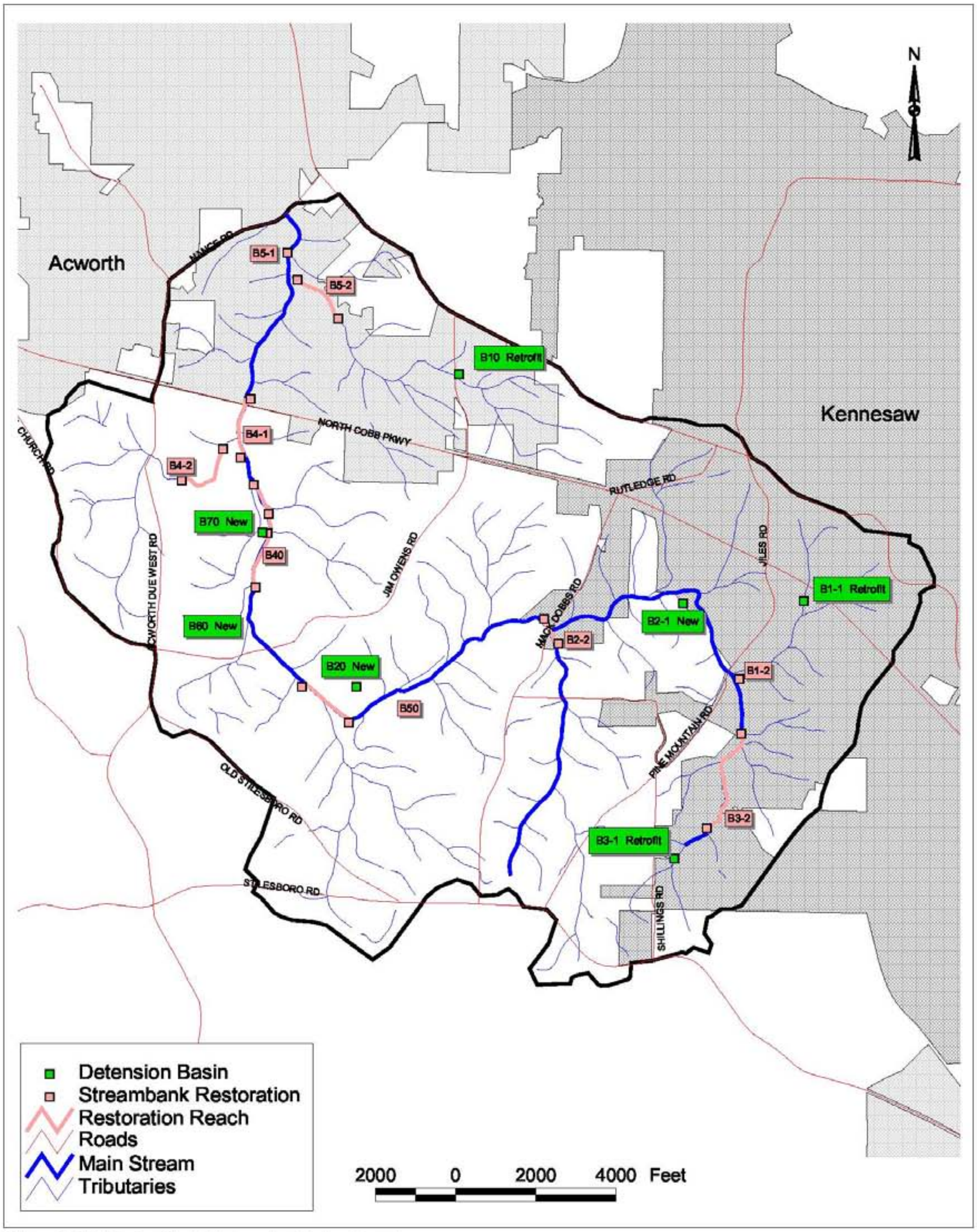


Figure BII-1 Butler Creek Restoration Project Locations

EXHIBIT “B”

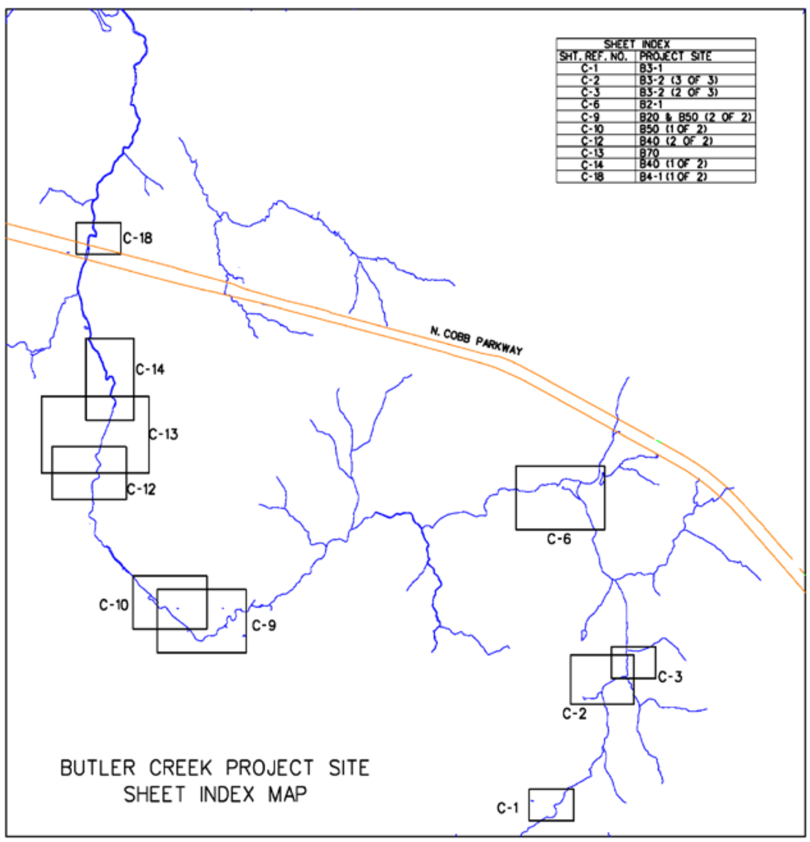

SHEET INDEX
SHT. REF. NO. | PROJECT SITE
C-1 | B3-1
C-2 | B3-2 (3 OF 3)
C-3 | B3-2 (2 OF 3)
C-6 | B2-1
C-9 | B20 & B50 (2 OF 2)
C-10 | B50 (1 OF 2)
C-12 | B40 (2 OF 2)
C-13 | B70
C-14 | B40 (1 OF 2)
C-18 | B4-1 (1 OF 2)
C-18
N. COBB PARKWAY
C-14
C-13
C-12
C-6
C-10
C-9
C-3
C-2
C-1
BUTLER CREEK PROJECT SITE
SHEET INDEX MAP

EXHIBIT "B-1"

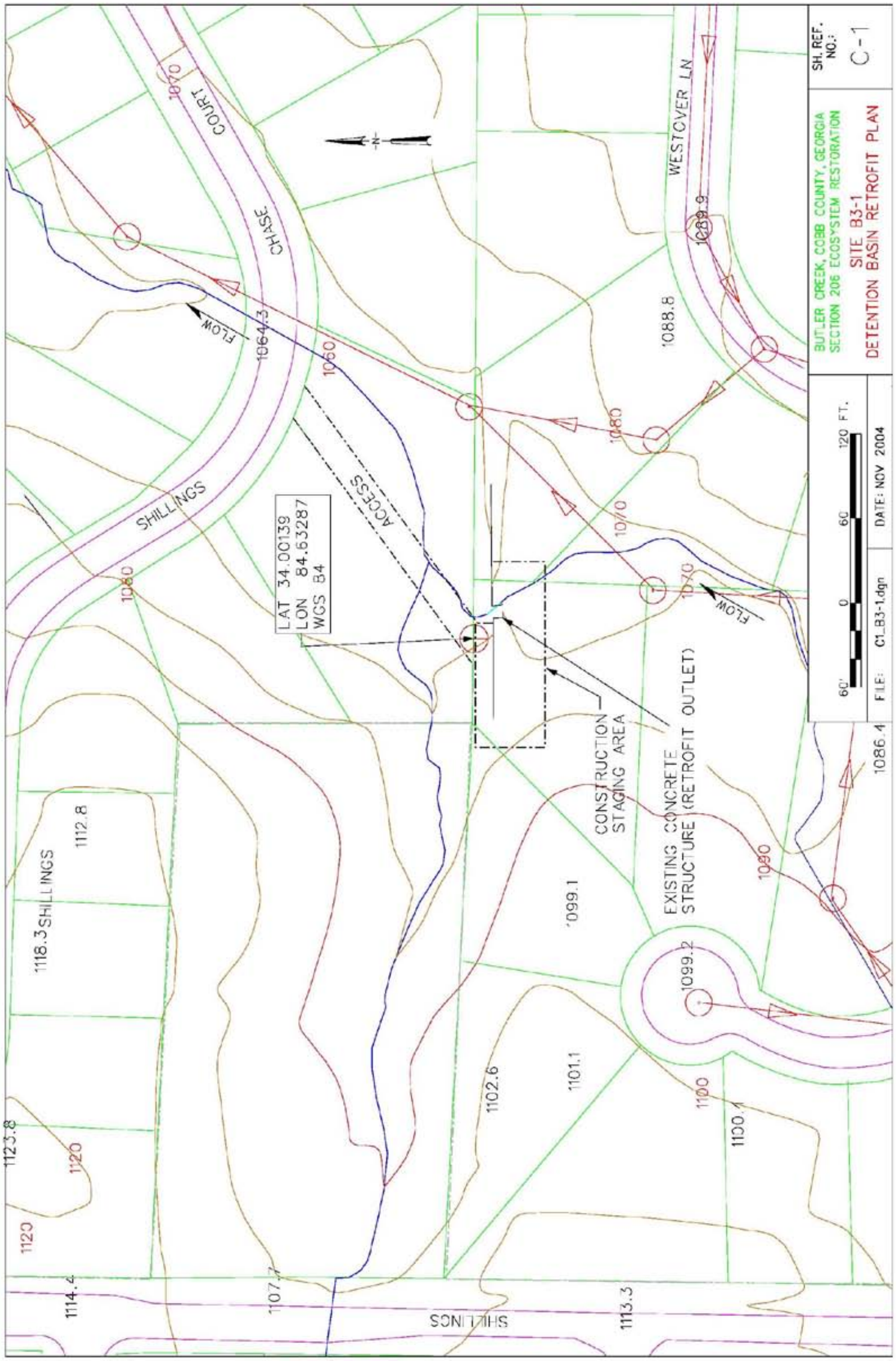

BUTLER CREEK, COBB COUNTY, GEORGIA
SECTION 206 ECOSYSTEM RESTORATION
SITE B3-1
DETENTION BASIN RETROFIT PLAN
SH. REF. NO.:
C-1
DATE: NOV 2004
FILE: C1_B3-1.dgn
60' 0 60 120 FT.
LAT 34.00139
LON 84.63287
WGS 84
CONSTRUCTION STAGING AREA
EXISTING CONCRETE STRUCTURE (RETROFIT OUTLET)
ACCESS
FLOW
SHILLINGS CHASE COURT
WESTOVER LN
SHILLINGS

EXHIBIT “B-2”

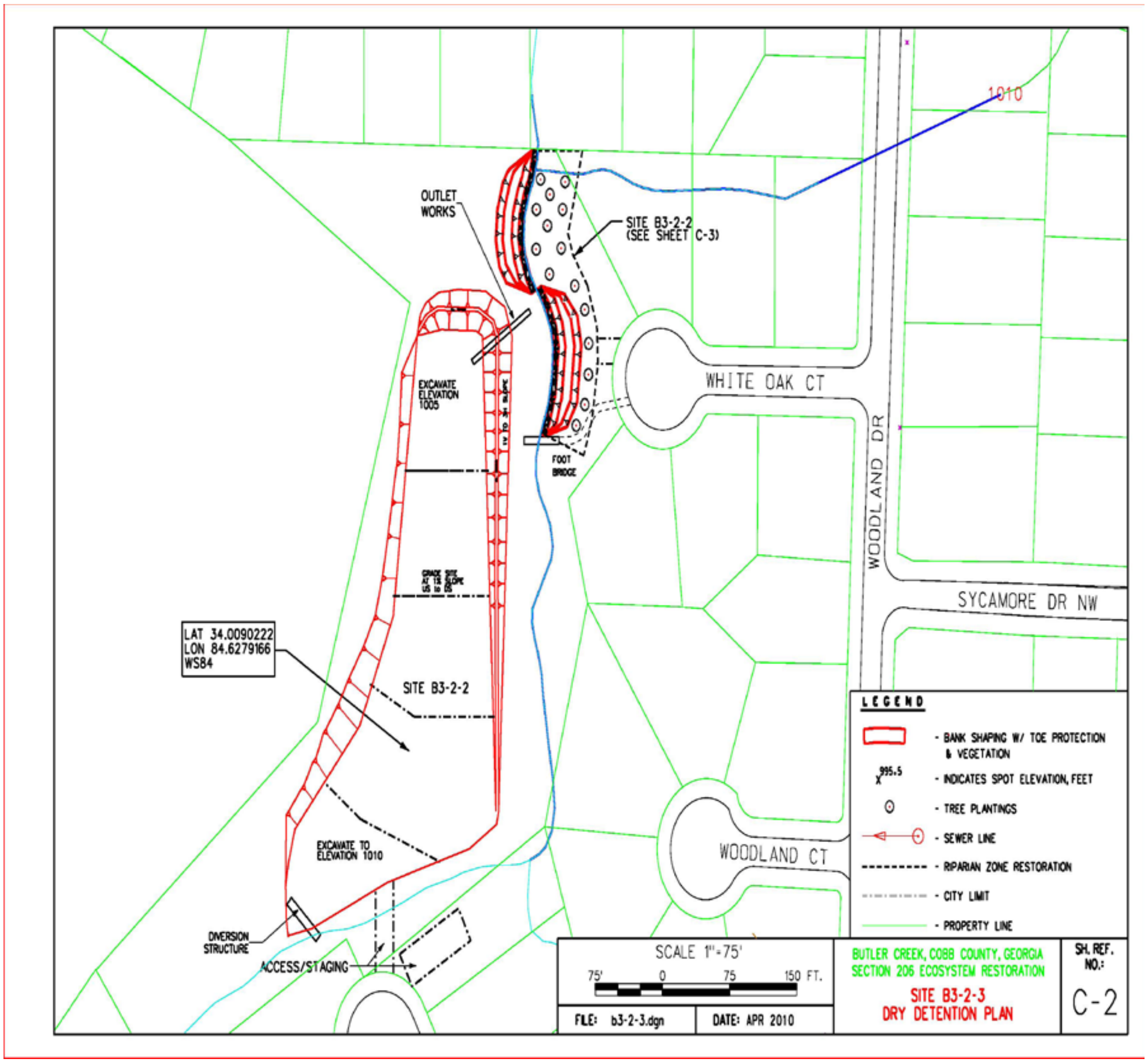

1010
OUTLET WORKS
SITE B3-2-2 (SEE SHEET C-3)
EXCAVATE ELEVATION 1005
FOOT BRIDGE
WHITE OAK CT
WOODLAND DR
SYCAMORE DR NW
LAT 34.0090222
LON 84.6279166
WS84
SITE B3-2-2
EXCAVATE TO ELEVATION 1010
DIVERSION STRUCTURE
ACCESS/STAGING
WOODLAND CT
LEGEND
- BANK SHAPING W/ TOE PROTECTION & VEGETATION
995.5
- INDICATES SPOT ELEVATION, FEET
- TREE PLANTINGS
- SEWER LINE
- RIPARIAN ZONE RESTORATION
- CITY LIMIT
- PROPERTY LINE
SCALE 1"=75'
75' 0 75 150 FT.
FILE: b3-2-3.dgn
DATE: APR 2010
BUTLER CREEK, COBB COUNTY, GEORGIA
SECTION 206 ECOSYSTEM RESTORATION
SITE B3-2-3
DRY DETENTION PLAN
SH. REF. NO.:
C-2

Exhibit "B-3"

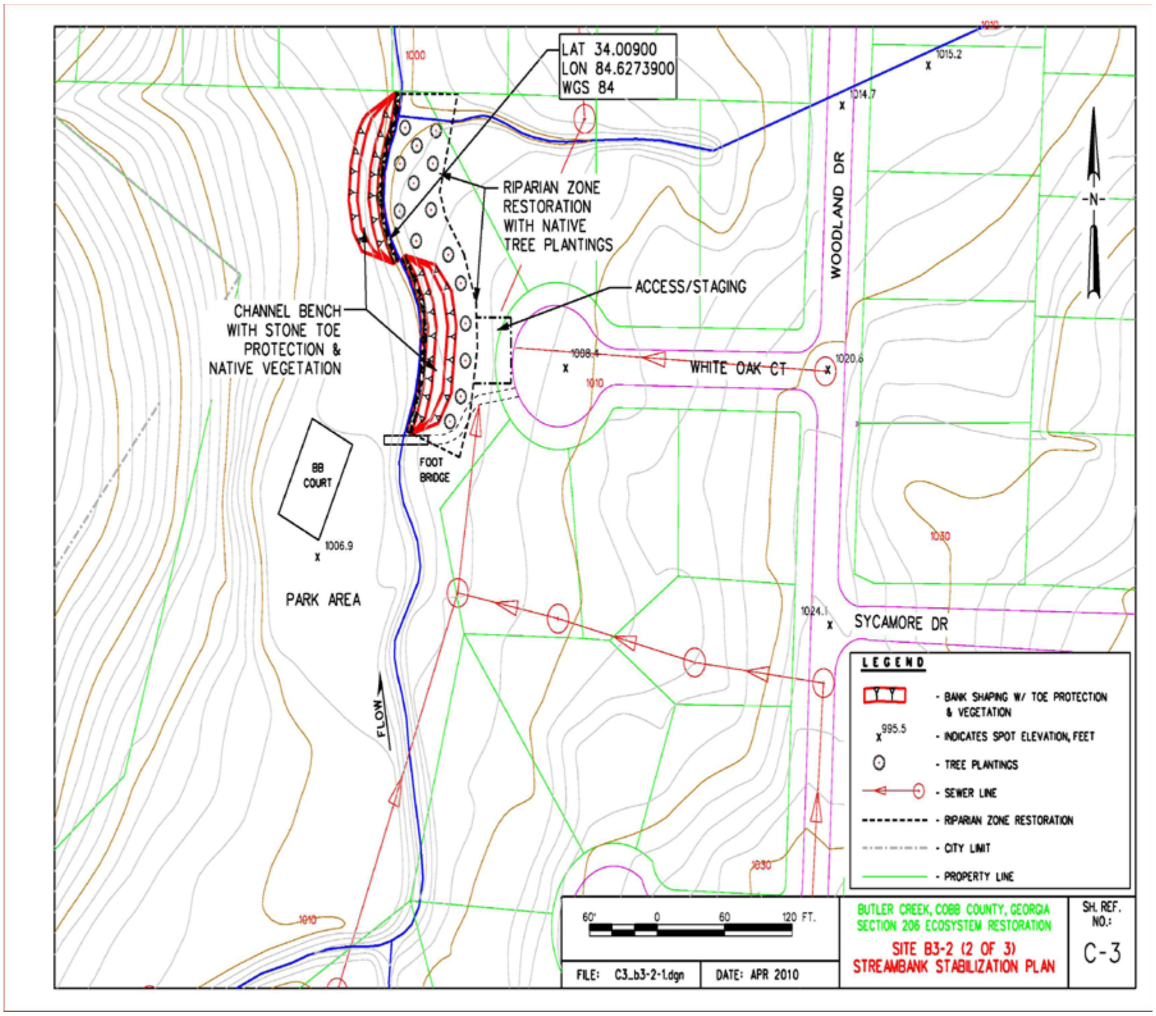

LAT 34.00900
LON 84.6273900
WGS 84
RIPARIAN ZONE
RESTORATION
WITH NATIVE
TREE PLANTINGS
ACCESS/STAGING
CHANNEL BENCH
WITH STONE TOE
PROTECTION &
NATIVE VEGETATION
WOODLAND DR
WHITE OAK CT
BB
COURT
FOOT
BRIDGE
PARK AREA
SYCAMORE DR
FLOW
-N-
LEGEND
- BANK SHAPING W/ TOE PROTECTION & VEGETATION
- INDICATES SPOT ELEVATION, FEET
- TREE PLANTINGS
- SEWER LINE
- RIPARIAN ZONE RESTORATION
- CITY LIMIT
- PROPERTY LINE
60' 0 60 120 FT.
FILE: C3_b3-2-1.dgn
DATE: APR 2010
BUTLER CREEK, COBB COUNTY, GEORGIA
SECTION 206 ECOSYSTEM RESTORATION
SITE B3-2 (2 OF 3)
STREAMBANK STABILIZATION PLAN
SH. REF. NO.:
C-3

Exhibit “B-4”

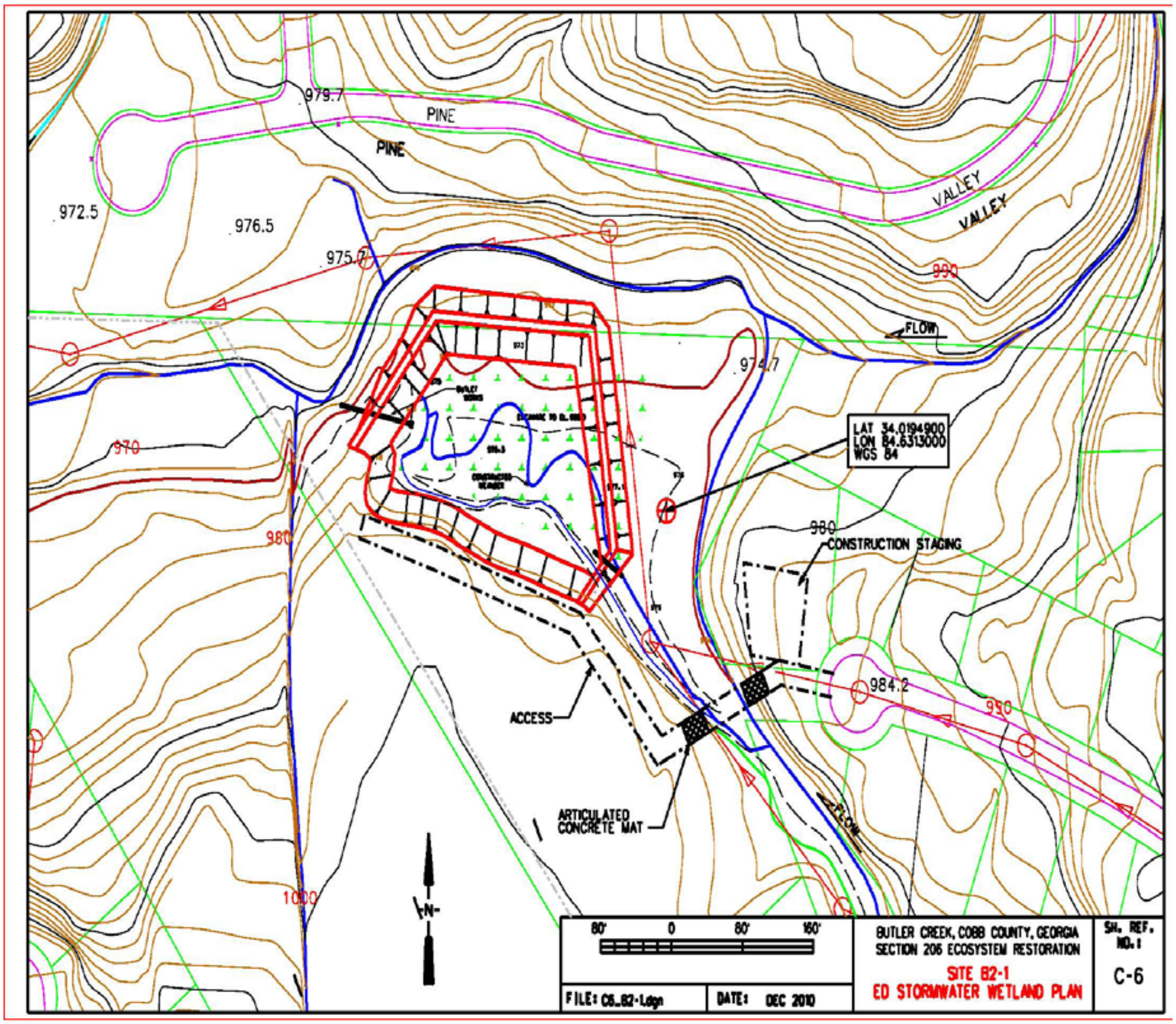
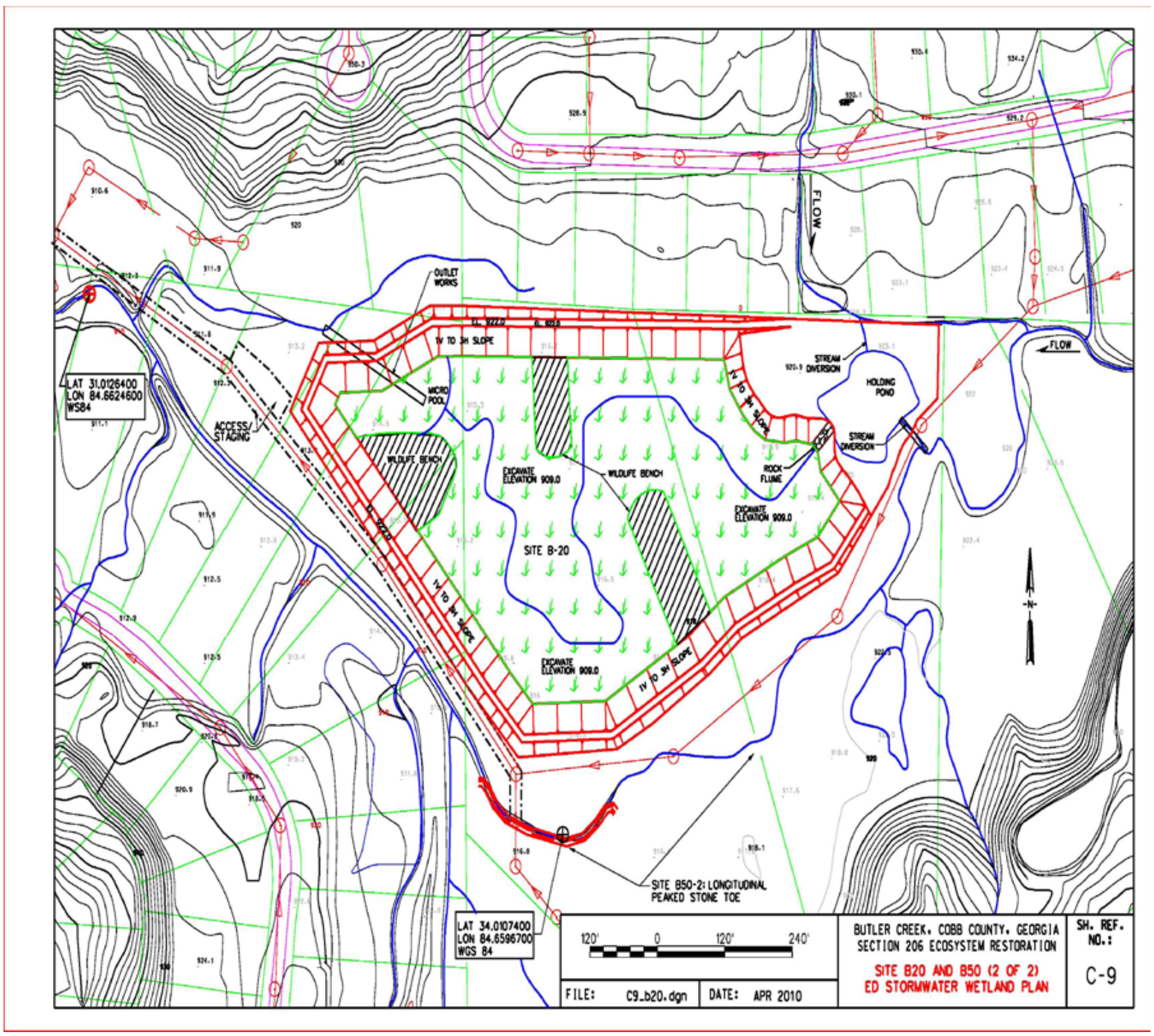

979.7
PINE
PINE
972.5
976.5
975.7
VALLEY
VALLEY
990
FLOW
974.7
LAT 34.0194900
LON 84.6313000
WGS 84
970
980
980
CONSTRUCTION STAGING
984.2
990
ACCESS
ARTICULATED CONCRETE MAT
FLOW
1000
N
80' 0 80' 160'
FILE: C6_B2-1.dgn
DATE: DEC 2010
BUTLER CREEK, COBB COUNTY, GEORGIA
SECTION 206 ECOSYSTEM RESTORATION
SITE B2-1
ED STORMWATER WETLAND PLAN
SH. REF. NO. 1
C-6

Exhibit “B-5”



OUTLET WORKS
EL. 922.0
1V TO 3H SLOPE
MICRO POOL
STREAM DIVERSION
HOLDING POND
FLOW
LAT 31.0126400
LON 84.6624600
WS84
ACCESS/ STAGING
WILDLIFE BENCH
EXCAVATE ELEVATION 909.0
ROCK FLUME
SITE B-20
SITE B50-2: LONGITUDINAL
PEAKED STONE TOE
LAT 34.0107400
LON 84.6596700
WGS 84
-N-
120' 0 120' 240'
FILE: C9_b20.dgn
DATE: APR 2010
BUTLER CREEK, COBB COUNTY, GEORGIA
SECTION 206 ECOSYSTEM RESTORATION
SITE B20 AND B50 (2 OF 2)
ED STORMWATER WETLAND PLAN
SH. REF. NO.:
C-9

Exhibit "B-6"

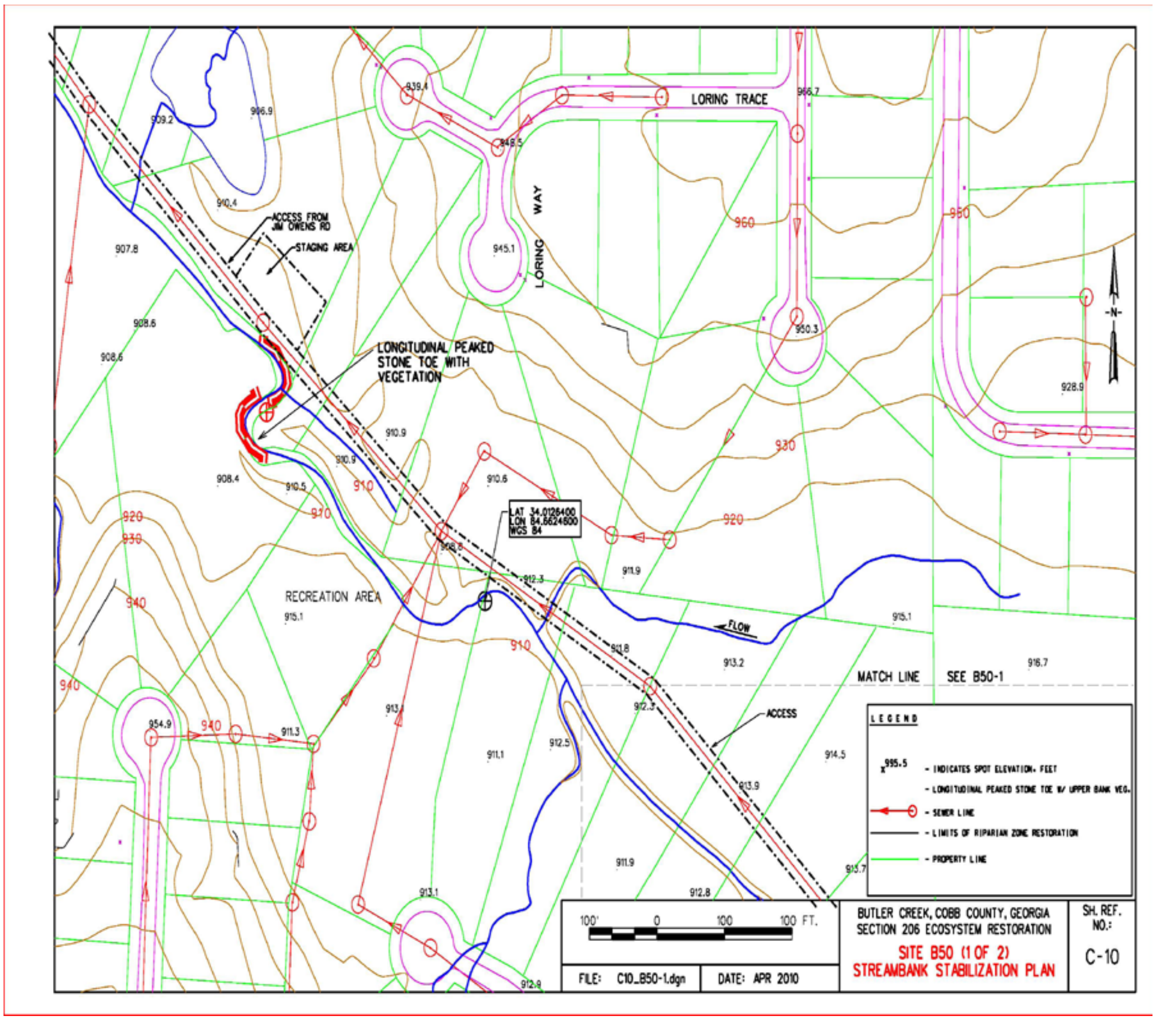

LORING TRACE
LORING WAY
ACCESS FROM JIM OWENS RD
STAGING AREA
LONGITUDINAL PEAKED STONE TOE WITH VEGETATION
LAT 34.0126400
LON 84.6624600
WGS 84
RECREATION AREA
FLOW
MATCH LINE SEE B50-1
ACCESS
LEGEND
- INDICATES SPOT ELEVATION, FEET
- LONGITUDINAL PEAKED STONE TOE W/ UPPER BANK VEG.
- SEWER LINE
- LIMITS OF RIPARIAN ZONE RESTORATION
- PROPERTY LINE
BUTLER CREEK, COBB COUNTY, GEORGIA
SECTION 206 ECOSYSTEM RESTORATION
SITE B50 (1 OF 2)
STREAMBANK STABILIZATION PLAN
SH. REF. NO.:
C-10
FILE: C10_B50-1.dgn
DATE: APR 2010

Exhibit “B-7”

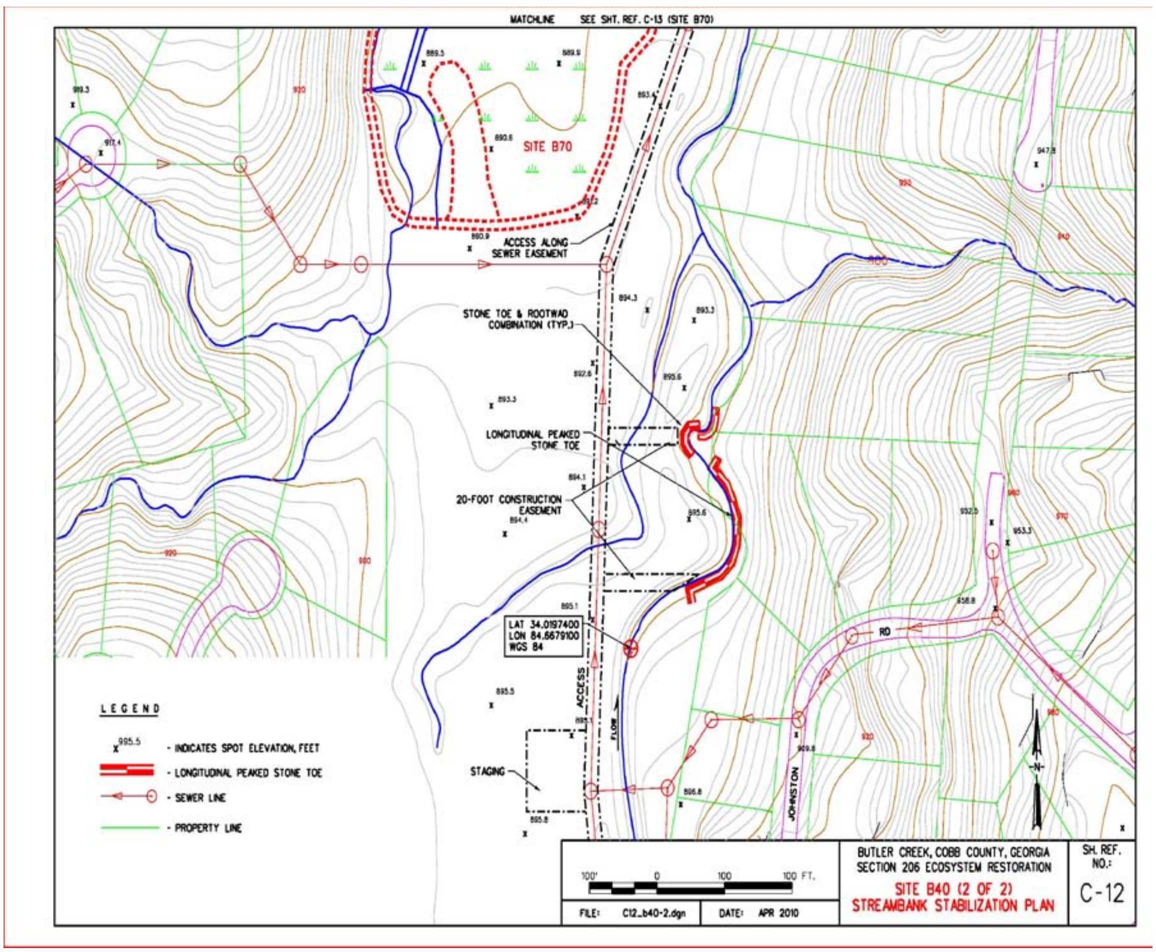

MATCHLINE SEE SHT. REF. C-13 (SITE B70)
SITE B70
ACCESS ALONG SEWER EASEMENT
STONE TOE & ROOTWAD COMBINATION (TYP.)
LONGITUDINAL PEAKED STONE TOE
20-FOOT CONSTRUCTION EASEMENT
LAT 34.0197400
LON 84.6679100
WGS 84
ACCESS
FLOW
STAGING
RD
JOHNSTON
-N-
LEGEND
895.5 - INDICATES SPOT ELEVATION, FEET
- LONGITUDINAL PEAKED STONE TOE
- SEWER LINE
- PROPERTY LINE
100' 0 100 100 FT.
FILE: C12_b40-2.dgn
DATE: APR 2010
BUTLER CREEK, COBB COUNTY, GEORGIA
SECTION 206 ECOSYSTEM RESTORATION
SITE B40 (2 OF 2)
STREAMBANK STABILIZATION PLAN
SH. REF. NO.:
C-12

Exhibit “B-8”

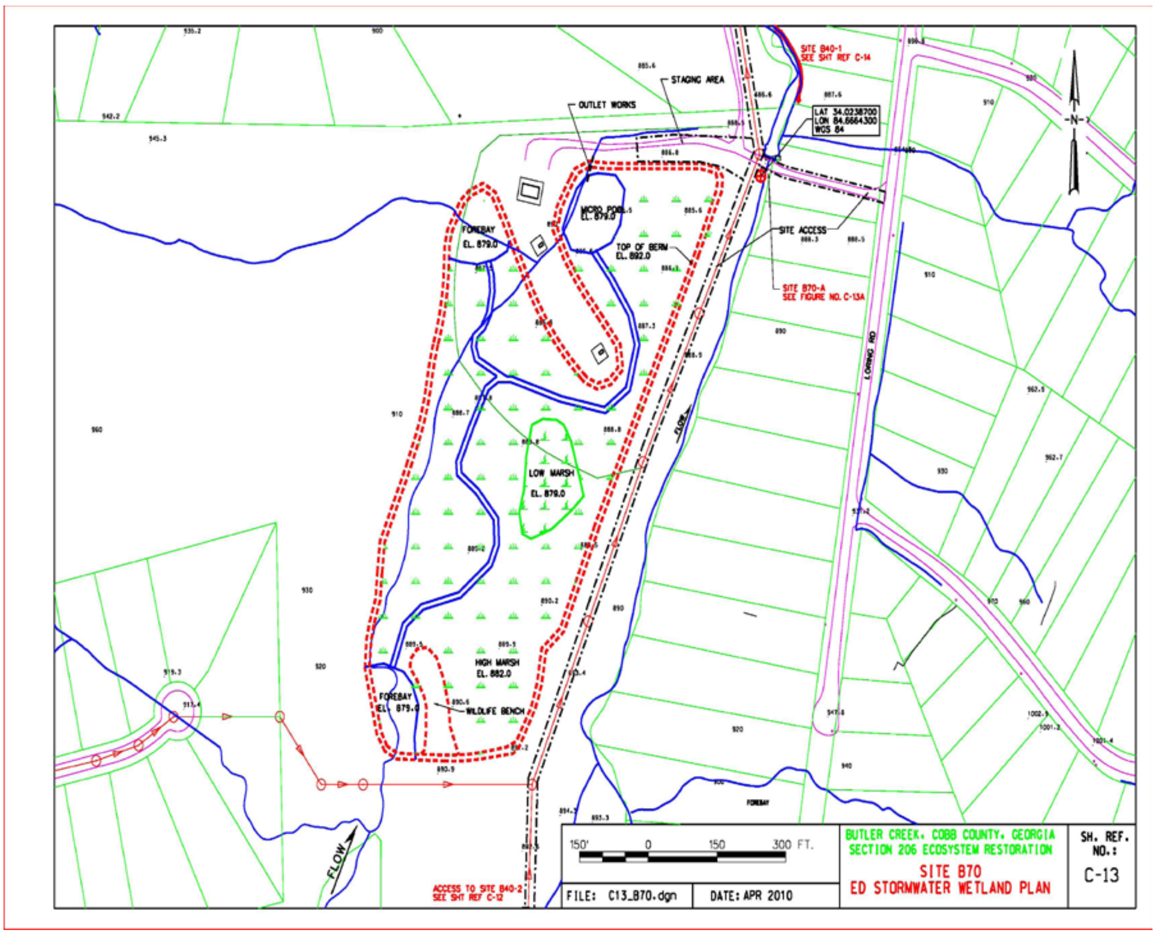

SITE B40-1
SEE SHT REF C-14
STAGING AREA
OUTLET WORKS
LAT 34.0238700
LON 84.6664300
WGS 84
MICRO POOL
EL. 879.0
FOREBAY
EL. 879.0
TOP OF BERM
EL. 892.0
SITE ACCESS
SITE B70-A
SEE FIGURE NO. C-13A
LORING RD
LOW MARSH
EL. 879.0
HIGH MARSH
EL. 882.0
FOREBAY
EL. 879.0
WILDLIFE BENCH
FLOW
FOREBAY
ACCESS TO SITE B40-2
SEE SHT REF C-12
150' 0 150 300 FT.
FILE: C13_B70.dgn
DATE: APR 2010
BUTLER CREEK, COBB COUNTY, GEORGIA
SECTION 206 ECOSYSTEM RESTORATION
SITE B70
ED STORMWATER WETLAND PLAN
SH. REF. NO.:
C-13

Exhibit “B-9”

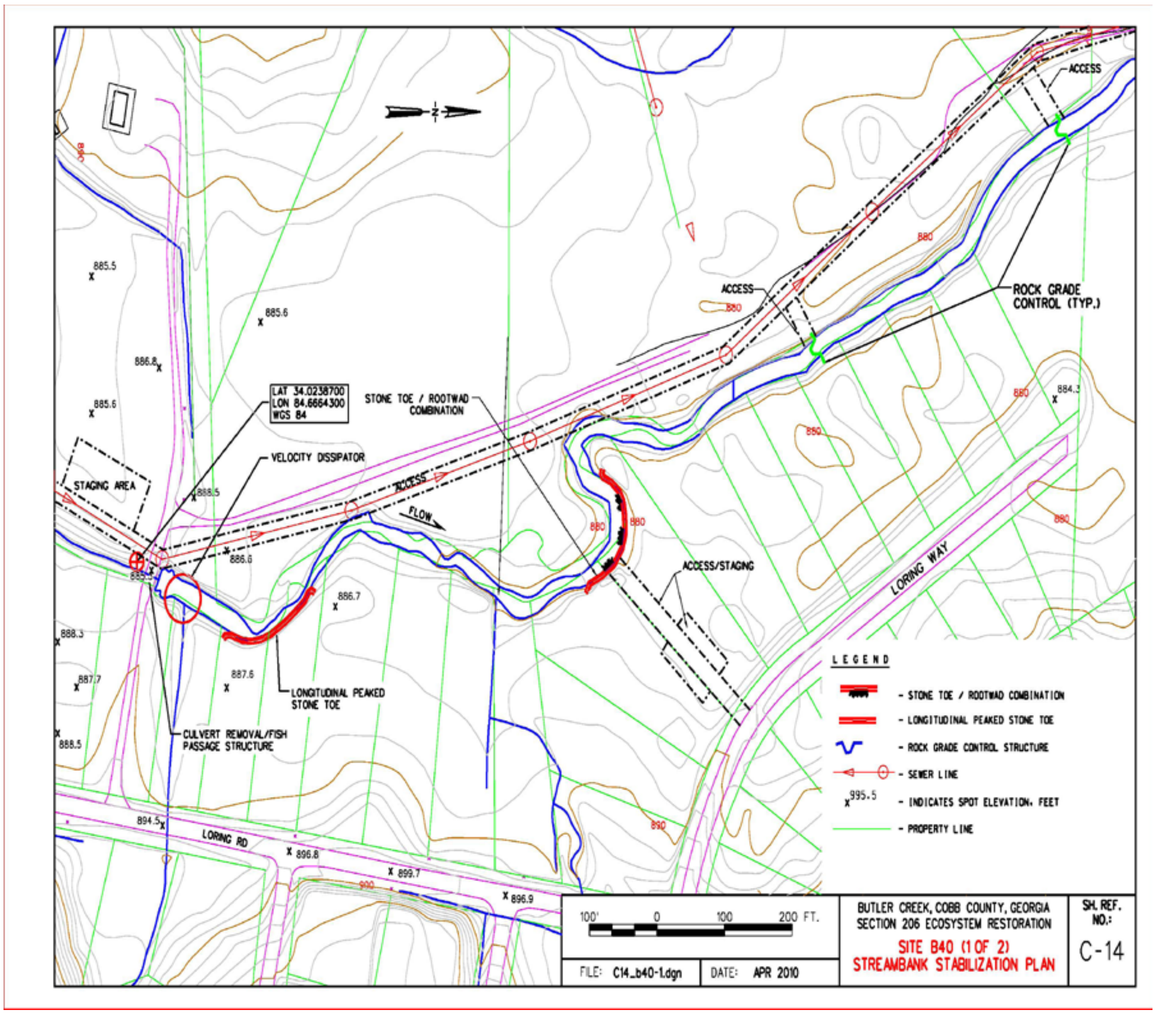

ACCESS
ROCK GRADE CONTROL (TYP.)
ACCESS
LAT 34.0238700
LON 84.6664300
WGS 84
STONE TOE / ROOTWAD COMBINATION
VELOCITY DISSIPATOR
STAGING AREA
ACCESS
FLOW
ACCESS/STAGING
LORING WAY
LONGITUDINAL PEAKED STONE TOE
CULVERT REMOVAL/FISH PASSAGE STRUCTURE
LORING RD
LEGEND
- STONE TOE / ROOTWAD COMBINATION
- LONGITUDINAL PEAKED STONE TOE
- ROCK GRADE CONTROL STRUCTURE
- SEWER LINE
- INDICATES SPOT ELEVATION, FEET
- PROPERTY LINE
100' 0 100 200 FT.
BUTLER CREEK, COBB COUNTY, GEORGIA
SECTION 206 ECOSYSTEM RESTORATION
SITE B40 (1 OF 2)
STREAMBANK STABILIZATION PLAN
SH. REF. NO.:
C-14
FILE: C14_b40-1.dgn
DATE: APR 2010

Exhibit “B-10”

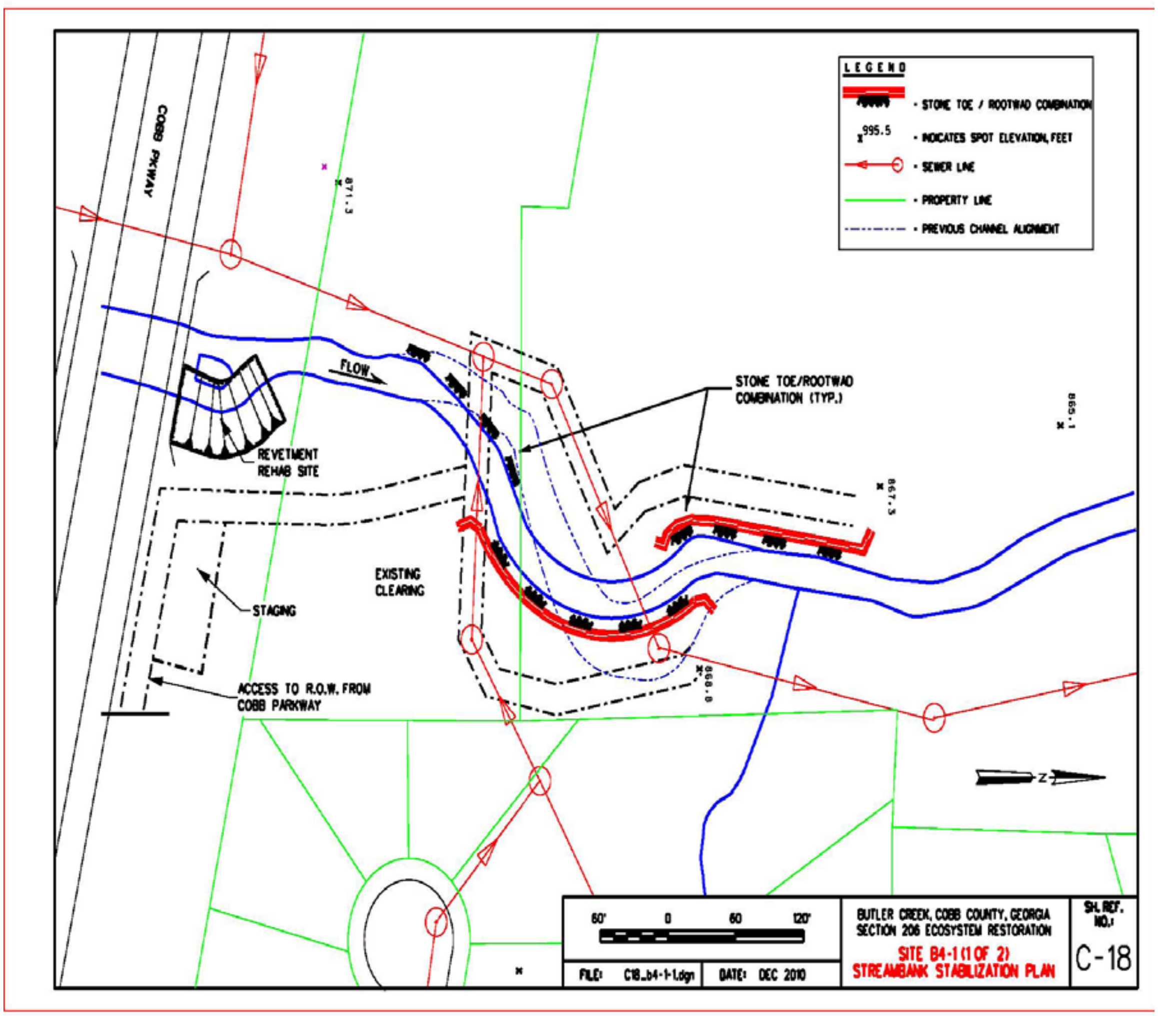

LEGEND
- STONE TOE / ROOTWAD COMBINATION
995.5
- INDICATES SPOT ELEVATION, FEET
- SEWER LINE
- PROPERTY LINE
- PREVIOUS CHANNEL ALIGNMENT
COBB PARKWAY
871.3
FLOW
REVETMENT REHAB SITE
STONE TOE/ROOTWAD COMBINATION (TYP.)
865.1
867.3
EXISTING CLEARING
STAGING
868.8
ACCESS TO R.O.W. FROM COBB PARKWAY
N
60' 0 60 120'
FILE: C18_b4-1-1.dgn
DATE: DEC 2010
BUTLER CREEK, COBB COUNTY, GEORGIA
SECTION 206 ECOSYSTEM RESTORATION
SITE B4-1 (1 OF 2)
STREAMBANK STABILIZATION PLAN
SH. REF. NO.:
C-18

Exhibit "C"

AUTHORIZATION FOR ENTRY FOR CONSTRUCTION

I, *(name of accountable official)* , *(title)* ________________ for *(name of non-Federal sponsor)* _______, do hereby certify that the _______ *(name of non-Federal sponsor)* has acquired the real property interests required by the Department of the Army, and otherwise is vested with sufficient title and interest in lands to support construction of *(project name, specifically identified project features, etc.)* . Further, I hereby authorize the Department of the Army, its agents, employees and contractors, to enter upon ____ *(identify tracts)* __ to construct *(project name, specifically identified project features, etc.)* as set forth in the plans and specifications held in the U. S. Army Corps of Engineers'____________________ District Office, (*city and state*)

WITNESS my signature as _______ *(title)* __ for __ *(name of non-Federal sponsor)* ____this ______ day of ________________, 20___________.

BY: _______ *(name)* _______________________

_______ *(title)* ________________________

ATTORNEY'S CERTIFICATE OF AUTHORITY

I, ______ *(name)* ________________ , ______ *(title of legal officer)* ____ for ___ *(name non-Federal sponsor)* ______, certify that ______ *(name of non-Federal sponsor)* _____ has authority to grant Authorization for Entry; that said Authorization for Entry is executed by the proper duly authorized officer; and that the Authorization for Entry is in sufficient form to grant the authorization therein stated.

WITNESS my signature as _________ *(title)* _______ for __ *(name of non-Federal sponsor)* , this___________day of________________, 20_____.

BY: _______ *(name)* ______________________________

_______ *(title)* ______________________________

Exhibit "D"

DEPARTMENT OF THE ARMY
MOBILE DISTRICT, CORPS OF ENGINEERS
P.O. BOX 2288
MOBILE, ALABAMA 36628-0001

REPLY TO
ATTENTION OF: SAM-RE-P

COBB COUNTY, GEORGIA - BUTLER CREEK
SECTION 206 ECOSYSTEM RESTORATION PROJECT

COBB COUNTY WATER SYSTEM – NON FEDERAL SPONSOR

ASSESSMENT OF NON-FEDERAL SPONSOR'S
REAL ESTATE ACQUISITION CAPABILITY

1. **LEGAL AUTHORITY:**

   a. **Does the sponsor have legal authority to acquire and hold title to real property for project purposes?** YES

   b. **Does the sponsor have the power of eminent domain for this project?** YES

   c. **Does the sponsor have "quick-take" authority for this project?** UNKNOWN

   d. **Are any of the lands/interests in land required for the project located outside the sponsor's political boundary?** YES

   e. **Any of the lands/interests in land required for the project owned by an entity whose property the sponsor cannot condemn?** YES
      i. **Private Property:** ✓
      ii. **State-Owned Property:** ✓

2. **HUMAN RESOURCE REQUIREMENTS:**

   a. **Will the sponsor's in-house staff require training to become familiar with the real estate requirements of Federal projects including P.L. 91-646, as amended?** YES

   b. **If the answer to 2(a) is "yes", has a reasonable plan been developed to provide such training?** NO

   c. **Does the sponsor's in-house staff have sufficient real estate acquisition experience to meet its responsibilities for the project?** YES

Page 1

d. **Is the sponsor's projected in-house staffing level sufficient considering its other workload, if any, and the project schedule?** No

e. **Can the sponsor obtain contractor support, if required, in a timely fashion?** YES

f. **Will the sponsor likely request USACE assistance in acquiring real estate? (If "yes", provide description).** No

3. <u>OTHER PROJECT VARIABLES:</u>

a. **Will the sponsor's staff be located within reasonable proximity to the project site?** YES

b. **Has the sponsor approved the project/real estate schedule milestones *(answer is contingent upon whether the real estate milestones have been defined at this point in the project)*?** No

4. OVERALL ASSESSMENT:

a. **Has the sponsor performed satisfactorily on other USACE projects (if applicable)?** YES

b. **With regard to this project, the sponsor is anticipated to be: Highly capable; Fully capable; Moderately capable; Marginally capable; Insufficiently capable. (If sponsor is believed to be insufficiently capable, please provide explanation).**

5. COORDINATION:

a. **Has this assessment been coordinated with the sponsor?** YES

b. **Does the sponsor concur with this assessment?** YES

[redacted]

Page 2

Exhibit "E"

DEPARTMENT OF THE ARMY
MOBILE DISTRICT, CORPS OF ENGINEERS
P.O. BOX 2288
MOBILE, ALABAMA 36628-0001

REPLY TO
ATTENTION OF:

Real Estate Division
Planning Section

[redacted]

Subject: Cobb County, GA – Butler Creek, Section 206 Ecosystem Restoration Project - Formal Risk Notification Letter to Non-Federal Sponsor

Dear Mr. Higgins,

The intent of this letter is to formally advise Cobb County, as potential Non-Federal Sponsor for a proposed project, of the risks associated with land acquisition prior to the execution of a Project Partnership Agreement (PPA) or prior to the Government's formal notice to proceed with acquisition. If a Non-Federal Sponsor deems it necessary to commence acquisition prior to an executed PPA for whatever reason, the Non-Federal Sponsor assumes full and sole responsibility for any and all costs, responsibility, or liability arising out of the acquisition effort.

Generally, these risks include, but may be not be limited to, the following:

(1) Congress may not appropriate funds to construct the proposed project;

(2) The proposed project may otherwise not be funded or approved for construction;

(3) A PPA mutually agreeable to the non-Federal sponsor and the Government may not be executed and implemented;

(4) The non-Federal sponsor may incur liability and expense by virtue of its ownership of contaminated lands, or interests therein, whether such liability should arise out of local, state, or Federal laws or regulations including liability arising out of CERCLA, as amended;

(5) The non-Federal sponsor may acquire interests or estates that are later determined by the Government to be inappropriate, insufficient, or otherwise not required for the project;

1

(6) The non-Federal sponsor may initially acquire insufficient or excessive real property acreage which may result in additional negotiations and/or benefit payments under P.L. 91-646 as well as the payment of additional fair market value to affected landowners which could have been avoided by delaying acquisition until after PPA execution and the Government's notice to commence acquisition and performance of LERRD;

(7) The non-Federal sponsor may incur costs or expenses in connection with its decision to acquire or perform LERRD in advance of the executed PPA and the Government's notice to proceed which may not be creditable under the provisions of Public Law 99-662 or the PCA. Reference ER 405-1-12 (Change 31; 1 May 98) Section 12-31 Acquisition Prior to PCA Execution.

Please acknowledge that the Non-Federal Sponsor for the proposed project accepts these terms and conditions.

[redacted]

Appendix M
Wetland Report

TECHNICAL MEMORANDUM

Butler Creek Watershed: Proposed Alternative Sites Wetland Delineation

August 2011

Purpose

The U.S. Army Corps of Engineers (USACE) Mobile District has proposed an aquatic ecosystem restoration project under Section 206 of the Water Resources Development Act of 1996, as amended. The National Ecosystem Restoration (NER) Plan for Butler Creek includes 9 individual sites within the Butler Creek watershed (Figure 1). This technical memorandum (TM) presents findings from a site visit conducted at these alternative sites, which include B2-1, B3-1, B3-2, B3-2-3, B4-1, B20, B40 (2 components), B540 (2 components), and B70. The site visit was conducted to evaluate the presence of jurisdictional wetlands or other waters of the United States that require delineation and potential permitting in accordance with Section 404 of the Clean Water Act (CWA), which is administered by the USACE Savannah District Regulatory Division. The Savannah District would verify the report findings and determine if wetlands and other waters of the United States would require permitting under section 404 of the CWA. CH2M HILL conducted an evaluation of the proposed Alternative Sites on June 17, 2010. This TM represents the professional opinion of CH2M HILL regarding the presence or absence of wetlands and their boundaries within the study areas.

Wetland Determination Methodology

Wetland Definition

Wetlands for the purpose of this study were defined as:

> "*…those areas inundated or saturated by surface or groundwater at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs, and similar areas*" (USACE, January 1987, pg. 12).

This definition identifies three essential characteristics possessed by wetlands: 1) hydrophytic vegetation; 2) hydric soils; and 3) wetland hydrology.

Waters of the United States

The term "waters of the United States" has broad meaning and incorporates both deepwater aquatic habitats and special aquatic sites, including wetlands, as follows (33 *Code of Federal Regulations* [CFR] Part 328.3(a)):

"1. All waters which are currently used, or were used in the past, or may be susceptible to use in interstate or foreign commerce, including all waters which are subject to the ebb and flow of the tide;

2. All interstate waters including interstate wetlands;

3. All other waters such as intrastate lakes, rivers, streams (including intermittent streams), mudflats, sandflats, wetlands, sloughs, prairie potholes, wet meadows, playa lakes, or natural ponds, the use, degradation or destruction of which could affect interstate or foreign commerce including any such waters:

Which are or could be used by interstate or foreign travelers for recreational or other purposes; or

From which fish or shellfish are or could be taken and sold in interstate or foreign commerce; or

Which are used or could be used for industrial purpose by industries in interstate commerce;

4. All impoundments of waters otherwise defined as waters of the United States under the definition;

5. Tributaries of waters identified in paragraphs (a)(1)-(4) of this section;

6. The territorial seas;

7. Wetlands adjacent to waters, (other than waters that are themselves wetlands) identified in paragraphs (a)(1)-(6) of this section;

8. Waste treatment systems, including treatment ponds or lagoons designed to meet the requirements of the Clean Water Act (other than cooling ponds as defined in 40 CFR 123.11 (m) which also meet the criteria of this definition) are not waters of the United States.

9. Waters of the United States do not include prior converted cropland. Notwithstanding the determination of an area's status as prior converted cropland by any other federal agency, for the purposes of the Clean Water Act, the final authority regarding Clean Water Act jurisdiction remains with the EPA."

For the purpose of this TM, discussion of "waters of the United States" occurring within the project area will be separated into wetlands and non-wetland waters. Non-wetland waters refer to all waters that do not meet the wetland criteria (hydrophytic vegetation, hydric soils, and hydrology), as defined in the 1987 Manual (USACE, 1987). Lakes, ponds, impoundments, and permanent and intermittent streams outside of wetlands are commonly included as non-wetland waters. However, the determination of CWA jurisdiction lies with the USACE.

Alternative Site Descriptions

All the proposed Alternative Sites are within the Butler Creek watershed, which is located in the Etowah River Basin in northwestern Cobb County, Georgia, and drains into Lake Acworth. Lake Acworth is a subimpoundment of Lake Altoona, a federally managed multi-use reservoir. The Butler Creek watershed encompasses 6,016 total acres (9.4 square miles) and contains a total of approximately 12.7 stream miles (7 miles of main stem and 5.7 miles of tributaries). Topography in the Butler Creek watershed ranges from 1,100 feet above mean sea level (msl) in the headwaters to 850 feet above msl, where the stream enters the backwaters of Lake Acworth. The Butler Creek watershed is located entirely within Cobb County, which is part of the northern Piedmont physiographic province. The watershed includes portions of the Cities of Kennesaw and Acworth and unincorporated areas of Cobb County, with the headwaters being the most developed portion of the watershed.

Alternatives B3-2, B4-1, B40, and B50, are sections of Butler Creek or associated tributaries and include the creek bed and a 50 foot buffer on both banks. Alternative B2-1 includes a section of a Butler Creek tributary and the surrounding floodplain area. Alternatives B3-2-3, B20, and B70 are open field and wooded areas adjacent to Butler Creek tributaries. Finally, Alternative B3-1 is a manmade structure located in the stream channel of a Butler Creek tributary. Table 1 lists the access and approximate linear feet or acreage of the proposed Alternative sites.

TABLE 1
Alternative Sites
Wetland Delineation – Butler Creek, Georgia Site

Alternative Site	Location/Access	Linear Feet or Acreage
B2-1	End of Wellcrest Drive	1.55 ac.
B3-1	Shillings Chase Court	0.12 ac.
B3-2	End of White Oak Court	235 ft.
B3-2-3	End of Woodland Place	1.68 ac.
B4-1	North of Cobb Parkway, accessed from gravel road near guardrail	618 ft.
B20	Sewer easement from Jim Owens Road	10.21 ac.
B40 (1 of 2)	Loring Way was blocked off, so accessed from the sewer easement crossing Loring Drive	349 ft.
B40 (2 of 2)	Sewer easement near Johnston Road	283 ft.
B50 (1 of 2)	Sewer easement from Jim Owens Road	277 ft.
B50 (2 of 2)	Sewer easement from Jim Owens Road	184 ft.
B70	Loring Road	9.90 ac.

Notes:
ft. = linear feet
ac. = acres

Wetland Delineation Results

One jurisdictional wetland (W02 – Latitude: 34.0233, Longitude: -84.6682) was identified in the open field area of Alternative B70 (Figure 2). The area exhibited hydrophytic vegetation, hydric soils and positive indicators of wetland hydrology. The wetland, measuring approximately 1.178 acres, was classified as palustrine and emergent. The vegetation was dominated by soft rush (*Juncus effuses)*, Frank's sedge (*Carex frankii*), and buttonbush (*Cephalanthus occidentalis*). The soils in this area had redoximorphic features characteristic of hydric soils and were saturated to the surface (Attachment 1).

Conclusions and Permitting Requirements

CH2M HILL identified one wetland at Alternative B70. The USACE Mobile District has proposed to reroute the intermittent tributary through a sediment forebay and into 9-acre extended detention created wetland at the Alternative site. Permitting requirements will be determined upon completion of project planning.

References

U.S. Army Corps of Engineers. January 1987. *Corps of Engineers Wetlands Delineation Manual*. Environmental Laboratory, Department of the Army.

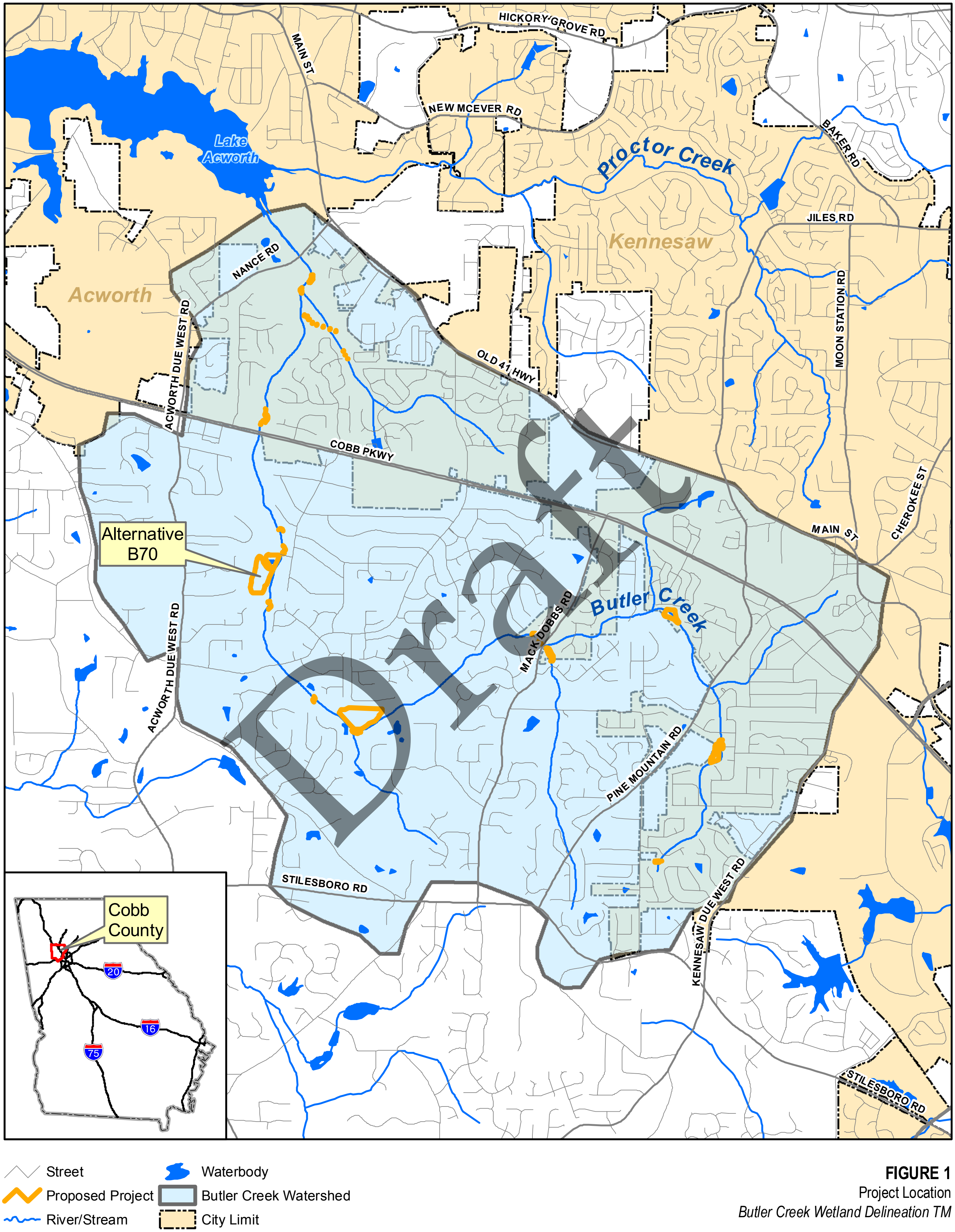
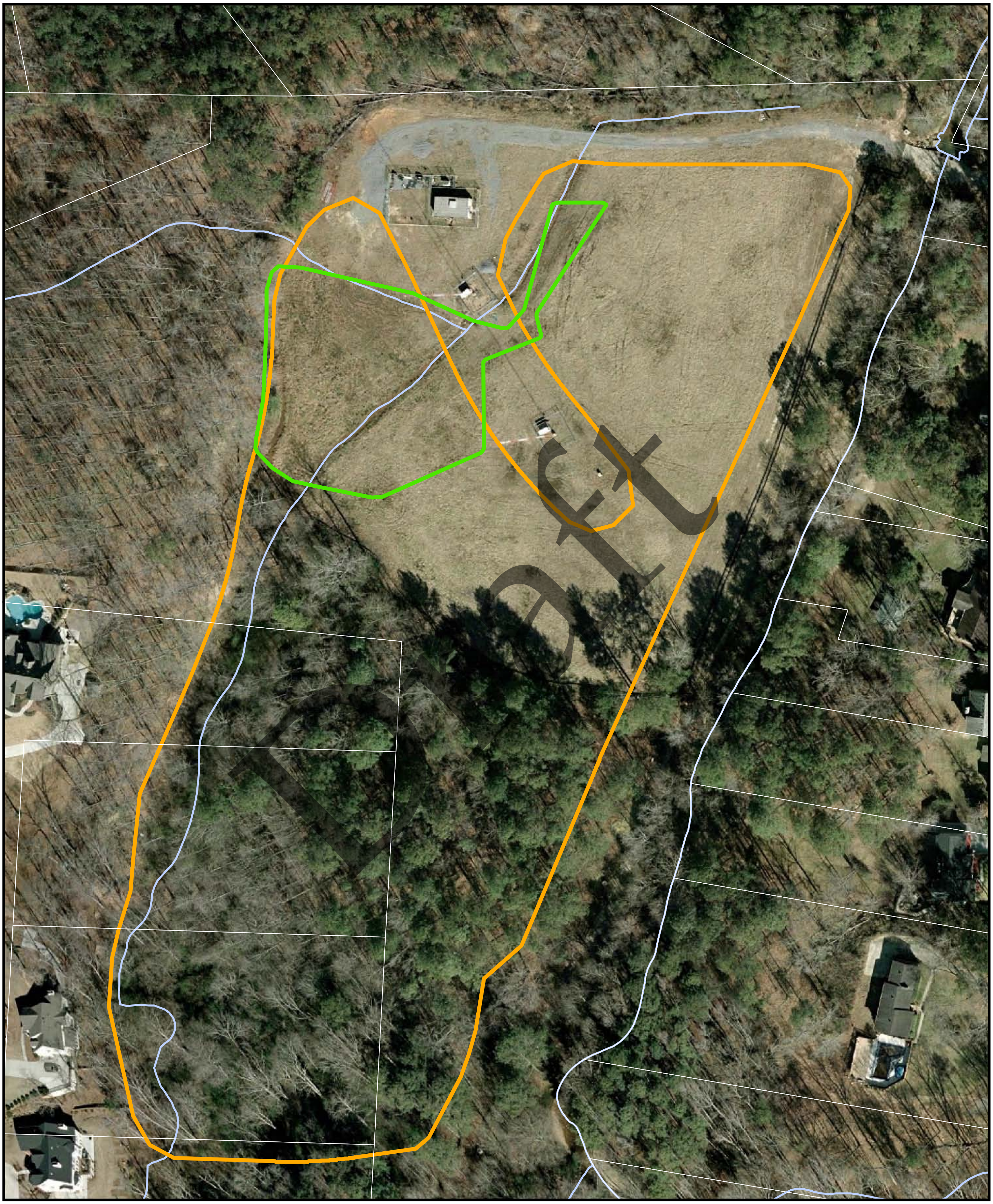


FIGURE 1
Project Location
Butler Creek Wetland Delineation TM

Source: Cobb County, 2009

CH2MHILL

\\GALILEO\PROJ\BUTLERCREEK\MAPFILES\WATERSHED.MXD JMINIX 5/24/2010 16:05:49



River / Stream

Wetland W02

Alternative B70 Project Footprint

Property Parcels

0 50 100 Feet

FIGURE 2
Wetland W02
Butler Creek Wetland Delineation TM

Source: Cobb County, 2009

CH2MHILL

\\GALILEO\PROJ\BUTLERCREEK\MAPFILES\WETLAND.MXD JMINIX 7/1/2010 10:12:55

Attachment

DATA FORM
ROUTINE WETLAND DETERMINATION
(1987 COE Wetlands Delineation Manual)

Project/Site: Alternative B70 - Butler Creek		Date:	6/17/10
Applicant/Owner: Cobb County / USACE Mobile District		County:	Cobb
Investigator: S.K./J.J - CH2M HILL		State:	GA
Do Normal Circumstances exist on the site?	☐ Yes ☑ No	Community ID:	Wetland
Is the site significantly disturbed (Atypical Situation)?	☐ Yes ☑ No	Transect ID:	
Is the area a potential Problem Area? (If needed, explain on reverse.)	☐ Yes ☑ No	Plot ID:	

VEGETATION

Dominant Plant Species	Stratum	Indicator	Dominant Plant Species	Stratum	Indicator
1. Juncus effusus	herb	Facwt	9.		
2. Carex frankii	herb	Obl	10.		
3. Cephalanthus	shrub	Obl	11.		
4. occidentalis			12.		
5.			13.		
6.			14.		
7.			15.		
8.			16.		

Percent of Dominant Species that are OBL, FACW or FAC (excluding FAC-). 100% → 100% vegetation cover

Remarks: wetland in open field adjacent to [redacted] intermittent stream channel and two radio towers. Stream channel is tributary to Bulter Creek.

HYDROLOGY

☑ Recorded Data (Describe in Remarks):
- ☐ Stream, Lake, or Tide Gauge
- ☑ Aerial Photographs
- ☐ Other

☐ No Recorded Data Available

Field Observations:

Depth of Surface Water: 3 (in.)

Depth to Free Water in Pit: 0 (in.)

Depth to Saturated Soil: 0 (in.)

Wetland Hydrology Indicators:

Primary Indicators:
- ☑ Inundated
- ☑ Saturated in Upper 12 Inches
- ☐ Water Marks
- ☐ Drift Lines
- ☐ Sediment Deposits
- ☑ Drainage Patterns in Wetlands

Secondary Indicators (2 or more required):
- ☑ Oxidized Root Channels in Upper 12 Inches
- ☐ Water-Stained Leaves
- ☐ Local Soil Survey Data
- ☐ FAC-Neutral Test
- ☐ Other (Explain in Remarks)

Remarks: stream channel visible on aerial photograph

SOILS

Map Unit Name (Series and Phase): —

Taxonomy (Subgroup): —

Drainage Class: —

Field Observations

Confirm Mapped Type? ☐ Yes ☐ No

Profile Descriptions:

Depth (inches)	Horizon	Matrix Color (Munsell Moist)	Mottle Colors (Munsell Moist)	Mottle Abundance/ Size/Contrast	Texture, Concretions, Structure, etc,
0 - 12+	A	7.5YR 4/1	7.5YR 4/6	30%	Sandy clay loam

Hydric Soil Indicators:

- ☐ Histosol
- ☐ Histic Epipedon
- ☑ Sulfidic Odor
- ☐ Aquic Moisture Regime
- ☐ Reducing Conditions
- ☑ Gleyed or Low-Chroma Colors
- ☐ Concretions
- ☐ High Organic Content in Surface Layer in Sandy Soils
- ☐ Organic Streaking in Sandy Soils
- ☐ Listed on Local Hydric Soils List
- ☐ Listed on National Hydric Soils List
- ☐ Other (Explain in Remarks)

Remarks:

WETLAND DETERMINATION

Hydrophytic Vegetation Present?	☑ Yes	☐ No	(Check)
Wetland Hydrology Present?	☑ Yes	☐ No	
Hydric Soils Present?	☑ Yes	☐ No	

(Check)

Is this Sampling Point Within a Wetland? ☑ Yes ☐ No

Remarks

Approved by HQUSACE 3/92

Forms version 1/02

DATA FORM
ROUTINE WETLAND DETERMINATION
(1987 COE Wetlands Delineation Manual)

Project/Site: Alternative B10 - Butler Creek		Date: 6/17/2010
Applicant/Owner: Cobb County / USACE Mobile District		County: Cobb
Investigator: S.K. / J.J. - CH2M HILL		State: GA
Do Normal Circumstances exist on the site?	☐Yes ☑No	Community ID: Upland
Is the site significantly disturbed (Atypical Situation)?	☐Yes ☑No	Transect ID:
Is the area a potential Problem Area? (If needed, explain on reverse.)	☐Yes ☑No	Plot ID:

VEGETATION

Dominant Plant Species	Stratum	Indicator	Dominant Plant Species	Stratum	Indicator
1. Rubus betulifolius	herb	Fac	9.		
2. Pinus taeda	tree	Fac-	10.		
3. Liriodendron tulipifera	tree	FacU	11.		
4. Liquidambar	tree	Fac	12.		
5. Styraciflua			13.		
6.			14.		
7.			15.		
8.			16.		

Percent of Dominant Species that are OBL, FACW or FAC (excluding FAC-). 50%

Remarks: Upland point was recorded at the edge of the open field adjacent to the forest.

HYDROLOGY

☑ Recorded Data (Describe in Remarks):
- ☐ Stream, Lake, or Tide Gauge
- ☑ Aerial Photographs
- ☐ Other

☐ No Recorded Data Available

Field Observations:

Depth of Surface Water: 0 (in.)

Depth to Free Water in Pit: 16+ (in.)

Depth to Saturated Soil: 16+ (in.)

Wetland Hydrology Indicators:

Primary Indicators:
- ☐ Inundated
- ☐ Saturated in Upper 12 Inches
- ☐ Water Marks
- ☐ Drift Lines
- ☐ Sediment Deposits
- ☐ Drainage Patterns in Wetlands

none

Secondary Indicators (2 or more required):
- ☐ Oxidized Root Channels in Upper 12 Inches
- ☐ Water-Stained Leaves
- ☐ Local Soil Survey Data
- ☐ FAC-Neutral Test
- ☐ Other (Explain in Remarks)

Remarks: The aerial photograph shows pine and different vegetation from the wetland area.

SOILS

Map Unit Name (Series and Phase): —

Drainage Class: —

Field Observations —

Confirm Mapped Type? ☐ Yes ☐ No

Taxonomy (Subgroup): —

Profile Descriptions:

Depth (inches)	Horizon	Matrix Color (Munsell Moist)	Mottle Colors (Munsell Moist)	Mottle Abundance/ Size/Contrast	Texture, Concretions, Structure, etc,
0-12+	A	7.5YR 5/6	NA	NA	clay loam

Hydric Soil Indicators: none

- ☐ Histosol
- ☐ Histic Epipedon
- ☐ Sulfidic Odor
- ☐ Aquic Moisture Regime
- ☐ Reducing Conditions
- ☐ Gleyed or Low-Chroma Colors
- ☐ Concretions
- ☐ High Organic Content in Surface Layer in Sandy Soils
- ☐ Organic Streaking in Sandy Soils
- ☐ Listed on Local Hydric Soils List
- ☐ Listed on National Hydric Soils List
- ☐ Other (Explain in Remarks)

Remarks: Likely fill material from building the radio towers

WETLAND DETERMINATION

Hydrophytic Vegetation Present? ☐ Yes ☑ No (Check)

Wetland Hydrology Present? ☐ Yes ☑ No

Hydric Soils Present? ☐ Yes ☑ No

(Check)

Is this Sampling Point Within a Wetland? ☐ Yes ☑ No

Remarks